Homo) spanning at least 800,000 years or so (Fig. 1). The first step towards understanding the nature of these mortuary behaviours — the actions and beliefs surrounding the treatment of the dead — is to reconstruct the series of human actions associated with the deposition of a body.

Not all mortuary behaviours leave traces that are archaeologically visible. The importance of a burial is that it documents a sequence of planned and deliberate actions involving: the creation of an artificial space to contain the body; the placement of a body or body parts into that space; and the covering of the body, often using the sediment that was removed during preparation of the grave[6]. Each of these stages can, but might not always, leave visible archaeological traces, so not all burials will be recognized as such. Other actions that leave enduring traces in the archaeological record relate to processing of the corpse, and might involve the removal of soft tissues, separation of body parts, or signs of cooking or chewing indicative of cannibalism. Examples have been found in the archaeological record of human bones that have been shaped into tools and used as decorative objects.

The second step towards understanding these mortuary behaviours is to infer whether there was any meaning associated with the treatment of the dead beyond the practical measures required to avoid attracting animal scavengers to spaces used by the living and to prevent contamination of those spaces during decay of the body. Strictly functional interventions might also include disarticulation of the body to facilitate transportation, nutritional cannibalism, or the opportunistic use of bones or teeth as tools or as a raw material for manufacturing an object. Inferring signs of symbolic behaviour in burials is one of the more contentious areas of archaeology.

Behaviours that might point towards a departure from purely practical motivations and towards a more meaningful treatment of the dead are those that involve an investment of time and resources beyond what is strictly required to dispose of or make use of the corpse. Such actions include careful placement of the corpse in the grave to achieve a desired body position or orientation, the wrapping or binding of the body for reasons other than to aid transportation, or the deliberate incorporation of items of value in the grave. Such items include objects that could reasonably be considered to have a personal or decorative significance, and those linked to the social role of the deceased. The interred objects might also encompass articles thought to be needed by the deceased in another existence, such as food or medicine. Repeated depositions of corpses over a prolonged period at a single location might signify the recognition of a place for the dead[6], particularly if that location is difficult to access and other causes for the accumulation of the remains can be ruled out. The fossil assemblages at Sima de los Huesos in Spain[7] and Rising Star Cave in South Africa[8] can be interpreted as early examples of placement of the dead in a designated space (Fig. 1).

The presence of symbolic aspects elevates treatment of the dead from mortuary behaviour to funerary behaviour[9]. The burial reported by Martinón-Torres and colleagues reveals the care and effort taken to achieve a desired body position by supporting the child's head and wrapping the upper body. This burial, together with a previous report of the burial of a child around 74,000 years ago, associated with a shell ornament in South Africa at Border Cave[10], suggests that a tradition of symbolically significant burials, at least for the very young, might have been culturally embedded in parts of Africa in the later part of the MSA.

Understanding the treatment of the dead intersects with our understanding of social organization, symbolic behaviours and the use of landscape, resources and technology. The act of burial restricts dispersal of the body and the other contents of the grave, increasing the likelihood of archaeological recovery, and provides an unambiguous association between the deceased — and hence the species they represent — and a certain set of behaviours at a specific time and place. Future discoveries in Africa and beyond could shed even more light on the evolution of modern traits and behaviour during the emergence of our species.

Louise Humphrey is at the Centre for Human Evolution Research, Department of Earth Sciences, Natural History Museum, London SW7 5BD, UK.
e-mail: l.humphrey@nhm.ac.uk

1. McBrearty, S. & Brooks, A. S. *J. Hum. Evol.* **39**, 453–563 (2000).
2. Hublin, J.-J. *et al. Nature* **546**, 289–292 (2017).
3. Bergström, A., Stringer, C., Hajdinjak, M., Scerri, E. M. L. & Skoglund, P. *Nature* **590**, 229–237 (2021).
4. Balzeau, A. *et al. Sci. Rep.* **10**, 21230 (2020).
5. Martinón-Torres, M. *et al. Nature* **593**, 95–100 (2021).
6. Pettitt, P. *The Palaeolithic Origins of Human Burial* (Routledge, 2011).
7. Arsuaga, J. L. *et al. J. Hum. Evol.* **33**, 109–127 (1997).
8. Dirks, P. H. G. M. *et al. eLife* **4**, e09561 (2015).
9. Pomeroy, E. *et al. Evol. Anthropol.* **29**, 263–279 (2020).
10. d'Errico, F. & Backwell, L. *J. Hum. Evol.* **93**, 91–108 (2016).
11. McCown, T. D. & Keith, A. *The Stone Age of Mount Carmel* Vol. 2 (Clarendon, 1939).
12. Vandermeersch, B. *Les Hommes Fossiles de Qafzeh (Israel)* (CNRS, 1981).
13. Vermeersch, P. M. *et al. Antiquity* **72**, 475–484 (1998).
14. Clark, J. D. *et al. Nature* **423**, 747–752 (2003).
15. Rosas, A. *et al. L'Anthropologie* **116**, 57–76 (2012).
16. Grün, R. & Stringer, C. *J. Hum. Evol.* **39**, 601–612 (2000).
17. Fernández-Jalvo, Y., Carlos Díez, J., Cáceres, I. & Rosell, J. *J. Hum. Evol.* **37**, 591–622 (1999).
18. White, T. D. *Am. J. Phys. Anthropol.* **69**, 503–509 (1986).

Astrophysics

Black hole jets bent by magnetic fields

Joydeep Bagchi

The large-scale impact of magnetic fields on galaxy clusters has been unclear. Images from the MeerKAT radio telescope suggest that such fields can bend jets of particles ejected from massive black holes in galaxy clusters. **See p.47**

Supermassive black holes (SMBHs) are millions to billions of times heavier than the Sun and lurk in the centres of almost all massive galaxies. In our cosmic neighbourhood, most of these galactic SMBHs are inactive. However, some are extremely active, releasing enormous amounts of energy across the electromagnetic spectrum as matter falls into them under gravity[1–3]. Some spectacular manifestations of active SMBHs are radio galaxies — galaxies that eject two powerful, highly collimated jets of matter that emit radio waves. These radio jets are thought to be launched, focused and shaped by magnetic fields[4–6], but direct evidence of this process is limited (see go.nature.com/3xvingm). Now, on page 47, Chibueze *et al.*[7] report the observation of an interaction between such radio jets and magnetic fields in a galaxy cluster.

In a radio galaxy, much of the observed radiation is produced by electrons that are ejected in the vicinity of the galaxy's SMBH at speeds close to that of light. Magnetic fields in the surrounding gas cause these particles to follow circular paths and, in doing so, to emit radio waves. Such fields also hold the particles together and focus them into two narrow jets. If left undisturbed (for example, when located outside galaxy clusters), these radio jets typically extend up to hundreds of thousands of parsecs before dissipating (1 parsec is about 3 light years). In some rare cases, they can even stretch across millions of parsecs[8] — roughly 100 times the size of the Milky Way. Consequently, these jets are extremely sensitive probes of the environment near their host galaxies.

Chibueze and colleagues obtained high-resolution images of the radio galaxy MRC 0600-399 (and a nearby radio galaxy) in the galaxy cluster Abell 3376 using the MeerKAT radio telescope in South Africa. MeerKAT consists of 64 antennas working collectively, and is one of the most sensitive radio telescopes in the world. The images show that the radio jets of MRC 0600-399 bend sharply by almost 90° (Fig. 1), as seen previously[9]. They also reveal diffuse regions of radio emission on both sides of the jet-deflection points, referred to as double-scythe structures. The authors used state-of-the-art computer simulations to demonstrate that the bent jets and double-scythe structures can be explained if the jets travel at supersonic speed and strike a curved layer of strong, ordered magnetic fields that they cannot penetrate.

The origin of this strong magnetic layer is connected to ongoing cluster-building processes. Radio and X-ray observations of the cluster Abell 3376 have revealed a pair of giant arcs that trace radio emission from charged particles energized in powerful shock waves at the cluster's outskirts[9] (see Fig. 1a of the paper[7]). These shock waves are caused by matter (comprising galaxies and cold gas) falling into the cluster under gravity and releasing energy through violent collisions and mergers.

X-ray images of Abell 3376 show an odd, comet-like structure consisting of a cold gas cloud, which encompasses both MRC 0600-399 and its nearby radio galaxy, and a long gas tail[9] (see Fig. 1a of the paper[7]). Chibueze *et al.* propose that the gas cloud was ejected from the centre of Abell 3376 at supersonic speed, and that the pressure of the hot gas in the cluster on this fast-moving cloud produces the gas tail. They also suggest that this pressure causes the previously mentioned strong magnetic layer to drape around the boundary of the gas cloud, known as the cold front[10] (Fig. 1). Without this protective magnetic layer, the cloud would evaporate rapidly, and the cold front would not form[11,12].

If the authors' interpretation is correct, it is a remarkable finding, because it implies that relatively strong, ordered magnetic fields (of a few tens of microgauss in strength) exist in the highly disrupted environments of galaxy clusters such as Abell 3376. For comparison, relatively weak magnetic fields (of a few microgauss) have been detected[13] in the gas at the centres of clusters less disrupted than Abell 3376. So far, it has proved extremely challenging to detect and measure magnetic fields in clusters and in the space between galaxies, and the origin of cosmic magnetic fields is still mysterious. Consequently, any observational evidence for such fields in cluster environments is valuable.

However, there is another plausible explanation for the bent jets, referred to as the slingshot model. In this scenario, MRC 0600-399 and the nearby radio galaxy are falling back towards the centre of Abell 3376 after being ejected from the centre at supersonic speed. The radio jets of MRC 0600-399 are bent simply by the pressure of gaseous wind acting in the opposite direction to the galaxy's motion. Although this alternative model can explain the bent jets, it cannot account for the peculiar double-scythe structures, which suggest that the jets are interacting with a layer of strong, ordered magnetic fields. One limitation of the current work is that the magnetic-field strength in the jet-interaction region was not measured directly but was obtained from numerical simulations.

> **"The observations might help to explain poorly understood processes involving gas dynamics in galaxy-cluster formation."**

The most exciting aspect of Chibueze and colleagues' finding is that the observations of radio jets from SMBHs in galactic centres might help to explain poorly understood processes involving gas dynamics in galaxy-cluster formation. Sensitive measurements of the polarization of radio waves could confirm the strength and ordering of the magnetic fields in the magnetic boundary layer. Moreover, the discovery of other examples of strongly distorted radio jets might enable scientists to, for example, measure the total energy injected into jets by SMBHs, understand the role of magnetic fields in jet stabilization and determine the magnetic-field strength of the gas inside clusters. In the upcoming years, the most sensitive radio telescopes ever built will reveal many spectacular processes in the Universe that cannot be seen using optical instruments.

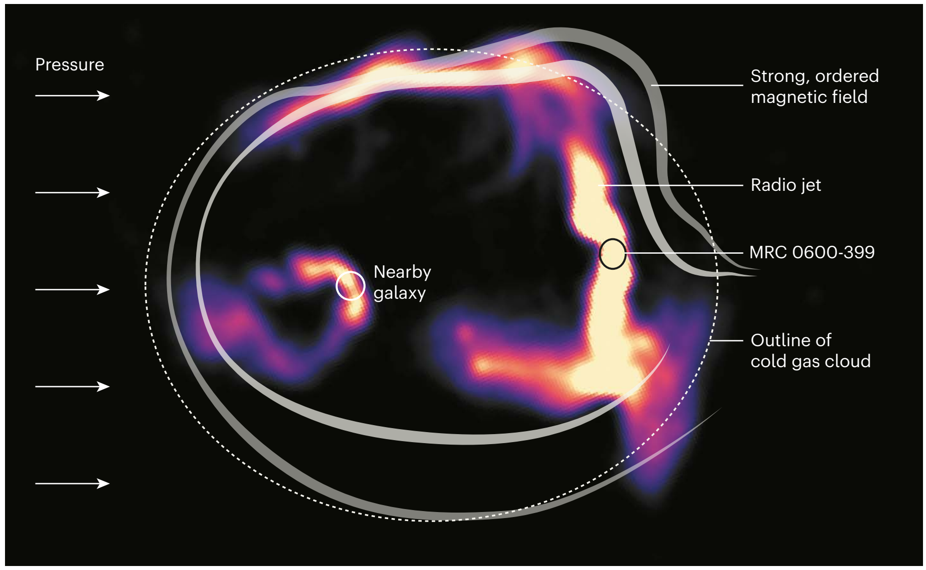

Figure 1 | Interaction between radio jets and magnetic fields. Chibueze *et al.*[7] observed the galaxy MRC 0600-399 (and the nearby galaxy) in the galaxy cluster Abell 3376 using the MeerKAT radio telescope. These two galaxies produce radio jets — powerful jets of matter that emit radio waves. The MeerKAT images show that the jets of MRC 0600-399 bend by almost 90° and reveal diffuse regions of radio emission (shown in purple) on the left and right sides of the jet-deflection points, referred to as double-scythe structures. MRC 0600-399 and the nearby galaxy are contained in a cloud of cold gas. The authors propose that this cloud is moving at high speed, and that the pressure of hot gas in the cluster causes strong, ordered magnetic fields to drape around the cloud. They suggest that the bent radio jets and double-scythe structures result from the jets interacting with this strong magnetic layer. (Concept by Mami Machida, National Astronomical Observatory of Japan.)

Joydeep Bagchi is in the Department of Physics and Electronics, CHRIST (Deemed to be University), Bengaluru 560029, India.
e-mail: joydeep@iucaa.in

1. Lynden-Bell, D. *Nature* **223**, 690–694 (1969).
2. Sołtan, A. *Mon. Not. R. Astron. Soc.* **200**, 115–122 (1982).
3. Begelman, M. C., Blandford, R. D. & Rees, M. J. *Rev. Mod. Phys.* **56**, 255–351 (1984).
4. Blandford, R. D. & Znajek, R. L. *Mon. Not. R. Astron. Soc.* **179**, 433–456 (1977).
5. Gabuzda, D. *Galaxies* **7**, 5 (2018).
6. Meier, D. L., Koide, S. & Uchida, Y. *Science* **291**, 84–92 (2001).
7. Chibueze, J. O. *et al. Nature* **593**, 47–50 (2021).
8. Dabhade, P. *et al. Astron. Astrophys.* **635**, A5 (2020).
9. Bagchi, J., Durret, F., Lima Neto, G. B. & Paul, S. *Science* **314**, 791–794 (2006).
10. Markevitch, M. & Vikhlinin, A. *Phys. Rep.* **443**, 1–53 (2007).
11. Dursi, L. J. & Pfrommer, C. *Astrophys. J.* **677**, 993–1018 (2008).
12. Lyutikov, M. *Mon. Not. R. Astron. Soc.* **373**, 73–78 (2006).
13. Carilli, C. L. & Taylor, G. B. *Annu. Rev. Astron. Astrophys.* **40**, 319–348 (2002).