Faces of the ancestors revealed: discovery and dating of a Pleistocene-age petroglyph in Lene Hara Cave, East Timor

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A petroglyph showing a human face found in East Timor is dated to the late Pleistocene. It recalls ancient Australian forms and raises the possibility of connecting early cave art with the better known painted figures of Lapita/Austronesian art ten millennia later. This new discovery at a known cave shows what precious evidence still lies in store even in well-trodden places.

Keywords: Southeast Asia, East Timor, rock art, pigment, petroglyph, Austronesians, Lapita, human face, Pleistocene art

Introduction

One of the largest and most diverse concentrations of rock art in Island Southeast Asia is found near the small village of Tutuala, at the eastern end of East Timor (Figure 1; O’Connor 2003). Over 20 individual shelters and caves containing art have now been recorded, but to date only pigment art had been found here, as elsewhere in East Timor (O’Connor 2003; O’Connor & Oliveira 2007).
In 2009 a small group of petroglyphs was discovered during sampling of breccia deposits in Lene Hara Cave. Despite multiple seasons of excavation by several teams and many visits to photograph the painted rock art, the petroglyphs had previously eluded discovery. Local landowners accompanying our team were also unaware of their presence. On being shown the petroglyphs, which take the form of human faces, they expressed the view that the ancestors had revealed themselves to us. Here we describe the petroglyphs and the results of Uranium/Thorium (U/Th) dating of the speleothem substrate on which the art was engraved. The dating of one of the faces to the terminal Pleistocene begins to bridge the apparent disparity in the antiquity of early artistic production between Island Southeast Asia and the western Pacific on the one hand, and Australia on the other.

**History of research at Lene Hara Cave**

Lene Hara is a massive, vaulted tunnel cave that extends into the side of an east-facing hillside (Figures 2 & 3). The parent limestone is predominantly fine-grained and well bedded, but bands of conglomerate are embedded in the limestone at the rear of the cave. The floor of the cave is broadly flat but slopes gently down from the rear to the entrance. The roof at the cave entrance rises to over 6m above the current floor. A number of large speleothem columns are present within the cave, one cluster towards the rear and a second group near the entrance. A larger number of short stalactites hang from the roof, generally with flattened drip surfaces below.

Lene Hara Cave was first excavated by the Portuguese anthropologist António de Almeida in the early 1960s. He subsequently published a brief report of the excavation (de Almeida & Zbyszewski 1967) and some painted rock art motifs at Lene Hara as well as three other shelters in the region of Tutuala: Ile Kere Kere, Sunu Taraleu Scarp (also known as Suntaleo)
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and Tutuala Scarp (de Almeida 1967). Ian Glover (1972) also visited Lene Hara with John Mulvaney in 1967 and examined Almeida’s still open trench. He photographed the cave and some of the painted art (Glover 1972: 42).

O’Connor, Spriggs and Veth initiated the East Timor Archaeological Project in 2000 and carried out the first scientific excavation at Lene Hara, positioning a 1 × 1m test pit adjacent to Almeida’s excavation area, in the south chamber (Figure 2). This excavation produced Pleistocene-age deposits with cultural finds dating back to 35 000 BP comprising marine shellfish, animal bone and stone artefacts, and a thin upper layer that contained the same range of materials, as well as earthenware pottery (O’Connor et al. 2002). In 2002 three additional test pits were excavated revealing that different areas of the site had different occupational and chronological histories and that the site had a rich record of fauna and material culture spanning the Holocene, the Last Glacial Maximum (LGM) and terminal Pleistocene (O’Connor & Veth 2005; O’Connor & Aplin 2007).

Further research on the pigment art was also carried out which described the range of motifs, and supported Almeida’s earlier suggestion that the Lene Hara art displayed some distinct features that set it apart from the cliff-edge shelters of the same region (O’Connor 2003). Notable differences were the location of motifs, which in Lene Hara included...
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The petroglyphs were defined in two groups (A & B) carved into near vertical faces of speleothem columns located near the cave entrance (Figures 2 & 3). One group (A1–A3) is located on the inward-facing surface of an in situ remnant of the partially collapsed column at the cave entrance. There is no evidence of recent calcite accumulation on this column; to the contrary, its outer surfaces are extensively pitted and locally exfoliating. A second group of two petroglyphs (B1–B2) is located on an intact column (B) standing well within the dripline (Figures 2 & 3). The surface of this column is variable in character; some parts are discoloured and pitted, while others are fresher and unpitted, suggestive of more recent phases of calcite deposition. Column B sits upon a flowstone-covered pedestal.
that is slightly raised above the surrounding unconsolidated cave floor sediments. A third larger, intact column sits atop a more elevated, flowstone-covered platform (Figure 2). No petroglyphs were located on this column which appears subject to more widespread recent calcite accumulation. Columns at the rear of the cave are clearly active and display no pitting or discolouration.

Description of the petroglyphs
All the petroglyphs are frontal, stylised faces, and include eyes, noses and mouths and one (B1) has a circular headdress with rays, framing the face. Group A faces are carved on what appears to be a continuous sheet of calcite approximately 1cm thick (Figure 4). A few small areas show minimal weathering and remain essentially smooth but much of the surface is marked by discrete pits or deeply corroded through an aggregation of pits. The extent of weathering of the petroglyphs in Group A corresponds with the local degree of weathering of the surface and this observation suggests to us that the motifs were engraved into an essentially unweathered surface. The engraved calcite sheet is exfoliating on the right side of the panel and it is possible that part of an original panel has been lost. What remains are a minimum of three faces and a maximum of six, the three ambiguous motifs indicated on
the more weathered parts of the surface by suggestive linear alignments of pits and general symmetry of weathering features. If there are six faces in this cluster, they are aligned in two series of three, the upper series on a more vertical face and the lower series on a gently rounded bench.

Details are best preserved in face A1 (Figure 5) which is located in an area of minimal weathering. On this motif the nose and lips are outlined by a regular series of discrete pits, presumably formed by a drilling or pecking action. In contrast, the major outline of the face and the outer circle of the eyes are formed by more continuous grooves that enclose numerous pits of variable size. Some of these are probably due to subsequent weathering but it is possible that some are remnants of a two-part manufacturing process that involved drilling or pecking followed by abrasion to create a continuous groove.

The three definite faces in Group A are highly stylised. All appear triangular, being wide and flat at the top and pointed towards the chin. The clearest of the faces in Group A, A1, has the eyes formed from two concentric circles with a deep pecked hole in the centre of the inner circle (Figure 4). The outer circle of the eye socket extends into and forms a continuous line with the line forming the top of the head. The nose is a triangle and widest at the base. The mouth is oval with a deep linear groove placed centrally as if to show an open mouth. The chin area is indistinct due to weathering. The features of A2 are harder to determine. They seem generally similar to those on A1 but the face has two diagonal lines running from the base of the nose. A3 is too indistinct to describe the features other than to say the face is also triangular.
Column B features a clearly discernible ‘sun-ray’ face motif, B1, centred 1.6m above ground level on the north face (Figure 6), and a second very indistinct circular motif, B2, centred 1.7m above ground level on the south face. B1 is carved into the surface of a speleothem boss which has a lower fringe of small, finger-like lobes. The carved surface shows algal discoloration and is extensively pitted, the latter extending onto the lobules and clearly post-dating their formation. Little definite evidence remains of manufacture except to note that the shape of the nose is made using the intaglio technique whereby the stone is removed from the entire feature, leaving it in negative. Importantly, the incised surface is also irregularly pitted thus leaving little doubt that the weathering post-dates the creation of the motif.
The sun-ray face, B1, incorporates both curvilinear and rectilinear design elements. It is curvilinear in that the motif is constructed around a series of concentric circles. However, the rays dissecting the circles framing the face are rectilinear. While difficult to distinguish due to the severity of weathering, it appears that the face was originally ringed by three rayed circles. Only two are still clearly visible. The face is roughly circular but narrows towards the chin. The eyes are formed by concentric circles with deep horizontal linear grooves in the centre. The nose is triangular, wider at the base, and appears to extend to the edge of the inner circle framing the face. Two straight lines extend from either side of the nose, passing through the inner rayed circle, and making up part of the rayed infill. They may continue through the outer circle. The second motif of Group B, B2, has a diameter of approximately 30cm but was too indistinct to trace in the field or draw out from photographs. However, the circular shape and suggestion of radiating lines in the motif point to a greater degree of similarity with the sun-ray face B1, than any of the motifs in Group A.

**Dating the Lene Hara petroglyphs**

Samples of calcite were taken from columns A and B to establish a chronological context for the Lene Hara petroglyphs using U/Th determinations, reported with 2 sigma errors and shown in Table 1. A maximum age determination of 36.76±1.3 ka was established for the petroglyph Group A based on the age of the surface calcite (LH09-1-3c) on which the petroglyphs are carved. Ages of 29.4±0.53 ka and 39.62±1.2 ka for powder samples from the periphery (LH09-1-1) and the truncated top (LH09-1-2) of the speleothem mass respectively, indicates a complex growth history. The timing of calcite deposition occurred unevenly across the speleothem mass, with calcite continuing to be deposited at its periphery up to 10–7 ka after calcite deposition ceased at the truncated top and vertical surface on which the petroglyphs are carved.

Five high precision U-series age determinations were produced for Column B with the sun-ray face petroglyph. The lobe samples (LH09-2-1a and b) taken from the calcite fringe immediately below B1 returned ages of 13.72±0.16 ka and 12.63±0.22 ka indicating that growth of the fringe lobe spanned a period of at least 1000 years; the younger of the two dates is taken as a maximum age for the petroglyph. The sample (LH09-2-2a-c) from the fresh calcite sheet adjacent to B1 produced a tight cluster of three age determinations of 10.10±0.35 ka, 10.17±0.19 ka and 10.18±0.20 ka. This sheet thus appears to have formed quite rapidly. Although it did not directly overlap the petroglyph itself, removal of a small piece from the margin of the fresh calcite sheet demonstrated superimposition over the calcite layer into which the petroglyph is carved. Furthermore, the underlying calcite surface displayed an equivalent degree of weathering to that affecting both the carved surface and the petroglyph itself. Deposition of the sampled calcite sheet, which itself shows minimal pitting, thus appears to have taken place after the petroglyph was carved and subsequently weathered. These determinations are therefore thought to constrain the age of production of petroglyph B1 to within the period between c. 12.5 ka and c. 10.2 ka.
Table 1. TIMS U/Th isotopic data and ages reported with $2\sigma$ errors. Note: all errors are quoted at 2 s.d. Ratios in parentheses refer to activity ratios. All ages were calculated using Isoplot EX 3.6 program of Ludwig (2008) and decay constants of Cheng et al. (2000). All $^{230}$Th ages were corrected for the contribution of non-radiogenic $^{230}$Th assuming a non-radiogenic $^{230}$Th/$^{232}$Th atomic ratio of $4.40 \pm 2.2 \times 10^{-6}$ typical of fine-grained sediments. Samples LH09-ST2-2a to LH09-ST2-2c are three subsamples taken from the same thin sheet of calcite. Samples LH09-ST2-1a and LH09-ST2-1b are subsamples of the fringe lobe.

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Sample description</th>
<th>U (ppm)</th>
<th>$^{232}$Th (ppb)</th>
<th>($^{230}$Th/$^{232}$Th)</th>
<th>($^{234}$U/$^{238}$U)</th>
<th>($^{230}$Th/$^{238}$U) corr.</th>
<th>$^{230}$Th age (ka)</th>
</tr>
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<tr>
<td>LH09-ST1-1</td>
<td>Powder, from side of Column A</td>
<td>0.4599 ± 0.0006</td>
<td>16.43 ± 0.18</td>
<td>21.331</td>
<td>1.0275 ± 0.0011</td>
<td>0.2511 ± 0.0010</td>
<td>29.40 ± 0.53</td>
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<tr>
<td>LH09-ST1-2</td>
<td>Powder, from top of Column A</td>
<td>0.6119 ± 0.0007</td>
<td>49.47 ± 0.51</td>
<td>12.654</td>
<td>1.0514 ± 0.0015</td>
<td>0.3372 ± 0.0025</td>
<td>39.62 ± 1.2</td>
</tr>
<tr>
<td>LH09-ST1-3c</td>
<td>Piece, from vertical surface of Column A</td>
<td>0.3783 ± 0.0002</td>
<td>34.32 ± 0.21</td>
<td>10.495</td>
<td>1.0311 ± 0.0013</td>
<td>0.3138 ± 0.0010</td>
<td>36.76 ± 1.3</td>
</tr>
<tr>
<td>LH09-ST2-1a</td>
<td>Piece, from Column B fringe lobe</td>
<td>0.8141 ± 0.0009</td>
<td>8.497 ± 0.27</td>
<td>37.607</td>
<td>1.0690 ± 0.0017</td>
<td>0.1294 ± 0.0006</td>
<td>13.72 ± 0.16</td>
</tr>
<tr>
<td>LH09-ST2-1b</td>
<td>Piece, from Column B fringe lobe</td>
<td>0.8712 ± 0.0010</td>
<td>13.470 ± 0.023</td>
<td>24.058</td>
<td>1.0830 ± 0.0015</td>
<td>0.1226 ± 0.0007</td>
<td>12.63 ± 0.22</td>
</tr>
<tr>
<td>LH09-ST2-2a</td>
<td>Piece, from Column B fresh calcite sheet</td>
<td>1.5533 ± 0.0023</td>
<td>20.889 ± 0.086</td>
<td>23.011</td>
<td>1.1037 ± 0.0012</td>
<td>0.1020 ± 0.0007</td>
<td>10.17 ± 0.19</td>
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<tr>
<td>LH09-ST2-2b</td>
<td>Piece, from Column B fresh calcite sheet</td>
<td>1.6226 ± 0.0026</td>
<td>22.966 ± 0.098</td>
<td>21.932</td>
<td>1.1038 ± 0.0015</td>
<td>0.1020 ± 0.0006</td>
<td>10.18 ± 0.20</td>
</tr>
<tr>
<td>LH09-ST2-2c</td>
<td>Piece, from Column B fresh calcite sheet</td>
<td>1.6350 ± 0.0017</td>
<td>25.05 ± 0.11</td>
<td>20.153</td>
<td>1.1034 ± 0.0013</td>
<td>0.1020 ± 0.0013</td>
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Comparisons with pigment and petroglyph art in East Timor

Pigment art recorded previously, including that in Lene Hara cave, comprises a mixture of linear decorative motifs, anthropomorphic figures, boats, hand stencils and animals (O’Connor 2003; Lape et al. 2007). Most of the paintings utilise red ochre although black, yellow, brown, orange, white and even in one instance green pigments occur. The more complex of the designs and human figures incorporate more than one colour. Although anthropomorphs are the most common of all figurative motifs in the East Timor painted art corpus, they are predominantly small full body figures shown in profile or frontally (O’Connor & Oliveira 2007). Some figures are a composite of linear designs and human bodies such as the anthropomorph with a large scroll design in place of the head at Lene Hara (O’Connor 2003). Human faces are rare, but of the three known face depictions, two occur in Lene Hara cave and a third at a nearby shelter, Kurus. The Lene Hara painted faces are simple outlines in red pigment showing eyes, mouth and in one case a nose (Figure 7). The Kurus face has eyes, a nose and an elaborate headdress but no mouth (Figure 8).

Human heads made of wood, and occasionally coral and stone, were traditionally carved in East Timor and many are now in museum collections (Barrkman 2009). Although the precise function of these is uncertain, they are described in the literature as ‘masks’. They are hollowed out at the back of the face and usually have holes for attachments at the sides or a short handle below the chin. These masks are thought to have been worn by Timorese warriors in rituals associated with inter-clan raids and to have been worn into battle to obscure the face of the warrior and instil terror in the enemy (Barrkman 2009: 121). The masks were believed to embody the powers of the ancestors and could cause illness or even death (Barrkman 2009: 121). Some also incorporate carved decorative designs that may represent tattooing (Figure 9). Carved wooden and stone statues of men and women shown
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Figure 8. Kurus painted face (photograph by Sue O'Connor).

in frontal stance were also traditionally carved in East Timor and represent the ancestors. They are still made today on the island of Atauro and elsewhere in East Timor (Barrkman 2009: 115). At the eastern area of East Timor near Lene Hara Cave, ancestor posts with simple stylised features are carved by ritual specialists for placement on ceremonial platforms and graves where offerings are made to them (Barrkman 2009: 60–1; O’Connor pers. obs.). The antiquity of this carving tradition is unknown as no examples have been found in archaeological contexts.

Comparisons with petroglyphs elsewhere in Island Southeast Asia and the Pacific

Specht (1979: 63) was the first to identify the west vs east division between engraving and pigment art, noting that pigment art dominated in mainland Papua New Guinea and to the west in Island Southeast Asia whereas petroglyphs were more common to the east. Well known PNG mainland examples include the petroglyphs in the Sogeri area of Central Province, which include deep pits with central incisions, cupules, concentric motifs, rayed stars and anthropomorphs, and the geometric designs and scrolls found on boulders in Goodenough Bay (Rosenfeld 1988: 128, 130). Petroglyphs in the form of face designs have been reported on Umboi Island, Morobe Province (Wilson 2002: 60).

Petroglyphs are abundant in the Bismarck Archipelago, the Solomons, Vanuatu and New Caledonia (Rosenfeld 1988: 131) and include face-like forms (Specht 1979: 74). Face motifs in New Britain and New Ireland include the heavily carved faces with relief in New Britain (Wilson 2002: 66, 70). Wilson’s (2002: 154) quantitative analysis of petroglyphs in Vanuatu identified the ‘face’ as the most common figurative motif. Specht (1979) characterised the widespread body of engravings sharing a number of characteristics, in particular an emphasis
on curvilinear motifs, an association with open locations and water sources and a distribution corresponding with Austronesian language-speaking areas, as the Austronesian Engraving Style.
Petroglyphs are also extremely common in the eastern Pacific in the Marquesas, Hawai‘i, New Zealand and Easter Island and occur in Fiji. Hawai‘i for example has more than 70 petroglyph sites and some have over 20 000 individual motifs. Simple human face designs occur amongst the petroglyphs found in most of these areas (Lee & Stasack 1999: 164).

In Australia petroglyphs have a wide distribution, but human face motifs are relatively uncommon. Face motifs predominantly occur in a wide band across the arid zone, stretching from the Burrup Peninsula in the coastal Pilbara to the Cleland Hills in the central Desert, with a small outlier group at the Jalibang 2 site, over 1000km to the north of the Cleland Hills (McDonald 2005: 130). Remarkably, the Australian archaic faces show some similarities in form and manufacturing technique with the Lene Hara faces, particularly face A1. The Australian engravings are generally characterised by heart- or pear-shaped face outlines, with the eyes formed by small deeply pecked depressions which are surrounded by one or more concentric circles formed by pecking, or a combination of pecking and abrading. They have mouths and some also show the nose and ears. In some examples features are created using the intaglio technique. Rare examples with headdresses are also known (McDonald 2005).

**Chronology of rock art in Island Southeast Asia/the western Pacific**

**Pigment art**

Ballard (1992: 98) proposed that the painted rock art of his western Melanesian region, including Timor, shared a number of key locational and stylistic attributes which suggested shared origins. He also noted the high correlation between sites with pigment art and Austronesian language-speaking areas (however see O’Connor & Oliveira 2007). On this basis Ballard (1992: 98) suggested a maximum age for the art postdating the spread of Austronesian-language speakers into the region c. 3500 years ago, with an age of c. 2000 years BP more likely for the spread of the style to the eastern and western extremities of the region. Thus he coined the term the Austronesian Painting Tradition (APT) to describe the painted art across this region which shared these features (Ballard 1992). However, in areas with a long history of occupation, such as East Timor, there is no a priori reason why older art should not be found. Indeed there are indications of a much older rock art tradition in the region. Recent U/Th dating of layers of calcite sandwiching red pigment on a detached wall fragment from Lene Hara demonstrates that the practice of painting on walls extends back at least 30 000 years (Aubert et al. 2007). Early pigment art has also been found in Borneo where a programme of U/Th and radiocarbon dating has produced minimum ages of c. 9800 BP for a range of motifs (Plagnes et al. 2003). The dated motifs in Borneo are hand-and-arm stencils with decorative infill and have been suggested to have affinities with the rock art in northern Australia and New Guinea (Chazine 2005). The painted rock art in Leang Sakapao 1, Sulawesi, is also likely to be of Pleistocene-age based on the subject matter of the art itself and the age of the cultural deposits in the cave (O’Connor & Bulbeck in press). However, there has been little in the way of detailed analyses or direct dating of rock art undertaken to test this proposition.

Wilson and colleagues have carried out the only systematic dating programme in the western Pacific and it focused exclusively on Vanuatu. In 1997 Wilson sampled
carbon-bearing substances relating to a series of black hand stencils; the most common motif type in Vanuatu. All stencils were from Hopnarop (MK4) Cave on Malakula and indicated that this motif type was produced in the past 200–300 years and continued to be made as late as the 1950s (Wilson et al. 2001). A broader dating programme undertaken by Wilson and colleagues in 2000 acquired an additional 16 AMS dates (Wilson 2002: 170–2). Motifs dated include black pigment stencils of hands, a fish and a stick as well as black linear designs. Ages obtained ranged from 2200 ± 40 BP (OZE562) for a black hand stencil, to modern for a simple linear motif (Wilson 2002, vol. 2: fig. 7.3). These dates from Vanuatu confirm that pigment art was being produced by at least 2200 BP. On the basis of the dating results and the superpositioning of motifs, styles and colour, Wilson (2002) was able to propose a relative chronology for the art in Vanuatu. In essence the results of her statistical analyses and dating programme lent support to Ballard’s earlier proposition for the APT in relation to the earliest body of painted art, but demonstrated that over time art styles in Vanuatu diversified away from the design elements and other defining characteristics of the APT.

Petroglyphs

Petroglyphs usually present even more of a challenge for dating than pigment art. Petroglyphs are rare east of mainland New Guinea and there are no previously published dates for this art form in Island Southeast Asia. Williams (1931) described variability in patina on the PNG Sogeri petroglyphs and suggested that this indicated that they spanned a considerable time period. Rosenfeld (1988: 120) on the other hand, stated that ‘occurrence of engravings in the Melanesian islands on exposed limestone and other rock surfaces suggests that we may not be dealing with high antiquities.’

In the western Pacific, connections have been drawn between the designs on Lapita pottery and petroglyphs. These include the face motifs, the visual similarity in form between cupules and dentate impressions in pottery, the use of curvilinear designs, and stylistic traits such as concentricity (Wilson 2002: 210). The oldest dated petroglyphs in the western Pacific are from Northwest Guadalcanal where a buried cupule-based motif at Vatulumu Posovi was dated to c. 3000 BP (Roe 1992: 118, fig. 5). While on the one hand Roe (1992: 113) states that the find gives ‘some support to the putative association of rock art, or its designs, with Austronesian-speaking groups, including the bearers of the Lapita cultural tradition, in island Melanesia (cf. Ballard 1992)’; he also allows the possibility that the art predates the Lapita cultural tradition. The latter would seem to be a real possibility in view of the fact that the Solomons were settled in the Pleistocene and that the date of burial provides only a minimum age for the art. For the rest of the Pacific the age of the art is obviously constrained by the time period of human settlement – to the late Holocene.

As well as the stylistic similarities already noted, the Australian human face petroglyphs are the best candidates for being of a comparable age to those from Lene Hara. While no absolute dates have been obtained they are widely referred to as ‘archaic faces’ as they are heavily weathered, sometimes patinated and the substrate on which they occur is often geologically altered. Researchers documenting the Australian archaic faces have consistently
argued for their great antiquity, with McDonald (2005: 130) recently suggesting that a terminal Pleistocene age (c. 25 000–10 000 BP) seems likely for many of them.

Conclusion

Stylised faces occur as engraved motifs in Melanesia, Australia and throughout the Pacific. The age of the latter are constrained by the date of initial human colonisation to the late Holocene; however, the age of the face petroglyphs on the New Guinea mainland, the Bismarcks, and within Australia, is likely to be significantly greater. While we see no point in drawing stylistic comparisons between different media, separated by thousands of kilometres, the Lene Hara faces clearly demonstrate that this type of iconography and the techniques used to produce it have deep antiquity in Island Southeast Asia and the western Pacific, predating any Austronesian influence by almost ten thousand years.

Across the vast reaches of Island Southeast Asia are hundreds of islands with limestone caves and shelters. In most of these regions no archaeological survey has been carried out. That such a comparatively well known site as Lene Hara cave can produce a new discovery in 2009 hints at the potentially large numbers of art sites that remain to be discovered in this region. Finding, recording and dating this rock art should be a priority for future research.

Acknowledgements

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Technical note on uranium series dating procedure

Samples

Samples taken from column A were: LH09-1-3c, a loose piece from the margin of the exfoliating layer into which the petroglyphs are carved; LH09-1-1, a powder sample drilled from the left periphery of the speleothem mass; and LH09-1-2, a sample drilled from the truncated top of the column. These samples were expected to yield maximum ages for the petroglyphs on column A. The minimum age of this group of petroglyphs is probably constrained by the time of onset of surficial weathering of the engraved calcite layer. Unfortunately, at present we have no way of estimating the time of onset of the weathering.

For column B, two samples were taken in proximity to the sun-ray face petroglyph, B1. Sample LH09-2-1 (a and b) was taken from the inside of one of these lobes, immediately below B1, and is expected to produce a maximum age for petroglyph B1 and for the weathering of the surface. Sample LH09-2-2(a-c) was taken from the edge of a relatively unweathered calcite sheet that forms the outermost layer of the column to the immediate left of petroglyph B1. As such, the calcite sheet is expected to provide a minimum age for petroglyph B1 and samples LH09-2-1 and LH09-2-2 thus represent probable bracketing ages for production of this petroglyph.

Analytical procedures

Samples were crushed into 40-80 mesh with an agate mortar and a pestle and rinsed three times with Milli-Q H₂O. Samples were then ultrasonically cleaned in Milli-Q H₂O for 15 minutes and rinsed three to five times until water was clear. Weathered samples (LH09-1-3c) were ultrasonicated with 15% H₂O₂ for 20 minutes to oxidise organics and loosen clay minerals trapped in the sample micropores. This procedure was followed by five to eight rinses with Milli-Q H₂O to remove all clay minerals.

Chemistry preparations for thermal ionisation mass spectrometry (TIMS) U-series analysis of the samples are modified from Edwards et al. (1987) and Ludwig et al. (1992) and follow those described in Zhao et al. (2001) and St Pierre et al. (2009). In brief, weighed samples were dissolved with diluted HNO₃ after spiking with a ²²⁹Th-²³³U-²³⁶U tracer. Samples were refluxed at 70°C to ensure complete blending with spike tracer and H₂O₂ was added to destroy organics. Iron hydroxide was used to co-precipitate Uranium and Thorium and precipitates were dissolved with 7N HNO₃. Conventional anion ion-exchange column chemistry was used to separate Uranium and Thorium, which were loaded with graphite to single Re filaments for isotope measurement on a VG Sector 54 TIMS at the Radiogenic Isotope Facility, University of Queensland.