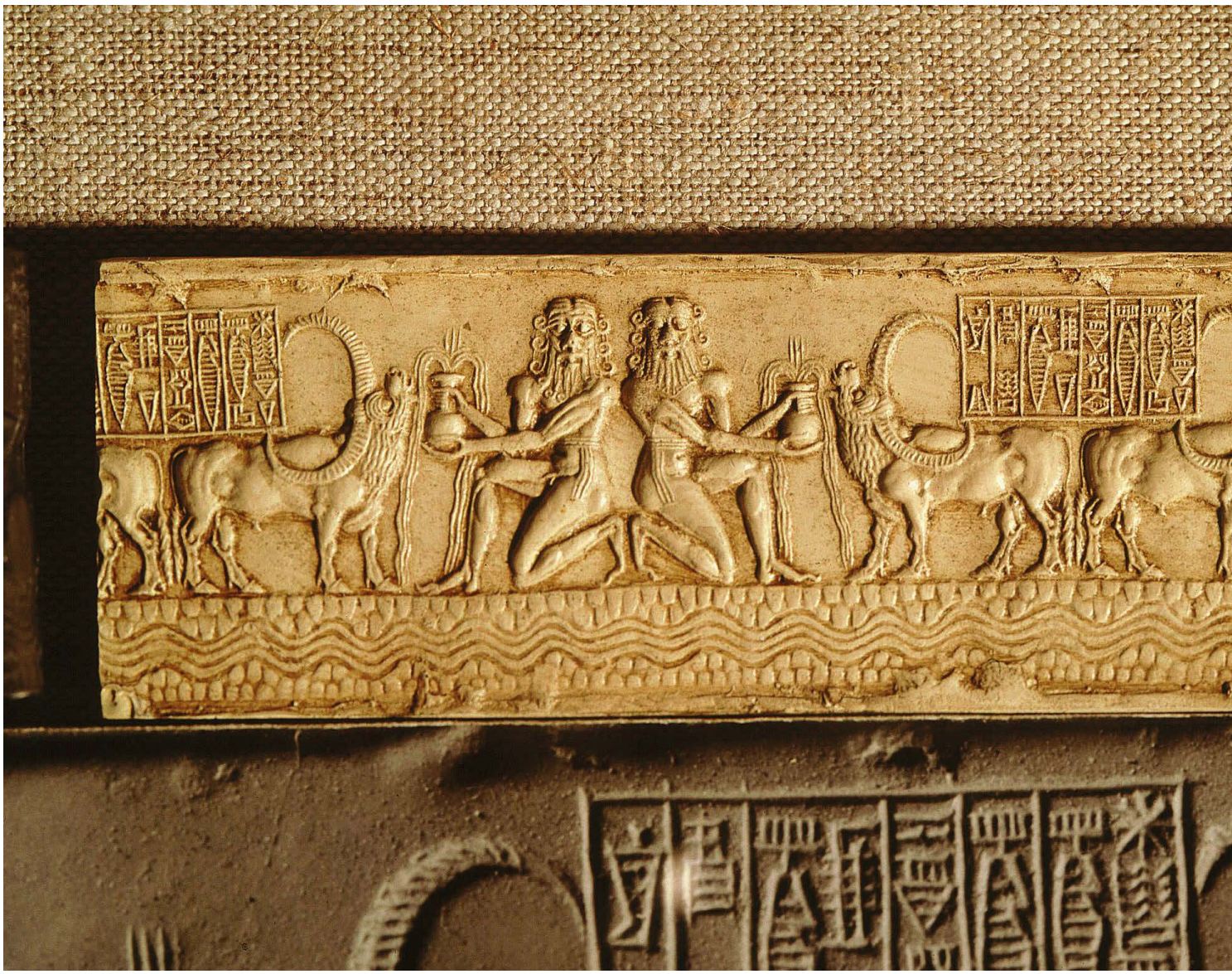


Water flows from a vessel held by a god in this seal of an Akkadian king from around 2200 BC, about the time that a drought affected the empire.

THE ART ARCHIVE/SHUTTERSTOCK

DID A MEGA DROUGHT SEED GLOBAL CHAOS 4,200 YEARS AGO?

People abandoned thriving cities in Mesopotamia, the Indus Valley and farther afield at about the same time as a decades-long drought gripped parts of the planet. **By Michael Marshall**

The missing earthworms were a sign. As archaeologist Harvey Weiss and his colleagues excavated a site in northeast Syria, they found a buried layer of wind-blown silt so barren there was hardly any evidence of earthworms at work during that ancient era. Something drastic had happened thousands of years ago – something that choked the land with dust for decades, leaving a blanket of soil too inhospitable even for earthworms.

The drought hit in roughly 2200 BC, when the Akkadian Empire dominated what is now Syria and Iraq. By 2150 BC, the empire was no more. The central authority had disintegrated, and many people had voted with their feet, leaving the region.

The overlap between an epic drought and the collapse of the Akkadian Empire was no mere coincidence, according to Weiss, an archaeologist at Yale University in New Haven,

Connecticut. When he and his colleagues discovered the evidence of drought in the early 1990s, they proposed that the abrupt climate disruption had brought the ancient empire down[1]. This example has become a grim warning of how vulnerable complex societies can be to climate change.

For Weiss, it was the start of a research endeavour spanning decades. He has become convinced that the drought of 2200 BC was not confined to Mesopotamia, but rather that it had effects around the globe. What's more, the Akkadian Empire was not the only complex society that was disrupted or overthrown as a result. "We've got Mesopotamia, the Nile, the Aegean and the Mediterranean all the way to Spain," says Weiss. In all these places, he says, there is evidence from around 4,200 years (kyr) ago for a drying climate, for the collapse of central authorities, and for people moving to escape the newly arid zones.

The drying is now known by many in the field as the 4.2 ka BP event; also written as 4.2 kyr BP (BP meaning before 1950). It has become increasingly prominent in studies of Earth's recent past. Most significantly, in 2018 it became enshrined in the geological timescale as the start of the current age, the Meghalayan, named after a region in India in which a stalagmite holds a record of the climatic shift. Such geological boundaries can only be defined on the basis of global transitions – so the implication was that the 4.2 ka BP event affected the entire planet.

However, the 4.2 ka BP event has been dogged by controversy. The choice to use it to mark the start of the Meghalayan has faced constant criticism. Many researchers argue that evidence indicates the event was not a global one. Instead, it seems that there was a series of droughts around this time, rather than one long dry spell – or that the shifts were confined to certain regions.

The difference between a global drought and asynchronous dry spells matters, because it has implications for understanding the origins of the climatic changes. Furthermore, the debate touches on the long-running anthropological arguments over whether climatic shifts can be said to cause societal disruption, and what is meant when societies are said to have collapsed.

Nevertheless, a consensus is beginning to emerge that some type of drying event happened around 4,200 years ago across an extended area that had an impact on the people living there – even if it was not the global upheaval that Weiss argues for.

"It's pretty conclusive that the 4.2 ky event exists in the Mediterranean," says Nick Scroxton, a palaeoclimatologist at Maynooth University in Ireland. The drought affected parts of the Middle East, but he says that the evidence elsewhere is "inconclusive".

This isn't just a matter of ancient history. If a centuries-long drought gripped large parts of the planet thousands of years ago, it could happen again. So researchers say it is crucial to nail down exactly what happened during that drought so long ago.

Abandoned city

The story of research into the 4.2 ka BP event begins in northeast Syria, at an archaeological site called Tell Leilan. This hill holds the preserved remains of a city that thrived there for centuries before and during the time of the Akkadian Empire. Weiss and his colleagues started excavating there in the late 1970s.

In the early 1990s, Weiss realized that the city had temporarily been abandoned. People lived there from 2700 to 2200 BC and then, after a 300-year hiatus, there are signs of occupation again around 1900 BC, he says.

What's more, it seemed obvious why. The team found evidence in the soil that Tell Leilan's climate dried out around 2200 BC, and that this drought lasted for decades[1]. They described a 20-centimetre-thick layer of grey sand-like pellets, mixed with other fine powders – a stark contrast to the thick loams from around 2300 BC. "We didn't have an explanation for what had caused it, but we knew from our local data that there was an aridification event," says Weiss.

The drought presumably made it harder to raise crops, meaning there would not have been enough food for the city's population. And the pattern was not unique to Tell Leilan. "There were similar abandonments extending from the Mediterranean to the Indus," says Weiss. This suggested that the drought spanned much of southwest Asia, leading to societal upheaval.

Weiss and his colleagues published their evidence for the Tell Leilan drought[1], and the idea of a wider climate event, in 1993. He describes the initial reaction from colleagues as disbelief at the idea of a "major abrupt climate event disturbing a regional empire". But he was not the first to make such a claim for that time period, and supporting evidence gradually built up. In 2006, a team that included geochemist Giovanni Zanchetta at the University of Pisa in Italy reported evidence[2] from an Italian cave of a drought in the region around 4,200 years ago.

On the archaeological side, Weiss and others compiled evidence that societies on several continents were disrupted around 4,200 years ago. In Egypt, a time of instability known as the First Intermediate Period occurred roughly from 2181 to 2055 BC. The pharaohs of the preceding Old Kingdom lost control of the country and competing power bases emerged.

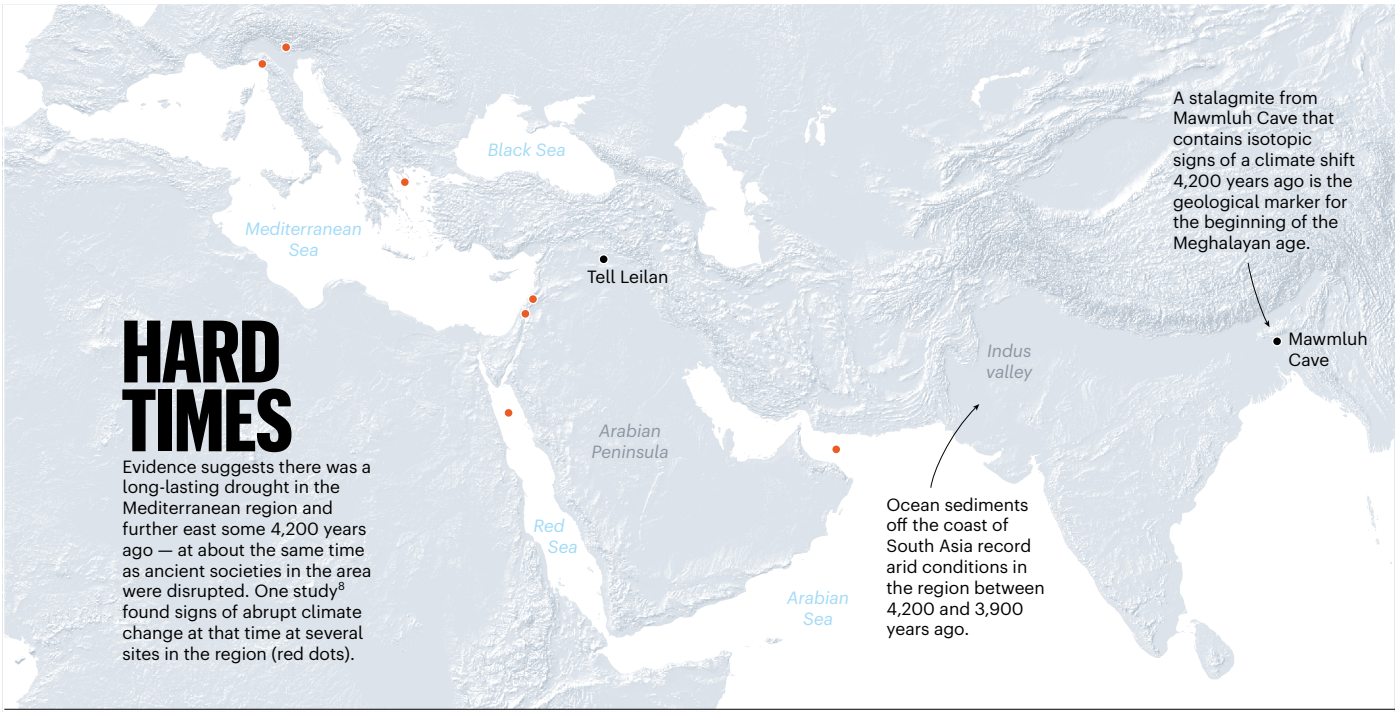
There is evidence that the flow of the Nile River decreased from 2200 BC. Weiss says the best explanation is a decrease in the monsoon rains that feed the Nile, which would have contributed to the political instability that felled the Old Kingdom. (Egyptologists are wary of this argument, however; some maintain that political upheaval at the time didn't lead to the abandonment of cities.)

The 4.2 ka BP event achieved even greater prominence in 2018, when the International Commission on Stratigraphy recognized geological evidence of the 4.2 ka BP event as the beginning of the Meghalayan. To mark the start of this age, the commission chose a record of past climate contained in a stalagmite in Mawmluh Cave in the Meghalaya region of India[3]. But even as the commission's decision meant that the 4.2 ka BP event was now official, it also brought underlying problems to the fore.

Debating dates

The main uncertainty bedevilling the detective story around the 4.2 ka BP event is that it is hard to reconstruct past climates.

There are a number of difficulties, including how to interpret the inherently indirect data



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from climate proxies. And it is not always possible to precisely date a climatic shift or event. One of the best methods is uranium–thorium dating, which relies on the radioactive decay of uranium to thorium, and can give dates with an uncertainty as small as 1%. But if a stalagmite never had much uranium in the first place, or has been heavily contaminated with other substances, the dates become fuzzy. "What's happened is that a lot of the records that are used to describe a global 4.2 event were not originally intended for this type of analysis," says Stacy Carolin, a palaeoclimatologist at the University of Cambridge, UK. Many of the records, she says, have a low resolution and there are no markers that can be dated at — or near — the time of the 4.2 ka BP event.

That was the problem with the dating of the Mawmluh Cave stalagmite, she says: "Originally, it was just done at low resolution and there weren't very many uranium–thorium ages." Later analyses of other stalagmites in the cave found that the drying event did not occur at 4,200 years BP, but at 4,300 years BP. "It's 100 years off," says Carolin.

Multiple specialists, including Scroxton and Zanchetta, agree that the Mawmluh Cave record is not reliable enough.

Weiss contests this. "The continuous and global replication of the Mawmluh Cave 4.2 ka BP event over the past 10 years, at high resolution, is one of the marvels of modern palaeoclimatology," he says.

Many researchers say that error margins spanning centuries are commonplace in studies of geological records from this time period. As a result, some climatic changes that happened centuries before or after 4,200 years ago have been taken as evidence for the 4.2 ka BP drought, says Bruce Railsback, a geochemist at the University of Georgia in Athens.

When the resolution is better, it often reveals a messier picture. In a 2020 preprint[4], Scroxton and his colleagues studied a stalagmite from Madagascar and found evidence of drying for much of the period between 4,320 and 3,830 years BP. The 'classic' timeframe of 4,200 years BP falls in that period, but the drought seems to have been drawn out — although not entirely continuous — rather than abrupt.

These types of uncertainty regarding exactly how and when the climate changed in each region make it harder to draw links to changes in human societies. And there are other controversial aspects to the idea of climate-driven collapses. Many anthropologists argue against this kind of explanation because it neglects societies' abilities to adapt. In a 2021 study[5], environmental historian Dagomar Degroot, at Georgetown University in Washington DC, and his colleagues identified five pathways by which past societies survived climatic crises — for example, switching to meat-rich diets when cereal harvests became unreliable. This means that there is no simple causal relationship between climatic shifts and societal disruption.

"It's very difficult to identify the relationship between an environmental event and a societal effect."

"It's very difficult to identify the relationship between an environmental event and a societal effect," says Monica Bini, a geoarchaeologist at the University of Pisa.

It is also crucial to consider what aspects of a society have collapsed, says Alan Greaves, an archaeologist at the University of Liverpool, UK. "The palace system or that kind of thing, for certain, may collapse." Societies such as the Maya stopped building monumental structures. But Greaves says we should not read too much into that. "Are you talking about the collapse of an entire society," he asks, "or the very visible elite palace structures?" The people of the Akkadian Empire did not all die 4,200 years ago. "We haven't got mass graves of people who all died of starvation."

Weiss agrees that it is important not to misinterpret the word 'collapse'. He says there is clear evidence that when the drought struck Mesopotamia, many people left. "Humans have the resilient capacity to actually move from a place that is affected by drought to a place that is not." The Akkadian people moved towards the Tigris and Euphrates rivers, where people had long practised irrigation agriculture.

Other societies had even more complex stories. Scroxton and his colleagues studied the Harappan society of the Indus Valley in South Asia. According to Scroxton, people abandoned the northern cities between 4,200 and 3,900 years BP, and the southern cities more gradually between 3,900 and 3,300 years BP — making the Harappan civilization a largely rural society.

It had previously been suggested that the summer monsoon rains in that region failed as a result of the 4.2 ka BP event, but Scroxton and colleagues' analyses[6] of palaeoclimate records suggested evidence of two successive droughts. The first was associated with the 4.2 ka BP event, but it affected winter rainfall, which was reduced between 4,260 and 3,970 years BP. This, they argue, contributed

to the early exoduses from northern cities. The second drought struck between 4,000 and 3,700 years BP, and contributed to the abandonment of the southern cities. This drought did affect the summer monsoon, but came long after the 4.2 ka BP event.

"We're the first study to show a mechanism by which the 4.2 ka event can influence the Harappan civilization," says Scroxton. The drought associated with the 4.2 ka BP event helped to drive the abandonment of some Harappan cities, and might have left the others vulnerable to the second drought that followed.

Studies such as this indicate that the effects of the 4.2 ka BP event extend well beyond Mesopotamia. But just how big the event was remains contested.

A global event?

Weiss has compiled records from around the world, published over the past few decades, that he argues show drying around 4,200 years ago. In his view, the event was not confined to western Asia but was truly global, reaching even the Americas. The evidence extends "from Colorado to Massachusetts and down the western spine of South America and even to Brazil", he says.

Most other climatologists are deeply sceptical about this. "There's really not great evidence that it had great impacts in North America," says Kathleen Johnson, a palaeoclimatologist at the University of California, Irvine. She adds that, in general, the Southern Hemisphere is under-sampled, so researchers don't have a clear picture of how the climate there changed.

Climatologists and archaeologists also object, saying that there is, as yet, no solid explanation for why the global climate would have changed so drastically at that time. "There's no trigger for this type of event," says Carolin. She uses an earlier climatic shift, the 8.2 ka BP event, when global temperatures abruptly cooled[7], as a comparison. This change has been linked to the collapse of part of an ice sheet in North America, causing two glacial lakes to drain into the sea and disrupting the transport of heat from the Equator to the poles. "We know when water rushed into the North Atlantic," says Carolin. Without such a mechanism, the evidence for a global 4.2 ka BP event relies solely on the disputed coincidence of the palaeoclimate records.

So, for now, most palaeoclimatologists are inclined to agree with Scroxton and say that the strong evidence for the 4.2 ka BP event is limited to the Mediterranean and southern Asia. "It wasn't a global event," says Johnson.

In line with this, last year Greaves and his colleagues reanalysed 14 palaeoclimate records that claimed to find an abrupt climate shift around 4,200 years ago[8]. They found a mixed picture: some did show an abrupt drying, some showed a drying that lingered for many centuries, and some showed no significant change. The simplest explanation for the pattern, they found, was a drought in the central Mediterranean and Levant, which led to increased dust storms in Mesopotamia and the Zagros Mountains. "It's regionalized, it's localized," says Greaves. The team proposes that a rainfall belt might have shifted north, causing localized droughts. "It's a very tentative suggestion," he says.

A further possibility is that the 4.2 ka BP event was actually several distinct droughts or changes in precipitation patterns, which have been conflated owing to the uncertainties in palaeoclimate dating. In 2018, Railsback and his colleagues published evidence[9] from a cave in Namibia that there was not one event, but two, that, in total, lasted about a century around 4.1 ka BP. He adds that the effects were not the same everywhere. "It was a dry event in some places, most notably the mid-latitude North Hemisphere, and a wet event in others, most notably latitudinal zones in the Southern Hemisphere."

Carolin and her colleagues identified a similar pattern in a 2019 study[10] of a stalagmite from Iran. They found two periods with increased levels of magnesium and calcium, which suggest a dustier environment. The first dusty spell began abruptly 4,510 years BP and lasted 110 years; the second began about 4,260 years BP and lasted 290 years. The team interprets this as being driven by two successive droughts.

"There are a number of megadrought events around that time that have all been lumped together," says Johnson. "They don't all start at the same time, and there are conflicting records from some places that show wet conditions."

Pinning this down will require more palaeoclimate data. That includes assessing under-sampled places such as Africa and the Americas. But palaeoclimatologists also need to be more picky, says Carolin. "You can't just use any old stalagmite, especially if it's dirty and it's going to cause inaccuracies in your ages."

If the 4.2 ka BP event truly was localized, it could invalidate the Meghalayan boundary, because such stage divisions are supposed to be global. But, more importantly, grasping the extent and timing of the event will clarify how much and how suddenly the climate can change. If there was no external trigger such as ice release into the North Atlantic, Scroxton says, the 4.2 ka BP event is "the largest unforced event we know of, the largest example of what the climate system just does on its own".

And that has researchers wondering whether something like the 4.2 ka BP event could happen again, somewhere in the world – adding immeasurably to the damage done by human-caused climate change. "How likely is it," asks Carolin, "that we're going to shift into a period of drier conditions that lasts for 100 years?"

H. WEISS/YALE UNIVERSITY

Excavations at Tell Leilan in Syria revealed signs of a drought when people left the city.

Michael Marshall is a science journalist in Devon, UK.

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