BRIEF REPORTS

New data on Venezuelan rock art

By KAROLINA JUSZCZYK
and STANISŁAW RZEŹNIK

1. Introduction

The central-northern coast of Venezuela is a mountainous region characterised by the forested hills and valleys of the Cordillera de la Costa. In pre-Hispanic times, this area functioned as a natural boundary between the coastal beaches and the interior of the continent, traversed by pathways running along river valleys. The body of this research contributes to the cultural heritage of the historical Tacarigüa region (Páez 2021) and broader circum-Caribbean region (Steward 1948), a significant area where pre-Hispanic communities likely established and maintained local and regional mobility and exchange networks while navigating various water routes among the islands (Hofman et al. 2010: 4). The ethnoarchaeological roots of the communities that settled this area trace back to the central Amazon, from where numerous migrations of people to the north took place (Antczak et al. 2017).

No excavations in the rock art contexts have been done so far. The chronology of these sites is not precisely known due to the lack of comparative material for dating. Some stylistic analyses have been made by researchers (i.e. Padilla 2009; Sujo Volsky 2007). The present documented material was developed in 2022 and corresponds to the graphic aesthetics of the whole circum-Caribbean and Amazonian region.

2. Research query

Although Venezuelan rock art sites have been documented since the 19th century (e.g. Rojas 1953 [1878]; Marcano 1971 [1889]), the central-northern coast remains underexplored and lacks comprehensive documentation. In 2021 and 2022, we conducted research focused on the modern documentation of sites featuring rock art.

This work was preceded by a thorough query of library and archival materials to collect documentary evidence produced by earlier researchers, including Tavera Acosta (1956), Cruxent (1960), Delgado (1977), Idler (1985) and Sujo Volsky (2007), among others. Although there were many investigators working on rock art, there has been very little graphical material published so far. The most comprehensive rock art catalogue was published by Jeannie Sujo Volsky and Ruby de Valencia in 1987. Based on this catalogue, we selected 122 rock art sites for investigation. However, it quickly became apparent that since its publication, many of these sites have disappeared or been destroyed due to natural and human factors. Therefore, the fieldwork commenced with land surveys searching for rock art sites.

3. Fieldwork methodology

The documentation of each rock with petroglyphs included topographic measurements using a manual Garmin eTrex20 GPS, photography with a scale, a north arrow, and an IFRAO Standard Scale (Bednarik 1991: 78; Fig. 1). Additionally, it recorded basic inventory information, including the numbering and details of individual sites and boulders, their landscape and the petroglyphs themselves. This included orientation with respect to the cardinal directions, state of preservation (considering both natural and anthropogenic factors) and the rock art signs.

As the rock has a metamorphic origin, its surface is black and glitters, reflecting light in the camera. This makes the petroglyphs difficult to distinguish from the rock surface. In this case, traditional photography was not sufficient for proper documentation, which required us to create 3D photogrammetry of all the decorated panels using a Canon EOS 50D camera.

The documentation of petroglyphs was made

Figure 1. *Photographic documentation of a rock art boulder.*

Figure 2. *A view of a 3D mesh model in Agisoft Metashape software.*

possible by the assistance and guidance of colleagues, friends and local people who accompanied us through different stages of the fieldwork. They provided us with common local knowledge and stories about rock art and its history in that region, which significantly enriched the data acquired from the literature.

4. Data elaboration

The fieldwork documentation was digitised and processed using various software programs. We created 3D models of almost all documented boulders in Agisoft Metashape (Fig. 2). These models provide a complete overview of all panels and allow for significant close-ups of petroglyph details. Next, we generated separate orthophoto 2D views (Fig. 3a) of the decorated panels and inserted them as raster matrix files into AutoCAD. Finally, we redrew all visible petroglyphs from the orthophotos in vector form, producing complete drawings of the rock panels with petroglyphs (Fig. 3b).

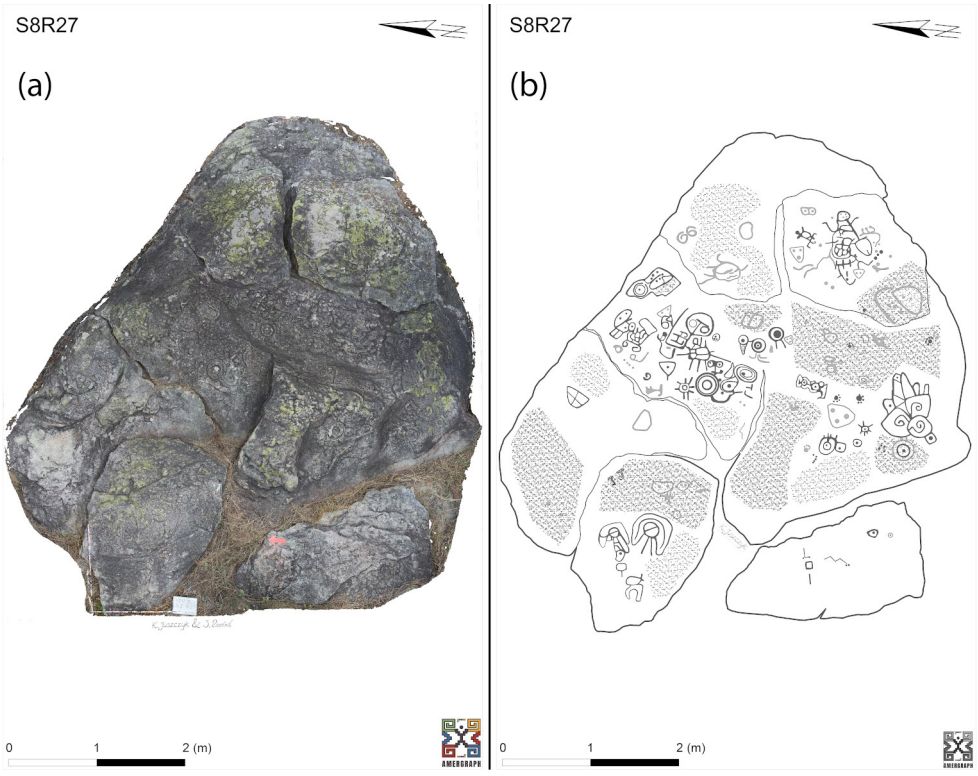

Figure 3. *Examples of a 2D orthophoto view (a) and a CAD drawing (b).*

We processed the descriptive documentation along with GPS coordinates in MS Excel to create a database containing all the documented data, which was then transferred to QuantumGIS (Geographical Information System software). This database facilitates locating specific features, such as boulders and motifs and enables geospatial analysis of documented boulders.

As a preliminary analysis of the collected data, we conducted an initial classification of the petroglyphs. We fol-

lowed the approach of Clados et al. (2022), distinguishing individual graphic units based on Panofsky's (2006 [1975]) method, which differentiates signs at the graphic level. Additionally, all collected data on sites, boulders and individual graphic units were subjected to basic statistical analyses.

5. Results

We documented 275 rocks with petroglyphs across 35 sites within a 4682 km² area, encompassing the Venezuelan states of the Capital District, La Guaira, Miranda, Aragua and Carabobo (Fig. 4). The investigation identified four complex sites, each with more than ten boulders, and 31 sites with isolated petroglyph-bearing boulders. The documented complex sites are Museo Piedra Pintada in Vigírima (111 boulders), Montalbán (34 boulders), Patio Domingo Flores in Carabobo (19 boulders), La Cumaca in Carabobo (11 boulders).

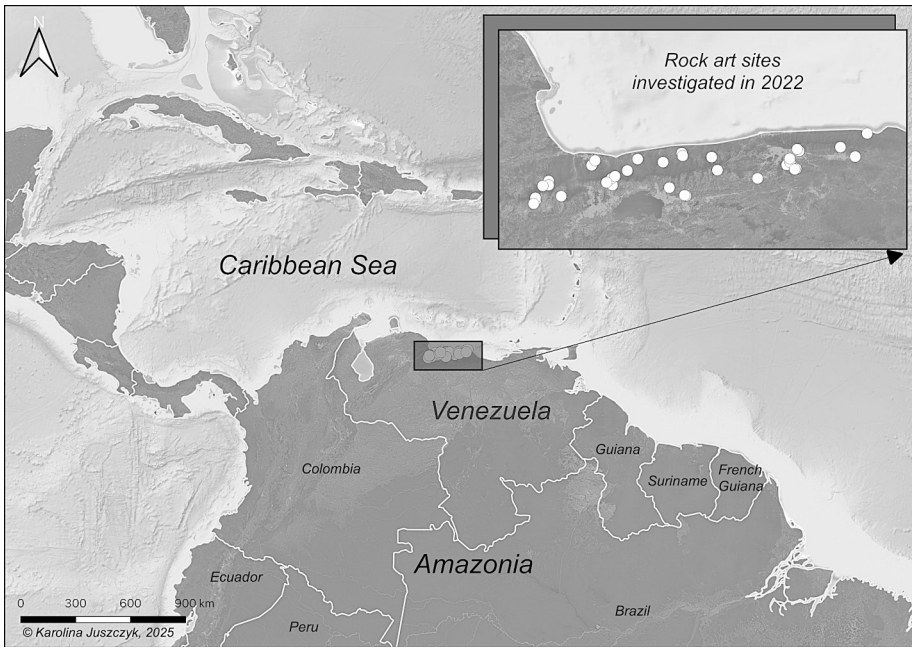

Figure 4. *Locations of the rock art sites investigated in 2022.*

As a result of descriptive and graphical data processing, we prepared a catalogue comprising geographical data, descriptions, photographs, and drawings of all documented boulders, providing a comprehensive record of these cultural artefacts (Juszczyk 2023).

Thanks to the GIS database and statistical analyses, preliminary conclusions concerning boulders with petroglyphs can be drawn. Of all the registered boulders, the petroglyphs have survived in a very good condition on only 31%, while as many as 69% are damaged, caused by thermal and eolithic weathering, as well as mud and rockslides. Specific site concentrations appear in some areas, such as central Carabobo and northern Miranda. The analysis indicates that the petroglyphs' creators preferred no particular orientation in any part of the investigated area analysed so far. Additionally, 37% of the registered sites are situated near water sources, such as river corridors.

The boulders range in size from several dozen centimetres to a few metres in length and height, with one to six engraved panels containing single or multiple motifs on each. The petroglyphs, made using various techniques and likely different tools, range from 5 to 60 mm in depth and 5 to 25 mm in width (the deepest of them are considered to be mortars). We found a few examples of petroglyphs made with metal tools, which may suggest their colonial origin. Apart from the technical diversity of the petroglyphs, we preliminarily observed at least four distinct styles that appear to reflect different aesthetic traditions (Fig. 5).

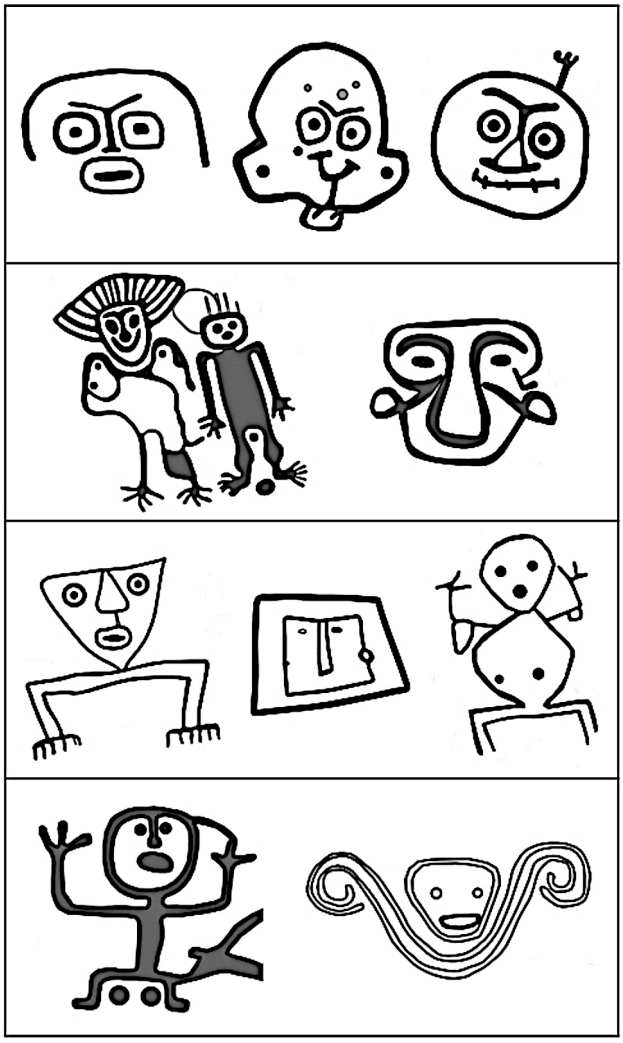

Figure 5. *Examples of four rock art styles identified in the investigated area.*

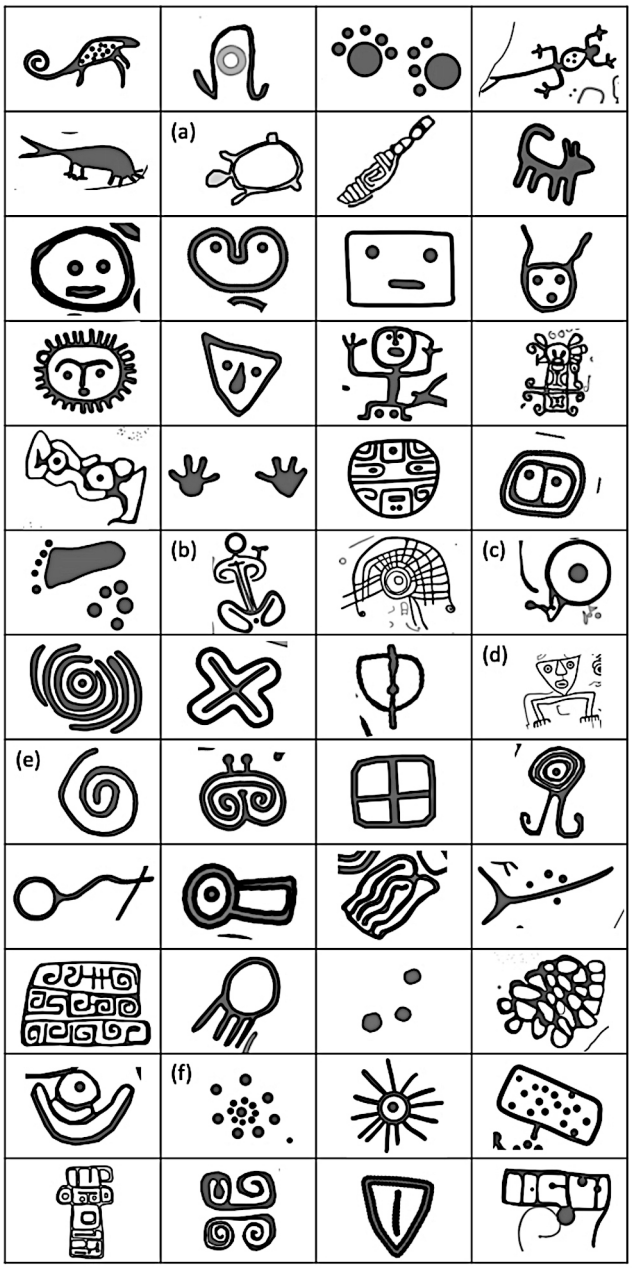

Figure 6. *The representations of the distinguished 48 graphic units, with the less common ones being (a) 'frog', (b) 'woman giving birth', (d) 'double legs', while the most common ones are (c) circle with a dot, (e) spiral, and (f) dots.*

The repertoire of documented rock art signs is diverse and complex. While analysing the digitised graphic data, we distinguished 48 graphic units (items distinguished on the graphical level that is under investigation; Clados et al. 2022) (Fig. 6). These labels serve only for identification purposes and do not reflect semantic value. The most common graphic units are the dots (cupules, found on 40% of all boulders), spirals (35.6%) and circles with dots (27.6%). In contrast, some unique or rare signs to mention include 'frogs' (0.4%), 'women giving birth' (0.7%) and 'double legs' (1.1%) (Fig.7). A total of 71 boulders display a single graphic unit, while one boulder bears as many as 27.

The graphic units and aesthetics of the documented petroglyphs resemble the graphic conventions of the Amazon and Caribbean. Our initial analysis of rock art analogies from Amazonian sites revealed graphical correspondences between the rock art of northern-central Venezuela and the Amazonian region (see Greer 2001; Pérez Gómez and Swidorowicz 2023; Riris et al. 2024). This supports previous research on the migratory movements of pre-Hispanic people from the lower Amazon and Middle Orinoco northward (Antczak et al. 2017; Oliver 1989). These preliminary results provide a solid foundation for future in-depth investigations.

Venezuela lacks a comprehensive inventory of rock art sites. From the prepared list of 122 sites (Valencia and Sujo 1987), we were able to reach six of them, which stands only for 4.9% of the total. The remaining 29 documented sites correspond to newly identified sites (Juszczyk 2023). Our catalogue is the result of

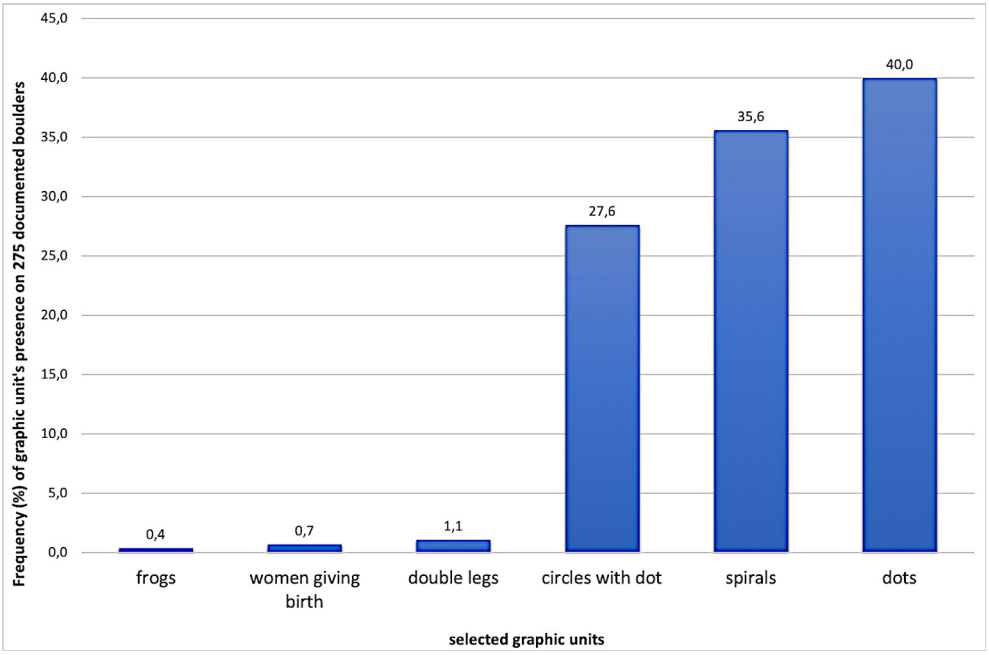

Figure 7. *Percentage distribution of the selected graphic units.*

the most systematic registration possible of rock art in northern-central Venezuela.

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RAR 43-1488

Antlion pits and the origin of cupules: an ethological hypothesis for rock art

By ANIL KUMAR and DHAMMITRA

Cupules are among the most enduring and widespread forms of pre-Historic rock art. They have been recorded on virtually every inhabited continent, across environments that range from the sandstone outcrops of central India to the granite boulders of Australia and the basalt flows of Africa. In some cases, cupules have been dated to the Lower Palaeolithic, placing them among the earliest known expressions of symbolic human behaviour. The famous Daraki-Chattan cave in India, for instance, contains over 500 cupules predating the Acheulian. The diversity of cupule contexts complicates interpretation: they appear on horizontal and vertical surfaces, in caves and open-air settings, and in association with water sources, burial grounds and ritual locales (Bednarik 2008; Kumar 1996). This variability suggests that cupules were multifunctional and deeply embedded in cultural systems of meaning.

The question that drives this article is whether cupules could have been inspired by natural patterns, specifically the conical depressions created by antlion larvae. The visual and functional resemblance between these naturally formed pits and cupules suggests a possible case of observational mimicry or symbolic

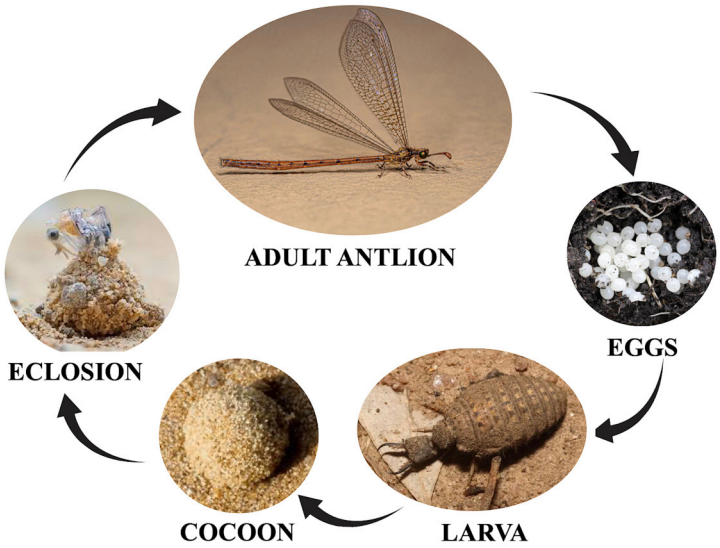

Figure 1. *Developmental cycle of an antlion (Myrmeleontidae), illustrating complete metamorphosis from egg to adult.*

replication.

Antlions (family Myrmeleontidae) inhabit dry, sandy environments worldwide. They undergo complete metamorphosis (holometaboly) through four stages: egg, larva, pupa (within a cocoon) and adult. Females lay eggs in loose sand; larvae hatch and immediately begin constructing conical pits to trap small prey such as ants. These larvae—often called 'doodlebugs'—are voracious and can remain in the larval stage for weeks to months, depending on environmental conditions. Once mature, the larva spins a sand-coated silken cocoon in which it pupates. After metamorphosis, the adult antlion—resembling a damselfly—emerges through eclosion. Adults are chiefly nocturnal and short-lived (Mansell 1999).

Antlion larvae build conical pitfall traps to ambush prey. Franks et al. (2019) showed that larvae employ spiral excavation, a technique that promotes wall instability and trap efficacy while conserving energy and reducing backfill. Matsura (1987) demonstrated that pit distribution is density-dependent: as larval populations rise, pits become more evenly spaced owing to mutual interference, forming a self-organising spatial pattern. These pits display precise, symmetrical geometry and a central focal point that enhances trapping efficiency (Lucas 1989). Such deliberate and repetitive environmental modification is rare among small animals; ethologists cite similar complex constructions—spider webs and termite mounds—as both functional and cognitively salient.

Fossil evidence confirms that antlions have existed for more than 150 million years. Jurassic specimens and mid-Cretaceous (~99 Ma) larvae preserved in Burmese amber exhibit morphology and pit-trapping behaviour nearly identical to modern species (Badano et al. 2018; Cerretti and Badano 2018). Antlion pits are highly sensitive to environmental change, particularly rainfall, which flattens their conical walls and obscures their form. In anticipation of rain, larvae burrow deeper, resurfacing after the ground dries to rebuild new pits (Gotelli 1993). This visible cycle of disappearance and re-emergence may have appeared mysterious or

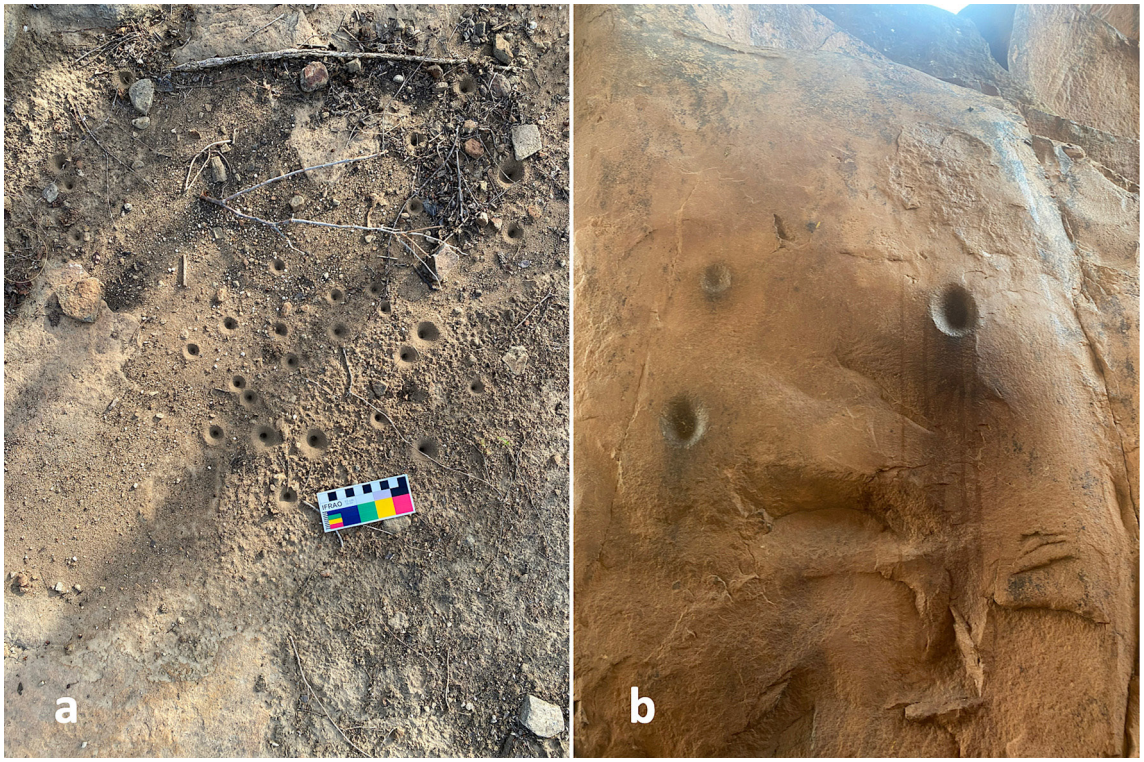

Figure 2. *(a) Antlion pits near rocky outcrop; (b) cupules on sandstone at Chief's Rock, Bhimbetka, Madhya Pradesh, India.*

portentous to early human observers.

These behaviours reflect adaptive ecological algorithms rather than incidental construction. Their geometric clarity, spatial regularity and functional elegance may have resonated visually and cognitively with early humans. The consistent morphology—concave form, size clustering and central symmetry—mirrors characteristics of cupules in pre-Historic rock art. Viewed through a cognitive-ethological lens, antlion pits could have inspired symbolic or ritual replication in human cultural expression, reinforcing the plausibility of a biological origin for early symbolism.

This hypothesis proposes that early humans, through close observation of their surroundings, noticed the distinctive and regular structures created by antlion larvae and chose to replicate or symbolise them in more permanent media such as stone. Although speculative, the idea invites exploration of how animal behaviours might have influenced the symbolic and artistic development of early people.

Photographic evidence and field observations. During fieldwork in India, we recorded numerous antlion pits in dry, sandy terrain. Some were located in open jungle near rocky outcrops, others in open fields. The pits measured 8–25 mm in diameter. Their arrangement appeared non-random, with spacing and distribution shaped by environmental conditions. Photographs captured under diffused light highlight the precision of antlion pits. While cupules are generally larger and permanent, their basic geometry closely resembles the pits observed in the field.

Morphological and symbolic comparison. Key parallels between antlion pits and cupules include:

- *Shape and form:* Both exhibit circular or sub-circular outlines with central depressions. Although antlion pits form in loose soil and cupules are pecked into stone, the resulting geometry is comparable.
- *Arrangement:* Both occur singly or in clusters, randomly spaced or evenly distributed according to ecological or cultural factors.
- *Visual symmetry:* Both display regularity and a focal centre that likely draws visual attention.

These similarities suggest that cupules may represent formal mimicry of antlion pits or an interpretative engagement with natural forms. The recurrence of such shapes in both natural and cultural contexts hints at a shared cognitive and symbolic thread (Bednarik 2008).

Bednarik has devoted much time to the study of cupules worldwide. He synthesises over 200 years of research, categorising 71 proposed explanations into 11 groups (Bednarik 2013). He notes that cupules are as small as technically possible yet cut very deep relative to rock hardness, presenting greater technological difficulty on harder lithologies. Despite the diversity of theories, researchers generally agree that cupules were deliberate, meaningful and often repeated acts reflecting cognitive and symbolic behaviour (Bednarik 2008).

Conclusion. Cupules, among the most persistent and enigmatic forms of pre-Historic rock art, may have more complex origins than previously imagined. This report proposes that the ubiquitous, patterned and behaviourally fascinating pits of antlions could have inspired early symbolic artists. While circumstantial, the evidence warrants rigorous ethological, archaeological and experimental investigation. If supported, the hypothesis could reshape our understanding of the origins of symbolic thought and artistic practice.

Acknowledgments

Field photographs of antlion pits and cupules were taken by the author. The life-history figure was created using images sourced online. The authors thank Swapnil, Sumedh, Deepti Bunkar, V. Jalaj and A. Jalaj for assistance during field studies and acknowledge insights from scholars in ethology and rock art research. The authors also acknowledge the use of OpenAI's ChatGPT (GPT-4) for linguistic refinement. All interpretations remain the authors' responsibility.

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RAR 43-1489

Tracing quinary numeral systems in pre-Historic contexts: archaeological, linguistic and typological perspectives

By JULIEN d'HUY

The notion that human numerical cognition is embodied is well attested. Swadesh (1972: 183–184) observed that in many languages the lexical item for *five* frequently coincides with, or derives from, the lexical item for *hand*, with the reference clearly related to the fingers. Similarly, *ten* is often rendered as 'two hands', 'a pair of hands' or 'the upper part', while *twenty* may be expressed as 'all the fingers', 'hands and feet' or 'the whole person'. Numerals between six and nine are commonly based on finger-counting, with *six* sometimes denoting 'one on the other hand' (op. cit.: 183–184). Such patterns have long informed hypotheses on the origins of counting and bear a notable resonance with Palaeolithic parietal art.

Rouillon (2006) proposed that the negative hand stencils at Cosquer Cave (c. 27,000 BP) constitute a form of digital counting system. His analysis identified sequential finger configurations corresponding to the numerals one through five. Overman (2014), in this journal, extended this hypothesis to additional decorated caves, emphasising that certain biomechanically complex postures are unlikely to be accidental. The relative absence of the numeral *four* compared with *five* parallels attested developmental patterns in number acquisition, potentially indicating an emergent stage of numerical conceptualisation.

These proposals, though contested (see Etxepare and Irurtzun 2021), raise a central question: if the hand motifs at Gargas and Cosquer encode a numeric system, what type of system might this represent? Archaeological considerations suggest that the predominance of unimanual motifs is consistent with a quinary base. The more general issue, however, is whether a quinary system can plausibly be reconstructed for the Palaeolithic period. The present study addresses this question using an areal-typological approach, examining the geographical distribution of numeral systems as an indirect means of reconstructing their historical development. Areal methods have previously been applied to the reconstruction of linguistic features (e.g. Nichols 1992, 1994; d'Huy 2024), mythological motifs (e.g. Hatt 1949; Berezkin 2013; Le Quellec 2021) and ritual practices (e.g. Stépanoff 2019).

The analysis draws upon the Grambank database (v1.03; Skirgård et al. 2023a, 2023b; *https://grambank.clld.org/*), a systematically coded typological resource covering over 2400 languages and 195 grammatical features. Three features concern numeral systems: GB333 (decimal systems), GB334 (quinary systems), and GB335 (vigesimal systems). Each is encoded in binary fashion, with presence marked as *1* and absence as *0*. It should be noted that the Grambank dataset is unevenly distributed; well-documented languages are overrepresented, which may bias global patterns. Moreover, hybrid systems (e.g. decimal–vigesimal mixes) are here reduced to binary categories, an unavoidable simplification that obscures internal variation. Nonetheless, Grambank remains the most comprehensive and reliable cross-linguistic resource currently available for pursuing the present analysis.

Following database conventions, for each numeral system and each macro-area, the proportion of languages exhibiting the feature was calculated as the number of languages coded *1* divided by the total number of coded languages (*0 + 1*). A separate line was added for non-Austronesian Papuan languages, based on metadata.

Table 1 presents the normalised proportions of each system across macro-areas. Since systems are independently coded, totals may exceed or fall short of 100%. This is expected, as many languages employ different bases for distinct numeral ranges (e.g. quinary for small numerals, decimal for tens, vigesimal for higher values) or display none (e.g. reduced systems). This non-exclusive coding logic reflects the complexity and plasticity of numeral systems across the world's languages.

Macro-area	GB333	GB334	GB335
Africa	0.8444	0.3175	0.1909
Australia	0.0238	0.0465	0.0
Eurasia	0.911	0.0146	0.1405
Papunesian (non-Austronesian)	0.2281	0.4138	0.1826
Papunesia	0.6943	0.3194	0.1181
North America	0.5885	0.2542	0.421
South America	0.2808	0.3184	0.0546

Table 1. *Proportion of languages within each macro-area exhibiting a decimal system (GB333), a quinary system (GB334) or a vigesimal system (GB335).*

As a control, latitude thresholds from 15°N to 35°N in 5° increments were defined for the Old World (defined in contrast to the Amerindian languages, i.e. those of the New World). At each threshold, languages were divided into northern and southern zones, and the normalised proportion of each numeral system was calculated (Table 2).

The results reveal strong typological polarisation across macro-areas. Decimal systems (GB333) dominate in Eurasia (91.10%) and Africa (84.44%) but are infrequent in South America (28.08%) and Australia (2.38%). Quinary systems (GB334) are nearly absent in Eurasia (1.46%) yet relatively common in Africa (31.75%), Papua (31.94%, rising to 41.38% if we ex-

Latitude Threshold	Zone	GB333	GB334	GB335
15	North	0.9189	0.0146	0.1378
15	South	0.6883	0.2943	0.1411
20	North	0.9203	0.0097	0.1439
20	South	0.7031	0.2781	0.1383
25	North	0.9207	0.0091	0.1687
25	South	0.72	0.2576	0.131
30	North	0.9444	0.0102	0.1684
30	South	0.7375	0.2312	0.1352
35	North	0.9325	0.0062	0.1801
35	South	0.7448	0.2259	0.1346

Table 2. *Normalised proportions of numeral system traits in the Old World (North/South zones, latitude thresholds from 15° to 35°N).*

clude the more recent Austronesian languages) and South America (31.84%). Vigesimal systems (GB335) appear primarily as a regional innovation, particularly frequent in North America (42.1%) but marginal elsewhere.

The latitude-based analysis corroborates these patterns. Decimal systems are disproportionately frequent in northern zones (mean 92.74%) compared to southern zones (mean 71.88%). Conversely, quinary systems are nearly absent in the north (0.99%) but occur in approximately one-quarter of southern languages (25.74%). Such a southern distribution is compatible with early *Homo sapiens* dispersal zones along coastal routes. This spatial correlation, while not direct proof, offers an empirical basis for exploring the hypothesis of a very ancient origin of the quinary system. The vigesimal system remains weakly represented overall, with similar averages between the north (15.98%) and the south (13.60%), showing no clear geographical differentiation, reinforcing its interpretation as a secondary innovation.

According to Struik (1948), the quinary system and the decimal system are so biologically inevitable that they eventually emerge among primitive peoples in many parts of the world. However, results suggest a more complex evolutionary scenario, in which a quinary system, potentially linked to bodily perception, could have constituted an early numerical base among populations in low latitudes. This system would then have been progressively supplanted or replaced by the more systematic decimal system, whose current dominance in northern macro-regions may be linked to later agricultural and state expansions, requiring the ability to count a greater number of items.

Four strands of evidence support this view:

(1) Her et al. (2024) demonstrate a probable African origin for the *initial-base* order (base × n), predominant in Niger-Congo languages, and correlated with head-initial phrase structure. Phylogenetic reconstructions also suggest its presence at the root of global and African language trees, though its southern areal distribution is underexplored. The existence of numerical syntax prior to the dispersal from Africa suggests that humans were already able to construct larger numbers by combining smaller ones, thereby strengthening the hypothesis that numerical bases may have existed at that time.

(2) Additionally, subitising—the ability to rapidly and effortlessly enumerate small sets of items—allows humans to perceive up to about 3–4 objects without deliberate counting. Beyond this range, the mind must rely on slower, sequential strategies (Kaufman et al. 1949; Piazza et al. 2003). To overcome this perceptual threshold, the simplest and most universal bodily support is the hand. Its five fingers provide a natural higher-order unit that extends the subitising limit and underpins the quinary grouping observed in many traditional numeral systems (Fisher and al. 2012; Overmann 2021). An early quinary system in *Homo sapiens* can also be explained by communicative efficiency (Xu et al. 2020): precise terms for 1–5, grounded in the hand as a natural unit, balanced accuracy with minimal cognitive cost. Recursive use of 'five' (e.g. 'two hands' = 10) provided expressive power at low complexity, making quinary numeration a near-optimal solution for early human communication needs. Under these conditions, it is plausible that, if early *Homo sapiens* employed numerical systems, these were primarily organised on a quinary basis.

(3) While the spontaneous emergence of quinary systems may explain local cases (Barlow 2023), it cannot alone account for their diffusion across the entire southern hemisphere of the Old World. Moreover, various elements point to the antiquity of quinary systems in the Southern Hemisphere, notably in Proto-Bantu (Zerbian and Krifka 2008; Epps et al. 2012) and in Papuan languages north of New Guinea before the spread of Austronesian languages (Galis 1960), suggesting that this counting method existed in Africa and Oceania before the appearance of these language families.

More generally, although Papuan languages display numerous different numeral systems, they usually have complex expressions for numbers 'six' to 'ten' (Schapper 2015). According to Bowern and Zentz (2012), many Australian languages possess an atomic term for 'five' (54/189), with a substantial proportion (23) derived from 'hand'. However, this does not necessary imply a quinary base.

In many languages, 'finger' is not lexically distinguished from 'hand' but rather encoded as a part of it. This colexification occurs primarily in Australia and North America, less frequently in South America, and only sporadically in other regions, including Africa, mainland Southeast Asia, New Guinea and Polynesia (Brown 2005). Such a distribution, notably absent from northern Eurasia, may reflect early *Homo sapiens*

migrations and could indicate that, at least during the settlement of Australia and the New World, the hand was conceptualised as a set of five units—traces of which may still be preserved in certain Papuan and Australian languages.

In Africa, the widespread quinary pattern in Chadic and Cushitic—numerals 6–9 formed as 5+1…5+4, with 5 often derived from 'hand'—contrasts with Semitic, Berber and Egyptian, where 6–9 are lexicalised (Zaborski 1987: 317–318). This suggests that early Afroasiatic was not uniformly decimal and that the quinary layer in Chadic and Cushitic may represent a substrate feature, later overlaid or replaced by decimal innovations elsewhere. Accordingly, the fact that the Sandawe form *kwà'áná* 'five' resembles the surrounding Cushitic forms for the same number has been interpreted as a borrowing from Tanzanian Cushitic into Sandawe (Mous 2025), but it is also possible that Sandawe (that uses base 5 and 10; Epps et al. 2012) and Cushitic languages preserves the same substratal form (see also for comparable examples in Kießling et al. 2007). The Bushman numeral system is basically binary, but shows occasional quinary traits, e.g. in Naron, 'four' is expressed as 'two fingers and two fingers'; 'five' as 'hand'; 'ten' as 'both hands'; and 'fifteen' as 'both hands and one foot' (Schapera 1960: 220).

(4) Numeral words, especially those corresponding to structural bases (one, two, three, five, ten, twenty), are recognised as among the most stable lexical units in the world's languages. In Indo-European languages, numbers, like pronouns, evolve more slowly than other grammatical categories for the same frequency of use (Pagel et al. 2007). In Indo-European, Bantu and Austronesian languages, the words for numbers one through five exhibit extremely slow rates of lexical replacement. They can persist for between 3500 and more than 100,000 years—3.5 to 20 times longer than the average lifespan of a basic vocabulary item (Pagel and Mead 2018). This suggests that numeral terms have greater historical resilience. Moreover, Dumézil (1955) showed that the striking similarities between the first six numbers in Turkish and Quechua could only be explained by a very ancient common inheritance rather than chance. In 1957, with Curien (Dumézil and Curien 1957), he reinforced this thesis with a statistical demonstration making coincidence highly improbable. The correspondences are particularly strong for the first five numbers, extended by the sixth, thus suggesting the existence of a quinary system already present in the Upper Palaeolithic and transmitted to the Americas at the time of their settlement.

A methodological issue remains. Several notched bones, often interpreted as tally sticks, exhibit sequences of incisions that demonstrably served as durable records of quantities (e.g. d'Errico et al. 2018; Courtenay et al. 2025). None, however, shows explicit visual grouping in sets of five. Yet, before the abstraction of number concepts, enumeration relied on the one-to-one mapping of fingers to objects—a cognitive foundation of counting (Dehaene 2011: 81). Within this framework, the hand constitutes the most natural unit of aggregation. Rather than expecting perfect groups of five incisions, sequential notching itself may be understood as an externalisation of manual counting: each incision mirroring the raising of a finger for each item. In this view, the notches function as 'fossilised fingers'. If quantities were mentally organised in sets of a 'full hand', explicit demarcation would not have been required. A quinary structure may therefore have existed cognitively, without being visually encoded in the artefact.

Taken together, archaeological, linguistic and typological data support the plausibility of quinary systems during early *Homo sapiens* dispersals. However, several limitations need to be underlined. The North/South contrast, while indicative, is not immune to confounding factors, since subsequent historical processes—including the spread of large language families such as Indo-European, Bantu or Sino-Tibetan—have substantially reshaped earlier distributions. The current typological patterns should therefore be interpreted with caution: they reflect a combination of possible deep substrata and later layers of contact, diffusion and language replacement, rather than a direct snapshot of Palaeolithic reality.

In conclusion, the areal-typological evidence indicates that quinary systems likely formed part of the numerical repertoire of early human populations along dispersal routes out of Africa. While not definitive, this finding lends independent support to interpretations of Palaeolithic hand stencils as numerical representations, while acknowledging that multiple interpretations remain possible.

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RAR 43-1490

New technologies for the recording of geoglyphs: the case of Alto Caramucho

By GONZALO PIMENTEL G., MARIANA UGARTE F., LUIS PÉREZ R., JUAN GILI H. and JAVIER ARÉVALO L.

… objectivity must always be understood in a relative sense, and the absolute is unattainable
(Kandinsky 1947 [1926]: 124)

Introduction

Using the geoglyphs of Alto Caramucho in the Atacama Desert as a case study, we examine how new recording technologies—specifically aerial photogrammetric surveys and digital terrain models—enable the production of more accurate, measurable and comparable records, in contrast to earlier documentation. These methods improve the archaeological interpretation of these monumental figures while eliminating disturbances during the recording process. However, technological progress does not resolve inherent challenges, such as anthropogenic damage and persistent subjectivity in the reading of images.

A geoglyph is a manifestation of rock art consisting of a figure created through the intentional large-scale modification of the earth's surface. The contrast that defines the figure is mainly achieved through two techniques: subtraction or clearing, by removing the dark surface material towards the contour to expose the lighter subsurface, or addition, by accumulating material of a contrasting colour upon the original ground. Along with their monumentality, geoglyphs stand out for their visibility over long distances.

The Atacama Desert (northern Chile) hosts thousands of geoglyphs distributed between the regions of Arica and Antofagasta. These are consistently associated with ancient trans-desert caravan pathways and were mostly inscribed on hillslopes, designed to be viewed in motion from the very paths of transit (e.g. Núñez 1976; Briones et al. 2005; Briones 2006; Pimentel 2011; Valenzuela and Clarkson 2014; Gallardo et al. 2018). These large-scale images, generally exceeding 10 m in length, began to be created in the Atacama Desert at least 3000 years ago, proliferating during the Late Intermediate Period (c. 1000–550 BP) and continuing into colonial times (Pimentel and Barros 2020).

Geoglyphs have been the subject of multiple archaeological interpretations since the nineteenth century, with the prevailing hypothesis over the past fifty years suggesting that they functioned as 'traffic markers' for Andean caravanners (Núñez 1965: 29, 1976). More recently, it has been proposed that they were not merely road signage, but integral components of Andean mnemonic systems, through which historical memory was inscribed upon the hillslopes along the trans-desert pathways (Pimentel and Barros 2020; Pimentel et al. 2025).

Within this vast corpus, the Alto Caramucho site (also known as Alto Barranco) stands as an emblematic case, both for its history of documentation and for its accelerated deterioration: vehicular traffic and off-road competitions have made it one of the most threatened geoglyph assemblages in northern Chile (Figs 1 and 2). Since the second half of the twentieth century, the site has been the subject of various drawings, descriptions and interpretations (Schaedel 1957; Iribarren 1968; Núñez 1965, 1976; Cerda et al. 1985; Briones et al. 2005; Núñez and Briones 2017; Pérez and Sandoval 2020). The earliest photographic record known to us was made by Jorge Checura around 1959 (Fig. 3).

Challenges in documentation and interpretation

The recording of geoglyphs is an intrinsically

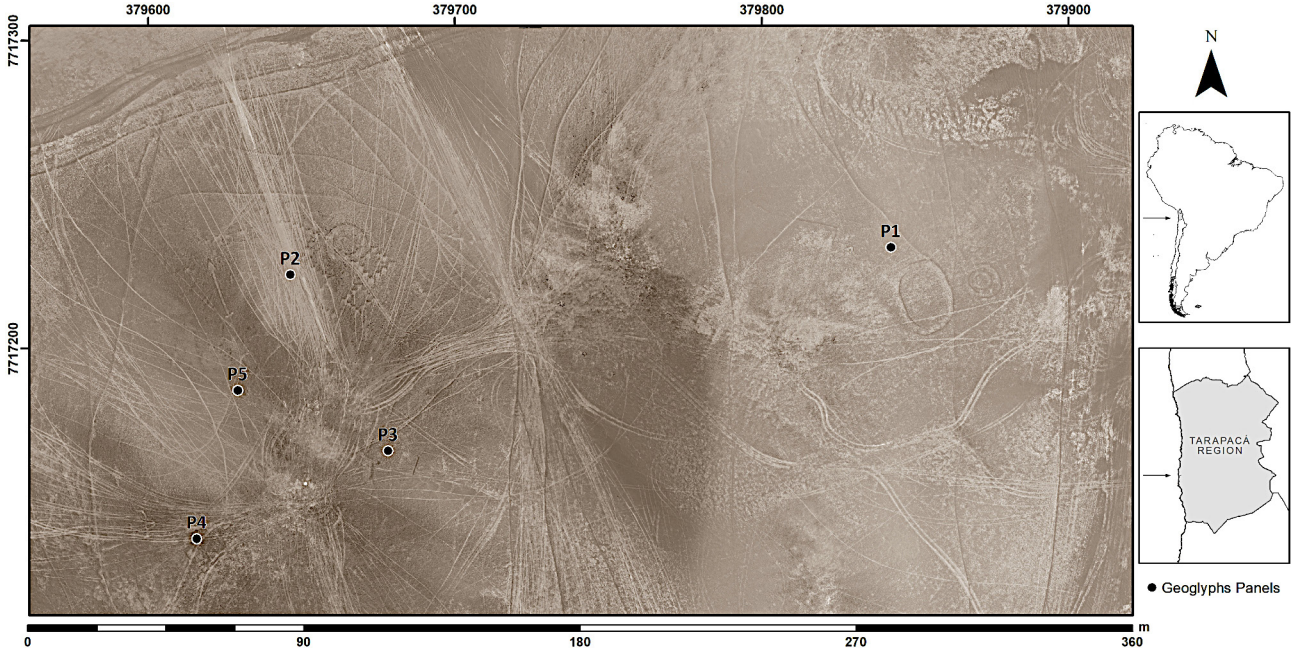

Figure 1. *Location map and general photogrammetric overview of the Alto Caramucho Geoglyphs.*

Figure 2. *General view of the Alto Caramucho Geoglyphs site. Note the extensive disturbance caused by off-road vehicular traffic. See heritage alert at: https://www.nytimes.com/2024/09/24/science/geoglyphs-atacama-desert-rallies.html*

Figure 3. *Photograph taken by Jorge Checura (c. 1959) showing Panel 2 undisturbed. Courtesy of the Regional Museum of Iquique.*

complex task. The visibility of the figures depends on variable factors such as light intensity, viewing angle and distance, or the extent of natural or anthropogenic damage. Consequently, twentieth-century records show notable discrepancies in number, form and interpretation (Fig. 4).

Traditionally, geoglyph recording was carried out mainly from the ground, and aerial documentation (using balloons, light aircraft, helicopters, or ultralight planes) was rare and inconsistent in altitude and perspective. Measurements were taken by walking alongside the figures, and although various methods were employed to minimise damage, deterioration inevitably occurred. Geoglyphs are extremely fragile

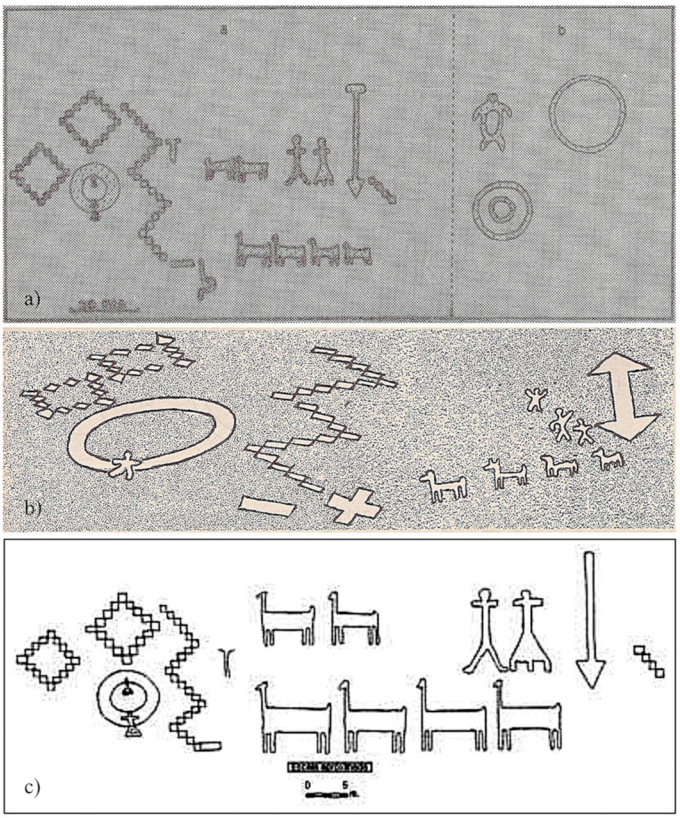

Figure 4. *Drawings of the Alto Caramucho geoglyphs in the twentieth century. a) after Núñez 1976: 155; b) after Cerda et al. 1985: 321; c) after Briones et al. 2005: 219 (drawn in 1968).*

manifestations that, despite surviving for millennia thanks to the desert's minimal erosion rates, are highly vulnerable to anthropic action: the passage of a vehicle—or simply a pedestrian —leaves a conspicuous and indelible trace.

New tools for documentation

Contemporary aerial photogrammetric technologies—such as drone-based surveying and digital image processing—have radically transformed the recording of geoglyphs. These tools enable the generation of measurable orthophotos, digital terrain models, and high-resolution nadir views, significantly enhancing the precision with which motifs are identified and compared (e.g. Pimentel et al. 2017; Sánchez-Borja et al. 2024). This not only enhances our capacity for recording and interpretation but also completely eliminates physical disturbances to the figures during documentation.

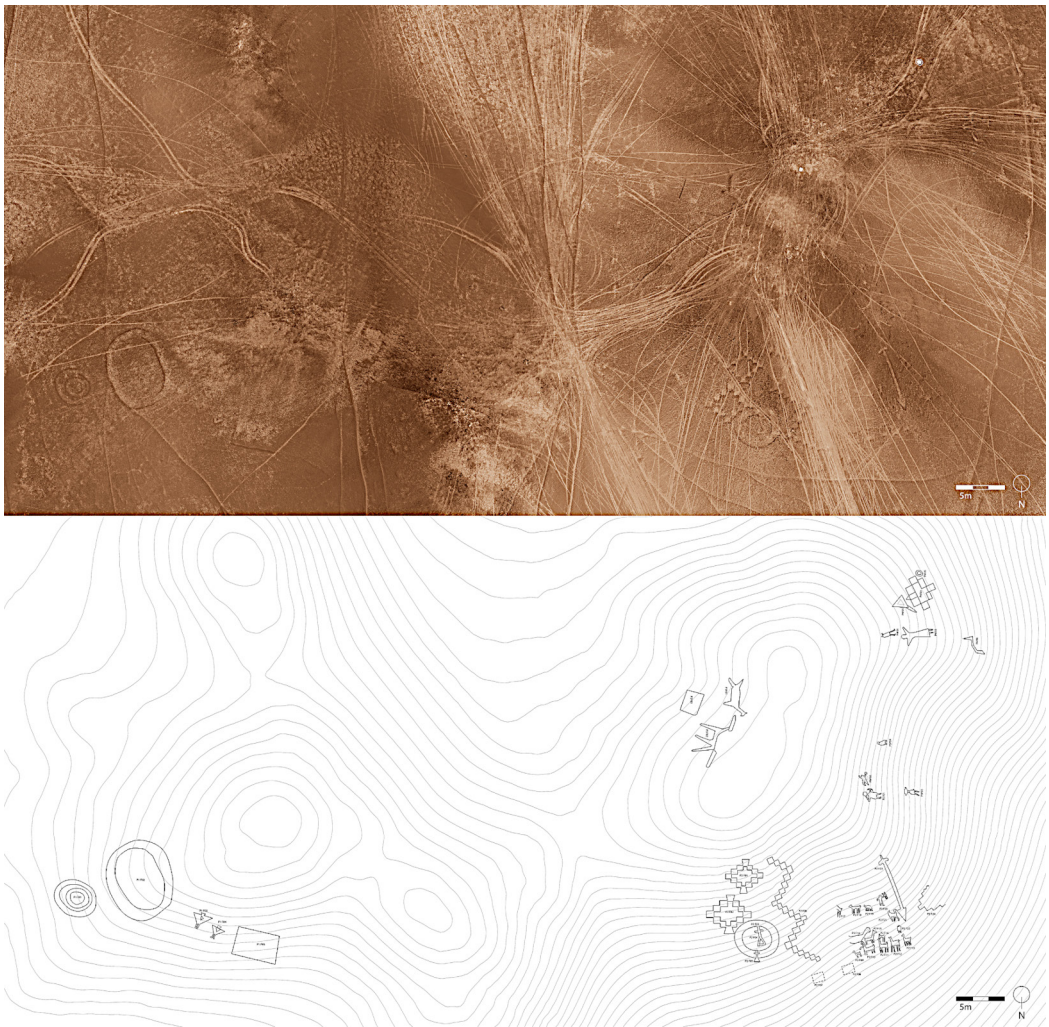

Figure 5. *Current photogrammetric survey of the site and line drawing of motifs.*

Photogrammetric imagery now provides a clear, high-resolution view of archaeological sites. The first researchers to apply these tools at the site were Pérez and Sandoval (2020), who substantially expanded the record, identifying a total of five panels and 39 figures. We recently conducted a new aerial photogrammetric survey, improving lighting conditions and resolution, which allowed us to confirm the existence of all five panels and increase the number of recorded motifs to 42 (Table 1, Fig. 5).

	Núñez 1976	Cerda et al. 1985	Briones et al. 2005	Pérez & Sandoval 2020	Ours
Number of panels	2	1	1	5	5
Number of motifs	22	23	18	39	42

Table 1. *Comparison of panels and motifs recorded at Alto Caramucho.*

Results

Descriptive datasheets were compiled for each figure following the most recent photogrammetric survey and subsequently compared with earlier imagery and documentation. The largest motif measures 35.9 m in length, and the smallest 3 m, with an average of 12.11 m.

In terms of typological categories, geometric motifs predominate (36%), among which 24% are composite—such as three-stepped Andean crosses or *chakanas*—and 12% are simple, including circles and rectangles. Zoomorphic motifs follow with 33%, composed mainly of camelids in caravan scenes (*Lama glama*). Anthropomorphic motifs account for 24%, all of which are complex, depicting details of clothing and other paraphernalia (Table 2, Fig. 7).

Category	**Motif**	**P1**	**P2**	**P3**	**P4**	**P5**	**Total**	**%**
Simple Geometric	Oval	1					**1**	**2%**
	Circle		1		1		**2**	**5%**
	Rectangle	1		1			**2**	**5%**
Composite Geometric	Concentric circle	1					**1**	**2%**
	Stepped Andean cross		2		1		**3**	**7%**
	Zig-zag step-fret		1				**1**	**2%**
	Stepped motif		1				**1**	**2%**
	Vertical arrow		1				**1**	**2%**
	Christian cross on pedestal		2				**2**	**5%**
	Triangle with appendage				1		**1**	**2%**
Zoomorphic	Camelid		12	1			**13**	**31%**
	Camelid?			1			**1**	**2%**
Anthropomorphic	Complex anthropomorph	2	2		2	4	**10**	**24%**
Indeterminate			2		1		**3**	**7%**
Total		**5**	**24**	**3**	**6**	**4**	**42**	**100%**

Table 2. *Quantity and types of motifs recorded per panel.*

Stylistic analysis suggests that most of the figures correspond to the Late Intermediate Period (c. 1000–550 BP), although certain superimpositions of caravans and differences in camelid styles—ranging from naturalistic to schematic representations—may represent earlier phases. The presence of two Christian crosses on pedestals confirms the continuity of these representations into colonial times (sixteenth–eighteenth centuries).

Discussion and conclusions

The comparison between twentieth century and current records reveals substantial changes in our capacity to observe and document geoglyphs. The new technologies applied to the recording of rupestrian representations have proven extremely useful for quantifying motifs and better recognising their referents, while allowing for metrically precise documentation.

Unfortunately, the accelerated deterioration of the Atacama Desert geoglyphs due to anthropic activity has become an increasing constraint on their interpretation, making comparison with previous images, drawings and descriptions absolutely necessary.

Undoubtedly, rupestrian documentation is not static, and technical advances do not eliminate interpretative limitations: the reading of geoglyphs continues to rely on the researcher's experience and the visual and cultural context in which they are interpreted.

In summary, the history of the recording of the Alto Caramucho geoglyphs exemplifies how the incorporation of digital photogrammetry can redefine the scale and detail of archaeological documentation, opening new possibilities for the conservation and understanding of these unique cultural landscapes of the Atacama Desert.

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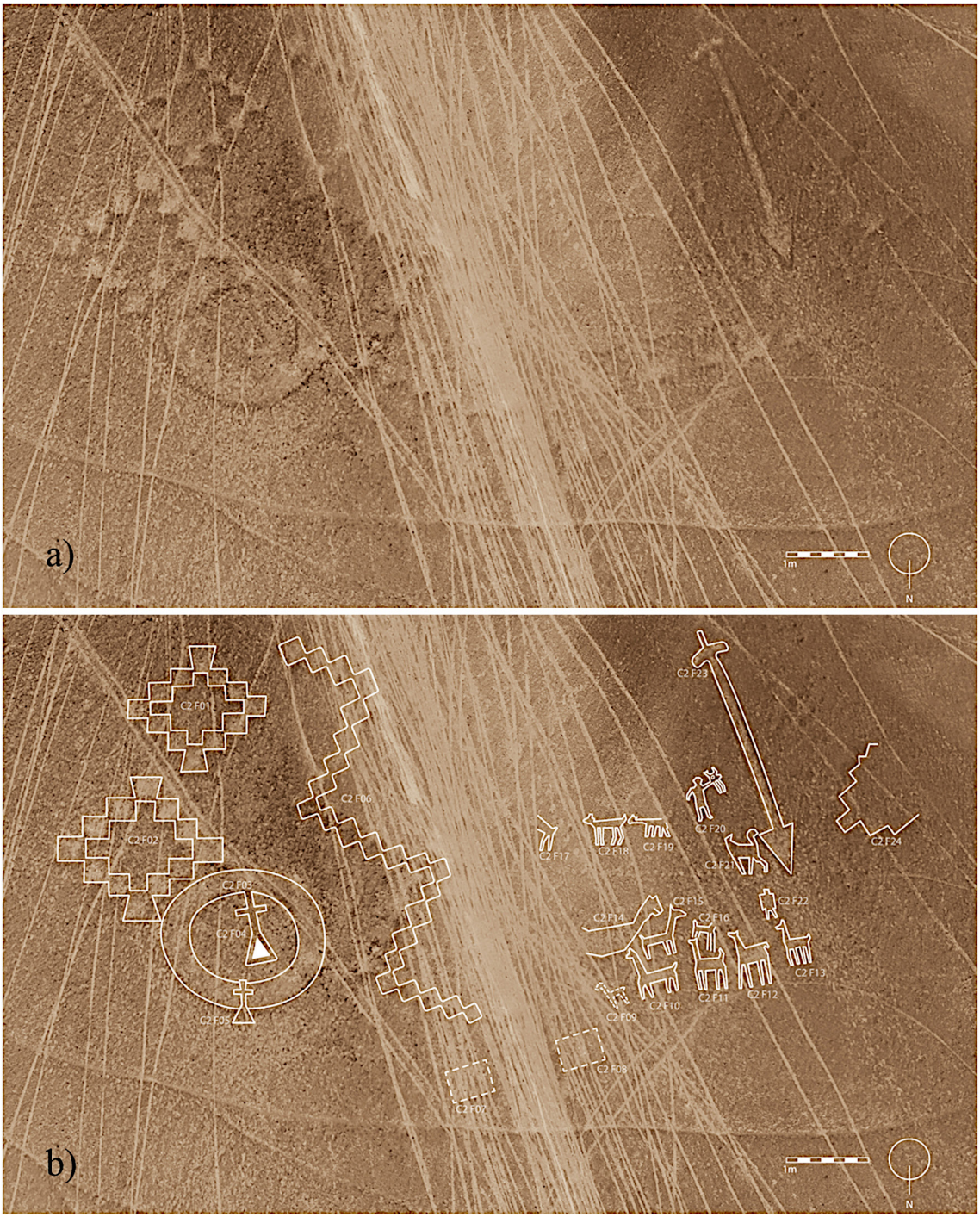

Figure 6. *Detail of the central panel (P2): a) photogrammetric image; b) superimposed line drawing.*

community of Caleta Caramucho.

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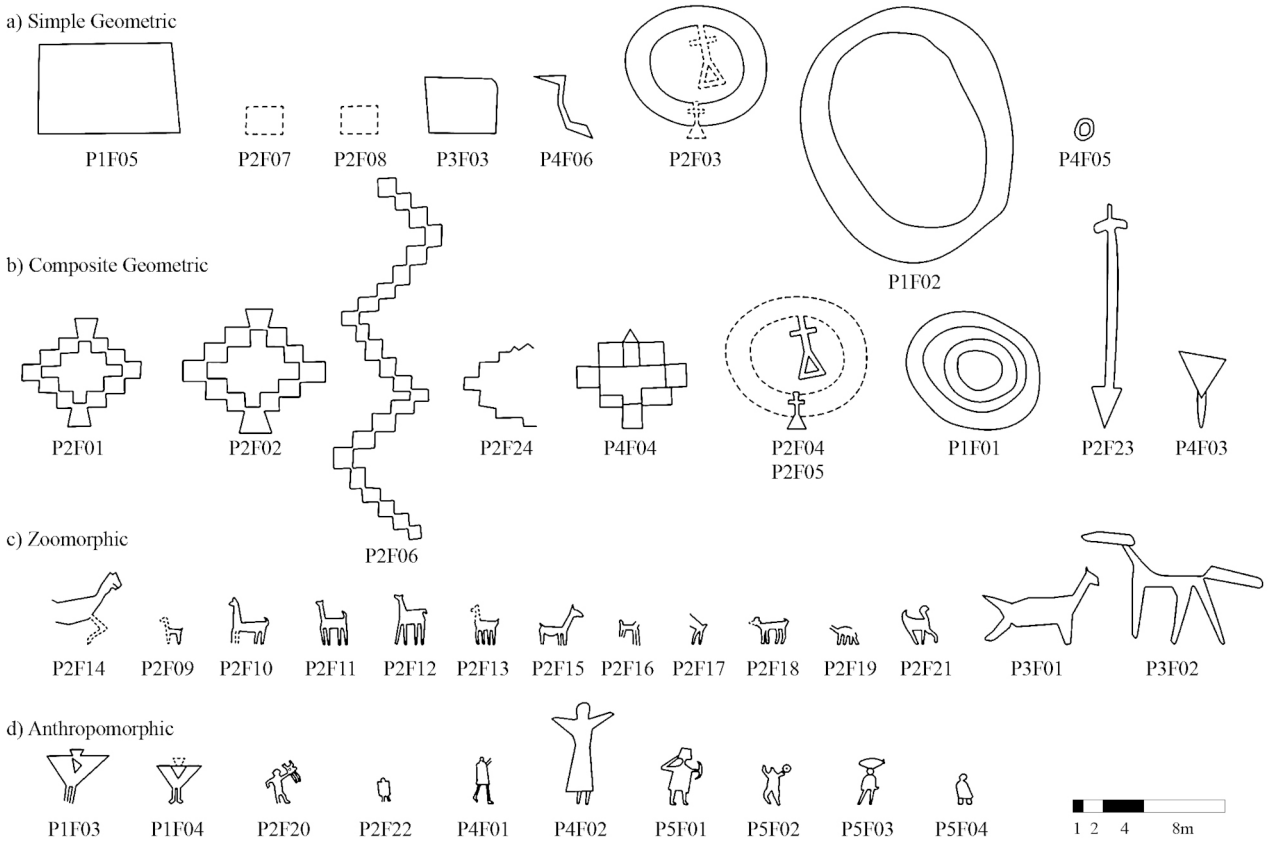

Figure 7. *Line drawings of motifs grouped by category.*

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RAR REVIEW

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ASSESSING WEATHERING DAMAGE TO HELANKOU ROCK ART BY INTEGRATING MORPHOLOGICAL AND IN-SITU PERFORMANCE DATA

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Assessing weathering damage to rock art requires a holistic understanding of physical degradation mechanisms and their environmental drivers. Static morphological assessments focus on visible symptoms of damage, whereas dynamic performance-based assessments examine intrinsic properties. However, these assessments remain disconnected. Moreover, traditional survey methods reflect the extent of weathering effects but fail to evaluate stability effectively. Therefore, this study used an integrated approach combining morphological observations and in situ non-destructive performance data to evaluate the deterioration of Helankou rock art. Leeb hardness testing, thermal imaging, moisture measurements and ultrasonic wave velocity analyses were conducted. Correlation analyses were used to examine the relationship between the structural deterioration and internal rock quality. In addition, a dynamic deterioration model was developed for the temporal evolution of weathering. Furthermore, multiple-criteria decision-making methods were used to quantify the relative importance of weathering criteria. The results revealed significant mechanical weakening in areas subject to splitting and blistering associated with internal voids and fissures. Thermal and hydrological anomalies associated with these defects accelerated weathering through increased thermomechanical stress and moisture retention. The rock quality index was validated as an effective metric for quantifying deterioration extent. The results identified the progressive evolution from latent fissures to active splitting and irreversible delamination. Splitting was the most critical hazard, which could guide future conservation prioritisation. This study highlights the importance of continuous environmental monitoring and advanced diagnostic techniques for supporting sustainable rock art preservation. Moreover, this integrated methodology provides a transferable framework for assessing and managing rock art deterioration.

EXPLORING THE CULTURAL HUB SIGNIFICANCE OF THE TANGBALETASI CAVE PAINTINGS FROM ICONOGRAPHIC AND GIS PERSPECTIVES

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Rock art, as a vital legacy of early human spiritual culture, holds distinctive value in archaeological and religious studies. The Altay region of Xinjiang, China, preserves a rich corpus of rock art with diverse forms, among which anthropomorphs are particularly prominent. This paper focuses on the Tangbaletasi cave paintings and employs an integrated approach combining iconographic interpretation with GIS-based spatial analysis. Iconographic analysis reveals the shamanistic features embodied in these anthropomorphs and systematically demonstrates the site's central role in regional shamanistic interactions. The GIS analysis further underscores the significance of the southern foothills of the Altai Mountains in the early religious and cultural networks of Eurasia. The findings not only provide new empirical evidence for understanding the spatial distribution and regional dynamics of

shamanistic culture in this area but also contribute methodological insights into exploring early religious interactions and cultural exchanges across Eurasia.

SPATIAL PATTERNS OF CLIFF ROCK ART IN GUANGXI'S ZUOJIANG RIVER BASIN: A GIS APPROACH

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From the perspective of landscape archaeology, the study of rock art extends beyond the symbolic interpretation of imagery to consider the broader environmental context shaped through interactions between ancient communities and their surroundings. This research focuses on the cliff rock art of the Zuojiang River Basin in Guangxi, examining how spatial distribution patterns reflect the dynamic relationship between people and landscape. Employing ArcGIS and archaeological survey reports, a comprehensive GIS-based database of identified rock art sites is established. The analysis investigates key spatial variables—geomorphology, elevation, hydrology, viewsheds, cliff face orientation, and proximity to other archaeological sites—to understand their influence on the placement and significance of rock art. By quantitatively analysing the spatial patterns of these sites, the study underscores the strong interrelationship between rock art and its environmental setting. The findings contribute not only to a deeper understanding of cultural landscape formation in the region but also offer valuable guidance for the conservation and sustainable management of cliff rock art in the Zuojiang River Basin.

A STUDY ON THE STAGES, AGES AND MEANING OF SEXUAL SACRIFICE OF THE KANGJIA SHIMENZI PETROGLYPHS

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Kangjia Shimenzi petroglyphs in Hutubi County have attracted much attention from the academic community since their discovery, and their stages, ages, authors and content have always been a hot topic of discussion among scholars. By teasing out the relevant literature, conducting field surveys, and comparing similar remains of the same age, such as the Xiaohe cemetery and the Gumugou cemetery in Kong Que River, this article redefines the stages of Kangjia Shimenzi petroglyph. It is believed that the petroglyph has outstanding commonalities with the series of symbolic elements of the Xiaohe cemetery. The first Kangjia Shimenzi petroglyphs are no later than the end of the 3rd millennium BCE, or even earlier, the latest age is about the mid of the 2000 BCE, or even later. The authors of the petroglyphs are proposed to be people of the Xiaohe culture. The content of the petroglyph shows that the ancestors of Xiaohe chose the deep mountain valley in the Danxia Mountain in Kangjia Shimenzi as a sacred place, to carry out a ceremony and show the image expression of reproduction worship with the help of natural landscapes with sexual divine power.

HISTORICAL LEGENDS AND CULTURAL HERITAGES: ON INTERPRETATION OF DONGYI CULTURE ON JIANGJUNYA ROCK ART

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There are abundant rock art cultural heritages in China. Due to a lack of dynamic inheritance and accurate archaeological stratigraphy data, as for most rock art heritages represented by Jiangjunya, the interpretation of rock art images and the exhaustive root investigation of relics' connotation are affected. Multiple arguments are enriched by giving full play to materials like historical legends. There are cultural customs, such as early agricultural civilisation, Stone Altar (Shi She), sun and bird worship, in the Dongyi cultural area where Jiangjunya is located, which have become critical evidence for interpreting Jiangjunya rock art. The applicability of interpreting rock art heritages by historical legends is also explored through research.

PRELIMINARY EXPLORATION OF ROCK ART IN DONGSHAN, LINGWU, NINGXIA, CHINA

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The Dongshan rock art in Lingwu, Ningxia, discovered in the late 1990s, is numerous and relatively diverse in type. It can be said that this discovery fills a geographical distribution gap of rock art in Ningxia and plays a significant role in revealing the complex trajectories of regional cultural interaction and civilisational exchange. However, due to its relatively recent discovery and the scholarly literature remaining scarce, there is limited public awareness of it. Based on this, this paper will provide a brief introduction to the Lingwu rock art, covering its discovery, geographical location, depicted content and manufacturing techniques. It will also preliminarily discuss its chronology, artistic style and cultural affiliation, aiming to draw academic attention and thereby stimulate further in-depth research into this regional rock art tradition.

岩石上的秘密：墩德布拉克岩画遗址的分析与讨论

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中国新疆维吾尔自治区阿勒泰地区拥有丰富的岩画资源，其中墩德布拉克岩画群对研究该地区古代文化发展的具有重要意义。本研究采用高光谱技术对墩德布拉克 号岩画点进行数据采集与分析，通过信号分解、颜料分类、聚类及光谱曲线分析等方法，深入挖掘岩画高光谱数据中的信息。此外，还运用交叉验证法揭示岩画中隐藏的信息。为理解这些隐藏信息，研究团队通过文献检索、图像分析等手段进行了更为深入的历史溯源，揭示了 号岩画点与切木尔切克文化之间的内在联系，为阿尔泰地区青铜时代文化的研究提供了新的材料。

欧洲极北地区的石器时代岩画及其学术史

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本文简要梳理了欧洲极北地区一个世纪以来的岩画研究历程。在过去，研究者们能够通晓广袤地域内的物质文化，而在考古资料极大丰富的今天，这几乎已无法实现。本次研究首先介绍了当前岩画文献记录和综述的现状，接着探讨了芬诺斯堪的亚（注：芬诺斯堪的亚，指科拉半岛、斯堪的纳维亚半岛、卡累利阿及芬兰地区的地质及地理名词）岩画的断代问题，然后深入分析了岩画上所呈现的“船只”意象以及岩画的岩石画布，最终引发人们对时空维度的更广泛的思考。本次对芬诺斯堪的亚岩画学术史的梳理不仅系统地回顾了前人的探索历程，更为跨越国界的岩画研究奠定了坚实的基础。通过重访早年记录的岩画遗址，并运用全新视角与现代化的记录技术，我们或许能够从岩画中挖掘出更多跨越时空的信息。本文主张应重新将重点放在岩画出版物（尤以数字化为优）上，以此构建跨越行政边界与国界的综合性研究视域。

ORIENTATION

Review: 'Towards a scientific paradigm: multidisciplinary rock art research in China' and the development of the rock art discipline in China

FENG YIFEI and SHU XIHONG

Abstract. Rock art, of ancient cultural symbols transcending boundaries of time, language and ethnicity, carries the spiritual expressions and cognitive modes of pre-Historic humanity. In recent years, with the advancement of digital technology, dating techniques and international collaboration, rock art research has increasingly moved towards greater 'scientific rigour, systematisation and internationalisation'. Tang's *RAR* paper represents a crucial scholarly contribution to the ongoing transformation of Chinese rock art research towards a more scientific and systematic approach. The paper not only reviews the historical development and current state of the field in China but also offers a critical examination of the coexistence of two major research paradigms—humanistic and scientific. It presents recent progress in methodological innovation, interdisciplinary integration and global cooperation. This article comments on Tang's work and looks forward to the future development of Chinese rock art studies. It offers its own relevant insights in response to the current problems faced by the development of the Chinese rock art discipline, hoping to contribute to the further development of Chinese rock art studies.

I. The global wave of scientific transformation in rock art research

Since the 1990s, under the leadership of Robert G. Bednarik, President of the International Federation of Rock Art Organisations (IFRAO), global rock art research has undergone a profound scientific revolution. The core aim of this movement is to construct rock art studies as a rigorous scientific discipline. Key steps in this transformation have included the development of international research standards and ethical codes, the unification of terminological systems, and, most importantly, the establishment of a scientific methodology. Tang Longhao (2025) points out that Chinese rock art research has evolved from the 'discovery–record–description' stage toward a phase characterised by 'analysis–interpretation–systematic study'. Although early empirical efforts focused mainly on local surveys and case documentation and helped accumulate a body of rock art data, they remained methodologically and theoretically underdeveloped. Since the 1980s, with the involvement of archaeology, ethnology and anthropology, the field has shifted towards background analysis and the interpretation of meaning. This paradigmatic shift has enabled more precise identification of the dating, techniques and weathering processes of rock art and has spurred the application of advanced techniques such as nanolayer analysis, micro-stratigraphy and micro-erosion dating. As Bednarik emphasised, the distinction between natural markings and anthropogenic symbols is a prerequisite for any meaningful discussion of rock art.

Influenced by this global trend, Chinese rock art research has also begun to embrace scientific methods in the 21st century. However, much like many other regions of the world, earlier Chinese studies were predominantly guided by empiricism or humanistic approaches and lacked a formal disciplinary system, universal methodologies, standardised terminology and integration with the international scientific community—despite decades of practical work. Traditional studies often focused on interpreting the imagery of rock art by associating it with known objects, relying heavily on subjective analogies. While still influential today, Tang stresses that such interpretations, though valuable for reflecting the researcher's self-awareness of the images, are fundamentally unfalsifiable and therefore not genuinely scientific. At present, Chinese rock art research exists within a dual-paradigm landscape (Tang L. 2025).

Based on the developmental history of rock art studies, there are three stages: art (grand narrative), humanities (positivism) and science (verification) (Bednarik 2007: 1–7). The study of Chinese rock art is currently in a critical period of transition from the 'observation-explanation-analogy' stage of the humanities to the 'identification-measurement-modelling' stage of science. This transformation is not only reflected in the renewal of research techniques and analytical tools, but also in the deep adjustment of research paradigms. In the current research landscape, humanistic-oriented research methods still dominate in revealing social significance, interpreting cultural symbols and restoring historical contexts, providing in-depth interpretations of the cultural context and spiritual connotations of rock art. However, with the continuous introduction of multi-disciplinary methods such as archaeology, digital technology and

environmental geography, the scientific characteristics of 'quantifiability', 'verifiability' and 'reproducibility' in rock art research are gradually strengthening. This scientific trend is not only reflected in technical aspects such as the detection of pigment components, the determination of engraving ages and the modelling of geographical spaces but also promotes rock art research to place greater emphasis on empirical foundations, data support and model construction, thereby enhancing its importance in the knowledge system.

II. The Chinese experience in rock art research

Over more than half a century of research, Chinese rock art research has yielded numerous notable accomplishments, evidenced by a substantial body of published scholarly works. In his article, Tang Longhao gives special attention to the academic symposium titled 'Chinese Paradigms of Rock Art Research in Multidisciplinary Contexts', held in April 2024 in Shijiazhuang, Hebei Province. Organised by Hebei Normal University, the event brought together over sixty scholars from domestic and international universities, research institutes and international rock art organisations. The symposium represents a symbolic moment in the institutional and organisational support emerging for rock art studies in China, reflecting a growing scholarly consensus on the need to pursue a more scientific orientation in this field.

The proceedings of the symposium were categorised into three major thematic areas: theories and methodologies of rock art research; new applications of science and technology in rock art studies; and humanistic interpretations of rock art. In the first section, scholars such as Bednarik and Giriraj Kumar emphasised the necessity of incorporating methodologies from geology, geomorphology and tribology to enhance the repeatability and verifiability of rock art studies. Chinese scholars, including Li Yongxian, Gao Xing and Xu Feng, drew from local research experiences to propose concrete steps such as improving data standards, strengthening interdisciplinary cooperation and systematising fieldwork practices. It can be said that while preserving traditional domestic research practices, Chinese scholars are also actively aligning their work with international scientific discourse.

Tang does not portray science and the humanities as mutually exclusive; rather, he highlights their practical coexistence in contemporary Chinese rock art research. In the second thematic section of the symposium, four experts demonstrated the concrete applications of natural scientific methods in rock art dating, documentation, and conservation. These studies emphasised the principle of falsifiability—a core tenet of the scientific method—arguing that scholarly claims must be subject to empirical testing and potential refutation. While the third section, focusing on humanistic approaches, may lack falsifiability, it nonetheless holds irreplaceable value in interpreting cultural meaning, symbolic structures and sociocultural transmission. As the article notes, ten experts in the humanities session presented research on topics such as typology of rock art imagery, cross-regional cultural comparisons, connections to mythology and folklore, and correlations with archaeological cultural systems. Although such studies do not produce rigorous data on dating or technical processes, they provide crucial insights into issues of ethnic identity, religious belief and collective memory embedded in rock art. This dual approach—melding scientific verifiability with humanistic depth—illustrates the multidimensional character of rock art as both material evidence and symbolic text.

III. Key challenges in constructing a scientific paradigm for Chinese rock art research

The symposium yielded substantial outcomes, highlighting both the increasing trend toward multidisciplinary participation in Chinese rock art research and the growing consensus around a scientific turn. Tang Longhao's summary report also profoundly revealed the multiple challenges currently faced. There are currently the following problems in the research of rock art in China:

1. Lag in distinguishing natural markings from anthropogenic engravings; weak understanding of ancient rock art production techniques. Bednarik's 'first principle' of scientific rock art research—the clear distinction between naturally occurring marks and artificially created imagery—remains underdeveloped in China. This foundational issue is critical, as it underpins all subsequent investigations such as dating, technical analysis and interpretive studies. Without rigorous identification criteria and methodological training, researchers misinterpret natural phenomena as the artistic behaviour of the ancients. Moreover, progress in the detailed study of production techniques has been slow, mainly due to a lack of investment in experimental archaeology. Insufficient understanding of the technologies used to create rock art compromises documentation precision (as Bednarik warned regarding terminological inconsistency) and obstructs inquiries into creative processes, labour divisions and cognitive capabilities.

2. Scientific dating techniques still need breakthroughs and popularisation. Nevertheless, techniques such as uranium-series dating and microerosion analysis have made advances. For example, Bednarik has collaborated with Chinese scholars to carry out further large-scale microerosion dating work in Henan Province, Lianyungang, Ningxia and other places (Tang et al. 2017). A breakthrough in reliable and standardised dating methods has yet to be achieved. Issues persist with the accuracy of uranium-series applications for the Palaeolithic era, along with the general applicability, cost and standardisation of such techniques.

3. Excessive reliance on unfalsifiable humanistic

explanations, and few research results using new technologies and methods. While vibrant and valuable, humanistic research in China often operates in domains that resist empirical validation. At the symposium, many presentations—centred on symbolic interpretations, ethnic affiliations or mental worlds—were, as Tang observed, essentially unfalsifiable. For example, the judgment that certain pigment residues on the rock surface 'resemble' something cannot be objectively refuted outside the mind of the person who made it. Style comparisons are also often unreliable because researchers may not be able to grasp the true style parameters of ancient rock paintings accurately. There's a scarcity of research outcomes utilising new technologies and methods. For instance, international scholars often employ extensive mathematical and statistical analyses, which are less evident in the works of Chinese scholars (Xiao and Che 2024). Additionally, there's a discrepancy in archaeological methodologies between domestic and foreign scholars. While Chinese scholars focus more on typological analysis, foreign scholars have begun integrating rock art into the dynamic evolution of archaeological cultures (Ponomareva 2021).

4. Inadequate mechanisms for deep interdisciplinary collaboration; unclear disciplinary positioning and marginalisation. Although Bednarik and Kumar have long advocated for deeply integrated multidisciplinary cooperation, such integration remains weak in the Chinese context. As Li Yongxian noted, rock art research lacks strong connections with related fields such as history, archaeology and ethnology. While the symposium promoted interdisciplinary interaction, genuine dialogue across disciplines was limited. Most presentations remained within their own disciplinary frameworks, with few attempts at deep cross-boundary integration. Furthermore, rock art has not yet developed into a standalone discipline in China. Researchers typically operate under the umbrella of other academic fields, often without access to dedicated resources or institutional support. Consequently, there is no clear academic trajectory for scholars specialising in rock art, which hinders the long-term development of expertise (Shu and Xia 2022).

IV. Advancing the construction of a scientific paradigm for Chinese rock art research

In the conclusion of his article, Tang Longhao envisions an ambitious future for rock art research in China: to employ scientific methodologies in exploring how human conceptions of 'reality' are formed (Bednarik 2021). This perspective is particularly thought-provoking. Rock art, beyond being a visual remnant of pre-Historic societies, also serves as a medium for understanding how early humans constructed their cognitive and conceptual frameworks. Tang argues that a truly scientific rock art discipline should ultimately aim to uncover how humans developed their sense of reality under specific environmental, technological and ideological conditions—rather than relying on mythical or symbolic narratives (Tang L. 2025). To achieve this, future Chinese rock art research must focus on the following priorities:

1. Give priority to developing basic identification capabilities and follow the principles of rock art research. In the book *Rock art science* (available in Chinese; Bednarik 2020), Bednarik proposed a set of rock art research principles, which standardised all aspects of rock art research and had an important impact on rock art research around the world (Bednarik 2007). Bednarik recommended that distinguishing natural markings from artificial images, which had led to countless misidentifications, should be at the core of all rock art research work. The wide promotion and application of scientific methods to identify these differences are essential. Rock art research in China must establish its own rigorous standards and operating protocols to ensure that all subsequent research rests on a credible and consistent foundation.

2. Strengthen the application and innovation of scientific and technological methods. Sustained investment is needed to optimise dating technologies and explore cross-validation approaches that combine multiple methods. Advanced documentation technologies—such as multi-angle 3D reconstruction, multispectral imaging and laser scanning—should be more broadly applied. Artificial intelligence (AI) techniques, particularly in image classification, can assist in recognising patterns in rock art and generate new 'data-driven' insights for interpretation.

3. Shift the research emphasis from unfalsifiable symbolic interpretations toward verifiable scientific analysis. The future of Chinese rock art research lies in areas that allow for empirical testing—such as scientific identification, documentation, dating, conservation and technical analysis. As Bednarik asserted, 'We can only credibly interpret some aspects of rock art when we have assembled exhaustive rock art science'. Interpretations should be grounded in solid empirical evidence, and their scope of verification must be clearly defined.

4. Establish and rigorously implement national and international standards for field surveys, data recording and data sharing. China should build a national-level rock art database that includes geographical information, high-resolution images, 3D models, dating results, environmental data and conservation records. This open-access platform would enhance transparency, allow scholarly validation and promote collaborative research across institutions.

V. Challenges facing the disciplinary formation of rock art studies in China

The ultimate goal of constructing a scientific paradigm for Chinese rock art research is to establish it as an independent academic discipline. Gai Shanlin

defines the term 'rock art studies' as follows: 'Rock art refers to the paintings or engravings made by ancient people on rocks. These beautiful artistic images play a significant role in the study of the progress of human civilisation and are highly valued worldwide' (Gai 1998). However, as Tang notes, the core conceptual domain and methodological boundaries of rock art studies in China have yet to be clearly defined. A rigorous theoretical framework is urgently needed to answer the fundamental question: What constitutes the discipline of rock art studies? Without such a definition, any effort to institutionalise the field risks lacking cohesion and sustainability. Although China already possesses technical capacities for dating, scanning and material analysis, these natural science tools are often applied in isolation. There is a lack of integration with cultural analysis and iconographic research. After dating rock paintings, scientists often fail to communicate with humanists. As a result, their research usually only yields a rough age, without further exploring the cultural contexts of image style, production background or historical setting. This division between the scientific and humanistic spheres prevents the accumulation of disciplinary knowledge. A scientifically and precisely defined disciplinary connotation often can effectively highlight the core characteristics of a discipline and its uniqueness compared with other disciplines (Tong and Zhou 2024). The modernisation of Chinese rock art studies should not be understood as the simple replacement of the humanities by science. Rather, it requires an interaction, reconciliation and reintegration of diverse methodological frameworks. In this process, the explanatory power of traditional humanities and the precision of modern science must form a complementary structure. Chinese rock art research must transcend the mere reconstruction of historical narratives and instead focus on the deeper epistemological significance of rock art as material evidence of human cognitive evolution, symbolic system development and processes of reality construction. This requires researchers to adopt the grand scientific vision advocated by Bednarik, moving beyond the confines of archaeology or art history alone.

In China's academic landscape, rock art studies are not part of the mainstream; they represent a highly marginalised field. Archaeologists often dismiss rock art for lacking stratigraphic context and therefore 'empirical' value, while art historians exclude it due to the absence of known authorship or canonical lineage (Xiao and Che 2024). Archaeologists, who have always regarded themselves as the mainstream of academia, even look down upon rock art research as an offshoot and an improper approach (Tang H. 2014). This ambiguous disciplinary identity forces rock art researchers to work within unrelated academic structures, leaving them with minimal resources and support. Consequently, rock art research results are rarely published in high-impact journals, and young scholars in the field face significant barriers to academic advancement. Many undergraduate and graduate students who choose rock art as a research topic are frequently blocked during thesis defences due to the topic's perceived marginality. As a result, many talented young scholars are forced to abandon the field, leading to a severe talent gap—one of the most critical threats to the development of rock art studies in China. These issues can only be addressed through top-down institutional planning at the national level. For example, establishing national research platforms or key laboratories, such as a 'National Rock Art Science Centre' would centralise resources and coordination. Governance must also be strengthened across universities, research institutes and heritage protection agencies. Moreover, educational systems should encourage and guide more interdisciplinary young talent to enter the field, creating viable academic career paths and ensuring the long-term sustainability of the discipline. Chinese rock art researchers must have the same level of confidence as researchers in other disciplines, recognise rock art studies on par with other fields and unite to make their voices heard. Only in this way can the discipline of Chinese rock art find its own place.

VI. Conclusion

Tang Longhao's paper provides both theoretical grounding and practical direction for the scientific transformation of Chinese rock art research. Not only does the article meticulously review current developments, but through a symposium-based structure, it also organically integrates multiple disciplines, research paradigms and methodological approaches. This reflects the author's deep capacity for academic organisation and methodological reflection. In the broader context of the modernisation of China's humanities, the challenges and opportunities faced by rock art studies vividly embody the epistemological restructuring of contemporary knowledge systems.

As a cultural form situated between art and material heritage, rock art inherently demands an interdisciplinary research framework. In this emerging paradigmatic structure, it is essential to preserve the humanistic depth of meaning-based interpretations while also reinforcing scientific tools that address authenticity, chronology and environmental adaptation. The current methodological plurality in Chinese rock art research is an inevitable feature of this transitional phase. The divergences and convergences between different schools of thought are not only signs of theoretical development but also serve as dynamic engines driving disciplinary growth. Only by recognising and respecting the value of each research approach can rock art studies evolve into a truly integrated and systematic field. In doing so, China's rich rock art resources can finally move beyond being mere objects of visual association ('what does it resemble?') and become vital scientific evi-

dence for understanding the evolution of the human mind. This would enable China to make a distinctive and substantial contribution to the global landscape of rock art science.

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RAR 43-1492

The black pigment phase – A clarification

RAONI VALLE and ROY QUEREJAZU LEWIS

Introduction

In 2024, we had an article published in *Rock Art Research* (*RAR* 41-2), the peer-reviewed journal of the Australian Rock Art Research Association (AURA) and the International Federation of Rock Art Organisations (IFRAO), entitled 'Rethinking the Nordeste Tradition in Bolivia – The Dry Diagonal Hypothesis', revisiting the problem of continental-scale diasporas of rock art styles in South America. It partially stemmed from our preliminary research results with some rock art sites in the Chiquitanía region, SE Bolivia, documented in 2022 by both authors. Among the sampled sites, one of the most intriguing was Juan Miserendino Cave, due to its rock art and seemingly long history as a persistent and meaningful place (Schlanger 1992; Zedeño and Bowser 2009), re-signified and reused from plausibly the Early Holocene (Drakic 2022) up to contemporary times by Indigenous and non-Indigenous people.

In this site, Raoni Valle stayed for 1 hour and 45 minutes in February 2022, taking photographs, notes and GPS points. Based on the analysis of the recorded materials and observations in situ, it was possible to identify different paint layers in the panels of Juan Miserendino Cave, allowing for a preliminary and coarse understanding concerning the diachronic nature of that rock art. It includes graffiti as the last painting phase, on top of at least four other layers of pre-colonial and maybe colonial Indigenous pictograms. Whereas Roy Querejazu started investigating the possibility of a Nordeste Tradition (NET)[1] influence in Bolivian rock art, since the late 1980s, first in the Santa Cruz Valleys and continuing in the Chiquitanía region since 2012, when he documented the Juan Miserendino Cave. He is currently undertaking complementary ethnographic research related to Juan Miserendino, a historical individual who lived in the cave in the early 20th century. A plausible scenario is that this particular cave dweller might have engaged with the pre-colonial Indigenous paintings in varied ways, some of which may have left material evidence.

The site features significant contemporary graffiti expressions, showcasing names and dates from various moments created with different materials, many

1 Nordeste Tradition (Northeast Tradition [NET]) of rock paintings is an archaeological construct associated with a hunter-gatherer horizon, painted in rockshelters from the Early to Middle Holocene, maybe earlier, in northeastern and central Brazil, and elsewhere (e.g. Querejazu Lewis and Valle 2024).

of which are black in colour, apparently charcoal, but not limited to this, as multiple colours and textures also appear. Made perhaps since the late 19th century to recent periods, they seem to be crafted by non-Indigenous people, mostly, who often came into the cave and marked it according to their specific referential contexts. However, a group of densely superimposed anthropomorphs, highlighted by a brownish yellow (Munsell Chart 10YR 6/8) anthropomorphous motif and other figures, stands out among the diversity of marking types in the site, because though resembling the canonical style of NET anthropomorphism, it intriguingly superimposes black markings very similar to Western alpha-numerical characters that, although not deciphered (further than a possible, though non-consensual number 3), raised a concern regarding the authenticity and creation context of the paintings on top of the black pigment phase. For the sake of concision, we will call it 'Panel X' (x as the letter, not the Roman numeral 10).

Therefore, this clarification statement aims to address the authenticity issue of Panel X, which was not mentioned in our published work that partially relied upon evidence from that site. Some crucial aspects contributed to that omission, for instance, it fell quite outside of our article's purpose and research objectives, or the fact that pertinent archaeometric evidence, whether to back up or refute such a claim, was missing. Moreover, following editorial advice, we agreed that addressing such a complex issue in the caption of an image was just not the best approach. Facing an expand-or-omit type of dilemma, coupled with space restrictions, we opted to remove it. Hence, it is our opinion that the authenticity issue regarding Panel X is an unsolved problem in the rock art of that site. It remains a plausible speculative question, though, so far lacking published, undisputed archaeometric proof and, thus, deserving further scrutiny.

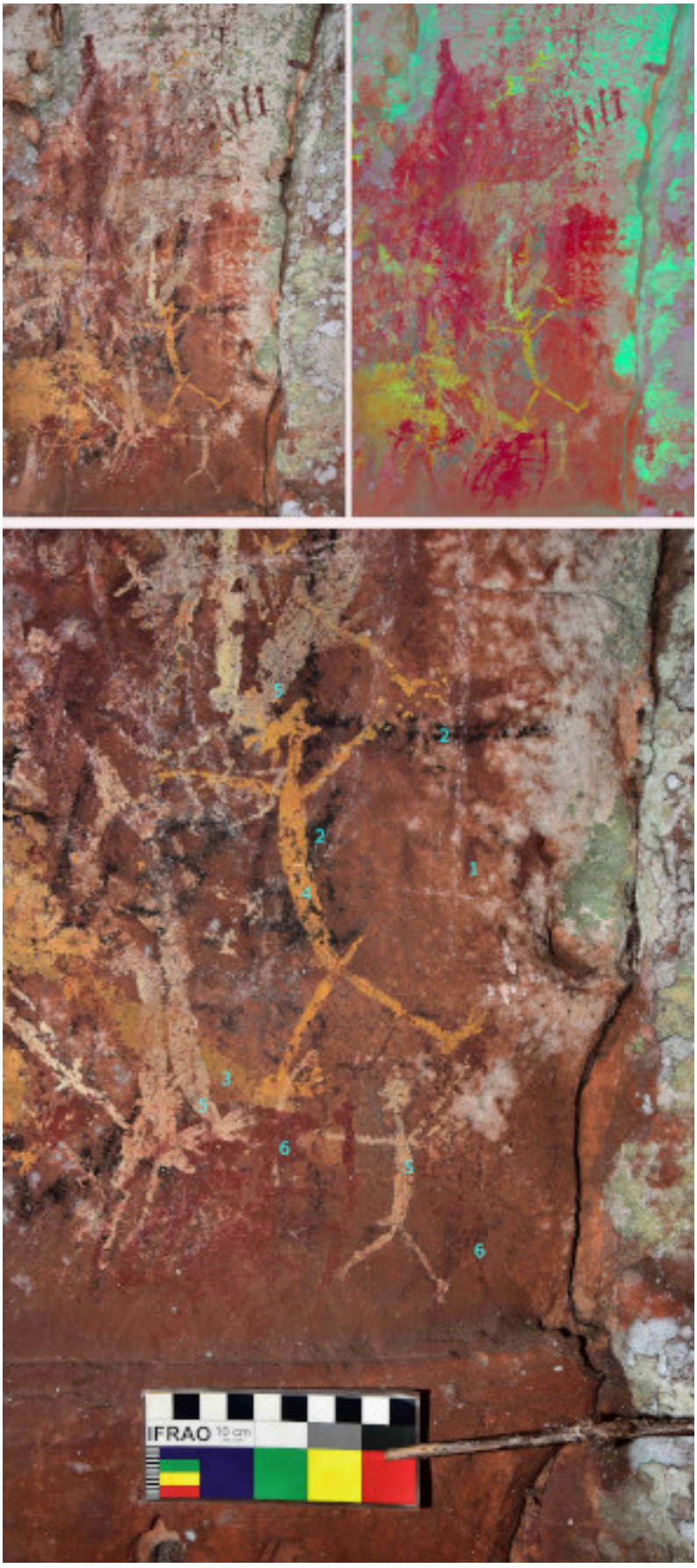

Figure 1. *The original image setting for Figure 15 as presented in the corrected manuscript version, before the final editorial adjustments to fit in the* RAR *template (RV, 2022–2023).*

Posing the problem from our perspective

In our 2024 *RAR* article, Figure 15, on page 131, shows a section of Panel X, and in its caption, one can read the following:

> Figure 15. Cueva Juan Miserendino, from left, white light photo and DStretch (LRE), both by RV, 2022–

2024. On the right, the hypothetical chronological sequence of a minimum of six painting phases.

However, in the earlier draft version submitted to the *RAR* peer-review process on July 05, 2023, the caption of Figure 15 (in that version, Figure 13) had a piece of significantly different information:

> Figure 13. The most densely painted area inside Cueva Juan Miserendino shows evidence of at least six pictorial chronological phases, denouncing its complex diachrony. The black pigment is one of the earliest phases, but intriguingly resembles contemporary writing. (Photo: R. Valle, 2022).'

In the corrected draft version presented later, the caption of Figure 15 (see Fig. 1 here) was significantly expanded to better approach what previously was mentioned as 'The black pigment is one of the earliest phases but intriguingly resembles contemporary writing'. Accordingly, in the corrected draft version sent to the editor on February 07, 2024, one can read the following:

> Figure 15. One of the most densely painted sections of Cueva Juan Miserendino (on top, under white lightening and after d-stretch LRE filter), containing a hypothetical chronological sequence (green numbers in the bottom image) of a minimum of 6 pictorial phases, the last three are anthropomorphic. However, likely datable charcoal drawings in the second phase are intriguingly similar to numerical Western characters. If archaeometrically confirmed, this will probably constitute a colonial to contemporary reuse of the site by Indigenous painters, otherwise a sophisticated fraud, with an emulation of ancient anthropomorphic patterns carefully superimposed upon each other, on the graffiti, and over the original rock paintings. The site has abundant examples of contemporary and even XIX-century graffiti superimposing pre-colonial Indigenous paintings. So far, however, attempts to disambiguate the black drawings of the second phase in this section proved inconclusive. Multispectral photography may help clarify this issue (photos and d-stretch: RV, 2022–2024).

During the final steps of the editorial process, however, to prepare the corrected manuscript to fit under the *RAR* template and organise the page layout to accommodate the amount of visual information we intended to present, some image captions had to undergo considerable size reduction to find space, where we could fit the intended number of images. Therefore, Figure 15's caption was considerably reduced to reach its actual size and format in the published article. As a result, all the information regarding the issue of the black pigment phase and the superimposed layers of anthropomorphic figures under the scope of its probable recent and Western origin was deemed speculative at that point, without undisputed evidence other than regular digital photography + DStretch (Harman 2009). Thus, we ended up considering it inappropriate to treat such a complex matter in the caption of a figure in a hasty way, obviously deserving a more attentive and careful treatment in a focused paper. Moreover, as that detail did not affect our research results in any possible aspect, we agreed to remove that speculative content. Even though we kept the images as a faithful record of the site's graphic complexity, irrespective of the age and cultural provenance of the markings.

A further contribution to this debate

In a recent article published in the Boletín of the Sociedad de Investigación del Arte Rupestre de Bolivia (*Boletín SIARB* 38, July 2024), almost simultaneously to our *RAR* article, that same issue has resurfaced under a finer, microscopic grain. In the report section of that document, pages 30–43, an article entitled 'Limpieza de grafitis en la Cueva Juan Miserendino, Santiago de Chiquitos, Santa Cruz, Bolivia' ('Cleaning of graffiti in Juan Miserendino Cave, Santiago de Chiquitos, Santa Cruz, Bolivia'), authored by the researchers Freddy Taboada and Roberto Moreno, brought further light into that particular matter, improving our understanding and confirming our initial suspicion. Yet, crucial evidence to solve that problem undisputedly is still missing. That is, archaeometrically probing with XRF and Raman spectrometers the respective pigments, followed by proper disambiguation of the 'writing' content of the black graffiti. In any case, they brought helpful information regarding this issue with their article.

The first indication they offer, which we thought illuminated our initial suspicion, appeared when they describe the pigment types in the site, on page 34. Considering that a previous analysis made by Calla (2007) supposedly misidentified pink and yellowish-brown colours as belonging to the original rock painting colour palette, they commented: '(…) and the yellowish-brown is posterior, *placed on top of graffiti*' (translation and emphasis ours). That punctual information caught our attention because it seemed to be partially describing the Panel X sequence, matching our proposed chronological sequencing at the same spot, suggesting that the graffiti underneath the yellowish paint was actually what we had identified as the black pigment phase. However, the attributes of the graffiti beneath the yellow paint are not presented in their account. Therefore, the correspondence between that and the black pigment, as the first layer/moment/phase of presumably contemporary interventions over the original paintings, was established by us, based on coherence and consistency with what we have found there.

Subsequently, in Figure 6 B, page 36, when they state in the caption: *grafitis amarillos, pintura sintética* (yellow graffiti, synthetic painting [translation ours]). In this case, they refer to the superimposed anthropomorphous figures as graffiti as well, so both the yellowish and some of the underlying pigment were considered graffiti. Further on in their work, they mention on page 41 the category of 'unprocessed graffiti' (*graffitis no procesados*) where they refer again to those same paintings, defining the following: 'Yel-

low coloured graffiti: zoomorphic, phytomorphic and anthropomorphous figures very similar to the original rock art images of the site' (translation ours). In the following field on the same page/table, the authors clarify that they did not clean those due to the complex disposition of the graffiti on top of the original rock art, which demands further study and precision in operational procedures to avoid damaging the underlying paintings. At this point, it is convenient to state a commonsensical understanding of graffiti in the context of pre-colonial Indigenous rock art, that is, recent Western markings in origin, detached from an ethnographic or archaeological character, bearing a more mundane sense of intrusion and defacement of Indigenous cultural heritage; in other words, an act of vandalism, some may say.

Although partially agreeing with some of the conclusions of that study, we noticed that crucial archaeometric probing of the physicochemical properties of the respective painting phases is missing in their assessment of what they call yellowish graffiti and those underlying it. They explicitly acknowledge that fact in Footnote 3, on page 34: '(…) Further specialised studies such as portable Raman and XRF analysis, applied in the study of the rock and of the pigments, were not possible yet because of the technical limitations of our means and the low budget of the project' (translation ours). Therefore, despite plausibility, we consider their claims so far untested, thus deserving factual confirmation regarding material evidence and appropriate chemical analysis.

Scientific conditionals

We have been somewhat sceptical regarding those specific paintings from the beginning, as we demonstrated in the glimpses of the editorial process of our article, regarding the treatment given to that particular information, expanding it, but then, removing it from the respective caption due to, among other things, a lack of archaeometric evidence to support our suspicion. Therefore, we salute the subsequent work conducted by the Bolivian colleagues, as it provided urgent conservation measures, while deepening our understanding of the case. Indeed, in our report to the Bolivian organisation CEPAD (Valle and Querejazu Lewis 2022), about the small sample of sites we visited in the region in February 2022, with the support of that organisation, we strongly recommended the need for an archaeometric diagnosis for conservation purpose in that site, considering the worrisome amount of graffiti and recent anthropic interventions in the cave. To solve the conundrum raised by our initial suspicions reinforced and substantiated by the claims of the second study, regarding the authenticity and nature of the brownish yellow painting (and all other superimposed paints in that part of the cave), as well as, the underlying black pigment phase (as a plausible earlier Western intrusion), we consider necessary providing the following four scientific preconditional and entwined strands of evidence (e.g. Lewis-Williams 2002):

1. Application of Raman spectroscopy on the black pigment to check if it is organic, plant or bone charcoal-based (e.g. Coccato et al. 2015), or mineral-based, such as manganese oxide, or other source materials.
2. If organic, sample and send it for AMS radiocarbon dating, knowing that the result will only show the date of the death of the original plant or animal organism, not the 'graffiti' age. Notwithstanding, this could constitute an approximation for the complexity of the case if the charcoal dating leads to an ancient (i.e. pre-colonial) result or, on the other hand, it could improve the conditions to demonstrate without a doubt that the following phases are from recent (e.g. 20th–21st centuries), likely non-Indigenous provenance. However, if the age estimation points to an early or mid-colonial period, the Indigenous provenance of the subsequent phases cannot be discarded. Indigenous rock art made during Colonial and Republican times was widely demonstrated in Bolivia by Querejazu Lewis (e.g. 1992, 2014, 2019).
3. Disambiguation of the information 'written' with the black pigment underlying the yellowish pigment, as the second study suggests that these are also contemporary graffiti. The issue here is that, depending on the content, it could fall anywhere within the colonial chronological spectrum, post-European invasion, that is, from the 16th to the 19th centuries, using alphabetic and numerical Western characters, including those used by Indigenous peoples themselves. Consequently, precisely checking what and how information is written there with the black pigment, beyond a possible 'number 3', will be necessary to clarify what type of *Westernicity*, if any, may be implied in that content/context. DStretch has proven insufficient to allow a thorough understanding. Therefore, we would recommend detailed multispectral photography of the whole conjunct, particularly of the black content and its directly superimposed phases and graphic structures, and the improvement of the segregation of the black information from the multi-coloured superimposed content (attempted in Figs 2 and 3).
4. Application of Raman and x-ray fluorescence spectroscopy to each one of the pigments superimposed over the black pigment, which comprises at least four different layers of successive paintings of distinct colours and likely different paint recipes, including red ones superimposing the yellow and several shades of brown and yellow. The complexity of the superimpositions in this particular section of the cave is paramount, and disambiguation work will be demanding. We are just scratching the surface of the problem, and the best way to verify the issue has not been put forward yet. Therefore, Raman and XRF probing

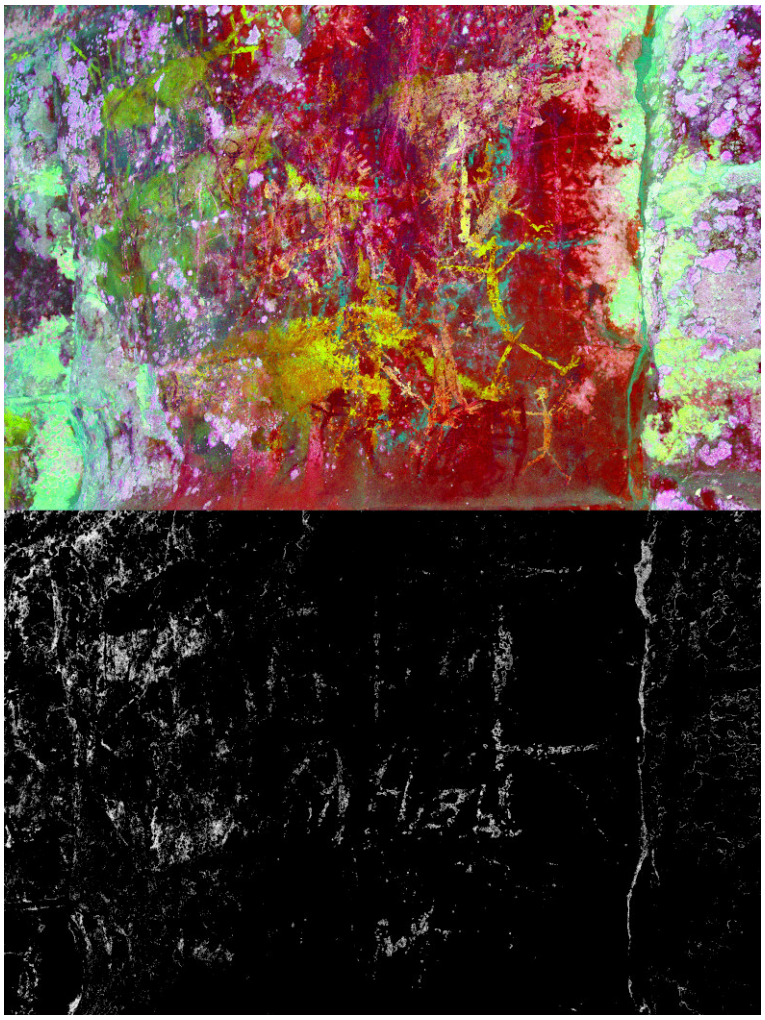

***Figure 2**. Inconclusive experiment. The Panel X of Juan Miserendino Cave in a DStretch (CRGB) version and after selecting only the black pigment colour using GIMP 2.0, to remove all the others, showing a possible sequence of numerals (photo and post-processing: RV, 2023–2025).*

on the phases on top of the black pigment, and the Raman and AMS of the black, are necessary to test claims of 'unauthenticity'.

Discussion

In our understanding of this issue, one cannot assume it is a yellow graffiti, consisting of a modern intrusion with its historical and ethnographic significance somehow diminished, nor could one consider it a Western creation at face value, detached from the past and contemporary native people's histories in that region, without observing the four conditional and entwined strands of evidence mentioned above.

In that sense, contemporary Indigenous groups of Chiquitanía are socially and politically very active (Weber 2013). That is the case of the Chiquitano Indigenous people and other regional living Indigenous groups, not to mention the diverse and dense ethnohistory of the area following the colonial, early and late republican periods. Along that process, Indigenous peoples most likely visited and interacted with the paintings in the Juan Miserendino Cave, for instance, during the 16th–18th centuries CE. There is no historical reason to assume the contrary. Affording conditions for late colonial and post-colonial Indigenous rock art expressions inside the cave, already bearing a cultural repertoire containing alphanumerical signs, learned by several Indigenous writers since the 16th century.

So far, we have more technical opinions, informed by experience, than proper published physicochemical evidence or scientific probing. For instance, in our chrono-stylistic-like approach (e.g. Isnardis 2004), using DStretch applied to regular digital photography, not microphotography, disregarding any value judgement on the cultural qualities of the paintings, just organising formal variability over time. Still, we took the black pigment phase as an unsolved analytical problem. The authors of the second study seem to base their conclusions on digital microscopy (electronically reconstructed optical magnification). Though it is possible to detect industrial synthetic paints through their micromorphological signatures, they do not present further insight regarding the nature and content of the black pigment phase, its chemical constituents or absolute age estimation (if charcoal). Secondly, claiming the synthetic chemical nature of the subsequent yellow phase, defining it as graffiti, also seems to lack archaeometric proof.

Testing the hypothesis that the black pigment intervention in question is recent Western scribblings seems to be an interesting pathway towards resolving this issue. Despite sharing some of the second study's concerns and interpretations, we did not publish those because sound archaeometric evidence was missing in our methodological approach and results, and because that was not the aim of our investigation. It was just a side-effect of being there, observing, recording and later analysing with DStretch, further restricted by limited time for data gathering at the site. The black phenomenon resembles an alphanumeric Western code and could have been made anywhere between the 16th and the 21st centuries.

The proper interpretation of the other paintings heavily depends on that clarification. So, ruling out contemporary Indigenous (i.e. Native American) authorship of those dedicated emulations of the older anthropomorphous and zoomorphic graphic patterns and the complex series of superimpositions after the black pigment is unreasonable. It is even

more unreasonable not to consider the possibility of Juan Miserendino, in person, intervening in the production of the brownish-yellow figure and those related. Therefore, assuming that the material evidence discussed here is contemporary graffiti, seemingly dispossessed of ethnographic or historical value, without further archaeometric testing, does not seem to be the best approach. That is our point.

Querejazu Lewis, apart from sustaining the four scientific conditionals mentioned above, perceived that the yellowish figures differ in graphic presentation and technical execution aspects (Pessis 1989) from the original anthropomorphous figures painted in red, especially on the opposite side of the cave. Despite elements of morphological correspondence, as crescent-shaped heads, feet with toes, protruding headgear and the handling of artefacts, these are presented in critically different ways, and without performing scenes (discernible synchronic collective actions), except for a couple of red anthropomorphs superimposing this whole sequence and even more morphologically contrasting to the old red ones. Furthermore, the brownish-yellow strokes and respective paint physical properties, visible to the naked eye, as shown in how it is loosening from the rock wall, and cracking in minuscule flakes, all these aspects greatly differ from the original red ones. They suggest that those do not seem to have been painted by NET-related people, with their techniques and paints, but instead, by others, or someone emulating the red originals. From a different perspective, Querejazu Lewis summed up this comparative situation as a significant difference in the *graphic ethos* (Querejazu Lewis and Valle 2024) between the original red anthropomorphs and those from Panel X. Furthermore, about half a kilometre from Miserendino Cave, at the entrance of another cave (Miserato Cave), the erosion of two main types of sandstone rocks provides sand with the same colours as the two brownish-yellow figures. Due to its easy accessibility, this is an obvious source of the raw materials for anyone living in Cave Miserendino to produce mineral-based yellowish paint.

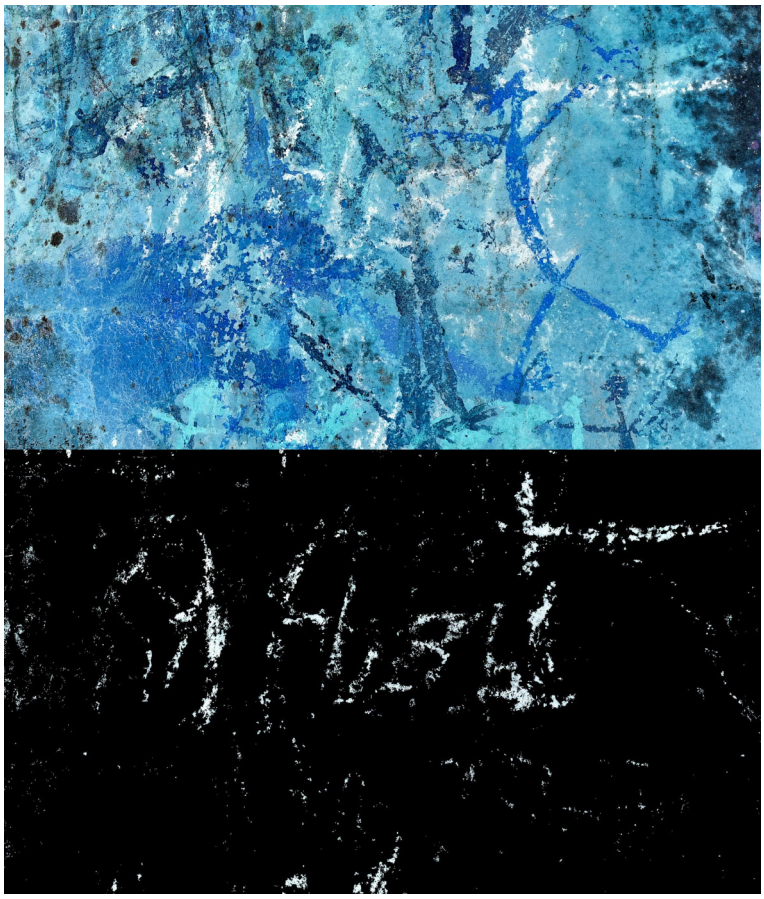

Figure 3. *On top: inverted detail of the crucial section on Panel X, showing critical evidence of superimpositions of several layers of paintings on top of the black phase (here seen in white colour, showing a possible numerical sequence [a date?]), obtained with the software Gimp 2.0. At the bottom: a selection of the information painted in black, presented in its white inverted version against a black background. This image was obtained with the aid of ChatGPT generative artificial intelligence, under request to isolate white, light grey and middle grey coloured pixels only. It also provided a further visual analysis of the resulting image, probabilistically testing its morphological resemblance to actual incomplete and degraded alphanumeric signs (60%) against random resemblance due to pareidolia (40%). Therefore, the experiment is still inconclusive. RV, 2022–2025.*

Even if recently made from synthetic materials, one cannot dismiss the anthropological value of that phenomenon. Sometimes, stating that a rock marking is graffiti may imply a qualitative downplaying judgment equating it with the depredation of a cultural resource and a criminal action of defacing an ancient and sacred space. We think a more interesting approach could be considering that phenomenon (Panel X [inverted detail in Fig. 3]) as a continuation and persistence of renewed symbolic practices under intriguing cultural circumstances, which we are entirely unaware of. Therefore, the question remains: what is it? An irresponsible and ignorant act of play? A dedicated hoax made with rock art experimental expertise to deceive unaware observers for fun? A recurring colonial/ republican/ contemporary example of Indigenous rock art production/resignification? Or may it be that the black pigment is not a modern inscription at all, and that the resemblance to an alpha-numerical code is a product of our contemporary Western pareidolic minds. Given any possible alternative explanation, the fact is that the visual information superposing the black does not look

Figure 4. *Petroglyph panel and written characters in the Baniwa language, a Northern Arawakan ethnic group, from the NW Amazon. The mythical being Kowai is portrayed in the rock art (the anthropomorph) and is related to the sacred flutes, music, poisons and shamanism. Photo taken in Jandú-Cachoeira, Middle Içana River, NW Amazon (RV, 2008; translation of the Baniwa writing kindly provided by Indigenous leader and intellectual, André Fernando Baniwa).*

like common graffiti (e.g. names and dates made by Western or Westernised persons) because it constitutes careful emulation of ancient graphic patterns on the same site, even bearing a complex sequence of superimpositions in that same spot, which may denote intense reuse and planning. We think this state of affairs deserves anthropological reflection after archaeometric data is secured.

Concluding remarks

At the bottom line, this topic hints at a thorough phenomenological, anthropological and political debate of what constitutes graffiti and what differentiates it from rock art. Cultural provenance? Age? Production techniques? Materials? Semiotic code? Social function? Intentionality? Morphology? Style? Westernicity? Indigenicity? Are these conceptual frontiers crystal clear in all possible cultural and political circumstances? Not at all.

So far, Querejazu Lewis has advanced what could be one of the most parsimonious scenarios accounting for the origin of those particular paintings in Panel X: Juan Miserendino himself. According to local oral tradition, Miserendino lived in that cave for some time, likely contributing to enriching the diversity and abundance of those parietal markings, including the brownish-yellow figures and others superimposed on the black drawn lines. An ethnographic and historical hypothesis may also concern the actual role of Juan Miserendino as a cave painter himself. This line of research is currently ongoing. However, if the information in black proves to be a date, as the possible 'number 3' suggests, and if it postdates his known death, then Miserendino's authorship can be questioned.

Nevertheless, readily discarding other scenarios is unwise, since these are still feasible. Colonial and republican Indigenous rock art expressions in Bolivia, as significantly reported by Querejazu Lewis (e.g. 2014, 2019), could be an alternative. The point is that South American Indigenous people still intervene in older rock art with modern materials and techniques, as Valle (2012) has demonstrated for the Upper Negro River area in the Northwest Amazon. In one such case (see Fig. 4), a written text below an old anthropomorphous petroglyph at the Jandú Cachoeira site, in the Içana River, says: *Kowai iñhanipemi Malimalieni.* It translates to: *Kowai devoured the sons of Malinali*. The writing mentions a passage from the mythical narrative of Kowai, the Arawakan flute demiurge, in which he devours three uninitiated boys who disobeyed his instructions not to eat a forbidden fruit at a particular time. Kowai opened his mouth until it formed a cave, through which the boys entered without hesitation, moved by curiosity. He then closed the cave with them inside, swallowing the boys. So, is that an example of South American Indigenous graffiti? Depredation of rock art or continuation? The writing information is in full context with the older rock art and myth-historical tradition, as the message invokes the deeds of Kowai. By using a contemporary visual code, it renews and adds another layer of visual information that reinforces and complements the original meaningfulness, turning that specific rock art very much alive in the ethnographic present, displaying a contemporary Amazonian style of fusing Indigenous graffiti and rock art in a symbiotic way, expressing content continuation coupled with a coding innovation.

So, what can we expect from that amazingly complex Panel X in Juan Miserendino Cave? Only science will tell, but just a part of that (hi)story because the total disambiguation of past cultural processes, even those recent ones, goes much further than what gets written in black.

Acknowledgments

We are grateful to: Jorge Morgan, an expert guide who safely took both of us to Juan Miserendino cave, in 2022 and in 2025; to the Indigenous intellectual and leader André Fernando Baniwa for translating and allowing us to use an image of a sacred place of his generous people; to Taboada and Moreno for their informative paper which helped us to readdress our own concerns on the authenticity of panel X. We are thankful to Rachel Velasco for insights on the yellow paint characteristics.

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EDITORIAL: world's best practice?

This issue of *Rock Art Research* features an article on the gradual destruction of the presumed largest concentration of rock art in the world by industrial emissions. The petroglyphs of the Dampier Archipelago in northwestern Australia share their location with the country's largest industrial polluters, both located on the archipelago's main island, Murujuga. There was no need for this to occur: no economic resources exist at Murujuga. The only reasons given for the unfortunate placement of the industry were that Murujuga was uninhabited (its traditional owners had been almost completely exterminated in three months of massacres in 1868) and suitable for a harbour. However, there are numerous alternative sites for harbours along the thousands of km-long western coast of Australia, without impacting one of the planet's most magnificent cultural monuments. The choice of Dampier is simply attributable to a blunder by the team of the Western Australian Museum's impact study. Its report stated that there are only 200 petroglyphs in the archipelago (Crawford 1964: 56).

The rock art monitoring study we prompted in 2002 has recently found that NO_2 and SO_2 are causing porosity in the rock's substrate (MRAMP 2024: 439), leading to the gradual breakdown of the base rock. Why do the Australian state and federal governments neglect to save the globally unique, priceless and irreplaceable rock art on Murujuga from destruction by gaseous industrial pollution?

In mid-2025, the Federal Government's Environment Minister, Murray Watt, acknowledged that the rock art on Murujuga is being irreversibly damaged by industrial pollution. Watt stated that the degradation could only be slowed if industrial emissions were reduced to undetectable levels. Industry responded that this was not possible, so the final limits on industrial emissions set by the Minister's ruling were insufficient to prevent further degradation of the rock art. However, the industry's concern is not to preserve the petroglyphs but to protect its highest profitability. How does the claim that it is using 'world's best practice' in avoiding excessive air pollution stand up to scrutiny?

Verstegen (2025) has analysed the implications of Watt's 'strict new conditions' and calculated that predicted pollution up to 2070 would total nearly 110,000 tonnes of NO_x. In 2030, emissions are to be reduced by 60%, followed by six smaller reductions every five years. This still falls well short of the world's best practice in emissions control for LNG production trains powered by gas turbines. That standard is achieved at Alaska LNG, where an NO_x concentration of 2 ppmv was attained. They use a combination of dry low NO_x (DLN) burners and selective catalytic reduction (SCR) scrubber technology (Alaska LNG 2022). LNG facilities that use or are installing electric-drive technology, which is cleaner than gas turbines, can achieve even lower NO_x levels and far lower greenhouse gas emissions. These include Freeport LNG in Texas and Hammerfest LNG at Melkøya, Norway (after 2028).

Verstegen has calculated that, until 2030, the Murujuga LNG facility will emit 37 times the NO_x level of best practice. From 2031 to 2035, the facility will still emit 15 times the NO_x level of best practice. The question Minister Watt needs to be asked is this: what prevents him from directing the Murujuga proponent to match the world's best practice in reducing polluting gaseous emissions in LNG production?

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