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Portable art from Pleistocene Sulawesi

Michelle C. Langley[1]✉, Budianto Hakim[2], Adhi Agus Oktaviana[3,4], Basran Burhan[1], Iwan Sumantri[5], Priyatno Hadi Sulistyarto[3], Rustan Lebe[6], David McGahan[1] and Adam Brumm[1]

The ability to produce recognizable depictions of objects from the natural world—known as figurative art—is unique to *Homo sapiens* and may be one of the cognitive traits that separates our species from extinct hominin relatives. Surviving examples of Pleistocene figurative art are generally confined to rock art or portable three-dimensional works (such as figurines) and images engraved into the surfaces of small mobile objects. These portable communicative technologies first appear in Europe some 40 thousand years ago (ka) with the arrival of *H. sapiens*. Conversely, despite *H. sapiens* having moved into Southeast Asia–Australasia by at least 65 ka, very little evidence for Pleistocene-aged portable art has been identified, leading to uncertainties regarding the cultural behaviour of the earliest *H. sapiens* in this region. Here, we report the discovery of two small stone 'plaquettes' incised with figurative imagery dating to 26–14 ka from Leang Bulu Bettue, Sulawesi. These new findings, together with the recent discovery of rock art dating to at least 40 ka in this same region, overturns the long-held belief that the first *H. sapiens* of Southeast Asia–Australasia did not create sophisticated art and further cements the importance of this behaviour for our species' ability to overcome environmental and social challenges.

The origin of modern cognition and the development of the resulting cultural behaviours constitutes a crucial and hotly debated issue in human evolutionary studies[1–3]. Approached using a variety of techniques and methodologies, manifestations of 'symbolic' behaviour have emerged as one of the only universally agreed upon forms of archaeological evidence able to provide direct insight into the changing cognitive capabilities of *Homo*[1,4–6]. Archaeological residues central to these investigations include used pieces of mineral colourants, objects of personal ornamentation (such as beads), and abstract and figurative images found both on rock-shelter walls and small fragments of bone, stone or other mobile artefacts[4].

Although *H. sapiens* moved into and through Southeast Asia (Sunda), Wallacea, and Australia–New Guinea (Sahul) at least 25 ka (refs. [7,8]) before the species penetrated Europe, the inventory of symbolic artefacts from this temporally and spatially expansive archaeological record has remained remarkably short until very recently. Most perplexing has been the apparent near-absence of a 'classic' Palaeolithic art form—portable artefacts depicting recognisable items from the natural world—drawing intensive attention from researchers[9–12]. Indeed, some authorities have used their absence in Sunda–Wallacea–Sahul to argue that the first *H. sapiens* of this region were less culturally 'advanced' than contemporary groups elsewhere in the Old World (especially Europe) and that traditions of material symbolic culture like portable art can be 'lost' when groups face challenging scenarios, particularly when colonising new environments[13,14].

Sulawesi is the largest island in the Wallacean archipelago (Wallacea), a biogeographically distinct region of oceanic islands spanning the divide between continental Asia (Sunda) and Australia (Sahul), and which in terms of faunal distributions represents a transitional zone between these separate landmasses. Formerly known as Celebes, Sulawesi is the world's eleventh largest island (~174,000 km^2) and is renowned among biologists for its complex history of in situ faunal evolution and extremely high rate of species endemism, especially among mammals. In Wallacea, ongoing archaeological research is uncovering and elucidating the diverse lifeways and symbolic material culture of the earliest modern human colonisers. In the southwestern peninsula of Sulawesi, in the near-coastal lowland limestone tower karst region of Maros, abundant archaeological evidence for these early human communities has been recovered[15], including at Leang Bulu Bettue (LBB), a cave and rock-shelter complex with abundant rock art (hand stencils) of a stylistic form recently dated in the Maros area to at least 39.9 thousand years ago (ka; ref. [16]; Fig. 1). It is at this site that the engraved stone artefacts described here were discovered.

Results

Archaeological context. At LBB, an annual programme of joint Indonesian–Australian excavations between 2013–15 and 2017–18 has revealed a long sequence of archaeological deposits, the uppermost portion of which is divisible internally and on stratigraphic and chronological grounds into two distinct human occupation phases: Phase II, historical (AD <1790) and Neolithic (1.7–1.6 calibrated (cal) ka BP); and Phase I, MIS 3/2 (~50–22 ka). Below the topmost Neolithic level, which is dated to 1.7–1.6 cal ka BP, are multiple thin layers of hard, flowstone-cemented sediment that, combined, reach a total thickness of ~1 m. This sequence of culturally sterile geogenic units is underlain by three distinct Pleistocene cultural deposits: a 1.5 m-thick sequence of archaeologically rich silty clays (Layers 4a–e) spanning 29.5–14 ka; and underlying a 50-cm-thick sandy clay layer (Layer 4f) preserved near the eastern wall of the cave and spanning 40–30 ka; and below Layer 4f, a 50-cm-thick sandy clay (Layer 5) containing sparse cultural remains and with an estimated age of ~50–40 ka (ref. [17]).

The two engraved stone artefacts described here were excavated in situ from the upper part of the stratified and undisturbed Layer 4a, a moderate yellowish brown (10YR5/4) slightly sandy 'mud' (silt, 50.3%; clay, 32.2%) that is up to 70-cm-thick and contains rich cultural and faunal assemblages. The high-precision U-series

[1]Australian Research Centre for Human Evolution, Environmental Futures Research Institute, Griffith University, Brisbane, Australia. [2]Balai Arkeologi Sulawesi Selatan, Makassar, Indonesia. [3]Pusat Penelitian Arkeologi Nasional (ARKENAS), Jakarta, Indonesia. [4]Place, Evolution and Rock Art Heritage Unit, Griffith Centre for Social and Cultural Research, Griffith University, Gold Coast, Australia. [5]Archaeology Laboratory, Hasanuddin University, Makassar, Indonesia. [6]Balai Pelestarian Cagar Budaya, Makassar, Indonesia. ✉e-mail: m.langley@griffith.edu.au

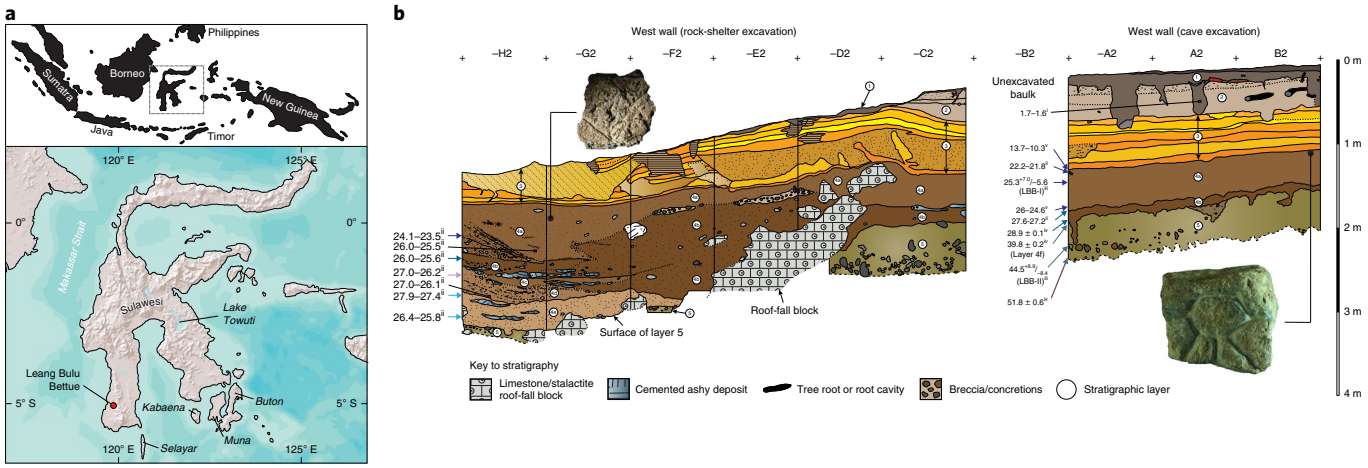

Fig. 1 | Find context of the two engraved plaquettes. a, Location of Leang Bulu Bettue in southwest Sulawesi. **b**, Locations of finds for the anoa and rayed-circle plaquettes. Dating methods used: (i) AMS radiocarbon (charcoal) in cal ka BP (95.4% probability); (ii) AMS radiocarbon (freshwater shell (*Tylomelania perfecta*)) in cal ka BP (95.4% probability); (iii) post-infrared stimulated luminscence (pIRIR) on feldspars; (iv) laser ablation U-series analysis of tooth; (v) solution U-series analysis of in situ stalagmite.

stalagmite chronology constructed for this portion of the depositional sequences allows us to bracket the time-depth of Layer 4a to between ~26 and 14 ka (refs. [17,18]). The minimum age for Layer 4a is based on a solution U-series date 13.7 ± 1.8 ka from the basal growth layer of a vertical, still-emplaced stalagmite that had formed on the upper surface of this sedimentary unit[17]. In an effort to more tightly constrain the age of Layer 4a, and given the lack of preservation of plant carbon in the deposit, accelerator mass spectrometry (AMS) ^{14}C-dating of freshwater gastropod (*Tylomelania perfecta*) shells and laser ablation U-series dating of a pig tooth were conducted[17]. Also carried out was AMS ^{14}C-dating on two *T. perfecta* shells collected from laterally continuous exposures of Layer 4a revealed by excavations inside the adjoining rock-shelter. These three independent dating methods indicate a maximum age of ~26–22 ka for Layer 4a and the material culture recovered from that context. Specific details of the dating methods described here, and further dating evidence for Layer 4a and underlying strata, are provided elsewhere[18].

Excavations in Layer 4a and underlying units conducted in 2015 and 2017–18 have yielded a diverse range of symbolic material culture from the levels dating to around the time of the last glacial maximum (LGM); in particular, utilized colourants, a possible pigment blowpipe for rock art creation, tool-stone with incised cortex, a bear cuscus phalange pendant and babirusa tooth disk-shaped beads[18]. Apparent examples of geometric 'portable art' previously recovered from the Pleistocene levels include small knapped chert artefacts ($n = 4$) and a fragment of limestone incised with arrangements of lines forming abstract patterns. Until now, however, figurative portable artworks have been absent. Current evidence suggests that this collection of symbolic artefacts was produced by the Pleistocene foraging group responsible for creating the dated parietal rock art (hand stencils and figurative animal paintings) in the karst caves and shelters of the Maros region. Despite increasing investigations throughout Wallacea and adjacent areas, the assemblage of LBB remains unique both for its diversity and richness of early symbolic material culture, raising questions about its role in the wider social landscape of Maros and Pleistocene Wallacea generally.

The engraved plaquettes. The first engraved stone plaquette was excavated from Layer 4a in 2017 (Fig. 1). It consists of a flat fragment of flowstone with maximum dimensions of 54.6 mm in width, 51.7 mm in length and 13.4 mm in height (weight = 47.7 g). The object is roughly square-shaped in plan form and, despite having suffered from post-depositional processes causing particulates to begin dissolving, anthropogenic alterations remain clearly identifiable and are restricted to one face. Stone tools are identified as the instruments used to make the image, as deduced from the characteristic V-shaped cross-section with internal linear striations clearly visible within the 17 artificial incisions (Fig. 2).

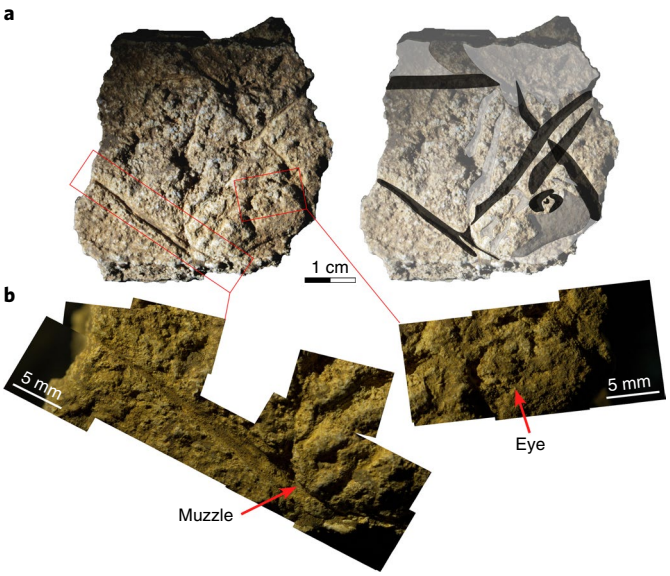

Fig. 2 | Stone plaquette featuring the engraved depiction of an endemic anoa (*Bubalus* sp.). a, Macrophoto of the plaquette is overlaid with tracing of the incised and sculpted areas. Dark grey indicates the deepest incisions, light grey the lowered areas. **b**, Microscope composites documenting examples of characteristic stone tool-made incisions and carved areas. Each composite image with the photographs was taken at ×12.6 magnification.

A single graphic element covers most of the surface of the small stone slab and depicts the head of an endemic anoa shown in left profile, turned back towards its flank. Anoas (*Bubalus* sp.) are dwarf bovids found only on Sulawesi[19]. They are the smallest of the world's extant wild cattle[10]. The taxonomic status of anoas is still debated;[19,20] however, these distinctive bovids with stout and rounded bodies[21]

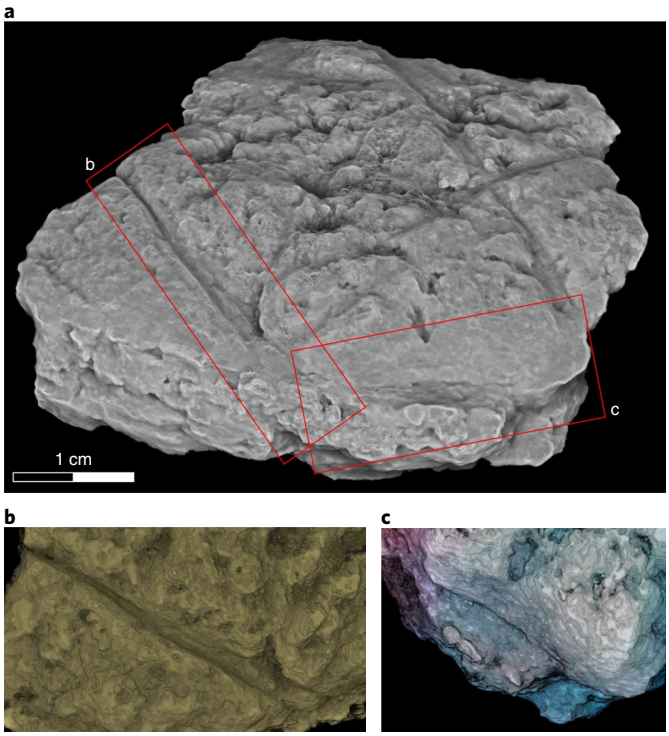

Fig. 3 | Micro-CT imaging of the anoa plaquette. a, Whole plaquette inclined at a 10º angle. **b**, Incised groove creating underbelly. **c**, Sculpting of jaw and cheek area.

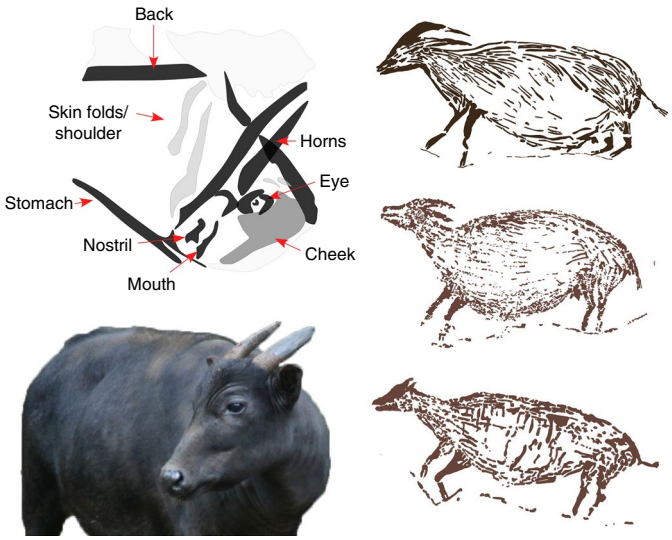

Fig. 4 | Anoa in Sulawesi Pleistocene art. Typical paintings of anoa in the Maros kasts of south Sulawesi (right; top painting has been flipped horizontally for comparison purposes). The LBB plaquette depiction (top left) shares stylistic choices observed in the painted versions: the face and back horn are drawn using one continuous thick line, the muzzle is trapezoidal and divided in two by a line representing the mouth and the skin/body of the animal is shown using undulating lines. For comparison, a photograph of an anoa in the same perspective depicted on the plaquette is shown bottom left. Credit: Photograph reproduced with permission from Zoo Leipzig.

and short limbs are separated on the basis of morphological characters and geographical distribution into two species: lowland anoas (*B. depressicornis*) and mountain anoas (*B. quarlesi*)[19,20]. The former, as the name suggests, predominately inhabit low-lying areas. *B. depressicornis* is the largest species, with adults measuring 60–100 cm at the shoulder and attaining a body mass of <300 kg (ref. [20]). Adult males are relatively hairless and tend to be black in colour with whitish to yellow limb markings. The horns on mature individuals are long (271–373 mm in males), straight to slightly curved, and backwardly directed, with a rugged texture[19,21]. Mountain anoas are about half the size of lowland anoas in terms of body mass (<150 kg) and usually, but not always, show a different pelage in the form of a fairly thick and wooly, black to brownish coat[20]. *B. quarlesi* favours undisturbed rainforest habitats and is mostly found in the mountainous terrain (up to 2,300 m above sea level) that characterises much of Sulawesi's rugged interior[20]. Adult horns of *B. quarlesi* are shorter and smoother than in *B. depressicornis* and differ in cross-section morphology (they are conical in shape rather than triangular, as in lowland anoa). Although small, anoas of both species are widely reputed to attack fiercely when disturbed. Recent investigation of pre-World War Two Dutch archaeological assemblages from Holocene cave sites in South Sulawesi suggests the existence of an earlier, now-extinct anoa (*B. grovesi*) that was about 30% larger in body size than *B. depressicornis*[22]. However, this species has been proposed on the basis of fragmentary fossil remains and its appearance relative to the two living anoas is poorly known.

Our identification of the engraved motif as an anoa is based on the resemblance not only to living animals today (notably, the elongated skull, large eyes, prominent muzzle with flaring nostrils, two slightly curved horns and wrinkled neck skin) but also the similarities of the engraved image to the paintings of anoas which are a striking feature of dated Pleistocene rock art in Maros and elsewhere in the southwestern peninsula of Sulawesi (Fig. 4 and Supplementary Fig. 10–12). Other artiodactyls depicted in Sulawesi's Pleistocene parietal art and which also feature long skulls include the babirusa (*Babyrousa* sp.), a primitive and endemic suid, and Sulawesi warty pig (*Sus celebensis*). Neither of these wild suids has horns, however, and as there were no other horned animals present on the island in the past 30 ka, the anoa is the only viable candidate. Further narrowing of the species depicted (inferring whether the subject represented may be the lowland (*B. depressicornis*) or mountain (*B. quarlesi*) anoa in particular, or even the putative, extinct *B. grovesi*) is hampered by the restrictions of the raw material, state of taphonomic deterioration of the piece and morphological similarities between the species.

Given the probable importance of anoas as a food (and possibly raw material) resource to Sulawesi's early modern human populations, it should not be surprising that this animal was selected for depiction in visual art. That this piece was not part of an image originally engraved into the wall of LBB (and is then simply a fallen piece of parietal art) is clearly evident from the size and composition of the image, which essentially follows the natural outline of the small stone slab.

The artist created the image of the anoa's head (36.8 mm long) by scoring a single line to delineate the top of the head and right horn, a stylistic choice also used in the rock wall paintings of this species (Figs. 2–4). The muzzle and cheek are sculpted, providing three-dimensional detail to the face (Figs. 2 and 3). The area under the chin and cheek has been lowered by scraping away at the surface of the flowstone, as have two areas at the top of the plaquette (shown in light grey in Fig. 2). Interestingly, while the area under the chin/cheek has been levelled out, the two areas at the top of the plaquette show grooves and undulations, perhaps suggesting that the piece was left unfinished. Facial features were carved into the stone, including a curved line for the mouth and nostril, which is anatomically correct. The eye is made up of three curved incisions—one starting at the left and moving up and to

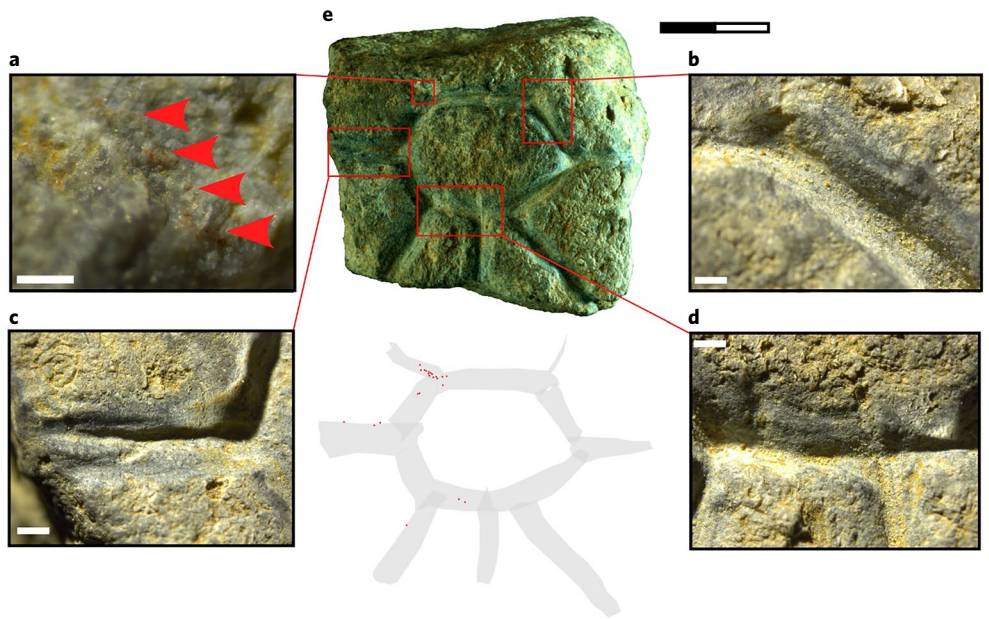

Fig. 5 | Engraving of a rayed circular form. a–e, The tracing shown below the artefact in the middle (**e**) indicates where each incision overlapped as well as the location of red colourant traces (red dots). **a**, Red colourant traces. **b–d**, Examples of line details showing characteristic lithic tool marks. Scale bars, 1 mm (**a–d**) and 1 cm (**e**), with photographs taken at magnifications ×32 (**a**), ×20 (**b**), ×12.6 (**c**) and ×12.6 (**d**).

the right to create the top of the eye. The second incision is oriented in the opposite direction, creating the bottom of the eye, while a third small c-shaped notch in between these two lines depicts the pupil. Just above the eye, a brow-line moving over the nose has been carved. The left horn (again depicted using a single line made through repeated drawing of a stone tool over the stone surface) is thicker at the horn base and tapers to a point finishing at the right edge of the plaquette. The flank of the animal is outlined by three deeply cut lines, creating an arched back and flat stomach. No legs are visible, although two scalloped lines on the neck area suggest wrinkled skin, a distinctive characteristic of anoas (see Supplementary Figs. 10 and 11), or the right shoulder. Photographs of live anoas standing towards the viewer with their head turned to the side (as in Fig. 4) provide a common perspective from which this animal would be viewed and reveals careful attention to detail and skill in the executed artwork (Supplementary Fig. 12).

The second engraved stone plaquette was excavated in situ from the upper surface of Layer 4a in 2018 (Fig. 1). It is made on a small, angular piece of fine-grained limestone and has maximum dimensions of 29.5 mm in width, 50.3 mm in length and 27.2 mm in height (weight = 57 g). As with the first artefact, the motif covers only one side of the stone. Seven deeply incised lines emanate from a central, facetted, oval form that dominates the engraved image (Fig. 5). The radiating lines and those comprising the circle-like form in the centre are all deeply etched (~2 mm) into the stone surface, with striations from the repeated use of a stone burin-type edge clearly evident in their cross-section profiles (Supplementary Fig. 16). The circumference of the oval has been further altered, with its distal edge bevelled-off to produce a rounded appearance to this central focal point. Microscopic examination of the initiation and termination of each incision found that the oval was inscribed in a clockwise direction. The 'rays' were then added to the image. A red mineral residue is visible within the incisions located on the left side of the motif (Fig. 5), suggesting that the image was traced or painted over with red pigment, perhaps to more clearly distinguish the incised lines—no red pigment residue was observed on any other part of the artefact surface.

This artefact differs notably from the decorated tool-stone pieces previously reported for LBB[18]. Specifically, the images found on the cortex of four stone flakes and a fragment of limestone are extremely shallow, being created with a single draw of a sharp edge across the surface and the designs consist of single oblique lines, consecutive parallel lines, or crosses. These geometric 'sketches' are difficult to see without the help of a directed light source and traces of colourant are only found on the working edge of one of the flakes (suggesting that it was used to produce ochre powder)[18]. No evidence for the tracing or smearing of ochre over these linear designs is present. Thus, the deeply engraved and red-traced image in a form commonly referred to as a 'sun-burst' or 'rayed-circle' in rock art studies[23–28] is strikingly different from the shallow cortex markings.

'Sun-burst' patterns in rock art are widespread both temporally and spatially being observed in both pictographs and petroglyphs across the Australian, African and American continents[23–28]. While researchers usually go to some effort to clarify that the meaning of such rayed motifs are essentially unknown, interpretations are proffered based on consultation with indigenous communities and range from celestial entities such as the Sun (or other stars) to small animals such as a starfish[23,25]. Given that the LBB artefact has been carefully crafted (unlike the faintly incised, non-figurative markings found on cortical surfaces of some artefacts), has been traced over with a red colourant, and is a form widely acknowledged to represent a physical entity (whatever that may be), we argue that it probably constitutes a second example of portable figurative art at this site.

Discussion

Portable art may be central to the effective linking not only of people with technology but also of people with people, a behaviour that is argued to have allowed *H. sapiens* to out-perform (or at least outlast) archaic hominin populations wherever they encountered them across the Old World[29,30]. Images facilitate the storage and communication of huge amounts of information, supporting increased efficiency in information transmission between individuals, groups and generations[29,31]. Indeed, information flow is proposed to have been essential to the successful colonization of new

landscapes[29,32–34], through allowing groups of 'explorers' (populations or communities moving into previously uninhabited environments) to maintain contact with ancestor populations while simultaneously building strategies to move through and exploit novel resources and habitats[35].

The appearance of abstract, but in particular, figurative images, in the archaeological record is generally agreed to attest to the presence of a modern human mind, and consequently the complete absence of portable versions of such realistic art from Pleistocene Southeast Asia–Wallacea–Australia has drawn intensive attention and debate[9–12]. Controversially, researchers have inferred that this region was either left behind or left out of the 'human revolution' occurring in Africa and Eurasia during the Late Pleistocene[36]. Indeed, there has been much centred around how such a key modern behaviour could seemingly disappear, and whether the stress of moving into and through new environments could result in great cultural and technological losses[13,14]. From the LBB plaquette finds, it is now evident that the apparent absence of portable images along the southern arc route towards Sahul does not reflect the inability to conceive of or use this particular communicative technology (owing either to the inability to do so from a cognitive perspective, or the loss of knowledge of this form of symbolic expression within colonizing populations) but is rather owing to a host of other factors, including researchers simply not having attained large enough sample sizes to find these almost invariably rare archaeological objects[9,11].

Artworks such as these—small enough (palm-sized) to be portable and depicting recognizable images of empirical categories from the natural world—were previously assumed to have been a unique and characterizing feature of Upper Palaeolithic Europe (beginning in the Aurignacian)[30,37,38] and, to a lesser extent, early modern human cultures in the Levant, where the earliest example is dated to ~23–16 ka (ref. [33]; see Supplementary Fig. 18). In Pleistocene African contexts, despite the deep evolutionary history of *H. sapiens* on this continent, the oldest known instance of figurative portable art only dates to ~27.5 ka (refs. [39,40]). Thus, the LBB plaquettes of Indonesia are comparable in age to the earliest examples from Levant and Africa, but most importantly, they are the first of Pleistocene age anywhere in the extensive Southeast Asia–Wallacea–Australia region.

Furthermore, the anoa plaquette is, as far as we are aware, the only other Pleistocene-aged use of the bas-relief method in image creation outside of Europe. Bas-relief, an advanced method of image creation through carving away or adding material to make a figure more prominent than its background, first appears in Aurignacian Europe some 40–35 ka (refs. [41,42]). Continuing in use throughout the European Upper Palaeolithic, its appearance in Sulawesi ~26–13 ka represents a distance of at least 11,000 km from its closest comparisons at similar time periods. Notably, there are several other similarities between the LBB anoa plaquette and broadly contemporaneous pieces from Western Europe. Specifically, the uneven treatment of the head (more detailed) as against the flank (only preliminarily sketched out) is an occurrence found for several animal representations from Upper Palaeolithic contexts, including a well-known bison depiction recovered from the French Pyrenean site of Isturitz (Supplementary Fig. 19)[42]. Another similarity is the choice of depicting the animal with its head turned back towards its rump. This posture is found on several famous artefacts dating to the Magdalenian period (21–14 ka cal), notably the 'licking bison' from La Madeleine (Dordogne, France) and 'ibex with bird' spear-thrower-butt series from Bédeilhac, Isturitz and Mas d'Azil (French Pyrenees)—all made on reindeer antler (Supplementary Fig. 17).

While of note, these similarities clearly do not provide grounds for repeated long-distance contact between European Palaeolithic communities and those located in Island Southeast Asia. Instead, these similarities could reflect independent but coinciding artistic developments in Western Europe and Sulawesi, in which case the role of changing environments (the LGM) and increasing population densities in how humans internalize, communicate and interpret the world around them requires further academic attention. If these similarities did, in fact, constitute evidence for connections between the east and west of the Eurasian continent around the time of the LGM, such information would have important ramifications for understanding human technological developments.

While it has become well established that behavioural plasticity was essential for the successful dispersal of our species around the globe[43], it is also apparent that producing mobile imagery (combining visual and tactile memory cues) was an important strategy for carrying modern communities through stressful social and environmental conditions. The ability of figurative art to coalesce and transmit enormous amounts of information gathered across generations is a powerful technology, driven by a distinctively human form of cognitive behaviour. It now seems that modern humans in Sulawesi around the time of the LGM used these tools to understand and mould their environment and themselves, in a manner that is similar to their counterparts in Palaeolithic Eurasia.

Methods

These artefacts were recovered during the 2018 field season at LBB (Sulawesi) and were taken to Griffith University (Nathan campus, Brisbane, Australia) for analysis. There, macrophotography of each artefact was undertaken using a Canon digital SLR camera, with these photographs serving as the basis for tracings and illustrations. A Zeiss Stemi 508 stereomicroscope fitted with an Axiom 105 camera was used to examine all surfaces of the artefacts. Measurements and photography used the Zeiss 'Zen' (Blue Edition) software. Photographs taken on the Zeiss were stitched together using the Canvas XII illustrating software. Micro-computed tomography (micro-CT) images were created by the X-ray Computer Tomography Laboratory, operated by the Department of Applied Maths at the Australian National University (ANU, Canberra). The X-ray detector is a 16-bit, scintillator-coupled 3,040 × 3,040 pixel CCD camera mounted on a linear rail. The radiographic data were translated with the ANU Supercomputer facility and rendered with Drishti software. Gross artefact metrics were obtained using Mitutoyo CD-6″ CX digital calipers, their metal arms coated with a thin plastic layer to protect the artefacts from scratches.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The artefacts reported here are currently curated at the Australian Research Centre for Human Evolution, Griffith University, Nathan, Australia. They will return to Indonesia at the conclusion of the project where they will be given accession numbers and be curated in Makassar by Balai Arkeologi Sulawesi Selatan.

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Author contributions

A.B. directed the excavation of LBB with B.H., A.A.O., B.B., I.S., P.H.S. and R.L. acting as counterparts and collaborators on the investigation of the Sulawesi sites being explored. D.M. created the micro-CT images included in this manuscript. M.C.L. undertook the qualitative and quantitative analysis of the presented artefacts. M.C.L. and A.B. wrote the manuscript, with contributions from the other authors.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to M.C.L.

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Data collection	Zeiss Stemi 508 stereomicroscope fitted with an Axiom 105 camera using the Zeiss "Zen (Blue Edition)" was utilised to examine and measure features of interest on both artefacts.
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The artefacts reported herein are currently curated at the Australia Research Centre for Human Evolution, Griffith University, Nathan, Australia. They will return to Indonesia at the conclusion of the project where they will be given accession numbers and be curated by in Makassar by Balai Arkeologi Sulawesi Selatan.

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Study description	Examination and analysis of archaeological samples -- stone artefacts -- using a qualitative analysis of anthropogenic features.
Research sample	High-resolution study of two artefacts -- only examples bearing figurative engravings thus far recovered from excavations in Sulawesi by Adam Brumm.
Sampling strategy	These two artefacts are currently the only examples bearing figurative engravings thus far recovered from excavations in Sulawesi by Adam Brumm -- therefore both were extensively examined.
Data collection	These artefacts were recovered during the 2018 field season at Leang Bulu Bettue (Sulawesi), and were taken to Griffith University (Nathan campus) for analysis. There, macrophotography of each artefact was undertaken using a Canon digital SLR camera, with these photographs serving as the basis for tracings and illustrations. A Zeiss Stemi 508 stereomicroscope fitted with a Axiom 105 camera was used to examine all surfaces of the artefacts. Measurements and photography utilised the Zeiss "Zen" (Blue Edition) software. Photographs taken on the Zeiss were stitched together using the Canvas XII illustrating software. MicroCT images were created X-ray Computer Tomography laboratory, operated by the Department of Applied Maths at the Australian National University (Canberra). The X-ray detector is a 16-bit, scintillator-coupled 3040x3040 pixel CCD camera mounted on a linear rail. The radiographic data were translated with the ANU Supercomputer facility, and rendered with Drishti software. Gross artefact metrics were obtained using Mitutoyo CD-6" CX digital calipers, their metal arms coated with a thin plastic layer to protect the artefacts from scratches.
Timing	The 2018 Sulawesi excavation began on the 9th July 2018, with the in laboratory analysis completed in early June 2019.
Data exclusions	No data was excluded from this analysis.
Non-participation	NA
Randomization	NA

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