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A stone age "Rosetta stone"

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Abstract

Our ancestors had the edge over several other contemporary species of human that were headed for extinction by about 40,000 years ago. What were they doing differently? Archaeological scientists are trying to find out using modern techniques to study traces of use left on stone tools and other artefacts.

Keywords

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A Stone Age ‘Rosetta Stone’

Richard ‘Bert’ Roberts, Richard Fullagar and Linda Prinsloo

Our ancestors had the edge over several other contemporary species of human, which were headed for extinction by about 40,000 years ago. So what were they doing differently?

INSERT IMAGE 1 ABOUT HERE

Deciphering what our ancestors were doing in the distant past, and how this sheds light on the evolution of the human body and mind are fascinating but immensely challenging topics. They are not made any easier by the scarcity of human bones and teeth and by the generally poor preservation of organic matter at timescales stretching back tens of thousands of years and longer. Much of what we know about our ancient forebears is based on the artefacts they made from stone, which is by far the most common tool material we find at places where people were living, hunting and gathering – hence the ‘Stone Age’.

But how much can stone tools tell us about human evolution? All artefacts made of stone are sometimes called ‘stone tools’, even though most artefacts are actually the waste products of making tools and were never used as tools themselves. Archaeologists classify stone artefacts by their shape, the techniques used to make them, and their function – what we think they were used for. Archaeology is replete with stone tool classifications for everything from arrowheads, axes and grinding dishes to regional and global ‘modes’ of technology that describe the level of stone tool complexity and are linked with evolutionary progression, the arrival of one human species and the disappearance of another.

Can we ever be certain about which human species made which stone tools? Not without a clear pattern of repeated association with the bones, teeth or DNA of a particular human species, or the recurring presence of other diagnostic artefacts. In Europe, for example, the presence of Neanderthals (*Homo neanderthalensis*) is often associated with stone tools made predominantly of flint using specific (Mousterian) technologies. The arrival of our species – anatomically modern humans (*Homo sapiens*) – is linked to the subsequent Aurignacian cultural tradition, characterised by new technologies, other tool materials (such as ivory and antler) and new kinds of artefacts, including ‘Venus’ figurines and some of the oldest-known cave paintings in the world.

Nonetheless, despite the large number of Stone Age sites excavated in Europe, ambiguities remain and disputes persist about the interaction and evolution of different human groups. The situation is much worse in less well-studied parts of the Old World, because we know toolmaking techniques can develop independently among different populations at various times, and similar technologies might be responses to a variety of problems. But we can be sure of one thing: we are unlikely to dig up a bony hand rich in DNA and clutching a stone tool diagnostic of a particular culture!

One of the most important but puzzling regions is mainland Asia and the archipelago of Southeast Asia. This vast landmass and the outlying tropical islands have intrigued stone and bone researchers since the 1890s, when *Homo erectus* fossils were found by the Dutch anatomist Eugène Dubois on the island of Java. Asia has played host to some of the most astonishing scientific discoveries of the past decade, and it now appears that several species of human – or, strictly speaking, ‘hominins’ (a term that encompasses all primates more closely related to us than to chimpanzees) – may have co-existed with the first influx of modern humans.

The tract of land between central Asia and northern Australia was a melting pot of humanity between 130,000 and 40,000 years ago. Four groups of hominins inhabited parts of Asia and

Southeast Asia at times during this period: modern humans, Neanderthals, the diminutive 'Hobbits' of eastern Indonesia (*Homo floresiensis*) and the enigmatic 'Denisovans' of the Altai Mountains in central Russia. Other possibly overlapping hominins include late-surviving populations of *Homo erectus* in Indonesia and ancestors of the 'Red Deer Cave' people in southwest China. Surprisingly, modern Aboriginal Australians and Melanesians retain genetic traces of Denisovans, who may have been widespread in Southeast Asia – possibly reaching Australia's shores – before going extinct.

But the clues, while tantalising, are scant. All that we know about *Homo floresiensis* is based on the evidence contained in a solitary cave on the island of Flores, and fossils of Denisovans currently consists of one finger bone and two teeth excavated from a single cave in southern Siberia. So how can archaeologists hope to get a toehold on human evolution, stone technology and tool function in this part of the world so far back in time?

We need a Stone Age equivalent of the 'Rosetta Stone', the famous Egyptian stone slab engraved with a decree in three scripts: Ancient Egyptian hieroglyphs, Demotic, and Ancient Greek. Because the same text is inscribed in all three languages, it provided the means to first decipher Demotic and finally crack hieroglyphs in the early 1800s. There are no written scripts to decode human evolution, artefact technology and tool use during the Stone Age, but scientific techniques for studying ancient tools are now lending a helping hand.

Welcome to the world of 'traceology' – the study of wear and other use-traces, including plant, animal and other residues trapped in crevices and adhering to tool surfaces. This expanding field of archaeological science began in earnest 50 years ago, with the English translation of Sergei Semenov's *Prehistoric Technology*, a landmark Russian study of ancient stone tools deduced from microscopic traces of their manufacture and use, together with the experimental replication of these patterns using modern analogues.

INSERT IMAGE 2 ABOUT HERE

These days, the optical microscope has been joined by scanning laser confocal and desktop electron microscopes to obtain high-resolution images and fast, reliable measurements of polished tool surfaces and visible residues. Sophisticated analytical techniques and instruments are also able to detect 'chemical fingerprints' of invisible residues from ancient biomolecules and associated non-radioactive forms (stable isotopes) of carbon, nitrogen and hydrogen. These approaches are increasingly used in parallel to open microscopic, molecular and isotopic windows on to the Stone Age, to determine details of stone tool function and to test theories about human subsistence, behaviour, cognition and evolution.

The hunting and butchering of animals, the processing and cooking of foods, the preparation and application of poisons and medicines, and the use of hafting technologies can potentially leave distinct chemical and use-wear signatures on stone tools and weapons. In South Africa, for example, traces of a compound adhesive (made of plant gum and red ochre) for hafting have been recovered from stone tools buried for 70,000 years in Sibudu Cave, and residues of ricin – a naturally occurring and highly toxic protein – were found on the end of a 24,000 year-old wooden stick at Border Cave.

The use of poison and the mixing of adhesives imply complex behaviour and cognitive abilities typical of modern humans. Neanderthals had other hafting arrangements to attach stone tips to their spears. Did Hobbits or Denisovans make hafted tools? The use of pounding stones to crack nuts is a technology common to all hominins and several other primates, including macaques and chimps. But which groups invented grinding technology? The choice of tool materials, processing methods and range of tool functions is likely to vary among different hominin groups, depending on resource availability, local environments, competition and social interactions.

Archaeological attention has thus far focussed on lipids (a group of naturally occurring molecules that includes fatty acids, waxes and sterols), carbohydrates, resins and gums, all of which are relatively resistant to degradation and have a high potential for preservation. Particular success has been made in separating (by liquid or gas chromatography) and identifying (by mass spectrometry) the left-overs of dairy products in Holocene-age pottery and ceramics from Eurasia, and aquatic food residues extracted from charred surface deposits adhering to Japanese pottery up to 15,000 years old.

Australia has been at the forefront of research into microscopic use-wear and residues, but currently plays almost no part in the 'biomarker revolution' – the term coined by Richard Evershed, an organic chemist at the University of Bristol in the UK, to describe the gathering pace of organic residue analysis in archaeology. But this situation is about to change. The Centre for Archaeological Science at the University of Wollongong is venturing into archaeological chemistry – thanks to the support of an Australian Research Council Laureate Fellowship – to learn more about the lives of our predecessors and those of the Neanderthals, Hobbits and Denisovans.

We will focus initially on residues attached to stone artefacts from sites in Asia, Southeast Asia and Australia that are thought to date to between 130,000 and 40,000 years ago, including the type sites of the Hobbits and Denisovans. Our initial questions are straightforward: for example, how did these species process particular foods? And did they utilise similar sorts of plant and animal products? We will scour these Stone Age archives for information about hominin resource use, subsistence behaviour and adaptations to new and diverse environments using chromatography and mass spectrometry methods in tandem with infrared and Raman 'vibrational' spectroscopy techniques, which detect molecular vibrational motions. By coupling the spectrometers to a microscope, tiny samples can be measured directly and non-destructively.

INSERT IMAGE 3 ABOUT HERE

As well as scrutinising a wide range of artefacts for surviving biomarkers and stable isotopes, we will also need to investigate the geochemistry of organic compounds in the surrounding sediments – the 'background' environment in which the artefacts have been buried for millennia. And because organic residues are seldom stable for long periods of time in warm climates, due to the damage inflicted by biological activity and chemical weathering, we shall follow in Sergei Semenov's footsteps and perform a series of experiments and blind tests to validate our inferences about the likely origins of particular residues and the probability of their long-term survival in nature.

With appropriate archaeological samples, controlled experiments and this multi-strand approach to characterising residues and tool function, we hope to ultimately develop a 'Rosetta Stone' of chemical fingerprints that will bridge the gaps between human evolution, artefact technology and tool use in the Stone Age.

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IMAGE 1

Stock photo of the actual 'Rosetta Stone'

The 'Rosetta Stone' is a slab of rock inscribed with a decree made in 196 BC by the Egyptian ruler Ptolemy V Epiphanes. The script is written three languages – Ancient Egyptian hieroglyphs, Demotic and Ancient Greek – which allowed the hieroglyphs to be deciphered in the early 19th century. We need the prehistoric equivalent of the Rosetta Stone to piece together the story of human evolution, artefact technology and tool use in the Stone Age, using multiple scientific techniques to decipher the microscopic and molecular traces of ancient human activities.

Photo credit: [stock image]

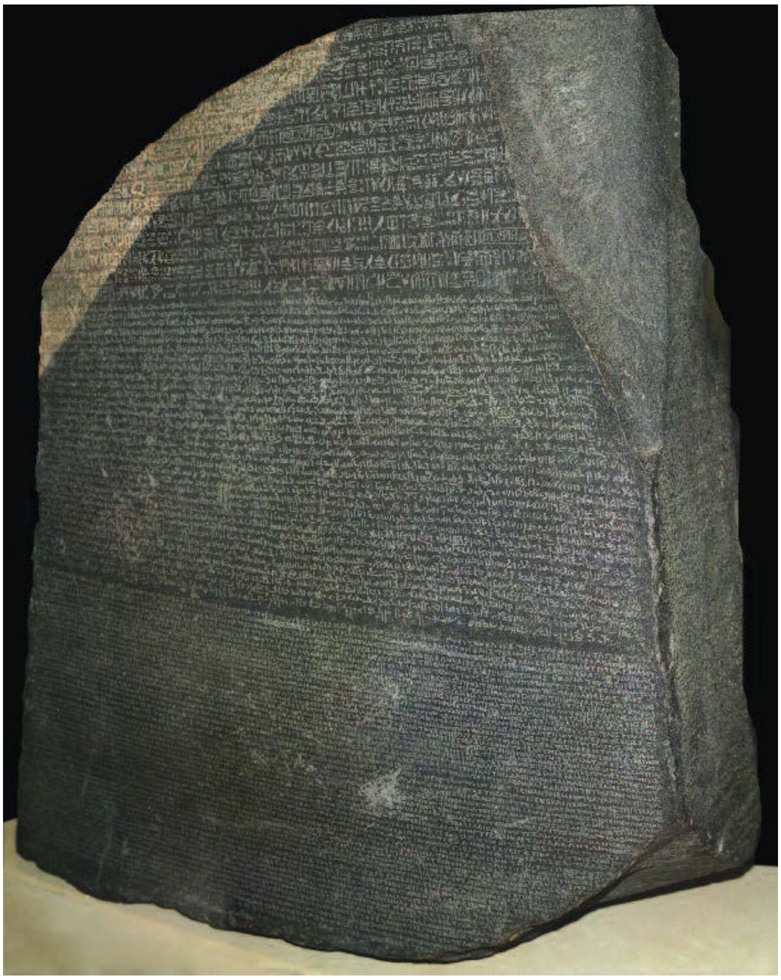
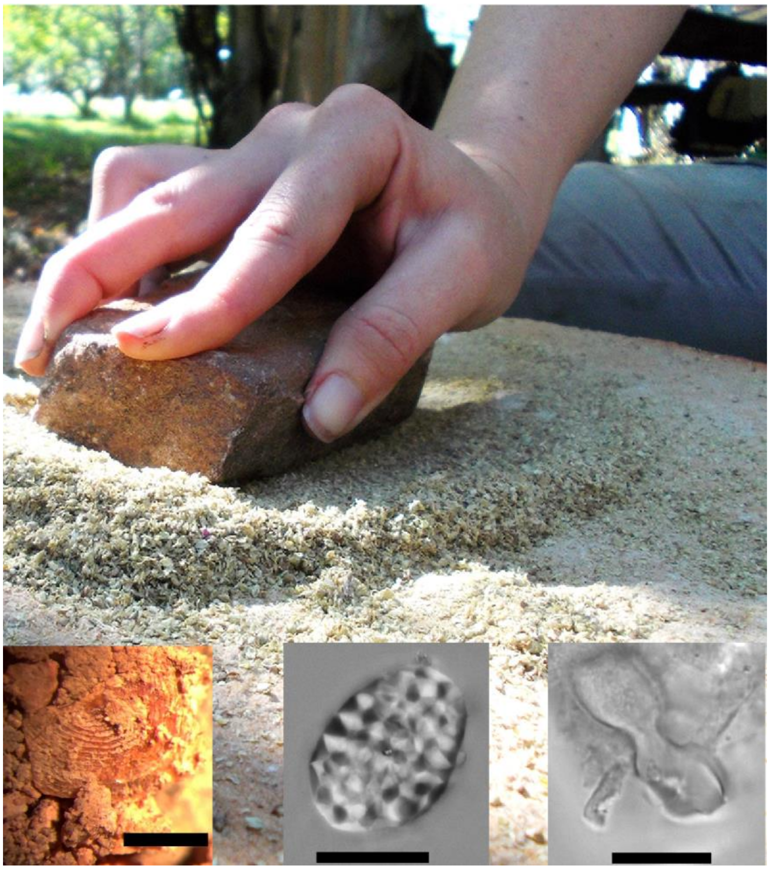


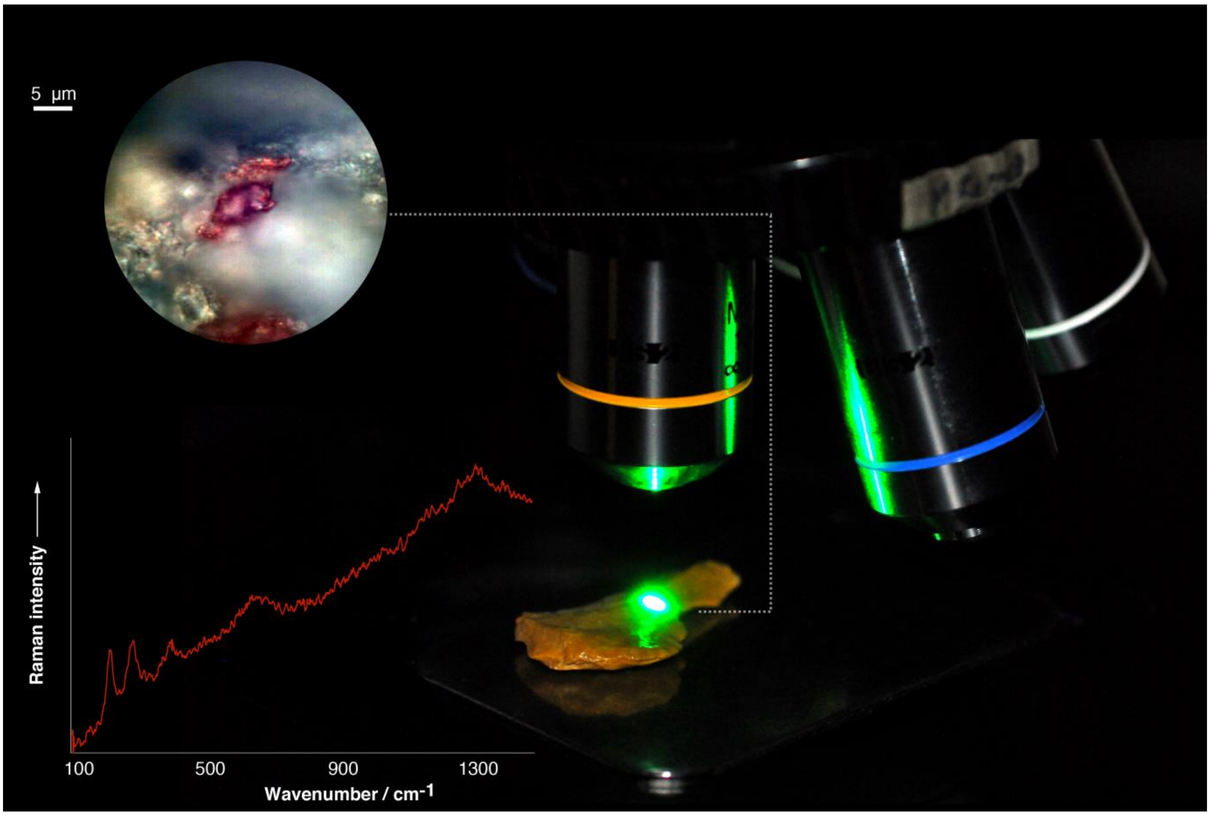
IMAGE 2



Modern experiments form the basis for studying use-wear on archaeological artefacts and also the microscopic residues that are sometimes preserved intact on ancient tools. The inset photos show (left to right) a fish scale on a Pleistocene stone tool from Siberia (scale bar 1 mm), a grass compound starch grain from a Pleistocene grinding stone in Australia (scale bar 0.01 mm) and a grass phytolith from the same grinding stone (scale bar 0.005 mm).

Image credits: R. Fullagar (main photo and fish scale) and J. Field (starch grain and phytolith)

IMAGE 3



In Raman spectroscopy, light of a specific colour is shone on to a sample and the resulting scattered light is collected to obtain a chemical fingerprint. Samples as small as 2 micrometres (0.002 millimetres) in size can be viewed through the objective lens of a microscope and then analysed non-destructively using a laser beam. This photo composite shows the Raman spectrum obtained by shining green laser light on to a tiny spot of haematite (red ochre) attached to the surface of a polished flake tool from northern Australia.

Image credits: J. Janse van Rensburg (main photo) and J. Prinsloo (haematite and Raman spectrum)