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ARCHAEOLOGY

Tools go back in time

The finding of 3.3-million-year-old stone flints, cores, hammers and anvils in Kenya suggests that the first stone tools were made by human ancestors that pre-dated the earliest known members of the genus *Homo*. SEE ARTICLE P.310

ERELLA HOVERS

The earliest production of stone tools by human ancestors marked the dawn of an innovative behavioural strategy that transformed the ecology, social systems and culture of humans through social learning of skills and technology. Direct evidence for this behaviour is found in the archaeological record, and its earliest appearance has been gradually pushed deeper into time over the past five decades[1]. On page 310 of this issue, Harmand *et al.*[2] report findings from Lomekwi 3 (LOM3), a site on the western side of Lake Turkana, Kenya, that extend the record of material culture by some 700,000 years, to 3.3 million years ago.

Palaeoanthropologists have long predicted, on evolutionary and archaeological grounds, that the first stone tools should be older than the previously oldest known instances, which date to around 2.6 million years ago (Ma). Once thought to be unique behaviours of hominins (the group that includes humans and their close extinct ancestors), tool use and toolmaking are now well documented in extant taxa of non-human primates — mainly chimpanzees, but also orangutans, gorillas and certain monkeys. Parsimony suggests that hominin tool use and toolmaking were practised by the last common ancestor of chimpanzees and hominins[3], some 7–5 Ma, but that the making of tools from stones is unique to hominins, with the notable exception of chimpanzee nut-cracking hammer stones[4]; the tools of other primates are mostly twigs or other plant matter. However, the stone tools at sites dated to 2.6 Ma or slightly later, which are assigned to the archaeological complex known as the Oldowan[1], seem to be too well made to have been the first experiments of early humans in producing sharp-edged stone flakes by free-hand core-reduction techniques (when a stone block, or core, is held in the hand and hit with a hammer stone)[5,6].

Thus, core reduction as a technique for producing sharp edges for cutting plant and animal material was hypothesized to have first emerged among early hominin ancestors, but the time of its first appearance remained undefined in the absence of direct evidence. Furthermore, archaeologists did not have a 'template' with which to search for these proposed very early stone tools, and open questions remained regarding the selective processes that might have led to the emergence of stone toolmaking.

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Figure 1 | A Lomekwi tool. This stone was found on the surface at the Lomekwi 3 site in Kenya, where stone tools found in sedimentary layers have been dated to 3.3 million years old. The scars on the stone's surface indicate that it was used as a core from which flakes were produced.

Harmand and colleagues' findings inform us on the first two issues. Extensive geological mapping of the project area, and the presence of well-dated volcanic ash layers, together with palaeomagnetic correlations, constrained the age of the geological layer in which the authors had found the tools to 3.31–3.21 Ma. This range was narrowed down to 3.3 Ma on the basis of sedimentation rates. Because the sediments in these layers are fine-grained, and a flake found by the authors could be fitted back onto the core from which it had been detached, it is unlikely that the tools accumulated through stream activity or that substantial disturbance of the sediments occurred after the tools had been discarded.

The small collection of stone tools at LOM3 is unlike those from known Oldowan localities, which contain mainly flakes. Most of the LOM3 items (around 76%) are cores, anvils, hammer stones and worked cobbles, indicating that the main activities were associated with pounding against anvils rather than hand-held core reduction. Some items bear traces of having been used for multiple techniques — as an anvil or hammer stone, or as a core to produce flakes — which hints at their use for exploiting variable resources (Fig. 1). All types of object in LOM3 are larger than their counterparts in the later Oldowan sites. The flakes are more massive than the accidentally produced flakes found in chimpanzee nut-cracking localities, but the anvils and hammers are within the size range of chimpanzee nut-cracking kits[4,7,8].

The surface characteristics of the items indicate the use of forceful blows during the application of both pounding and hand-held core reduction. However, whether the hand anatomy and precision grip that are needed for tool use and toolmaking were already present in the various species of hominin that existed around 3 Ma is debated[9–11]. The earliest known[12] appearance of the genus *Homo* is at 2.8 Ma, suggesting that the LOM3 toolmakers may have belonged to other lineages of early hominin.

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Harmand and colleagues contrast the postulated multiple uses for the LOM3 items with the generally single-purpose tools used by extant non-human primates. The authors suggest that the LOM3 tools could represent a technological stage between a hypothetical pounding-oriented stone-tool use by hominins earlier than those at LOM3 and the flaking-oriented behaviour of later Oldowan tool-makers. Primatologists may take issue with the first statement and argue that tool use in primates is multifaceted[13]. Evolutionary theorists may prefer less gradualist interpretations, and archaeologists could argue that one must not exclude the possibility that, at the beginning of each discrete episode of its use, each stone object was perceived merely as available raw material. The cognitive implications in this last case would differ from those offered by Harmand and colleagues. Therefore, we should focus on the evidence[14,15] for core reduction as a marker of new cognitive abilities and a new technological path on which hominins embarked at 3.3 Ma.

The age and nature of the finds from LOM3 call for a re-evaluation of models[16,17] that tie together the timing and patterns of environmental change, hominin evolution and the origins of technological behaviour around 2.5 Ma. However, caution is warranted. Our understanding of ancient hominins and their cognitive, cultural and social capacities is only as good as the available archaeological and fossil data. Similar to animal bones from Dikika, Ethiopia, that date to at least 3.39 Ma and arguably bear stone-inflicted cut marks[18], the stone tools from LOM3 are at present an isolated occurrence. To maintain that either of these instances marks innovations in hominin behavioural evolution, the temporal gaps must be filled in with more data. In this respect, the LOM3 discoveries stand to have an immediate impact on human-origins research in eastern Africa by providing the long-needed search template for early stone tools.

Moreover, until now, the search for 'older than the Oldowan' archaeological sites has focused on a few areas that contain sediments dated to between 2.9 and 2.6 Ma, with the aim of establishing a sequence with known Oldowan sites. The discoveries at LOM3 allow research also to focus on the time range 3.4–2.9 Ma, which so far has not been tapped for evidence of material culture. And why not dig deeper in time? LOM3 may not be the final — or rather, the first — word on the roots of human technology. ■

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QUANTUM PHYSICS

Squeezed ions in two places at once

Experiments on a trapped calcium ion have again exposed the strange nature of quantum phenomena, and could pave the way for sensitive techniques to explore the boundary between the quantum and classical worlds. SEE LETTER P.336

TRACY NORTHUP

In Schrödinger's famous thought experiment, a cat is prepared in a quantum superposition of being both alive and dead by being trapped in a box with a flask of poison. As if that were not enough, the poor cat is now being squeezed too — all in the name of quantum measurement. In laboratory experiments, atoms have been prepared in superpositions of being in two places at once, playfully called Schrödinger's cat states[1]. On page 336 of this issue, Lo *et al.*[2] demonstrate superposition states of a trapped ion in which its position is not only split between two locations, but also squeezed. Squeezing refers to the process of suppressing quantum fluctuations for a particular measurement, such as that of a particle's position.

Quantum mechanics tells us that the position of a particle (or Schrödinger's fictitious cat) has an inherent uncertainty even when it is at rest, a feature known as the standard quantum limit. When the particle is prepared in a squeezed state, however, we can pinpoint its position to better than that limit (Fig. 1). There is a price to pay for squeezing, though. When fluctuations in position are squashed down, additional fluctuations arise in the particle's momentum, such that the product of position and momentum fluctuations still satisfies Heisenberg's uncertainty relation — which states that there is a fundamental limit to the precision with which a particle's position and momentum can be simultaneously determined. Nevertheless, by suppressing fluctuations in the quantity that they intend to measure, researchers can improve measurement precision. For example, squeezed states have been used to achieve record

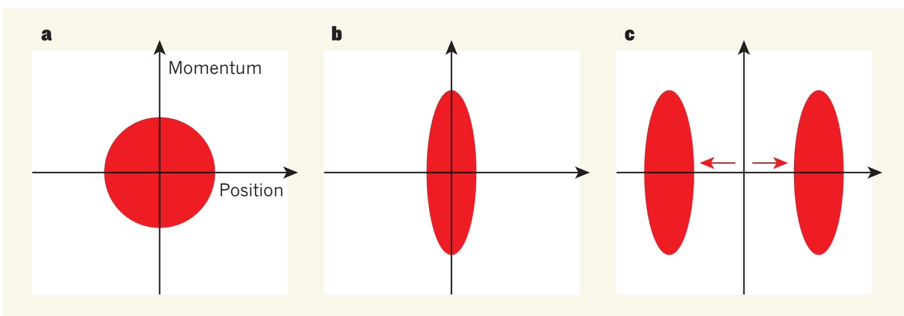

Figure 1 | Squeezing an ion's positional uncertainty. Every object's momentum and position are subject to fluctuations, which become pronounced on the atomic scale. **a,** The red circle indicates the uncertainty in position and momentum for a calcium ion (Ca^+) in its motional ground state. **b,** Lo *et al.*[2] used laser pulses to squeeze fluctuations in position, at the cost of amplifying the fluctuations in momentum. **c,** They then displaced the ion in opposite directions at once, so that it would be equally likely to be found in one of two distinct states. The squeezing operation provides a better signal-to-noise ratio for the ion's position, so that it is easier to distinguish between the states.

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