IRAAR 2026 conference

Quarries and Rock-cut Sites through the Lens of Archaeology

Edinburgh (UK) 14-15 May 2026

ABSTRACTS

THE UNIVERSITY of EDINBURGH
School of History, Classics and Archaeology

UK Research and Innovation

UNIVERSITÉ PAUL VALÉRY MONTPELLIER 3

ASM Archéologie Sociétés Méditerranéennes

LABEX ARCHIMEDE

FRANCE 2030

Inrap Institut national de recherches archéologiques préventives

CONSULAT GÉNÉRAL DE FRANCE À EDIMBOURG ET GLASGOW
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IN SUPREMÆ DIGNITATIS 1343 UNIVERSITÀ DI PISA

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SCARF Scottish Archaeological Research Framework

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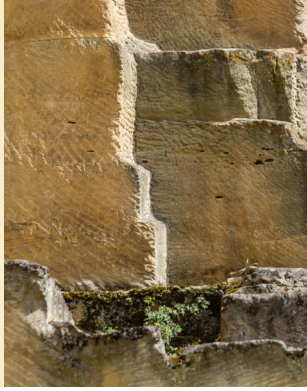
mappa metodologie digitali applicate all'archeologia

SESSION 1 Facing risks: challenges, adaptations, and transformations in quarrying and rock-hewing practices



Before quarrying begins: an exploration trench in a coastal limestone quarry near Marathon (Attica, Greece)

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The north-eastern margins of Attica (Greece) are geologically renowned for their white marbles, which are still quarried today. Within this predominantly marble landscape, an ancient coastal quarry exploiting bioclastic limestone has recently been identified. Located north of the Marathon plain, the littoral quarry known as Drakonera supplied large ashlar blocks for monumental construction. Both the extraction techniques and the standardized block modules strongly suggest an ancient date of exploitation. While the overall quarrying methods are comparable to those documented in other Greek coastal “poros” quarries (such as Aegina or Skyros), one feature deserves closer attention and forms the focus of this paper. This feature consists of a narrow trench over 2 m deep, just wide enough for a single worker to stand and cut, excavated into a sector of the limestone outcrop that was otherwise never quarried. After considering several possible interpretations, we argue that this trench should be understood as a test excavation carried out by quarry workers. Its purpose was likely to assess stone quality, document the local lithostratigraphy, and evaluate both the depth and the exploitable volume of the deposit before large-scale extraction began. The fact that this sector of the outcrop was never quarried subsequently explains the preservation of the trench.

This discovery offers rare insight into the decision-making processes and technical strategies employed by ancient quarrymen when evaluating a stone resource. It invites a reassessment of what may be termed ancient geological prospecting practices. By examining how quarry workers investigated the subsurface and tested raw material quality, this case study contributes to a wider discussion of ancient technical knowledge and the practical understanding of geology in the context of stone extraction.

The influence of the physical environment on stone extraction processes in the quarries of Petra (Jordan) and the subsequent production of architectural stones

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Petra, the ancient capital of the Nabataeans, is uniquely suited for the study of quarrying processes and rock-cutting techniques, as well as freestanding architecture, which is closely related to the rock-cut architecture. The city’s landscape is dominated by towering sandstone formations, within which several quarries are located close to the city center. Nevertheless, these quarries were not the only sources of stone. In the course of constructing the monumental rock-cut façades, these were also used as quarries to maximize the use of extracted stone, particularly from the interiors. Even

the bedrock in the center of the valley basin was temporarily used as a quarry while it was systematically cut away to clear space and create foundations for the monumental buildings before they were constructed. Petra is a prototypical example of a landscape surrounded by rock formations, in which historical architectural evidence is closely linked to the rock itself. Previous research on Petra's rock-cut architecture has focused on technical and artistic aspects. During the 1990s, particular attention was given to the quarries and stone extraction methods. However, the relationship between rock-cut architecture and freestanding architecture has rarely been addressed. Furthermore, there remains a knowledge gap regarding the influence of extraction methods, the physical environment, and characteristics of the natural stone on the production of prefabricated architectural components.

This paper examines the extraction methods employed in Petra and their influence on the production of individual building elements from rough blocks. By analyzing traces on processed stones, their dimensions, and the production of decorative components from multiple segments we gain information about the manufacturing processes. When combined with knowledge of quarry activities, these findings reveal systematic extraction and stone-processing techniques – methods that were not only applied in Petra's sandstone quarries but also in distant limestone quarries.

Mesolithic microquartzite quarry sites in Brittany: petrographic characterization, lithic technological approaches and research perspectives

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The Armorican massif is a crystalline massif devoid of flint in primary position. From the end of the Paleolithic, prehistoric communities collected flint pebbles along the coast and developed strategies to acquire other knappable rocks like, for example, the microquartzite. Several microquartzite deposits have also been identified in northwestern Brittany, including the Crann deposit. In 1972, pits were discovered at this site. One of them was excavated. The lithic assemblage recovered from this excavation comprises 2,507 microquartzite artifacts and only 5 flint artifacts. Petrographic and technological analyses of these artifacts provide valuable insights into the strategies used for exploiting a raw material source during the Mesolithic period. Indeed, they contribute to a better understanding of the constraints inherent in microquartzite knapping, thereby enabling a more precise characterization of the adaptive strategies developed by stone knappers.

Geological surveys conducted in 2025 led to the discovery of a new exploited microquartzite deposit, the Kerriwal deposit (Finistère, France), where numerous extraction negatives can be observed. Their analysis demonstrates that knappers implemented a range of extraction strategies adapted to the physical properties of the microquartzite blocks, including heat treatment, exploitation of natural fissures, and knapping. The study of this exceptional site forms part of a collaborative research program entitled "Quarrying Perspectives: Identifying, Analyzing, and Integrating Lithic Raw Material Sources from the Armorican Massif within an integrated approach."

Chronological framework of the project encompasses two periods marked by intensive exploitation of lithic resources from the Armorican Massif : the Mesolithic and the Neolithic. The multidisciplinary approach is structured around four main research axes : petroarchaeological characterization of raw materials, extraction techniques and lithic technology, the impacts of quarrying activities on physical, material, and socio-cultural environments, and spatial organization.

Interpreting a quarried landscape: morphology, topography, and geological context in the Euganean Hills, Italy

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The volcanic terrain of the Euganean Hills (northeastern Italy) preserves a long and heterogeneous tradition of stone extraction, with volcanic and sedimentary lithologies exploited from the pre-Roman to the contemporary age. Quarrying in this region was shaped by significant geological and topographic constraints, including regional variability in outcrops, volcanic deposit depth, hill morphology, and physical and chemical characteristics. These factors influenced quarry extraction strategies, placement, and morphology. While recent remote sensing research has improved the detection of quarry features, interpretive frameworks that assess how geological characteristics relate to quarry location and form remain underdeveloped.

This study investigates how quarry distribution, clustering, and morphology reflect adaptive responses to the geological landscape, rather than solely chronological or cultural distinctions. The research evaluates quarry selection relative to lithological units, outcrops, slope, accessibility, and transport infrastructure. Statistical clustering of morphometric attributes assesses heterogeneity and relational patterns among quarry sites, revealing recurring extraction strategies across regions.

Results show quarry locations are strongly clustered within specific volcanic formations and accessible geomorphological settings, with quarry morphology conditioned by deposit thickness, slope stability, and exposure. These patterns indicate geological constraints played a primary role in shaping extraction practices and managing risk in complex terrain.

By foregrounding geology as an active force shaping quarrying practices, this research highlights how morphological variability records technical adaptation, resilience, and landscape transformation. More broadly, it argues that integrating geological context with spatial and statistical analysis enables archaeologists to interpret quarry landscapes as dynamic systems of constraint and innovation, rather than as static expressions of period-specific activity.

From laterite challenges to ritual forms: analysing the Lohara cave-complex and monolithic shrines

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Despite extensive studies of rock-cut architecture in the Deccan region, the laterite cave traditions of Southern Maharashtra remain undocumented, representing a critical gap in the typology of Indian rock-cut monuments. This paper presents a comprehensive architectural analysis of a recently discovered cave complex with adjacent monolithic shrines at Lohara village in Latur district, Maharashtra. Carved from challenging laterite a reddish, porous, and friable stone. The site demonstrates how material limitations shaped simpler yet robust architectural forms, reflecting regional adaptation.

The complex comprises two cave structures and six monolithic shrines, notable for the earliest depictions of door jambs and a prominent Shivalinga motif, suggesting proto-ritual innovations. Through systematic documentation, including ground plans, phased excavation evidence, and comparative analysis, this study highlights minimalist door jambs, sacred symbolism such as Shivalinga and

kalasha motifs, and the implications of constructing monolithic shrines in laterite. In the absence of epigraphic evidence, architectural features serve as the primary testimony to the site's historical significance.

The site faces acute vulnerability due to erosion, vegetation overgrowth, and laterite flaking, underscoring the urgent need for conservation. This research expands the geographical and material scope of Indian rock-cut architecture studies, offering new perspectives on regional practices, adaptive strategies, and the challenges of carving in laterite stone.

Rock-cut archaeology: reading the void through the reconstruction of traditional carving processes

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Rock-cut architecture is produced through subtraction: space emerges by removing bedrock, so that enclosure, structure, surfaces, and even furnishings remain materially continuous with the host rock. This material condition poses a distinctive challenge for archaeological interpretation. Rather than reading stratified mounds and superimposed deposits, rock-cut archaeology often requires reading a void—one enlarged by successive generations in response to changing needs. This paper examines traditional carving processes—site selection, assessment of rock quality, and the recognition and management of carving risks—and asks how such knowledge can refine the archaeology of rock-cut architecture.

To address this question, the paper reconstructs pre-industrial approaches to carving rock-cut spaces by documenting the tools, tacit knowledge, and embodied sensibilities that historically structured the work of traditional carvers. Focusing on Cappadocia (central Türkiye), one of the world's densest rupestrian landscapes, the study employs oral-history methods to recover quarrying and carving practices that are now rapidly disappearing.

Findings indicate that carvers operated with a highly developed "geological mental map" of the region. Rock types were differentiated by locality, evaluated for suitability, and selected according to intended function. Assessment relied on multi-sensory expertise—seeing, touching, smelling, and listening—through which carvers inferred hardness, moisture behaviour, stratification, and concealed fractures. Work typically began by opening a narrow tunnel, followed by progressive widening through the detachment of successive blocks, the opening of chimneys, and the removal and reuse of quarried material. Carving was inseparable from quarrying: extracted blocks were processed for masonry, debris served as fill and enabled terracing. Risk management was integral, with close attention to weak strata, intersecting cracks, and humidity control.

The paper argues that documenting this craft knowledge provides a missing interpretive layer for rupestrian archaeology. It supports the reconstruction of carving sequences, explains morphological choices, and refines the reading of tool marks, complementing survey and laboratory analyses. It also underscores the urgency of recording this expertise for conservation and heritage management in rock-cut landscapes.

Making rock art in a moving landscape: materiality, weathering, and stone selection at Saimaluu-Tash I (Kyrgyzstan)

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Javier LUENGO - Instituto Geológico y Minero de España (CN IGME-CSIC) (Spain)
Asunción DE LOS RÍOS - National Museum of Natural Sciences (MNCN-CSIC) (Spain)
Sergio PÉREZ-ORTEGA - Real Jardín Botánico (CSIC) (Spain)
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This interdisciplinary study examines the Saimaluu-Tash I rock art site in Kyrgyzstan through the lens of risk, challenge, and adaptation in rock-hewing practices within a high-mountain pastoral landscape. By integrating petrographic, petrophysical, chromatic, and iconographic analyses, the study adopts a geoarchaeological and materials science perspective to explore how geological constraints, environmental instability, and human agency shaped technical choices, visibility, and durability of rock carvings. Located in a glacial valley above 3,000 m a.s.l., Saimaluu-Tash I hosts one of the largest concentrations of petroglyphs in Central Asia.

Petrographic and SEM–EDS analyses identify a fine- to medium-grained feldspathic sandstone (arkosic arenite) with calcite cement (~10 vol%) and a clay-rich matrix (~15%), as well as a complex cement assemblage including early quartz overgrowths, ~10% euhedral calcite cement, and circumgranular iron-oxide coatings. The fresh stone exhibits surface alteration characterized by dissolution features and the development of secondary porosity. It is overlain by a heterogeneous dark patina enriched in Fe–Mn oxides and organic components. Vickers microhardness testing reveals a marked mechanical contrast between fresh stone (2801 ± 670 HV) and weathered surfaces (633 ± 197 HV), demonstrating that prehistoric carvers deliberately exploited mechanically weakened zones to facilitate engraving. Colorimetric (CIELAB) measurements show a strong chromatic contrast between the dark patina and the lighter, yellowish weathered substrate ($\Delta E^* \approx 22.7$), indicating that the carvings were originally highly visible within the landscape.

Iconographic and spatial analyses identify recurring motifs related to hunting and herding that are closely linked to the surrounding landscape. The carvings are concentrated on a block stream formed by the accumulation of blocks derived from slope collapse and glacial processes. This block stream is slowly moving downslope, progressively altering the orientation, visibility, and spatial relationships of the carved blocks over time. In contrast, in situ rocks on surrounding slopes generally lack surface patina. The gradual formation and darkening of patina on block stream surfaces therefore provides a qualitative chronological indicator, allowing a relative assessment of carving age.

The rock-cut tombs of Dadan from cutting traces to human being: source of technical and social information

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The site of Dadan, located in north-western Arabia, 3.5 km north of the city of al-'Ulā, has become increasingly well known in recent years following multiple Franco-Saudi archaeological missions led by J. Rohmer and A. Alsuhaibani. One of the site's distinctive features is its rockcut necropolis.

Currently dated to the second half of the 1st millennium BCE, the tombs were carved into the cliff of Jebel al-Khuraybah, which borders the site to the east. Surveys have identified five types of rock-cut tombs at Dadan: pit tombs, loculi, chambers, small chambers and cells.

The study of the cutting traces for each of these types of tombs, supplemented by the expert opinion of Thierry Grégor, has enabled us to address several aspects of the work and investment required for their realization. It was determined that picks were the most commonly used tool. The main gestures and positions of the stonemasons were reconstructed for each type. Adaptations according to the quality of the rock and/or its geological characteristics were also observed, adding to our knowledge of the techniques used to create these rock tombs. Analysis of the interior of the burial chambers also provides an understanding of the stages involved in creating this type of tomb and allows us to address the economic aspect of such constructions. Indeed, some unfinished chambers bear traces of having been used as quarries.

Finally, their location in the cliff, overlooking the site, also allows us to hypothesise about aspects of funeral culture and the relationship that populations may have had with their landscape and the raw rock material.

SESSION 2 At the cutting edge: current research on quarries and rock-cut sites

Redefining rural catacombs from Late Antiquity through the Early Middle Ages: the multidisciplinary study of the rock-cut cemetery in Scorrione West (Sicily)

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Recent archaeological excavations at the rock-cut cemetery of Scorrione West near Modica (Sicily, Italy), have brought to light eight funerary chambers containing approximately 150 graves. These findings are redefining our understanding of catacombs in rural areas. Multidisciplinary research, combining the first stratigraphic excavation in a rural Sicilian catacomb with chemical, archaeometric, and anthropological analyses, has revealed not merely a burial place but a complex background linked to the economy of stone. The systematic typological and chronological study of the structures and grave slabs (a method never before employed in a Sicilian context) has revealed specialised mobile workshops in the region, that excavated the funerary chambers and extracted and worked the slabs in situ. Furthermore, the presence at Scorrione of monumental elements (such as baldachins or remains of architectural decoration), and a well-designed spatial hierarchy (reflecting social hierarchies), as well as grave goods and traces of mural painting, challenges the traditional distinction between urban and rural catacombs. Finally, the exceptional stratigraphic sequence (from the early 5th to the 9th century AD) documents Scorrione West as a long-term palimpsest. After the abandonment of its funerary use at the beginning of the 6th century, the site was reconfigured through phases of reuse linked to livestock shelter, the storage of foodstuffs, and perhaps on-site food production, as indicated by a fragment of a hand-quern quern for cereals. This project established Scorrione as a highly significant site for studying human-rock-cut-landscape relationships in the Late Antique and Early Medieval Mediterranean.

The study of the granite quarries of Via Nova, Terras de Bouro – North of Portugal: archaeology and geoarchaeology

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The *Via Nova*, also known as “Geira”, is one of the six Roman roads connecting Braga to the Iberian Peninsula. Opened in the late 1st century AD (c. 80 AD), it linked *Bracara Augusta* to *Asturica Augusta*, crossing the mining regions of the north-western Iberian Peninsula. Along its route in present-day Portuguese territory, several quarry areas have been identified, and advanced research on these sites is currently underway. The study of ancient quarries, initiated in the late 19th century, has undergone significant developments in recent decades through the contribution of related disciplines, demonstrating that this field continues to offer substantial research potential.

Located along the *Via Nova*, in the territory of the *Conventus Bracarensis* and today within the municipality of Terras de Bouro, these quarries constitute an exceptionally well-preserved extraction site, where the Romans quarried stone for various purposes, including the construction and maintenance of the road and its associated structures, such as bridges and milestones.

The research presented here adopts a multidisciplinary approach, combining archaeological survey and excavation, geoarchaeology, laboratory analyses, and 3D recording and visualisation. It aims to characterise the extraction sites, identify the granites employed, analyse stone extraction techniques, explore aspects of daily life within the quarries, and examine their relationship with the road itself. This study began in 2023 and is embedded in two research projects: the project "BracaViae-Roadscapes: the Roman road Geira in the Serra do Gerês" and the Interreg Sudoe project "Cultur-Monts – Valorisation of Mountain Cultural Landscapes: a resource for sustainable territorial development". The research seeks to consolidate knowledge of the Via Nova within the territory of Terras de Bouro and to clarify its strategic and economic significance within the broader context of the north-western Iberian Peninsula.

Rethinking cycladic marble extraction: multimodal survey and analysis of archaic quarries on Naxos

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Rebecca LEVITAN - King's College London, Classics Department (UK)
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Between the 7th – 5th c. BCE, marble extraction on Naxos played a central role in positioning the island as an economic and artistic power throughout the Archaic Aegean world. While the quarries themselves have been known since the earliest antiquarian interest and archaeological research in the Cyclades, the scale and complexity of these landscapes have made them difficult to document using conventional archaeological methods. This paper presents the results of the Naxos Quarry Project, which undertook multi-scalar investigation of the two primary ancient quarries on the island, collecting wide-ranging interdisciplinary evidence for marble quarrying and its impact. This project integrated high-resolution UAV lidar and photogrammetry with detailed architectural and sculptural analysis, geological sampling, archaeometric characterisation, ecological observation, and systematic archaeological field survey. This combined methodology allows for the precise documentation of quarry faces, extraction traces, working surfaces, transport infrastructures, and associated built features, while situating these elements within their wider topographic and environmental contexts.

Our results demonstrate that the application of cutting-edge documentation technologies enriches understanding of the *chaîne opératoire* of marble extraction on the island, ranging from quarry organisation, extraction strategies, and transport logistics, in addition to providing novel insight on the development and innovation of monumental architectural and sculptural traditions. In particular, the integration of archaeometric provenance analyses with detailed interdisciplinary archaeological, architectural, and ecological study offers a new interpretative framework that can be applied to other sites of premodern stone extraction.

The Perpétairi rock-cut tomb site (France): first geoarchaeological approaches to the diachronic transformation of a landform from prehistory onwards

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The site of Perpétairi / La Vouronnade (South of France) has been known since the early twentieth century for the presence of several Neolithic hypogea, a significant number of which were recorded and partially studied during the 1960s. Early excavations carried out in sedimentary deposits within some rock-cut shelters yielded material attributed to the Neolithic period, attesting to early occupation and modification of the hillside. However, the documentation produced by these investigations remains fragmentary and heterogeneous, making a comprehensive re-evaluation of the available data necessary today. In this context, a new phase of research has been undertaken, based on systematic field survey, as well as the identification and documentation of anthropogenic features visible across the entire slope. A geomorphological approach plays a key role in this work. It enables the distinction between natural landforms and human-shaped reliefs, the characterization of the processes involved in the morphological evolution of the slope, the establishment of elements of relative chronology, and the provision of essential interpretative frameworks for the study of modified rock-cut sites. After two years of field survey, the site of Perpétairi / La Vouronnade appears to be far more complex than initially anticipated. It comprises rock-cut shelters with diverse morphologies and spatial organizations, reflecting successive interventions from the Neolithic period to the present day. Beyond the preservation of prehistoric features, the site illustrates the progressive, continuous, and multi-layered anthropization of a single space, offering a particularly valuable case study for investigating long-term dynamics in the transformation of rocky slopes. The presentation will focus on the results of the 2025 study. Changes in vegetation and the geomorphological study, combined with the use of a drone, have enabled the (re)discovery of other cavities and structures.

Tracing stability in a moving landscape: geoarchaeology of quarrying in the Carrara marble basin (Italy)

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The Carrara marble quarrying basin (Tuscany, Italy) covers approximately 10.5 km² and has been shaped by nearly two millennia of extractive practices, resulting in profound and continuous landscape transformations. These long-term interactions between human activity and geological sub-

strates have severely affected the preservation of earlier quarrying features, as new quarry fronts and modern spoil deposits (ravaneti) frequently obliterate or rework evidence of past phases. This dynamic setting poses major challenges to archaeological investigation and calls for approaches capable of producing meaningful data from highly disturbed contexts.

This paper presents an integrated geoarchaeological investigation of an ancient quarry area in the Miseglia basin, where the mechanical removal of a modern spoil heap exposed an extended surface with quarrying traces and a well-preserved palaeosol. Field survey also led to the recovery of pottery fragments and iron working tools, suggesting on-site activities linked to extraction phases.
The aim of the study is to assess how geoarchaeological approaches can enhance archaeological interpretation in active and heavily reworked quarry landscapes, where stratigraphic continuity and structural evidence are often fragmentary or absent. The deposit was documented and analysed using an integrated set of methods, including artefact study, 3D documentation of quarrying traces, geochemical analyses, soil micromorphology, and radiocarbon dating.

The stratigraphic position of the palaeosol, sealed by quarry debris, provides a marker for identifying phases of landscape stability related to quarrying activities. Micromorphological analysis refines this interpretation through the characterisation of soil formation processes, pedogenetic and anthropogenic signatures, allowing the distinction between natural soil development and quarry-related disturbances.

The combined analysis of quarrying traces and sedimentary archives associated with ravaneti thus offers valuable insights into the organisation and chronology of ancient extraction systems, contributing to a more robust reconstruction of quarrying practices within highly dynamic extractive landscapes.

Quarrying and working hard laconian stones in antiquity: a quest for understanding

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A small area in Laconia Greece has been the center of stone-working activity that transects different historical epochs, from the well-documented use of lapis lacedaemonious by Neanderthals, to its use in Minoan and Mycenaean times and to the intense interest in this stone and its geological cousin—the breccia verde di Sparta—by the Romans and until early Byzantine times. Despite the historical importance of these hard colored stones, with the respective findings spanning a vast spatio-temporal sphere and including innumerable fine examples and references in literature, to date no ordinary archaeological excavation has been conducted in the broader area aimed at better understanding the quarrying and working of these unique stones. Yet, accumulated evidence from a site close to an excavated Mycenaean cemetery indicates advanced, local, ancient stone-working activity. This site matches older descriptions of remains, thought to correspond to ancient Krokea. In this context, the authors have collected, and discuss field evidence pointing to an almost continuous and intense stone-processing at that site, while they have also experimented using ancient manual tools involving emery, and testify on the extreme arduousness of the work required to cut, shape and polish these hard and high-tenacity polychrome stones. The study discusses a variety of field findings (worked pieces), pointing to details associated with the original tools used. Open research questions are also reviewed regarding possible advancements in the tools and techniques (e.g., from Minoan to Roman times), as well as the exploitation of the raw material and the eventual abandonment of the quarries.

Quarrying, ritual topography, and rock-cut monuments in the Fasıllar Region: reassessing a multifunctional Hittite landscape

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This paper presents new archaeological results from the Fasıllar Regional Survey, an archaeological research project directed by the author, examining a landscape in the Beyşehir region of southwestern Central Anatolia where quarrying activity, rock cut ritual monuments, and long term cultural memory intersect. The site of Fasıllar is dominated by an unfinished Hittite colossus, 8.3 m in height and carved from local trachyte, traditionally interpreted as evidence of a quarry supplying stone for monumental projects elsewhere. Recent field investigations challenge this interpretation and demonstrate that Fasıllar functioned simultaneously as a stone extraction zone, a ritual gathering place, and a focal point within a wider sacred topography. Archaeological, geological, and spatial analyses show that the hill on which the monument stands displays characteristics commonly associated with Hittite ritual planning, including elevated topography, proximity to perennial water sources, and strong visual connections with surrounding mountain ranges. The identification of an unfinished Hittite sphinx carved directly into the bedrock approximately 800 m northwest of the colossus supports the interpretation of Fasıllar as a deliberately conceived ritual landscape intended to remain in situ rather than serving solely as a production area. When considered within regional settlement patterns and reconstructed road networks, Fasıllar appears closely connected to the Hittite spring sanctuary of Eflatunpınar, located about 27 km to the northwest. The two sites are best understood as distinct yet conceptually related cultic foci embedded within the politically sensitive frontier zone of the Hūlaya River Land during the thirteenth century BC. By integrating archaeological observations with landscape scale analyses, this study redefines the Fasıllar region as a multifunctional Hittite landscape in which quarrying practices, rock imagery, and cultic performance intersect.

The rock-cut landscape in Messinia, southern Greece: from quarries and roads to tombs, cisterns and hermitages used, reused - and abused

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My research aims to highlight the significance of rock-cut archaeology in Messinia, a province in the Peloponnese region of southern Greece, where information about structures carved in and from the local limestone is limited. First, I will present a comprehensive registry of all-purpose rock-cut sites, mapping them within a diachronic and multicultural framework. Next, I will identify the functions of these sites, discussing their historical and environmental contexts. Additionally, I will examine the structural features of the sites, as well as traces of tools found in situ and potential dating clues. Finally, I will address alarming cases of rock-cut sites that have suffered damage due to human interventions or extreme climatic conditions. The ultimate goal is to enhance the archaeological significance of these rock-cut sites and to advocate for their preservation as part of the regional Messinian heritage. Also, the potential for utilising some of them for meeting pressing modern-day needs, such as multiple cisterns for water collection and provision, is currently proposed.

This paper encompasses aspects of Theme 2 and Theme 3 of the conference, sharing insights from my long-term fieldwork, original material, and previous small-scale publications.

Ethnoarchaeological approaches to rock-cut burials in southwest China: continuity in funerary practices and stone working traditions since the 10th century

Lia WEI - Institut national des langues et civilisations orientales (Inalco) (France)

Cliff burials have been practiced to an uncharted spatial and temporal extent across South China and Southeast Asia for over three millennia. For the last millenium, Chinese textual narratives allow us to chart an environmental imagination with cliff burial serving as a common denominator in Southwest China. Here, the strong visual presence of man-made caves cut in the red sandstone cliffs and their intrinsic liminality has fuelled tales of mystical encounters or “the barbarian other”. The transmittted texts, compiled in dynastic or local histories or gazetteers, can further be confronted with epigraphic sources from the 11th (Baiya, Leshan city, Sichuan province) to 19th century (Shanshuping, Enshi city, Hubei province). The epigraphic comments, inscribed in rock-cut burials dated between the 2nd and 10th century, alter and sometimes repurpose the spaces, enriching this form of environmental imagination, while mostly describing the practice from an outsider perspective.

Beyond text, both the funerary practices and the stone working processes that have fuelled the production of these landscapes can still be accessed today, in Yao and Tujia communities isolated by topographic conditions, but also through contemporary environmental and ethnic policies. Enquiries led by local ethnographers Huang Hai and Fan Zhaohui, complemented by interviews led since 2024 in Yaolu, Guizhou province and Tawo, Hunan province, followed four families that have practiced cliff burials in Yaolu for several centuries, and analyzed the modus operandi of the stone masons in Tawo, active since the 12th century. The ethnographic enquiry improves our understanding of the stylistic and technological choices in cliff burials and rock-cut monuments from the inside, and shows how this specific funerary practice and the availability of local sandstone contributed to consolidate local identities in the long term.

Keynote lecture

Beyond agency: tools, instruments and machines revisited through their technicity

Ludovic COUPAYE - Department of Anthropology University College London (UK)

In this work-in-progress presentation, I propose investigating technical objects (tools, instruments, and machines) by shifting the focus from an agency commonly understood as deriving from what they are designed to do (their function, roles or even usages) to how they operate as part of a wider field of relations. Drawing on the category of technicity, understood as a regime of relations between humans and their milieus, actualised during technical activity, I explore how their technical functioning, that is, their material, mechanical, and sensorial features actively shape the relations that form in their vicinity.

Building on my previous work on decorated yams as “relations-made-things,” I extend this relational analytic to technical objects whose functioning coordinates and socialises human action whilst also actualising particular logics (production, extraction, transformation) of engagement with their material environment. I invite the audience to explore whether the functioning of technical objects such as quarry equipment, that is their modes of operation, rhythms, and constraints, participates in shaping how material landscapes are perceived, valued and represented - as resource, obstacle, partner, or terrain of care.

Analysing technicity, I argue, helps unpack how the functioning of technical objects actively shapes, generates and/or stabilises material and social milieus.

Ludovic Coupaye is Associate Professor at the Department of Anthropology at UCL. His work explores technicity, material practices, and the relational processes through which technical activities and objects shape sociality and relations with environments. His research spans Melanesian ethnography, theories of materiality, digital anthropology and the anthropology of technics, with a particular focus on how technicity contributes to the stabilisation, transformation, or emergence of social, ecological, and institutional worlds. He is one of the founders and co-director of the Centre for the Anthropology of Technics and Technodiversity (CATT).

SESSION 3 Cutting into living rock: dialogue between quarries, rock-cut architecture and rock art studies

Rediscovering Sichuan's sandstone landscape: a critical reappraisal of early twentieth-century French expeditions and their perceptions of rock-cut monuments

Francesca BERDIN - Institut national des langues et civilisations orientales (Inalco) (France)

At the beginning of the twentieth century, French sinologists organized official missions to China, following in the footsteps of earlier military personnel and explorers who had travelled to the south-western provinces for topographical and anthropological surveys. The mission conducted in 1914 by Victor Segalen (1878-1919), a naval physician, doctor and sinologist, and Jean Lartigue (1886-1940), a naval officer trained in topography and serving as an interpreter, set out to explore Sichuan province and its sandstone lithic landscape, composed of Buddhist cave temples, cliff burials and stone pillars dating from the second to the tenth century. Drawing from maps, travel notes, personal correspondence, photographs and mission reports, this paper retraces the envoys rediscovery of this landscape and analyses their perceptions of these lithic monuments. The documentation produced during the mission reveals recurring themes, such as the reuse of ancient stone structures in later periods, attempts at restoration within religious practices and the perceived decline of the rock-cut sites due to anthropic and natural causes, factors often interpreted by the two envoys with negative connotations. Adopting a critical perspective, this presentation aims to situate such practices within the broader social and religious context of Sichuan province, reinterpreting them beyond the misunderstanding that perceives these phenomena in exclusively negative terms.

Cities of the Dead made Cities for the Living: nomadic reuse and reinhabitation of rock-cut Anatolian tombs in the long-nineteenth-century Ottoman Empire

Sean SILVIA - Princeton University (USA)

A surprise met Léon de Laborde when he visited ancient tombs cut into the mountainsides of Anatolia in the early nineteenth century. During his voyage through the Doğanlı valley, in the area of what is now known as Yazılıkaya, he did not find vacant, long-abandoned sites of burial. Instead, a community of nomadic yörüks had converted these rock-cut sepulchers into seasonal inhabitations and were living inside of them. This kind of nomadic, adaptive reuse of an ancient cliffside space is significantly understudied. The nomadic groups, due to their way of life, leave almost no traces in the archaeological record. Furthermore, while there is an increasing volume of research on reuse of antiquities as inhabitations in later eras, including in the Ottoman Empire, these studies bias heavily towards sedentary rather than nomadic communities. This paper aims to shed light on this fascinating chapter in the histories of Anatolia's rock-cut monuments.

While hardly any contemporary sources from nomadic communities themselves survive, this paper articulates their reinhabitation of the ancient tombs by reading against the grain of travel accounts such as Laborde's. Through them, it is possible to glean an understanding of the nomadic communi-

ties' experiences of the ancient mountainside sites. This paper illuminates their seasonal relationship to these spaces, their architectural relationship to their carved features, and their inhabited relationship to them. It is useful to apply a phenomenological lens to understand the nomadic communities' overlapping experiences of temporalities, in their simultaneous perception of the site's ancientness, of the site's seasonality, and of the temporality of daily life that comes when one inhabits a space. Far from solely sites of looting or reburial, the dominant cases in scholarly literature on rock-cut tomb reuse, nomadic communities could make these cities of the dead come alive as cities for the living.

Nea Paphos, a city carved into the rock: quarries and rock-cut structures in the Hellenistic capital of Cyprus

Claire BALANDIER - Avignon Université (France)

An exceptional series of underground quarries and rock-cut architectural remains is preserved in Paphos, on the south-west coast of the island of Cyprus. According to the results of recent archaeological excavations and studies, notably undergone by the French archaeological expedition at Paphos, these remains date mainly from the Hellenistic period, from the founding of the port of New Paphos at the end of the 4th century to the 2nd century BC, when the city became the seat of the Ptolemaic representative on the island. Some of these rock-cut sites continued to be used during the High Empire, undergoing modifications. We will therefore focus on the quarries themselves and how they were exploited, then on the underground spaces created in some of these quarries, and finally on how urban planners and architects were able to take advantage of the rock to plan the city and erect public buildings (city wall, theatre, temples, aqueducts, fountain and cisterns), as well as dwellings and necropolises.

Stone cutters and architects took advantage of the qualities of calcarenite rock, which remained soft and easy to quarry if it was not worked on the surface, which had been weathered by the elements. However, this rock erodes easily and is difficult to preserve, particularly because of the faults that run through it, facilitating the infiltration of rainwater. We will therefore address the issue of the conservation and enhancement of these underground quarries and rock remains.

Cutting the rock at Populonia (Piombino, Italy): quarrying for construction, carving for the dead

Caterina PREVIATO - Università di Padova (Italy)

Since 2024 the University of Padua has been carrying out a research project focused on the ancient stone quarries of the Etruscan-Roman site of Populonia (Piombino, Italy), whose exploitation spans from the earliest settlement phase in the 9th century BC through the Roman period. Current research focuses on the largest quarry located in the suburban area of the city, in the locality of Le Grotte, where parallelepiped calcarenite blocks were extracted. The archaeological significance of the site lies in the extraordinary extent of the extraction area - covering approximately 5 hectares - the exceptional preservation of quarrying evidence, and its close topographical relationship with a nearby rock-cut necropolis. Opposite the steeply inclined quarry front in fact rises a vertical rock face into which a series of chamber tombs were carved at di erent elevations, with the earliest examples dating to the 4th–3rd century BC.

Adopting a multidisciplinary approach that integrates 2D and 3D geometric survey, systematic documentation of tool marks, and archaeometric analyses aimed at understanding the use of stone

within the urban context, the project seeks to reconstruct in detail the exploitation dynamics and chronology of the quarry, as well as its spatial, chronological, and functional interplay with the adjacent rock-cut necropolis. This contribution presents the first results of the ongoing research, using the Le Grotte quarry as a case study to explore rock-cut sites as complex and long-lived landscapes. Here, the same rock outcrop was exploited over centuries for fundamentally di erent purposes: supplying construction material for the city of the living and providing a monumental setting for the burial of the dead.

Recarving the rock: the modification of Nabataean tombs at Petra (Jordan)

Lucy WADESON - School of Classics, University of St Andrews (UK)

The hundreds of monumental façade tombs that animate the rocky landscape of Petra are testament to the architectural and sculptural ingenuity of the Nabataeans who carved them between the 1st century BCE and the 1st century CE. They symbolise the wealth, power and prestige acquired by the Nabataeans as middlemen in the trade of luxury goods, such as frankincense, that were conveyed from South Arabia to Egypt, the Mediterranean and Mesopotamia. The cultural exchange that occurred because of this trade is reflected in the design of the façades, which feature Egyptian, Greek and Mesopotamian architectural influences.

While it is not currently known if the Nabataeans conceived of an afterlife, study of the tomb space and its rock-cut features, together with the information in the Nabataean funerary inscriptions, suggests that the tombs were regarded as sacred, inviolable and intended for eternity. Thus, it is surprising to find occurrences at Petra in which tombs have been either modified or destroyed, whether for an ‘upgrading’ of sorts or as part of a larger architectural project. This paper will present the results of a detailed examination of these cases (including the carving of the famous al-Khasneh / the ‘Treasury’), shedding light on the motivations behind these changes to the rock-cut architecture, potential developments in carving techniques, and shifting conceptions of the funerary space. The removal of stone that has already been carved is a significant act that can further our understanding of the Nabataeans’ relationship with the rock and the transformation of Petra’s landscape over time.

Fossor vide ne fodias*: interaction between extractive and funerary practices in the rupestral landscape of the city of Rome*

Dan DIFFENDALE - Scuola Normale Superiore, Pisa (Italy)

Several of the famous Roman catacombs are said to have begun as extensions or modifications of earlier pozzolana quarries. These are only one example of a repurposing or coexistence with other uses of quarries in the landscape in and around Rome in antiquity, however. In the Monteverde district, in particular, extensive quarries of volcanic tuff seem to have offered convenient locales for the creation of rupestral tombs and catacombs, some of which were in turn threatened by renewed extractive activity, both in antiquity and in the modern period. Extraction shared space with ritual practice in rupestral settings as well, which may in some cases have been connected with work in the quarries themselves. This contribution aims to trace the interactions between these different types of rupestral intervention in the volcanic rock of Rome over the course of more than two millennia as well as to situate them in their broader peninsular context. (Funding statement: the research is carried out within the project IN-ROME “The INscribed city: urban structures and interaction in imperial ROME”, Grant Agreement 101054143, CUP E53C22001640006.)

The afterlife of the necropolis: from Phoenician–Punic tombs to quarrying at Roman Nora (Sardinia)

Jacopo BONETTO - University of Padova, Department of Cultural Heritage (Italy)
Simone DILARIA - University of Padova, Department of Cultural Heritage (Italy)

The suburb of the ancient city of Nora (Sardinia, Italy), located on a peninsula at the southwestern margin of the Gulf of Cagliari and investigated since 2014 through excavations conducted by the University of Padua, constitutes a rare stratigraphic palimpsest of a suburban area spanning from the Archaic period to the Late Vandal age. Archaeological investigations have documented the transformation of a Phoenician–Punic funerary area exploiting a Quaternary sandstone bench into, first, a productive quarrying zone and, later, a modest residential quarter. In the first phase, the rock-cut necropolis, characterized by Phoenician shaft tombs and Punic hypogea, was extensively reworked through quarrying, which removed substantial portions of the sandstone bedrock, leaving tombs recognizable only as faint traces in the cuts. Associated with quarrying was the construction of cisterns, either newly built with elongated layouts or obtained by converting earlier Punic hypogea. Material assemblages, corroborated by 14C dating of charcoal from cistern mortar, suggest a middle–late Republican date, broadly corresponding to the decades following the establishment of the province of Sardinia et Corsica after the end of Punic control of the island (237 BCE). Quarrying likely continued through the High Imperial period until extraction areas were abandoned and deliberately infilled with sediments, ceramics, and construction debris and producing deposits. Modest residential installations were subsequently established over these fills; ceramic and numismatic evidence provisionally dates this reorganization to the 4th – 5th centuries CE.

This contribution presents the recorded quarry morphologies and evidence for the reorganization of a funerary landscape into a productive one, showing that tombs were exploited for both block extraction and cistern conversion. Several cuts display distinct 45° pick-marks and abrupt rectilinear faces, indicating manual techniques and directional removal of block-sized modules. In some cases, these cuts completely removed the Tyrrhenian Quaternary sandstone bench down to sterile geological levels of unconsolidated sand at c. +0.4 m a.s.l., where extraction appears to have halted. This “terminal surface” provides an exceptional record of the full thickness of the Quaternary bench, enabling the reconstruction of quarrying strategies, extraction sequences, and the spatial logic of resource exploitation within a peri-urban context.

Cutting, re-cutting, and erasure: stratigraphy and mobility in the rock-cut church of Pancarlık (Cappadocia)

Anaïs LAMESA - University of Edinburgh (UK)
Idil ÜÇBAŞARAN - Kapadokya University (Türkiye)

Rock-cut monuments in Cappadocia have long been approached as stylistically datable, functionally fixed structures, their carving into stone paradoxically reinforcing an image of architectural immutability. This paper challenges that assumption through a stratigraphic reassessment of the rock-cut church of Pancarlık (Ortahisar), arguing that its significance lies not in a single chronological attribution but in the cumulative dialogue between stone, carving practices, and successive acts of reappropriation.

Rather than treating sculpture, painting, architecture, and inscription as parallel datasets, the study reads their intersections as evidence of phased interventions into a “living” rock mass. Early monumental carving, architectural typology, and epigraphic forms point to a late antique phase that predates the widespread dominance of painted programmes. These elements were not merely superseded but actively cut into, overwritten, and partially erased by later modifications, transforming decoration itself into stratigraphic evidence. Subsequent re-carving episodes- traditionally overlooked- demonstrate that later communities prioritised spatial expansion, light, and altered liturgical practices over the preservation of earlier decorative schemes.

This paper further argues that the technical coherence observed across Pancarlık suggests the movement of carving workshops within the region of Cappadocia, foregrounding mobility and shared expertise rather than isolated monument production. Pancarlık thus emerges as a stratified material landscape produced through repeated engagements with stone, in which cutting, destruction, and reuse are inseparable processes.

By reintroducing stratigraphic reasoning into the study of rock-cut architecture, this contribution advocates for a methodological realignment within Cappadocian studies and, more broadly, for a conception of rock-cut sites as dynamic assemblages shaped by continuous negotiation between material properties, technical practices, and changing social meanings.

SESSION 4 Heritage:
archaeological quarries and rock-cut sites in the present

Theorising ancient quarries part II: landscapes, labour, and materiality

Christopher LYES - School of Archaeology, University of Oxford (UK)

At the inaugural IRAAR meeting I presented “Theorising Ancient Quarries: How Far Have We Come?” which argued that studies of stone have too often remained empirical and siloed, dominated by provenance, logistics, and narrowly defined datasets. That paper urged the field to engage more directly with wider archaeological theory and with the grand challenges identified by Kintigh and others, highlighting the need to move beyond Mills’ dichotomy of “grand theory” versus “abstract empiricism”. It called for an agenda attentive to inequality, decolonisation, and agency, and for quarry studies to develop frameworks capable of linking detailed evidence to larger disciplinary questions.

This follow-up contribution applies that agenda through a focused case study of the tufo quarries of the Roman Campagna. Here, quarry archaeology is approached through a Wittgenstein’s Toolbox approach embracing materiality theory, Ingold’s concept of the taskscape, Actor–Network Theory, and Material Engagement Theory amongst others. These perspectives underpin the introduction of a new concept, the habit of extraction, to describe the culturally embedded and repetitive nature of quarrying in Etruria and Rome. The analysis draws on field evidence from quarry faces, unfinished blocks, tool marks, and later reworking, revealing how the physical affordances of tufo—easily cut when fresh, hardening upon exposure—demanded adaptive strategies. These responses inscribed distinctive rhythms of labour into the landscape, binding human gestures and geological processes into reciprocal practice.

The argument advanced here reflects the opinions developed by the 2nd Iraar conference in that that stone itself must be treated as an active participant in these processes, shaping technical routines, labour hierarchies, and cultural memory. In this sense, quarries emerge not as inert scars but as dynamic cultural landscapes where human action and material agency intersect. By extending the theoretical agenda articulated at Iraar 1 into empirical practice, this paper demonstrates how quarry studies can contribute directly to wider debates on resilience, agency, and the longue durée of human–stone relations.

Carrara marble and its medieval revival: material, mobility, and artistic production

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Luca PALOZZI - University of Pisa, Dep. of Civilisations and Forms of Knowledge (Italy)

Carrara marble, quarried in the Apuan Alps of central Italy, is among the most renowned lithic materials in the history of European art. Extensively extracted in a proto-industrial manner during the Roman Imperial period, its artistic use underwent a profound disruption from the third century CE

onwards, when the quarries of Luni were progressively abandoned due to political, economic, and social transformations. While the renewed large-scale use of Carrara marble in the thirteenth century is well documented, the earlier phase of reactivation between the eleventh and twelfth centuries remains insufficiently investigated by both archaeology and art history.

This paper aims to identify the moment and modalities of the reopening of the Carrara marble quarries through an integrated analysis of architectural evidence, sculptural production, and documentary sources. The study reveals that in the Carrara area, between the late eleventh and mid-twelfth centuries, some monuments are extensively built with Carrara marble, while archival references to active quarries and marble workers are remarkably scarce. By contrast, archival records survive in Genova that document both the use of Carrara marble in civic and religious architecture and the circulation of skilled carvers at the end of the twelfth century.

Rather than addressing quarry reactivation primarily through archaeological indicators of extraction, this study adopts an historical-artistic perspective, using stylistic analysis, architectural comparison, and workshop attribution as indirect tools for tracing the circulation and renewed availability of marble. By shifting the focus from quarry sites to finished works and construction contexts, the paper demonstrates how artistic production can serve as a key source for reconstructing phases of material exploitation that are otherwise hardly documented. This methodological approach contributes to a broader discussion on the role of art historical evidence in the study of medieval resource management and building practices.

On borrowed time: quarry conservation in the National Trust for Scotland

Derek ALEXANDER - The National Trust for Scotland (UK)

The National Trust for Scotland is Scotland's largest conservation charity and looks after over 76,000 ha of ground, including around 12,000 archaeological sites and features. Quarrying has until recently always been, by necessity, a localised and site-specific activity, and very much forms part of our cultural heritage landscapes. There are numerous quarry sites across our national estate with entries in our Historic Environment Record but there are probably many more that are, as yet, un-recorded. The known sites range in date from a Neolithic axe quarry (5000 years old) through to rubble stone quarrying for 1950s hydro-electric schemes. This paper will examine the wide range of quarry features in our care from millstone rough-outs, to sandstone quarries for castles, to the remains of the marble quarry on the Hebridean island of Iona. The latter site is a designated Scheduled Monument located on the foreshore at the southern end of the island and is exposed to the full effect of Atlantic storms that have a particular detrimental impact on the iron quarry machinery. It forms part of walking route around the island and has been interpreted for the public who manage to locate it. From the ubiquitous borrow pit to the obvious scar of the St Kilda roadstone quarry, how do we manage and interpret such sites that can often be an overlooked and forgotten part of our cultural heritage.

Inside the stone: a multidisciplinary diagnosis of the underground medieval church of Saint-Émilion, France

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Underground architectural heritage constitutes a unique environment, subject to a series of conservation challenges. A crucial and complex step in safeguarding material heritage is diagnosing its state of conservation and identifying the factors responsible for deterioration. In this sense, standard approaches developed to assess the conservation state and degradation factors of conventional buildings cannot be directly applied to the specific conditions of rockhewn architecture. Although some case studies on the degradation of carved spaces have been published, no comprehensive methodological procedure has yet been developed to achieve an in-depth understanding of degradation factors and their effects.

To address this gap, a new multidisciplinary diagnostic methodology is being applied to rare early-medieval (late 11th and early 12th century) underground church located in southwest France, in the Nouvelle-Aquitaine region: the underground church of Saint-Émilion.

The diagnostic methodology, applied to this structure classified as a historical monument, initially focuses on the characterization of the calcareous rock known as “calcaire à astéries”. Minimally destructive methodological approach has been developed to identify its key properties and characteristics.

Over 450 points are being studied in-situ using colorimetry, microscopic digital imaging, and pXRF (portable X-Ray Fluorescence) to assess the variability of the sedimentary bedrock. After careful selection, small samples from the church walls are being analyzed through petrography, XRD (X-Ray Diffraction), and SEM-EDXS (Scanning Electron Microscopy linked to X-Ray Spectrometry). Geotechnical studies are also carried out to determine the rock’s mechanical properties, including in-situ measurements of uniaxial compressive strength.

Crack inventory and analysis provide initial information on the nature of structural damages. Monitoring of external factors, such as hydrochemical analyses (both in-situ and exsitu through ionic chromatography), microclimatic conditions, and tourism frequentation, contributes to defining the specific conservation context.

The impact of aforementioned parameters on the walls is being observed through timelapse micro-ERT (Electrical Resistivity Tomography), allowing the monitoring of water content variations within the wall surface.

Altogether, integrating these multidisciplinary and multiscale datasets represents a major challenge, yet a necessary step toward establishing a robust diagnostic framework.

The underground chambers of Fabrika Hill at Nea Paphos WHS: condition survey and conservation recommendations

Michalis CONSTANTINOU - Katholieke Universiteit Leuven (Belgium)

The Archaeological Site of Nea Paphos was inscribed on the UNESCO World Heritage List in 1980, primarily for the exceptional quality of its mosaic floors and architectural remains. While the rockcut Tombs of the Kings are referenced in the justification of Outstanding Universal Value, other rockcut features within the site are not mentioned. Among these are the fourteen Underground Chambers (UGCs) of Fabrika Hill, inventoried and dated by the French archaeological mission at Paphos to the early Hellenistic period, which represent significant examples of rock-cut underground quarries and cultic spaces. Despite their historical and cultural importance, the UGCs have received limited scholarly attention and minimal conservation intervention since the beginning of archaeological research at Nea Paphos. As a result, their condition has progressively deteriorated. This research aims to assess the state of preservation of the UGCs, identify the main conditions and damages affecting them, and determine the key threats to their heritage values in order to inform conservation planning. A multidisciplinary methodology was adopted, combining on-site investigations conducted in November 2022 and March and June 2023, systematic observation, photographic documentation, and literature review. The study focused on recording construction characteristics, material behaviour, and deterioration patterns. The integration of 3D photogrammetric documentation and orthophotos supported accurate mapping of conditions and enhanced the analytical process. The assessment identified three primary categories of threats: (a) water infiltration and associated rock erosion, (b) structural instability and seismic vulnerability, and (c) impacts from human activities. Based on these findings, a set of targeted and sustainable conservation measures is proposed, addressing both preventive and remedial actions. The study highlights the importance of inclusive conservation strategies that extend beyond well-known monuments and demonstrates how systematic condition assessment can contribute to the long-term protection and management of overlooked rock-cut heritage within World Heritage Sites.

Cutting in the loess of North China: vulnerability and heritage issues

Constantin CANAVAS - Hamburg University of Applied Sciences (Germany)

Cutting in the loess in order to create or modify living space constitutes a multi-layer issue in Chinese cultural history known under the generic Chinese term yáodòng that can be literally translated as cave dwelling. Loess in North China is a soil form that originates from yellow-grey sediment sand carried by the wind from the Gobi desert; it is easily cut, but also highly subdued to erosion processes. The claim of the present paper is that the particular physical vulnerability and the high demand on maintenance of technical constructions based materially on loess impose not only particular construction and maintenance procedures, but also a derogatory framing that enhances the negative social connotation associated with living in a cave. Typical background of the latter assessment is the exodus of the rural population from the central and northern regions of China towards the eastern coast. The abandon of rural housings and entire villages is a general phenomenon in China during the last decades of the 20th and the beginning of the 21st century; however, the higher vulnerability of abandoned yáodòng villages shifts the public perception unfavourably towards them, and stabilises the stereotype of yáodòng as ephemeral vernacular architecture linked to poverty.

Positive connotations of the yáodòng function insofar as they demonstrate compensating or overcoming the particular vulnerability. Prominent is the association of these dwellings with reference to the role of the yáodòng complex at Yan'an, Sha'anxi province, as headquarters of the Chinese Communist Party under Mao Zedong between 1935 and 1947 – the loess landscape with the vulnerable dwellings serving as background for contrasting with the persistent struggle of the Communist movement to overcome a menacing historical situation. Moreover, the large typological variety of the North-Chinese yáodòng becomes itself an instrument of eclectic public perception and current economical and political choices regarding a vast region formerly characterised by poor rural population, e.g. when associating a particular yáodòng complex with cultural heritage, touristic re-use, and travel romanticism, or when future-orientated projects suggest ways of overcoming or compensating vulnerability and inconveniences of yáodòng housing through technological innovations that enhance the thermic-energetic advantages of living in the loess.

Rock-cut chamber burials of Iron Age period in South-Western India: a typological and architectural study

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In South India, the Iron Age is characterised by the widespread construction of megalithic burial monuments, the introduction and extensive use of iron, and the associated Black and Red Ware (BRW) ceramic tradition. The megalithic burial forms include cists, dolmens, menhirs, cairn circles, stone circles, rock-cut chambers, umbrella stones, capstones, hood stones, anthropomorphs, sarcophagi, and urns. Among these, rock-cut chambers are subsurface tombs excavated into laterite bedrock, typically adopting hemispherical or rectangular plans, with access generally provided through either a lateral entrance passage or a vertical porthole from the surface. They represent a distinctive mortuary tradition largely confined to the south-western coastal region.

This study examines typological and architectural variations of rock-cut chambers using secondary data derived from published reports of archaeological excavations, and surveys, complemented by primary data obtained through systematic field surveys and detailed architectural documentation in the Palakkad region of Kerala, treated here as a focused micro-regional case study.

The analysis reveals a wide spectrum of architectural forms, ranging from single-chambered burials with entrance passages to more complex multi-chambered complexes incorporating elements analogous to domestic architecture. These features include steps, pillars and pilasters, benches, beds, portholes, low seats, hangers, and vessel stands. The Palakkad case study further demonstrates considerable internal variability, showing that geology, resource availability, and cultural preferences significantly influenced architectural form and spatial organisation.

Further, this study draws urgent attention to the need to address the severe threats posed to these monuments by modern quarrying activities and accelerating land-use changes. In this context, it emphasises the critical application of three-dimensional digital recording techniques, particularly photogrammetry, for the systematic documentation, conservation, and comparative analysis of this vulnerable yet invaluable archaeological heritage.

Carved from bedrock: engineering the Petra garden and pool complex

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Petra is a UNESCO World Heritage site in southern Jordan, renowned for its monumental tomb façades carved into the multicolored sandstone and limestone cliffs that encircle the valley in which the capital of the Nabataean kingdom thrived from the 4th century through the 1st century CE. These monuments are the most visible outcome of a broader tradition of Nabataean engineering. The construction of both rock-cut and freestanding architecture required the systematic extraction, shaping, and leveling of bedrock, and Petra's rugged topography consequently preserves extensive evidence for quarrying as an integral component of urban development. Quarrying was an element of the building programs of tombs, temples, palaces, residential quarters, and streets, as well as the sophisticated networks of channels, aqueducts, and cisterns that regulated water supply and enabled the city to thrive within an arid wadi environment.

The Petra Garden and Pool Complex (PGPC), a component of a palatial complex at the heart of the city, represents one of the most ambitious applications of this integrated approach to engineering and resource management during the reign of Aretas IV (9 BCE–40 CE). Archaeological evidence indicates that the complex was created through the deliberate cutting back of the natural rock slope to generate space for a monumental pool, while the newly exposed cliff face was modified to incorporate water features, caverns, and viewing platforms. Stone detritus produced by this quarrying activity was not discarded, but strategically redeposited to create a level terrace over the lower, gravelly slopes. The PGPC thus exemplifies Nabataean practices of coordinated rock-cutting, water control, and material reuse, demonstrating how engineering solutions were employed to transform a challenging landscape into a highly ordered, monumental, and hydrologically managed urban setting.

POSTERS

New research on the chronology of the limestone quarries at Thugga (Tunisia)

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A recent archaeological and geological survey conducted on a vast extraction area in the ancient city of Thugga (Tunisia) highlights the variety of activities that took place in the north-western suburb of the city: necropolises, a large sanctuary, quarries and a hippodrome succeeded one another or coexisted on some four hectares. These activities and developments provide chronological landmarks and span, sometimes with great precision, from the end of prehistory to the end of the Roman period.

The Roman quarries expanded at the expense of the Punic and Numidian necropolises, and in some areas, quarrying gave way to a Roman necropolis. Finally, although the Severan circus was not built directly on the outcrop, it altered the route used to transport blocks to the nearby city. These activities are therefore closely intertwined and make it possible to construct a relative chronology. The study of the traces left on the nummulitic limestone outcrop by sometimes unusual extraction techniques is facilitated by comparison with the monumental remains of the urban centre, often dated thanks to epigraphy; it allows precise markers to be established in the exploitation of different sectors and provides keys to understanding the exploitation strategies of this peri-urban area during Antiquity.

From the erection of menhirs in the Early Neolithic to occasional quarrying in the Middle Bronze Age: management of lithic raw materials by the first sedentary populations in the north-western quarter of the Massif Central

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Discovered in 1990, the site of Bussière-Galant (Limousin, France) revealed a megalith broken into two pieces, made of biotite ± muscovite granite, isotropic (originating 5-6 km to the northeast). The first fragment (No. 1a) measures 2.70 m x 0.93 m x 0.69 m and weighs 5 tonnes. The second fragment, (No. 1b) measures 0.90 m x 0.80 m x 0.68 m and weighs 1.3 tonnes. Initial surveys in 2016, identified a foundation pit. Further work in 2022 showed this to be intersected by a second pit measuring 3.36 m x 0.70 m. The architecture of the pits was carefully designed, combining the plastic quality of the clay to create a crown of massive foundation stones capable of supporting Menhir 1. Optimal support was ensured by filling the pit with small stones in a well-drained sandy matrix. A second monolith, 3 m long but broken into five pieces, was found in another pit. An access trench to small monoliths (Nos. 3 and 4), possibly attached to the substrate, showed signs of prehistoric extraction. Though standing stone sites are generally characterised by their lack of movable artefacts,

well-used stone hammers had been discarded in the foundation pits. The acidic subsoil has limited potential for C14 dating. However, collaboration with the Megalithic Project led by Prof. K. Jørkov Thomsen (Tech. Univ. of Denmark) has made it possible to test the contributions and limitations of OSL at Bussière-Galant. Our aim is to establish the absolute dating of the construction and destruction phases at the site and thus the duration of use of the architecture. With postdoctoral researcher T. Freisleben, 55 samples have so far yielded eight reliable dates for the anthropogenic structures, while others are consistent with the geological levels or are currently being analysed. Occupation at the site is evident from the late Mesolithic, then from the Early Neolithic with the installation of one or two menhirs, followed by the erection of massive posts and, finally, by extractive activity in the Middle Bronze Age.

Dynamic use of chiseling and scooping out rock for rock-cut architecture and rock art in ordination and meditation in Buddhism

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The process of carving and excavating rocks to spread Buddhist teachings dynamically led to the creation of rock-cut architecture for monastic life and ordination, with rock art later added to the walls. These were simple shelters, later becoming elaborate halls. This was a spiritual tradition for meditation and worship—a tradition that dates back to the Buddha him self's use of caves for retreat. Monastic Life and Meditation: The process of excavating caves provided monks with a dedicated, quiet place to live and meditate, a practice established by the Buddha. Initially, natural caves were adapted for shelter. Wild birds, in a spirit of mitta, even coexisted with the monks! This involved starting from the top of the rock and working downward, creating the outer shell of a planned structure, such as a chaitya-griha (prayer hall) and a vihara (monastery). As rock art evolved, rock-cut structures became more elaborate, decorated with intricate carvings, sculptures, and murals. These artworks, which often depicted scenes from the life of the Buddha, inspired meditation for monks and visitors, were easy to understand, and reinforced Buddhist teachings. Rock-cut structures blended into the natural landscape in order to achieve integration with the environment, a fundamental principle of Buddhist art and philosophy. The act of shaping rock was also a way to bring order and spiritual meaning to the natural world. For example, the Ajanta Caves in India are known for their intricate sculptures and vibrant murals, which represent a wide range of Buddhist art and literature. Similarly, the Ellora Kailasa Temple is a massive single-rock temple carved from top to bottom, representing a monumental achievement in rock-cut architecture and sculpture. The Barabar Caves, one of the earliest examples of rock-cut caves, were excavated by the Mauryan dynasty for ascetics. The role of Emperor Ashok always remember for the cause of dhamma.

Cutting into living rock: the case of the haouanet of El Harchia Region (Northern Tunisia)

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The Haouanet, which are rock tombs carved into sandstone or limestone in northern Tunisia, are a testament to the diversity of protohistoric funerary monuments in Tunisia and North Africa. Their location in cliffs, geographical distribution and architectural features reflect local and regional characteristics, as well as broader Mediterranean influences. The decorations also reflect this evolution: while many of the tombs are undecorated, those that are decorated incorporate a number of well-documented symbols and are mostly the result of cultural exchanges with other parts of the Mediterranean basin.

The results of our research on the haouanet in the El Harchia region of northern Tunisia are here presented. The number and distribution of these monuments varies. Two types of haouanet have been identified, ranging from simple, single-chambered structures to more elaborate, multi-chambered ones. The excavations demonstrate an advanced understanding of the rock substrate, with carefully regularised walls. The exterior and interior architectural elements vary from one monument to another. Some chambers retain traces of red ochre decorations, which are sometimes associated with engravings. These monuments can be compared with similar funerary monuments in the Mediterranean basin.

Living rock landscapes across time: continuity and change. The medieval settlement of Nicosia (EN)

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The medieval settlement of Nicosia (EN) in central Sicily, has considerable archaeological potential, primarily due to the impressive rock habitat characteristic of the Mediterranean landscape. The morphology of the area and the availability of water have favoured settlements here since ancient times. The area is characterised by numerous rock complexes that have often been used continuously from ancient times to the present day for various purposes, such as burial areas, places of worship, dwellings and production facilities. These complexes are always characterised by a close connection between functional needs, environmental resources and road networks.

The continuous repurposing of the quarries is an important historical and archaeological issue for to understand the transformations of the settlement during the medieval period, as well as the different territorial organisations during the Byzantine and Islamic periods, up until the Norman conquest which redefined the spaces of the power and the landscaped of the production within the Island. In this context is important clarify the long-term transformation linked to the continuous rock shaping in the St. Catherine rock district, located on the slopes of the Castle and the Church of Santa Maria Maggiore, built by the Normans.

Even the place names speak of the presence of an important production complex linked to sheep farming which reuses pre-existing arcosolium graves through intense digging activities. Later this complex was completely reconfigured with the arrival of the Normans, who redeveloped the neighbourhood for residential use. Probably this coincided with the construction of the Church of Santa Maria Maggiore in the Latin Quarter and with the moving of this production area outside the new settlement.

The Algajola granite quarry in Corsica: how to unravel two millennia of potential extraction?

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A particularly aesthetic and monumental granite has been quarried along the sea in NW Corsica, near Algajola. Its masterpiece is a 17 m long shaft carved for a monument celebrating Napoleon 1st, and left in the quarry. This rock has been quarried until the beginning of 20th century, in particular thanks to a railway crossing the outcrops, but when did quarrying began? Historical accounts and

direct archaeometric comparisons confirm its use in Florence, for the Medicis family monuments since 17th century, but was it quarried for exportation before? Curiously, it has not been observed in local medieval monuments of the Pisan period.

In the framework of a systematic provenance survey of granites used in antique and medieval sites throughout Europe as shafts and opus sectile, we encountered in two instances a granite visually similar to the one of Algajola quarry: one shaft in the lapidary museum of Autun (Burgundy, France), and two slabs in the 12th century floor of Salerno cathedral (Campania, Italy). Using both magnetic susceptibility and portable XRF analyses, we confirmed these artefacts are indeed from Algajola, by comparison with quarry samples and the Florence artefacts. The shaft in Autun is of unknown original setting but its fabrication is likely antique as Autun was a major Roman city. These findings imply quarrying in Algajola at the very least since the 12th century and likely since Antiquity.

Is it possible to discriminate on site the quarrying marks of modern, medieval and antique ages, to confirm and precise the above-mentioned reasoning? A large number of eroded sockets (10-20 cm long) have been identified over a circa 1 km square quarrying zone, and the purpose of this contribution is to open a discussion on how to estimate the age of these sockets.

Cultural and geological outreach around the site, at walking distance from a popular beach and in a picturesque landscape, should be worthwhile. However, how to do that without clear age determinations for the sockets?

Carved by stone and sea: coastal quarries as cultural landscapes in Puglia (Italy)

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Coastal quarries in Puglia (southern Italy) constitute a landscape and cultural heritage of exceptional significance, where natural processes and human intervention are inextricably intertwined. Excavated over centuries for the extraction of limestone, these sites supplied the building materials that shaped the region’s cities, towns, and rural architecture, thereby contributing decisively to the construction of the territorial identity of a region bordered by two seas, the Adriatic and the Ionian. Today, these quarries can be understood as stratified landscapes, offering tangible evidence of traditional productive practices, local knowledge systems, and long-standing historical relationships between coastal communities and the sea.

From a morphological and perceptual perspective, coastal quarries are spaces of strong visual impact, defined by sharp rock cuts, carved surfaces, and chromatic qualities that interact with the maritime horizon. This interaction produces a distinctive landscape in which the apparent opposition between artificiality and naturalness is resolved into a recognizable and identity-forming equilibrium. Both the widespread presence of these extractive areas and their gradual integration into the surrounding coastal landscape have contributed to their limited recognition as heritage assets worthy of preservation, despite their strong identity value. At the same time, their accessibility allows for a comprehensive reading of extractive practices in this area and of their enduring relationship with the sea.

Within a contemporary context characterized by tourism pressure, land consumption, and the erosion of shared cultural references, the coastal quarries of Puglia provide an opportunity to reconsider the concept of quarry landscape as a dynamic cultural construct. Their enhancement should not be conceived as static musealization, but rather as a conscious, project-based approach capable

of integrating conservation, sustainable use, and territorial narration. In this perspective, coastal quarries emerge as key elements for a critical interpretation of the Apulian landscape, understood not only as a legacy of the past but also as a strategic resource for the future.

The chisel's logic: a comparative study of rock-cut iconography in the Narmada (India) and Avon (UK) river valleys

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Located at the intersection of architectural conservation, and historical narrative, this paper presents a comparative analysis of the 'subtractive landscape'. By investigating the high-thermalmass cave shrines of Central India and the historic sandstone environments of the UK's West Midlands, the research observes a striking parallel in how these riverine landscapes are shaped by the 'Chisel's logic'. This paper presents a comparative study of two monumental rock-cut reliefs: the fifth-century Varaha (Boar) relief at Udayagiri in the Narmada Valley, and the fourteenthcentury "Guy of Warwick" giant at Guy's Cliffe in the UK.

Beyond their shared riverine geography, these sites represent two distinct human intentions carved into living stone. Central to this study is the spatial interiority of the living rock-viewing the caves in Narmada river valley as sacred volumes designed as medium for spiritual revelation, and the Guy's Cliffe hermitage as a storied domestic void. While the former articulates the divine through coded iconography, the latter survives as an eroding narrative of heroic monumentalism, where the distinction between natural cliff and designed interior has blurred over centuries.

Drawing on fieldwork in Birmingham and longitudinal research in India, the study examines the technical vulnerabilities common to both: specifically, the accelerated decay of residual iconography caused by river-fed moisture and salt crystallisation. More importantly, a critique is offered regarding the friction between 'material-led' Western conservation and 'value-led' Indian practices. Ultimately the paper advocates that for these sites to survive, we must move beyond treating them as fossilised archaeological evidence and instead adopt a 'biocultural' framework. This approach recognises that the stone is not just a substrate, but a living participant in a regional story that requires a more empathetic, narrative driven conservation methodology.

Quarries and lithic traces in Haut-Nyong (East Cameroon): archaeological approaches to a neglected heritage

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The Haut-Nyong department (Eastern Cameroon) preserves a collection of quarries and rock shelter sites that are still largely unknown. Despite this potential, the region has remained largely underexplored, with most archaeological research concentrated in the South, Central, and North regions of Cameroon, leaving significant gaps in our understanding of the lithic heritage of Eastern Cameroon. This study analyzes lithic remains to understand the production techniques, cultural uses, and social organization associated with them. Through systematic surveys, typological and technological analyses, and spatial mapping, it reveals a strategic archaeological heritage that is often invisible in scientific discourse. The results contribute to the valorization of heritage, while fueling transdisciplinary dialogue between archaeologists, geologists, and heritage specialists.

Water management in ancient churches and monasteries of Tigray, Northern Ethiopia: archaeological insights from rock-cut cisterns

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This study examines the ancient rock-cut cisterns associated with churches and monasteries in Eastern Tigray, northern Ethiopia, offering new archaeological insights into water management practices in highland religious sites. Within four selected ecclesiastical compounds, namely Mikael Amba Rock Hewn Church, Debre Damo Monastery, Mariam Wu'o Rock Hewn Church, and Mariam Qorqor Rock Hewn Monastery, a total of twenty-one rock-cut cisterns of various shapes (rectangular, circular, triangular, and L-shaped were surveyed during a nine-week field campaign in 2024. These cisterns are carved into sandstone bedrock (Enticho/Adigrat formations) and are fed by roof and hillside runoff via channels rather than by natural springs. Many continue to serve domestic, livestock, and ritual needs, while others have been abandoned or backfilled. The cisterns' sizes were calculated from direct measurements (for example, length × width or πr^2), their locations plotted via GPS, and their state of preservation documented. The analysis shows that these cisterns were strategically located in remote, elevated settings (2,200–3,000 m a.s.l.) where access to groundwater was limited and water demands associated with monastic life necessitated innovative storage solutions. Their durability, rock setting, and design reflect a long tradition of rainfall harvesting in semi-arid highlands. A relative chronology links the cisterns to the medieval period through their association with adjacent ecclesiastical edifices, although precise absolute dates remain pending. The survey highlights both functional continuity and emerging threats: some cisterns remain in use and represent living heritage, while others suffer neglect, alteration, or abandonment. The study argues for the integration of these rock-cut systems into both heritage conservation frameworks and sustainable water management discussions in comparable settings. Further research, including absolute dating methods (for example, OSL or radiocarbon) and hydrological modeling, will clarify their chronology, capacity, and potential as historical models of highland water resilience.

Visualising Roman quarrying landscapes in the inland Balkans

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With the Roman arrival in the inland Balkans, stone became essential for construction and an integral material in various aspects of Roman culture. Its durability made it a preferred, long-lasting material across the Roman Empire, and the provinces of the inland Balkans were no exception. The region's complex geological landscape enabled the exploitation of multiple stone types with varying properties and uses. In recent years, archaeological scholarship in the region has increasingly turned its attention to identifying quarrying zones and reconstructing patterns of stone supply in order to determine which quarries provided specific materials and products to nearby settlements.

This analysis focuses on local stone resources and their exploitation during the Roman period, drawing upon published archaeological data to assess the quarrying activities across the inland Balkans. The project aims to present its findings through an open-source map developed primarily using Geographic Information System. The digital map presents all currently documented quarry locations, alongside areas identified as potential stone sources based on geological and archaeological indicators. Each mapped location functions as an individual data node, providing users with access to key information concerning quarry characteristics. This includes the type of stone extracted, its

suitability for different forms of production, the settlements it is believed to have supplied, and the nature of the archaeological evidence attesting to Roman exploitation, such as toolmarks, extraction faces, or partially worked objects, as well as selected bibliography and photographic documentation, where available.

The principal aim of this digital map is to offer a comprehensive overview of stone exploitation in the inland Balkans during the Roman period. As an open-source and interactive resource, it is designed to support ongoing scholarly engagement, allowing for the incorporation of new data and fostering collaboration in the study of Roman quarries and resource management.

Metasassi project: digital storytelling for an accessible rupestrian heritage

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Metasassi – A METAverse for Social Accessibility and Inclusion in the Sassi of Matera is a project funded by PNRR resources, conceived to make an extraordinary yet challenging heritage accessible—particularly to people with mobility impairments and older visitors. The initiative focuses on the Sassi of Matera, a unique rupestrian landscape whose physical complexity often limits direct access.

The project is developed by a multidisciplinary team of engineers, computer scientists, and archaeologists, combining advanced technologies with deep historical and archaeological knowledge. At its core lies an AI system based on deep learning, trained on rupestrian settlements to answer visitors' questions in a natural, contextual, and engaging way.

Three emblematic case studies were selected: Madonna dell'Idris and san Giovanni in Monterrone, San Falcione, and Santa Barbara—rock churches that are difficult to reach physically but can now be explored through high-resolution virtual models. These models were created using laser scanner surveys and photogrammetry and are accessible through immersive headsets.

The experience goes beyond virtual visitation. When the headset is connected to a computer, visitors can interact directly with the AI, asking questions about the sites. The system has been trained to respond through narrative and storytelling approaches, avoiding overly formal or schematic explanations and instead unfolding a story tailored to each context. At Madonna dell'Idris, the focus is on caves and water; at San Giovanni in Monterrone, on the continuous reuse of the church over centuries—as storage, sacristy, private dwelling, and production space; at Santa Barbara, on the adventurous life of the saint and the rise of the Eastern community after the conquest of Constantinople in the 1453; at San Falcione, on wax and honey production, since the church also functioned as a pecchiara, an ancient apiary.

At the same time, users can explore technical topics—from carving cavities to fresco techniques and the concept of palimpsest—demonstrating how innovation, storytelling, and accessibility can redefine the experience and understanding of rupestrian heritage.

A rock-cut monument from the far north: Dwarfie Stane, Hoy, Scotland

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The Dwarfie Stane is a rock-cut chambered monument, hewn out from a large block of sandstone on the island of Hoy, Orkney, Scotland. This monument is currently interpreted as a Neolithic rock-cut tomb, although it presents two main issues that have long puzzled archaeologists. First, the Dwarfie Stane is the only prehistoric rock-cut tomb known in Britain. Rock-cut tombs are normally found in the Mediterranean and the Near East, where they formed a long-standing tradition between the Neolithic and the Nabatean kingdom period (c. 5000 BC to 1st c. AD). The Dwarfie Stane is out of place in Orkney, especially as the Scottish archipelago presents a major concentration of megalithic (stone-built) tombs from the Neolithic period. Second issue, the chronology of the Dwarfie Stane is unclear, as the contents of the tomb have been entirely cleared out centuries ago. The monument is assumed to be Neolithic; however, no attempts have been made to critically assess this assumption. How to date this monument without using invasive methods such as excavation? One possibility, which has been overlooked so far, is to study the tool marks that are still preserved on the ceiling of the chamber. These marks were made during the hewing process of the tomb. They were produced by pick tools made from either stone (Neolithic) or metal (Bronze Age and later periods). This paper will address these issues by presenting the results of a new photogrammetric survey of the Dwarfie Stane monument.

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