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The meaning of the Anthropocene: why it matters even without a formal geological definition

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What should the Anthropocene mean?

With or without a formal geological definition, the idea of a major planetary transition dated to the mid-20th century retains its integrity and utility across many fields of physical and social science, the humanities and policy.

Jan Zalasiewicz, Julia Adeney Thomas, Colin N. Waters, Simon Turner and Martin J. Head, with additional co-signatories

On 5 March 2024, the Subcommittee on Quaternary Stratigraphy (SQS) of the International Commission on Stratigraphy (ICS), the body responsible for defining units of geological time, announced it was rejecting a proposal to formalize the Anthropocene as a geological epoch representing a time of overwhelming human impact on the planet. The SQS had initiated this process in 2009, setting up the Anthropocene Working Group (AWG), which we represent, to recommend whether there was sufficient evidence for formalizing the Anthropocene – a process that would involve identifying a precise starting point within a specific geological stratum.

The rejection has prompted much debate, with strongly felt views expressed on both sides. In the meantime, however, the term ‘Anthropocene’ has been widely adopted to describe, analyse and interpret the transformed conditions in which humans now live.

Current usage runs in four main directions. The first is to the Earth System science community, in which the concept arose, and to scientific disciplines that model, assess and warn of the effects of human activities, including the transgression of environmental ‘planetary boundaries’¹. The second is to the humanities and social sciences, in which scholars seek to understand how human impacts eventually came to overwhelm the great forces of nature, and what that means to the analysis of history, philosophy, politics, economics, society and culture². A third is into the arts and museums, where the Anthropocene is inspiring many new cultural works. A fourth reaches to the public and to policymakers, urbanists and others, where understanding human transformation of the climate and biosphere is essential for formulating and implementing policies of stewardship, mitigation and adaptation¹.

With a formal geological definition of the Anthropocene now off the table, at least for the moment, we here explore how the Anthropocene may be best understood and used with these wider communities in mind. What should the Anthropocene fundamentally mean, for both specialized and general use?

Geological origins

The Anthropocene was initially proposed by atmospheric chemist Paul Crutzen in 2000, at a meeting of the Scientific Committee of the International Geosphere-Biosphere Programme (IGBP), a forum dedicated to discussing processes of global change. Crutzen's intention was to represent a formal new geological epoch consistent with the goals of this community³. But the purpose was not simply to denote an anthropogenically modified Earth. Geologically significant anthropogenic impacts stretch back through the Holocene Epoch, the post-Ice-Age chunk of geological time in which we still formally live, and deep into the Pleistocene that preceded it. As proposed by Crutzen, the Anthropocene denotes an Earth System that has changed from conditions typical of the Holocene – which include relatively stable atmospheric and ocean chemistries, climate (especially temperature) and (after around 7000 years ago) sea level – to a new, irreversibly changed and still evolving state, for which the name Holocene could no longer be regarded as appropriate.

The strikingly similar patterns of environmental markers such as greenhouse gas emissions bear witness to an abrupt transition, approximating to the change from a horizontal to a vertical line on a graph (Fig. 1). Crutzen initially suggested that the departures from Holocene conditions began with the start of the Industrial Revolution and increased coal burning in late 18th century Europe, though that was before the IGBP data extended that far back. Once new data was in, a mid-20th century onset became more evident⁴, linked to the concept of the 'Great Acceleration' of many socio-economic drivers and Earth system responses following the Second World War⁵.

The transformation this represents has been extensively detailed⁶⁻⁸. Among its main characteristics are: altered atmospheric chemistry; a warming climate; now irreversible ice-sheet melting and sea-level rise; accelerated erosion and sedimentation; a proliferation of industrial goods, many made of novel substances such as plastics; a biosphere transformed through species invasions, domestications and extinctions; and the rapid growth of the 'technosphere', of globally interlinked human-devised technological systems⁹.

Background to a proposal

This initial research propelled efforts to pin down the start of the Anthropocene, through the identification of a precise starting point within a geological reference section known as a Global boundary Stratotype Section and Point (GSSP; often called a 'golden spike'). Between 2020 and 2023, 12 research teams formulated proposals for candidate GSSP sections from eight distinct geological environments across five continents⁶.

After much discussion and formal voting, the AWG chose a level separating the summer and autumn seasonal sediment layers of 1952 CE laid down at Crawford Lake in Ontario, Canada, at the first marked upturn in plutonium isotopes, coinciding with the first hydrogen-bomb tests¹⁰. This signal is clearly seen in many of the proposed sites (Fig 2). Crawford Lake was selected for its undisturbed, seasonally deposited sediment layers that preserve a precise and continuous chronology, for its ease of access for future investigations and for its protected status within a conservation area. The annually resolved plutonium data is supported by fly ash, nitrogen isotope and biological markers. To give a specific date and time, a nominal start coinciding with the first H-bomb detonation (Ivy Mike) was chosen: 1

November 1952 at 07:15 local time at the site on Enewetak Atoll in the Pacific Ocean (19:15 on 31 October, GMT).

These strata may be precisely correlated around the world — in some places to the nearest year—by a plethora of stratigraphic signals⁶, allowing systematic quantitative comparison of processes before and after the time boundary represented by their deposition. The proposal was formally submitted⁷ by the AWG to the SQS on 31 October 2023.

The Anthropocene's extent

The idea behind a geological definition of the Anthropocene was to provide a precise, agreed reference point for the integrated study of a wide variety of phenomena as outlined above, placing contemporary changes within a deep time context. But it is the lived, experienced and observationally recorded phenomena that produce the intense wider interest in the Anthropocene well beyond geology: a fully legitimate interest, for the original guiding idea of the Anthropocene addresses the conditions of Earth's habitability.

In the Anthropocene, Earth's surface conditions have changed substantially by comparison with most of the Holocene: conditions are now hotter, more contaminated and more biologically degraded. These negative trends are on a trajectory to intensify and extend yet further outside the Holocene envelope¹. Some of the changes involved are long-lasting (such as climate change) and some are irreversible (such as biological extinctions). They are already exerting pressures on political institutions, legal frameworks and economic relations, all meant to protect human communities and give them meaning.

Precise geological definition to the year, day and hour is often less relevant when the Anthropocene is discussed in these wider contexts. We note that in older units of geological time, modest changes in a formal boundary do not generally result in a difference in how it is fundamentally understood. For instance, in 2008, the definition of the Holocene was changed by another SQS working group from beginning at *de facto* 10,000 radiocarbon years before present to a formally, stratigraphically defined 11,700 years before present¹¹, without changing its fundamental meaning as the most recent post-glacial interglacial phase.

The definition of the Quaternary Period is also instructive. This unit encompasses the Pleistocene and Holocene epochs, which was defined in 2009 to begin at ~2.6 Ma utilizing for practical purposes a pre-existing GSSP and a major paleomagnetic reversal. Intensification of Northern Hemisphere glaciation had in fact begun slightly earlier, at ~2.7 Ma, but this does not change this period's general meaning as representing the 'Ice Age' of common parlance¹². Other such examples may be found in the older record. It isn't the precise boundary level that controls the conceptual meaning of geological time units, but the fundamental characteristics of the units that they bound. Nevertheless, increasing the precision of their boundary levels makes geological time units more consistently useful.

We argue that an understanding of the Anthropocene as a mid-20th century planetary transformation remains broadly useful across disciplines. This point is closely associated in time with the beginning of the Great Acceleration – a term coined by the US historian J.R. McNeill – or its near-synonyms, such as the 'post-WWII boom', 'the Economic Miracle' in

Japan from 1949 to 1990, and 'Les Trentes Glorieuses', a term applied in France to describe its 30 years of uninterrupted economic growth from 1945 to 1975. Many indicators of human impact – from greenhouse gas emissions to metal and mineral production, and meat consumption to plastic use – show strong upward trends from around this point (Fig. 3).

For historians, this postwar period is characterized by a widespread transformation of social values in many parts of the world, including the spread of democracy, social welfare programmes, and women's education, powered by growth in the globalization of industry, trade and commerce, and managed by international and national institutions in both the Communist bloc and the West as they contended for power. Institutions such as the World Trade Organization, International Monetary Fund and World Bank were facilitated by international law frameworks after the Second World War. Globalization intensified in almost all sectors, and technological advances also saw an explosion in agricultural food production and contributed to high rates of global human population growth^{2,13}.

For anthropology, political theory, international law, and ethics, new questions arise over the implications of human forces coming to dominate the web of life and non-organic processes. People across the world are contending with a transformed Earth system, which different cultures experience, understand and respond to in accord with their distinct worldviews. The expanding technosphere necessary to power, feed, house, and clothe the growing human population has been accompanied by rising global inequality, the very poorest having seen a minuscule rise in GDP per capita. Neoclassical economics and its assumptions of an unlimited capacity for growth are also challenged by an understanding of an increasingly destabilized Earth system on a finite planet².

More ancient boundary levels have been suggested as a beginning for the Anthropocene, but we argue that they do not capture the fundamental step change, measurable across a wide range of metrics, as does a mid-20th-century transition. These include the 'Orbis spike' level around 1610, which corresponds to a dip of around 10 parts per million (ppm) in atmospheric carbon dioxide concentrations¹⁴. This dip has been proposed to result from a decline in population and recession of farming in the Americas following the deaths of indigenous peoples from the introduction of smallpox by European colonists. But this dip is small compared with the increase in CO₂ of around 140 ppm over the past two centuries, while other stratigraphic signals related to a 'Columbian exchange' in species between the Americas and Europe – such as the presence of maize pollen as this crop plant began to be cultivated in other parts of the world – occur at different times in different places, commonly centuries apart. They do not capture an abrupt, fundamental global transition on a par with that of the mid-20th century.

Similar objections can be raised against older boundary suggestions based on stratigraphic signals — for example, lead-smelting signals dating to around 3000 years ago found in peat bogs and Greenland ice¹⁵. Other proposed 'Anthropocenes' extend yet further back in time, including the 'Anthropocene event' which encompasses all significant preserved human impacts at least as far back as around 50,000 years ago, including the Parthenon, the Great Wall of China, the pyramids of Egypt, early deforestation, Mesolithic arrowheads and even the Late Pleistocene megafaunal extinctions¹⁶.

The recognition of a profound planetary transition in the mid-20th century would be strengthened by geological formalization. But even without this, recognizing it as a quasi-formal boundary reflects reality^{17, 18} and encourages clear communication in all those other disciplines where ‘Anthropocene’ has come to be used as shorthand for overwhelming environmental change. Interpretations that encompass all significant anthropogenic impacts through time represent something quite different and, if labelled as Anthropocene, risk avoidable confusion of meaning.

What the Anthropocene is and isn’t

Beyond discussions about when it can most usefully be considered to have begun, the Anthropocene has been interpreted in many ways among the various disciplines in which it has circulated. The resulting implications commonly reflect increasingly divergent perspectives, and diminishing mutual understandings, in our still-strongly-siloed academic landscape. These differences need to be explored and, when necessary, challenged.

- **Does the Anthropocene disregard sociopolitical inequalities?** In coining and using the word “Anthropocene”, Earth System science and geology are held by some to assign blame equally to all humans, rather than to those whose disproportionate consumption of resources is largely behind our altered (and altering) planetary state.

This misconception has arisen because the aims and procedures of Anthropocene physical science differ from those of the humanities and social sciences. The physical sciences are mainly concerned with measuring and describing Earth’s responses to impacts that are currently overwhelmingly anthropogenic. They are not generally interested in ascribing responsibility to particular human beings or to particular social, economic, and political systems—though strongly unequal responsibility for Anthropocene change has been noted from the concept’s introduction² and some studies⁵ include such correlations. The physical sciences also rarely explore the resulting social, economic, and political responses or the values that underlie people’s desires and hopes.

In approaches to the Anthropocene, there is thus a division, or spectrum, of disciplinary labour. Anthropocene physical scientists study Earth’s responses to human impacts, while Anthropocene social scientists and humanities scholars explore the human beings and societies behind those impacts. For most scholars in the humanities and social sciences, inequality will be central to socio-political analyses of the Anthropocene. There is no reason for these approaches to be in opposition; the Anthropocene as understood here provides a framework which implies complementarity and interdisciplinarity.

- **Does “Anthropocene” equate to “climate change”?** Rapid, recent climate change caused by rising atmospheric greenhouse gas levels poses a clear threat to human societies. Despite efforts to control emissions, over 100 million tonnes of CO₂ are added to Earth’s atmosphere daily. But while climate change is now the most important destabilizing force to the Earth System, the Anthropocene includes many other physical, chemical, and biological transformations, interlinked with new global economic, political, social and technological phenomena.

When Crutzen coined the term in 2000, atmospheric CO₂ levels were ‘only’ around 370 ppm, or around 85 ppm above pre-industrial maximum concentrations. Average global temperatures were not much more than half a degree above pre-industrial (taken as 1850–1900) levels, and so still within the envelope of conditions reached at other times during the Holocene. Warming might have been said, in 2000, to be incipient: but even then, the total changes to the Earth system clearly justified Crutzen’s proposal of a new epoch. By 2023, atmospheric CO₂ levels had exceeded ~420 ppm, with an average temperature 1.48°C above pre-industrial values¹, albeit in an El Niño year which might to be expected to be warmer than the running average. Factoring in the effects of methane, nitrous oxide and the chlorofluorocarbons brings the CO₂-equivalent to ~523 ppm, a level perhaps not seen in nature since the mid-Miocene some 17 million years ago. Not surprisingly, then, the Earth overall is now hotter than at any time in the Holocene. Meanwhile, biodiversity loss and the increasing homogenization of Earth’s once-distinct biogeographic assemblages make up another key aspect of the Anthropocene¹⁹. Climate change is a major component of the Anthropocene, but does not define it.

- **Did the Anthropocene begin when its causes did?** The boundaries of geological epochs are not generally taken at the beginnings of planetary transitions, but at the levels where they can be readily recognized and practically used. Many evolving developments, activities and beliefs ultimately led to the transformation of the Earth system in the mid-20th century. They reach back into deep time before the emergence of *Homo sapiens* and its mastery of fire and complex communication skills, through the development of animal domestication, agriculture, urban societies, writing systems, globalized trade, the steam engine, capitalism, the Haber-Bosch process for nitrogen fixing, and so on. The causes of the Anthropocene necessarily precede the Anthropocene. By analogy, the formal definition of the Holocene at 11,700 years ago comes¹⁰ towards the end of a long, complex, stepped pattern of warming and sea-level rise from glacial conditions which had started around 8,000 years earlier (Fig. 1). Subsequently, the Holocene, operating as an interglacial not greatly differently from previous ones, provided the physical conditions for civilization to develop, conditions that the Anthropocene is now over-riding.

A common sense for the Anthropocene

The Anthropocene was understood by Paul Crutzen not merely as representing human influence on Earth’s geological record (he was well aware of earlier anthropogenic influence) but to reflect an Earth system whose physical characteristics had, since industrialization, departed from the prolonged, relatively stable conditions of the Holocene Epoch.

An Anthropocene concept stabilized to begin in the mid-20th century is aligned both with the Great Acceleration and a fundamental shift in the Earth System state. Understanding the Anthropocene in this way would prevent the current confusion of the term being used to mean different things in different contexts. It complies with the originally intended meaning of the term, while reflecting a clearly distinct evidence-based geological signature. This Anthropocene is congruent with its use in Earth system science²⁰, and in new and emerging

¹ <https://climate.copernicus.eu/copernicus-2023-hottest-year-record#:~:text=2023%20marks%20the%20first%20time,than%20%2C%20B0C%20warmer.>

institutions such as the Center for Anthropocene Studies at KAIST University, Daejeon, Korea, the Center for Anthropocene History at Stockholm's KTH Royal Institute of Technology, Sweden, and the Max Planck Institute for Geoanthropology in Jena, Germany. It highlights geology's role in addressing problems of societal concern and is applicable also in the social sciences and humanities with respect to the enormous societal upheavals, changes in energy production and globalization of trade that have taken place. Policy and international law will also benefit from such an unambiguous definition, putting beyond doubt that we are now in a time of transformed planetary functioning wrought by overwhelming human impacts.

(Main text 2956 words).

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MATERIAL FOR FIGURES (TO BE DEVELOPED BY NATURE GRAPHICS DESIGNERS)

Figure 1 | Earth system shift. Detectable human influences on Earth's environment date back at least 50,000 years, but the impact on key metrics such as temperature and the concentration of atmospheric greenhouse gases has seen a step change in recent decades. Slight increases in CO₂ from 8 kyr and CH₄ from 5 kyr have been attributed by some to anthropogenic impacts but that these are dwarfed by the step change in the 20th century.

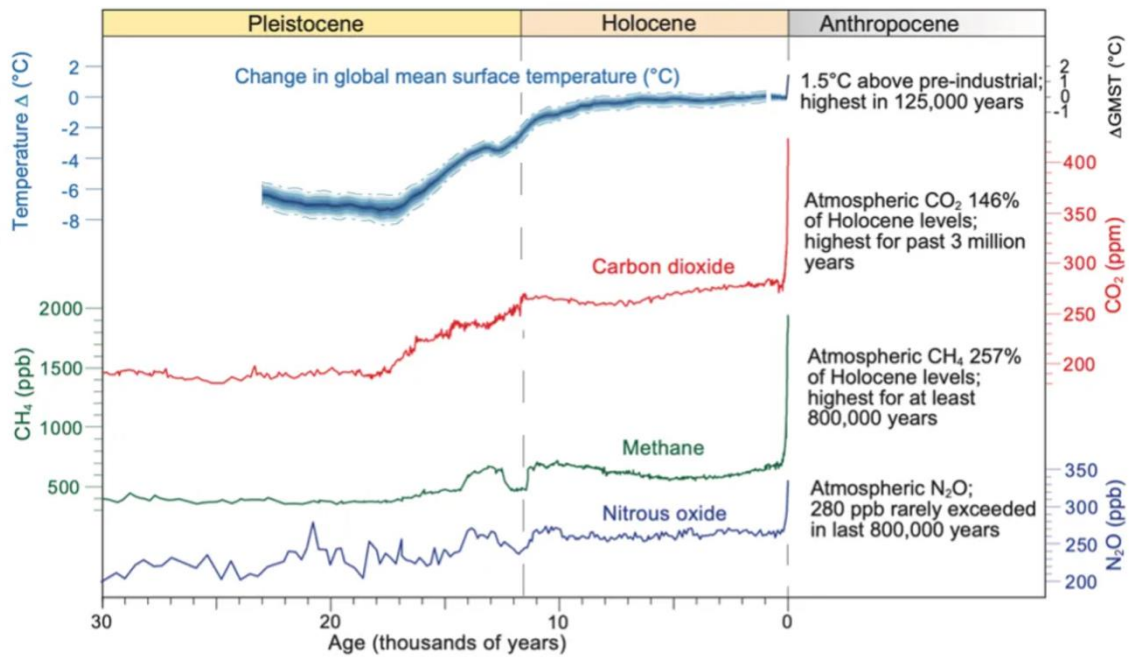
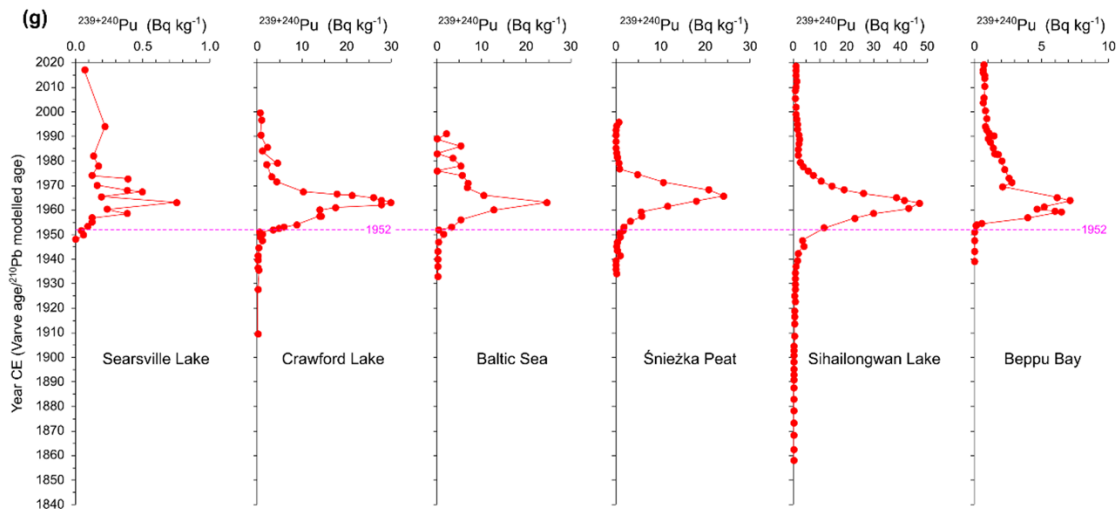


Figure 2 | A consistent boundary. The early 1950s saw the beginnings of a rapid spike in atmospheric plutonium concentrations as a result of the first (thermonuclear) H-bomb tests, as seen in a selection of the sites that were considered as potential GSSP candidates. The signature in sediments laid down in Crawford Lake in Ontario, Canada, was selected as the basis for the (now rejected) proposal to formalize the beginning of a geological Anthropocene epoch. From ref. 6).



Plutonium records in sedimentary layers from sites analysed for the Anthropocene proposal, showing precise worldwide correlation as basis for the boundary level selected, from the AWG proposal now published on EarthArXiv

Fig 3 | A sociohistorical turning point. Many metrics of human activity from 1750 CE to present, from population to mineral, plastics and meat production, show a marked uptick in the ‘Great Acceleration’ following the Second World War.

We could use either the tabular or graph representation of these metrics – might be one to throw at our graphics artists and see what they think.

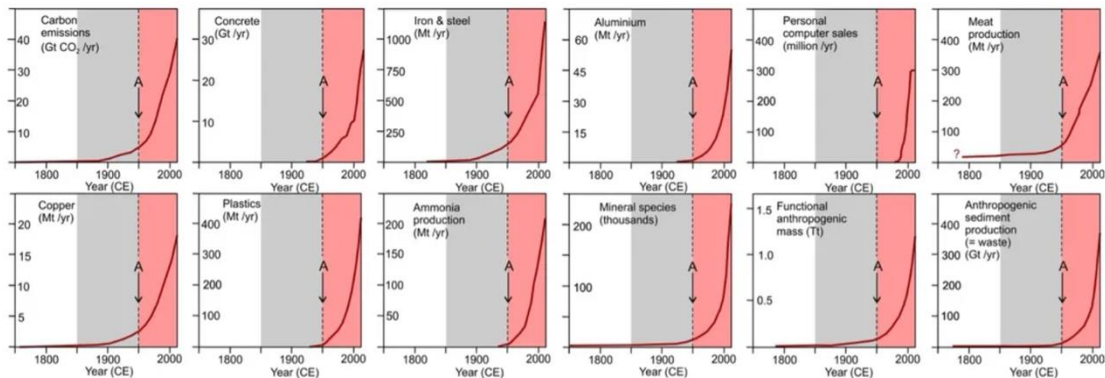


Figure by Colin Waters and Jan Zalasiewicz of new ‘Great Acceleration graphs’ of trends through a 274-year interval, used in a *Smithsonian Magazine* article

Supplementary information to:

What should the Anthropocene mean?

Comment to be published in *Nature*

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