

[Supplementary material]

Evaluating claims for an early peopling of the Americas: the broader context

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Table S1. A summary of a selection of the arguments made against the Cerutti Mastodon, and the replies to them.

Reference	Supporting	Opposed	Details
Holen <i>et al.</i> 2017, 26 April ¹ incl. extended data ¹ incl. supplementary data ¹	Yes		<p>Sedimentary history of the layer (E) demonstrates gentle flow regime, not sufficient to re-arrange bones and stones—silt and sand. Detached femoral heads next to anvil and vertical placement of tusk imply arrangement is human.</p> <p>Large bones are green bone fractures, many delicate bones unbroken. Pattern not explainable by post-depositional sediment loading or weight from modern heavy machinery.</p> <p>Bones and teeth (molars) occur in clusters around anvils—anthropogenic arrangement.</p> <p>Bone not carnivore damaged & no sign of trampling. Other cracks/damage to bone can be explained by pre- & post-depositional mechanisms that are unrelated to anthropogenic damage patterns.</p> <p>Other fossils/carcass scatters in floodplain unaccompanied by stones and show no percussion damage. They also do show fluvial arrangement. Damage therefore not natural local processes.</p> <p>Damage to bone can be experimentally produced by percussion. Use-wear (polish) and impact damage on andesite anvils and on pegmatite and andesite hammer stones. No evidence of butchery (cut marks) so humans were extracting marrow and breaking bones and teeth to make organic tools.</p>

Hovers 2017, 26 April	Yes	Cautiously supportive review by one of the paper's referees.
<i>National Geographic</i> webpages at time of announcement, 2017, 26 April	<i>Precis</i> of arguments both supporting and disputing	'Humans in California 130,000 years ago? Get the Facts. https://www.nationalgeographic.com.au/history/humans-in-california-130000-years-ago-get-the-facts.aspx Some good video footage of excavation and artefacts.
Haynes 2017, 21 June	Yes	Cites a range of opinions on the site's/paper's integrity and notes clever self-positioning of journal <i>Nature</i> . Argues that breakage of stone and bone is by heavy plant machinery. Cites a number of locations where these damage patterns are artificial due to heavy machinery. Dating is questioned and lack of struck lithics worrying.
Boëda <i>et al.</i> 2017, 22 June	Yes	Accepts the percussion character of damage on anvils and hammer stones; notes the damage is at exact place where impact damage would be expected (convex edge of clast)—serial impact points. Accepts the bone percussion evidence too (impact patterns are exactly what/where you would expect from this activity), as well as the dating. Unexpected results are validated by purely empirical observations, supported by actualistic data.
Braje <i>et al.</i> 2017, 17 July	Yes	Insufficient geological/sedimentary contextual data to establish the case for an undisturbed site. All the natural processes that could produce damage patterns to the bones, and introduce stones as well as fracture them, have not been effectively eliminated by the authors; alternatives are not comprehensively falsified. There is no archaeological background for humans in Beringia or North-eastern Asia at 130 kya, and after many years of searching there is no evidence along the north-west Pacific coast at this time.

Holen <i>et al.</i> 2018a reply to Haynes 2017, 21 November	Yes	Comprehensively refutes arguments of pressure from overhead by heavy machinery. Notes a number of Haynes's sites have been reinterpreted and the evidence now supports damage patterns on Cerutti bone. Lack of comparably aged sites due to archaeologists not looking for them, and lack of lithics reflects site function—short stay for marrow- and bone-processing. Lithic tools not needed.
Holen <i>et al.</i> 2018b reply to Braje, 2017, 22 November	Yes	Context of the site is a gently aggrading alluvial plain with no high ground nearby. The artefacts cannot be geofacts. That similar patterns of bone breakage could be a result of natural processes is acknowledged, but the <i>totality</i> of evidence renders this unlikely. There is some evidence for earlier sites than main occupation of Americas in South America, and an absence of sites in North America and Beringia is only an absence of evidence.
Callaway 2018, 7 & 8 February	<i>Precis</i> of replies	Reporting on Ferraro <i>et al.</i> 's (2018) critique and Holen <i>et al.</i> 's (2018c).rebuttal.
Ferraro <i>et al.</i> 2018, 8 February	Yes	Similar damage patterns to bones can be caused by a number of different non-anthropogenic mechanisms. Numerous examples offered and illustrated. Characteristic damage patterns caused by experimental hafted hammer stones (striations and pits) are not present on the Cerutti bones, and they should be. Cobbles are present in alluvial fans upslope. These could be easily be transported by modest fluvial activity to the site.
Holen <i>et al.</i> 2018c reply to Ferraro 2018, 8 February	Yes	There is no evidence of alluvial fans higher in the profile and Ferraro <i>et al.</i> do not explain the clustering of large bones and artefacts. Many broken bones/breaks are encased in a pedogenic carbonate crust, proving the breaks are ancient—cannot be a result of modern sediment loading/pressure. Crucially, Ferraro and colleagues focus on

		inappropriate damage patterns and so do not explain the really significant ones. They also fail to cite evidence which demonstrates that their natural breakage patterns have been experimentally proved to be anthropogenic.
Haynes's 2018 reply to Holen <i>et al.</i> 's Reply 2018, 23 April	Yes	Haynes feels he is misquoted/misunderstood on the dating, and the reinterpretations of the sites cited in Holen <i>et al.</i> 's (2018a) reply are just wrong. Encourages Holen and colleagues to provide more data on influence of plant machinery. Appeals to broader context of human dispersal into Americas for validating the site.
Gruhn 2018 7 May, 2018 ² ,	Yes (but only breaks are ancient)	Personally observed the carbonate crust over the breaks and confirms these are ancient.
Anonymous 'theNAT' website for San Diego Natural History Museum (undated)		'The Cerutti Mastodon Site: one year later' https://www.sdnhm.org/blog/blog_details/the-cerutti-mastodon-site-one-year-later/96/ Very briefly sums up the current status debate for a popular audience and provides many links to academic papers and journalistic accounts.
Sutton <i>et al.</i> 2019 27 March	Yes	Evidence for bone breakage and anthropogenic patterning at site is better explained as disturbance and trampling by other mastodons. No evidence for a bone tool technology elsewhere. The site would not pass the stringent criteria for hominin involvement that has been established for East Africa.

Ferrell 2019, 22 March	Yes	Damage to bones and artefacts is a result of construction. Importantly, he notes the carbonate crust is not present on every bone, and demonstrates that andesite cobbles/boulders and other rocks were naturally occurring on the floodplain.
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¹ Original article available only from *Nature's* website by subscription or purchase. Extended data freely downloaded from <https://www.nature.com/articles/nature22065>. This represents 10 plates with various images of the site, aspects of the archaeological and faunal remains; and graphs from the dating; supplementary data, freely downloaded from <https://www.nature.com/articles/nature22065>, contains a PDF with 10 sections—1) Geological and depositional setting; 2) Sediment analysis; 3) Use-wear and impact on the hammer stones and anvils; 4) Taphonomy of the bones—natural vs artificial placement; 5) Experimental studies on elephant limb bone breakage; 6) Taphonomy of other skeletons in vicinity; 7) RC and OSL dating; 8) U-series dating; 9) Asian origins of the human dispersal into North America; 10) References. In addition, the web address for the supplementary information has six videos of bone with impact marks, one of a broken hammer stone, one of the experimental breakage of bone. 26 April 2017 was online release; 27 April 2017 hard copy released.

² Link to the San Diego Natural History Museum web pages for the Cerutti Mastodon site: <https://www.sdnhm.org/exhibitions/the-cerutti-mastodon-discovery/>

Table S2. A selection of the more commonly cited fossil hominin remains from China and Taiwan from the Middle and Late Pleistocene.

Hominin	Site/layer	Age kya	Stone tools	References
<i>Homo erectus</i>	Zhoukoudian locality 1, skull V, layer 3	400+	Core and flake assemblage on local raw materials	(Shen <i>et al.</i> 2009)
	Hexian, Longtan Cave, skull cap, jaw fragment + 2	412±25	No mention of lithics	(Liu <i>et al.</i> 2017; Martínón-Torres <i>et al.</i> 2017)

	teeth, and 10 separate teeth, layer 4			
	Nanjing	580–620	No mention of lithics	(Wu <i>et al.</i> 2011; Bruner <i>et al.</i> 2015)
	Penghu 1. Mandible & other fauna recovered by dredging. ¹	10–70 or 130–190	No lithics recovered	(Chang <i>et al.</i> 2015; Liu <i>et al.</i> 2017)
<i>Homo sapiens</i>	Fuyan Cave (Daoxian) 47 modern-looking teeth	80–120	No mention of lithics	(Liu <i>et al.</i> 2017; Martín-Torres <i>et al.</i> 2017)
	Zhiren Cave, partial mandible, mandibular fragment, two molars; layer 2	106–110	No lithics recovered	(Martín-Torres <i>et al.</i> 2017)
	Luna Cave	70–127	Flake tools – not clear if from same layer or above	(Bae <i>et al.</i> 2014)
	Huanglong Cave Seven teeth	34–44 (ESR) or 39–103 (U-series)	Core and flake assemblage, hammer stones, bone tools	(Liu <i>et al.</i> 2010; Shen <i>et al.</i> 2013)

	Liujiang (Tongtianshan) ² Almost complete skull & post-cranial material	>68–< 153 preferred is 111– 139	No mention of lithics	(Shen <i>et al.</i> 2002, Bae <i>et al.</i> 2014)
<i>Homo</i> <i>heidelbergensis</i> / or archaic <i>Homo</i> <i>sapiens</i>	Dali, skull, open-air site on river terrace	<i>c.</i> 270	Core and flake assemblage. Small scrapers and point— described as ‘rough’-looking	(Sun <i>et al.</i> 2017)
	Xujiayao, skull	260–370 (mean age)	Core and flake assemblage on local raw materials. Focus on crude-looking tools	(Anon 1980; Ao <i>et al.</i> 2017)
	Jinniushan, partial skeleton from layer 7 ³	260	Stone tools in layers 4–6, not clear if in layer 7 as well	(Rosenberg <i>et al.</i> 2006)
	Zhoukoudian, New Cave, locality 4	248–269	Core and flake assemblage on local raw materials	(Shen <i>et al.</i> 2004a)
	Zhoukoudian locality 15, no fossils but stratigraphically similar to New Cave locality 4	As New Cave	Core and flake assemblage on local raw materials	(Shen <i>et al.</i> 2004b)
	Chaoxian (Chaon/Yinshan), maxilla and occiput	310–360	No lithics recovered	(Shen <i>et al.</i> 2010)

¹ The date ranges for Penghu were generated by comparing the fluorine and sodium content of the jaw with those of a hyaena species of known temporal range. See Chang *et al.* (2015) and their online supplementary material for more details.

² Both cited references note concerns about the precise provenance of the skull that may have been recovered from re-deposited(?) cave breccia. Dating uncertainties reflect different potential provenances.

³ Holen *et al.* (2017: supplementary material) suggest that this skeleton is showing the beginnings of adaptations to cold climate that would presage the later ability to survive Late Pleistocene climates in Beringia. Rosenberg *et al.* (2006) note that the skeleton's proportions (certainly related to northern latitudes) are consistent with other Middle Pleistocene specimens of *Homo*, and that she is associated with evidence for a warm climate! Her population were probably dispersing east and southwards, not northwards.

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