

The ‘Anthropocene’: *alea iacta est*

The proposal of the ‘Anthropocene’ as a new geological epoch, characterized by the anthropization of the Earth System, has finally been submitted for formalization and there is no turning back

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Almost two and a half decades after its introduction, the ‘Anthropocene’ is still an informal term whose precise definition remains uncertain. However, this term is used for many scholars as if it was already a well-defined formal epoch of the Geological Time Scale (GTS). Scientific rigor is as important in geology as in any other discipline, and the terms and concepts used are subjected to a process of formalization.

The units of the GTS are represented in the International Chronostratigraphic Chart (ICC), and for a new unit to be incorporated, it should meet the requirements of the International Stratigraphic Guide (ISG) and must be approved by the International Commission on Stratigraphy (ICS) and ratified by the International Union of Geological Sciences (IUGS). This process is similar to the addition of a new element to the Periodic Table of Elements (PTE), which is overseen by the International Union of Pure and Applied Chemistry (IUPAC). Without the ICC, it would not be possible to understand the geological history of our planet or the origin and evolution of life on it. Such a fundamental framework requires high scientific accuracy.

The ‘Anthropocene’, as a prospect for a new geological epoch, was evaluated by the Anthropocene Working Group (AWG), which recently submitted a proposal to the ICS Subcommittee of Quaternary Stratigraphy (SQS) for approval, as a first step for formalization. In a former paper, I provided the main clues for understanding of ‘Anthropocene’, which was still in a prospective state (Rull, 2017). In the last years, the significant progress has been made in addressing this issue, leading to the completion of the current AWG proposal. Here I summarize the main developments that have precipitated such recent acceleration for a nonspecialist audience.

In a nutshell

Twenty-four years ago, the Danish environmental chemist Paul Crutzen and the American ecologist Eugene Stoermer coined the term ‘Anthropocene’ to emphasize that the global consequences of human activities on the Earth system have already surpassed the range of variability of the Holocene – the epoch in which we live since the end of the last glaciation – and that the definition of a new geological epoch was needed (Crutzen & Stoermer, 2000). Notably, the term used to designate this new unit implicitly suggested the rank of an epoch, as the suffix ‘-cene’ is reserved for the epochs of the Cenozoic era (e.g., Paleocene, Miocene or Pleistocene).

This proposal began to be analyzed in 2009 by the AWG, led by the British geologists Jan Zalasiewicz until 2019 and Colin Waters from that date onward. The AWG has periodically published its main progresses, which have been criticized by influential stratigraphers, including the ICS Secretary General, the British geologist Philip Gibbard, the IUGS Secretary General, and the American geologist Stanley Finney, who are directly involved in the approval/ratification of the AWG proposal (Finney, 2015; Gibbard & Walker, 2014; Edwards, 2015; Finney & Edwards, 2015).

One of the main critiques is that the AWG uses environmental criteria to define this new epoch, but a valid chronostratigraphic unit must be defined on the basis of distinct and characteristic rock bodies following the criteria of the ISG. According to these criteria, the first step is to locate the rock strata that characterize the new unit and the particular features (the stratigraphic markers) that differentiate it from the underlying unit. Then, the base of the new unit is dated using geological methods to provide the chronological framework.

Altogether, this body of evidence is known as the Global Boundary Stratotype Section and Point (GSSP), or more popularly the “golden spike”. Without the GSSP, it is not possible to measure geological time; therefore, the definition of a new chronostratigraphic unit makes no sense. Indeed, rock strata are the only available evidence for measuring geological time. Without rocks, time passes but it cannot be measured by geological methods. This situation is similar to that of a sandglass with no sand.

In the case of the ‘Anthropocene’, the GSSP remains undefined. In 2016, the AWG members voted that the starting point of the ‘Anthropocene’ be placed in the mid-20th century, coinciding with the Great Acceleration, when many indicators of Earth’s anthropization experienced an abrupt increase (Head et al., 2022). The most suitable stratigraphic markers would be radioactive fallout, mainly plutonium (²³⁹Pu) and radiocarbon (¹⁴C), which were generated by atomic tests carried out in the early 1950s (Zalasiewicz et al., 2017). Therefore, a specific date and a set of stratigraphic markers based on environmental considerations were given before identifying the GSSP, which is contrary to the ISG rules.

This proposal was questioned, not only because of the procedure but also because other previously proposed starting points were dismissed. Indeed, in the original proposal, Crutzen and Stoermer postulated that the ‘Anthropocene’ could encompass the last centuries or the last millennia, even the whole Holocene, which began 12.7 thousand years ago. Since then, numerous studies have proposed a wide range of dates within this timeframe, and have emphasized the diachronic (nonsynchronous) nature of human impact across the globe (Lewis & Maslin, 2015). Another critique was that the sedimentary record accumulated in barely 75 years is insufficient for characterizing a geological epoch.

However, the AWG decisions were confirmed in 2019 and this task group concentrated on identifying the GSSP representative of this time period, that is, a rock body that met the preestablished conditions.

Latest developments

After a thorough review of the available evidence (Waters et al., 2018), the AWG concluded that the most suitable candidates for the ‘Anthropocene’ GSSP were paleoarchives able to provide high-resolution (annual or seasonal) records from the 20th century, such as (i) annually laminated (varved) sediments from lakes and anoxic marine basins; annual growth rings from trees and corals; or accumulation layers from polar ice caps. The most suitable markers were

proposed to be the previously mentioned radionuclides, fly ash, heavy metals, biotic turnovers and anthropogenic introductions, among others (Table 1).

Combining the better suited archives and stratigraphic markers, a total of 12 localities around the world were selected for a more intensive study as GSSP candidates (Figure 1). Using these criteria, the 'Anthropocene' was tentatively dated between 1945 and 1968, with most dates occurring in the 1950s (Table 1). After a detailed site-by-site analysis, the AWG voted that the best GSSP candidate was the Canadian Crawford Lake, which was announced in July 2023. In the sediments of this lake, the bomb test signal (^{239}Pu) is clearly visible at approximately 15.6 cm depth, which corresponds to 1950. This boundary is also marked by an enhanced sediment supply from the basin due to the rapid industrialization of the surrounding area during the Great Acceleration, along with an abrupt decline in elm pollen due to a documented widespread disease of this tree.

Some critics, especially the American geologist and former ICS member Lucy Edwards, argue that barely a few centimeter of unconsolidated lake sediments can easily be mixed or removed – even the whole lake could dry out in a matter of centuries or millennia – which would irreversibly eradicate the 'Anthropocene' GSSP (Perkins, 2023). However, the AWG decision was made and the final proposal, still unpublished, considered the Crawford Lake GSSP to define the 'Anthropocene'.

Further complications

In the last few years, a new possibility has emerged that may challenge the progress made by the AWG during the last decade. Indeed, a group of stratigraphers consider that the 'Anthropocene' could be defined as an event, rather than an epoch (Gibbard et al., 2022). This could affect the 'Anthropocene' formalization process, as this group includes the most influential ICS/IUGS critics quoted above.

A geological event is a time-transgressive concept that does not need to be homologated using a fixed point in time, and is therefore able to accommodate the spatiotemporal heterogeneity characteristic of human impact on Earth. An event is not a minor geological feature, as it can imply fundamental global transformations. For example, the Great Oxidation Event (GOE) radically changed the course of evolution, including the development of multicellular life and the colonization of land. The GOE was not a point in time but rather a gradual process lasting approximately 300 million years (2400-2100 Ma).

According to Gibbard et al. (2023), an 'Anthropocene Event' could incorporate a far broader range of transformative diachronic anthropogenic practices than an 'Anthropocene Epoch'. The AWG replied that an event would include all kinds of human activities that occurred over the last 50 millennia and would obscure the recent abrupt planetary change, which is what the 'Anthropocene Epoch' wants to emphasize. In addition, they recall that the suffix '-cene' characterizes Cenozoic epochs and is therefore inappropriate for naming an event (Head et al., 2023).

What's next?

The AWG proposal was submitted to the ICS on October 31, 2023 and is now under discussion. Within the ICS, the first instance is the SQS – which is led by two relevant AWG members, Zalasiewicz (Chair) and the Canadian geologist Martin Head (Vice-Chair) – and the second instance is the ICS Executive, where the opponent Gibbard is the Secretary General. In both cases, a minimum of 60% majority is needed for approval. This will not necessarily be a quick

step, as the SQS should analyze in detail the proposal. If approved, the proposal will be submitted for ratification to the IUGS where Finney, one of the most active critics of the AWG proposal, is the Secretary General.

According to Waters (pers. comm.), the current AWG Chair, none of these steps are guaranteed to pass and there is no preliminary feedback from the ICS, as the Executive of this organism prevented the AWG members from discussing the issue with the SQS members. Waters also noted that the SQS is not favorable for publishing the submitted proposal for the moment, but this possibility may not be ruled out in the future.

Expectations

The risk of the 'Anthropocene' proposal not being formalized is real, as suggested by the fact that a number of relevant ICS/IUGS members have repeatedly questioned AWG decisions. Noteworthy, the AWG always reaffirmed its position and answered the critiques without reconsidering the questioned points, which did not contribute to changing the opponent's perspective. What are the alternatives to an eventual rejection?

The AWG members, including Zalasiewicz and Head, were reluctant to modify the current proposal to downgrade the 'Anthropocene' to one more Holocene stage/age, as suggested by Gibbard and other critics (Gibbard et al., 2022). They emphasize that changes associated with the 'Anthropocene' are of greater magnitude than those associated with current subdivisions of the Holocene. Zalasiewicz also stated that there is no plan B and that the AWG will remain attached to the 'Anthropocene' concept. Regarding the possibility of the 'Anthropocene' to be upgraded to an era – actually the 'Anthropozoic' (Rull, 2021) – Edwards highlighted that, curiously, the AWG has never considered such an option. Gibbard and Edwards also commented on the survival of the 'Anthropocene' term, regardless of the final outcome, in a cultural sense to emphasize the human influence on global environmental issues, a topic that is beyond the competence of geological organisms.

The whole discussion on potential alternatives can be found in Rull (2018), but the general impression is that both proponents and opponents of the current 'Anthropocene' proposal remain attached to their own positions and are reluctant to change their mind. The AWG has already crossed its Rubicon, and now we should wait for the result of the SQS deliberations. This subcommission may endorse or reject the proposal but can also request modifications. According to Waters (pers. comm.), some SQS members have published strongly in favor of the AWG proposal and others strongly against, and the result is uncertain, especially if we consider that a 60% majority is required. *Alea iacta est.*

Societal impact

The 'Anthropocene' concept has been adopted by a wide range of disciplines (philosophy, sociology, politics, environmental activism, etc.) with different meanings, including an expression of modernity, an attack on Earth's biosphere, a biological imperative inherent to our own species, a consequence of global capitalism or the decoupling between environmental health and human welfare (Autin, 2016). In some extremist sectors, an eventual rejection of the 'Anthropocene' proposal would be viewed as a 'negationist' attitude from scientific sectors. However, as the ICS/IUGS opponents clearly emphasized, the formalization or not of this epoch will neither stop nor aggravate the global environmental problems caused by humankind. Others, including a number of scientists, are indifferent about the formalization issue and have already adopted the 'Anthropocene' as a matter of fact, regardless of the final scientific decision (Rull, 2018).

The persistence of all these options creates confusion in the general public, and in many nonspecialist scholars, who feel insecure about what actually is the 'Anthropocene' and whether or not it is a scientifically valid term and concept. Popular media greatly contribute to this disorientation by declaring that the 'Anthropocene' was already formalized every time the AWG announced some progress in their deliberations. This was very obvious, for example, in 2016, when the task group voted about the onset and the stratigraphic markers chosen to define the new epoch, and in 2023, when Crawford Lake was selected as the GSSP. In both cases, the purported formalization of the 'Anthropocene' was explicitly announced in headlines such as 'welcome to the Anthropocene' or 'the Anthropocene is here'. Curiously, the recent submission of the AWG proposal for formalization has not received the same attention, likely because this would be inconsistent with their recurrent message that 'the Anthropocene is real', which is another popular headline.

In this environment, saying that the 'Anthropocene' is still a prospective geological epoch and that the proposal for its formalization has just been submitted to competent scientific organisms seems reckless. As a consequence, a number of scientists aware of this do not stop using the term, perhaps trusting that formalization is only a matter of time. However, as we have seen above, the approval and ratification of the current 'Anthropocene' proposal is not guaranteed. Scientists aware of the situation and concerned with scientific rigor should clearly explain the current status of the 'Anthropocene', not only in scientific publications but also in dissemination and popular media, rather than leaving nonspecialists and the public in the hands of careless, uninformed or biased scholars, writers and speakers.

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Links to the involved organizations

- Anthropocene Woring Group (AWG) - <http://quaternary.stratigraphy.org/working-groups/anthropocene/>
- International Commission on Stratigraphy (ICS) - <https://stratigraphy.org/>
- International Union of Geological Sciences (IUGS) - <https://www.iugs.org/>
- Subcommission of Quaternary Stratigraphy (SQS) - <http://quaternary.stratigraphy.org/>

Table 1. The localities of Fig. 1, with indications of the type of archive, the date suggested for the beginning of the ‘Anthropocene’ at each site (A-onset), the thickness of the ‘Anthropocene’ sediments (A-thick) in cm, and the stratigraphic markers used. AAs, anthropogenic artifacts; BTIs, biotic turnovers/anthropogenic introductions; HD, historical documentation; LT, lithology; SCPs, spheroidal carbonaceous particles (fly ash). Raw data from Waters et al. (2023).

| Site | Map | Archive | A-onset | A-thick | Stratigraphic markers |
|--------------------------|-----|------------------------------|----------------------|-----------|--|
| East Gotland, Baltic Sea | EG | Anoxic marine basin | 1956±4 | 26.5 | LT, ^{239}Pu , ^{241}Am |
| San Francisco, USA | SF | Estuary | Mid-20 th | 230 (?) | Unclear |
| Searsville, USA | Sv | Lake | 1948 | 366 | ^{239}Pu , SCPs, Pb, BTIs |
| Crawford, Canada | Cf | Lake | 1950 | 15.6 | ^{239}Pu , SCPs, $\delta^{15}\text{N}$, BTIs |
| Sihailongwang, China | Sl | Lake | 1953 | 8.8 | LT, ^{239}Pu , ^{129}I , ^{14}C , SCPs, PAHs, $\delta^{13}\text{C}$ |
| Flinders, Australia | Fl | Coral reef | 1958 | 36.9 | ^{239}Pu , ^{14}C , Sr/Ca, $\delta^{18}\text{O}$, $\delta^{15}\text{N}$ |
| West Flower Garden, USA | WF | Coral reef | 1957 | 28.4 | ^{14}C , ^{239}Pu |
| Palmer, Antarctica | Pm | Ice sheet | 1952 | 3490 | ^{239}Pu , SCPs |
| Ernesto, Italia | Er | Cave speleothem | 1960±3 | 0.4 | ^{14}C , S |
| Śnieżka, Poland | Sk | Peatland | 1950-1955 | 39.5-44.5 | ^{239}Pu , ^{14}C , BTIs |
| Beppu, Japan | Bp | Bay | 1953 | 64.6 | LT, ^{239}Pu , ^{210}Pb , $\delta^{15}\text{N}$ |
| Vienna, Austria | Vn | Urban anthropogenic deposits | 1945-1959 | 30 | ^{239}Pu , AAs, HD |

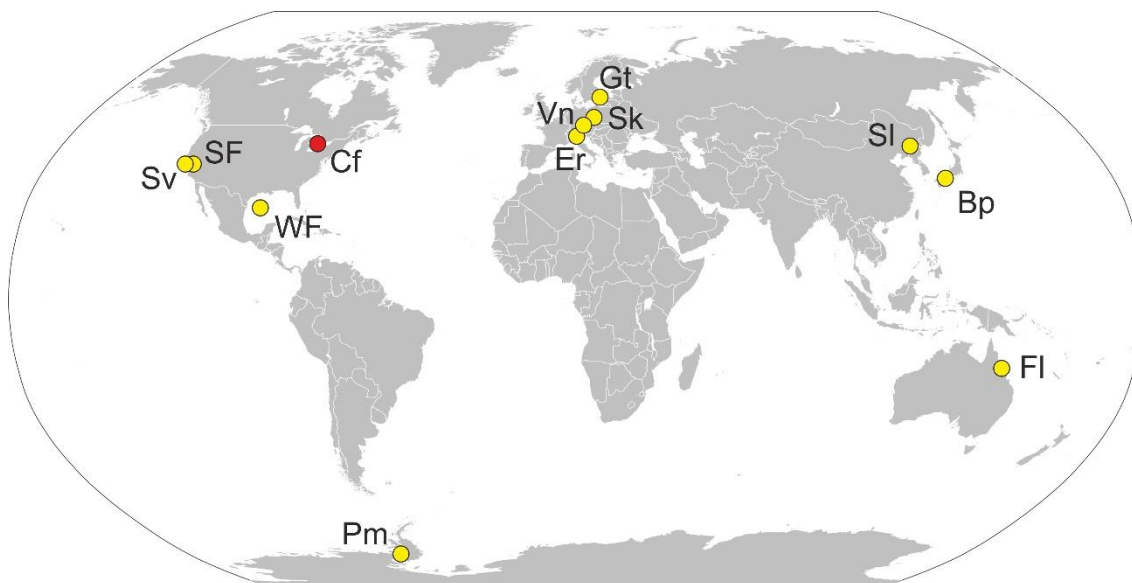


Figure 1. The 12 localities selected by the AWG to determine the most suitable GSSP for the ‘Anthropocene’. The locality selected by the AWG as the best GSSP candidate (Crawford Lake; Cf) is highlighted in red. Redrawn from Waters et al. (2023).