Is this really the Anthropocene?

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‘Is this thing for real, geologically?’

It was February 2000 and the Nobel laureate Paul Crutzen was sitting in a meeting room in Cuernavaca, Mexico, stewing quietly. Five years earlier, Crutzen and two colleagues had been awarded the Nobel prize in chemistry for proving that the ozone layer, which shields the planet from ultraviolet light, was thinning at the poles because of rising concentrations of industrial gas. Now he was attending a meeting of scientists who studied the planet's oceans, land surfaces and atmosphere. As the scientists presented their findings, most of which described dramatic planetary changes, Crutzen shifted in his seat. "You could see he was getting agitated. He wasn't happy," Will Steffen, a chemist who organised the meeting, told me recently.

What finally tipped Crutzen over the edge was a presentation by a group of scientists that focused on the Holocene, the geological epoch that began around 11,700 years ago and continues to the present day. After Crutzen heard the word Holocene for the umpteenth time, he lost it. "He stopped everybody and said: 'Stop saying the Holocene! We're not in the Holocene any more,'" Steffen recalled. But then Crutzen stalled. The outburst had not been premeditated, but now all eyes were on him. So he blurted out a name for a new epoch. A combination of anthropos, the Greek for "human", and "-cene", the suffix used in names of geological epochs, "Anthropocene" at least sounded academic. Steffen made a note.

A few months after the meeting, Crutzen and an American biologist, Eugene Stoermer, expanded on the idea in an article on the "Anthropocene". We were entering an entirely new phase of planetary history, they argued, in which human beings had become the driving force. And without a major catastrophe, such as an asteroid impact or nuclear war, humankind would remain a major geological force for many millennia. The article appeared on page 17 of the International Geosphere-Biosphere Programme's newsletter.

At this point it did not seem likely the term would ever travel beyond the abstruse literature produced by institutions preoccupied with things such as the nitrogen cycle. But the concept took flight. Environmental scientists latched on to what they saw as a useful catch-all term for the changes to the natural world – retreating sea ice, accelerating species extinction, bleached coral reefs – that they were already attributing to human activity. Academic articles began to appear with "Anthropocene" in the title, followed by entire journals dedicated to the topic. Soon the idea jumped to the humanities, then newspapers and magazines, and then to the arts, becoming a subject of photography, poetry, opera and a song by Nick Cave. "The proliferation of this concept can mainly be traced back to the fact that, under the guise of scientific neutrality, it conveys a message of almost unparalleled moral-political urgency," wrote the German philosopher Peter Sloterdijk.

There was just one place where the Anthropocene seemed not to be catching on: among the geologists who actually define these terms. Geologists are the guardians of the Earth's timeline. By studying the Earth's crust, they have carved up the planet's 4.6bn years of history into phases and placed them in chronological order on a timescale called the International Chronostratigraphic Chart. Modifying it is a slow and tortuous process, overseen by an official body, the International Commission on Stratigraphy (ICS). You can't just make up a new epoch and give it a convincing name; the care taken over the timescale's construction is precisely what gives it authority.

To many geologists,the notion that a species that has been around for the blink of an eye was now a genuine geological force seemed absurd. Few would deny we are in a period of climatic turmoil, but many feel that, compared with some of the truly apocalyptic events of the deep past – such as the period, 252m years ago, when temperatures rose 10C and 96% of marine species died – the change so far has not been especially severe. "Many geologists would say: it's just a blip," Philip Gibbard, the secretary general of the ICS, told me.

But as the idea of the Anthropocene spread, it became harder for geologists to ignore. At a meeting of the Geological Society of London, in 2006, a stratigrapher named Jan Zalasiewicz argued that it was time to look at the concept seriously. Stratigraphy is the branch of geology that studies rock layers, or strata, and it is stratigraphers who work on the timescale directly.

To Zalasiewicz's surprise, his colleagues agreed. In 2008, Gibbard asked if Zalasiewicz would be prepared to assemble and lead a team of experts to investigate the matter more deeply. If the group found evidence that the Anthropocene was "stratigraphically real", they would need to submit a proposal to the ICS. If the proposal was approved, the result would be literally epoch-changing. A new chapter of Earth's history would need to be written.

With a mounting sense of apprehension, Zalasiewicz agreed to take on the task. He knew the undertaking would not only be difficult but divisive, risking the ire of colleagues who felt that all the chatter around the Anthropocene had more to do with politics and media hype than actual science. "All the things the Anthropocene implies that are beyond geology, particularly the social-political stuff, is new terrain for many geologists," Zalasiewicz told me. "To have this word used by climate commissions and environmental organisations is unfamiliar and may feel dangerous."

What's more, he had no funding, which meant he would have to find dozens of experts for the working group who would be willing to help him for free. Having spent much of his career absorbed in the classification of 400m-year-old fossils called graptolites, Zalasiewicz did not consider himself a natural people manager. "I found myself landed in this position," he said. "My reaction was: goodness me, where do we go from here?"

Working out the age of the planet has always been a fraught business. The Bible stated that God created everything in six days, but it wasn't until the 17th century that scholars made a concerted effort to work out precisely when that week might have been. For some time, the estimate of one scholar, an Irish archbishop named James Ussher, held sway: the world began on 23 October 4004BC.

Then, in the late 18th century, a different theory emerged, one based on the close observation of the natural world. By studying the near-imperceptibly slow process of the weathering and forming of rocks, thinkers such as the Scottish landowner James Hutton argued that the Earth must be far, far older than previously thought.

The invention of geology would go on to transform our sense of our place in existence, a revolution in self-perception similar to the discovery that the Earth is not at the centre of the universe. Human beings were suddenly an astonishingly recent phenomenon, a "parenthesis of infinitesimal brevity", as James Joyce once wrote. During the almost inconceivable expanse of pre-human time, successive worlds had risen and collapsed. Each world had its own peculiar history, which was written in rock and waiting to be discovered.

In the early 19th century, geologists began naming and organising different rock formations in a bid to impose some order on the endless discoveries they were making. They used clues within the rock layers, such as fossils, minerals, texture and colour, to tell when formations in different locations dated to the same time period. For instance, if two bands of limestone contained the same type of fossilised mollusc, alongside a certain quartz, it was likely they had been laid down at the same point in time, even if they were discovered far apart.

Geologists called the spans of time that the rock formations represented "units". On the timescale today, units vary in size, from eons,

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which last for billions of years, to ages, which last for mere thousands. Units nestle inside each other. Officially, we live in the Meghalayan age (which began 4,200 years ago) of the Holocene epoch. The Holocene falls in the Quaternary period (2.6m years ago) of the Cenozoic era (66m) in the Phanerozoic eon (541m). Certain units attract more fanfare than others. Most people recognise the Jurassic.

As geologists began dividing deep time into units, they came up against the difficult question of boundaries – defining precisely where one phase of history transitions into the next. In the late 19th century, it was recognised that if the field was to advance, global cooperation and coordination would be necessary. The International Commission on Nomenclature, the forerunner of the present-day ICS, was established in 1881 with the mandate of creating an international language of geology, one that was to be enshrined in the timescale.

The task of interpreting and classifying 4.6bn years of Earth history continues today. Geologists have barely begun to describe the Precambrian eon, which spans Earth's first 4bn years. Meanwhile, wellstudied units are revised as new evidence unsettles old assumptions. In 2004, the Quaternary period was unceremoniously jettisoned and the preceding period, the Neogene, extended to cover its 1.8m years. The move came as a surprise to many Quaternary geologists, who mounted an aggressive campaign to redeem their period. Eventually, in 2009, the ICS brought the Quaternary back and moved its boundary down by 800,000 years to the beginning of an ice age, a point considered more geologically significant. Having now "lost" millions of years, Neogene scientists were incandescent. "You might ask: who wasn't upset by it?" Gibbard told me.

Modifying the geological timescale is a bit like trying to pass a constitutional amendment, with rounds of proposal and scrutiny overseen by the ICS. "We have to be relatively conservative," said Gibbard, "because anything we do is going to have a longer-term implication in terms of the science and literature." First, a working group drafts a proposal which is submitted to an expert subcommission for review and vote. From the subcommission, the proposal advances to the voting members of the ICS. Once the ICS has voted in its favour, it passes to the International Union of Geological Sciences (IUGS), geology's highest body, to be ratified.

Whether or not a new proposal successfully passes through all these rounds comes down to the quality of evidence that the working group can amass, as well as the individual predilections of the 50 or so seasoned geologists who constitute the senior committees. This did not bode well for Zalasiewicz as he began to put together the Anthropocene working group. In fundamental ways, the idea of the Anthropocene is unlike anything geologists have considered before. The planet's timekeepers have built their timescale from the physical records laid down in rocks long ago. Without due time to form, the "rocks" of the Anthropocene were little more than "two centimetres of unconsolidated organic matter", as one geologist put it to me. "If we think about the Anthropocene in purely geological terms – and that's the trouble, because we're looking at it with that perspective – it's an instant," said Gibbard.

Zalasiewicz grew up in the foothills of the Pennines with his parents, sister and a growing collection of rocks. He started volunteering at the local museum in Ludlow in the summer, where he met people who were expert in the things he cared most about, such as where to find trilobites. By his mid-teens, he told me, "geology was it".

Now 64, Zalasiewicz has worked in Leicester University's geology department for 20 years, and presents himself as a quintessential geologist, a wearer of leather elbow patches and lover of graptolites. Yet among geologists, he is a known provocateur. His reputation stems from one of his papers, published in 2004, in which he argued that stratigraphy should throw out some of the terminology that has been in use since the discipline's earliest days in favour of more modern terms. It was, to some, an audacious suggestion. When I emailed David Fastovsky, the former editor of the journal Geology, who had published the paper 15 years ago, he remembered it well. "The general feeling at the time," he wrote, "was that it might be possible, but who would dare to take the first shot?"

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Over the years, Zalasiewicz has indulged in thought experiments that are, among geologists, peculiar. In 1998, he wrote an article for New Scientist in which he imagined what mark humans might leave on the Earth long after we are extinct. His ideas became a book, published 10 years later, called The Earth After Us. Geologists tend to have their minds trained on the deep past, and Zalasiewicz's forward-thinking approach marked him out. When, in 2006, Zalasiewicz broached the subject of the Anthropocene at the Geological Society meeting, Gibbard recalled thinking: "Well, these two go together very well."

After he was appointed chair of the Anthropocene working group, Zalasiewicz needed to assemble his team. "At the time, it was simply a hypothetical and interesting question: can this thing be for real geologically?" Zalasiewicz told me when I visited him in Leicester last year. "It was arm-waving with very little specific detail. The diagrams were back-of-the-beer-mat things."

Stratigraphic working groups are, not surprisingly, usually composed of stratigraphers. But Zalasiewicz took a different approach. Alongside traditional geologists, he brought in Earth systems scientists, who study planet-wide processes such as the carbon cycle, as well as an archeologist and an environmental historian. Soon the group numbered 35. It was international in character, if overwhelmingly male and white, and included experts with specialisms in paleoecology, radiocarbon isotopes and the law of the sea.

If the Anthropocene was, in fact, already upon us, the group would need to prove that the Holocene – an unusually stable epoch in which temperature, sea level and carbon dioxide levels have stayed relatively constant for nearly 12 millennia – had come to an end. They began by looking at the atmosphere. During the Holocene, the amount of CO_2 in the air, measured in parts per million (ppm), was between 260 and 280. Data from 2005, the most recent year
recorded when the working group started out, showed levels had climbed to 379 ppm. Since then, it has risen to 405 ppm. The group calculated that the last time there was this much CO_2 in the air was during the Pliocene epoch 3m years ago.

Next they looked at what had happened to animals and plants. Past shifts in geological time have often been accompanied by mass extinctions, as species struggle to adapt to new environments. In 2011, research by Anthony Barnosky, a member of the group, suggested something similar was under way once again. Others investigated the ways humans have scrambled the biosphere, removing species from their natural habitat and releasing them into new ones. As humans have multiplied, we have also made the natural world more homogenous. The world's most common vertebrate, the broiler chicken, of which there are 23bn alive at any one time, was created by humans to be eaten by humans.

Then there was also the matter of all our stuff. Not only have humans modified the Earth's surface by building mines, roads, towns and cities, we have created increasingly sophisticated materials and tools, from smartphones to ballpoint pens, fragments of which will become buried in sediment, forming part of the rocks of the future. One estimate puts the weight of everything humans have ever built and manufactured at 30tn tonnes. The working group argued that the remnants of our stuff, which they called "technofossils", will survive in the rock record for millions of years, distinguishing our time from what came before.

By 2016, most of the group was persuaded that what they were seeing amounted to more than a simple fluctuation. That year, 24 working group members co-authored an article, published in the journal Science, announcing that the Anthropocene was "functionally and stratigraphically distinct" from the Holocene.

But the details were far from settled. The group needed to agree a start-date for the Anthropocene, yet there was nothing as clean as a colossal volcanic eruption or an asteroid strike to mark the point where it began. "From a geological point of view, that makes life very difficult," said Gibbard, who is also a member of the working group.

The group was split into opposed camps, largely according to their academic specialisation. Initially, when he first proposed the notion of the Anthropocene, Crutzen, who is an atmospheric chemist, had suggested the industrial revolution as the start-date because that was when concentrations of CO_2 and methane began accumulating significantly in the air. Lately the Earth system scientists had come to prefer the start of the so-called "great acceleration", the years following the second world war when the collective actions of humans suddenly began to put much more strain on the natural world than ever before. Most stratigraphers were now siding with them – they believe that the activity of the 1950s will leave a sharper indentation on the geological record. This concerned the archaeologists, who felt that privileging a 1950 start-date dismissed the thousands of years of human impact that they study, from our early use of fire to the emergence of agriculture. "There is a feeling among the archaeologists that because the word 'anthropo' is in there, their science should be central," one geologist said privately. Agreeing the start-date, Gibbard warned, could be the Anthropocene's "stumbling block".

At the end of last summer, the working group gathered at the Max Planck Institute for Chemistry in Mainz, near Frankfurt, for their annual meeting. Crutzen, now in his mid-80s, spent much of his career at the institute, and he was present both as a spectator and in the form of a bronze bust in the foyer. I asked him what he made of the progress of his idea. "It started with a few people and then it exploded," he said.

Under the glow of a projector in a darkened classroom, two dozen researchers shared their latest findings on topics such as organic isotope geochemistry and peat deposits. Things proceeded without a wrinkle until the second day, when a debate broke out about the start date, which then turned into a debate about whether it was OK for different intellectual communities to use the term "Anthropocene" to mean different things. Someone at the back suggested adding the word "epoch" for the strictly geological definition, so "Anthropocene" by itself could be used generally.

In the front row, Zalasiewicz watched with the air of an adjudicator. Eventually, he chimed in. "Certainly, in terms of our remit, we can only work from the geological term. We can't police the word 'Anthropocene' beyond that," he said. Throughout the meeting, Zalasiewicz seemed at pains to emphasise the Anthropocene's geological legitimacy. He was aware that a number of influential geologists opposed the idea, and he was worried about what might happen if the working group was seen to be straying too far from the discipline's norms.

One of the loudest critics of the Anthropocene is Stanley Finney, who as the secretary general of the IUGS, the body that ratifies changes to the timescale, is perhaps the most powerful stratigrapher in the world. During the meeting in Mainz, I was told that Finney was both a "big phallus of the discipline" and "really vehemently anti-Anthropocene".

When Finney first came across the term "Anthropocene", in a paper written by Zalasiewicz in 2008, he thought little of it. To him, it just seemed like a big fuss over the human junk on the surface of the planet. Finney, who is 71 and a professor of geological sciences at California State University, Long Beach, has spent much of his career trying to picture what the planet was like 450m years ago, during the Ordovician period, when the continents were bunched together in the southern hemisphere and plants first colonised land. Over the years, he has worked his way up through stratigraphy's hierarchy. By the time Zalasiewicz was appointed chair of the working group, Finney was chair of the ICS. The two scientists knew each other professionally. Zalasiewicz's favourite fossils, graptolites, are found in Ordovician strata.

But for some time the pair had not seen eye to eye. When Zalasiewicz published his 2004 paper arguing that stratigraphers should cast

The stratigraphic evidence for the Anthropocene is compelling

off their long-established terminology, Finney was affronted by this lack of respect for the discipline's traditions.

Finney only decided to look at the Anthropocene in detail after he began getting comments from people who thought it was now an official part of the geological timescale. The more he looked, the less he liked the idea. “You can make the ‘big global changes’ issue out of it if you want, but as geologists we work with rocks, you know?” he told me. To Finney, a negligible amount of “stratigraphic content” has amassed since the 1950s. As the Anthropocene working group gained momentum, he grew concerned that the ICS was being pressured into issuing a statement that at its heart had little to do with advancing stratigraphy, and more to do with politics.

Academics both inside and outside geology have noted the Anthropocene’s political implications. In After Nature, the law professor Jedediah Purdy writes that using the term “Anthropocene” to describe a wide array of human-caused geological and ecological change is “an effort to meld them into a single situation, gathered under a single name”. To Purdy, the Anthropocene is an attempt to do what the concept of “the environment” did in the 1960s and 70s. It is pragmatic, a way to name the problem – and thus begin the process of solving it.

Yet if a term becomes too broad, its meaning can become unhelpfully vague. “There is an impulse to want to put things in capital letters, in formal definitions, just to make them look like they’re nicely organised so you can put them on a shelf and they’ll behave,” said Bill Ruddiman, professor emeritus at the University of Virginia. A seasoned geologist, Ruddiman has written papers arguing against the stratigraphic definition of the Anthropocene on the grounds that any single start-date would be meaningless since humans have been gradually shaping the planet for at least 50,000 years. “What the working group is trying to say is everything pre-1950 is pre-Anthropocene, and that’s just absurd,” he told me.

Ruddiman’s arguments have found wide support, even from a handful of members of the working group. Gibbard told me he had started out “agnostic” about the Anthropocene but lately he had decided it was too soon to tell whether or not it really was a new epoch. “As geologists, we’re used to looking backwards,” he said. “Things that we’re living through at the moment – we don’t know how significant they are. [The Anthropocene] appears significant but it would be far easier if we were 200 to 300, possibly 2,000 to 3,000, years in the future and then we could look back and say: yes, that was the right thing to do.”

Yet for the majority of the working group, the stratigraphic evidence for the Anthropocene is compelling. “We realise the Anthropocene goes against the grain of geology in one sense, and other kinds of science, archaeology and anthropology, in another sense,” Zalasiewicz told me. “We try and deal honestly with their arguments. If they were to put out something that we couldn’t jump over, then we’d hold up our hands and say: OK, that’s a killer blow for the Anthropocene. But we haven’t seen one yet.”

For all the years of discussion, research and debate, after the meeting it was obvious that the Anthropocene working group was still a long way off submitting its proposal to the ICS. Zalasiewicz’s favourite joke, that geologists “work in geological time”, was starting to wear thin. Proposals to amend the timescale require evidence in the form of cores of sediment that have been extracted from the ground. Within the core there must be a clear sign of major environmental change marked by a chemical or biological trace in the strata, which acts as the physical evidence of where one unit stops and another begins.

The core extraction and analysis process takes years and costs hundreds of thousands of dollars – money that, at that point, and despite grant applications, the group did not have. They discussed the problem on the train. "Beg, borrow and steal. That is the working group motto," Zalasiewicz said, a little bitterly.
But in the months that followed the meeting, their fortunes changed. First, they received €800,000 ($890,000) in funding from an unexpected source, the Haus der Kulturen der Welt, a state-funded cultural institute in Berlin that has been holding exhibitions about the Anthropocene for several years. The money would finally allow the group to begin the core-extraction work, moving the proposal beyond theoretical discussion and into a more hands-on, evidencegathering stage.
Then, in late April, the group decided to hold a vote that would settle, once and for all, the matter of the startdate. Working group members had one month to cast their votes; a supermajority of at least 60% would be needed for the vote to be binding. The results, announced on 21 May, were unequivocal. Twenty-nine members of the group, representing 88%, voted for the start of the Anthropocene to be in the mid-20th century. For Zalasiewicz, it was a step forward. "What we'll do now is the technical work. We've now moved beyond the general, almost existential question of 'is the Anthropocene geological?'" he said, when I called him. The important votes at the ICS were still to come, but he felt optimistic.
In Mainz, after the train pulled into the airport, the group made for the departure zone. Among the chaos of wheelie suitcases and people hurrying about, suddenly a voice cried out: "Fossils!" Zalasiewicz was off to one side, eyes fixed on the polished limestone floor. "That's a fossil, these are fossil shells," he said, pointing to what looked like dark scratches. One was the shape of a horseshoe, and another looked like a wishbone. Zalasiewicz identified them as rudists, a type of mollusc that had thrived during the Cretaceous, the last period of the dinosaurs. Rudists were a hardy species, the main reef-builders of their time. One rudist reef ran the length of the North American coast from Mexico to Canada.
Staring at the rudists encased in limestone slabs that had been dug out of the ground and transported many miles across land, it was strange to think of the unlikeliness of their arrival in the airport floor. The rudists beneath our feet had died out 66m years ago, in the same mass extinction event that wiped out the dinosaurs. Scientists generally believe that the impact of an asteroid in Yucatan, Mexico, plunged the planet into a new phase of climatic instability in which many species perished. Geologists can see the moment of the impact in rocks as a thin layer of iridium, a metal that occurs in very low concentrations on Earth and was likely expelled by the asteroid and dispersed across the world in a cloud of pulverised rock that blotted out the sun. To stratigraphers, the iridium forms the "golden spike" between the Cretaceous and Paleogene periods.
Now that the working group has decided roughly when the Anthropocene began, their main task is picking the golden spike of our time. They are keeping their options open, assessing candidates from microplastics and heavy metals to fly ash. Even so, a favourite has emerged. From the pragmatic stratigraphic perspective, no marker is as distinct, or more globally synchronous, than the radioactive fallout from the use of nuclear weapons that

began with the US army's Trinity test in 1945. Since the early 1950s, this memento of humankind's darkest self-destructive impulses has settled on the Earth's surface like icing sugar on a sponge cake. Plotted on a graph, the radioactive fallout leaps up like an explosion. Zalasiewicz has taken to calling it the "bomb spike".

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