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Earliest known hominin activity in the Philippines by 709 thousand years ago

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Abstract

Over 60 years ago, stone tools and remains of megafauna were discovered on the Southeast Asian islands of Flores, Sulawesi and Luzon, and a Middle Pleistocene colonization by Homo erectus was initially proposed to have occurred on these islands. However, until the discovery of Homo floresiensis in 2003, claims of the presence of archaic hominins on Wallacean islands were hypothetical owing to the absence of in situ fossils and/or stone artefacts that were excavated from well-documented stratigraphic contexts, or because secure numerical dating methods of these sites were lacking. As a consequence, these claims were generally treated with scepticism. Here we describe the results of recent excavations at Kalinga in the Cagayan Valley of northern Luzon in the Philippines that have yielded 57 stone tools associated with an almost-complete disarticulated skeleton of Rhinoceros philippinensis, which shows clear signs of butchery, together with other fossil fauna remains attributed to stegodon, Philippine brown deer, freshwater turtle and monitor lizard. All finds originate from a clay-rich bone bed that was dated to between 777 and 631 thousand years ago using electron-spin resonance methods that were applied to tooth enamel and fluvial quartz. This evidence pushes back the proven period of colonization of the Philippines by hundreds of thousands of years, and furthermore suggests that early overseas dispersal in Island South East Asia by premodern hominins took place several times during the Early and Middle Pleistocene stages. The Philippines therefore may have had a central role in southward movements into Wallacea, not only of Pleistocene megafauna, but also of archaic hominins.

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Earliest known hominin activity in The Philippines by 709 thousand years ago.

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More than 60 years ago, stone tools and mega fauna remains were discovered on the Southeast

Asian islands of Flores, Sulawesi and Luzon, and a Middle Pleistocene colonization by *Homo erectus* **was initially proposed for these islands[1-4]. However, until the discovery of** *Homo floresiensis* **in 2003, claims for the presence of archaic hominins on Wallacean islands were hypothetical due to the absence of** *in situ* **fossils and/or stone artefacts excavated from well-documented stratigraphic contexts, or because secure numerical dating methods of sites were lacking. As a consequence, these claims were generally treated with scepticism[5]. Recent excavations at Kalinga in the Cagayan Valley of northern Luzon in The Philippines have yielded 57 stone-tools associated with an almost complete disarticulated skeleton of** *Rhinoceros philippinensis* **showing clear signs of butchery, together with other fossil fauna remains attributed to stegodon, Philippine brown deer, fresh-water turtle and monitor lizard. All finds originate from a clayey bone bed dated to between 777 thousand and 631 thousand years ago using electron-spin resonance method applied on tooth enamel and fluvial quartz. This evidence pushes back the proven period of colonization[6] of The Philippines by hundreds of thousands of years, and furthermore suggests that early overseas dispersal in Island South East Asia (ISEA) by premodern hominins took place several times during the Early and Middle Pleistocene[1-4]. The Philippines therefore may have played a central role in southward movements into Wallacea, not only of Pleistocene mega fauna[7], but also archaic hominins.**

The most recent recoveries in Flores[8,9] and Sulawesi[10] (Indonesia) provide a unique documentation of over-seas hominin dispersal during the early Middle Pleistocene. An early presence in The Philippine archipelago has been speculated since the 1950s, with the reporting of presumably Pleistocene mega-faunal remains and 'Palaeolithic' industries consisting of chopping-tools and flakes (the 'Cabalwanian' and 'Liwanian' Industries respectively) from surface finds and excavations in the Cagayan Valley basin of northern Luzon[3,4]. Despite the fact that these early discoveries took place more than 60 years ago, no direct association between mega-fauna and lithic industries has ever been documented since then, and no secure numerical dating of both fossil fauna and lithics has been available for this region[11]. To date, the discovery of a human metatarsal in Callao Cave in northern Luzon[6], directly dated at 66.7 ± 1.0 ka, represented the oldest evidence for the peopling of The Philippines.

In 2013, a survey of the Cagayan Valley near the Rizal Municipality (Kalinga Province) led to the discovery of a concentration of vertebrate bones and stone artefacts scattered on the surface near what became our new excavation site. The Kalinga site (17°33'45.0318"N; 121°33'35.7372"E) (Fig. 1,b) has been excavated annually since 2014 and has resulted in the discovery of *in situ* mega-fauna and associated stone artefacts. The substrate consists of the upper part of the Awidon Mesa Formation, a 400m thick sequence of alluvial stream deposits (mainly sandstones and claystones) intercalated with volcaniclastic and pyroclastic layers (Fig. 1a). These sediments were deposited on an alluvial fan system in braided streams of the paleo-Chico River as a consequence of uplift in the Central Cordillera to the west[12,13]. During a poorly constrained Pleistocene phase of folding in response to east-west compression, alluvial fan deposition in the Kalinga area came to a halt.

We conducted the main 16m² excavation at the head of a modern, dry stream valley, north of a small hill and down to a maximum depth of 2m (Fig. 1c, see Supplementary Information: excavation methods and Sedimentology). A 25m x 1m slot trench was excavated down the hill to the Main Excavation. Together, these excavations revealed a total of 7.5m of stratigraphy comprising four main sedimentary units, in ascending order: Unit A, Unit F, Unit G and Unit J (Fig. 1d,e; Extended Data Fig. 1). An almost complete disarticulated skeleton of *Rhinoceros philippinensis* (Extended Data Fig.2) was found embedded in the basal sediments of Unit F lying across the base of an erosional channel surface that cuts down vertically into sandy Unit A. This channel was filled with an up to 3.25m thick mudflow (Unit F; see Extended Data Fig. 3 and 4), which covered the bones, along with an *in situ* tektite as well as 57 stone-tools and sparse fossils of other animals (Geoemydidae, *Varanus* cf. *salvator*, *Stegodon* cf. *luzonensis* and *Cervus* cf. *mariannus*) (see Supplementary Information: Faunal analysis). The archaeological layer (Unit F) is conformably overlaid by a ~1.15m thick, sterile, cross-bedded coarse sandy fluvial unit with silty lenses (Unit G), which is in turn conformably overlaid by Unit H, a 2.5m thick silty pedogenised layer with rhyzoliths.

The 57 stone artefacts account for six cores, 49 flakes and two possible hammer stones, all originating from Unit F (Fig.2, see Supplementary Information: Lithic analysis). With the exception of the two possible hammer stones (Fig.2b), all artefacts lack a patinated lustre and have a fresh appearance, indicating that any transport was minimal. The knapping strategies were oriented towards short and unorganized core reduction, resulting in non-standardized flake morphologies and dimensions, and all artefacts were lacking any intentional retouch. The Kalinga lithic assemblage is diverse in its techniques, technology and final products, and appears similar to the chert industry described at Arubo 1 site[14] (See Supplementary Information: Lithic technology). Also recovered from the Unit F excavation area was a 600g pebble among hundreds of pebbles all lighter than 200g, and which we interpret as a possible manuport.

Among the more than 400 bones recovered from Unit F, the most striking remains are a disarticulated, ~75% complete skeleton of a single *Rhinoceros philippinensis* individual (Fig. 3; Extended Data Fig. 2). The bones were found lying on top of the erosional surface down-cutting Unit A, and were embedded in the basal clayey sediments of Unit F along the deepest part of the paleo-channel bed (Extended Data Fig. 3). Although none of the rhinoceros bones were found articulated, the recovered skeletal elements occur within a 3m x 2m area, suggesting that disarticulation occurred sub-aerially and that transport prior or during deposition of mudflow Unit F was minimal. Thirteen of the excavated rhino bones, all of which in life had a thin cover of soft tissue (i.e. the ribs and metacarpals)[15,16], display cut marks (Fig. 3; Extended Data Fig. 2). Both rhinoceros humeri have similar percussion marks on the anterior surface for the right humerus and on the posterior surface for the left humerus, and both were presumably made with the intention to smash the bones and gain access to the marrow[17]. This percussion action resulted in the breakage of the left humerus into five pieces, which is the only bone found fragmented – and yet the fragments were still clustered together within a small 1m^2 area of the excavation. On the right humerus, however, percussion did not result in fragmentation of the bone (Fig. 3).

To constrain the age of the bone-bed and the stone artefacts it contained, we applied three different dating methods to various materials (Fig. 1). Single crystal ^{40}Ar/^{39}Ar dating was applied to plagioclase crystals from the sandy units directly below and above the archaeological Unit F and yielded two statistically undistinguishable weighted mean ages of 1050 ± 28 ka and 1007 ± 29 ka, respectively (1σ confidence interval) (see Supplementary Information: ^{40}Ar/^{39}Ar dating and Extended Data Fig. 5). These ^{40}Ar/^{39}Ar dates yielded an age for the formation of the volcanic plagioclase crystals. Quartz grains from the same two sandy units were also dated using the Electron Spin Resonance (ESR) method[18], and resulted in a maximum depositional age of 727 ± 30 ka for the deposition of Unit A, and a minimum depositional age of 701 ± 70 ka for Unit G (1σ confidence interval) (see Supplementary Information: ESR dating). To directly constrain the age of the rhinoceros skeleton and the cut-marks, we applied ESR/uranium-series dating on the enamel of the rhinoceros's right maxillary third premolar from the Unit F bone-bed. The tooth yielded an age of 709 ± 68 ka (1σ confidence interval), which is in agreement with the ESR results on quartz (Fig. 1; see Supplementary Information: ESR-uranium series dating, Extended Data Fig. 6, Extended Data Table 1 and Supplementary Information Table 1). In addition, a palaeomagnetic sample was taken from a laminated silty lens in the lower part of Unit G and was found to have a normal magnetic polarity (see Supplementary Information: palaeomagnetic dating and Extended Data Fig. 7). The presence in Unit F of a reworked Australasian tektite (see Supplementary Information: Non-destructive characterization of the tektite, Extended Data Fig. 8), which was formed during a major meteoritic impact just before the onset of the Brunhes Normal polarity epoch at 781 ka[19,20], also provides further support for these closely grouping dating results. These results further suggest that the volcanic plagioclase crystals from unit G on which the ^{40}Ar/^{39}Ar date was obtained were reworked from older volcanoclastic deposits, and therefore provide a maximum age for the sequence (see Supplementary Information: Sedimentology). Taken together with the ESR dating results, it follows that the rhinoceros skeleton was buried by a mudflow at least 631 thousand years ago.

Our excavations at Kalinga and the numeric dating results clearly provide the first securely dated evidence for human colonization of The Philippines by the early Middle Pleistocene, and long before the appearance of modern humans in both the local context and wider ISEA region[21]. Although the identity of these archaic toolmakers remains unknown, it is likely that they dispersed over at least one sea barrier to reach Luzon Island[22]. The most likely points of origin are Borneo through Palawan to the west, or China through Taiwan to the north, this latter island being connected to mainland Asia during periods of low sea-level[23]. The Middle Pleistocene fauna from the Awidon Mesa Formation contains a wider range of vertebrates than the Pleistocene faunas from two islands to the south of The Philippines that have both yielded evidence for the occupation by premodern humans, Sulawesi[9] and Flores[26] (Extended Data Fig. 9). Overseas dispersal throughout Wallacea of land mammals, including hominins, could have been primarily but not exclusively in a north to south direction, following the major surface current flow patterns.

Beyond the chronological gap yet to be filled, a question clearly linked to our discovery is the origin of the Callao Cave hominin dated at 66.7 ± 1 ka. This diminutive Callao hominin may represent a direct descendent from a Pleistocene migration stock related to these early Kalinga toolmakers – similar to what happened on Flores Island – or may be derived from a more recent migration wave of anatomically modern humans[6,21,24,25].

Despite the current evidence, it still seems too farfetched to suggest that *Homo erectus*, or another as yet unknown Pleistocene ancestral candidate for the Kalinga toolmakers (e.g.'Denisovans'[27]), were able to construct some sort of simple watercraft and deliberately cross sea barriers to reach these islands[28]. However, considering evidence of over-seas dispersal during the Middle Pleistocene is increasing in number[29,30], such a hypothesis cannot currently be rejected.

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Supplementary Information is available in the online version of the paper.

Author Contributions T.I., J.d.V. and A.B. conceived the study with C.J-o. and G.v.d.B. in collaboration with N.A., G.L., P.A. and M.L. The site stratigraphy was recorded and analysed by G.v.d.B. Samples for ESR/U-series dating were analysed by J-J.B., Q.S. and C.F. Samples for ESR dating on quartz were analysed by P.V. Samples for ^{40}Ar/^{39}Ar dating were analysed by S.N. and A.P. D.Y. analysed samples for palaeomagnetism. P.R. analysed the tektite. The lithic material was studied by H.F. and G.C. Palaeobotanical remains were analysed by A-M.S. and C.K. The faunal and taphonomical analysis was conducted by T.I., K.M., M.R. and N.A. T.I. and G.v.d.B. wrote the manuscript

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request

Main text Figure captions

Figure 1 | Geology and sedimentology of the Kalinga Excavation site. a, Digital elevation map of

the Cagayan Valley surrounding the Rizal municipality (located in **b**, Northern Luzon Island, east of

Huxley's and north of Wallace's Lines). The Kalinga site (red star) is located at the southern tip of the

weakly folded Cabalwan Anticline. Geological units of the area bounded by the Cagayan River on the

East and the Chico River on the West are after Mathisen (1981)[13]. Stratigraphically, the site layers pertain to the upper part of the Awidon Mesa Formation, a Pleistocene sequence of alluvial stream deposits intercalated with volcaniclastic and pyroclastic deposits. The depositional environment of the Awidon Mesa Formation was characterized by braided rivers on an alluvial fan system that formed in response to uplift in the Cordillera Central to the West[12,13]. **c**, Contour map of the Main Excavation and the adjoining slot Trench H along the small valley where the Kalinga site is located. **d**, Detailed stratigraphy of the excavation with the absolute ages of the sedimentary units. Unit A constitutes a fining upward complex of sandy to silty cross-bedded fluvial sediments. The top of Unit A is eroded and cuts down vertically over at least 2.5 m. This erosive channel is filled with Unit F, a poorly sorted mudflow deposit with a maximum thickness of 3.25 m. The rhino skeletal elements and most of the stone artefacts were found lying directly above the erosional contact, and were found embedded in the clayey mud of Unit F. Unit F is conformably overlaid by a sequence of horizontally layered coarse sandy to silty layers (Unit G), which is in turn conformably overlaid by a thick sequence of silty deposits overprinted by paleosols (Unit H). **e**, Southward view of Trench H showing the lower and upper contacts between mudflow Unit F and sandy Unit G and between sandy Unit A and mudflow Unit F.

Figure 2 | Lithic artefacts from Kalinga. **a**, Cortical flake on chert (II-2014-J1-362; L= 100, B= 55, Th=33mm); **b**, possible hammerstone on dacite (II-2014-J1-371), although its highly eroded aspect precludes any definitive conclusion; **c**, Siret kombewa flake on jasper (II-2014-J1-391; L=40, B=18, Th=8mm) having a longitudinal and oblique fracture on the inferior two-thirds of the left side resulting from a knapping accident while flaking; **d**, double-backed flake on flint (II-2014-J1-519); **e**, core on quartz (II-2014-J1-396) -showing clear marks of knapping on anvil- with its diachritic diagram.

Figure 3 | Different types of marks at the surface of the bones. a, Left humerus (II-2014-J1-368) found broken into three fragments in the excavation with an anthropogenic conchoidal percussion mark (P) on its anterior surface most likely produced to get access to the marrow; **b1**, **b2** and **b3**, sub-complete rib (II-2014-J1-475), having a diagnostic anthropogenic cutmark with V-shape cross-section (V), hertzian cones (H), asymmetrical profile (A) and shoulder effect (S) on its lateral surface resulting from defleshing. Black stains are also present inside the cutmark resembling the ones observed on the surface of the rib and are the result of taphonomic processes that occurred after this cutmark was made (see Fernández-Jalvo and Andrews, 2016: 156)[17]; **c1** and **c2**, rib fragment (II-2014-J1-403) having a shiny surface on its lateral face resulting from multiple multidirectional striations, presumably due to trampling; **d1** and **d2**, right metacarpal IV (II-2014-J1-282) with parallel and rectilinear anthropogenic cutmarks (R) on its medial surface presumably generated during disarticulation; **e**, right humerus (II-2014-J1-289) with an anthropogenic conchoidal percussion mark (P) similar in size and shape to the percussion mark on the left humerus, but located on its posterior surface and more distally and associated with a small adhered bone flake (F) (see Fernández-Jalvo and Andrews, 2016: 298)[17]; **f**, three-dimensional surface topography of another rib (II-2014-J1-466) showing a linear mark (on the left) with V-shaped cross-section (V) of anthropogenic origin, as well as hertzian cones (H) and a linear mark (on the right) with a base as broad as the heights of the walls of the grove, commonly attributed to trampling but also with assymetrical walls and possible microstriations in the bottom (M) of the groove, commonly attributed to anthropogenic marks.

Extended data legends

Extended Data Figure 1 | Geology and sedimentology of the Kalinga Excavation site. a, Detailed stratigraphic drawing of Trench H also showing the East wall of the S quadrant of the main Excavation. The sedimentary patterns are the same as in Figure 1. Representative logarithmic grainsize diagrams are shown for samples from each sedimentary unit; **b,** Detailed stratigraphic drawing of the Main Excavation walls; **c,** Overview towards the northwest of the quadrants N and NW of the Main Excavation in 2015. The concentration of faunal remains and stone tools lying at the base of Unit F is exposed, just above the eastward sloping erosional contact with Unit A; **d,** Detailed view of quadrant NW showing the position of a flake lying next to the rhinoceros left femur; **e,** Detail of quadrant N showing the piece of waterlogged wood fragment (yellow outline) recovered near a rhinoceros rib extremity (blue outline); **f,** Detail of quadrant NE showing the tektite recovered in Unit F along with

the faunal and lithic remains.

Extended Data Figure 2 | Faunal remains from Kalinga archaeological Unit F. a, Drawing

showing the preservation of the rhinoceros and position of the taphonomical marks. A total of 97

fragments of ribs of all sizes have been recovered and not all of them could be clearly positioned on

the skeleton. We estimate that about 75% of the skeleton has been recovered. **b,** Fibula of *Varanus*

salvator. **c,** Radius of a Cervidae. **d,** Molar of *Cervus* cf. *mariannus*. **e,** Molar fragment of *Stegodon* cf.

luzonensis.

Extended Data Figure 3 | Digital Elevation Model (DEM) of the Main Kalinga Excavation,

showing the contact surface topography between Unit A and Unit F and the vertical projections (black

squares) of the archaeological materials (coloured points) on this surface. This DEM has been

produced by interpolation through a kriging method from 37 three-dimensional coordinates recorded

in the Main Excavation with a Total station on the erosional surface that cuts down into Unit A. This

surface of contact corresponds to an erosional channel cutting down into sandy Unit A. All the

material has been recovered lying across the base of the clayey Unit F along this channel, between

0.7m and 1.3m deep.

Extended Data Figure 4 | X-ray diffraction pattern of powdered Unit F clays. CPS is counts per

second. Cu K-alpha corresponds to the wavelength. Quartz corresponds to the bipyramidal quartz

crystals, some of which are visible to the naked eye. Bipyramidal quartz, albite, hornblende, nontronite

and saponite all have a volcanic origin. Albite are plagioclase feldspar frequent in pegmatites.

Hornblende is a common silicate mineral in igneous and metamorphic rocks. Nontronite is an iron-rich

smectite type of clays which can be produced by hydrothermal alteration. Similarly, the smectite

mineral saponite results from alteration of volcanic glass. The mineral composition of Unit F supports

the interpretation as a mudflow set in a volcanic environment.

Extended Data Figure 5 | ^{40}Ar/^{39}Ar fusion ages of single potassium feldspar crystals for samples

from Unit A and Unit G, presented as probability diagrams (**a**) that are correlated to the related

inverse isochrones (**b**).

Individual ages in **a** are ± 1σ.

Extended Data Figure 6 | Measurements of dose rates (Da) and calculation of equivalent dose

(De) to compute the ESR ages from quartz crystals and tooth enamel. a, Al and Ti centre ESR

spectra of natural and bleached aliquots for Unit A quartz showing that Al signal is not totally reset although not measurable because extremely weak and covered by noise. **b**, ESR Dose-response curve obtained for the rhinoceros tooth (Archaeological number: II-2014-J1-095; sample code: CGY1501). The equivalent dose (DE) was extrapolated using a single saturating exponential function (Origin Microcal software) following the recommendations of Duval and Grün[9] (DE< 500 Gy, so Dmax< 5000Gy for this sample). Vertical bars account for the standard deviation around the mean for each measurement. The red curve is for the dose-response curve. The blue curves account for the 95% confidence interval of the dose-response curve. **c-f**, ESR Dose Response curves, for Aluminium (Al) and Titanium-Lithium (Ti-Li) centers of layers G1 and A4. Vertical bars account for the standard deviation around the mean for each measurement. The red curve is the dose-response curve. The blue curves account for the 95% confidence interval of the dose-response curve.

Extended Data Figure 7 | Progressive demagnetization curves (lower left of each panel), equal area projection stereoplots (upper left) and Zijderveld diagrams (right) for the six analysed specimens from Layer G_2. a-e: specimens treated by alternating field demagnetization; **f**, specimen HT-1E treated by thermal demagnetization. Open circles in the Zijderveld diagrams represent the inclination while closed circles represent declination. Open and closed circles in the equal area projection (stereoplot) represent the upper and lower hemisphere, respectively. Equal-area projections of the mean ChRMs directions of all analysed specimens, **g**, before and **h**, after demagnetization. Solid squares represent the upper hemisphere. Black cross indicates the mean ChRMs direction of the six specimens combined, surrounded by the α95circle. Red cross represents the present-day magnetic direction.

Extended Data Figure 8 | Analysis of the Kalinga tektite recovered from the archaeological layer Unit F. a, picture of the tektite: **b**, μXRF spectra (un-indexed peaks correspond to the Rh source) showing its composition: c, comparison of the Kalinga tektite glass composition through μXRF with an australasite tektite from China measured in the same conditions (red squares) and with an average australasite composition (blue diamonds) following Koeberl[50].

Extended Data Figure 9 | Fauna diversity of the Kalinga site as compared to contemporaneous faunas from other islands in the region. Contemporaneous to those faunas are 'classic' *Homo erectus* faunas on Java Island[97], the Mata Menge Fauna of Flores Island, which includes the putative ancestor of *Homo floresiensis*[98], and the Walanae Fauna on the southwestern branch of Sulawesi[99,100]

Extended Data Table 1 | ESR/U-series results for the rhinoceros tooth. a, U-series data for the tooth CGY1501. b, ESR/U-series data and age.

Eventual radium and radon losses from the dental tissues were estimated from cross-checked γ and α data101. Dose conversion factors of Guérin and co-authors25 were used. Water contents of 0±0%, 7±5% and 10±5% were used for enamel (fixed), dentine (fixed) and sediments (difference in mass between the natural sample and the same sample dried for a week in an oven at 50°C) respectively.

[1] A k-value of 0.13 ± 0.02 was used following Grün and Katzenberger-Appel102.

[2] The enamel thickness removed during preparation process was taken into account in the beta contribution calculation[103]. The following values were used for the age calculation: 1505±376µm, 351±88µm and 45±12µm for the initial thickness, thickness after preparation on the dentine side and on the sediment side respectively.

[3] Cosmic dose was estimated from depth using the Prescott and Hutton's formulae[30]. Because we have at present no means to know precisely when the erosion took place and since when the archaeological material became buried under less than 7m of sediment, a depth of 2.75m was used for the cosmic dose rate estimation as an intermediate value between the 7m of sediments that once covered the archaeological layer and the present 70cm to 1.20m depth at which the archaeological material was recovered, and as an average between the once full thickness of the archaeological layer and its present thickness where the archaeological material was recovered. A cosmic dose estimated from a depth of 7m would result in a 10% older age for the Unit F and a cosmic dose estimated from a depth of 1m would result in a 7% younger age for the Unit F.

[4] Uncertainties on the ESR/U-series ages were calculated using Monte-Carlo approach following Shao and co-authors[104]
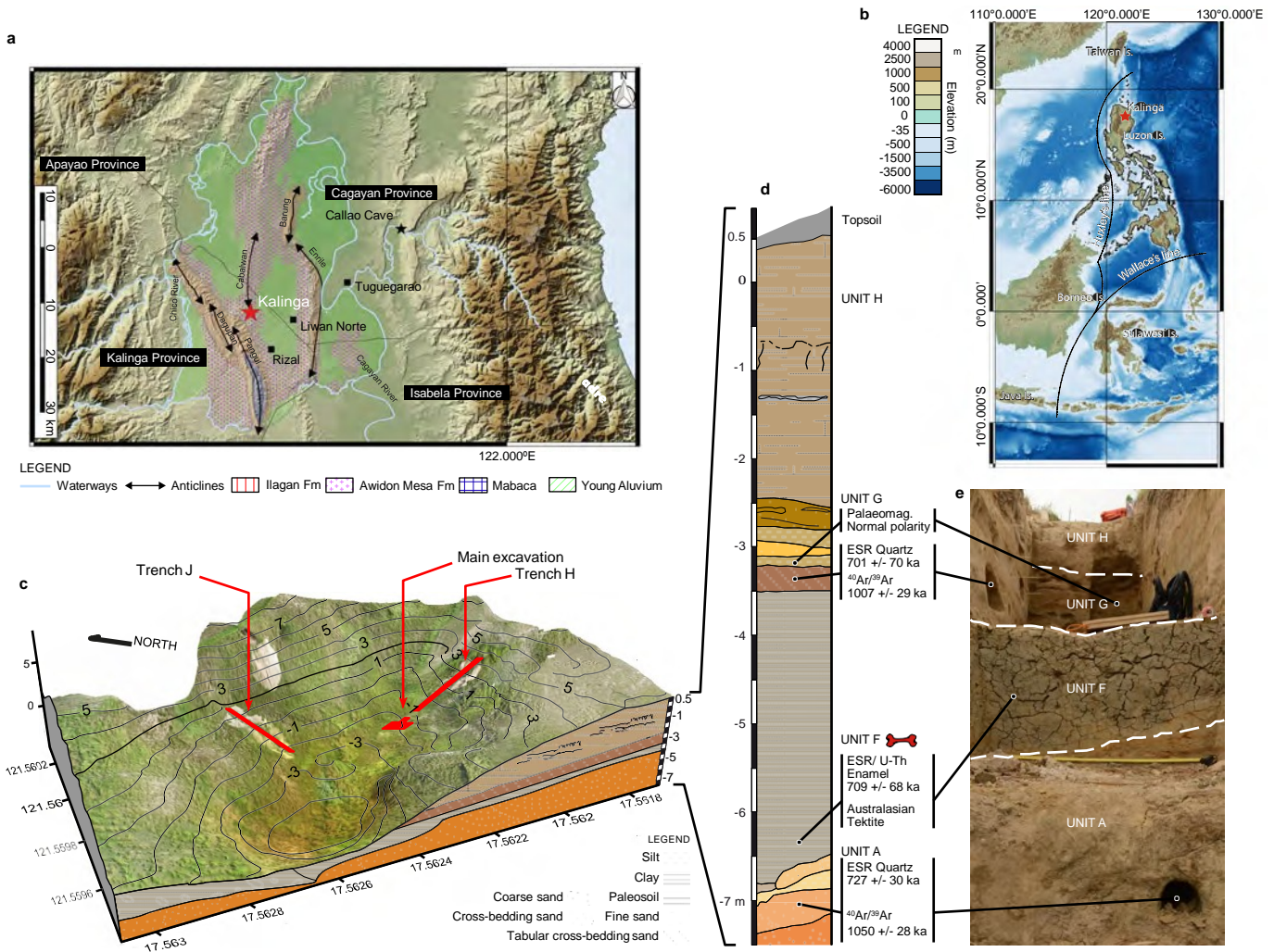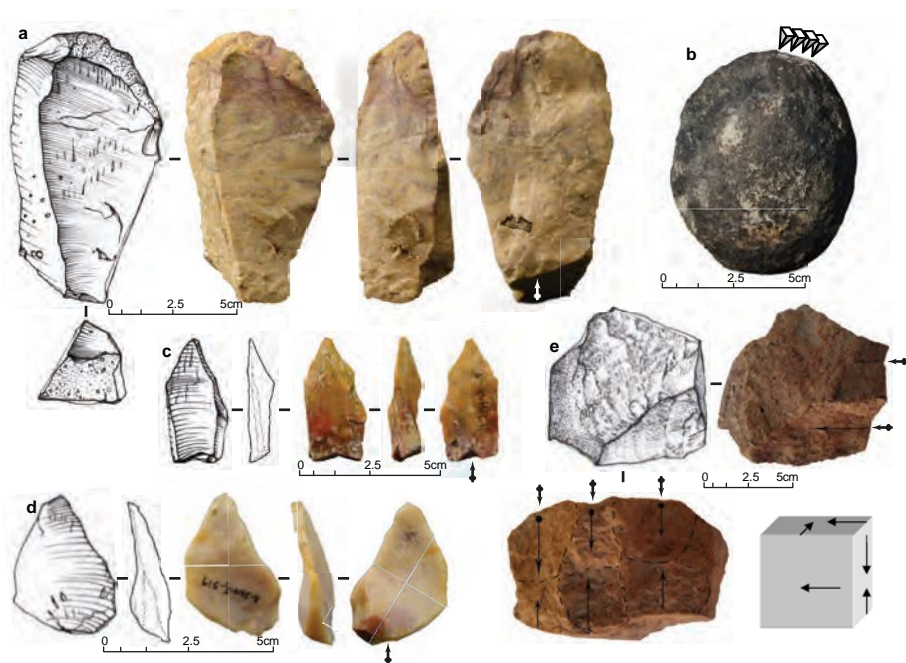
Figure 1

Figure 2

Figure 3