

Forensics in Australian cave art research

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Abstract: *In illustrating the practical application of the tenets and techniques of forensic science in rock art research, the authors relate the work of specific projects conducted in Australian limestone caves. Australia has the second-largest known concentration of cave art in the world, which is being studied by the Parietal Markings Project, established in 1981 and responsible for the discovery and investigation of over forty decorated caves. Several of the sites have yielded evidence attributing the petroglyphs to the Pleistocene, and it is assumed, by extrapolation from established data, that much if not most Australian cave art is of that period. Forensic methods have been applied to this corpus for decades and some of the recent work is presented by the authors, illustrating methods of observation, analysis and replication procedures to explore production processes.*

The Parietal Markings Project

This project is concerned with the wall markings found in limestone caves around the world, both of anthropic and natural origins, and was commenced in 1981 (Bednarik 1982). Most of its work over almost 30 years has been conducted in Australia, where rock art in deep limestone caves is a comparatively rare phenomenon. Nevertheless, with currently forty-eight known sites (not counting sites where the rock art is limited to the entrances of caves; e.g. David & David 1988), the Australian corpus is the second-largest body of cave art in the world. Of these sites, forty-one were discovered by the Parietal Markings Project (PMP), which in total investigated over 300 caves in Australia and a similar number in five other continents collectively. With few exceptions (Lane & Richards 1966; Gallus 1968, 1971; Hallam 1971; Morse 1984; Cosgrove & Jones 1989), the well over fifty publications addressing the cave art of Australia are the work PMP researchers. In contrast to the cave art occurrences in other parts of the world, Australian cave art consists largely of petroglyphs and is entirely non-figurative. Pictograms, almost always in the form of hand stencils, occur at only six of the sites.

There is limited evidence that some of the Australian cave art dates from the Holocene (e.g. Bednarik 1998), and more extensive, albeit mostly circumstantial evidence, that it is of Pleistocene ages. The latter includes many strands of evidence, including geological, radiometric, stylistic and the contextual relationship with features demanding such age, e.g. where the palaeoart pre-dates megafaunal scratch marks.

The work of the PMP has focused on several specific topics, among them the discrimination between natural and humanly made rock markings in caves (Bednarik 1980, 1986a, 1991), and the development of forensic methods to analyse cave markings. Indeed, mastering the distinction of anthropic and non-anthropic wall markings is itself very much dependent upon forensic science. It often hinges on intensive examination, in much the same way as traceology has to attempt the

discrimination between markings that were made, for instance, with steel or stone points. Among the natural markings in caves, those of animal claws are particularly prominent in Australian caves, just as those of cave bears are in Europe (Bednarik 1993), but plant root marks (of mycorrhizal origin), clastic movement marks and other taphonomic markings occur also. Without safely identifying natural cave marks there can be no effective study of cave art, as the frequent misidentifications by archaeologists show (e.g. Bednarik 1986b, 1994, 2002).

Description of Australian cave petroglyphs

A *simplified* taxonomy of Australian cave petroglyphs leads to the identification of six basic classes:

- A. *Finger flutings*: They occur on formerly soft calcite deposits which in all but two sites are of a secondary, i.e. reprecipitated carbonate (moonmilk, *Montmilch* or *Mondmilch*). Consisting of a microscopic, snow-like lattice of calcite crystals, it can absorb up to 60% water and is initially just as soft as snow. These white cave deposits were extensively marked by pre-Historic people (in France, Spain, U.S.A., Dominican Republic, Papua-New Guinea and Australia), and they survived in some cases through carbonatisation or desiccation (Bednarik 1999). Only about sixty such sites are known worldwide, and the majority of them occur within 40 km of Mount Gambier in South Australia.
- B. *Karake genre*: These petroglyphs are deeply abraded (up to 40mm deep) and probably often pounded. Motif types are dominated by circles and cell-like arrangements of curvilinear enclosures. The circles are usually under 50cm but may range up to about a metre in diameter, while the panels of mazes may extend over several metres. Motifs also include parallel lines, arcuate designs, "convergent lines motifs" (including the "trident" but also with two, four or five "toes" which are not necessarily connected at the point of convergence), rare wave lines, circles with internal design (vertical barring or lozenge lattice), and radial and dot arrangements. This motif range has many parallels in other Australian rock arts, which are frequently considered to be of Pleistocene age (Bednarik 2010) and it is very similar to that of pre-iconic art globally. Several of these sites have provided good evidence for such Pleistocene antiquity for this genre.
- C. *Tool marks*: There is no indication that these are utilitarian and, in contrast to the Karake motifs which are found on walls only, they are as likely to occur on ceilings. They may form groups of sub-parallel lines or occur as apparently unstructured assemblages, but occasionally they form apparent patterns such as lattices. The tool material used in their production has been identified at two of the sites (Nungkol and Mandurah Caves), and forensic analysis has provided much information about production sequences (e.g. Bednarik 1992a).
- D. *Deep pits*: Traces of a widespread activity in which a soft rock, such as a cave wall, has been extensively marked by a non-utilitarian but quite specific percussion activity that resulted in panels featuring deep gashes, including the highly distinctive, pocket-shaped "alveoli". This phenomenon is not restricted to caves and has not been properly examined, described or even recognised at open sites.
- E. *Shallow engravings*: They are incised with usually single strokes of a pointed tool, and are frequently responses to earlier designs of which they are sometimes

copies. The "shallow engravings" occur at very few cave sites and are separated from the preceding Karake style by a substantial layer of cutaneous calcite precipitate in Malangine Cave (Bednarik 1984).

F. *Recent petroglyphs*: Occur at only two of the cave sites, and only at the entrances.

Despite several credible age estimations the chronology of Australian cave petroglyphs remains largely unresolved. Apart from the clear sequence at some sites of classes A-B-E/F, chronological relationships remain under investigation. Class C and D markings may relate to any phase, or to none of the others, but class C has never been observed to precede class A, and there is corroborating evidence (such as past fluctuations in floor level) suggesting that C postdates A. Nevertheless, some of the finger flutings are certainly of Holocene age, in fact there are known occurrences even of modern finger markings in five Australian caves. In particular, the finger flutings in Prung-kart Cave near Millicent are thought to be of mid-Holocene age, on the basis of laminae-derived radiocarbon dates (Bednarik 1998, 1999). The relative chronological placement of the chert mining remains uncertain, except that at all art sites where it occurs it coincides with finger flutings. But this may still be coincidence, and the mining evidence also occurs at three caves without the finger marks (Bednarik 1992b, 1995).

Some of the Australian cave petroglyph sites have been subjected to detailed archaeological studies: Orchestra Shell Cave (Hallam 1971), Koonalda Cave (Gallus 1971; Wright 1971), Malangine and Koongine Caves (Frankel 1986, 1989) and New Guinea 2 Cave (by P. Ossa). Most of the archaeological data are not directly relevant to the art as the sites were frequented at various times; the art cannot be convincingly related to any of the occupation phases, and may in fact relate to none of them. In some cases the occupation evidence is probably much more recent than the art, e.g. in Orchestra Shell Cave, where the occupation stratum is in a deposit that formed after a floor subsidence occurred, whereas the art antedates the time of that collapse (Bednarik 1978/88).

Forensic work in Australian caves

Specific forensic methods employed early on by the PMP have included the determination of the types of tools used in making wall markings, including the recognition of the signatures (Fig. 1) of specific rock types (e.g. Bednarik 1987-88, 1992a); the determination of the approximate ages of the producers of finger flutings (e.g. Bednarik 1986b, 2008); the detection of geomorphological events related to the rock art, such as tectonic adjustments, roof falls, subsidences, inundations, speleo-weathering processes or biospheric weathering (e.g. Bednarik 1989, 1999); the reconstruction of superimposition sequences of finger flutings (Fig. 2) (e.g. Bednarik 1984, 1985, 1986b); the determination of the order tool applications (Fig. 3) and their direction to reconstruct wall marking events (e.g. Bednarik 1987-88, 1992a, 2006); and a variety of replicative experiments to test hypotheses. Another highly relevant aspect is any evidence of other human activities in the caves, which may have coincided with the rock art production. For a number of reasons it is crucial to establish whether such relationships can be documented.

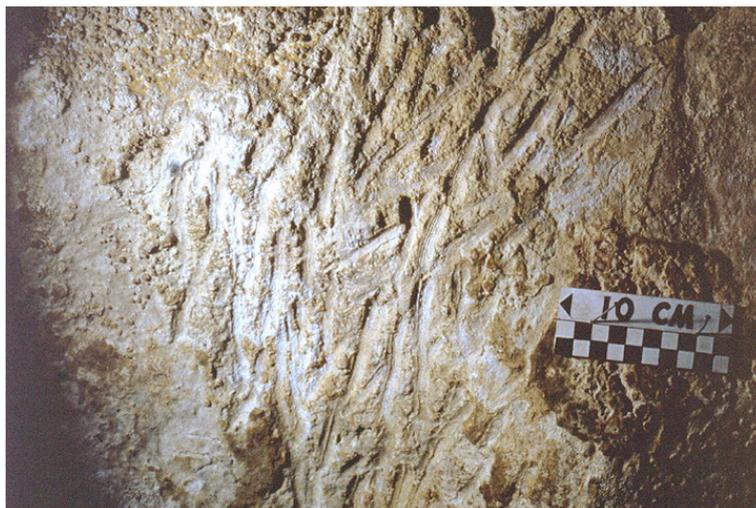


Fig. 1. Analysed superimposition of several different tool point applications, Nung-kol Cave, South Australia (1985).



Fig. 2. Analysed superimposition sequence of finger flutings in Malangine Cave, South Australia (1983).



Fig. 3. Tool marks in Koonalda Cave, South Australia.

Specific anthropic activities demonstrated to have occurred in Australian caves include the mining of sedimentary silica deposits, their use as campsites and living quarters, and the exploration of deep passages. The PMP focused especially on the chert mining evidence in Karlie-ngoinpool and Gran Gran Caves (Fig. 4) and the chalcedony mining in Koonalda Cave (e.g. Bednarik 1986a, 1990, 1992b, 1995), which in some cases involved the application of specialised techniques and tools, established through forensic evidence provided by tool marks and actual impressions of tool points (Fig. 5). Pleistocene silica mining is known from one cave site each in Hungary and France (Bednarik 1986a; 1990), and from two alluvial sites in Egypt (Vermeersch et al. 1986). In Australia, extensive traces of subterranean silica mining have been located in nine caves so far, and in six of them they occur close to petroglyphs. The reconstruction of the activities that led to these traces by forensic methods has provided a basis of distinguishing five basic mining methods at the Australian pre-Historic silica mines (Fig. 6).



Fig. 4. Chert mining traces with petroglyphs in Karlie-ngoinpool Cave, South Australia.



Fig. 5. Impression of the point of a wooden stake among extensive chert mining traces in Gran Gran Cave, South Australia.

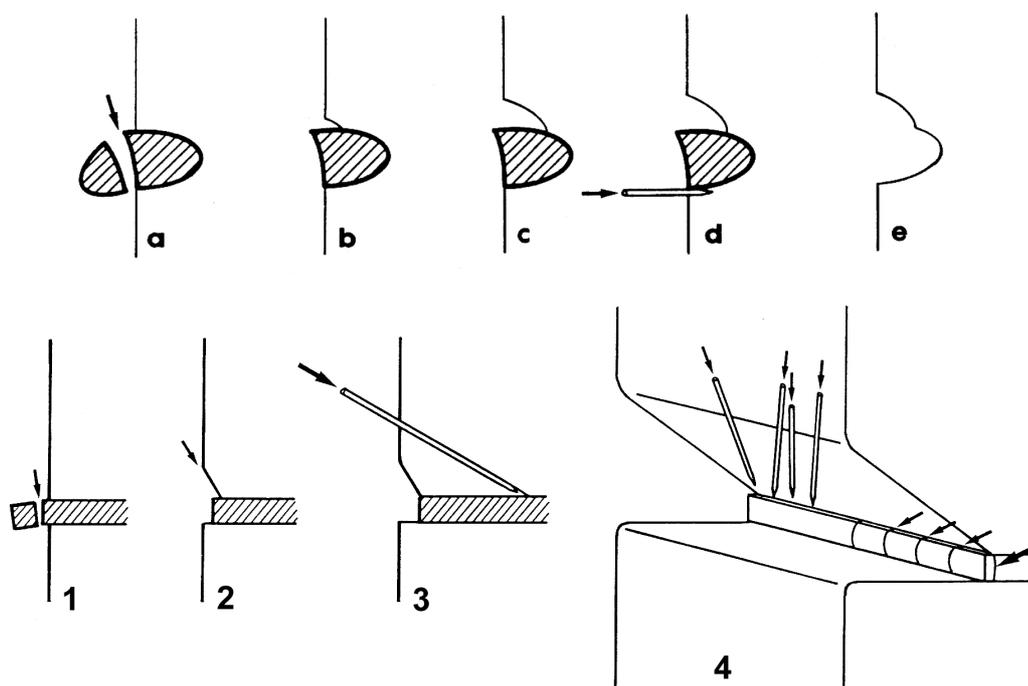


Fig. 6. Methods of chert mining in caves as determined by forensic study (1985).

A recent example of forensics

In the last four years, the authors have focused on one site, Ngrang Cave, used here to illustrate some generic principles of forensic work with cave art. Such work, generally intended to establish precisely "what happened at a given site", involves various levels of analysis (see also Montelle 2009):

1. The macro-level: overall setting of the cave, its speleogenesis and establishing how the present evacuational and convacuational spaces developed through time.
2. The medium level: the site formation processes that contributed to the present state of the immediate environment of the cave art (i.e. within a few metres of it).
3. The micro-level: the precise details of the features which the previous levels of investigation have identified as relevant, such as wall markings, weathering details, speleothems, or any form of tectonic, fluvial, phreatic, vadose or biological traces.
4. The microscopic level: the magnified examination of tools, markings, residues, traces and so forth, details which are not visible to the unaided eye.
5. Replication: this refers to the experimental work of reproducing observed outcomes or traces for the purpose of testing specific hypotheses concerning specific observations.

This sequence is crucial to the optimal understanding of the circumstances of the production of the rock art in question, and in combination with an understanding of taphonomic effects and the relative or absolute chronology of events it forms the basis of any scientific appreciation or analysis. In the absence of knowledgeable owners or custodians of the rock art, no other approach can possibly lead to valid interpretation.

In the case of Ngrang Cave, we are dealing with a fluvial tunnel cave formed by a Pleistocene subterranean stream that very likely drained into the nearby Glenelg River. After the general lowering of the region's aquifer levels during glacial periods the horizontal tunnel, just a few metres below the surface plain, began to collapse in some places along its course. This tunnel is now accessible in one place, from where it can be followed for about 30m. Anthropogenic wall markings (Fig. 7) occur in much of the low passage, but we have focused on one specific location, a series of 52 tool-made cavities ("deep pits" or "alveoli") forming a single panel, up to 25cm deep, how they were made and how they relate to their surroundings (Fig. 8).



Fig. 7. Anthropogenic wall markings in the low passage of Ngrang Cave, South Australia.



Fig. 8. Part of the deep pits panel in Ngrang Cave.

The present entrance of Ngrang Cave is at a roof collapse proceeding E to W, whose rim retreat rate exceeds the build-up of the cone deposit inside it, facilitating continued access to the tunnel (Fig. 9). Because the quantity of the collapsed rock is known from the tunnel's morphology and size, the contents of the cone slope can be estimated: 32 m³ limestone (c. 78 t) and 14 m³ sediment (c. 25 t), assuming airspaces of about 2 m³. Pleistocene sediment from the exterior descends down the slope and contributes to creating the cone deposit's stratigraphy. Within it occur dense lenses of evidence of occupation, comprising charcoal, bone fragments, emu eggshell fragments and chert tools. As the rim of the collapse retreats with every new rock fall, the lower limestone strata (the tunnel roof) become similarly unstable and are claimed by gravity. One such event has claimed the northern end of the panel of deep cupules, when a projecting wall portion bearing seven of the deep pits broke off and fell to the ground relatively recently (Fig. 10).



Fig. 9. The gradual retreat of the cave entrance of Ngrang Cave towards west, producing an elongate doline.



Fig. 10. Wall portion with seven deep pits that fell to the ground since their manufacture, Ngrang Cave.

Thus the history of the site can be broadly reconstructed through its geomorphology and tectonic adjustments over time. This provides a relative timeframe within which the production of the extraction pits on the wall ledge must be situated. The preservation and surface texture of the fallen block with deep pits differ considerably from the rest of the panel, which demonstrates the great effects of taphonomy: the wall is subjected to the regime of capillary and ambient substrate moisture (subjected to slight variations depending of surface geometry), while the fallen block is cut off from the rock's internal hydrology.



Fig. 11. One of the deep pits in Ngrang Cave, showing clear tool traces.

Placing the extraction pits (Fig. 11) into a relative chronological framework proved to be more demanding. Their contemporaneity with any one occupation episode cannot be readily demonstrated; in fact they cannot even be related with any of the numerous other tool marks deeper in the cave. They are not related to any speleothem, and only one of them has been truncated by a subsequent mass-exfoliation event (the debris could not be located). This leaves only one index of relative age, surface retreat by speleo-weathering, but it can be applied in three different ways. First, the limestone contains tiny marine fossil casts that tend to weather significantly less than the matrix, and at the opening of one of the holes, such a cast extended 9mm above the present surface. This would suggest a considerable surface retreat since the hole was made, but it needs to be assumed that the cast was not protruding some of the distance at that time. Secondly, the holes contain numerous tool marks, and their relative degree of weathering is a measure of antiquity. However, several factors complicate the utility of this index: weathering rates differ depending on the depth within the hole; the morphology of the tool gauges at the time they were made is unknown and must be assumed; and the type of tool used is not known. These considerations render it desirable to conduct replicative experiments to better deal with these issues.

The third indicator of the age of the holes is perhaps the most reliable, and the easiest variable to quantify. The rims of the holes are considerably more rounded today than they can be assumed to have been at the time of manufacture. There can be no doubt that the more acute rims become progressively rounded with time. To determine their initial morphology, replication is again required.



Fig. 12. Experiment in Ngrang Cave in progress, showing application of kangaroo long-bone by indirect percussion to manufacture replication deep pit. Note pre-Historic pits in the left background.

Since 2007 a series of experiments has been conducted to establish (a) what tools and what extraction method(s) were most likely to have been used in making the pits; and (b) what would the rims of the fresh pits have looked like. For this purpose flat surfaces on blocks of the same limestone forming the cave walls were selected and a dozen holes were created under controlled conditions, using three types of tools: a broken leg bone of a kangaroo with a hammerstone (Fig. 12); a wooden pointed chisel, also using indirect percussion; and large stone picks, hand-held in direct percussion. This led to the realisation that the hollow bone was the most effective in terms of speed of operation and in replicating the grooves seen in the extraction pits. Its effectiveness is in part due to its functioning in the manner of a core drill, as the internal channel fills with limestone dust. This does not necessarily prove that such bones were used, but a key technological factor is that the pits have mostly sidewalls parallel with their central axis, in fact in several cases they flare out with increasing depth to a diameter greater than that close to the rim. This suggests strongly a very deliberate effort to create holes of the greatest possible ratio of opening diameter to depth. Most are two or three times as deep as they are wide. Creating this distinctive, alveolar shape demands a very focused effort and the use of an extraction tool making this procedure practically possible. The broken end of a long-bone is clearly the most likely candidate of tool used.

Outlook and summary

The project of applying forensic methods to cave markings commenced almost 30 years ago in Australia. Progress since then may seem modest, especially as no attempt has been made to sensationalise findings or over-interpret data. Nevertheless, such analytical methods were first applied in Australian caves, and indeed to rock art generally, and this work has in more recent years inspired various developments. Among them are the work by Kevin Sharpe and Leslie Van Gelder, who is here with us. The PMP project has in recent years focused on a few specific caves near Mt Gambier and investigating specific key issues, because quite obviously the mass of information waiting to be recorded and processed in this field is simply monumental and overwhelming. We suggest that it will involve virtually centuries of forensic investigations. In this field we shall need to very patiently learn to walk before we can expect to run.

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