CTA-185-Humans vs Earth

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For a Diver Every day is Ocean Day

NEWS FEATURE
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Humans versus Earth: the quest to define the Anthropocene

Researchers are hunting for nuclear debris, mercury pollution and other fingerprints of humanity that could designate a new geological epoch.

The first explosion of a nuclear bomb in 1945 and later blasts spread radionuclides around the globe.Credit: Modified from Corbis via Getty

Crawford Lake is so small it takes just 10 minutes to stroll all the way around its shore. But beneath its surface, this pond in southern Ontario in Canada hides something special that is attracting attention from scientists around the globe. They are in search of a distinctive marker buried deep in the mud — a signal designating the moment when humans achieved such power that they started irreversibly transforming the planet. The mud layers in this lake could be ground zero for the Anthropocene — a potential new epoch of geological time.

This lake is unusually deep for its size so its waters never fully mix, which leaves its bottom undisturbed by burrowing worms or currents. Layers of sediment accumulate like tree rings, creating an archive reaching back nearly 1,000 years. In high fidelity, it has captured evidence of the Iroquois people, who cultivated maize (corn) along the lake's banks at least 750 years ago, and then of the European settlers, who began farming and chopping

down trees more than five centuries later. Now, scientists are looking for much more recent, and significant, signs of upheaval tied to humans.

Core samples taken from the lake bottom “should translate into a razor-sharp signal”, says Francine McCarthy, a micropalaeontologist at nearby Brock University in St Catherines, Ontario, “and not one blurred by clams mushing it about.” McCarthy has been studying the lake since the 1980s, but she is looking at it now from a radical new perspective.

Crawford Lake is one of ten sites around the globe that researchers are studying as potential markers for the start of the Anthropocene, an as-yet-unofficial designation that is being considered for inclusion in the geological time scale. The Anthropocene Working Group (AWG), a committee of 34 researchers formed by the International Commission on Stratigraphy (ICS) in 2009, is leading the work, with the aim of crafting a proposal to formally recognize the Anthropocene. This new epoch would mark a clear departure from the Holocene, which started with the close of the last ice age. To define a new epoch, the researchers need to find a representative marker in the rock record that identifies the point at which human activity exploded to such a massive scale that it left an indelible signature on the globe.

Given how much people have done to the planet, there are many potential markers. “Scientifically, in terms of evidence, we’re spoiled for choice, but we have to pin it down,” says Jan Zalasiewicz, a palaeobiologist at the University of Leicester, UK, and chair of the AWG.

Researchers collect a sediment core from Crawford Lake to study possible markers of the Anthropocene. Credit: Tim Patterson

The committee's current plan is to look to the legacy of the atomic age, when radioactive debris from mid-twentieth-century nuclear bomb blasts left a fingerprint of radioisotopes in the atmosphere, rocks, trees and even humans. "There's a big bomb spike somewhere between 1952 and 1954 that is quite distinct and unmistakable," says Zalasiewicz.

Once they pick their representative marker, researchers working with the AWG need to gather enough evidence from around the world to convince the governing bodies of geoscience that they have found a truly reliable signal for the start of the Anthropocene. But some scientists argue that human activity has been shaping the planet for thousands of years, and that the working group has settled too quickly on the 1950s for the start of the proposed epoch. Erle Ellis, a geographer at the University of Maryland, Baltimore County, and an AWG member, has criticized the committee's plans for designating the start of the Anthropocene. "The AWG decided the timing of the boundary before deciding on the marker, not the other way around," says Ellis.

Hard evidence

In the end, it will be the rocks that have the final say. The decision on whether to officially designate the Anthropocene will come down to stratigraphic evidence preserved in the geological record — that is, whether humans have left a distinctive set of marks preserved in rock, seafloor mud or glacial ice that indicates a fundamental change in the planet.

After a decade of investigating this question, the AWG decided in May that humans had, in fact, left an indelible geological mark. In a binding vote in May, 29 of the 34 members opted to move forward with developing a proposal supporting the designation of the Anthropocene.

Anthropocene: The human age

The AWG's next task is to put forward a formal proposal identifying a global boundary stratotype section and point (GSSP), or 'golden spike' (see C. N. Waters *et al. Earth Sci. Rev.* **178**, 379–429; 2018). A GSSP is a primary geological marker at one location that can be correlated with sites around the globe in diverse environments. The Anthropocene's golden spike needs to demonstrate that there was a globally synchronous moment when physical, chemical and biological processes amounted to the irreversible crossing of a geological threshold from the Holocene to something altogether different.

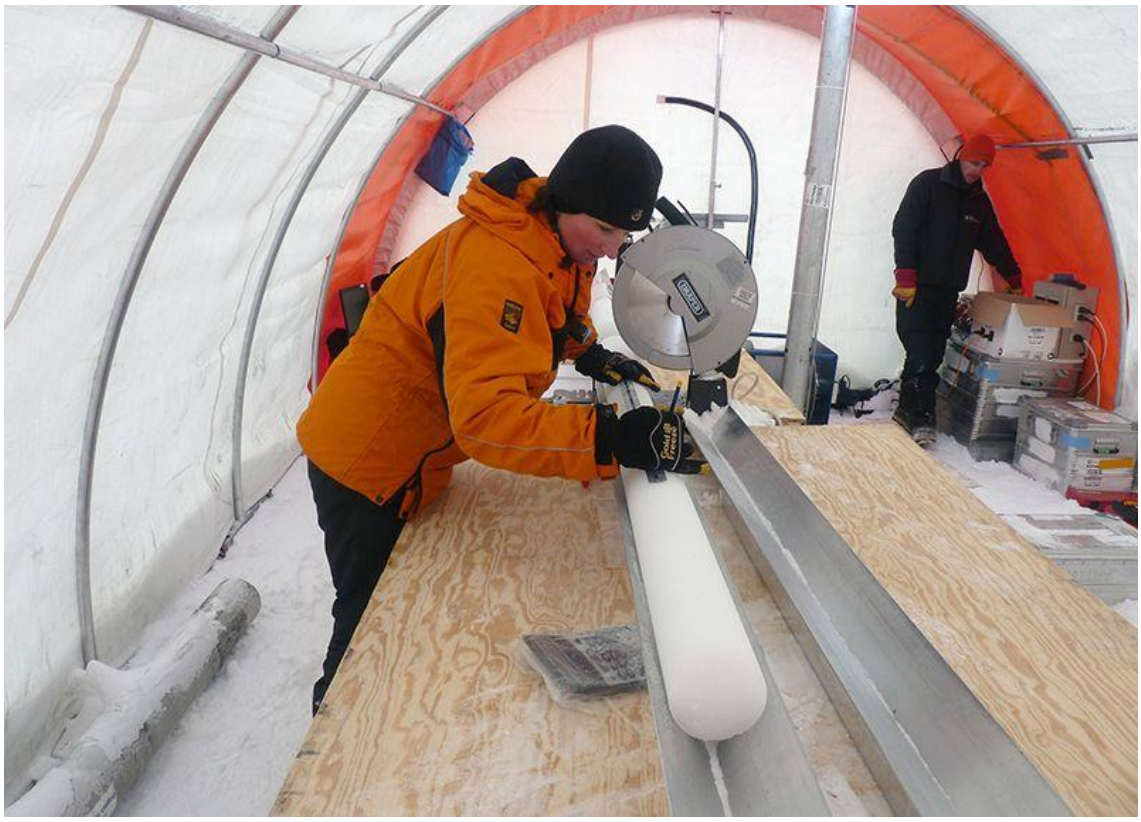
In its recent vote, the AWG members decided overwhelmingly to pursue a GSSP in the mid-twentieth century. This time marks the start of the 'Great Acceleration', a vast transformation after the Second World War when the growing population began consuming resources and creating completely new materials at an exponential rate, eclipsing even the Industrial Revolution. All that activity poured unprecedented amounts of persistent organic pollutants into the environment, ramped up the rate of animal extinctions and created geological features that had never before existed. These include 4-kilometre-deep gold mines and landfills more than 70 metres high, such as Teufelsberg in Berlin, where rubble from the Second World War was piled into an artificial hill. Although the AWG is still exploring several potential golden spikes, the radioactive record from the nuclear age has emerged as the front runner. "Radionuclides still look like the sharpest signal," says Zalasiewicz. The AWG summed up its current work in *The Anthropocene as a Geological Time Unit*, published in February by Cambridge University Press.In post-war Berlin, rubble was piled into a hill that became known as Teufelsberg, or Devil's Mountain.Credit: ullstein bild via Getty

Crawford Lake has serious competition in the contest to become the location for the golden spike. Colin Waters, a geologist at the University of Leicester and AWG secretary, is coordinating research teams that are studying a reservoir in California, an ice core from Antarctica, cave deposits in northern Italy, coral reefs in the Caribbean and Australia, and a peat bog in Switzerland, among other sites. All will be testing for the radionuclide signal, most probably carbon-14 and the long-lived isotope plutonium-239, as well as for secondary markers ranging from persistent organic pollutants and microplastics to fly ash from coal burning.

Despite the long list of potential sites and markers, progress has been slow. "The geological time scale is a tool that is used by all geologists around the world," says Martin Head, an Earth scientist at Brock University and an AWG member, "so it's very important that gratuitous changes don't occur. Any change should be very, very carefully considered."

Quest for the golden spike

The quest for a golden spike leads back to those variegated layers beneath the still waters of Crawford Lake. McCarthy is collaborating with researchers elsewhere in Canada and around the world to analyse core samples from 1940 to 1965, the years bordering peak nuclear fallout along with the onset of the Great Acceleration.



A laboratory in Zurich in Switzerland is testing for the primary marker of radionuclides, and a team in London is looking for other signals, such as surging concentrations of fly ash, to see if they are all synchronous. A group in the United States will be measuring the abundance of testate amoebae — single-celled microorganisms surrounded by a shell that persists for thousands of years. Populations of these amoebae explode, often to the detriment of other species, when nutrients from human habitation and agricultural run-off provide excessive nourishment. Researchers in Toronto, Canada, will search for microplastics that could have arrived by water, by wind on airborne fibres, or even with insects that had ingested them.

Palaeoclimatologist Liz Thomas measures an ice core in Antarctica.Credit: Liz Thomas

At another candidate site, Searsville Lake in California's San Francisco Bay area, a team is testing for radionuclides along with other proxies of human influence. They will examine sediment samples from the lake bottom to identify changes in land use in the region as well as increasing amounts of lead and mercury pollution.

"We hope to create a real 'motion picture' of the Bay Area over the last century to millennium," says Elizabeth Hadly, a biologist at nearby Stanford University and one of the principal investigators at the Searsville site. But, for the purposes of the Anthropocene designation, she and other researchers would need to find a clear golden spike around 1950 that signals a distinct leap in human activity that also lines up with what other candidate sites across the globe are finding.

Meanwhile, in the Southern Hemisphere, Liz Thomas, a palaeoclimatologist at the British Antarctic Survey in Cambridge, UK, will lead a team analysing an ice core from the Antarctic Peninsula. The human signals of radionuclides, along with heavy metals and fly ash particles, have been found even on this remote continent. Her team will also analyse temperature, snow accumulation, carbon dioxide and methane, which all changed markedly in the mid-twentieth century, although perhaps not precisely in sync with the bomb spike.

A series of votes

Like the stratigraphic record that the researchers are studying, the decision to officially designate the Anthropocene is multilayered. The AWG aims to present a final proposal identifying a mid-twentieth-century GSSP to its parent body, the Quaternary Subcommission of the ICS, by 2021. If approved, the proposal will be voted on by the ICS and will then proceed to the executive committee of the International Union of Geological Sciences (IUGS) for final ratification. Only if it passes all these hurdles will the Anthropocene officially become a new unit of the International Chronostratigraphic Chart, more commonly known as the Geological Time Scale. So far, all 65 GSSPs that have been ratified are from marine environments, except for the one marking the start of the Holocene, which uses a Greenland ice core.

The formal process has moved much more slowly than has popular culture, which has already embraced the Anthropocene and used the term on everything from record albums to magazine covers. But the AWG is clear that its mandate is to make decisions based on the stratigraphic record alone.

A sediment core recovered from the bottom of Lake Crawford shows the layers that build up year by year, a high-fidelity record of human activity going back centuries.Credit: Tim Patterson

Not everyone is convinced it can do that yet. One sore point is that the working group made a decision on when to set the boundary, even though it had not yet settled on a golden spike in the stratigraphic record. “It is an imposition of ideas onto matter, shaping evidence to fit, but it should be the other way around,” says Matt Edgeworth, an archaeologist at the University of Leicester.

Edgeworth is a member of the AWG but voted against the decision to recognize the Anthropocene. One concern is that the radionuclide signal, although it will persist for 100,000 years, will weaken as the radioactive elements decay. “In geological terms, where most boundaries in time are millions of years old,” argues Edgeworth, “that is not a very durable marker.”

Other critics, notably William Ruddiman, a palaeoclimatologist at the University of Virginia in Charlottesville, have pushed for starting the Anthropocene when humans first began terrascaping Earth with agriculture thousands of years ago, or when they wiped out the megafauna of Australia and North America many millennia before 1950 (see W. F. Ruddiman *Prog. Phys. Geogr. Earth Environ.*http://doi.org/gd4shx; 2018). Some have argued against designating the Anthropocene at all, given that the Holocene has been marked by escalating human influences since the end of the last ice age.

Zalasiewicz readily acknowledges that human impacts are well recognized throughout much of the Holocene, but the scale of global change since the start of the Great Acceleration, along with the sudden introduction of completely new substances to the planet, are wholly unprecedented. “When I first started this work, I thought that the Anthropocene as a geological unit might fall apart, because everything would be wishy-washy and just a gradation,” he says, “but in fact, it has sharpened up.”

Although Edgeworth questions the single mid-twentieth-century marker, he does not deny that our species has altered the globe. “I see first-hand the enormous impact that humans are continuing to have on surface strata,” he says. “It is almost as though a new layer, geologically speaking, is forming on the surface of the Earth.”

Max Berkelhammer, an Earth scientist at the University of Illinois at Chicago who is not involved in the current debate, but whose research contributed to the designation of the Holocene, defends the AWG’s conclusions. “It’s hard to say that what’s been happening in the twentieth century is just another manifestation of what’s been happening over the last few thousand years,” he says. “The scale of change is so much larger. And it’s difficult to imagine reversing course.”

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