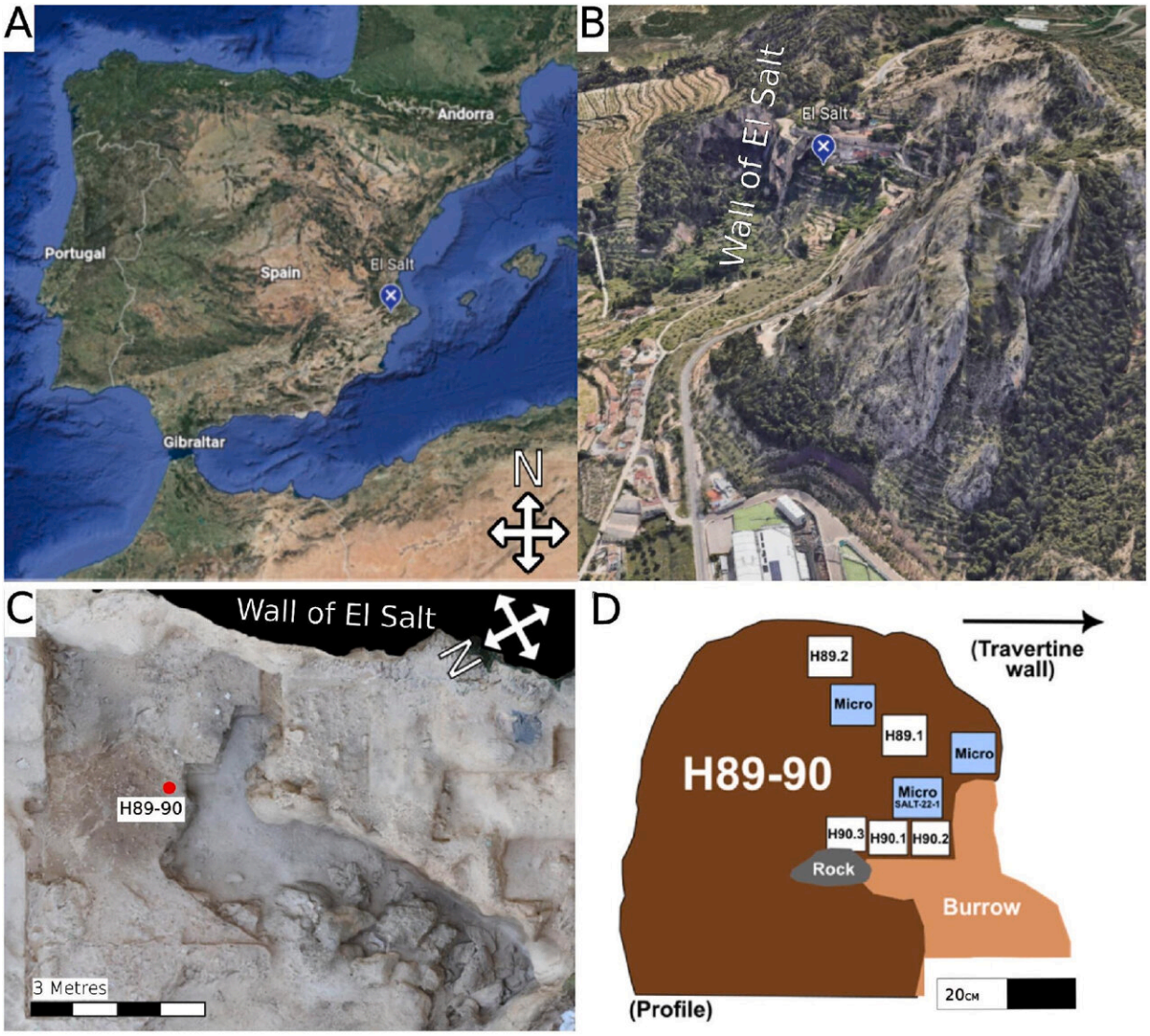
Beneath pale ash, a quantum microscope reveals hidden traces of Neanderthal fire use preserved for millennia

July 24 2026, by Sayan Tribedi



A) Location of site in Spain, B) Location of site on landscape. A) and B) sourced from Google Earth. C) Location of the combustion feature H89-90 on site, D) Scheme of the samples location within H89-90 (blue squares = micromorphology samples; light red circles = H89 archaeomagnetic samples; dark red circles = H90 archaeomagnetic samples). Credit: Ada Dinçkal et al, The hearth of the matter: A high-resolution magnetic microarchaeological study of a Neanderthal combustion feature utilizing Quantum Diamond Microscopy, *Journal of Archaeological Science* (2026). DOI: 10.1016/j.jas.2026.106612

An ancient hearth at El Salt (Spain) is giving up its secrets—not with flames, but with physics. Scientists have already established that Neanderthals used to make fires at this site (spanning from 80,000–45,000 years ago), but deciphering the intricacies of each layer of ash and earth proved difficult due to overlapping hearths and natural mixing. However, with the help of quantum technology, the answer can be found.

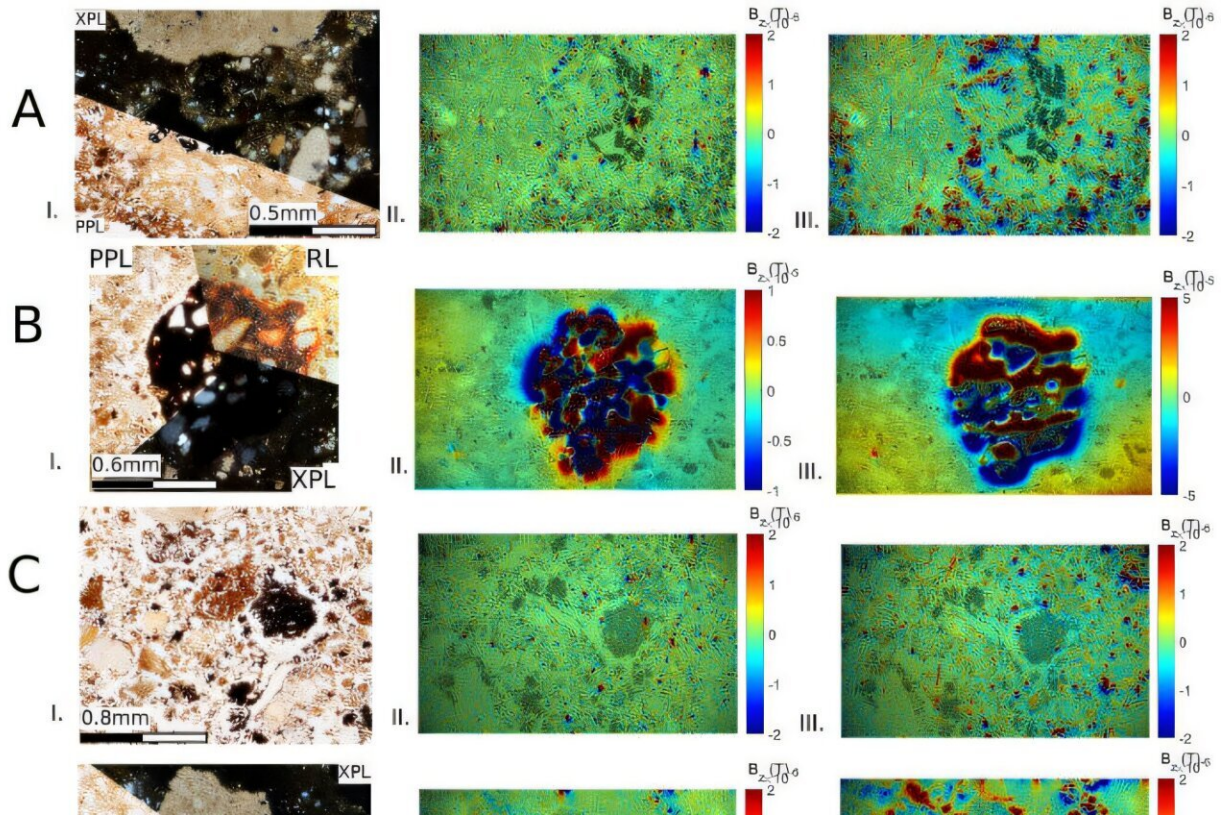
In a study, published in the *Journal of Archaeological Science*, scientists combined standard archaeology with quantum diamond microscopy (QDM) to detect the minute magnetic fields in the layers of hearth. In this way, the magnetic pattern in the ash became a clue to fuel use and fire maintenance.

Unearthing ancient fires

El Salt provides a palimpsest of hearths: numerous fires left behind by different Neanderthal occupation periods. At first glance, such a heap of ashes and charcoal seems to be just one big pile—was there a continuous fire for a very long time or several short ones?

Determining whether a burned patch of soil still lies "in situ" (where the

fire was originally made) is crucial. In this particular case, researchers paid attention to a complex of the combustion layers labeled as H89/90 and applied various methods, including geophysical analysis and even chemical testing.



A vibrant, close-up view of ancient hearth layers, revealing hidden magnetic patterns. From the subtle magnetic fields around a coprolite (A) to the intense glow of an iron nodule (B), and the distinct patterns in organic material (C) and ash layers (D, E), this image shows how quantum technology can make the invisible forces of a Neanderthal campfire visible. Credit: Ada Dinçkal et al, The hearth of the matter: A high-resolution magnetic microarchaeological study of a Neanderthal combustion feature utilizing Quantum Diamond Microscopy, *Journal of Archaeological Science* (2026). DOI: 10.1016/j.jas.2026.106612

These classic methods already showed H89/90 is unusually well-preserved and undisturbed. The boundary between the pale ash layer above and the red-brown burned soil below is sharp—unlike other El Salt fires, which often have a dark, charcoal-rich layer under the ash. (Earlier excavations found that many El Salt hearths had a blackened organic layer beneath a white ash layer; here that layer is missing, meaning the fire may have burned the ground clean of organics.)

Magnetic tests indicated the samples have a consistent magnetic signal that records the Earth's field at the time of burning. In short, everything suggests H89/90 stayed put since Neanderthals made it. But to dig deeper, the team turned to a quantum trick.

Hearth under a quantum lens

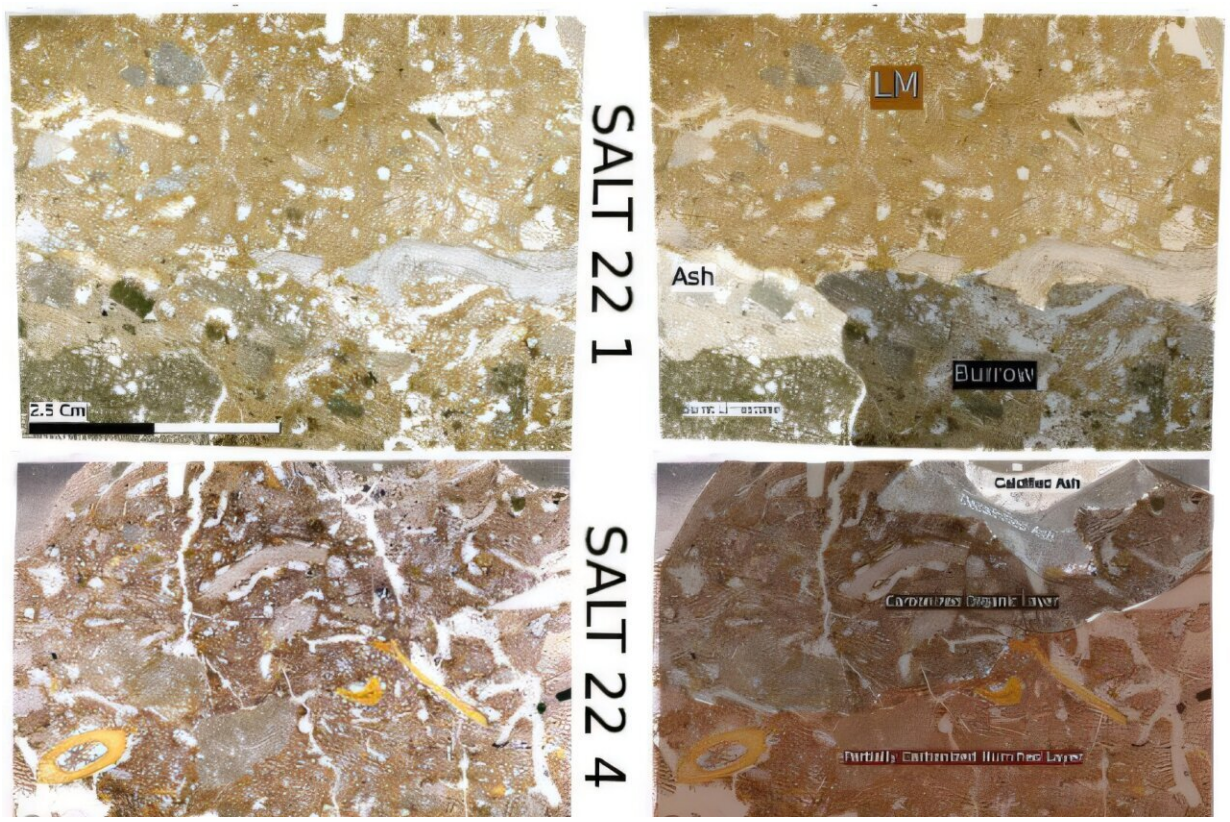
Scientists employed a Quantum Diamond Microscope (QDM) to watch the hearth of a volcano. A diamond chip embedded with small quantum sensors helps make a high-resolution map of the magnetic fields from individual minerals using QDM.

This map can reveal heating patterns and ingredients that are invisible under a light microscope. "This study represents an early step in the longer-term development of QDM as a tool in geoarchaeology and archaeological sciences," the researchers note in their paper.

With the QDM data in hand, the team compared different spots in the hearth slice. The results were striking. The magnetic signatures in the ash layer were almost identical across samples, and aligned in the same direction as Earth's field. This suggests the ash cooled in place after a single major burning episode.

In fact, the consistent mineralogy and magnetism—plus the undisturbed layers seen under the microscope—"point to it being a single hearth

formed with deliberate human fuel management," the authors report.



Thin Sections used in Micromorphology Analysis. Left, clean the plate of each thin section. Right, separation of stratigraphic units in each thin section. Note, due to the thinness of the ash unit above the burnt limestone in Salt 22-1, the separation between calcified and decalcified ash hasn't been marked. Credit: Ada Dinçkal et al, The hearth of the matter: A high-resolution magnetic microarchaeological study of a Neanderthal combustion feature utilizing Quantum Diamond Microscopy, *Journal of Archaeological Science* (2026). DOI: 10.1016/j.jas.2026.106612

Fuel clues in the flames

What were Neanderthals burning? The combined analyses found telltale botanical residues. The thin sections revealed plant fibers and silicified grass structures mixed into the ash. The magnetic maps also pointed to grass-based fuels: grass and leaves leave a distinctive fine magnetic signal when charred. It appears the Neanderthals were adding fibrous plants to keep the fire going—an everyday task now visible after tens of thousands of years.

The magnetic measurements also allowed scientists to infer how hot the fire must have been. Both the white ashes and the red layers underneath them showed signs of high-temperature magnetic properties, meaning they were heated up to around 600–700 °C or even higher. (To give some idea, it is known from experimentation that pit hearths usually reach temperatures around 300°C.)

There is also an interesting chemical feature—the main mineral responsible for the magnetic properties in the ashes is maghemite, which usually needs plenty of oxygen to form. This is an unusual component of a prehistoric hearth—its presence may mean additional oxygen was available when the fire went out.

A new fire story to tell

The authors emphasize that this is just one hearth, so more work is needed to know how typical these clues are. But the approach holds great promise. Archaeologists were able to disentangle fires from overlapping layers at El Salt and beyond, thanks to combining micromorphology, chemistry and the new quantum-magnetic maps.

As QDM tools advance (and become more widespread), researchers aim to establish reference libraries of the magnetic signatures of known soils and fuels. In the future, it could be applied to fire pit layers, burned earth patches, or even archaeological campsites to reveal fire

management strategies.

Meanwhile, the research demonstrates how a sophisticated physics technique can shed light on remarkably human details of long-gone everyday life. A Neanderthal may have tossed some grass on a fire to warm up, but, centuries later, they glow in the data like a neon clue.

As one researcher put it, advanced magnetic imaging is making "behaviors, such as gathering vegetation to sustain a fire, more visible in the archaeological record." The quantum diamond microscope has given us a new lens on the humble campfire—and with it a richer view of our ancient ancestors' world.

More information: Ada Dinçkal et al, The hearth of the matter: A high-resolution magnetic microarchaeological study of a Neanderthal combustion feature utilizing Quantum Diamond Microscopy, *Journal of Archaeological Science* (2026). DOI: 10.1016/j.jas.2026.106612