astrophysical black holes through gravitational waves, initiated by the US-based Laser Interferometer Gravitational-wave Observatory (LIGO). Hawking and others have linked the surface area of a black hole's event horizon to its entropy, a measure of disorder. When interviewed by *Nature*'s news team in 2016 about LIGO's first detection of gravitational waves from merging black holes, Hawking said that he hoped future detections would be sensitive enough to confirm a prediction he had made in the 1970s: that the surface area of a post-merger black hole should exceed the combined surface areas of the original objects that formed it.

Together with cosmologist Thomas Hertog, another of his former students, Hawking had also explored cosmic inflation — a brief period of rapid expansion in the first moments of the Big Bang — and how it could spawn several universes, a 'multiverse'. The pair set out to transform the idea of a multiverse into a testable scientific framework, says Hertog. "This was Hawking: to boldly go where *Star Trek* fears to tread." ■ SEE OBITUARY P.444

PALAEOANTHROPOLOGY

Surprise roots for human culture

Technology developments linked to climate turbulence.

BY JEFF TOLLEFSON

Early humans in eastern Africa crafted advanced tools and displayed other complex behaviours tens of thousands of years earlier than previously thought, according to a trio of papers published on 15 March in *Science*[1–3]. Those advances coincided with — and may have been driven by — major climate and landscape changes.

The latest evidence comes from the Olorgesailie Basin in southern Kenya, where researchers have previously found traces of ancient relatives of modern human as far back as 1.2 million years ago (see 'Complex lives'). Evidence collected at sites in the basin suggests that early humans underwent a series of profound changes at some point before roughly 320,000 years ago. They abandoned simple hand axes in favour of smaller and more advanced blades made from obsidian and other materials obtained from distant sources. That shift suggests the early people living there had developed a trade network — evidence of growing sophistication in behaviour. The researchers also found gouges on black and red rocks and minerals, which indicate that early Olorgesailie residents used those materials to create pigments and possibly communicate ideas.

A TIME OF CHANGE

All of these changes in human behaviour occurred during an extended period of environmental upheaval, punctuated by strong earthquakes and a shift towards a more variable and arid climate. These changes occurred at the same time as larger animals disappeared from the site and were replaced by smaller creatures. "It's a one-two punch combining tectonic shifts and climate shifts," says Rick Potts, who led the work as director of the human origins programme at the Smithsonian Institution in Washington DC. "That's the kind of stuff out of which evolution arises."

The studies push back the timeline for such behaviour by around 100,000 years, adding to a growing body of evidence suggesting that the roots of human culture are deeper and more extensive than once thought.

The latest evidence is "probably not enough to put the question to rest as to what effect the climate variability had on human behaviour", says Nick Blegen, an anthropologist at the Max Planck Institute for the Science of Human History in Jena, Germany. But he says that the findings from Olorgesailie provide solid evidence for a shift towards sophisticated behaviour that predates the earliest evidence for *Homo sapiens*. Researchers have traditionally thought that *H. sapiens* emerged around 200,000 years ago, but fossils discovered in Morocco could push that date to more than 300,000 years ago[4].

Blagen has documented the transport of obsidian in central Kenya roughly 200,000 years ago[5], and he is preparing another study that would push that record back to 396,000 years ago at the same site. The record for such complex behaviour is likely to extend back even further, he says, but it is not clear whether the environment is shaping human behaviour, or whether advances in human behaviour are enabling them to inhabit riskier environments.

COMPLEX TOOLS

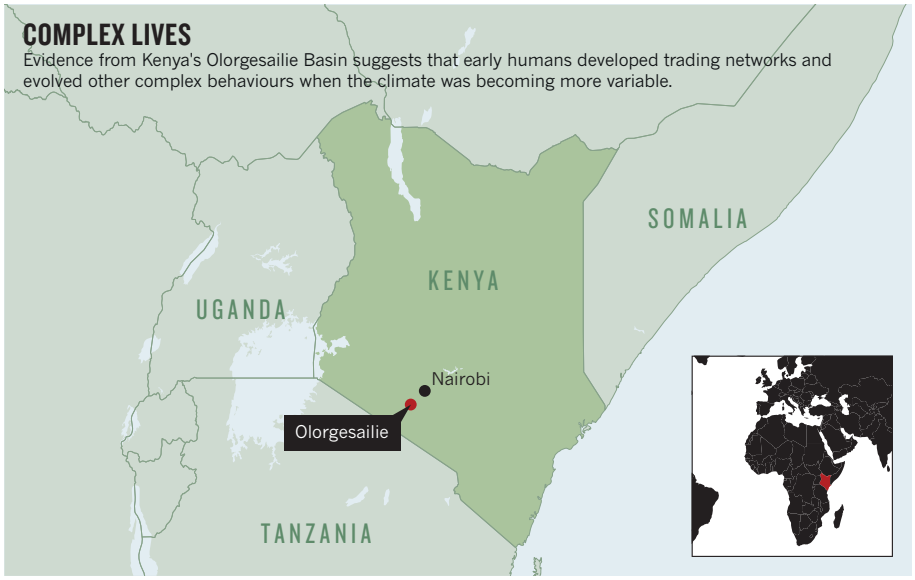
Excavations in the Olorgesailie Basin have been turning up Stone Age artefacts ever since Louis and Mary Leakey pioneered work there in the 1940s. But this is the first time that scientists have documented evidence of more advanced tools and behaviours typically associated with the Middle Stone Age, which lasted until 25,000–50,000 years ago, says Alison Brooks, an anthropologist at George Washington University in Washington DC, who led the dating and analysis of the latest artefacts.

Isotopic dating techniques helped the team to pin down the age of the stone tools, and the researchers traced the obsidian back to its sources, which were mostly located 25–50 kilometres away in multiple directions. "It's the best evidence yet for the exchange of raw materials" so early in time, Brooks says.

Curtis Marean, a palaeoanthropologist at the

HUMAN ORIGINS PROGRAMME, SMITHSONIAN

Simpler tools (left) gave way to smaller and more complex versions (right) in Kenya's Olorgesailie Basin.



University of Arizona in Tempe, says he isn't yet convinced by the evidence for trade. "To demonstrate extended social networks, I would like to see regular and systematic transport of raw material across a number of artefact types on the order of 100 kilometres," he says.

The team cannot say exactly how long before 320,000 years these changes happened because an extended period of erosion at the site wiped out the archaeological record there between 499,000 and 320,000 years ago.

Some information could come from several projects that drilled into ancient lake beds in Kenya and Ethiopia to collect a detailed record of environmental and ecological changes in the region[6]. Potts and his team drilled two of those cores in the southern Olorgaseilie Basin, and Potts says the cores cover the entire period that is missing from the archaeological record. Comparisons with cores drilled elsewhere in East Africa should help scientists to differentiate between events happening locally and broader regional climatic trends.

"The drill cores I hope will be a game changer, because of the precision of the environmental record and hopefully the precision of the dating," Potts says. Then it's a matter of working to understand how animals and people might have responded to the changing environment, Potts says. "Only then can we say anything about how climate is really affecting human evolution." ■

1. Potts, R. *et al. Science* http://dx.doi.org/10.1126/science.aao2200 (2018).
2. Deino, A. L. *et al. Science* http://dx.doi.org/10.1126/science.aao2216 (2018).
3. Brooks, A. S. *et al. Science* http://dx.doi.org/10.1126/science.aao2646 (2018).
4. Hublin, J.-J. *et al. Nature* **546,** 289–292 (2017).
5. Blegen, N. *J. Hum. Evol.* **103,** 1–19 (2017).
6. Cohen, A. *et al. Sci. Dril.* **21,** 1–16 (2016).

POLITICS

China creates grand science ministry

Reforms spark fears that fundamental research will suffer.

BY DAVID CYRANOSKI

Chinese leaders released plans last week to expand the powers of the country's science and technology ministry (MOST). The beefed-up agency will continue to oversee science policy and major projects, but will take on extra responsibilities for funding research grants and for recruiting foreign scientists. Politicians say that the reforms will streamline government procedures, but some science-policy experts warn that the changes could weaken support for basic research.

The announcement came at the annual assembly of the National People's Congress in Beijing, where the government revealed that more than 15 ministries and agencies will be merged, restructured or abolished. The National Natural Science Foundation of China (NSFC), the major grant-funding agency, will no longer sit under the powerful State Council, but will be managed by the science ministry.

Other agency changes include expanding the office that oversees intellectual property, creating a ministry of ecological environment to monitor pollution and forming a conservation agency to help in the protection of endangered species, such as the Przewalski's gazelle (*Procapra przewalskii*).

The plans to expand the science ministry will have the biggest impact on researchers, and took many Chinese scientists by surprise. The NSFC funds modestly sized competitive grants that are initiated by individual investigators. In 2016, its budget of 26.8 billion yuan (US$3.9 billion) accounted for nearly one-third of China's basic research funding, and was used to support 44,000 research projects. The science ministry, by contrast, manages large projects that are aligned with national goals. Scientists often criticize the ministry for supporting projects on the basis of political and personal connections, rather than expert advice. "Placing NSFC under MOST is likely to complicate these missions," says Cao Cong, a science-policy researcher at the University of Nottingham in Ningbo, China.

Cao, who met with science-ministry colleagues last week, says that many didn't seem to know about the reshuffling. "The reorganization was kept in the dark until the last minute," he says.

Cao says that the reforms could be a sign that the Chinese leadership is unhappy with the progress of the country's previous major reorganization of science, in 2014, which attempted to streamline competitive funding.

The repercussions of the latest reforms will take time to unfold, Cao says. But one scenario is that the NSFC will gradually lose control over basic-research funding, says Cao. "If so, the entire scientific community will be unhappy," he says. NSFC grants are highly regarded by scientists because they are peer-reviewed and place less emphasis on scientists' personal connections. They're also one of the only sources of funding for new PhD students.

Many prominent Chinese researchers say that China's basic-research spending is already too low compared with that of other nations that invest heavily in science. In 2017, China spent 92 billion yuan on basic research, or 0.1% of its gross domestic product (GDP). The United States invests 0.2% of its GDP in basic science.

The NSFC's new head, Li Jinghai, who took over the reins last month, told *Nature* that details about the integration of MOST and the NSFC "need to be discussed and figured out in the coming months". But he said the State Council had promised more money for basic science in a document released in January. "I am sure that basic science in China will be further strengthened," he says. ▶