PROCEEDINGS OF THE IFRAO CONGRESS
September 2010

2013 # 5

http://www.palethnologie.org
ISSN 2108-6532

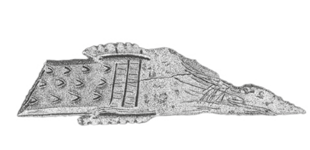
directed by
Jean CLOTTES

PLEISTOCENE ART OF THE WORLD

Short articles








P@LETHNOLOGY
Bilingual review of prehistory

SYMPOSIUM 7

APPLICATION OF FORENSIC TECHNIQUES TO PLEISTOCENE PALAEOART INVESTIGATIONS

Chairmen

Yann-Pierre MONTELLE
(New Zealand)

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(Australia)

➜ full version

FOR1 Montelle-Bednarik
Full article, pp. 1169-1182

THE RELEVANCE OF FORENSIC SCIENCE IN PLEISTOCENE INVESTIGATIONS

Yann-Pierre MONTELLE, Robert G. BEDNARIK

Forensics is a process that follows five basic methodological stages: detection; documentation; collection; analysis; interpretation. Common to all these stages is the concept of evidence. To the question, "what constitutes evidence?" and limited by space, only a generic definition will be proposed here: evidence includes all items observed and potentially collected from a scene (a site). At this juncture, it is important to reiterate the fact that these investigations operate in complete absence of informants and therefore motivations and purposes. The rock art site becomes a "crime scene".

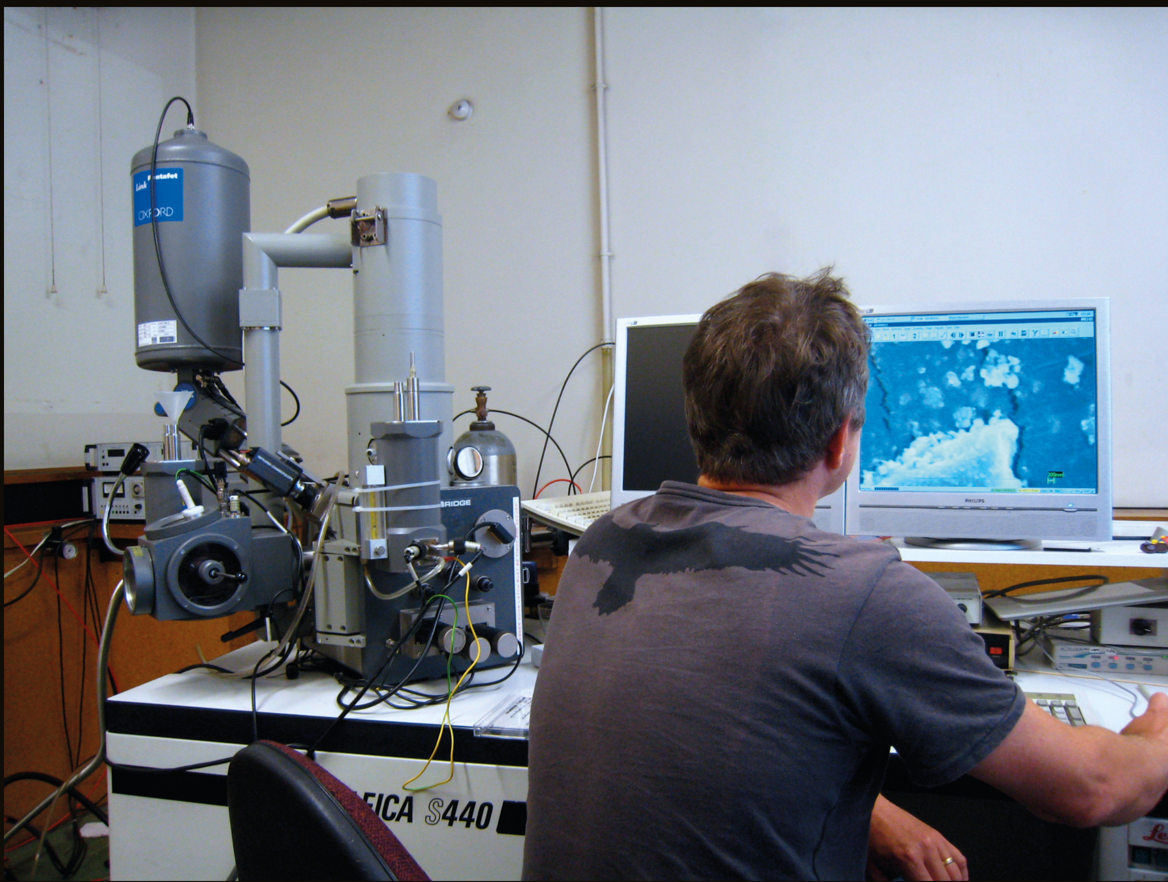
This is evidence that does not forget…

Even in the absence of the "perpetrator(s)", we are still able to reconstruct their behaviour based on the fact that "Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as a silent witness" (Harris v United States 1947).

Consequent to the exchange principle is the concept of trace evidence. "Trace evidence is a generic term for small, often microscopic fragments of various types of material that transfer between people, places, and objects, and persist there for a time", according to Houck. Trace evidence is critically important for determining the nature of the transfer. In forensics, trace evidence is any type of material left at the scene. In the context of rock art evidence, trace evidence results from the contact between the site's surface and material transported, applied, buried or forgotten. The generic typology of trace evidence includes, among others, fingerprints, hair, fibres, glass, soil, organic residues, DNA... The degree of force involved in the process of producing trace evidence will result in the transfer of variable amounts of substance from the surface of the substrate to the surfaces of the tool and vice versa. Transferred trace evidence found on modified surfaces can help reconstruct the biomechanical nature of the contact, the provenance of the substance, an absolute or a relative date for the transference, and once thoroughly examined can potentially feed a deduced interpretation.

The taphonomy of trace evidence

The taphonomy of trace evidence, here defined as "evidence dynamics" (ED) is another fundamental aspect of forensics, which needs to become standard in rock art investigations. ED refers to any agency that has played a critical role in changing, relocating, obscuring, or obliterating physical evidence. ED comes into play during the interval that begins with the discovery of the trace evidence to its completed analysis, either in situ or in lab conditions.



Using SEM for discrimination of quartz particles in haematite
(Canterbury University, New Zealand).

But the established fact that contacts leave traces is not enough on its own. Often missing from the analysis is a consideration of those influences that have changed the identified physical evidence prior to or as a result of its examination. The list of possible taphonomic modifications of an item of evidence is too voluminous to be detailed here, suffice to say that the investigator is required to understand the taphonomic history of a site or of an artefact and how these processes of decay might have influenced the shape and localisation of the evidence as observed at the time of discovery.

The spectrum of modifications as by-products of ED is broad and complex. Physical evidence can be modified at the micro- or macro-level. Indexing these modifications is a prerequisite. Prior to the collection of samples and artefactual evidence, the site and the artefact need to be analysed thoroughly so that any observed modifications can be documented in order to be replicated. Replication is the methodological culmination of the forensic process. Through controlled experiments, the investigator will replicate aspects of the taphonomic history and the environment as well as the biomechanical process responsible for the deposition of traces and the modification of the observed physical evidence. Only then is the collected data useful for testing hypotheses and propositions.

A new discipline?

The forensic-inspired approach should not be understood as a new discipline, but rather approached as a forum where past efforts, recent developments, and future innovations could be effectively synthesised. The aim is to create a coherent and rigorous axis around which contributing disciplines articulate and communicate by using standardised methodologies to collect, analyse, describe evidence, and assess propositions. The dawn of this approach can be traced back to the year 1957 with the publication of Prehistoric technology by S. A. Semenov. Thus the idea of replicative analysis was launched and, combined with microscopy and traceology, brought the investigation about our past one step closer to forensics. Semenov's groundbreaking methodologies inspired many, amongst them A. Marshack and F. D'Errico. Marshack's internal analysis has ushered us into the forensic concept of trace analysis and tool marks. D'Errico, on the other hand, has given microscopy its lettres de noblesse by demonstrating that tool marks and other traces on portable artefacts could be empirically identified and hence matched to collected evidence. The matching of observed modifications to actual evidence is at the core of forensics. Inspired by these robust and rigorous methodologies, recent investigators have made commendable efforts to adopt some of these techniques and to adapt them to field conditions. An exhaustive list of innovators would certainly start with the remarkable work of the teams involved with the Chauvet Cave. Large sections of the cave have been sealed for future investigations that will certainly benefit from more advanced technologies. The result is large areas where evidentiary material is most likely unspoiled, uncontaminated – a perfect "crime scene".

FOR2 Montelle
Full article, pp. 1183-1195

INDEXING THE TRACES OF ANTHROPOGENIC ACTIVITIES AND MODIFICATIONS IN DEEP KARST ENVIRONMENTS

Yann-Pierre MONTELLE

Indexing the traces of anthropogenic activities in underground environments constitutes a fundamental contribution to future studies of the use of caves by Paleolithic humans. This taxonomically oriented investigation is mainly based on the forensic principle of "exchange" during the time of contact between two agents and the traces that this contact leaves. The observation, analysis and reproduction in the laboratory of the biomechanical and taphonomic processes implied in the production and preservation of these traces are also an important aspect of this research. A catalogue of structural traces and modifications must be constructed and its contents should be based on observation, recording, taxonomy and comparative analysis of the traces left by modern speleologists and analogous ones found in underground prehistoric sites; all of this together composes an empirical database that researchers can use to corroborate, question or formulate new hypotheses on the use of caves by humans during prehistory. In 1919, in his opening speech to the Academy of Sciences, Edmond Locard (1877-1966), a criminology specialist and pioneer in forensic police investigation, postulated that: "Any author of a crime forcibly leaves material

The author observed anthropogenic traces on a clay floor
in the Gallery of Crosshatching, Chauvet Cave (photo: J.-M. Geneste, 2008).

evidence of his presence at the crime scene". Today, this principle is known to forensic police investigators as the "Locard Principle of Exchange" (PEL). PEL can be resumed as follows: when there is contact, there is transfer – this transfer can be of a cosmic or microscopic dimension; whatever the nature of this transfer, it will leave its trace, a trace whose permanence depends on the taphonomic hazards to which it is subjected; its detection and interpretation are dictated by the taphonomic knowledge of the investigator. Adapted to the underground conditions of deep caves, Locard's principle of exchange becomes the fundamental axiom for a rigorous investigation "of the interferences between humans and the cave". Traces indicative of a logical action, footprints indicating a pause, or evidence of a modification made to facilitate circulation, are usually located on surfaces that have resisted water run-off, trampling and other random processes.

Some types of traces are well-known, such as prints left by feet, hands, knees or spear points; as is the transport of organic material that breaks and that we trample; the movements of bone remains that leave their negative imprints, or traces of modifications to structural elements of the cavity (broken concretions, for example). But there are other traces that we cannot yet identify because we haven't "thought" of them. They require a paleo-chronological approach. They cannot be separated from the biomechanical processes of which they are the signatures. These traces would have been subject to the taphonomic modifications associated with underground environments. It is therefore necessary to take these modifications into account when analyzing a cave floor and that which could appear to be banal would rapidly become the ichnological subject of an original behavior. The systematic progression of a speleologist would be dictated by the volume of the traces observed and, being conscious of the modifications created by his progression, he would precisely record all of the identifiable traces. This implies that the speleologist would be able to integrate both the progression techniques adapted to the requirements of the terrain and a global knowledge of the cavity (from a karstic, geological, climatological and taphonomic perspective) in order to identify and describe the nature and the typology of the observed traces and modifications.

The morphology of the cavity is a determining factor in the choice of trajectories. Whether it is vertical or horizontal, it has been observed that the path follows a topographic logic. The progression of the speleologist forms an axis of circulation punctuated by the morphological aspects of the floors and walls. The testimonies of speleologists through time can be arbitrarily taxonomized in two main categories: intentional and non-intentional contacts. We can thus distinguish three groups of traces: the first includes the traces of progression (dynamic foot and handprints, slides, falls, broken concretions); the second includes the traces of stopping (brief station, "pause", catching one's breath, contemplating difficulties, problems of orientation or lighting); the last group is that of the traces associated with modifications made to the site.

This taxonomy is a solid foundation onto which we can add other criteria such as: the morphological variations of the space crossed; the physical capacities of the individual; his or her age; previous knowledge of the topography; the technical means used to facilitate progression across a difficult terrain; the lighting; the simultaneous presence of predators, etc. This non-exhaustive and preliminary list is nonetheless sufficiently descriptive to illustrate the level of complexity in which this taxonomy operates. When analyzing a trace, empirical observations of its morphology and typology do not suffice; it must rather be integrated into a research context in which this trace is projected into an analytical system oriented toward interrogations concerning functions and motivations, for example.

FOR3 Bruzek *et al.*
Full article, pp. 1197-1206

HANDPRINTS IN PARIETAL ART:

Interpretive Possibilities and Limits from the Perspective of Forensic Anthropology

Jaroslav BRŮŽEK, Martina LÁZNIČKOVÁ-GALETOVÁ
Patrik GALETA, Jéremy MAESTRACCI

In parietal art, handprints are sometimes directly attributed to the authors of the representations located near them. Recent attempts to estimate the sex of individuals based on handprints rely on the sexual dimorphism of this body part and its dimensions, and in particular the proportional index between the length of the second and fourth fingers ("digit ratio" or Manning index). The aim of our study is to show, from a forensic perspective, the degree of precision and reliability of sex determination based on this index and hand dimensions.

The sample studied consists of 100 adult subjects from a homogeneous population composed of 50 men and 50 women, all students of the University of Bordeaux 1. The subjects are between 19 and 28 years old and their average height is 1 646 mm for the women and 1 783 mm for the men. We measured six linear dimensions: the length and width of the hand, the length of the fingers from digit 2 to (D2) to digit 5 (D5), according to the definitions by Martin presented in the work of Knussmann, published in 1988. Two indices were calculated from these measures.

Before presenting our results, it is essential to clarify the terminology used. In the forensic domain, the most common technique of classification is discriminant analysis, which leads to the establishment of discriminant functions (DF). We can employ terms such as "precision" (the rate of individuals classed in concordance with the true sex) and the "reliability" of the methods (rate of individuals classed correctly in another population), the common criteria of correct classification (probability limit of 0,5) and the rate of reliable classification (probability limit of 0,5).

To respond to the question of whether it is possible to determine the sex of an individual based on handprints, we tested the reliability of the DF no. 3 proposed by Snow in 2006 in the journal *Antiquity*, which attained a precision of 79%. It correctly classed 73% of the French sample. All of the women except one were correctly determined while half of the men were classed as women. The overlap zone overlapping for the two sexes is thus very large. For this reason, the rate of reliable classification is very low (24%), with only one woman and 21 men out of 100 subjects. To conclude, the DF no. 3 is not reliable and its use is not recommended.

The second DF no. 4 of Snow employs indexes (that of Manning D2/D4 and that of D2/D5). The rate of correct classification applies to only 59% of the cases in Snow's original sample. The application of this function to the French sample was also a complete failure. All of the individuals are situated in the zone of male values. The DF no. 4 is inadequate for an estimation of sex based on handprints. To verify that the failure of discriminant function analysis was not linked to the sexual dimorphism of hands in the French population, we then realized a calculation of

Red hand stencil in the Cosquer Cave
(photo: J. Clottes).

discriminant functions unique to our sample. The discriminant calculated for the French sample was based on the same variables resulted in a higher rate of classification (89%). The dimensions of the hands, like those of other body parts, are forcibly influenced by the format, which partly masks the effect of the form, as Bruzek and Murail pointed out in their synthesis published in 2006. The discriminant functions of the dimensions of the hand, as well as those of bones, are usually specific to a given population. The variability of the Manning index is enormous. Sexual differences exist in all populations, but the absolute values of the index are variable for each one. This is the main reason that discriminant functions cannot be used for sex determinations.

The human hand shows a significant sexual dimorphism in relation to height. Despite this differential expression, discriminant analysis of the variables of the hand produces a relatively high rate of correct classification (around 80%), but with a very large overlap zone. This reduces the rate of reliable classification and plays a major role in its use for classification. The information obtained from this forensic anthropological analysis shows that sex determinations based on handprints in parietal art are not reliable.

FOR4 Van Gelder
Full article, pp. 1207-1220

NEW METHODS AND APPROACHES IN THE STUDY OF FINGER FLUTINGS

Leslie Van GELDER

Finger flutings, lines drawn with fingers over soft surfaces, appear in a number of Paleolithic caves throughout southwest Europe, Australia, and New Guinea. Flutings can appear as figurative images, recognized symbolic forms, and more often as lines which show no recognizable symbol, pattern, or picture.

My work has focused predominantly on the development and testing of methodologies focusing on the accuracy with which one can determine individual fluters within the cave environment. If one is able to determine the actions and activities of individuals, this will yield far greater insight and information regarding the purpose and meaning of behaviors, thus allowing researchers for the first time in cave art to separate out the idiosyncratic behavior of the individual from more general culture behavior description. Further, it takes these individuals from the abstract and returns them to the unique individuals they once were, imbuing them once more with their individual identities.

This paper gives a brief summary of the methodological advances previously made in the study of finger with an emphasis on the determination of individuals, and then looks at a new methodological inquiry into the study of single finger fluted figurative images. The corner-stones of this approach have consistently been to include multiple examinations of the flutings being studied, to engage in laboratory work and experimentation, and to primarily put aside questions of meaning in favour of posing questions which are answerable. The physical data in the flutings themselves comprise what we seek: how were they constructed, how they functioned, and who were their creators.

Mammoth 223
(located in Galerie Henri Breuil) in Rouffignac.

Previous research into the determination of individuals has suggested that one can ascertain an increasingly more robust image of the identity of an individual fluter by using the width of the measure of a unit three fingers as a basis. As one works in the field, however, the question rises as to what is the most accurate point of measure for determining a particular individual.

Specific unique characteristics of the individual's profile can be established particularly when distinctive or idiosyncratic. In clear instances, one can calculate the actual distance between finger heights for an individual using triangulation. The thick or thinness of finger tips can be noted to assist in the determination of the age of the fluter.

Single finger drawn animals appear in both Gargas Cave and Rouffignac Cave among many others. This study looks at 8 different finger drawn mammoths in Rouffignac Cave and contrasts the data found there with experimental lab work using contemporary individuals who created a series of single fingered mammoths with both right and left hands in gib plaster smoothed onto cardboard sheets which were held up at chest height to simulate a wall placement.

The central question of this inquiry was: *Can we determine the individual who created a single fingered animal using a method based on the measurement of fingers?*

Other questions which then arose in the course of trying to determine a response to this were:
1. If we know the three fingered width of an individual and know the measure of their drawing finger, can one identify them based on that measure when drawing an animal?
2. Does that single finger vary in the width of the line it makes?
3. If there is variability in the measure of a single fingered line, where is the best place to measure on an animal to determine the most reliable correlation to a 'known' single finger?
4. If one can reliably identify an individual with this method, what factors account for differences in the way in which a known individual has different measures when creating the same animal?

Ultimately, based on both the laboratory work and observations and measures of 8 mammoths within the cave, it does not seem that the measure of finger width alone is an accurate means by which to determine the identity of an artist for an image created with a single finger. One cannot correlate with any accuracy three fingered flutings to say whether or not they were fluted by the same artist as a figurative line or even to identify whether nearby fluted units were created by the same individual. If relying solely on the data, one must say that it is not possible to connect those lines with each other to reveal individual identity. Laboratory work such as that described here is imperative for researchers focused on developing adequate and accurate methods which can yield reliable data in the field.

New technologies and methodologies will produce better means which may allow for further exploration of the identities of individuals based on the physical data they leave behind. At this stage, while the measuring of single finger fluted animals is important, the measure of the line is not as yet a suitable means and method for determining an individual's identity even among a known group of individuals.

On the larger scale, the use of the three fingered measure for determining individuals continues to prove to be a successful approach, continually being fine tuned through repeated observation. As more researchers begin to use this approach and refine its use, undoubtedly the corpus of our knowledge about the fluters of the Upper Paleolithic will continue to grow.

THE DECORATED PALEOLITHIC CAVE OF BAUME LATRONE (FRANCE, GARD):

3D Time Travelling…

Marc AZÉMA, Bernard GÉLY,
Raphaëlle BOURRILLON, David LHOMME

Since 2009, a new research program in the cave of Baume Latrone (France, Gard), directed by Marc Azéma, has consisted of recording its astonishing parietal images, drawn in clay or engraved on limestone, using a combination of traditional techniques and three-dimensional digitalization. This technological association introduces a fourth dimension into the digital field model by confronting several chronological phases on the wall, which was vandalized and then cleaned during the 1980's, thus allowing us to travel through time...

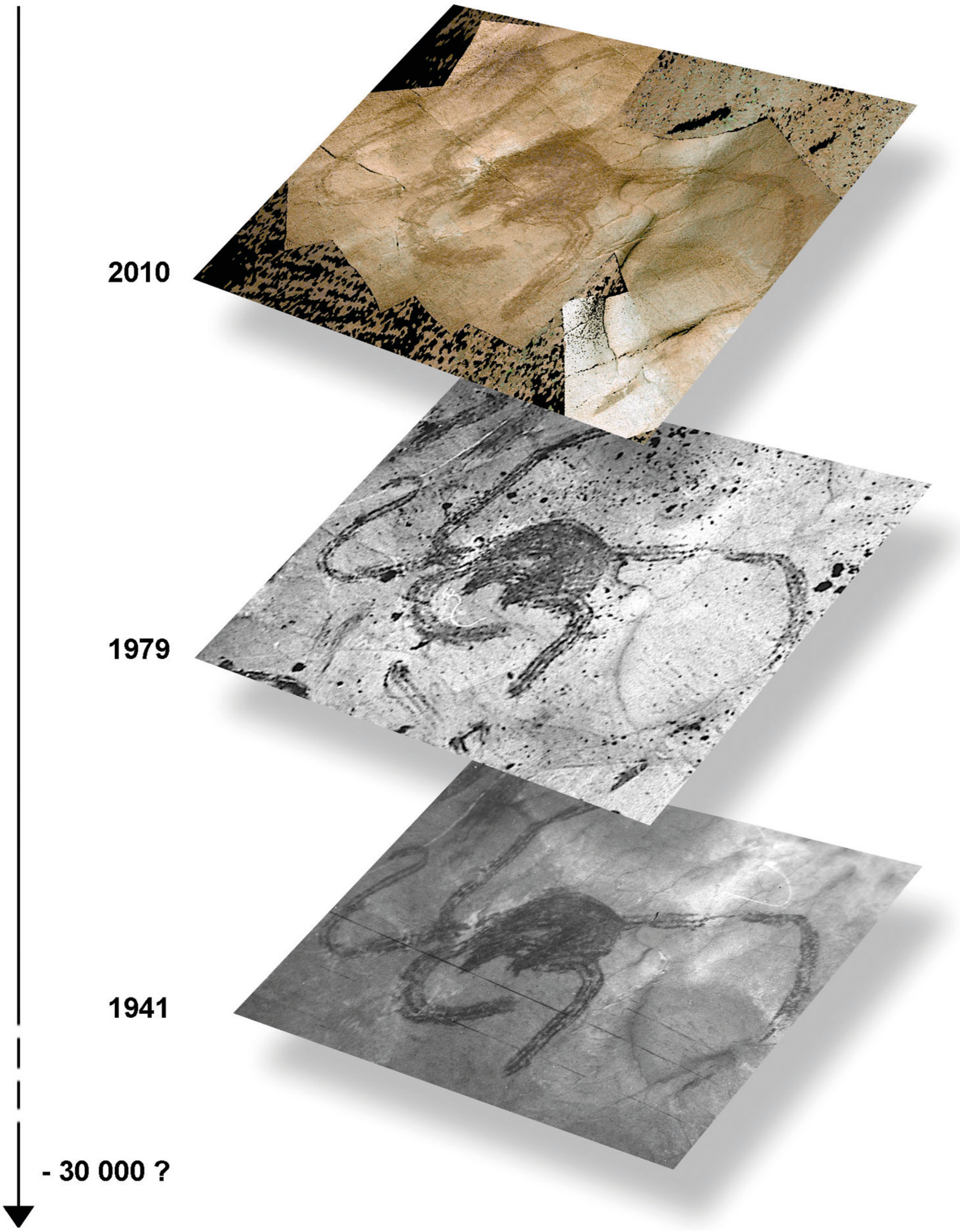
A cave to be rediscovered

Baume Latrone is one of five decorated caves in the Gard Department of France. Many of the figures are located on the western walls of the Bégouën Chamber. They were discovered in 1940 and then studied by A. Glory and P. Fitte during the same year. From the time of its discovery, the cave has suffered from human presence and acts of vandalism. Two restoration sessions were realized in 1982 / 1984 by I. Dangas and J. Brunet for the *Laboratoire de Recherche des Monuments Historiques*. The Great Ceiling, which has the most spectacular graphic ensemble, is composed of a large feline representation (3 m) surrounded by 7 or 8 mammoths and a horse and / or rhinoceros. The style of the images is original, with the animal profiles being reduced to a minimum and some anatomical details left out. Both engraving and painting was employed, but it is the multi-finger technique with large bands that is most original in the Baume Latrone parietal decoration.

Though it is impossible to precisely determine the period(s) of human presence in the cave, due to the absence of significant artifacts and wood charcoal, all researchers agree that the decoration can be attributed to an early phase of parietal art.

The contribution of 3D scanning to the recording of parietal art at Baume Latrone

The main aspect of our study of the decorated walls is to record and analyze the different human interventions. For the past fifteen years, photographic recording, which is the technique traditionally used in decorated caves and rock art, has been enhanced by advances made in 3D digitalization techniques (orthophotographic recording).



3D time travelling at Baume Latrone – mammoth no. 11 scanned from the present to 1941, and soon to be restored to its original state (2010, photo: ATM3D; 1979, photo: A. Ruppel; 1941, archives L. Bégouën).

A first three-dimensional recording session was realized in the Bégouën Chamber in January 2009, with the objective of digitalizing the environment of the figures. During the second session, in 2010, the entire Great Ceiling was digitalized at sub-millimeter scale.

At the same time, the entire Great Ceiling was photographed: 205 photos were taken and then computer enhanced (color levels, contrast and focus were optimized and the photos were organized) to prepare for 3D mapping. The orthophotographs thus produced would serve as a support for the recording. Once it is completed, this recording well be reintegrated into the original three-dimensional environment of the model.

Travelling in time

At Baume Latrone, the method of recording through orthophotography revealed an unexpected dimension: time. The decorated wall that we see today is different from that observed by the discoverers in 1940. Its condition has evolved due to vandalism during the first decades and restoration operations in the 1980's. These different "periods" were photographically documented. Since the beginning of our study, we have recovered these precious testimonies and have constituted a photo-library of hundreds of photos in the process of being enhanced and originating from archives.

Despite the technological limits associated with the time when the photos were realized (format differences, black and white and color), a first analysis of this photographic database shows that it will be possible to reconstruct several wall and floor surface states with the digital field model, using the method described above and by calibrating the photos to each other.

This voyage in time could go even further. We believe it will be possible to realize a virtual restoration of the decorated wall (and floors), similar to that made for the Great Panel of the cave of Marsoulas.

FOR6 Krishna-Kumar
Full article, pp. 1239-1255

UNDERSTANDING THE CREATION OF SMALL CONICAL CUPULES IN DARAKI-CHATTAN (INDIA)

Ram KRISHNA, Giriraj KUMAR

The present paper is in continuation of our efforts to understand the creation of cupules in Daraki-Chattan by the process of cupule replication, started in 2002. Daraki-Chattan is one of the richest Palaeolithic cupule sites in the world. It is situated in the heavily metamorphosed quartzite buttresses of Indragarh hill in the Chambal basin in central India. It bears more than 500 cupules executed on both its vertical walls. The excavations carried out at Daraki-Chattan under the EIP Project have produced unambiguous evidence of Lower Palaeolithic petroglyphs. Daraki-Chattan is being studied under the EIP Project. We have identified four categories of cupules at Daraki-Chattan.

1. big circular cupules, saucer-shaped or deeply rounded;
2. circular or oval cupules of conical shape;
3. small smooth cupules of shallow or deep depth;
4. small cupules with angular periphery and deep angular depth.

Circular conical cupules about 30 to 40 mm in diameter and a depth of more than 5 mm represent category 2. We really need to show how hard it is to make a small cupule of 30 to 3 mm in diameter of conical shape and a depth of 9 mm.

Ram Krishna working on the replication of a small conical cupule on an experimental rock by the side of Daraki-Chattan.

In order to understand the creation of cupules and their significance in Daraki-Chattan we did experiments and replicated the cupules of category 1 in 2002 and 2004, and that of category 2 in 2008 and 2009. The vertical wall in a rockshelter by the left side (south) of Daraki-Chattan is our experimental rock and is made of the same hard quartzite like that of the cave. Our experiments in 2008-2009 were focused on showing how hard it was to make a small cupule of 30 to 3 mm diameter with a conical depth of 9 mm.

Our experiment established that in Daraki-Chattan, big circular cupules of category 1, saucer-shaped or deeply rounded, appear to be a work more of strength and commitment and less of mind. They were produced by using a very simple and primitive technology of direct percussion. They appear to represent the earliest stage of cupule production. It also indicates that to produce big cupules of category 1a necessitates two to six hammerstones on cobbles or pebbles, depending on the quality of the stone used and the strength of the person at work. It is a tough and tedious task to produce a cupule on hard quartzite rock. It requires motivation, commitment, strength, endurance and patience for their production. Cupules of category 1b can be produced similarly by using hammerstones with stout and sturdy striking heads. It needs longer and high concentration besides all the above-mentioned qualities. At the same time it requires the use of multiple hammerstones to achieve a deep round and smooth depth.

Cupules of category 2 are comparatively small with a conical depth, particularly of category 2a. In 2008 Ram Krishna created cupule No. RC-6 in 21 661 comparatively soft strokes, working 172 minutes over three days. Its depth is conical and it measures 33.5 × 32.5 × 9 mm.

For most of the time he used direct percussion technique, but for 22 minutes he also used indirect percussion technique. We need to use only direct percussion technique. Hence we again did an experiment in June 2009. This time Ram Krishna created a cupule, No. RC-9, by using soft strokes and direct percussion technique only. In the light of the experience we gained while creating RC-6 and RC-7, we used mostly small pebbles with angular heads as hammerstones. Thus, we were able to produce a small cupule with conical depth (RC-9), measuring 32.0 × 31.5 mm in diameter and 9 mm in depth. It was created in 28 327 strokes in 372 minutes over two days. Seventeen unmodified striking heads on ten hammerstones of hard quartzite were used.

RC-9 is the smallest cupule with conical shape we have produced. The comparatively longer duration and greater number of strokes were obvious. In order to go deep into the cupule while keeping its diameter under control we had to maintain the striking end of the hammerstone at a right angle to the striking surface. It required great concentration and changing the striking head / hammerstone at the proper time.

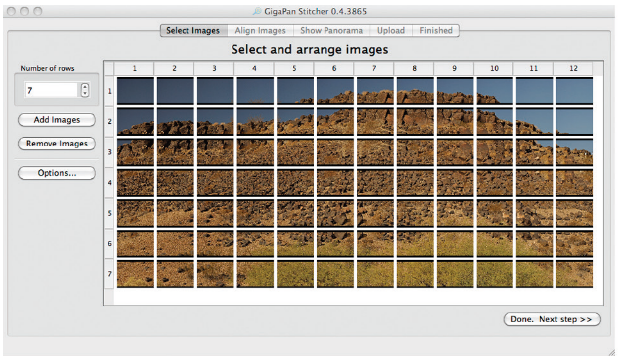
Thus, our experiment has shown that it is incredibly hard to produce such small cupules of conical shape. They appear to be the work of a modified technology of direct percussion, which requires proper planning, immense skill and great precision and patience. The person at work on cupule production cannot afford one wrong stroke, even in a thousand, as it will increase the diameter of the cupule by one millimetre. Replication also showed that cupule creation is definitely not a leisure work or the result of play. It is a very tough job and appears to be closely associated with something special and deeply related with life.

FOR7 Mark-Billo
Full article, pp. 1257-12264

USING SUPER-HIGH RESOLUTION PANORAMAS (GIGAPANS) TO DOCUMENT AND STUDY ROCK ART PANELS

Robert MARK, Evelyn BILLO

Panoramic photography began in the middle of the nineteenth century. Images were 'stitched' in the darkroom. It wasn't until the late twentieth century that Apple Computer Corporation provided a practical approach to digitally stitching images (QuickTime Virtual Reality, QTVR). This required very careful photography, and then describing the relations between images in an arcane script. The projection was limited to a cylinder. It was shortly thereafter that we started using panoramas to document rock art panels. We experimented with both panoramas (photographed from one point) and mosaics from multiple points. Because automatic stitching software programs are designed to stitch panoramas, stitching mosaics can be quite difficult.



Gigapan
at Sears Point
274 Megapixel
25 785 by 10 664) image,
stitch from an array of 12
by 7 telephoto images.

Array of images in the Gigapan stitcher, prior to stitching. A full rectangular array is required. This is a very small example; arrays of several hundred images are possible. Also shown are the robotic pan head and the stitched example.

Advances in both hardware and software came quickly. Early major software advances included stitchers that permitted graphically placing images, and supported spherical and other projections. Hardware advances included panheads which permitted rotation in precise increments about two axes. Additional improvements in stitching and blending algorithms permitted more flexibility in photography, and now many panoramas are generated from handheld photographs. Modern stitchers will automatically position the images, in most cases, without user intervention. For a comparison of the many stitchers now available, see *http://en.wikipedia.org/wiki/ Comparison_of_photo_stitching_applications.*

The most recent advance is super high-resolution Gigapan panoramas (*http://en.wikipedia.org/wiki/Gigapan*), which permit zooming in to see minute details of elements within a larger panel. This is made possible by the use of a robotic panhead, which is programmed to take a rectangular array of hundreds of overlapping telephoto images. Since their relative positions are known, stitching with the Gigapan stitcher is efficient (figure). Gigapan panoramas can be viewed with a graphics program, such as Photoshop, or with a browser on the Gigapan website or with Zoomify. Links to these and other Gigapan rock art panoramas can be found at *http://www.rupestrian.com/* or *http://www.gigapan.org/gigapans/most_recent/?q=rmark*. Be sure to select "Launch Full Screen Viewer" and allow time for screen update when zooming in.

Conclusion

Panoramas and mosaics are very useful in the documentation of rock art panels. Printed panoramas can be taken into the field for annotation and the marking of sample locations, such as pXRF (portable x-ray fluorescence) measurements. The Gigapan process provides not only systematic overlapping photographs of large areas of interest such as an entire panel, but also provides a single image with full resolution of details for digital annotation and analysis in the office.

P@LETHNOLOGY
Bilingual review of prehistory