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Supplementary Table 1: The main rainforest fauna fossil sites in Southeast Asia and Southern China that contain rainforest fauna associated with modern human evidence (site locations in Extended Data Fig. 1b); locations, fossil content and chronologies. Of the 16 sites that contain either *Homo sapiens* or *Homo* material, eight of them contain an estimated or unknown chronology.

Cave	**Location**	**Fauna**[a]	**Chronology (kyr)**[b]	**Reference**
1. Luijiang	Southern China	*H.*, O, P	68-111	Shen et al., 2002[75]
2. Liucheng		P,O	?	Kahlke, 1961[76]
3. Hoshantung		P, O	~200-125 **E**	Kahlke, 1961[76]
4. Hei-Tu'ung		P, O	?	Kahlke, 1961[76]
5. Changyang		*H.*, P	~125 **E**	Kahlke, 1961[76]
6. Hsing-an		P, O	~125 **E**	Kahlke, 1961[76]
7. Lang Trang	Vietnam	*H.*, O, P	350-180	de Vos, Long, 2001[77]
8. Tham Khuyen		*H.*, O, P	~475	Ciochon et al., 1996[78]
9. Thung Lang		O	300-200 **E**	Cuong, 1985[79]
10. Hang Hum		*H. sapiens*, O	140-80	Cuong, 1985[79]
11. Ma U 'Oi		*H.*, E	169-(80-60) **E**	Bacon et al., 2004[80]
12. Tham Om		*H. sapiens*, O	200-80 **E**	de Vos, 2007[81]
13. Keo Leng		*H. sapiens*, O	42-37	Ciochon et al., 1996[78]
14. Tham Hang	Laos	*H.*, O, P	?	de Vos, 2007[81]
15. Tham P'a Loi		*H.*, O	?	de Vos, 2007[81]
16.Thum Wiman Nakin	Thailand	*H.*, O, P	>169	Tougard et al., 1998[82]
17.Thum Phra Khai Phet		*H.*, O	~125 **E**	Tougard et al., 1998[82]
18. Phnom Loang	Cambodia	O	?	Tougard et al., 1998[82]
19. Niah Cave	Malaysia	*H. sapiens*, O	~40	Barker et al., 2007[83]
20. Lida Ajer	Indonesia	*H. sapiens*, O	~80 **E**	de Vos, 1983[11]
21. Prambangan		*H. sapiens*, O	~80 **E**	de Vos, Long, 2001[77]
22. Punung		*H. sapiens*, O	118-128	Westaway et al., 2007[16]

[a] *H.* – *Homo*, O – Orang-utan, P – Giant Panda, E – Elephant
[b] **E** – sites with estimated chronologies

SUPPLEMENTARY INFORMATION - section 1:

Supplementary discussion │ Background to the research at Lida Ajer

The lack of chronological resolution of AMH arrival in Island Southeast Asia relates in large part to an absence of applied dating techniques. For example, Supplementary Table 1 outlines 22 key fossil sites in the region all containing rainforest fauna, with some associated with modern human evidence (site locations in Extended Data Fig. 1b). Of the 16 sites that contain either *Homo sapiens* or *Homo* sp. material, eight of them only have an estimated or unknown chronology. Even the sites with solid chronologies are significantly younger than expected if we accept mtDNA phylogeographic predictions of arrival. The dearth of good chronological evidence of early AMH in Southeast Asia also relates to an absence of older sites, poor preservation, poor excavation strategies and insufficient exploration[84]. For example, cave sites such as Leang Burung II in South Sulawesi, Indonesia (~31 kyr[85]), and Lang Rongrien in Thailand (~43 ka[86]) contain unconsolidated sediments that are subjected to subsidence, reworking and bioturbation. In addition, they are seldom excavated to any great depth, e.g. Niah Cave has only been dug to ~3 m[83] and prior to 2002 Liang Bua had only been excavated to 3.5 m[48].

Bone-bearing breccia, a valuable source of fossil evidence often found in limestone regions of Southeast Asia (Supplementary Table 1 and Extended Data Fig. 1), has yet to be fully exploited due to the lack of a suitable dating strategies extending beyond the radiocarbon window[87]. The application of red TL dating of breccia matrix and U-series dating of flowstones was successfully used to determine the age of Punung faunal stage in East Java[16]. The use of this combination of techniques offers a means of improving breccia fossil chronologies and establishing the significance of rainforest sites and the initial arrival of AMH in the region.

Sumatra is an elongated island along a northwest-southeast axis, dominated by a spine of active volcanoes comprising the Burit Barisan Mountains. The island is bordered by the Indian Ocean on the west, northwest and southwest sides and by the Strait of Malacca on the northeast side, which separates it from the Malay Peninsula. Sumatra sits on the equator, which passes through the West Sumatra and Riau provinces (see Fig. 1b). To the north of the regional capital of western Sumatra, Padang, sits one of the larger cities in the Padang Highlands, Bukittinggi (literally “high hill”). It is located in the Minangkabu Highlands (elevation of 930 m) and was once a Dutch outpost known as ‘Fort de Cock’. A Lower Carboniferous limestone belt runs in a northeast-southwest trajectory between Padang to the west and Pekanbaru to the east and the limestone cave site of Lida Ajer is located to the east of Bukittingi close to a large rounded karst hill, Gunung Sago (Extended Data Figure 1d).

Dubois excavated Lida Ajer between 1887-1890[10,11]. He originally attributed the fossils to the Holocene[88] but later indicated that they might be significantly older[89]. In addition to this cave he also excavated many other caves in the same area; Sibrambang and Djamboe (sometime spelt Jambo) being the only other two identified by name. As the caves contained very similar faunal assemblages, taphonomy, and depositional circumstances he grouped them together and referred to the faunal assemblages as ‘the Sumatran caves’ (see Supplementary Table 2 for a faunal list). Lida Ajer was revisited by Skelton, Drawhorn and de Vos in 1985 and a relative age of >81 kyr and >70 kyr, was obtained from AAR on bone[13,14]. To our knowledge no-one has been able to relocate the Sibrambang or Djamboe caves. We relocated Lida Ajer by examining Dubois’ original field notebook (courtesy of Naturalis Biodiversity Center in Leiden, Netherlands), which contained simple maps depicting the location of Lida Ajer, brief descriptions of the entrance chamber and a plan of the entire cave (Extended Data Fig. 1c,e). Dubois described a large calcite column in the entrance chamber and a rear chamber containing the fossil breccia with exactly the same dimensions as we describe (Extended Data Fig. 1e,f).

Lida Ajer cave deposits
The cave entrance is 4.8 m wide and 2.1 m high, facing an easterly direction (00° 19 06.7 S, 100° 35 37.6 E) is located about 150 m above the valley carved by Batang Babuwe River. It comprises a small solution cave with two main chambers and a rear sinkhole. The front chamber has some speleothem decorations and columns, and a cave floor of unconsolidated sediment, while the rear chamber contains the fossil breccia deposit (Fig. 2). This breccia is diamictic in appearance and composed of angular clasts and large-bodied mammal teeth within a sandy clay matrix, comprising a mixture of allochthonous and autochthonous sediments (Fig. 2). It is evident that the breccia deposit in this chamber has been heavily eroded, although whether by natural or anthropogenic agents remains unclear. All of the excavated material consists of teeth, and most display evidence of gnawing with only the crown of teeth remaining[11], suggesting it likely represents a porcupine accumulation.

The fossil chamber in Lida Ajer comprises four areas of preserved breccia deposits (Fig. 2). Area 1 (2.23 m above the sinkhole) contains a heavily lithified breccia that is cemented on the cave wall directly above the sink hole. The breccia contains a sandy silt matrix suitable for luminescence dating, but is clast supported with many angular clasts (70% composition volcanic, metavolcanic and limestone) and fossils, and is reddish brown in colour (5YR 5/4). Area 2 comprises of a breccia that has been deposited on top of an *in-situ* flowstone on the southerly wall of the fossil chamber, it has a similar appearance to the Area 1 breccia and is similarly dense with fossils (lies 1.60 m above the cave floor). The underlying flowstone is ~10-15 cm thick comprising thick laminations of yellow and white calcite with large crystals, and has a sharp lower bedding contact where it has been precipitated directly against the limestone cave wall.

Area 3 is located in the centre of the fossil chamber. There, the breccia sits 1.75 m above the cave floor. Four large stalactites have formed directly above this area, producing thick calcite columns overlying the breccia. This has preserved the underlying breccia and formed large hanging accumulations of speleothem and breccia resembling ‘elephant feet’. The thick columns (50 cm diameter) comprise a clean pure-white calcite but the associated flowstones have a rough and wavy lower bedding contact with the underlying breccia, contain layers that have entrained the brown matrix and have a darker brownish colouration and sandy composition. The breccia has a similar composition to the Area 1 and 2 accumulations and is also rich in fossils. Area 4 is located on the northerly wall of the chamber (the same wall as Area 2) and comprises a thick breccia cemented to the cave wall, and an overlying ‘dirty’ flowstone. At its thickest this flowstone is approximately 5 cm, and it contains thin laminations of brownish calcite with small crystals (but noticeable by eye). Its lower bedding contact is also rough and wavy and has penetrated in and around the underlying breccia unit, seeping around the individual clasts, indicating that this flowstone was formed *in-situ* and has not been reworked.

All of four breccias have a similar diamictic appearance, lack any internal sedimentary structures, contain identical fossils, and are located at a similar height. Therefore, we consider the breccias to represent the remains of the same sedimentary unit prior to erosion, such that the base of the calcite columns in Area 3 represents the top level of the deposit. We consider it likely that this unit was emplaced as a single depositional event in the form of a fluidised mass movement, similar to those recorded in other caves in the region[79]. If this formation history is confirmed, this would indicate that the fossils all relate to a single depositional event of relatively minimal time-averaging. Furthermore, it strongly indicates that the fossils derived from the breccias themselves are highly unlikely to have been subjected to reworking following lithification of the unit.

No evidence of archaeology was observed in the cave or surrounding region. Hooijer[12] did "not consider the two teeth described above as evidence of human inhabitation in the prehistoric Sumatran caves". Hooijer's comments were made in reference to what he considered a non-occupation cave. No excavations have been conducted in the front of the cave, and whether or not prehistoric peoples used the cave remains to be demonstrated. Nevertheless, the assemblage reflects the fauna that were present on the landscape, humans included. Furthermore, we note the presence of human remains but an absence of archaeological evidence is a common feature in other Asian caves, such as Thum Wikin Nakin in Thailand, Punung in Java[16], and Fuyan in southern China[5].

The site and fossil chamber was mapped using a laser-range finder and the stratigraphy of the breccia and flowstone deposits were logged on site. The fossil chamber was divided into four main fossil areas and minor excavations were conducted to confirm the presence of fossil rainforest taxa (see Supplementary Table 2 for a comparison of Dubois's with our excavated material). This involved small scale digging with a chisel and hammer to remove fossil-bearing samples. The fossils were later cleaned, photographed and analysed at ARKENAS. The fauna recovered in this study (Extended Data Fig. 2) include *Hystrix, Elephas, Rhinoceros, Cervus, Pongo, Sus,* Cervidae, *Macaca,* Siamang gibbon, *Tapirus,* and Bovidae, and are all present in the original faunal list reported for the site (Supplementary Table 2).

Species	Sumatran Caves	This study
Homo sp.	Homo sapiens 2 teeth	
Pongo pygmaeus	143	present
Gigantopithecus blacki	0	
Presbytis/Trachypithecus/maca.	16	present
Hylobates sp.	a few	
Arctonyx collaris	a few	
Panthera pardus	a few	
Panthera tigris	a few	
Felis temmincki	a few	
Ursus thibetanus	0	
Ursus malayanus	6	
Ailuropoda melanoleuca	0	
Cuon javanicus	a few	
Crocuta crocuta ultima	0	
Paradoxurus hermaphoditus	a few	
Martes flavigula	0	
Paguma larvata	0	
Lutra perspicillata	0	
Elephas sp.	8	present
Stegodon orientalis	0	
Tapirus indicus	32	
Rhinoceros sp.	22	present
Sus scrofa 1027 a few hundred	>100	present
Large bovid	28	present
Naemorhedus/Capricomis sp.	3	
Muntiacus muntjak	167	present
Rusa sp.	43	present
Hystrix brachyura	>100	present
Rhizomys sp.	0	
Atherurus macrourus	0	
Rattus sp.	a few	

Supplementary Table 2: Faunal list for the Sumatran Caves (including Lida Ajer, Sibrambang and Djamboe) according to Dubois's excavations. The finds from a small scale excavation conducted in this study are presented in the last column for comparison.

SUPPLEMENTARY INFORMATION - section 2:

Supplementary discussion │Teeth morphology and metrics

The three samples prepared for metric comparisons are described in Supplementary Table 3. Crown heights shown against Sample 1 in Supplementary Table 4 (metric comparisons) are for Zhoukoudian[31] and Xujiayao[91] and against Sample 3 are recent modern[91]. (Dingcun upper central incisor; although considered to be "archaic *H. sapiens*"[93] the size {8.3mm mesiodistal x 6.4mm buccolingual} and aspects of the morphology, as described, are typical of fully modern Late Pleistocene *H. sapiens*[93-95] and for this reason it was not included in the comparative sample). *H. floresiensis* measurements in Supplementary Table 4 for Mata Menge are taken from van den Bergh *et al*.[96] and for Liang Bua are taken from Kaifu *et al*.[97].

The two Lida Ajer teeth, which were isolated finds without any associated bone were fully described by Hooijer[12]. This is updated in the following but there is no fundamental disagreement with the original descriptions.

Right Upper Central Incisor (RI^1)
The crown of this tooth is complete but the apex of the root is missing (8 mm of root remaining). The crown is small but the rounded triangular cross section of the root confirms its identity as a central incisor. There is a narrow line of dentine exposure along the length of the occlusal face and minor rounding and chipping of the labial occlusal edge. Larger chips of enamel have been removed at the mesiobuccal and distobuccal corners. There was slight overbite.

The crown shape viewed labially is ovoid[98] and the labial occlusal edge is straight (labial convexity grade 0). There is mild shovelling and double shovelling (grades 2 & 3 respectively). The lingual surface is flat, without finger-like projections, and there is a trace tuberculum dentale set mesially, seen as a broadening of the mesial marginal ridge for half the height of the crown. There is a mild distal horizontal interruption groove. The presence of regularly set mesial and distal interproximal facets indicates the absence of winging and midline diastema. The root tapers along its length in all views, greatest mesially when viewed buccally. Measurements of the root at the cervix are mesiodistal 6.5 mm and buccolingual 5.2 mm.

Left Upper Second Molar (LM^2)
There is no distal interproximal facet on this tooth. However, in view of the minimal wear, it could be a first or second molar in a developing dentition. It is considered that the relatively small size and lower height of the distal cusps, particularly the hypocone, and the relative mesiodistal narrowness of the tooth, make it unlikely that it is a first molar; and the regularity of its occlusal shape, together with the disposition of the cusps and the degree of inclination of the lingual surface, suggests a second molar rather than a third molar.

The crown of the tooth is complete but the individual roots have been broken off at the top of the root trunk. There is minor wear, most distally, and chipping of the hypocone cusp tip. There is a roughened and pitted area mesially on the buccal face in the occlusal half. There is a very deep line of furrow-form hypoplasia extending around the whole tooth just below the occlusal surface, occurring at approximately five years of age using recent human criteria[99] if the tooth is a second molar.

The occlusal shape is a rounded rectangle, with truncation of the distobuccal corner, especially buccally. From a mesial aspect, the buccal face is vertical towards the cervix and the lingual face convex, but there is no basal bulge. Both the metacone and the hypocone are size grade 3.5. The size sequence of the cusps, and relative cusp areas, are Protocone (36.3%) > Paracone (29.2%) > Metacone (19.7%) > Hypocone (14.9%). There is a low oblique ridge separating the distal fossa from a deep central fossa, with the mesiodistal occlusal groove running over it. Mesial and distal occlusal margins are both present and uninterrupted. The mesial margin of the protocone is distinctly lobed and joins the mesial margin of the tooth at the point where the mesiodistal groove goes over it, this then continuing to the buccal surface, bounding an anterior transverse groove. The essential ridge of the paracone is very prominent and extends into the mesiodistal groove, where it coalesces with the mesial margin, enclosing a small pit at the base of the anterior transverse groove. The protocone and the hypocone are separated by a deep fissure. The groove between the paracone and the metacone is not apparent on the buccal surface, and similarly the groove between the protocone and the hypocone is not apparent on the lingual surface. Both buccal and lingual surfaces have enamel extensions at the cervix, 2 mm buccally and 1 mm lingually. There is no wrinkling of the occlusal enamel, and cusp 5, mesial marginal cusps, Carabelli's trait, parastyle and buccal cingulum are all absent.

Hooijer[16] describes the roots as having been gnawed at by porcupines. It is not possible to determine the degree to which the roots were separated but it can be seen that the mesiobuccal root was not joined to the lingual root. The tooth is not taurodont. Measurements of the root at the cervix are mesiodistal 7.7 mm and buccolingual 10.7 mm.

There is little wear on the LM^2, and the LM^3 (if present) had not erupted. Likely age range using modern human criteria is therefore 12.5 to 17.5 years[100-101]. The relative levels of wear do not preclude the teeth coming from the one individual, but it might be expected that the severe furrow-form hypoplasia on the M^2 would be reflected on the root of the I^1, which is not the case.

Mesiodistal versus buccolingual dental metrics as collected by Hooijer[12] were compared to fossil orangutan teeth (37 for the incisor and 353 for the molar) from caves in the same area. Both the incisor and molar are much smaller than the range for fossil orangutan (Extended Data Fig. 3 a-b), and when plotted against the full range of *Homo* teeth from early Pliocene to recent modern[102] the incisor and molar plot in the middle of recent modern humans (Extended Data Fig. 3 c-d).

The difference in size between the *H. erectus*/"archaic *H. sapiens*" sample and the fully modern human samples (Supplementary Table 4) is most marked in the East Asian Late Pleistocene I^1 sample, where there is no overlap in the range of values for the mesiodistal dimension or for crown area, and little overlap in the buccolingual dimension. For both I^1 and M^2 the mean of the Southeast Asian Late Pleistocene to middle Holocene sample is larger than the mean of the East Asian Late Pleistocene sample in both dimensions. Mean figures for a sample of Mesolithic teeth from Niah Cave were very similar to the figures for the Southeast Asian sample (8.5 x 7.8 mm for I^1 and 10.5 x 12.2 mm for M^2)[103]. No published tooth measurements for early/middle Holocene sites on Sumatra could be found but there have been archaeological reports of gracile human remains with small teeth e.g. from an Epipaleolithic shell mound at Alur Itam, Tamiang[104] and from the late prehistoric site of Oeloe Tjanko Cave[105].

The Lida Ajer teeth are below the range of values of the *H. erectus*/"archaic *H. sapiens*" sample in both dimensions for the I^1, and in the mesiodistal dimension and crown area for the M^2. In addition, the I^1 is below the range of values of the Southeast Asian sample in the buccolingual dimension and in crown area.

For both I1 and M2 the mean crown index increases from the *H. erectus*/"archaic *H. sapiens*" sample through the East Asian sample to the Southeast Asian sample. The Lida Ajer I^1 is below range compared to the Southeast Asian sample, and the M^2 is above range compared to the *H. erectus*/"archaic *H. sapiens*" sample.

Compared to the recent human sample and the only unworn *H. erectus*/"archaic *H. sapiens*" teeth available for comparison, the crown height of the I^1 is high, if allowance is made for wear, but, in contrast, the crown height of the unworn M^2 is bottom of range. The Lida Ajer teeth therefore have the greatest affinity to the East Asian Late Pleistocene sample.

The teeth have a simple morphology and there is nothing to suggest that they are not modern human. The only unusual aspect is the lobed margin on the protocone of the M^2. There are two types of dental morphology in the East & Southeast Asian Middle Pleistocene, differences chiefly being in the premolars and lower canine - *H. erectus* (e.g. Sangiran, Zhoukoudian (Location 1) and Hexian) and *H. heidelbergensis*/"archaic *H. sapiens*" (e.g. Chaoxian, Jinniushan, Xujiayao)[106]. There are clear differences between these groups and fully modern *H. sapiens* in the two teeth being studied.

Traits present in the East and Southeast Asian Middle Pleistocene teeth that are not present in the teeth studied and are less frequently found in recent human teeth include for the upper central incisor:
i. Pronounced level of shovelling (grades 4 and 5) in Eurasian Middle Pleistocene and in Neanderthals[107,108];
ii. Pronounced labial convexity. Xing *et al.*[107] noted that labial convexity of I1s was weak in *H. sapiens* and African fossil hominids, increased in Eurasian Middle Pleistocene populations and is at its highest in European Middle Pleistocene and in Neanderthals. Bailey[109] found grades 2-4 convexity in all but one of a sample of 21 Neanderthals and in 3 of 5 *H. erectus*;
iii. Vertical grooving on labial surface[107]. Multiple narrow fissured grooves on some specimens, as opposed to the wider shallow mesial and distal grooves associated with double shovelling;
iv. Pronounced tuberculum dentale on lingual surface. This is also found in Neanderthals. The form varies between the two groups described above and also geographically between China, Indonesia and Neanderthals but all have a large swollen lingual tubercle, frequently subdivided, with one or more finger-like projections pointing towards the occlusal surface (the latter not being present in all Indonesian teeth)[108,107]. In *H. sapiens* the expression of the trait is milder or absent, as with this tooth;
v. Root shape. Viewed mesially/distally the root only tapers in the apical half, unlike the even tapering seen in *H. sapiens*[110,31].

For the upper second molar they include:
i. Occlusal shape. Most Asian Early to Middle Pleistocene M2s have a characteristic trapezoidal shape due to buccal/lingual expansion of the paracone and protocone. In contrast, in *H. sapiens* the outline is rhomboidal or triangular due to the hypocone being proportionally more reduced than the metacone[107].
ii. Wrinkling (crenulation of the enamel due to additional grooves and ridges). Bermúdez de Castro *et al.*[111] considered that wrinkling on posterior teeth is a primitive characteristic for the genus Homo. Wrinkling is ubiquitous in Asian *H. erectus* molars but less frequently found on recent human teeth[31]. In relation to this, a groove dividing the protocone into two portions is frequently found[107];
iii. Relative cusp areas. For fully modern humans the normal sequence of relative cusp sizes in M^2s is protocone>paracone>metacone>hypocone. In *H. erectus*/"archaic *H. sapiens*" the relative sizes of the metacone and hypocone can vary[106,109].

Traits not present in the SE Asian Middle Pleistocene teeth that are present in the teeth studied and found in recent human teeth include:

i. Double shovelling on upper central incisors at grade 2 and above. Irish and Guatelli-Steinberg[112] and Irish[113] considered this to be a derived trait in *H. sapiens*. Bailey[109] found no instances of double shovelling in *H. erectus* or early Afro-Asian moderns (Skhul and Qafzeh, and African MSA sites) and just one in a sample of 20 Neanderthals. However, it can occur at trace level on *H. erectus* teeth[94].

Xing *et al*.[106] (Fig. 14) presented the results of a geometric morphometric analysis of upper M^2 crown outline shapes and the orientation of occlusal grooves. The positive area of relative warp one is chiefly inhabited by Late Pleistocene *H. sapiens* and recent modern humans, and is characterised by the buccal and mesial occlusal grooves being oblique in relation to the buccolingual and mesiodistal axes of the crown respectively, and forming an obtuse angle between them, as in the Lida Ajer M^2. Scott and Turner[114] identify certain regional divisions of recent *H. sapiens* that have distinctive dental characteristics. For upper incisors and upper molars, the characteristics for which the Sino-Americas are noted are shovelling, winging, double shovelling, interruption grooves, and enamel extensions. Of these, the ones that show a distinct difference between China-Mongolia and Prehistoric Southeast Asia are I^1 shovelling > grade 2 (72%/29% respectively), I1 double-shovelling > grade 1 (35%/15%) and M1 enamel extensions >1mm (54%/22%). The greatest difference is in I^1 shovelling, and for this the shovelling on the Lida Ajer tooth would score as absent at grade 2. The difference between the Lida Ajer teeth and later Southeast Asian material is therefore principally in the size and shape of the I^1.

The crown dimensions of the Lida Ajer teeth clearly separate them from the *H. erectus*/"archaic *H. sapiens*" sample. The I^1 is also differentiated from later Malaysian and Indonesian teeth in both size and shape. Apart from Mata Menge, Pleistocene upper I^1s in the samples studied that have buccolingual dimensions less than 7 mm are only found in southern China Late Pleistocene sites (i.e. Huanglong, Tubo, Chuandong). The *H. floresiensis* upper central incisor is very similar to the Lida Ajer tooth in size and shape and the upper M^2s have the same/similar mesiodistal dimensions but smaller buccolingual dimensions. Unlike the East and Southeast Asian *H. erectus* and "archaic *H. sapiens*" I1s, the Mata Menge upper I^1 has no tuberculum dentale evident, and in addition there is no vertical grooving on the labial surface, but in other respects (in particular the root shape) it is similar to these and without any modern human characteristics[96]. The Liang Bua upper M^2s have the characteristic trapezoidal shape found in East and Southeast Asian *H. erectus* and "archaic *H. sapiens*" and no enamel extensions (they are too worn to determine the degree of wrinkling)[97,115].

As with the measurements, the morphology of the Lida Ajer teeth clearly differentiates them from *H. erectus*/"archaic *H. sapiens*" and identifies them as fully modern human. The morphology of the East Asian Late Pleistocene upper I^1s varies, where described, - shovelling: trace to distinct, labial convexity: straight to slight, lingual basal tubercle (tuberculum dentale): absent or trace, double shovelling: absent to marked, and so encompasses the morphology of the Lida Ajer incisor[110,94,95]. The grade 0 labial convexity, combined with distinct double shovelling, found in the Lida Ajer I^1 is also seen in the Huanglong upper I^1 [110], dated at 101 to 81 kyr[116], although the Huanglong root is more robust.

Note: "archaic H. sapiens"; although we do not regard this term as valid for archaic humans outside of Africa, we retain it here for consistency with the cited literature

1. East and Southeast Asian early / middle Pleistocene *H. erectus* and *H. heidelbergensis*/“archaic *H. sapiens*”	Reference
Zhoukoudian Location 1, China	Weidenreich, 1937[31]
Chaoxian, China	Bailey and Liu, 2010[117]
Hexian, China	Xing et al., 2014[107]
Jinniushan, China	Jianing, 2000[92]
Tongzi, China	Wu and Poirier, 1995[95]
Xujiayuo, China	Xing et al., 2015[102]
Yiyuan, China	Xing et al., 2016[106]
Yuanmou, China	Wu and Poirier, 1995[95]
Yunxian, China	Wu and Dong, 1980[118]
Sangiran 7, Java	Grine and Franzen, 1994[119]
Sangiran 4, 17	Wood, 1991[120]
Sangiran 27	Indriati and Anton 2008[121]
Sangiran Tjg 1993.05, Bpg 2001.04	Zaim et al., 2011[99]
Trinil 4, Java	Wood, 1991[120]
Tham Khuyen Cave, Vietnam	Ciochon et al., 1996[78]
2. East Asian late Pleistocene *H. sapiens*	
Tam Hang, Laos	Demeter et al., 2005[122]
Tam Pa Ling, Laos	Demeter et al., 2015 (SI)[123]
Chuandong, China	Wu and Poirier, 1995[95]
Fuyan Cave, Daoxian, China	Liu et al., 2015[5]
Huanglong, China	Liu et al., 2010[110]
Laibin, China	Demeter et al., 2005[122]
Liujiang, China	Demeter et al., 2005[122]
Lunadong, China	Bae et al., 2014[124]
Nalai, China	Wu and Poirier, 1995[95]
Tubo, China	Wu and Poirier, 1995[95]
Zhoukoudian Upper Cave, China	Demeter et al., 2005[122]
Dong Can, Vietnam	Demeter et al., 2005[122]
Hang Cho, Vietnam	Matsumura et al., 2008[125]
Mai Da Dieu, Vietnam	Matsumura et al., 2001[126]
Mai Da Nuoc, Vietnam	Matsumura et al., 2001[126]
Ma U'Oi, Vietnam	Demeter et al., 2005[122]
Mo Khiew Cave, Thailand	Matsumura and Pookajorn, 2005[127]
Ryonggok, Korea	Bae, 2010[128]
Minatogawa, Japan	Demeter et al., 2005[122]
3. Southeast Asian late Pleistocene to middle Holocene *H. sapiens*	
Gua Cha, Malaysia	Matsumura and Hudson, 2005[129]
Gua Gunung Runtuh, Malaysia	Matsumura and Zuraina, 1995[130]
Gua Kepah, Malaysia	Kaifu et al., 2015[115]
Niah Deep Skull, Sarawak	Jacob, 1967[131]
G Jimbe, Java	Storm, 1995[132]
G Kail, Java	Storm, 1995[132]
Hoekgrot, Java	Storm, 1995[132]
Sampung, Java	Jacob, 1967[131]
Wajak, Java	Storm, 1995[132]
Aimer, Flores	Kaifu et al., 2015SI[115]
Gua Alo, Flores	Kaifu et al., 2015SI[115]
Gua Nempong, Flores	Kaifu et al., 2015b[115]
Liang Momer, Flores	Kaifu et al., 2015SI[115]; Jacob, 1967[131]
Liang Toge, Flores	Kaifu et al., 2015SI[115]
Liang X, Flores	Kaifu et al., 2015SI[115]

Supplementary Table 3

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			Crown dimensions				Crown Height	
		n	Length (MD)	Breadth (BL)	Crown Area	Crown Index	n	
Upper central incisor								
Lida Ajer			8.2	6.5	53	79		>10.4
E & SE Asian	Ẋ	13	10.5	8.1	86.6	78.5	2	11.0/13.3
H. erectus/	SD		0.7	0.5	9.2	5.6		
"Arch *H. s.*"	Range		9.3-11.7	7.4-9.4	75-110	69-90		
E Asian	Ẋ	8	8.6	7.1	60.5	80.7		
Late	SD		0.3	0.7	8.3	6.3		
Pleistocene	Range		8.2-9.1	5.5-7.8	45-68	67-86		
Mata Menge			8.0	6.4	51	80		
SE Asian	Ẋ	13	8.8	7.7	68.5	87.2		10.0
Late Pl to mid	SD		0.7	0.4	8.2	4.7		
Holocene	Range		7.8-10.3	7.1-8.4	59-86	81-96		8.0-12.0
Upper second molar								
Lida Ajer			9.4	12.1	114	129		6.1
E & SE Asian	Ẋ	25	11.6	13.1	152.6	113.2	2	6.2/8.2
H. erectus/	SD		0.9	1.2	24.3	7.7		
"Arch *H. s.*"	Range		10.2-13.6	10.9-15.5	116-209	100-126		
E Asian	Ẋ	29	10.1	12.1	121.3	119.4		
Late	SD		0.8	0.9	17.2	8.8		
Pleistocene	Range		8.2-11.9	10.0-13.5	84-150	97-138		
Liang Bua			9.4	10.9	102	116		
SE Asian	Ẋ	23	10.3	12.6	130.4	122.4		7.2
Late Pl to mid	SD		0.6	0.7	12.6	7.0		
Holocene	Range		9.1-11.2	11.0-13.7	106-147	113-138		6.0-8.0

Supplementary Table 4

SUPPLEMENTARY INFORMATION - section 3:

Supplementary discussion │ Micro-computed tomography of fossil teeth

Given the taxonomic debate over enigmatic Asian fossils such as the Trinil molars[133,134] and the Tham Khuyen Cave dental remains[135], we applied microcomputed tomographic (micro-CT) imaging to assess the relative enamel thickness of the teeth (Extended Data Fig. 4). The RET value for the incisor tooth is very similar to mean values for modern humans, exceeding the range of values for extant orangutans (Supplementary Table 5). The molar tooth (ref 11472) showed a RET value that was intermediate between mean values of living humans and living and fossil orangutans.

The study sample for the EDJ shape analysis is listed in Supplementary Table 6. The sample includes first, second and third (third molars not available for all taxa) molars of *Australopithecus africanus*, *Australopithecus robustus*, Early *Homo*, *Homo neanderthalensis*, fossil *Homo sapiens*, and recent *Homo sapiens*.

The process by which a corresponding set of landmarks and semilandmarks was generated for each specimen was as follows. First, for the ridge and cervix landmarks a smooth curve was fitted by starting at an initial point (the first collected landmark) and moving lingually around the curve. A cubic spline was used so that the curve is forced to pass through each measured coordinate. The four MAIN homologous landmarks were projected onto the ridge curve, dividing it into four sections. For each section, a large sample of very closely spaced coordinates was computed along the curve, and the distances between adjacent coordinates were calculated and summed together to approximate the length along the curve segments between the MAIN landmarks. Each length was divided by a given number based on an estimate of the relative contribution of each section of the ridge curve across the molars in the study sample (protocone-paracone = 18; paracone-metacone = 15; metacone-hypocone = 12; hypocone-protocone = 15), and the coordinate location at each equally spaced distance was recorded (Extended Data Fig. 4b). This step was repeated for the cervix curve, but in this case 30 equally spaced landmarks were derived. Thus, at this stage, all specimens had the same total number of landmarks (i.e. the homologous, fixed, landmarks on the tips of the dentine horns, plus equal numbers of semilandmarks on the ridge and cervix curves). We used the algorithm described by Gunz *et al.*[136], which allows semilandmarks to slide along tangents to the curve. These tangents were approximated for each semilandmark as the vector between the two neighbouring points. Semilandmarks were iteratively allowed to slide along their respective curves to minimize the bending energy of the thin-plate spline interpolation function computed between each specimen and the Procrustes average for the sample. After the application of the sliding algorithm, the four fixed landmarks and the 90 semilandmarks for the curves were considered homologous among each of the study specimens.

Each set of landmarks and semilandmarks was converted to shape coordinates by generalized least squares Procrustes superimposition. This removed information about location and orientation from the raw coordinates and standardized each specimen to unit centroid size; a size-measure computed as the square root of the sum of squared Euclidean distances from each semilandmark to the specimen's centroid. All data processing was done in Mathematica v6.0 (www. wolfram.com) using a software routine written by Philipp Gunz.

Extended Data Fig. 5 illustrates the external and internal structure of the Lida Ajer molar. Focusing on the EDJ surface the distal dentine horns are considerably shorter than the mesial dentine horns. There is a crest running into the occlusal basin from the paracone but no clear anterior fovea. The crista obliqua runs from the distal ridge of the protocone to the tip of the metacone dentine horn.

There is no manifestation of Carabelli's trait on the lingual face of the protocone. There is an accessory dentine horn on the mesial ridge of the metacone that is not immediately apparent at the enamel surface. The results of the PCA are illustrated in Extended Data Fig. 6, with the Lida Ajer molar falls well within the modern human morphospace. In summary, the data from the morphometrics and micro-CT scanning of the teeth confirm the original interpretation of the Lida Ajer teeth as modern human[12]. The relatively small size of the incisor, simple molar morphology, and relatively thick enamel compared to living and fossil orangutans (Supplementary Table 5), all suggest these teeth represent a modern human present in the landscape prior to deposition and cementation of the breccia in the cave.

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Supplementary Table 5: Relative enamel thickness (a dimensionless index) in the two Lida Ajer teeth compared to modern humans and living and fossil orang-utans (*Pongo*).

	LA RET	*Homo* mean	*Homo* range	*Homo* n	Extant *Pongo* mean	*Pongo* range	*Pongo* n	Fossil *Pongo* mean	*Pongo* range	Fossil n	Source
UI1	10.05	10.91	8.05 - 14.35	32	7.13	5.48 - 8.57	8	--	--	--	Smith et al.[35-37]
UM2	17.80	21.40	16.49 - 28.03	29	14.79	10.77 - 19.25	19	14.09	10.16 - 18.84	21	

Supplementary Table 6: Comparative sample used for EDJ analysis of the Lida Ajer molar.

Accession	Tooth	Taxon	Site/Source
STS 1	UM1	*Australopithecus africanus*	Sterkfontein
STS 22	UM2	*Australopithecus africanus*	Sterkfontein
STS 24	UM1	*Australopithecus africanus*	Sterkfontein
STS 28	UM2	*Australopithecus africanus*	Sterkfontein
STS 30	UM2	*Australopithecus africanus*	Sterkfontein
STS 52a	UM2	*Australopithecus africanus*	Sterkfontein
STS 56	UM1	*Australopithecus africanus*	Sterkfontein
STS 56	UM2	*Australopithecus africanus*	Sterkfontein
STS 57	UM1	*Australopithecus africanus*	Sterkfontein
STS 8	UM1	*Australopithecus africanus*	Sterkfontein
STS 8	UM2	*Australopithecus africanus*	Sterkfontein
STW 183	UM1	*Australopithecus africanus*	Sterkfontein
STW 183	UM2	*Australopithecus africanus*	Sterkfontein
STW 188	UM2	*Australopithecus africanus*	Sterkfontein
STW 252I	UM2	*Australopithecus africanus*	Sterkfontein
STW 252J	UM1	*Australopithecus africanus*	Sterkfontein
STW 280	UM2	*Australopithecus africanus*	Sterkfontein
STW 402	UM1	*Australopithecus africanus*	Sterkfontein
STW 450	UM1	*Australopithecus africanus*	Sterkfontein
STW 498a	UM2	*Australopithecus africanus*	Sterkfontein
TAUNG 1	UM2	*Australopithecus africanus*	Sterkfontein
TM 1511	UM1	*Australopithecus africanus*	Taung
DNH 57B	UM1	*Australopithecus robustus*	Drimolen
DNH 60A	UM1	*Australopithecus robustus*	Drimolen
SK 102	UM1	*Australopithecus robustus*	Swartkrans
SK 13.14	UM1	*Australopithecus robustus*	Swartkrans
SK 13.14	UM2	*Australopithecus robustus*	Swartkrans
SK 16.1591	UM1	*Australopithecus robustus*	Swartkrans
SK 16.1591	UM2	*Australopithecus robustus*	Swartkrans
SK 47	UM1	*Australopithecus robustus*	Swartkrans
SK 47	UM2	*Australopithecus robustus*	Swartkrans
SK 48	UM1	*Australopithecus robustus*	Swartkrans
SK 48	UM2	*Australopithecus robustus*	Swartkrans
SK 49	UM2	*Australopithecus robustus*	Swartkrans
SK 52	UM1	*Australopithecus robustus*	Swartkrans
SK 52	UM2	*Australopithecus robustus*	Swartkrans
SK 826a2	UM2	*Australopithecus robustus*	Swartkrans
SK 829	UM1	*Australopithecus robustus*	Swartkrans
SK 832	UM1	*Australopithecus robustus*	Swartkrans
SK 834	UM2	*Australopithecus robustus*	Swartkrans
SK 838a	UM1	*Australopithecus robustus*	Swartkrans
SK 89a	UM1	*Australopithecus robustus*	Swartkrans
SKW 33	UM2	*Australopithecus robustus*	Swartkrans

TM 1517a	UM1	*Australopithecus robustus*	Kromdraai
TM 1517a	UM2	*Australopithecus robustus*	Kromdraai
BD 8	UM1	Homo neanderthalensis	Bourgeois-Delaunay
BD 8	UM2	Homo neanderthalensis	Bourgeois-Delaunay
BD 8	UM3	Homo neanderthalensis	Bourgeois-Delaunay
Combe Grenal IX	UM1	Homo neanderthalensis	Combe Grenal
Combe Grenal XIII	UM1	Homo neanderthalensis	Combe Grenal
KRP 100	UM1	Homo neanderthalensis	Krapina
KRP 101	UM2	Homo neanderthalensis	Krapina
KRP 109	UM3	Homo neanderthalensis	Krapina
KRP 134	UM1	Homo neanderthalensis	Krapina
KRP 136	UM1	Homo neanderthalensis	Krapina
KRP 163	UM3	Homo neanderthalensis	Krapina
KRP 165	UM2	Homo neanderthalensis	Krapina
KRP 169	UM2	Homo neanderthalensis	Krapina
KRP 170	UM3	Homo neanderthalensis	Krapina
KRP 171	UM1	Homo neanderthalensis	Krapina
KRP 174	UM1	Homo neanderthalensis	Krapina
KRP 175	UM2	Homo neanderthalensis	Krapina
KRP 180	UM3	Homo neanderthalensis	Krapina
KRP 192	UM2	Homo neanderthalensis	Krapina
KRP 45	UM1	Homo neanderthalensis	Krapina
KRP 46	UM1	Homo neanderthalensis	Krapina
KRP 47	UM1	Homo neanderthalensis	Krapina
KRP 47	UM2	Homo neanderthalensis	Krapina
KRP 48	UM1	Homo neanderthalensis	Krapina
KRP 48	UM2	Homo neanderthalensis	Krapina
KRP 58	UM3	Homo neanderthalensis	Krapina
KRP 96	UM2	Homo neanderthalensis	Krapina
KRP 97	UM3	Homo neanderthalensis	Krapina
KRP 98	UM2	Homo neanderthalensis	Krapina
KRP 99	UM3	Homo neanderthalensis	Krapina
LA QUINA H18	UM1	Homo neanderthalensis	La Quina
LA QUINA H18	UM2	Homo neanderthalensis	La Quina
LE MOUSTIER	UM2	Homo neanderthalensis	Le Moustier
LE MOUSTIER	UM3	Homo neanderthalensis	Le Moustier
Roc de Marsal	UM1	Homo neanderthalensis	Roc de Marsal
SCLA4A3	UM2	Homo neanderthalensis	Scladina
SCLA4A4	UM1	Homo neanderthalensis	Scladina
SCLA4A8	UM3	Homo neanderthalensis	Scladina
SD 1105	UM1	Homo neanderthalensis	El Sidron
SD 1164	UM3	Homo neanderthalensis	El Sidron
SD 332	UM3	Homo neanderthalensis	El Sidron
SD 407	UM2	Homo neanderthalensis	El Sidron
SD 531	UM1	Homo neanderthalensis	El Sidron
SD 551	UM2	Homo neanderthalensis	El Sidron

SD 621	UM3	Homo neanderthalensis	El Sidron
St-Cesaire	UM2	Homo neanderthalensis	Saint Cesaire
St-Cesaire	UM3	Homo neanderthalensis	Saint Cesaire
DNH 39	UM1	Early *Homo*	Drimolen
DNH 70	UM1	Early *Homo*	Drimolen
KNM-ER 1590L	UM1	Early *Homo*	Koobi Fora
KNM-ER 1590M	UM2	Early *Homo*	Koobi Fora
KNM-ER 1808H	UM2	Early *Homo*	Koobi Fora
KNM-ER 1813	UM2	Early *Homo*	Koobi Fora
KNMWT 47767	UM1	Early *Homo*	West Turkana
Sangiran S4	UM1	Early *Homo*	Sangiran
Sangiran S7 3b	UM1	Early *Homo*	Sangiran
SE 1508	UM2	Early *Homo*	Sterkfontein
SK 27	UM2	Early *Homo*	Swartkrans
SKX 268	UM1	Early *Homo*	Swartkrans
Belgian 134c	UM2	*Homo sapiens*	Neolithic
Belgian 59b	UM1	*Homo sapiens*	Neolithic
Belgian A33	UM1	*Homo sapiens*	Neolithic
Belgian A34	UM1	*Homo sapiens*	Neolithic
Belgian A40	UM2	*Homo sapiens*	Neolithic
Belgian HUM001	UM2	*Homo sapiens*	Neolithic
Belgian M1D	UM1	*Homo sapiens*	Neolithic
Belgian M2G	UM2	*Homo sapiens*	Neolithic
MPI-EVA 072	UM3	*Homo sapiens*	Clinical extraction
MPI-EVA 104	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 106	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 11	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 121	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 13	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 163	UM3	*Homo sapiens*	Clinical extraction
MPI-EVA 183	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 186	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 187	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 189	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 272	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 289	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 2	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 45	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 49	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 513	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 51	UM1	*Homo sapiens*	Clinical extraction
MPI-EVA 530	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 565	UM3	*Homo sapiens*	Clinical extraction
MPI-EVA 581	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 60	UM3	*Homo sapiens*	Clinical extraction
MPI-EVA 660	UM2	*Homo sapiens*	Clinical extraction

MPI-EVA 69	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 95	UM2	*Homo sapiens*	Clinical extraction
MPI-EVA 9	UM2	*Homo sapiens*	Clinical extraction
Qafzeh10	UM2	Fossil *Homo sapiens*	Qafzeh
Qafzeh10	UM1	Fossil *Homo sapiens*	Qafzeh
Qafzeh 11	UM1	Fossil *Homo sapiens*	Qafzeh
Qafzeh 11	UM2	Fossil *Homo sapiens*	Qafzeh
Qafzeh 15	UM1	Fossil *Homo sapiens*	Qafzeh
Qafzeh 15	UM2	Fossil *Homo sapiens*	Qafzeh
Qafzeh 9	UM2	Fossil *Homo sapiens*	Qafzeh
Qafzeh 9	UM1	Fossil *Homo sapiens*	Qafzeh
Skhul I	UM1	Fossil *Homo sapiens*	Skhul
NMNH 16	UM3	*Homo sapiens*	Neolithic
NMNH 21	UM1	*Homo sapiens*	Neolithic
NMNH 6	UM2	*Homo sapiens*	Neolithic
NMNH 8	UM2	*Homo sapiens*	Neolithic

SUPPLEMENTARY INFORMATION - section 4:

Supplementary discussion | Luminescence dating of breccia matrix

In this region, the quartz is of volcanic origin so the resulting luminescence emissions are dominated by a longer wavelength red signal rather than the traditional shorter wavelength UV signal[137]. To be able to use the longer wavelength to estimate the time since deposition requires the use of a DAP red TL dating technique[43]. DAP was originally designed for samples with minimal amounts of quartz, hence the use of only two aliquots[43] but the use of many grains on each aliquot opens the possibility that some of the grains may not have been fully bleached prior to burial. Thus the red TL age estimate represents a maximum age for sediment burial. However, the use of multiple estimates of the palaeodose for other samples (e.g.,[123,138]) have demonstrated that the results are reproducible and compare well with independent ages estimates[139]. The feldspars in this volcanic region suffer from extreme anomalous fading[48], where despite the physics of lifetime predicting thermal stability of the signal, a loss of infra-red stimulated luminescence (IRSL) signal or 'fading' is observed, which can cause large underestimations in the final age estimate[20].

The red TL signal from the deposits in Lida Ajer cave compares favourably with the signal from the sediments at Liang Bua cave in Western Flores, Indonesia (e.g.,[43,137])(Extended Data Fig. 7 a-b), with a similar wavelength of emission (e.g., Morwood *et al*.,[48]) but stronger signal intensity. The feldspars display strong emissions (Extended Data Fig. 7e-f) with fading characteristics and *g*-values of 15-17% per decade, which is comparative to the feldspars from Liang Bua. However, the fading tests at the four temperature combinations indicate that a signal with negligible fading (g-values of 2.0-1.7%) can be successfully isolated and used for dating (Extended Data Fig 7h).

A modern sample (LA-MOD) was collected from the exposed cave entrance and analyzed using the quartz red TL signal and feldspars pIR-IRSL signal. The red TL emissions returned an aliquot A D_e of ~130 Gy, which represents the hard-to bleach component of the red TL signal. However, the aliquot B signal returned lower D_e values of between 1-2 Gy indicating sufficient bleaching of the easy-to-bleach red TL signal. This agrees with previous bleaching studies conducted on the Liang Bua material[48]. The feldspar analysis from the 270-300°C stimulation preheat combination on the same sample returned a residual of 5-8 Gy similar to that observed in the bleaching tests.

The dosimetry calculated using the high resolution gamma spectrometry data (1.141 Gy/ka^{-1}) is slightly higher than the dose rate determined using the portable gamma spec and in-laboratory beta counting (1.034 Gy/ka^{-1}; SI section 4 Table 7). We attribute this to a difference in the dosimetry of the matrix compared to the dosimetry of the breccia as a whole. The high resolution gamma spectrometry was conducted on just the matrix of the breccia and returns a higher dose rate than the *in-situ* measurement of the gamma contribution using the portable gamma spectrometer. This is due to attenuation the *in-situ* gamma from the profusion of limestone clasts in the breccia (greater than 70%). In addition, as the breccia sampled in Area 1 had a preserved thickness of ~15 cm the presence of the limestone wall and roof for the remaining 15 cm of gamma ray penetration would add to this attenuation effect. Therefore we have used the portable gamma spectrometer/beta counter combination of techniques to determine the dose rate as this more accurately reflects the *in-situ* dosimetry of the breccia, and have used the high resolution data for the purposes of disequilibrium determination and adjustment. Interestingly, the use of the higher dose rate produces a corrected red TL age of 77 ± 23 kyr, which still lies well within the minimum age (71 ± 7 kyr) of the overlying flowstone (Fig. 3).

High resolution gamma spectrometry of the cave sediments reveals three potential disequilibrium states; 1) in the ^{238}U chain a deficiency of 45% in ^{226}Ra compared to ^{238}U; 2) a ^{210}Pb deficiency of between 15% compared to ^{226}Ra; and 3) in the ^{232}Th chain a small excess of 13% in ^{228}Th compared to ^{228}Ra. Thorium is thought to be immobile in most sediments[140] and this combined with the short half-lives (t) of the daughter nuclides (^{228}Ra = 5.7 yrs and ^{228}Th = 1.91 yrs) means that this effect is negligible in samples older than 20 years[141]. The deficiency in ^{226}Ra and ^{210}Pb could potentially be the most problematic as ^{238}U is more mobile in the sediment column[141] and ^{226}Ra has a much longer half-life (1602 years). This deficiency indicates that radium redistribution is occurring in the sediment column possibly due to the effects of leaching in the cave environment. However, in a worst case scenario with a ^{228}Ra deficiency of 50% (the LA sample has only 45%) in a closed environment, the deviations from the dose rate are <3% and as ^{238}U contributes 27% of the total dose rate, <3% of the U chain equates to 0.81% of the total dose rate leading to an error of ~3 %, and this value would decrease to 0 after 40 kyr[141], which is less than the estimated age of the sample. Alternatively, if sediments in disequilibrium are deposited in an open system the potential disequilibrium from radium mobility is likely to cause a larger deviation than 0.81% and the error margin would increase to ~6% on the final age estimate[141]. The current disequilibrium in ^{226}Ra indicates that radium has been mobile during the last 10 kyr reflecting the proportion of limestone clasts in the breccia. The evidence from this site suggests that thorium redistribution is minimal and we suspect that Uranium mobilization via leaching occurred inside the cave after burial. Therefore to accommodate this additional source of uncertainty the error margin on the dose rates has been increased by 6%[141].

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Supplementary Table 7: Luminescence dating of sediments at Lida Ajer: dose rate data, equivalent doses, and age estimates

Technique[a]	Sample depth (m)	Field gamma dose rate (Gy kyr^{-1})[b]	Beta dose rate (Gy kyr^{-1})[b]	Cosmic-ray dose rate (Gy kyr^{-1})[c]	Internal dose rate (Gy kyr^{-1})	Water content (%)[d]	Total dose rate (Gy kyr^{-1})[e]	Equivalent dose (Gy)[f]	Age (kyr)[g]
Red TL U	2.23	0.189 ± 0.005	0.727 ± 0.037	0.088 ± 0.009	0.030 ± 0.010	16 / 15 ± 5	1.034 ± 0.068	132 ± 13	128 ± 16
Red TL B								88 ± 25	85 ± 25
pIR-IRSL		0.189 ± 0.005	0.727 ± 0.037	0.088 ± 0.009	0.720 ± 0.020	16 / 15 ± 5	1.723 ± 0.070	105 ± 6	62 ± 5
HRGS	**^{238}U (Bq/kg)**	**^{226}Ra (Bq/kg)**	**^{210}Pb (Bq/kg)**	**^{228}Ra (Bq/kg)**	**^{228}Th (Bq/kg)**	**^{40}K (Bq/kg)**			
	23 ± 3	14 ± 1	12 ± 4	19 ± 2	21 ± 7	177 ± 12	1.141 ± 0.084		

[a] Techniques used for processing sample LA-OSL1 – Red TL = red thermoluminescence - U, unbleachable signal (i.e., light-insensitive signal, last zeroed when the grains were heated), B, bleachable signal (i.e., light-sensitive signal, last reset when the grains were exposed to sunlight). pIR-IRSL = post infra-red infra-red-stimulated luminescence using a minimum age model (MAM). HRGS = high resolution gamma spectrometry to estimate the U, Th and K concentrations in the dried and powdered sample, provide a comparison of dose rate, and to test the degree of disequilibrium occurring at the site. Sample processed using the 90-125 µm size fraction. Fig 2 contains the sampling location.
[b] U, Th and K concentrations measured using a portable gamma-ray spectrometer at field water content to estimate the field gamma dose rate combined with beta counting measurements of dried and powdered sediment samples in the laboratory.
[c] Time-averaged cosmic-ray dose rates (for dry samples), each assigned an uncertainty of ± 10%.
[d] Field / time-averaged water contents, expressed as (mass of water/mass of dry sample) x 100. The latter values were used to calculate the total dose rates and ages
[e] Mean ± total (1σ) uncertainty, calculated as the quadratic sum of the random and systematic uncertain ties. Note this error has been increased by 6% to incorporate uncertainty determined by the high resolution gamma spectrometry
[f] Equivalent doses include a ± 2% systematic uncertainty associated with laboratory beta-source calibrations.
[g] Uncertainties at 68% confidence interval.

SUPPLEMENTARY INFORMATION - section 5:

Supplementary discussion │ U-series dating of speleothems

As all the samples are impure calcite with high levels of detrital components (i.e. sediment contamination), non-radiogenic ^{230}Th correction is essential and has been applied to each sample using two different correction schemes (see SI section 5 Table 8). In the first scheme, a bulk-Earth $^{230}Th/^{232}Th$ activity ratio of 0.825 ± 50% (with the ^{238}U-^{234}U-^{230}Th decay chain is assumed to be in secular equilibrium) was used for correction, as is typical of most other studies[60]. This correction scheme results in large error magnifications caused by the large assumed uncertainty (50%) of the $^{230}Th/^{232}Th$ activity ratio (see SI section 5 Table 8). In the second scheme, a measured $^{230}Th/^{232}Th$ activity ratio of 0.969 ± 3.7% (with the ^{238}U-^{234}U-^{230}Th decay chain is assumed to be in secular equilibrium) was used for correction. The value of 0.969 ± 3.7% was obtained by measuring $^{230}Th/^{232}Th$ in the nitric-acid insoluble residue of the flowstone sample (mean of replicate analyses from two separate digestions). This sample- or site-specific correction scheme is more realistic and the associated error magnifications are a lot smaller (see SI section 5 Table 8).

The overlying flowstone (LA-F1) was most seriously contaminated by detrital thorium as reflected by the lowest measured U/Th (0.47) or $^{230}Th/^{232}Th$ (1.2, note that measured $^{230}Th/^{232}Th$ is a function of U/Th and age of the sample) ratio of the flowstone. In addition, microscopic examination indicates that the impure calcite crystals typically consist of cores with later-stage overgrowth, possibly related to flushing of groundwater through this loose sediment-contaminated flowstone along the calcite grain boundaries during later-stage wet periods. Because of this, we applied time-controlled dilute nitric acid etching to remove the younger over-growths. The sample of the remaining cores was measured by the MC-ICPMS returning a corrected ^{230}Th age of 71 ± 7 kyr if the measured $^{230}Th/^{232}Th$ activity ratio of 0.969 ± 3.7% is used for non-radiogenic ^{230}Th correction. This result represents the best estimation for the precipitation of the overlying flowstone (SI section 5 Table 8).

The other two flowstone samples (LA-F2 and 3) were not as contaminated as LA-F1, as reflected by their slightly higher measured U/Th (2.8 and 0.93) or $^{230}Th/^{232}Th$ (1.7 and 2.6) ratios. They return corrected ^{230}Th ages of 11.0 ± 1.5 and 203 ± 17, respectively, consistent with their stratigraphic relations to the bone breccia.

A soda straw stalactite (LA-08) collected from the bone breccia contains the purest calcite of all the samples, as reflected by its significantly higher U/Th (10.4) and $^{230}Th/^{232}Th$ (17.9). As the calcite is significantly purer, the corrected ^{230}Th age is far more robust, as it is relatively insensitive to the choice of $^{230}Th/^{232}Th$ activity ratio values for the detrital component for non-radiogenic ^{230}Th correction. As can be shown in SI section 5 Table 8, the two corrected ^{230}Th ages obtained using the two separate correction schemes are analytically indistinguishable (84.7 ± 1.7 kyr vs 84.2 ± 1.0 kyr). Due to short residence times on the cave ceiling and propensity to be dislodged and incorporated into underlying accumulating breccias, straw stalactites provide maximum ages that are commonly close to the true age of the associated deposit[19,142,143]. Thus, it is highly probable that the corrected ^{230}Th age of 84.2 ± 1.0 kyr approximates the depositional age of the breccia.

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Supplementary Table 8: Uranium-series dating of Lida Ajer speleothem: age estimates and supporting data

Sample code /*location* [a]	^{238}U (ppm)	^{232}Th (ppb)	^{230}Th/^{232}Th activity ratio [b]	^{234}U/^{238}U activity ratio	^{230}Th/^{238}U activity ratio	Uncorrected ^{230}Th age (kyr)	Corrected ^{230}Th Age-I (kyr)[c]	Corrected ^{230}Th Age-II (kyr)[d,e]
Flowstones								
LA-F1/*4*[f]	0.407	868	1.206 ± 0.004	1.0290 ± 0.0007	0.849 ± 0.002	187 ± 1	98 ± 62	71 ± 7
LA-F2/*3*	0.134	47.6	1.72 ± 0.08	1.0309 ± 0.0023	0.201 ± 0.009	24 ± 1	13 ± 6	11 ± 2
LA-F3/*2*	0.0116	12.5	2.60 ± 0.04	1.0263 ± 0.0056	0.926 ± 0.016	246 ± 17	211 ± 23	203 ± 17
Soda straw								
LA08-29/*4*	0.0338	3.24	17.9 ± 0.1	1.017 ± 0.002	0.563 ± 0.004	88 ± 1	85 ± 2	84 ± 1

[a] The location refers to one of three areas within the chamber that contain breccia deposits; Areas 1-4 are marked on Fig. 2 with sample depths for F1-3 and LA08 of 1.23, 1.75, 1.60 and 1.23 m, respectively, measured from base of the cave floor to sampling height.

[b] All uncertainties at 95% confidence interval.

[c] Corrected ^{230}Th Age-I calculated using bulk-Earth ^{230}Th/^{232}Th activity ratio of 0.825 ± 50% and the ^{238}U-^{234}U-^{230}Th decay chain in secular equilibrium for non-radiogenic ^{230}Th correction.

[d] Corrected ^{230}Th Age-II calculated using a measured ^{230}Th/^{232}Th activity ratio of 0.969 ± 3.7% and the ^{238}U-^{234}U-^{230}Th decay chain in secular equilibrium for non-radiogenic ^{230}Th correction. The value of 0.969±3.7% was obtained by measuring ^{230}Th/^{232}Th in the nitric-acid insoluble residue (mean of replicate analyses from two separate digestions).

[e] Corrected ^{230}Th age-II is preferred as the ^{230}Th/^{232}Th activity ratio of 0.969 ± 3.7% for non-radiogenic ^{230}Th correction was directly measured from the nitric acid-insoluble residue of the flowstone sample, rather than assumed. As non-radiogenic ^{230}Th was mainly derived from non-carbonate sediments mixed into the speleothem, this non-radiogenic ^{230}Th scheme is more realistic and reliable (see SOM for detailed discussion).

[f] LA-F1/4 was measured by MC-ICP-MS, and the other flowstone and the straw samples by TIMS.

SUPPLEMENTARY INFORMATION - section 6:

Supplementary discussion │ Laser-ablation Uranium-series dating of teeth

The importance of the *Pongo* sp. tooth as a museum specimen from Dubois's original excavation collection (9967/A) meant that we were not able to cut the tooth as per other samples. Instead, we used a small drill to recover dentine from the surface of the specimen. As a comparison, we conducted a similar analysis on sample 7/LA/5/8. While not providing any information regarding U leaching – these analysis were conducted to demonstrate that the material collected by Dubois is roughly of the same antiquity as the material collected and dated from our minor excavations. This agreement is important for establishing a chronology for the modern human teeth discovered by Dubois.

U-series dating of bone and teeth is governed by the fact that the materials may uptake uranium following their burial. A range of models have been developed to account for this uranium uptake and provide a basis for open system dating. The diffusion-adsorption (D-A) model was developed by[143-145], and refined by[146-147]. It is based on laboratory experiments and assumes a continuous diffusion of uranium from the outside of a bone or tooth towards the interior, and that the partitioning between the bone and solution (groundwater) and the U concentration in the solution are constant. The bone is treated as a homogeneous medium with infinite plane geometry. Under constant conditions, the cross sections of bones that conform to the D-A diffusion model are expected to have both u-shaped U-concentration and apparent U-series age profiles, with the apparent ages at the surface being closest to the correct age of the sample. Deviations from such ideal profiles can be explained either by leaching or changes in the U concentration in the solution. A more sophisticated Diffusion-Adsorption-Decay (DAD) model expands the original D-A model for diffusion of ^{234}U and its decay during the diffusion process[148]. For a given volume in a bone, the DAD model postulates that ^{234}U is continually resupplied by diffusion. As a result, $^{234}U/^{238}U$ ratios change little over time, consequently DAD model ages are somewhat older than comparative D-A results. A fundamental principle of open system U-series dating of bone is that unless a major phase of leaching has taken place, all U-series age estimates on bone/teeth are minimum estimates for the age of the individual. It is important to note that it can be difficult or impossible to estimate by how much the U-series results underestimate the correct age of the sample[147].

It is expected from the diffusion-adsorption model for U-uptake[144-147] that spatially resolved analyses across a homogeneous bone yield U-shaped or constant U-concentration and apparent U-series age profiles. In ideal circumstances, a plot of apparent U-series age versus U-concentration would either be flat or show increasing U-series age estimates with increasing U-concentrations. For a tooth with an enamel barrier on the outside, a one-side diffusion is expected from the interior resulting in a decreasing or flat U-concentration and apparent U-series age profiles.

For the four fossil samples, D-A modelling of U-series age estimates was performed using both 1 and 2 dimensional diffusion. The former initially seemed appropriate where the enamel effectively blocked diffusion from the outer surface, but the model could not account for the steep date gradients at the surface and the shallow U concentration gradients. For most cases this could not be explained by leaching of U from towards the surface, and is therefore probably a result of the non-conformity of the teeth to the ideal infinite plane geometry used by the D-A model. Most of the spot and track data were unsuitable for modelling 2 dimensional diffusion because of their asymmetric U and date profiles, caused by the enamel acing as a barrier to uranium diffusion. However, track 13C is from dentine below the enamel crown and seems to conform to 2 dimensional diffusion-adsorption. By taking spot 3 on the tracks (of track 13C) as the innermost spot (the first two spots seem to run down the inner surface) a reasonable fit to the D-A model was obtained, at around 55 kyr with t'=1 (see Extended Data Fig. 8i) which should be taken as a minimum age for this tooth. This was the only track where a reasonable fit to the DA model was obtained. Clearly, these samples are not universally behaving according to the D-A model, most probably due to the complex geometry of a tooth.

To summarise, the age estimates on the fossil teeth have been analysed using the D-A model and, with one exception that gives a minimum D-A model age of 55 kyr, do not conform to scenarios of constant geochemistry and infinite planar geometry. Thus, the U-series age estimates have been provided as supporting evidence for the time of breccia deposition. However, the teeth have a consistent pattern of U-Th ratios at the surface, which are similar to those from the samples in the museum. This provides another connection between our material and Dubois's original excavations and fossils.

In this study, all profiles are from the interior to the exterior of the tooth (Supplementary Table 7). The enamel was too low in U concentration to calculate ages so only dentine measurements are mentioned. Except when explicitly stated, the elemental $^{238}U/^{232}Th$ ratios are all well in excess of 1000, which correspond to activity ratios of >3000. We cannot explicitly quantify the $^{230}Th/^{232}Th$ activity ratios, as we do not have a matrix matched ^{232}Th standard. However, the very high $^{238}U/^{232}Th$ ratios imply that any corrections for detrital ^{232}Th are not necessary. The measurements are all characterized by a decreasing or flat U-concentration and apparent U-series age profile except for some samples where the first two points are relatively lower. The assumption of the U-uptake model presented by [129], that the $^{234}U/^{238}U$ ratio in the vicinity of the bones' surfaces are constant over time, would have a negligible effect on any age calculations as all measured $^{234}U/^{238}U$ ratios are very close to 1 (except for sample 7/LA/5/8 profile A, B and C with a $^{234}U/^{238}U$ activity ratios of ~1.3).

Sample 7/LA/5/8

The analyses were carried out along four profiles (A-D). In the first profile (A), the uranium concentration decreases from about 5 ppm to 3 ppm in the first 4 spots and is relatively stable thereafter (Supplementary Table 7). The first spot has a relatively lower elemental $^{238}U/^{232}Th$ ratio of 183 corresponding to an apparent age of 94.9 +23.6/-19.7 kyr. The second spot has an apparent age of 33.5 ± 3.3 kyr while the other spots show a slightly reverse u-shaped age profile with apparent ages between about 15 and 25 ka. The last two spots are into the enamel and the uranium concentration is too low to calculate age estimates.

In the second profile (B), the uranium concentration is relativity stable at about 3 ppm except for spot #1, 3 (~4 ppm), and 5 (~8 ppm). For these three spots, the elemental $^{238}U/^{232}Th$ ratio is relatively lower at about 500. The age of spot #3 seems overestimated with an apparent age of 162 + 20.9/-17.9 kyr while spot # 5 is beyond the rage of U-series dating. These 2 spots have a $^{230}Th/^{238}U$ activity of 1.12 and 2.48 and are thus possibly affected by uranium leaching. The apparent ages for the other spots varies between about 15 and 30 ka. The last two spots are into the enamel and the uranium concentration is too low to calculate age estimates.

The third profile (C) shows a slightly decreasing uranium concentration from spot #3 (from 3.72 to 2.41 ppm). The first 2 spots have lower uranium concentrations at 2.67 and 3.13 ppm and are associated with lower elemental $^{232}Th/^{238}U$ of 103 and 176 and apparent older ages of 84 +3.9/-3.8 and 61 +2.7/-2.6 kyr. From spot #3, the apparent age drops from about 40 kyr to stabilize at about 30. They all have high elemental $^{230}Th/^{238}U$ except perhaps for spot 3 at 647. The last spot is into the enamel and the uranium concentration is too low to calculate an age estimate.

The fourth profile (D) is characterized by stable U concentration from spot #3 at about 3 ppm. The first two spots have higher U concentration but are not affected by lower elemental $^{232}Th/^{238}U$. Indeed, the elemental $^{230}Th/^{238}U$ is relatively high for all spots and the apparent ages are all relatively constant at about 14-17 kyr except for the last spot, which has an apparent age of 27.5 ± 0.7 kyr.

The results of these four profiles indicate apparent U-series minimum ages of 80-75 kyr close to the root canal and about 40-30 kyr further into the dentine.

Sample 12/LA/5/8
The two profiles (A, B) have similar characteristics with decreasing uranium concentration from the interior to the exterior of the tooth from about 7 to 4 ppm. The elemental $^{232}Th/^{238}U$ is high and the apparent age constant at about 30 kyr except for spot #1 in the first profile and spot #2 in the second profiles with a 25 kyr apparent age. The minimum age estimate for this sample is 30 kyr. The last two spots are into the enamel while the third spot contains a mixture of dentine and enamel. The uranium concentration is too low to calculate ages.

Sample 13/LA/5/8
In the first two profiles (A, B), the uranium concentration is relatively stable at about 7 ppm. The elemental $^{232}Th/^{238}U$ is high and apparent ages are higher in the first 2 spots at 44.2 ± 1 kyr and 33.8 ± 1 kyr (profile A) and 41.2 ± 1 and 35.2 ± 1.1 kyr (profile B). The apparent ages are relatively constant thereafter at about 28-30 kyr. The last four spots are into the enamel and the uranium concentration is too low to calculate age estimates.

In the third profile, the uranium concentration is higher in the first two spots at about 10 ppm. It then gradually decreases from about 8 to 6.5 ppm. The elemental $^{232}Th/^{238}U$ is high except for the first two spots at 21 and 221 ppm corresponding to apparent ages of 66.4 ± 1.4 and 65.4 ± 1.2 kyr. The first two spots (1 and 2) are possibly affected by detrital contamination resulting in age over-estimation. Post sampling photos reveal that these spots had not left any craters, so they probably were sampling the inner surface of the tooth, hence we have rejected them for the D-A modelling. The remaining apparent age profile shows a u-shaped profile with ages varying from about 50 and 40 kyr on the outside to about 35 kyr on the inside on the profile. The minimum age estimate for this sample is about 55 kyr.

Sample 21/LA/5/8
In the two profiles the U concentration is relatively stable at about 4.5 ppm except for the first two spots at about 3.5 ppm. The elemental $^{232}Th/^{238}U$ is high and the age decreases from about 40 kyr in the first two spots to about 30 kyr. It is possible that the first two spots could be affected by leaching of uranium. The last spot is into the enamel and the uranium concentration is too low to calculate age estimates.

Sample Dubois 9967/A surface drilling
Three spots were drilled into the dentine at the base of the enamel crown (Supplementary Table 8). The first 500 cycles were divided into 10 aliquots of 50 cycles each. The results are essentially only from the top surface of the dentine. It is also impossible to calculate U and Th concentrations from this type of analysis. The results seem to indicate a minimum age of 70-60 kyr.

Sample 7/LA/5/8 surface drilling
The sample was analysed using a similar process to previous sample (Supplementary Table 8) and the results seem to indicate a minimum age of 80-70 ka.

Overall, the four fossil teeth analysed provide a minimum age range of >80-75 ka. In addition, the Dubois tooth (9967/A) provided a rough estimate of 70-60 ka based only on surface drilling. We do not place too much emphasis on this later result (hence we have not presented the data on SI section 5 Table 8) and it has not been used in the Bayesian modelling, as we have no knowledge of the how leaching has affected this tooth. Instead, we use it to demonstrate that the tooth from the Dubois excavation is of a similar antiquity to the fossil teeth analysed using the profiling techniques.

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7/LA/5/8 profile 1

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10	Spot-11
Start	1528	1619	1710	1801	1892	1983	2074	2165	2256	2347	2438
End	1586	1677	1768	1859	1950	2041	2132	2223	2314	2405	2496
Top Start	1534	1625	1716	1807	1898	1989	2080	2171	2262	2353	2444
Top End	1574	1665	1756	1847	1938	2029	2120	2211	2302	2393	2484
Th-230	38	15	6	6	9	7	7	7	6	1	0
U-234	422	376	323	239	294	249	255	268	250	6	1
R85	141.1	141	142.1	143	142.1	143.5	140.5	142.6	142.8	276.8	-19.2
U (ppm)	4.99	4.52	3.97	2.88	3.59	2.99	3.1	3.24	3.01	0.08	0.01
Th (ppb)	27.29	3.1	0.55	0.97	0.31	-0.17	0.4	0.45	0.58	0.47	1
U/Th	183	1457	7232	2962	11464	-17078	7804	7214	5180	175	8
R08	0.7919	0.3475	0.1653	0.2166	0.2472	0.2287	0.2424	0.2322	0.1972	0.789	3.8425
R08-error	0.1165	0.0294	0.0131	0.0148	0.0118	0.0132	0.0169	0.0149	0.0135	46.7464	5.0854
R48	1.3222	1.2989	1.2706	1.2955	1.278	1.3038	1.2833	1.2921	1.2978	1.1903	1.4539
R48-error	0.0116	0.0112	0.0093	0.0108	0.008	0.0121	0.0117	0.0089	0.0117	6.258	0.8936
R04	0.5988	0.2675	0.1301	0.1672	0.1934	0.1754	0.1889	0.1797	0.1519	0.6628	2.6427
R04-error	0.0796	0.0217	0.0104	0.0119	0.009	0.0106	0.0132	0.012	0.0106	0.7143	1.682
R04	0.5989	0.2675	0.1301	0.1672	0.1934	0.1754	0.1889	0.1797	0.1519	0.6629	2.6429
R04-error	0.0883	0.0227	0.0104	0.0115	0.0093	0.0103	0.0133	0.0116	0.0105	39.4259	3.8565
CS age	94.9	33.5	15.1	19.8	23.3	20.9	22.7	21.4	17.9	113.7	0
Err+	23.6	3.3	1.3	1.5	1.2	1.3	1.8	1.5	1.3	0	0
Err-	19.7	3.3	1.3	1.5	1.2	1.3	1.7	1.5	1.3	0	0

7/LA/5/8 profile 2

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9
Start	2529	2620	2711	2802	2894	2985	3076	3167	3258
End	2587	2678	2769	2860	2952	3043	3134	3225	3316
Top Start	2535	2626	2717	2808	2900	2991	3082	3173	3264
Top End	2575	2666	2757	2848	2940	3031	3122	3213	3304
Th-230	11	5	42	7	189	7	6	4	1
U-234	337	228	342	211	759	255	222	183	3
R85	141	141	139.8	138.2	140	140.9	142.6	139	43.8
U (ppm)	4.13	2.74	3.88	2.57	7.95	3.09	2.73	2.25	0.01
Th (ppb)	7.78	0.67	8.28	0.22	15.9	0.81	0.32	0.42	0.62
U/Th	531	4060	469	11622	500	3816	8637	5343	22
R08	0.2835	0.19	1.1229	0.2919	2.4765	0.2453	0.2375	0.1966	5.3941
R08-error	0.0141	0.0173	0.0631	0.0206	0.159	0.0155	0.0158	0.0168	1.915
R48	1.2739	1.3022	1.3763	1.2817	1.4922	1.286	1.2703	1.2685	2.9505
R48-error	0.0104	0.0116	0.0099	0.0114	0.0194	0.0124	0.0124	0.0152	0.3501
R04	0.2226	0.1459	0.8159	0.2277	1.6595	0.1907	0.1869	0.1549	1.828
R04-error	0.0111	0.0138	0.0438	0.0169	0.1015	0.0114	0.0128	0.0144	0.9156
R04	0.2226	0.1459	0.8159	0.2277	1.6596	0.1907	0.187	0.1549	1.8282
R04-error	0.0112	0.0133	0.0462	0.0162	0.1087	0.0122	0.0125	0.0133	0.6843
CS age	27.2	17.1	162	27.9	0	22.9	22.4	18.3	0
Err+	1.6	1.7	20.9	2.3	0	1.6	1.7	1.7	0
Err-	1.5	1.7	17.9	2.2	0	1.6	1.6	1.7	353.2

7/LA/5/8 profile 3

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10
Start	3349	3440	3531	3622	3713	3804	3895	3986	4077	4168
End	3407	3498	3589	3680	3771	3862	3953	4044	4135	4226
Top Start	3355	3446	3537	3628	3719	3810	3901	3992	4083	4174
Top End	3395	3486	3577	3668	3759	3850	3941	4032	4123	4214
Th-230	19	17	15	11	9	8	8	7	7	1
U-234	227	265	314	273	261	231	222	219	195	2
R85	140.6	141.1	140.1	138.8	141.7	139.3	141.1	141	139.9	150.3
U (ppm)	2.67	3.13	3.72	3.31	3.15	2.84	2.7	2.65	2.41	0.02
Th (ppb)	25.87	17.76	5.75	0.58	1.15	0.8	0.55	0.69	0.76	0.5
U/Th	103	176	647	5687	2728	3539	4961	3845	3183	34
R08	0.7323	0.5784	0.4141	0.3442	0.3011	0.2779	0.3118	0.2768	0.2928	3.8381
R08-error	0.0212	0.0187	0.0145	0.0171	0.0224	0.0207	0.0192	0.0187	0.0194	115.886
R48	1.3272	1.3237	1.318	1.2877	1.293	1.2709	1.2809	1.2949	1.2653	1.5883
R48-error	0.0147	0.0114	0.0112	0.012	0.016	0.0121	0.0159	0.0133	0.014	3.7871
R04	0.5517	0.4369	0.3142	0.2673	0.2329	0.2186	0.2434	0.2137	0.2314	2.4164
R04-error	0.017	0.0144	0.0112	0.0132	0.0206	0.0175	0.0157	0.016	0.0171	1.3201
R04	0.5518	0.437	0.3142	0.2673	0.2329	0.2186	0.2434	0.2137	0.2314	2.4165
R04-error	0.0171	0.0146	0.0113	0.0135	0.0175	0.0164	0.0153	0.0146	0.0155	73.191
Age	84	61	40.5	33.5	28.6	26.7	30.1	26	28.4	0
Err+	3.9	2.7	1.8	2	2.5	2.3	2.2	2	2.2	0
Err-	3.8	2.6	1.7	1.9	2.4	2.2	2.1	2	2.1	0

7/LA/5/8

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8
Start	1445	1536	1626	1717	1808	1899	1989	2080
End	1503	1594	1684	1775	1866	1957	2047	2138
Top Start	1451	1542	1632	1723	1814	1905	1995	2086
Top End	1491	1582	1672	1763	1854	1945	2035	2126
Th-230	30	22	15	17	17	15	16	27
U-234	908	670	451	458	437	410	415	457
R85	140.4	140.3	141.2	140.6	140.1	140.1	139.7	139.4
U (ppm)	6.39	4.72	3.19	3.18	3.06	2.86	2.92	3.11
Th (ppb)	2.72	0.56	0.49	0.4	0.19	0.31	0.43	1.35
U/Th	2347	8494	6495	8020	16158	9227	6818	2304
R08	0.1336	0.1288	0.1338	0.1481	0.1563	0.1441	0.1546	0.2427
R08-error	0.004	0.0045	0.005	0.0057	0.004	0.0066	0.0055	0.0055
R48	1.051	1.0512	1.0461	1.0667	1.0578	1.0613	1.0497	1.0848
R48-error	0.0044	0.0056	0.0083	0.0057	0.0068	0.0072	0.0076	0.0071
R04	0.1271	0.1226	0.1279	0.1388	0.1477	0.1358	0.1473	0.2237
R04-error	0.0039	0.0044	0.0048	0.0056	0.004	0.0059	0.0056	0.0056
R04	0.1271	0.1226	0.1279	0.1388	0.1478	0.1358	0.1473	0.2237
R04-error	0.0038	0.0043	0.0049	0.0054	0.0039	0.0063	0.0053	0.0053
Age	14.8	14.2	14.9	16.3	17.4	15.9	17.4	27.5
Err+	0.5	0.5	0.6	0.7	0.5	0.8	0.7	0.7
Err-	0.5	0.5	0.6	0.7	0.5	0.8	0.7	0.7

13/LA/5/8 profile 1

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10	Spot-11	Spot-12	Spot-13	Spot-14	Spot-15
Start	884	976	1068	1160	1252	1344	1436	1528	1619	1711	1803	1895	1987	2079	2171
End	942	1034	1126	1218	1310	1402	1494	1586	1677	1769	1861	1953	2045	2137	2229
Top Start	890	982	1074	1166	1258	1350	1442	1534	1625	1717	1809	1901	1993	2085	2177
Top End	930	1022	1114	1206	1298	1390	1482	1574	1665	1757	1849	1941	2033	2125	2217
Th-230	91	77	70	60	58	61	61	59	56	52	54	1	0	1	1
U-234	1012	1077	1074	979	967	1007	1026	1013	964	922	961	35	5	1	0
R85	140.2	139.8	140	139.6	140.4	140.3	139.9	140.2	140.3	139.4	139.3	117.5	106.4	39	16.3
U (ppm)	6.93	7.42	7.4	6.85	6.73	6.99	7.06	7.01	6.67	6.38	6.67	0.23	0.03	0	0
Th (ppb)	6.65	0.98	0.24	0.3	0	0.01	-0.15	-0.42	-0.29	-0.03	-0.13	-0.16	-0.14	-0.48	-0.02
U/Th	1042	7556	30694	22723	2455974	712408	-47489	-16596	-23226	-244263	-50198	-1386	-215	-7	-84
R08	0.3581	0.2845	0.2583	0.238	0.2381	0.2397	0.2351	0.2285	0.2301	0.2248	0.221	0.1721	0.3422	4.054	12.5503
R08-error	0.0067	0.0067	0.0053	0.0053	0.0057	0.0053	0.0047	0.0053	0.0052	0.005	0.0048	0.0267	0.5075	2.1324	54.985
R48	1.0693	1.0632	1.064	1.0466	1.0534	1.0563	1.0648	1.0586	1.0594	1.0587	1.0559	1.1365	1.1335	1.1502	0.8291
R48-error	0.0044	0.0049	0.0047	0.0042	0.0055	0.0047	0.005	0.0046	0.0053	0.0063	0.0051	0.0387	0.1205	0.5499	10.7217
R04	0.3347	0.2675	0.2427	0.2273	0.2259	0.2269	0.2207	0.2158	0.2171	0.2123	0.2092	0.1513	0.3018	3.5235	15.1322
R04-error	0.0061	0.0062	0.005	0.005	0.0057	0.0049	0.0047	0.005	0.0048	0.0048	0.0048	0.0256	0.5772	0.716	0.814
R04	0.3348	0.2676	0.2428	0.2274	0.226	0.227	0.2208	0.2159	0.2172	0.2123	0.2093	0.1514	0.3019	3.5247	15.1375
R04-error	0.0064	0.0064	0.0051	0.0052	0.0056	0.0051	0.0046	0.0051	0.005	0.0049	0.0047	0.024	0.4488	2.5054	206.688
Age	44.2	33.8	30.2	28.1	27.9	28	27.1	26.5	26.6	26	25.6	17.8	38.9	0	0
Err+	1	1	0.7	0.7	0.8	0.7	0.6	0.7	0.7	0.7	0.6	3.1	105.7	0	0
Err-	1	0.9	0.7	0.7	0.8	0.7	0.6	0.7	0.7	0.7	0.6	3	0	0	0

13/LA/5/8 profile 2

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10	Spot-11	Spot-12	Spot-13	Spot-14	Spot-15
Start	2263	2355	2447	2539	2631	2723	2815	2906	2998	3090	3182	3274	3366	3458	3550
End	2321	2413	2505	2597	2689	2781	2873	2964	3056	3148	3240	3332	3424	3516	3608
Top Start	2269	2361	2453	2545	2637	2729	2821	2912	3004	3096	3188	3280	3372	3464	3556
Top End	2309	2401	2493	2585	2677	2769	2861	2952	3044	3136	3228	3320	3412	3504	3596
Th-230	88	67	64	64	66	59	70	68	63	59	63	1	1	0	0
U-234	1037	904	1029	1025	1071	1023	1117	1101	1019	1022	1061	30	5	1	0
R85	140.1	140.1	140.1	140.1	139.9	139.3	140	140	139.8	140.2	139.8	136.5	96.9	286	3.8
U (ppm)	7.02	6.27	7.08	7.09	7.38	7.14	7.74	7.61	7.12	7.05	7.33	0.21	0.04	0.01	0
Th (ppb)	5.23	1.5	0.68	0.62	0.37	-0.16	0.17	-0.04	-0.13	0.07	-0.19	-0.02	-0.64	0.03	-0.21
U/Th	1341	4176	10439	11448	19791	-44892	45718	-205074	-56149	96157	-38379	-8506	-58	214	-4
R08	0.3422	0.292	0.2467	0.248	0.2458	0.2269	0.2486	0.2433	0.2415	0.2283	0.2361	0.1635	0.4259	0.5622	9.6301
R08-error	0.0063	0.0073	0.0061	0.0052	0.0041	0.0053	0.0045	0.0067	0.0055	0.0044	0.0051	0.0356	0.6224	2.2718	217.02
R48	1.0828	1.0562	1.064	1.059	1.0644	1.0502	1.0576	1.0607	1.0484	1.0616	1.0603	1.0564	1.037	0.7909	0.7247
R48-error	0.0051	0.0046	0.0051	0.0052	0.0051	0.0056	0.0053	0.0046	0.0036	0.0055	0.0072	0.0402	0.2083	0.4709	26.9153
R04	0.3159	0.2764	0.2318	0.2341	0.2308	0.216	0.235	0.2293	0.2302	0.2149	0.2226	0.1547	0.4106	0.7106	13.2836
R04-error	0.0064	0.0072	0.0055	0.0049	0.0041	0.0055	0.0046	0.0064	0.0057	0.0043	0.0049	0.0323	0.7382	0.5759	0.8233
R04	0.316	0.2765	0.2319	0.2342	0.2309	0.2161	0.235	0.2293	0.2303	0.215	0.2227	0.1547	0.4108	0.7108	13.2882
R04-error	0.006	0.0071	0.0058	0.005	0.004	0.0052	0.0044	0.0064	0.0053	0.0043	0.0051	0.0342	0.6058	2.9036	577.265
Age	41.2	35.2	28.7	29	28.6	26.5	29.1	28.3	28.5	26.3	27.4	18.3	57.5	150.3	0
Err+	1	1.1	0.8	0.7	0.6	0.7	0.6	0.9	0.8	0.6	0.7	4.5	547.1	212.5	0
Err-	1	1.1	0.8	0.7	0.6	0.7	0.6	0.9	0.7	0.6	0.7	4.3	0	0	0

13.LA/5/8 profile 3

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10
Start	2364	2455	2546	2637	2728	2819	2910	3001	3092	3183
End	2422	2513	2604	2695	2786	2877	2968	3059	3150	3241
Top Start	2370	2461	2552	2643	2734	2825	2916	3007	3098	3189
Top End	2410	2501	2592	2683	2774	2865	2956	3047	3138	3229
Th-230	170	176	111	98	84	73	76	73	81	75
U-234	1482	1555	1196	1253	1195	1107	1110	1072	1046	987
R85	139.5	139.8	140.2	139.8	140.4	140.1	140.1	139.9	139.2	140
U (ppm)	9.81	10.3	8.03	8.45	8.02	7.47	7.45	7.23	7.07	6.61
Th (ppb)	474.92	46.49	2.98	1.04	0.61	0.31	0.89	1.31	1.68	5.25
U/Th	21	221	2694	8130	13209	23983	8417	5505	4211	1258
R08	0.4974	0.4919	0.3963	0.3341	0.3009	0.2796	0.2925	0.2878	0.3307	0.3277
R08-error	0.0073	0.0061	0.0078	0.0049	0.0069	0.0061	0.0064	0.0053	0.0068	0.0071
R48	1.0835	1.0831	1.0691	1.0639	1.0693	1.0635	1.0682	1.0636	1.0616	1.0715
R48-error	0.0048	0.0042	0.0048	0.0045	0.0033	0.0053	0.0049	0.0054	0.0044	0.0051
R04	0.4591	0.4542	0.3707	0.3141	0.2814	0.2629	0.2739	0.2706	0.3115	0.3058
R04-error	0.0072	0.0055	0.0078	0.0049	0.0066	0.0058	0.0058	0.0055	0.0065	0.0068
R04	0.4591	0.4541	0.3707	0.3141	0.2814	0.2629	0.2739	0.2706	0.3115	0.3058

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R04-error	0.0071	0.0059	0.0075	0.0048	0.0065	0.0059	0.0061	0.0052	0.0065	0.0068
Age	66.4	65.4	50.2	40.9	35.9	33.2	34.8	34.3	40.5	39.6
Err+	1.4	1.2	1.3	0.8	1	0.9	0.9	0.8	1	1.1
Err-	1.4	1.2	1.3	0.8	1	0.9	0.9	0.8	1	1.1

21/LA/5/8 profile 1

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8
Start	907	998	1089	1180	1271	1362	1453	1544
End	965	1056	1147	1238	1329	1420	1511	1602
Top Start	913	1004	1095	1186	1277	1368	1459	1550
Top End	953	1044	1135	1226	1317	1408	1499	1590
Th-230	44	43	45	44	45	39	27	1
U-234	547	605	680	661	654	625	483	4
R85	139.1	139.6	140.4	140.7	140.1	140.1	141	87.3
U (ppm)	3.66	4.06	4.61	4.51	4.47	4.24	3.28	0.03
Th (ppb)	0.51	0.85	0.13	0.34	0.32	0.48	0.67	0.4
U/Th	7195	4808	35761	13080	14085	8772	4879	79
R08	0.3438	0.3049	0.2823	0.281	0.2897	0.2625	0.2347	0.5736
R08-error	0.007	0.0065	0.0065	0.0069	0.0071	0.0083	0.0073	2.3266
R48	1.0713	1.0668	1.0578	1.0525	1.0503	1.0559	1.0552	1.0044
R48-error	0.0053	0.0071	0.0046	0.0061	0.0064	0.0056	0.0065	0.3304
R04	0.3209	0.2859	0.2669	0.267	0.2758	0.2486	0.2224	0.5711
R04-error	0.0067	0.0067	0.0065	0.0065	0.0066	0.008	0.0072	0.723
R04	0.3209	0.2858	0.2669	0.267	0.2758	0.2486	0.2224	0.5711
R04-error	0.0067	0.0064	0.0063	0.0067	0.0069	0.008	0.007	2.3241
CS age	42	36.6	33.8	33.8	35.1	31.1	27.4	92.2
Err+	1.1	1	0.9	1	1	1.2	1	130.4
Err-	1.1	1	0.9	1	1	1.2	1	0

21/LA/5/8 profile 2

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8
	1635	1726	1817	1908	1999	2091	2182	2273
	1693	1784	1875	1966	2057	2149	2240	2331
	1641	1732	1823	1914	2005	2097	2188	2279
	1681	1772	1863	1954	2045	2137	2228	2319
	43	39	49	45	49	44	37	2
	553	546	703	666	691	679	648	28
	140.3	140.4	139.7	139.2	140.5	138.7	139.7	124.3
	3.72	3.67	4.8	4.54	4.68	4.64	4.38	0.19
	1.26	0.62	0.29	-0.05	0.28	0.04	-0.1	-0.05
	2942	5929	16552	-93460	16534	111586	-44968	-3616
	0.3292	0.3053	0.2928	0.2833	0.298	0.2718	0.2409	0.3009
	0.0081	0.0073	0.0078	0.0074	0.0073	0.0072	0.0066	0.0364
	1.0667	1.0658	1.0502	1.0541	1.0587	1.0506	1.0605	1.0737
	0.0061	0.0055	0.0056	0.0058	0.0067	0.0068	0.0069	0.0336
	0.3086	0.2865	0.2788	0.2688	0.2815	0.2587	0.2272	0.2802
	0.0078	0.0067	0.0077	0.0071	0.0064	0.0071	0.0062	0.0335
	0.3086	0.2865	0.2788	0.2687	0.2815	0.2587	0.2272	0.2802
	0.0078	0.007	0.0076	0.0071	0.0071	0.0071	0.0064	0.035
	40.1	36.7	35.5	34	35.9	32.6	28	35.7
	1.1	1	0.9	1	1	1.2	1	130.4
	1.1	1	0.9	1	1	1.2	1	0

12/LA/5/8 profile 1

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10	Spot-11	Spot-12	Spot-13	Spot-14	Spot-15
Start	906	998	1089	1181	1272	1364	1455	1547	1638	1730	1822	1913	2005	2096	2188
End	964	1056	1147	1239	1330	1422	1513	1605	1696	1788	1880	1971	2063	2154	2246
Top Start	912	1004	1095	1187	1278	1370	1461	1553	1644	1736	1828	1919	2011	2102	2194
Top End	952	1044	1135	1227	1318	1410	1501	1593	1684	1776	1868	1959	2051	2142	2234
Th-230	53	57	56	54	55	49	43	45	40	46	43	38	17	0	0
U-234	988	926	880	859	833	806	702	744	619	720	686	627	274	1	6
R85	140	140.4	140.1	140.5	139.7	140.3	140	139.7	140.7	139.6	140.2	138.9	140.3	62.5	169.4
U (ppm)	6.82	6.41	6.11	5.96	5.77	5.56	4.89	5.14	4.26	4.99	4.79	4.34	1.91	0.01	0.06
Th (ppb)	0.02	-0.04	0.01	-0.27	0.04	-0.39	-0.24	-0.26	-0.16	-0.07	0.28	-0.03	0.2	0.07	0.79
U/Th	279474	-153649	1092164	-22048	134132	-14363	-20098	-19977	-26386	-76637	17203	-136510	9496	111	76
R08	0.2169	0.25	0.2549	0.2519	0.2661	0.2479	0.2468	0.2441	0.2632	0.2582	0.2504	0.2462	0.2447	1.2024	0.1913
R08-error	0.0051	0.0061	0.0063	0.0053	0.0058	0.0049	0.0068	0.0067	0.0057	0.0057	0.005	0.0056	0.009	0.688	2.3633
R48	1.0601	1.0571	1.054	1.0556	1.0567	1.0606	1.0511	1.0591	1.0646	1.0556	1.0469	1.0573	1.0484	0.782	0.7438
R48-error	0.0052	0.005	0.0054	0.006	0.0052	0.0055	0.0063	0.0049	0.0057	0.0054	0.0067	0.0053	0.0093	0.2038	0.726
R04	0.2046	0.2365	0.2419	0.2386	0.2518	0.2337	0.2348	0.2304	0.2472	0.2446	0.2392	0.2329	0.2334	1.5376	0.2571
R04-error	0.0048	0.0057	0.0058	0.005	0.0054	0.0052	0.0062	0.0062	0.0054	0.0057	0.0049	0.0055	0.0087	0.583	0.5885
R04	0.2046	0.2365	0.2419	0.2386	0.2518	0.2337	0.2348	0.2304	0.2472	0.2447	0.2392	0.2329	0.2334	1.5376	0.2571
R04-error	0.0049	0.0058	0.0061	0.0052	0.0056	0.0048	0.0066	0.0064	0.0055	0.0056	0.005	0.0054	0.0088	0.9667	3.187
Age	24.9	29.4	30.1	29.6	31.6	29	29.1	28.5	30.9	30.5	29.7	28.8	28.9	0	33
Err+	0.7	0.8	0.9	0.7	0.8	0.7	0.9	0.9	0.8	0.8	0.7	0.8	1.3	0	46.7
Err-	0.7	0.8	0.9	0.7	0.8	0.7	0.9	0.9	0.8	0.8	0.7	0.8	1.2	127.4	0

12/LA/5/8 profile 2

	Spot-1	Spot-2	Spot-3	Spot-4	Spot-5	Spot-6	Spot-7	Spot-8	Spot-9	Spot-10	Spot-11	Spot-12	Spot-13	Spot-14	Spot-15
Start	2279	2371	2462	2554	2645	2737	2829	2920	3012	3103	3195	3286	3378	3469	3561
End	2337	2429	2520	2612	2703	2795	2887	2978	3070	3161	3253	3344	3436	3527	3619
Top Start	2285	2377	2468	2560	2651	2743	2835	2926	3018	3109	3201	3292	3384	3475	3567
Top End	2325	2417	2508	2600	2691	2783	2875	2966	3058	3149	3241	3332	3424	3515	3607
Th-230	65	50	63	58	63	52	48	44	46	40	39	44	34	0	0
U-234	1068	944	998	951	979	848	776	705	726	651	599	698	545	8	2
R85	139.3	139.2	139.7	139.2	139.8	140	139.9	140.1	141.1	141	140.1	139.7	140.1	124	293.9
U (ppm)	7.42	6.56	6.89	6.6	6.8	5.84	5.41	4.89	5.03	4.48	4.12	4.87	3.76	0.06	0.02
Th (ppb)	0.62	0.31	0.51	-0.07	0.02	0.09	0.21	0.14	-0.02	-0.15	0.25	0	0.11	0.07	0.21
U/Th	11937	20960	13628	-98060	434695	68195	25313	34076	-230223	-29258	16592	-5E+06	35494	855	78
R08	0.2446	0.2156	0.2579	0.247	0.2585	0.2482	0.2485	0.2536	0.255	0.2507	0.2672	0.2555	0.2538	0.2438	0.7679
R08-error	0.0064	0.0056	0.005	0.0044	0.0039	0.0047	0.0053	0.0056	0.0068	0.0068	0.0066	0.0059	0.0063	0.4264	0.9207
R48	1.0532	1.0536	1.06	1.0536	1.0537	1.0628	1.0502	1.0543	1.0571	1.0618	1.0626	1.0493	1.0612	0.9942	0.9525
R48-error	0.0048	0.0055	0.0037	0.0047	0.0047	0.0047	0.0053	0.0078	0.0064	0.007	0.0066	0.0066	0.0057	0.0914	0.1855
R04	0.2322	0.2047	0.2433	0.2344	0.2453	0.2335	0.2366	0.2405	0.2412	0.2361	0.2515	0.2435	0.2391	0.2452	0.8062
R04-error	0.0062	0.0054	0.0046	0.0041	0.0037	0.0043	0.0052	0.0055	0.0069	0.0066	0.0068	0.006	0.0061	0.3693	0.4351
R04	0.2322	0.2047	0.2433	0.2344	0.2453	0.2335	0.2366	0.2405	0.2412	0.2361	0.2515	0.2435	0.2391	0.2452	0.8062
R04-error	0.0062	0.0055	0.0048	0.0043	0.0039	0.0045	0.0052	0.0056	0.0066	0.0066	0.0064	0.0058	0.0061	0.4294	0.9792
Age	28.7	24.9	30.3	29.1	30.6	28.9	29.4	29.9	30	29.3	31.5	30.4	29.7	30.7	184.1
Err+	0.9	0.7	0.7	0.6	0.6	0.6	0.7	0.8	1	0.9	0.9	0.8	0.9	91.8	260.4
Err-	0.9	0.7	0.7	0.6	0.6	0.6	0.7	0.8	0.9	0.9	0.9	0.8	0.9	0	0

Supplementary Table 9 - Raw U-series data

Dubois 9967A Drill hole A

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R08	0.5295	0.509	0.5	0.5999	0.5472	0.5222	0.6064	0.6463	0.5741	0.5159
R08-error	0.0241	0.0218	0.0254	0.0288	0.0289	0.0359	0.0458	0.0472	0.0681	0.0664
R48	1.2845	1.2787	1.2896	1.2661	1.2865	1.249	1.2398	1.2423	1.2191	1.2149
R48-error	0.0129	0.0134	0.0161	0.0159	0.0178	0.0214	0.0216	0.0213	0.0254	0.0248
R04	0.4122	0.3981	0.3877	0.4739	0.4254	0.4181	0.4891	0.5203	0.471	0.4246
R04-error	0.02	0.0179	0.0207	0.0253	0.0228	0.0337	0.0402	0.0425	0.0578	0.0612
CS age	56.7	54.2	52.4	68.2	59	57.8	71.4	77.8	67.9	59.2
Err+	3.5	3.1	3.5	4.7	4.3	5.4	7.9	8.6	11.7	10.5
Err-	3.4	3	3.4	4.5	4.1	5.2	7.4	8	10.6	9.7

Dubois 9967A Drill hole B

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R08	0.502	0.4903	0.556	0.5429	0.578	0.584	0.5846	0.5949	0.4821	0.5639
R08-error	0.0227	0.0268	0.0282	0.0307	0.0353	0.0406	0.0387	0.0504	0.0455	0.0863
R48	1.2819	1.2628	1.2777	1.285	1.2991	1.2617	1.2695	1.2474	1.243	1.1783
R48-error	0.0115	0.0135	0.0154	0.016	0.0198	0.0198	0.0218	0.0219	0.0277	0.0305
R04	0.3916	0.3883	0.4352	0.4225	0.4449	0.4629	0.4605	0.4769	0.3879	0.4786
R04-error	0.0178	0.0213	0.0231	0.024	0.0276	0.0352	0.0289	0.0403	0.0346	0.0697
CS age	53.1	52.6	60.8	58.5	62.5	66.1	65.6	68.9	52.6	69.6
Err+	3.1	3.8	4.2	4.5	5.3	6.5	6.2	8.4	6.6	15.9
Err-	3.1	3.6	4.1	4.3	5.1	6.2	5.9	7.9	6.3	14

Dubois 9967A Drill hole C

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R08	0.5224	0.5034	0.5719	0.5845	0.6271	0.6262	0.5964	0.6324	0.7138	0.501
R08-error	0.0249	0.0217	0.0274	0.0315	0.0494	0.0372	0.0483	0.0478	0.0645	0.0555
R48	1.2787	1.2807	1.2785	1.2673	1.2639	1.2834	1.297	1.3065	1.294	1.3164
R48-error	0.0098	0.0118	0.0146	0.0157	0.0157	0.0222	0.0245	0.0241	0.0288	0.0288
R04	0.4086	0.3931	0.4474	0.4613	0.4962	0.4879	0.4599	0.4841	0.5517	0.3806
R04-error	0.0209	0.0168	0.0224	0.024	0.0377	0.0316	0.0452	0.0375	0.0512	0.0441
CS age	56	53.3	63.1	65.7	72.6	70.9	65.3	70	84.2	51.1
Err+	3.5	3	4.2	5	8.3	6.2	7.5	7.7	12	7.5
Err-	3.4	2.9	4.1	4.8	7.8	5.9	7.1	7.2	11	7

7/LA/08 Drill hole A

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R08	0.4435	0.4796	0.6113	0.5977	0.632	0.6077	0.6431	0.6039	0.6372	0.6174
R08-error	0.0141	0.0196	0.0251	0.026	0.0251	0.0396	0.0485	0.0433	0.0423	0.0516
R48	1.2942	1.3016	1.2948	1.3026	1.3022	1.3016	1.2867	1.3071	1.3174	1.2846
R48-error	0.0088	0.0133	0.0124	0.0118	0.0161	0.0192	0.0209	0.0225	0.0218	0.0233
CS age	45	49.2	67.7	65.1	70.2	66.7	73.2	65.7	69.8	69.4
Err+	1.8	2.6	3.9	3.9	4.1	6.1	8.1	6.7	6.7	8.4
Err-	1.8	2.6	3.8	3.8	4	5.9	7.6	6.3	6.4	7.8

7/LA/5/8 Drill hole B

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R08	0.3954	0.4171	0.4345	0.5492	0.5491	0.5792	0.6101	0.6424	0.6704	0.622
R08-error	0.0149	0.0152	0.0176	0.0203	0.0393	0.0357	0.0338	0.0512	0.0602	0.0608
R48	1.2974	1.2889	1.2719	1.2856	1.2882	1.2776	1.2766	1.2927	1.3005	1.3214
R48-error	0.0085	0.0119	0.0101	0.0138	0.0152	0.0145	0.0212	0.0211	0.0234	0.0247
CS age	39.1	42	44.8	59.3	59.2	64.2	68.9	72.6	76.4	67.3
Err+	1.8	1.9	2.3	3	5.7	5.5	5.6	8.5	10.3	9.4
Err-	1.8	1.9	2.2	2.9	5.5	5.2	5.3	7.9	9.5	8.7

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7/LA/5/8 Drill hole C

	Aliquot-1	Aliquot-2	Aliquot-3	Aliquot-4	Aliquot-5	Aliquot-6	Aliquot-7	Aliquot-8	Aliquot-9	Aliquot-10
R85	138.6	139.3	137.5	137.9	139.6	138	139.5	137.8	135	144.3
R08	0.3272	0.4294	0.5012	0.5424	0.5207	0.6013	0.5386	0.5133	0.6223	0.5464
R08-error	0.0117	0.017	0.0206	0.0313	0.0256	0.0334	0.036	0.0453	0.048	0.0558
R48	1.294	1.283	1.2973	1.2925	1.3003	1.2746	1.276	1.3293	1.2979	1.2909
R48-error	0.0089	0.0082	0.0132	0.014	0.0164	0.0148	0.0199	0.0214	0.0213	0.0238
CS age	31.4	43.7	52.1	58	54.6	67.7	58.5	52	69.1	58.6
Err+	1.3	2.1	2.8	4.5	3.6	5.3	5.3	6	7.7	8.2
Err-	1.3	2.1	2.8	4.3	3.5	5.1	5.1	5.7	7.2	7.7

Supplementary Table 10 - A comparison of the drill holes from Dubois's tooth (9967A) and LA-5-8

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SUPPLEMENTARY INFORMATION - section 7:

Supplementary discussion │ Coupled U-series/ESR dating of teeth

In principle, the combination of ESR and U-series is used to get a better estimation of the age and U-uptake history[67,149]. However, we have experienced problems trying to model U-leaching from dental tissue in these samples, as the variability of the Uranium content was large. To address this issue, we have applied direct ESR dating to three teeth to enable coupled US-ESR analysis[69,70]. The teeth are well-preserved with only very light discoloration patches and very few cracks with slight soil infiltration but no severe alteration marks due to burial. Dentine did not exhibit sediments/soil intrusion. All teeth were complete but showed small cracks at the base were the enamel joined the roots.

The coupled US-ESR age of 13/LA/5/08 and 12/LA/5/08 fragments were estimated to be between 76 ± 7 kyr and 86 ± 13 kyr (Extended Data Fig. 9). The uptake model for 13/LA/5/08 and 12/LA/5/08 gives a p-value close to zero in both enamel and dentine, designating rather a linear uranium uptake in the sample. The calculated U-series minimum ages of 13/LA/5/08 and 12/LA/5/08 in the dentine directly in contact with the enamel fragment range between 48.4 ± 5.3 and 41.2 ± 2.6 kyr, respectively.

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Supplementary Table 11: Raw and measured parameters used for the coupled U-series/ESR dating of tooth fragments

SAMPLE	13LA508	12LA508
ENAMEL		
Dose (Gy)[a]	45.60 ± 0.80	55.50 ± 0.70
U (ppm)[b]	0.82 ± 0.07	1.05 ± 0.21
$^{234}U/^{238}U$ [b]	3.86 ± 0.02	3.25 ± 0.05
$^{230}Th/^{234}U$ [b]	0.31 ± 0.03	0.35 ± 0.04
Thickness (m)	1421 ± 215	1553 ± 272
Water (%)	0	0
DENTINE		
U (ppm) [b]	9.25 ± 0.49	6.52 ± 0.97
$^{234}U/^{238}U$ [b]	1.06 ± 0.01	1.07 ± 0.05
$^{230}Th/^{234}U$ [b]	0.28 ± 0.01	0.38 ± 0.01
Water (%)	10 ± 5	10 ± 5
SEDIMENT		
U (ppm) [c]	1.86 ± 0.69	1.86 ± 0.69
Th (ppm) [c]	5.20 ± 1.70	5.20 ± 1.70
K (%) [c]	0.57 ± 0.04	0.57 ± 0.04
Water (%)	16.3 ± 5	16.3 ± 5
EXTERNAL DOSE RATE SEDIMENT		
Beta (μGy a^{-1})	59 ± 11	55 ± 12
Gamma (μGy a^{-1})[c]	189 ± 5	189 ± 5
Cosmic (μGy a^{-1})	88 ± 9	88 ± 9
COMBINED US-ESR AGE		
Internal dose (μGy a^{-1})	236 ± 54	288 ± 96
Beta Dose dentine (μGy a^{-1})	28 ± 6	25 ± 8
P enamel	-0.14	-0.21
P dentine	-0.04	-0.46
Total Dose rate (μGy a^{-1}) [c]	600 ± 56	645 ± 98
AGE (kyr)	**76 ± 7**	**86 ± 13**

[a] Dose equivalent D_e obtained using McDose 2.0, with SSE.
[b] Uranium concentration values were obtained by LA-MC-ICPMS.
[c] In-situ gamma spectrometry measurements. Sediment content was extrapolated from activity values using ^{238}U: 1 Bq/kg = 81 ppb; ^{232}Th=1 Bq/kg = 246 ppb; ^{40}K= 1 Bq/kg = 0.00323%

SUPPLEMENTARY INFORMATION - section 8:

Supplementary discussion │ A modelled chronology

Bayesian modelling incorporating all chronological results was 68 ± 5 ka with an age range of 73-32 ka (Extended Data Fig. 10c). To evaluate depositional age of just the breccia the model was re-run using the red TL and pIR-IRSL dating on the matrix, and U-series on the flowstones and soda straw. This had a minimal effect on the age range (65 ± 5 kyr, 1σ; age range 70-60 ka) (Extended Data Fig 10c -A). To evaluate the age of the fossils, we re-ran the model just using the U-series and coupled US-ESR dating of the teeth (Extended Data Fig 10c -B). This deletion of age estimates increased the modelled age to 75 ± 5 kyr (1σ; age range 80-70 ka). This result indicates that the fossils are slightly older than the timing of breccia in the cave, which is consistent with a colluvial origin.

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