SAN DIEGO NATURAL HISTORY MUSEUM

Cerutti Mastodon Site
Q&A

Q1: What were the early signs that indicated the Cerutti Mastodon site was different from a typical paleontological site?

A1: There were many anomalies scientists noticed right away:

- The presence of cobbles in fine-grained sediment was unusual.
- Smaller pieces of sharply broken rock were found peppered throughout the Cerutti Mastodon Site. This is not typically something you would see as a result of normal geological processes.
- The combination of stones (cobbles found in an otherwise fine-grained, silty layer and the fact many were sharply broken) together with broken bones was interesting and instigated speculation regarding the possibility of human activity at the site.
- The discovery of one tusk oriented vertically and extending into underlying layers.
- Until that time, there was no site in San Diego County or southern California where evidence of human activity was found alongside extinct Ice Age mammals. This is what prompted us to excavate the Cerutti Mastodon Site differently—scientists and monitors set up a datum line and worked in a grid, allowing for documentation of the pattern and spatial control so they could plot and record the distribution of all notable finds.

Q2: How did you arrive at the conclusion that human activity was evident at the site?

A2: As we continued to excavate, more anomalies were recognized, eventually leading the research team to believe this was an archaeological site:

- The distribution pattern of bones—they were not distributed across the site in a homogenous fashion, but were instead concentrated in two key areas.
- The pattern of differential breakage—more fragile bones were intact while the heaviest/strongest were broken.
- The pattern of differential breakage—more fragile bones were intact while the heaviest/strongest were broken.
- The pattern of breakage itself—spiral fractures indicated breakage when the bones were fresh. Impact notches and cone flakes indicated breakage from percussion.
- The way in which the rocks were broken—pieces of broken rock were found scattered throughout the site, in many cases far away from the rock they came from; and several pieces could be refitted, indicating how and exactly where particular stones broke.
- There were two main areas of concentrated bones and rocks.

- Purposeful placement of some objects—mastodon femoral heads placed together side by side and the tusk driven vertically into lower sedimentary layers were two examples of these anomalies.
- The discrepancy between how the fossils were preserved compared to other Ice Age megafauna discovered at the same job site—a sloth, a camel, an ancient horse (now on display in *Fossil Mysteries*), a dire wolf, and a capybara—which were the same age. These other animals were mostly the entire carcass/fully articulated skeletons; the mastodon was much more incomplete, and remaining bones were disarticulated and broken.

The earliest dispersal of humans into North America is a contentious subject, and archaeologists generally agree that proposed early sites should meet the following criteria for acceptance:

- Archaeological evidence is in a clearly-defined and undisturbed geologic context.
- Age is determined by reliable radiometric dating.
- Multiple lines of evidence from interdisciplinary studies provide consistent results
- Unquestionable artifacts are in primary context.

At the Cerutti Mastodon Site, all of these criteria were met.

Q3: How did the research team rule out other natural or geological occurrences (a landslide or plunge pool, for example)?

A3: The research team ruled out other natural or geological occurrences for several reasons:

- The pattern of the mastodon bone bed differs from that of the skeletons of horse, dire wolf, and deer discovered in other strata within the same Pleistocene rock.
- The occurrence of large and small bones together with five large cobbles within an otherwise sandy silt horizon indicates that fluvial processes did not transport the bones and rocks.
- We studied sites where flood events left bone material redistributed. At those sites, moving water sorted the bones by density and size. This wasn't the case at the Cerutti Mastodon Site, where everything from small molar fragments to large rocks were distributed, unsorted, around the site.

Q4: Couldn't the breakage of the bones or the fact the rocks were in that location have been caused by floods or swiftly flowing water?

A4: The bones were found in the back swamp region of the riverbed where water doesn't flow with enough force to break bones. This location is supported by the fine sediment of the area and also supports that the rocks had to be carried to the area where they were found.

Q5: Could the breakage have been a result of gnawing or other behaviors by other animals?

A5: No. The breakage of the bones could not have been a result of gnawing by carnivorous animals for the following reasons:

- No Pleistocene carnivore was capable of breaking a fresh mastodon femur at mid-shaft or producing the observed wide impact notch.
- The presence of attached and detached cone flakes is indicative of hammerstone percussion, not carnivoran gnawing, and there is no carnivoran bone modification at the Cerutti Mastodon Site nor bone surface modification from gnawing.
- The differential preservation of fragile ribs and vertebrae rather than heavy limb bones argues against trampling (also no telltale trampling markings) and is consistent with selective breakage by humans.

Other skeletons of extinct mammals that were found in the same layer/strata were

Q6: Could grading equipment have broken the fossils?

A6: No. The backhoe clipped the edge of the tusk, which is how we identified the site—it was at the edge of a hill which served as a natural sound berm. The rest of the bones were deeply buried, many up to 10 feet deep. Other Ice Age mammals found nearby were not broken in this way—a dire wolf and horse, for instance.

One can tell the difference between bones that were broken by equipment (which would show dry bone fractures, for instance) and bones that were broken in ancient times while fresh, which show spiral fractures and other patterns of breakage.

Additionally, the specimens were encased inside concretions of solid soil carbonite. This is like an envelope that preserves the evidence of the past and provides evidence the breakage was in ancient times.

Q7: Let's talk about the stones. How do you know these rocks were used as tools and not "just rocks"?

A7: Rocks showing usewear <u>are</u> tools. In fact, rocks used as hammers are the simplest tools of all … you can't make any more tools without a hammer. The rocks found on this site are interpreted as hammers and anvils many several reasons, including the fact that they show microscopic and macroscopic wear marks and striations consistent with impact.

Breaking bone with hammers and anvils has been a technology used for millions of years—it's one of Homo's earliest technologies and is still used today. As the authors propose this was a bone processing site used to harvest marrow to eat or bones to use as raw materials—not a site where the animal was killed or butchered for meat—there was no need for finer stone tools.

Q8: What other clues did you find on those tools to indicate they were used by early humans? Couldn't those marks have been caused by other factors?

A8: The stone tools (hammers and anvils) were used to break the bones. A bone was held in place on an anvil stone and a stone hammer was used to strike and break the bone. Both experimental stones and the archaeological stones at the Cerutti Mastodon site have very similar marks that indicate fresh stone-on-stone impact and patches of smoothing or polish and striations or scratch marks formed at the moment of impact—marks entirely consistent with breaking bones. Several of the authors, Dr. Dan Fisher and Dr. Steve Holen, have shown that

some features in broken bones assemblages (including notches and cone flakes) are diagnostic of hard impact by humans. Moreover, cone flakes and spiral fractures only occur on fresh bone.

There are two good reasons why humans smashed these bones. First, people were extracting marrow. Second, people were breaking the bones into fragments and taking them away to make bone tools. In support of this well-known human technology spanning millennia, several bones were broken at the site but were missing from the assemblage (e.g. femur heads present and femur shafts missing).

The stones are too large to be transported by wind. They must have been found in nearby high energy river channels, and carried to the site by people. Co-author Dr. Jared Beeton has shown that the large rocks cannot be transported by water to the site because the required force to move such large rocks would have also moved pebbles and gravels on to the site, and stripped away fine sediment; and such forces could not possibly leave the mix of fine silt, delicate small bones, large tusks, and rocks in the distinctive pattern with two broken bone fragment concentrations. Instead of high energy deposition (required to move large rocks, pebbles, and gravels), the sediments at the site are silts. We know these details because of the careful fieldwork of Richard Cerutti and his field crew's documentation and large area excavations over five months, with total site sieving through fine mm mesh sizes.

Q9: How do we know the layer containing the bones and stones is that old?

A9: State-of-the-art radiometric dating methods used in 2014 determine the age of a material using the rate of decay of its radioactive isotopes. The distributions of natural uranium and its decay products both within and among these bone specimens show remarkably reliable behavior, allowing us to derive an age that is fairly specific.

More than a hundred analyses of bone, tooth enamel, ivory, and soil carbonate were made on specimens from the Cerutti bonebed and adjacent excavations. The best age estimate of 130,700 (±9,400 years) is a weighted average of multiple samples of bone.

The 130,000-year age estimated from bone dating is consistent with geologic interpretations based on soil development, and with the site's location with respect to 120,000-year-old paleo shoreline terraces.

Q10: Why weren't there any human remains?

A10: Human remains in North America are extremely rare, and the possibility of finding human remains in deposits of this age is remote. There are only two human remains for Clovis, and human remains in a site that is 130,000 years old would be exceptional, as chances for preservation are decreased as we go back in time. Additionally, populations were likely very small, especially considering this could have been a failed colonization attempt—we just don't know.

Furthermore, the paradigm is shifting when identifying archaeological sites—it's not always about finding knapped stone tools, but about finding bones that have shown certain types of

breakage or rocks showing patterns of use. What is exceptional about this site is that is has both.

Q11: Who were these people? Do you believe these to be *Homo sapiens* or another species such as *Homo neanderthalensis* (Neanderthals) or *Homo erectus*?

A11: The simple answer is that we do not know. We assume they came from northeast Asia because of its proximity, physical anthropology, and genetic evidence of living populations (some of the possibilities are discussed in the Supplementary Information available on Nature's website, and published with the letter in Nature.) Some will think it is more likely that an archaic or even a modern form of Homo sapiens arrived in the Americas first, especially if it involved a sea crossing. Nevertheless, we think the capabilities of Neanderthals and Denisovans has been underestimated, and there is evidence that Neanderthals and even Homo erectus made sea crossings. Prior to ~135,000 years ago, there is less secure evidence for Homo sapiens in eastern Asia, and, moreover, people could have walked across Beringia into what is now North America—making it more likely that Neanderthals and/or Denisovans arrived in the Americas at this time. We do not know whether first colonization at this time resulted in their extinction or not.

In the last 5-10 years, we've learned a lot about the capacity of early humans' cognitive capabilities and a range of skills that mimic early African human activity, e.g. creating hafted tools (such as stone tipped spears), building fires, and grinding pigment. Neanderthals remains and their toolkits have been found in several parts of Siberia about 130,000 years ago. Genetic evidence shows that Denisovans were also in Siberia at about this time. Homo erectus remains have not been found in Siberia, but have been found further south in China from at least 1.4 million years ago. When Homo erectus became extinct in eastern Asia is not known. The most recent H. erectus remains are dated to about 140,000 years ago on Java. Anatomically modern human remains have not been found in Siberia at 130,000 years ago, but their teeth were found in China and are dated to about 80-120,000 years ago.

While this site won't tell us which species it was, it does open the door for more research, and we think it is likely other archaeological sites will be discovered in the time range between 130,000 years ago and 20,000 years ago.

Q12: How did they get here?

A12: 130,000 years ago was an interesting time when the Bering Land Bridge between Asia and North America was being inundated by rising sea levels. If the early humans were coming by land, they would have to have arrived in Alaska prior to 130,000 years ago (people were in the Arctic 50,000 years ago). Alternatively, these early humans could have had boats. We know they crossed small bodies of water (e.g. islands/Indonesia) so it's possible they crossed larger bodies of water like the Bering Strait as well.

Q13: What is the current, commonly accepted hypothesis/evidence for earliest humans in North America, and specifically our region?

A13: The Debra L. Friedkin site, Texas, contains an assemblage of artifacts that define the Buttermilk Creek Complex and dates between ~13,200 and 15,500 years ago. The Buttermilk Creek

Complex confirms the emerging view that people occupied the Americas before Clovis. (Waters et al. 2011) http://science.sciencemag.org/content/331/6024/1599?sid=05a8d855-ad7a-4f4e-a7ee-6c36bbfc3b4c

There is evidence of humans (18,500-14,500 years ago) in Monte Verde, Chile. (Dillehay et al, 2015) http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0141923

Stone tools and mastodon bones occur in an undisturbed geological context at the Page-Ladson site, Florida. Radiocarbon ages show that ~14,550 years ago, people butchered or scavenged a mastodon next to a pond in a bedrock sinkhole within the Aucilla River. (Halligan et al. 2016) http://advances.sciencemag.org/content/2/5/e1600375

Excavations conducted at Bluefish Caves (Yukon Territory, Canada) led archaeologists to propose that early humans were in Alaska and the Yukon Territory approximately 24,000 years ago. (Bourgeon et al. 2017)
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0169486