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Palaeolithic cave art in Borneo

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Site description

The cave paintings of the Sangkulirang-Mangkalihat Peninsula (SMP) where first observed by Luc-Henri Fage in 1994. While visiting Gua Mardua with Jean-Michel Chazine, he noticed the paintings located high on the cave walls and ceiling, contrasting with the black drawings located in the more accessible areas of the cave. Immediately realizing the importance of this discovery, they enlisted Pindi Setiawan and from 1995, sometimes with the help of local bird's nests hunters who previously observed similar markings in other caves without realizing what it was, discovered other cave paintings sites[2-11, 43].

In this research, a total of 15 calcium carbonate samples were collected in association with 13 motifs at six separate cave sites, offering the opportunity to provide minimum and/or maximum ages for the images under study. Individual samples were divided into multiple aliquots (between 3 and 7, and with a total of 65) (Supplementary Table 1).

Lubang Jeriji Saléh

Lubang Jeriji Saléh is a large limestone solution cave located on Batu Raya Mountain (Fig.1). It is around 320 m above sea level and 200 m from the foot of the mountain, and hence requires a difficult climb to reach. This remote cave has a large main chamber with high ceilings as well as multiple side chambers. The cave is 140 m long and is lit by three separate porches. Approximately 300 hand stencils and 20 images of animals and humans have been documented so far. The cave contains multiple superimpositions of different painting styles.

Samples LJS1 and LJS1A (Fig. 2) are part of a calcite flow that has formed over a large rock art panel containing at least three large infilled reddish orange-coloured animal paintings as well as reddish orange-coloured and mulberry-coloured hand stencils. The panel is on the low-hanging roof of a narrow side chamber located 6 m from the main cave entrance. The samples are located 1.6 m inside the side chamber and 1 m from the cave floor. Sample LJS1 and LJS1A are situated over what appears to have been the hindquarters of one of the large animal paintings, a figurative representation of what is possibly a wild bovid (i.e., Bornean banteng) (Fig. 2). The rear part of the animal painting where the samples were collected is heavily weathered, possibly as a result of water flows feeding the speleothem used for dating. A mulberry-coloured hand stencil is located to the left of the sampling area (Fig. 2). Physicochemical analyses of the pigment associated with the animal painting (P2) – samples LJS1 and LJS1A (P3) – and the mulberry-coloured hand stencils to the left of the sampling site (P1) were unable to differentiate between the three (see Pigment Analyses below). However, the pigment associated with samples LJS1 and LJS1A is of the same reddish orange-coloured hue as other parts of the figurative animal painting in question, and the pigment layer we have dated appears to have been applied with a brush or finger rather than sprayed or projected from the mouth. These observations indicate that the dated pigment layer corresponds to the animal painting rather than to a hand stencil.

Sample LJS2 (Extended Data Fig. 4) is associated with a reddish orange-coloured hand stencil located in a small side chamber 9 m from the main cave entrance. The side chamber is located 1.5 m above the cave floor and the painting is situated on the cave wall 1.3 m from the floor of the side chamber.

Samples LJS3 and LJS4 (Extended Data Fig. 5) are associated with a mulberry-coloured hand stencil located on an archway 46 m from the main cave entrance and 2.3 m from the cave floor.

The two hand stencils associated with samples LJS5 and LJS6 (Fig. 3) are located in a side chamber 100 m from the main cave entrance and 4 m above the cave floor. In 2003, a French-Indonesian team reported the dating of two hand stencils associated with a large cave drapery in this side chamber[15]. The team removed a large piece of the cave drapery (approximately 50 cm long, 15 cm wide, by 1 cm thick) found overlaying two reddish orange-coloured hand stencils (Fig. 3). The sample was broken into pieces that were then analyzed for U-series and radiocarbon dating. Except for subsample BOR5, the results showed a discrepancy between the U-series and radiocarbon age estimates whereby the U-series age estimates were older than the radiocarbon results. Moreover, the U-series age estimates were in reverse chronological order, suggesting that the cave drapery in this instance behaved as an open system for uranium. Nonetheless, compared to the other subsamples, BOR5 consisted of "compact" calcium carbonate material and was located at the base of the cave drapery. For this subsample, the U-series and radiocarbon analysis returned a similar age estimate of ~10 ka. Cave draperies, or "curtains," are distinct and notoriously porous forms of secondary calcium carbonate deposition and are thus not ideal for U-series dating. Nevertheless, owing to the particular way in which these speleothems form, the base of the drapery is generally less porous and more suitable for U-series dating. In our study, sample LJS5 is located immediately below sample BOR5 (Fig. 3). It is composed of dense calcite material immediately below the cave drapery. The ages we obtained are all older than ~10 ka (obtained for BOR5) and are in stratigraphic older (approximately 15, 17, 18, and 37 ka) (Fig. 3). Sample LJS6 is associated with the other hand stencil (immediately below the one mentioned above) (Fig. 3) and is composed of dense calcite material located to the left of the cave drapery.

Lubang Ham

Lubang Ham is located on Batu Raya Mountain (Fig. 1). It is situated 340 m above sea level and 2 km south of Lubang Jeriji Saléh. It is a large limestone solution cave with a large main chamber with high ceilings, a large top chamber and multiple side chambers. The rock art assemblage at this site is heavily dominated by hand stencils, with up to 500 individual hand stencils, and only 5 other rock art motif types, recorded so far. Sample LH1 is located on a large column on the edge of the top chamber and faces the cave entrance 20 m away (Extended Data Fig. 8). The sample is 1 m from the base of the column. LH2 is located on the same column but faces the opposite direction and is located 2 m from the base of the column (Extended Data Fig. 7).

Liang Banteng

Liand Banteng is a rock shelter located on Batu Nyéré Mountain (Fig. 1). The shelter is 20 m long by 9 m wide and faces eastward. The site is 180 m above sea level and has only one chamber with two main panels. One of the panels is difficult to reach and contains a large figurative animal painting (possibly a banteng). It is stylistically similar to large animal paintings from Sulawesi (Extended Data Fig. 9). The other panel contains several mulberry-coloured decorated hand stencils with three-like motifs as well as small animals and stick-like human figures. Unfortunately, this panel has been subject to vandalism, having been defaced with bright red spray paint in 2014 or 2015. LBT1 and LBT2 (Extended Data Fig. 6) are associated with two separate decorated hand stencils.

Liang Sara

Liang Sara is located on the southern part of Batu Tutunambo Mountain (Fig. 1) and is 117 m above sea level. The cave is 100 m long by 2-4 m high and has two entrances. Liang Sara has one chamber with two galleries. The paintings are all relatively small (10-20 cm) and consist of mainly human and animal figures with occasional hand stencils. Samples LSR1 and LSR2 (Fig. 4) are located 6.5 m from the main cave entrance. LSR1 and LSR2 are respectively 1.2 m and 1.4 m from the cave floor.

Liang Tewét

Liang Tewét is a relatively small cave located on the western side of Batu Gergaji Mountain (Fig. 1). The cave is located 90 above the Marang River and contains more than 100 hand stencils, as well as representations of small animals. Almost all the images are located on the ceiling. The hand stencils are mainly mulberry-coloured with internal decorations and tree-like motifs. Sample LT1 (Extended Data Fig. 5) is associated with a reddish orange-coloured hand stencil 6 m from the cave entrance and 5 m from the cave floor.

Liang Karim

Liang Karim consists of three small rock shelters located near Liang Tewét (Fig. 1). Two of the rock shelters contain a few hand stencils and are in a poor state of preservation. The third shelter, where sample LK1 is located (Extended Data Fig. 5), is 6 m up the main floor. The shelter is about 5 m long by 2 m wide and is heavily painted. The art is generally in a good state of preservation, except for parietal artworks located in the bottom part of the site. This shelter contains a large figurative painting of what appears to represent multiple beehives, as well as small human figures and hand stencils. There is also a large infilled reddish orange-coloured animal painting (possibly a tapir). Two calcite flows are associated with the animal’s head, but on close inspection, the paint was shown to be on top of the calcite flow and thus sample LK1 could only provide a maximum age for the animal painting.

Pigment Analyses

Physicochemical analyses were conducted on pigment samples from Lubang Jeriji Saléh. We sought to gain more information about the probable sources, application and taphonomy of rock art paints[44] by combining Synchrotron Powder Diffraction for mineral identification, Synchrotron X-Ray Fluorescence Microscopy (XFM) for chemical characterisation and Scanning Electron Microscopy to investigate surface geomorphology and confirm chemical abundances on features of interest (with Energy Dispersive X-Ray Spectroscopy). The use of these complementary techniques proved invaluable in characterising the small paint surface samples, as each technique in isolation would not have identified the colour producing constituents.

The colour producing mineral in mulberry paints was identified as the iron oxide hematite. While none of the red rock art (P2, P3) returned iron oxide phases in the powder diffraction data, XFM revealed all paints to be iron based. The red sample P3 is aluminium enriched, suggesting use of ochre associated with a bauxite deposit (Extended Data Table 2). Boehmite and gibbsite minerals form in lateritic soils/gravels within tropical and subtropical regions of high rainfall. Such aluminium hydroxides are generally colourless, though they can tint red from impurities[45]. Previous work on rock art in northern Australia has identified red aluminium oxide/ hydroxide paints with lateritic gravels the purported red colouring agents[46]. Kalimantan contains large, commercially exploited bauxite deposits indicating plentiful sources of aluminium rich ochres[47]. That these minerals were not identified in the second sample location for this motif (P2) is likely interference from the major gypsum peak swamping the diffraction pattern, impeding the detection of minor phases.

Powder diffraction also showed consistent environmental signatures associated with the paint surfaces, namely geological salts (gypsum) and re-precipitated calcite (Supplementary Table 2), with the exception of sample P3. XFM analysis of the surface and cross section of red paint from location P3 showed sulphur and calcium do not overlay the paint in contrast to all other rock art pigments examined (Extended Data Fig. 3). This is consistent with sample P3's location in an active wash zone. XFM and Scanning electron microscopy confirmed the post-depositional nature of gypsum and calcite overlying iron paints in rock art samples P1, P2 and P4 (Extended Data Fig. 3).

Comparison with rock art from Northern Australia

In Kalimantan, the Kimberley of Western Australia and the Kakadu-Arnhem Land region of Australia's Northern Territory the early parts of rock art sequences are similar[48], with stencil phases (primarily hands, hand-and-forearms; sometimes material culture) quickly followed by naturalistic animal depictions (as in Sulawesi[1]) and then phases dominated by human[27,28]. Stencils continued to be made over time and during subsequent phases. In each region what are identified as male figures have large, elaborate headdresses. Often they hold spears and/or throwing sticks such as boomerangs. The East Kalimantan Datu Saman figures particularly resemble the numerous Dynamic Figures of Kakadu-Arnhem Land[27], as well as the so-called Elegant Action Figures of the Kimberley[28] (Extended Data 2, 10). Dynamic Figures and Elegant Action Figures have been argued to date to the Pleistocene on various grounds but they have not been precisely scientifically dated due to the challenges of dating rock paintings in sandstone shelters. The similarity of the Kalimantan Pleistocene human figures to those of northern Australia may reflect comparable hunter-gatherer cultures rather than direct connections. The parallel process of the development of visual representation at rock art sites in Indonesia and Australia – from stencils, to static naturalistic paintings of animals to human figures engaged in activity – may provide insight into how human symbolic expression in fixed landscape locations changed over time. Given the shift over time in technique and subject matter is similar to that observed at some Pleistocene European rock art sites the study and dating of East Kalimantan rock art provides insights into shared cognitive and cultural change despite vastly different environments.

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Supplementary Table 1 | This table contains the results of uranium-series disequilibrium dating of rock art motifs (N=13). Note: Ratios in parentheses are activity ratios calculated from the atomic ratios. Errors are at 2δ level. The ages are calculated using Isoplot 3.75 Program[37] with decay constants from Ref. 36. Corrected Age-I and Age-II were calculated assuming initial/detrital $^{230}Th/^{232}Th$ activity ratio equal 0.825 (± 50%) (the bulk-Earth value, which is the most commonly used for initial/detrital ^{230}Th corrections) and 1.8 (±50%), respectively. When the value of initial/detrital $^{230}Th/^{232}Th$ activity ratio = 1.8 is used, the corrected age for the stratigraphically younger sample LJS2.2 will become older than that for the stratigraphically older sample LJS2.3. See text for discussion. Corrected Age-I is therefore the optimal approach for detrital correction.

Supplementary Table 2 | Mineral phase identification of rock art pigments. A and B are replicates from the same chip.