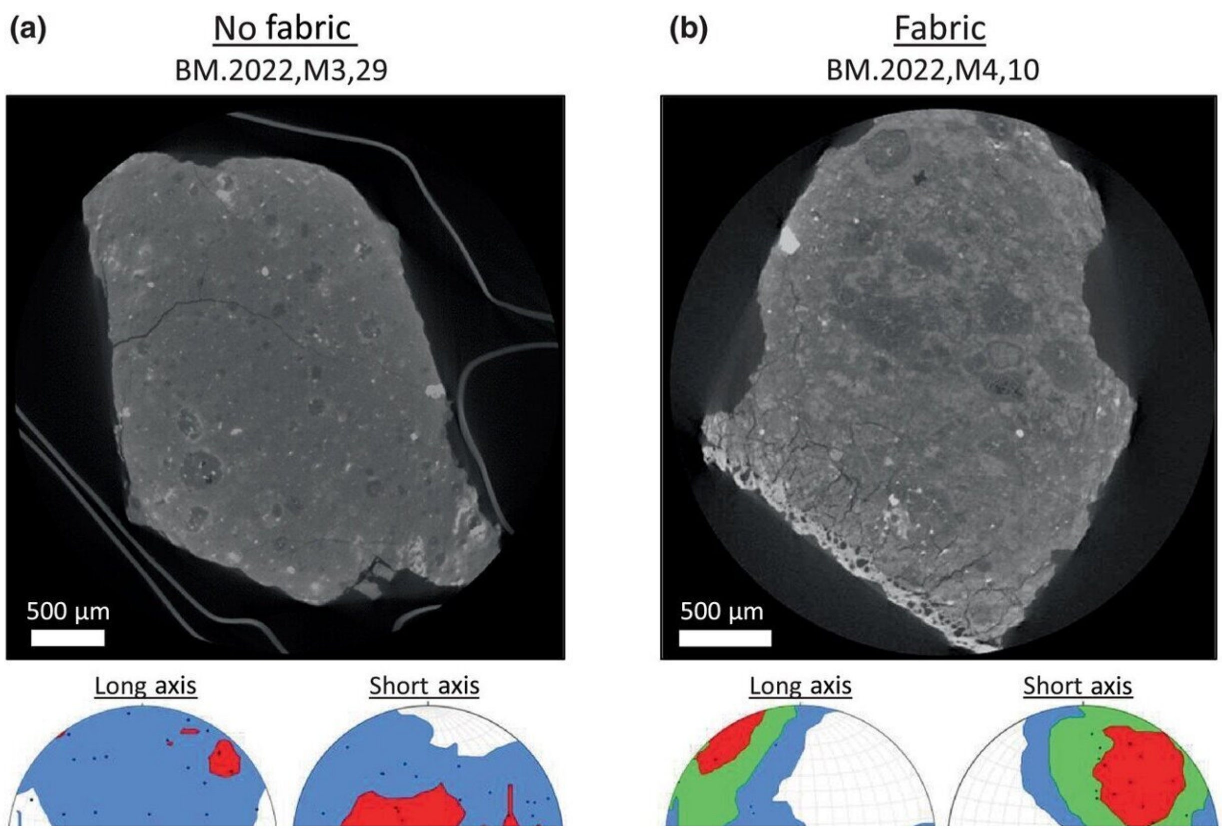
New analysis reveals the brutal history of the Winchcombe meteorite's journey through space

April 15 2024



Representative µCT slices from chips of the Winchcombe meteorite and contoured orientation data on the long and short shape axes of chondrules plotted on a lower hemisphere stereographic projections and n denotes the number of chondrules measured for each plot. Credit: *Meteoritics & Planetary Science* (2024). DOI: 10.1111/maps.14164

Intensive new nano-analysis of the Winchcombe meteorite has revealed how it was affected by water and repeatedly smashed apart and reassembled on the journey it took through space before landing in an English sheep field in 2021.

Researchers from dozens of institutions in the UK, Europe, Australia, and the U.S. collaborated on the research. Together, they subjected mineral grains in fragments of the Winchcombe meteorite to a diverse range of cutting-edge analytical techniques.

Their work, which was conducted on a scale more typically reserved for investigating samples returned to Earth by multibillion-dollar space missions, has given them unparalleled insight into the history of the Winchcombe meteorite in the process.

Their analysis has helped them roll back the clock to the meteorite's earliest days as an ice-bearing dry rock, then trace its transformation through the melting of the ice into a ball of mud which was broken apart and rebuilt over and over again.

The Winchcombe meteorite is an unusually well-preserved example of a group of space rocks called CM carbonaceous chondrites, which were formed during the earliest periods of the solar system. They carry minerals altered by the presence of water on their parent asteroid.

Analysis of those minerals within the Winchcombe meteorite will help scientists unravel the answers to questions around the processes which formed our solar system, including the possible origins of the Earth's water.

Unlike most meteorites, which can lie undiscovered for months or years after entering the Earth's atmosphere, the Winchcombe meteorite was recovered within hours of hitting the ground. Members of the public, citizen scientists and the amateur meteorite enthusiast community recognized that rocks had hit the ground and helped scientists to identify the location of samples, aiding their recovery.

The speed of its recovery helped prevent it from being further altered by exposure to the Earth's atmosphere, offering scientists a rare opportunity to learn more about CM chondrites by scrutinizing it down to the atomic level.

In a paper published in the journal *Meteoritics and Planetary Science*, researchers describe how they explored the complex breccia of the Winchombe meteorite.

A breccia is rock formed from chunks of other rocks cemented together in a structure called a cataclastic matrix. The team's analysis carried out using sophisticated techniques including transmission electron microscopy, electron backscatter diffraction, time of flight secondary ion mass spectrometry and atom probe tomography, showed that the Winchcombe breccia contains eight distinct types of CM chondrite rocks.

The team found that each type of rock has been altered to different degrees by the presence of water, not just between the types of rocks but also, surprisingly, within them. The team found many examples of unaltered mineral grains next to completely altered ones, even down to the nano-scale. For comparison, a human hair is around 75,000 nanometers thick.

The team suggests that the likely explanation for the jumbled nature of the different types of rocks and their extreme variation in aqueous alteration is that the Winchcombe asteroid was repeatedly smashed into pieces by impacts with other asteroids before being pulled back together.

Another significant finding of the analysis is the unexpectedly high proportion of carbonate minerals like aragonite, calcite, and dolomite, along with minerals that have subsequently replaced carbonates, in the samples the team analyzed.

This suggests that the Winchcombe meteorite was more carbon-rich than previously thought and likely accumulated abundant frozen CO_2 before it melted to form the carbonate minerals the team observed. The team's analysis could help explain the large carbonate veins that have been observed on the surface of the Asteroid Bennu by NASA's OSIRIS-REx mission.

The study was led by Dr. Luke Daly of the University of Glasgow, who is also the lead author of the paper. Dr. Daly also led the search party which recovered the largest fragment of the Winchcombe meteorite after it was spotted as a fireball streaking across the skies over Gloucestershire on February 28th, 2021.

Dr. Daly said, "We were fascinated to uncover just how fragmented the breccia was within the Winchcombe sample we analyzed. If you imagine the Winchcombe meteorite as a jigsaw, what we saw in the analysis was as if each of the jigsaw pieces themselves had also been cut into smaller pieces, and then jumbled in a bag filled with fragments of seven other jigsaws.

"However, what we've uncovered in trying to unjumble the jigsaws through our analyses is new insight into the very fine detail of how the rock was altered by water in space. It also gives us a clearer idea of how it must have been battered by impacts and reformed again and again over the course of its lifetime since it swirled together out of the solar nebula, billions of years ago."

Dr. Leon Hicks from the University of Leicester and co-author of the study said, "This level of analysis of the Winchcombe meteorite is virtually unprecedented for materials that weren't directly returned to Earth from space missions, like moon rocks from the Apollo program or samples from the Ryugu asteroid collected by the Hayabusa 2 probe."

Paper co-author Dr. Martin Suttle from the Open University said, "The speed which the fragments of Winchcombe were recovered left us with some pristine samples for analysis, from the centimeter scale all the way down to individual atoms within the rocks. Each grain is a tiny time capsule that, taken together, helps us build a remarkably clear view into the formation, re-formation, and alteration that occurred over the course of millions of years."

Dr. Diane Johnson from Cranfield University, a co-author of the paper, added, "Research like this helps us understand the earliest part the formation of our solar system in a way that just isn't possible without detailed analysis of materials that were right there in space as it happened. The Winchcombe meteorite is a remarkable piece of space history and I'm pleased to have been part of the team that has helped tell this new story."

More information: Luke Daly et al, Brecciation at the grain scale within the lithologies of the Winchcombe Mighei-like carbonaceous chondrite, *Meteoritics & Planetary Science* (2024). DOI: 10.1111/maps.14164

Provided by University of Glasgow

space (2024, April 15) retrieved 2 May 2024 from https://phys.org/news/2024-04-analysis-reveals-brutal-history-winchcombe.html