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EVOLUTIONARY ANTHROPOLOGY

Homo 'incendius'

An analysis of microscopic and spectroscopic features of sediments deposited in a South African cave one million years ago suggests that human ancestors were using fire much earlier than had been thought.

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Figure 1 | The crucible of combustion. View inside Wonderwerk Cave, South Africa, from the bottom of excavation 1, looking towards a massive stalagmite formed 30 metres inside the cave entrance. The photograph was taken before the deepest archaeological layer (stratum 12) had been excavated. Berna *et al.*[1] analysed the *in situ* remains of ashed plants and burnt bones from stratum 10, which occurs mid-profile in the section shown in the right foreground. The ghostly grid pattern in the photo is due to the string lines used to demarcate the excavation in 1-yard (approximately 0.9-metre) horizontal intervals, and their vertical projections towards the floor. (Photo courtesy of P. B. Beaumont.)

Humans have long been captivated by the flickering flames of the campfire. But when did our ancestors first master the use of fire, and which ancient human species was the first to do so? In *Proceedings of the National Academy of Sciences*, Berna and colleagues[1] report that they have found fragments of burnt bone and ashed plants in one-million-year-old sediments at Wonderwerk Cave, Northern Cape province, South Africa. This evidence of fire occurs in the same sedimentary layers as Acheulian stone tools, usually considered the handiwork of *Homo erectus*. Their discovery more than doubles the accepted antiquity of the habitual use of fire by humans[2,3], and highlights the benefits of using microscopic and molecular techniques to identify 'cryptic combustion' at sites of human occupation — whatever their age.

Controversy has dogged previous claims for the early use of fire by hominins (primates more closely related to humans than to chimpanzees), such as australopithecines or *H. erectus*. The discovery[4] in the 1940s of apparently charred bones at a 3-million-year-old fossil site in South Africa inspired pioneering Australian palaeoanthropologist Raymond Dart to dub these 'proto-humans' *Australopithecus prometheus* — a new australopithecine species named after the giant in Greek mythology who stole fire from the heavens. However, chemical analysis by English palaeoanthropologist Kenneth Oakley[5] showed that the bones were not burnt, but coated in black oxides of iron and manganese.

Subsequent claims for early fire use have received a similarly cool reception. Some studies have suggested that australopithecines or *H. erectus* had tamed fire by 1.4 million years ago in southern and eastern Africa[6,7], and that cooking has played a pivotal part in the evolution of early *Homo* species[8]. These proposals have been contested, however, either because the burnt remains are not in their original depositional context or because they are found at open-air sites where bush fires ignited by volcanic activity or lightning strikes cannot be ruled out. Acheulian toolmakers were using fire almost 800,000 years ago in Israel[9], but evidence for its habitual use does not emerge until after 400,000 years ago[2,3]. This later date places pyrotechnology (the intentional use and control of fire) in the hands of only Neanderthals and *Homo sapiens*, leaving *H. erectus* and earlier hominins out in the cold.

The Earlier, Middle and Later Stone Age deposits inside the 140-metre-long Wonderwerk Cave have been excavated[10] since the 1940s. Excavation 1 — the deepest of the six in the cave — is sheltered behind a massive stalagmite (Fig. 1) and comprises 12 archaeological strata. Berna *et al.*[1] studied stratum 10, one of the Earlier Stone Age layers that contains Acheulian stone tools and that was deposited between 1.1 million and 1 million years ago, as indicated by measurements of radionuclides produced by cosmic rays and of magnetic polarity[11,12]. The authors observed that this layer also contains a variety of pyrogenic features visible to the naked eye, including bones and teeth with charred surfaces and a whitened appearance that indicates their thermal decomposition. Using a technique known as Fourier transform infrared (FTIR) spectroscopy[13], the researchers found that the bones and adhering sediments had been heated to 400–700 °C. Moreover, the surfaces of many of the stone tools had dimpled, 'pot-lid' fractures, which are typically created at high temperatures[9]. But the authors' most compelling proof of *in situ* combustion was found under the microscope and from direct chemical analysis of intact blocks of sediment.

Examination of intact sediments at the microscopic scale — the 'micromorphology' — provides a powerful means of investigating site formation processes and post-depositional alterations in an undisturbed context[14]. Micromorphological analysis has previously been used to support suggestions of fire use in Israel 400,000 years ago[2], and to refute claims of similar antiquity for the 'Peking Man' site at Zhoukoudian in China[15]. These studies used FTIR spectroscopy to identify burnt materials, but Berna *et al.*[1] take this technique a step further by coupling micromorphology to FTIR spectra measured on burnt materials still embedded in resin-impregnated blocks of undisturbed sediment. For this purpose, they used a FTIR spectrometer attached to an infrared microscope. This analysis revealed *in situ* combustion features that are invisible to the naked eye, including abundant and well-preserved remains of ashed plants and angular fragments of burnt bone.

Berna *et al*. emphasize that extracting this 'smoking gun' evidence required the application of both microscopic and molecular techniques to study intact, undisturbed deposits. Their results represent a call to arms for archaeologists to make *in situ* analyses at other sites to search for cryptic traces of anthropogenic burning and to gain insight into site formation processes more generally. Complementary techniques can also be used to investigate the human history of fire use. For example, many minerals undergo structural transformation when exposed to high temperatures, and this can be recognized using established physical and chemical techniques[13]. The magnetic and thermoluminescent properties of sediments and stone tools can also provide records of ancient heat treatment[16] (thermoluminescence is the release, upon heating, of previously absorbed radiation energy as light). And the abundance and isotopic composition of pyrogenic carbon — from the macroscopic to the molecular in scale[17] — can help to establish combustion conditions in archaeological deposits and identify the most promising strata for further micromorphology and FTIR-microscopy investigations.

With the pyrotechnology pendulum swinging back to 1 million years ago, the fire-making credentials of *H. erectus* have begun to be restored. Widespread acceptance of controlled burning at such an early date will require the establishment of a pattern of ancient fire use at multiple sites, as observed in Europe after 400,000 years ago[3]. The evidence from stratum 10 at Wonderwerk Cave should ignite the search for such a pattern in Africa using *in situ* and other microanalytical techniques.

And what of stratum 12, the deepest archaeological layer in the cave? This stratum, which was deposited more than 1.4 million years ago along with Oldowan stone tools[1,10–12], has been reported[10] to contain wood ash, charred and whitened bones, and stones with pot-lid fractures. Berna *et al*. examined the purported ash and concluded that it is weathered rockfall and flowstone[1], but work now under way on the bones and stones may yet produce further fireworks from *Homo* 'incendius'. ■

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