

Microstratigraphic evidence of in situ fire in the Acheulean strata of Wonderwerk Cave, Northern Cape province, South Africa

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AUTHOR SUMMARY

Controlled use of fire was a major turning point in human evolution, but efforts to pinpoint its initial appearance have had limited success (1–3). Whereas extensive deposits of ash, charcoal, and burned stone artifacts from sites dating to the past 400,000 y are well documented (1, 2), the evidence for fire from earlier contexts is subject to alternative interpretations because they are from open-air sites where the action of wildfire cannot be ruled out and because microscopic analysis of the context within sedimentary sequences is missing (1, 2). We were able to overcome this methodological shortcoming in the present study of the prehistoric deposits at Wonderwerk Cave (South Africa). Our results are the oldest direct evidence of fire associated with early humans.

In this study, we combine micromorphology—the microscopic analysis of the components, features, and fine-level structures of soils—and Fourier transform IR microspectroscopy to identify traces of combustion in the Early Acheulean deposit, Stratum 10, at Wonderwerk Cave (4). Stratum 10 is one of 12 archaeological strata in Excavation 1 located 30 m from the present cave entrance. Strata 12 through 5 contain Earlier Stone Age artifacts, beginning approximately 1.8 Mya, inclusive of Oldowan to Acheulean assemblage (4) (Fig. P1A). The stone artifacts of Stratum 10, dated to 1.07 to 0.99 Mya (Jaramillo normal subchron), are characterized by handaxes shaped by a relatively small number of flake removals characteristic of the Early Acheulean (4). A clear surface within Stratum 10, identified by micromorphology, contains abundant remains of ashed plants (Fig. P1C) and bone fragments, a few of which appear to be heated at approximately 500 °C as assessed by Fourier transform IR microspectroscopy (Fig. P1D and E). The angularity of bone fragments and the exceptional state of preservation of the ashed plant material (Fig. P1C and D) indicate that these components were not transported into the cave by wind or water, but were combusted and accumulated locally.

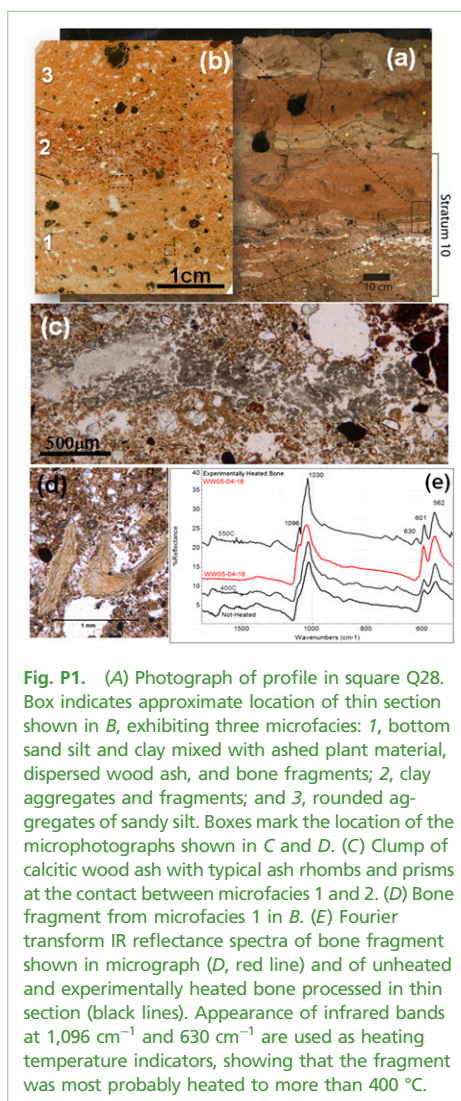


Fig. P1. (A) Photograph of profile in square Q28. Box indicates approximate location of thin section shown in B, exhibiting three microfacies: 1, bottom sand silt and clay mixed with ashed plant material, dispersed wood ash, and bone fragments; 2, clay aggregates and fragments; and 3, rounded aggregates of sandy silt. Boxes mark the location of the microphotographs shown in C and D. (C) Clump of calcitic wood ash with typical ash rhombs and prisms at the contact between microfacies 1 and 2. (D) Bone fragment from microfacies 1 in B. (E) Fourier transform IR reflectance spectra of bone fragment shown in micrograph (D, red line) and of unheated and experimentally heated bone processed in thin section (black lines). Appearance of infrared bands at 1,096 cm^{-1} and 630 cm^{-1} are used as heating temperature indicators, showing that the fragment was most probably heated to more than 400 °C.

Thus, wood combustion took place in situ approximately 25 ms in from the cave entrance. Spontaneous combustion of guano—a rare event but one documented inside caves—can be excluded because guano remains and characteristic high temperature phosphates deriving from its combustion are locally absent. Similarly, it is unlikely that a series of wildfires could have penetrated this deep inside the cave.

Our results shed new light on similar but less contextualized findings relating to early use of fire (i.e., 1.0–1.5-Myr-old burnt bones at Swartkrans, South Africa) (5). At Wonderwerk, the evidence from micromorphology is supported by the prevalence of burned bone in the faunal sample from Stratum 10 and the high frequency of worked ironstone introduced in the cave by early humans showing scars (referred to as “pot-lid fractures”) characteristically produced by contact with fire. Our research at Wonderwerk demonstrates that the fabric and composition of combustion deposits are best documented at a microscopic scale and explains why traces of early fire have been so difficult to document. We strongly believe that further microscopic studies of the archaeological deposits at Wonderwerk Cave and other early human sites will have a significant impact in providing fundamental evidence for the appearance of the intentional use of fire and its role in human adaptation and evolution (3, 5).

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