affects the proton's total charge distribution. The authors also determine the strange quarks' contribution to the proton's magnetic moment. An individual proton behaves like a tiny bar magnet. The contribution of hidden quark flavours to this magnetization can be thought of as being induced by the circulation of electric charge about the proton's polarization axis (Fig. 1). Sufian *et al.* show that strange quarks provide a small enhancement of $(0.8 \pm 0.2)\%$ of the proton's total magnetic moment. They confirm the existence of a positive contribution at the 99.99% confidence level.

The authors' simulation confirms the prediction of an earlier calculation[5] of the behaviour of strange quarks in the proton, and allows a comprehensive assessment of systematic uncertainties to be made for the first time. The tremendous precision of Sufian and colleagues' magnetic-moment result is more than ten times better than that of the most precise experimental measurement[6]. This outcome contrasts starkly with results for most aspects of the proton's structure. For instance, experimental measurements of the proton's total magnetization are some tens of millions of times more precise than can be determined in numerical calculations of QCD[7,8].

Isolating the strange-quark component of the proton's magnetization is challenging, because it requires precise parity-violation measurements (measurements of the difference between the scattering of left-handed and right-handed polarized electrons from protons). By contrast, isolating this component in a numerical calculation is relatively straightforward. As computational techniques improve, it will be both feasible and desirable to obtain precise results for the proton's total magnetization, which should provide further confirmation of our understanding of the interactions between quarks and gluons.

Beyond the study of quarks and gluons in QCD, Sufian and colleagues' findings could have an immediate impact on the analysis of the Q_{weak} experiment in Virginia[9]. This experiment measures the 'weak' interaction between a proton and an electron, providing a test of whether quarks have an internal structure with a spatial resolution of less than 10^{-19} metres (ref. 10). One of the main components of background in this experiment arises from the magnetization of strange quarks in the proton. The authors' calculations could allow this background to be more easily identified, enabling the experiment to set stronger constraints.

As the precision of QCD studies of the proton improve, there is scope for these numerical calculations to be used in diverse areas of physics. For example, strange quarks in the proton play a key part in the ongoing search for dark matter, the 'missing' mass in the Universe. One of the favoured explanations for dark matter is that it consists of weakly interacting massive particles (WIMPs). The interactions of WIMPs with protons could occur through the Higgs force, which is associated with the famous Higgs boson. Because up and down quarks have minuscule masses, these interactions are likely to be governed by strange quarks and other hidden flavours in the proton. With strange quarks aptly named for the behaviour revealed in subatomic particles 70 years ago, it would make for a fascinating tale if they were again to be instrumental in unveiling new strange behaviour in nature. ■

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ARCHAEOLOGY

Unexpectedly early signs of Americans

Humans are thought to have reached the Americas less than 15,000 years ago. But evidence of stone tool use on an animal carcass excavated in California points to a much earlier arrival of human relatives from the genus *Homo*. **See Letter p.479**

ERELLA HOVERS

The sixteenth century was an era of global exploration called the 'age of discovery'. This was when many nations learnt about the newly found continent later known as America, which was nicknamed 'the New World'. But the Americas had already been found by prehistoric *Homo sapiens* who, after colonizing all other habitable continents, reached there arguably around 14,500 years ago[1], close to the end of the Pleistocene epoch. On page 479, Holen *et al.*[2] challenge this view with archaeological evidence that offers a different perspective on the time of human arrival in the Americas. And their report raises the question of which group of human ancestors — hominins from the genus *Homo* — these early inhabitants might have belonged to.

Holen and colleagues analysed evidence from the Cerutti Mastodon archaeological site in southern California, which contains a sequence of stream-deposited sediments, excavated[3] in 1992 and 1993 using a careful documentation protocol. One deposited layer, a bone bed known as Bed E, contained the remains of a mastodon — an extinct animal distantly related to elephants. The mastodon's long bones (Fig. 1), molars and tusks were found in a fragmented state, bearing modification marks similar to those formed by repeated battering by hammerstones (percussion), and in spatial arrangements not usually found when a carcass decays after death from a natural or accidental cause. In addition, the ends of some bones were broken off, suggesting that this was done to extract the nutritious bone marrow. Wolf and horse bones in adjacent layers did not show these unusual characteristics. Moreover, the mastodon bones were in two separate spatial clusters, each associated with two or three stone cobbles of local raw material. The cobbles were oversized compared with the rest of the layer's fine-grained sediment matrix.

A meticulous protocol was used to sample the sediments from the sequence of layers in the various excavation areas. The refitting of unintentionally detached stone flakes back onto the 'parent' cobbles, and bone flakes back onto the long bones, suggests that Bed E was rapidly buried, and therefore well preserved. There is a striking contrast between the contents of Bed E and the layers above and below (Beds F and D, respectively), which contained only shells and rodent teeth and lacked any possible stone tools. Detailed sediment analyses by the authors do not support material displacement through the action of water, trampling by animals or other burial or fossilization processes that could affect an archaeological find as explanations for the peculiar features of Bed E.

The authors undertook experimental studies using stone cobbles for percussion of large elephant bones (see Supplementary Video 8 accompanying the paper[2]). Bones and stones from archaeological and experimental contexts were subjected to use–wear analyses, and the authors created a database of the modifications expected when stones are used to break the carcasses of large animals and when hammerstones strike a bone placed on a stone anvil. Holen *et al*. note the similarities between the modification marks on the cobbles and bones that occurred after particular actions in their experiments and those uncovered in Bed E. The authors did not find evidence that the stones were modified by other actions, such as tool manufacture by purposeful flaking. They therefore interpret the large cobbles (10–30 centimetres in diameter) in Bed E as hammerstones and anvils used to process a mastodon carcass.

Similar 'single carcass sites' are known from the earliest archaeological periods[4,5] until late in the prehistoric record. The mastodon bones might have been broken to extract bone marrow for food or to create bone tools. A number of primate species, including our own lineage, have used percussion to extract food from plant or animal tissue[6].

The big surprise is the site's age. Rigorous uranium-series dating of the bones yielded an estimated burial age of 130,700 ± 9,700 years ago, coinciding with the beginning of the wet and warm last interglacial period. The finds from Bed E could place hominins in the New World more than 100,000 years earlier than previously thought.

An ongoing debate about the human colonization of the Americas is whether it involved a coastal or inland route. In the Supplementary Information accompanying the paper, the authors propose coastal entry, given claims that hominins reached Asian and Mediterranean islands more than 100,000 years ago[7,8]. They argue that, despite sea-level rise during the last interglacial, the distances to the Americas by water were within the capabilities of human populations at that time; the warm interglacial conditions would have facilitated adaptation to the newly discovered environment on land.

Several hominin species roamed Eurasia 130,000 years ago, although different species had not necessarily developed similar technological behaviours. Possible hominin candidates for the 'authors' of the Cerutti Mastodon site are late populations of *Homo erectus*, Neanderthals and the elusive Denisovans (known through genetic analysis of only a bone and some teeth). Genetic analysis[9] of present-day Amazonian Native Americans links them to indigenous Asian and Australian populations, which are linked[10] in turn to the Denisovans. Such traits are weak or absent in modern indigenous North and Central American populations, and in North Americans from the late Pleistocene[9,11], which might indicate a diverse set of founding populations of the Americas. This could support at least one early (before 14,500 years ago) entry to the Americas, but the exact timing remains an open question[9]. Holen and colleagues do not report skeletal or DNA evidence that could reveal the identity of the hominins whose presence is inferred at the site.

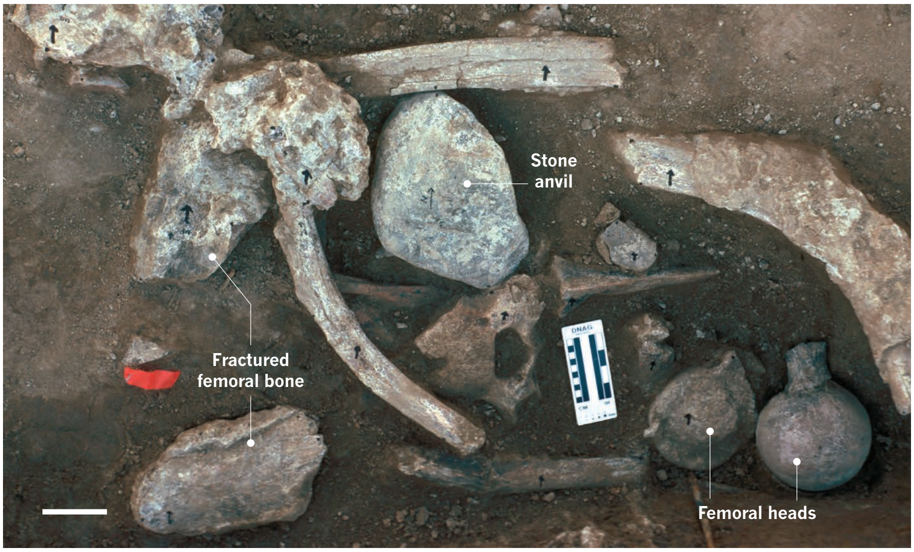

Figure 1 | Broken mastodon bones and possible stone tools at a 130,000-year-old archaeological site in California. Holen *et al.*[2] report analysis of the findings made from excavation of the Cerutti Mastodon site[3]. Some stones found there, such as a possible anvil (the stone shown here weighs 8.3 kilograms), might have been used to break the femur bone of a mastodon, an extinct animal distantly related to elephants. Possible signs of tool-mediated bone breakage, including a fractured femoral bone and separated, fractured ends of the femur known as femoral heads, could indicate activity by ancient humans. Scale bar, 10 centimetres.

Holen *et al*. do not consider the insular *Homo floresiensis* as a probable early colonizer of America. And most evidence indicates that modern *H. sapiens* had not yet dispersed out of Africa 130,000 years ago[12]. Early forms of modern humans — bearing anatomical similarities to modern humans — such as the Qafzeh–Skhul people of the Near East, might have been dispersing from Africa to Eurasia at that time[13]. The authors speculate that archaic *H. sapiens* could be responsible for the Cerutti Mastodon site.

What happened after these hominins reached the Americas? The archaeological record is silent until much more recent times. The best-known and controversial archaeological claims for early human entry into the Americas are from the Calico Hills in California (originally thought to be 80,000–50,000 years old or even older)[14,15], Pedra Furada in Brazil (40,000–20,000 years old)[16] and Old Crow in the Yukon Territory of Canada[1]. However, the interpretations of site context, the nature of the stone items, and the human 'signature' on fossil faunas offered in support of these claims have been criticized. In these cases, the findings could be explained as the outcome of geological or biological processes that superficially mimic human-made items, or the associations of the dated sediments with the artefacts are questionable[1,17–19].

The evidence from the Cerutti Mastodon site has been rigorously researched and presented, and might be more difficult to refute, even though the proposed hominin narrative derived from these data has some gaping holes that need filling. Time will tell whether this evidence will bring a paradigm change in our understanding of processes of hominin dispersal and colonization throughout the world, including in what now seems to be a not-so-new New World. ■

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