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News & views

Archaeology

Oldest known evidence of controlled fire ignition

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A 400,000-year-old site excavated in England reveals signs of deliberate fires made using the mineral iron pyrite to produce sparks.

Uncovering convincing evidence for the identification of ancient traces of fire is a real challenge. Writing in *Nature*, Davis *et al.*[1] report success on this front. Using diverse techniques and a contextual approach, this multidisciplinary team presents a set of consistent evidence for the oldest known controlled use of fire, including signs of deliberate ignition of flames. The traces of fire are dated to 400,000 years ago in Barnham in southern England.

Over time, combustion structures are affected by degradation processes, making them more difficult to identify the further back in history that scientists try to investigate. It is even more complicated to distinguish with certainty between fires made by humans or ancient human relatives (who, like *Homo sapiens*, belong to the group called hominins) and those with natural origins. Clues are often slight or indirect, and different underlying causes can leave similar traces. In general, it is hard to come to definite conclusions, especially in open-air contexts, where natural fires can thermally alter artefacts more easily than in enclosed environments, such as caves.

Archaeological studies of fire (a branch of science known as pyroarchaeology) have made great strides forwards with the development of new methods (see go.nature.com/48naazd). For example, archaeomagnetic analyses can identify heated sediment and offer a way to study what happened during heating events[2]. This technique reveals aspects of the Earth's magnetic field, such as its intensity and direction, recorded in ferromagnetic minerals, which enables scientists to date when sediments were heated. When this approach is combined with a method called archaeostratigraphic analysis, the time between the last uses of two fireplaces can even be measured to between decadal and centennial levels of precision[3]. Characterization techniques, such as various spectroscopy approaches, can show whether heating occurred and with what strength, enabling the identification of traces of fires that are sometimes not noticeable or barely noticeable without such measurements[4,5].

Studying combustion-generated organic compounds known as polycyclic aromatic hydrocarbons (PAHs) is increasingly used in archaeology because the ratio of light to heavy PAHs can be used to distinguish hominin-made and natural fires[6]. The demonstration of the recurrence of several fire events in the same place is also a good indication of the habitual use and control of fire by hominins[7].

Davis and colleagues present what they identified during excavation work as being a potential open-air fireplace marked by localized reddened sediment. The Barnham site is difficult to study because the traces are extremely old and it is an open-air site, with a few burnt stone artefacts but no charcoals, ashes or burnt bones. On their own, these remains do not unequivocally demonstrate the use of fire by human relatives in the past. A natural fire could have left similar traces.

To demonstrate that the remains observed at Barnham are indeed the remains of a fireplace, the researchers used complementary techniques to analyse the reddened sediments. The method of micromorphology — studying sediment blocks using microscopy to identify and interpret combustion features[8] — revealed localized heat alteration of sediments, a finding consistent with the presence of a fireplace rather than a wildfire.

Environmental-magnetism analysis confirmed that magnetization of the reddened sediment was due to heat. Moreover, the magnetic properties of the archaeological sediments were interpreted through comparison with experimental reference material, indicating repeated short-duration fire events at the fireplace, consistent with the use of a hominin-made fireplace. The identification and analysis of PAHs in the sediments revealed a higher abundance of heavy PAHs than light ones, confirming the use of fire by hominins. Analysis of the sediments revealed that the fire temperatures reached at least 750 °C in some places. The authors also identified burnt stone artefacts that were reddened and cracked by heat.

Furthermore, geological analysis of rocks in the environment of the site indicates that the mineral iron pyrite, which was found at the site (Fig. 1), is scarce near Barnham. This suggests that the two iron pyrite fragments found there were brought to the site from somewhere else. Study of the pyrite fragments (using high-resolution imaging and mineralogical-characterization techniques) indicate that they underwent a process of oxidation at

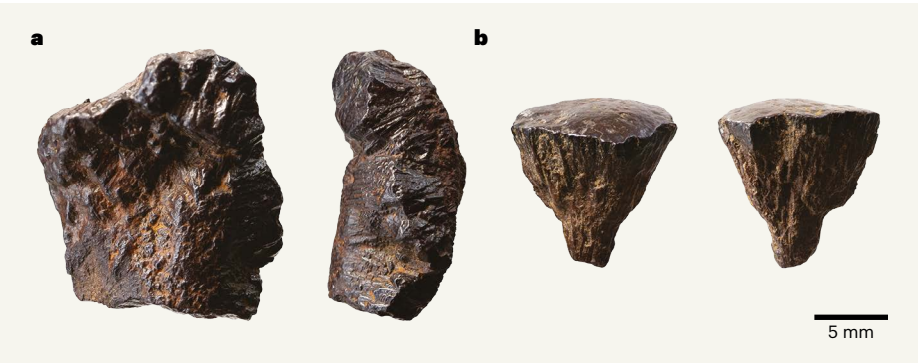

Figure 1 | The spark-generating mineral iron pyrite found associated with an ancient fireplace. Davis *et al.*[1] report evidence for the oldest known controlled use of fire at a 400,000-year-old site in southern England. The authors found signs of fires at the site and the presence of iron pyrite, which was rare locally and probably transported to the site as a tool to deliberately ignite fires. Two fragments (**a** and **b**) of pyrite from the 400,000-year-old site, shown at different angles. (Adapted from Fig. 4 of ref. 1.)

some stage after they arrived at the site. This suggests that pyrite in its non-oxidized form, which can be used to generate sparks to light a fire, was brought to the site (then after its burial, in layers unearthed by excavation, it became oxidized and incapable of generating sparks).

The authors' geological studies provide extensive chronological and environmental evidence confirming the antiquity of the fire traces. Together, the data that Davis and colleagues present strongly suggest that hominins had the capacity to ignite fires as early as 400,000 years ago.

Iron pyrite has previously been identified in a major Middle Palaeolithic site (a period spanning from around 300,000 to 40,000 years ago). For example, some was found in the Scladina cave in Belgium (dated to around 42,200 to 44,600 years ago, when that site was occupied by Neanderthal populations), but those sites lack a clear link with features associated with traces of fire[9]. Davis and colleagues' work does not present the oldest evidence of fire use, given reports that earlier hominins used fire (presumably naturally lit fires) more than one million years ago in Africa and around 500,000 years ago in Europe[7,10], but it rather reveals one of the earliest known cases of fire mastery and its habitual use in western Europe. And above all, this is the earliest case for which it can be proposed that human relatives were capable of igniting fires.

Unfortunately, there are no reported finds yet at the Barnham site of the corresponding fire-lighter tools (stones bearing traces of friction from interaction with pyrite, characteristic of flint being used as a lighter). Such evidence, as has been found in more-modern Middle Palaeolithic contexts[11] (of about 50,000 years ago), would unequivocally demonstrate the capacity for ignition by uncovering traces of the fire-lighting action itself. Nevertheless, the authors have successfully built a convincing case with a strong body of evidence, for the repeated controlled use and lighting of fire at will by hominins at this site.

Davis and colleagues' research is a rigorous and effective combination of complementary methods that also draws on having robust experimental reference samples. It provides a good example of methodology to follow at sites where ashes, burnt bones and charcoals are not preserved in the fireplace structure. This study pushes back in time the origin of when controlled use of fire entered the technological repertoire of hominins, because it has generally been considered that the habitual use of fire emerged sometime between 400,000 and 300,000 years ago[10]. Davis and colleagues' results will encourage further searches for traces of fire on ancient sites, even where these remains might be difficult to perceive due to alterations after their deposition. This research shows how multidisciplinary teams can work together efficiently to reveal, characterize and interpret traces of ancient fires.

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