



The Anthropocene is not an official stratigraphic unit

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Main theme: Ever since the idea of a new geological unit, the Anthropocene, was launched in 2000 by Paul Crutzen, an atmospheric chemist and Nobel Prize winner, the scientific community has been inflamed by the current global warming situation, and passionate debates have raged between those in favor of this new anthropogenic unit and those opposed to it. The discussion has spread well beyond the geological community, yet it is geologists, and geologists alone, who are able to formally define geological units, in this case stratigraphic units. Our article will review the rules of stratigraphy and show that the introduction of the Anthropocene as a stratigraphic unit does not comply with these rules. After 15 years of debate, the ICS (International Commission on Stratigraphy) has just officially rejected the Anthropocene as a stratigraphic unit. **In conclusion, the Anthropocene must be considered as a 'Geo-ethical' unit and not as a 'Geological' unit.**



Example of the [GSSP stratotype](#) from the Thanetian geological stage (Paleocene, see Figure 1). Note the golden spike (see text below). Photography : Pierre Thomas.

1. INTRODUCTION

Time in geology is not a simple matter... We need to distinguish between two different and complementary registers: that of chronology, which seeks to establish a succession of events or the synchronism of two events, and that of duration, during which phenomena take place. It should be noted that time is not fossilized; it is only accessible through traces that constitute rare recordings of phenomena that have taken place. These traces provide access to chronological markers ([De Wever et al. 2010](#)).

Chronostratigraphy is the part of stratigraphy devoted to establishing the chronology of successive sedimentary layers (or 'strata'). Stratigraphy makes it possible to establish a relative stratigraphic chronology based on the principles of continuity and superposition (= 'principle of stratigraphy', [here](#) and [here](#)). **Stratigraphic analysis uses [several hierarchical and codified units](#) (also [here](#)), the most important of which is the geological stage (= 'stage') lasting a few million years (average duration 5 or 6 Ma).** These divisions or units are each represented by sets of layers to which time intervals correspond, which are geochronological divisions ([svt71](#), [Gastou, 2011](#)). Their fossil content makes it possible to carry out remote correlations (= stratigraphic paleontology). By considering the lithological nature of the layers and their age, **we can formally define** lithostratigraphic divisions, biostratigraphic divisions and chronostratigraphic divisions, to which we assign a set of layers constituting time intervals or geochronological divisions. The basic division is the stage. Other very useful stratigraphic units have been added to those of classical stratigraphy, such as isotope stratigraphy, sequence stratigraphy, cyclostratigraphy, seismic stratigraphy, chemostratigraphy, ecostratigraphy, magnetostratigraphy, and so on.

2. THE GEOLOGICAL STAGE

Let's come back to the floor, the keystone or basic unit of the international chronostratigraphic scale. It has a long history, beginning in the 18th century and taking shape for the first time in the [19th](#) century. In the 19th century, geologists, and more specifically stratigraphers, grouped together on the same reference outcrop (=type section) sets of sedimentary layers sharing common paleontological characteristics. These outcrops, or type sections, are natural or artificial (quarries and even boreholes) and are called [stratotypes](#). They therefore represent reference sites for defining specific time intervals: stages, each characterized by its duration or age. The name of the stratum is usually that of a geographical location, to which the suffix -ien is added (e.g. the Frasnian of Frasnies in Belgium, the Aptian of Apt in France). This place is generally, but not necessarily, where the stratotype is found (for example in the cliffs of Givet, in Givet for the Givetien, but on the flank of a Jebel in Morocco for the Eifelian...). Several stages form a series (the geochronological equivalent is the epoch), then several series form a system (geochronological equivalent = period), then several systems form an erathem (geochronological equivalent = era) and several erathems form an eonothem (geochronological equivalent = eon) (Figure 1). Smaller divisions divide the stage, the most used being the chronozone (geochronological equivalent = chron).

3. STRATIGRAPHIC RULES

Let us remember the fundamental principle of the management of these units: we have material divisions (= the geological layers, example = the stage) which have durations (example the age for each stage) hierarchical and valid for the whole of geological time and valid at global, regional, and local scales. [National and International Stratigraphy Commissions \(ICS\)](#) were created during the 20th century to manage these units (definition, creation, abandonment, etc.), which are constantly being improved following the acquisition of new geological data (outcrops, mapping, paleontology, drilling, seismic, etc.). [A stratigraphic code or guide](#) has been established and is followed by the geology community to facilitate a common method and language. It is systematically taught to geoscience students from the first years of their baccalaureate. It is the basis for learning geology. [Episodes](#) is the 'Journal of International Geoscience' which discusses these points and reports on the official decisions taken in this field, based on the most recent studies. This Open Access journal is the link that connects the geology community on the largest possible international scale. **Any unit validated by the community becomes official and formal. Unvalidated units are rejected and can be used informally.** This Open Access journal is the link that connects the geological community on the largest possible international scale. The history of the nomenclature of stratigraphic units is regularly discussed and recommendations suggested. It is a work in progress.

There is no question here of going into the details of stratigraphic analysis, the key point of which is the definition of the stratotype(s) (= '*standard section or reference*

section') of the various units and particularly that of the stage. Geological science has evolved considerably over the last 30 years, and the emphasis is now on the **'marker levels'** of a stage (or other unit), rather than on the reference section historically used. This new approach is based on the concept of the **GSSP** (*Global Boundary Stratotype Section and Points*) or (temporal) boundary stratotype ([Walsh et al. 2004](#)). In other words, each stage (or other unit) is defined at a precise point on the planet (cf. GPS coordinates) by a **temporal marker**, i.e. a timeline that is materialized by placing or fixing a nail ([Veltz, 2020](#)), sometimes a plate. **This is the famous 'golden nail' or 'golden spike' used by geologists, which can be found on the geological time scale (Figure 1) at the various stage boundaries for those where the definition has been validated by Episodes.**

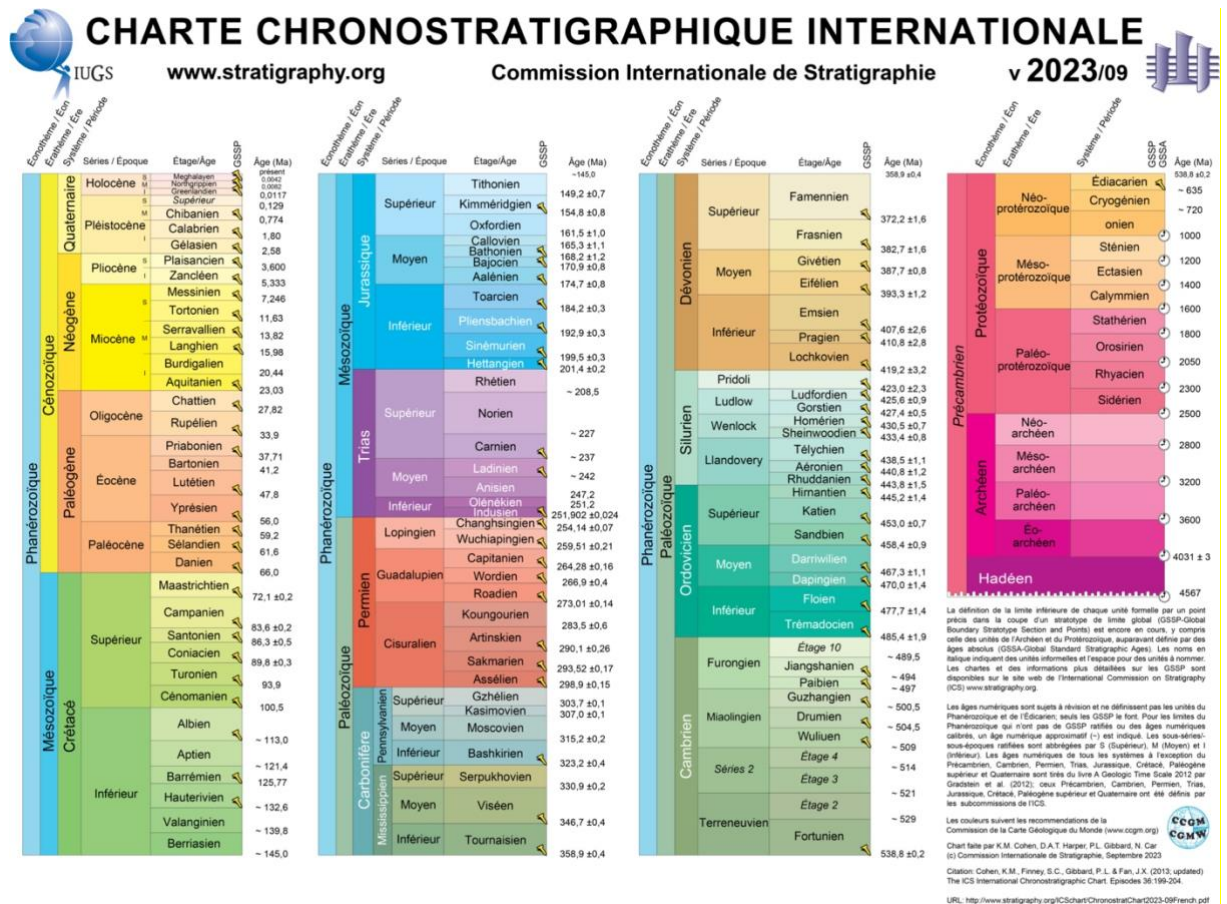


Figure 1. The different geological stages (the basis of geology) are dated by absolute chronology and some are marked by a time marker for a 'gold nail' (= golden spike) in each stratotype concerned. This scale is not fixed and is improved every four years or so following the acquisition of new data and the results of more detailed studies (according to [stratigraphy.org](#)).

4. STRATOTYPES

For each geological stage there is therefore *a reference section or type section* corresponding to an elapsed time. These are stratotypes (one per stage) which were defined ('more or less well') at the end of the 19th century. In the 20th century, the stages were marked by a limit, i.e. a time marker, and we then moved on to **limit stratotypes or 'limitotypes' (GSSP)**. Both systems are used today, with the second being increasingly popular. The aim is to correlate layers as closely as possible on the largest possible global scale. With this new approach, the base or lower limit of a floor (or other unit) is defined by the marker selected (represented by the 'golden nail' in a protected site) and the top of the floor in question corresponds to the base of the next floor (Figure 1). Let's take the example of the Givetien stage, for which the historical stratotype or reference section was established at Givet in 1879. This choice proved to be inappropriate over time (see history in [Préat et Bultynck, 2006](#)), and today the base of the Givetien stage is defined by a biostratigraphic marker (GSSP) in the Jebel Mech Irdane section, in the Anti-Atlas of southern Morocco. This is bench no. 123, approved by Episodes in 1995 (see [Walliser et al., 1995](#)) following validation by the ICS (*International Commission of Stratigraphy*) and the [IUGS](#) (*International Union of Geological Sciences*). **As this is an official decision, the geological community is obliged to refer to it.** In the 'new' limitotype concept, the top of one stage is defined by the base of the next. The top of the Givetien therefore corresponds to the base of the next stage, the Frasnian, and the limitotype was set, by the same international commissions mentioned above, on a biostratigraphic basis, in the Puech de la Suque section in the Montagne Noire in southern France ([Klapper et al., 1987, Galbrun, 2022](#)). Figure 1 shows that the duration of the Givetien stage ranges from $387.7 \pm 0.8\text{Ma}$ to $382.2 \pm 1.6\text{Ma}$. Every four years or so, these ages are revised or clarified in the light of new studies. An example of this can be seen with the base of the Thanetian dated at 59.2 Ma (Figure 1, 2024), whereas it was dated at 58.7 Ma (see the panel on the first figure at the top of the article).

The daily practice of stratigraphy to establish temporal units on a global scale implies that several unavoidable criteria must be met: (1) sedimentary continuity and (2) significant modification of temporal zones (mainly - but not exclusively - biozones, based on the evolution of (micro)fauna (e.g. foraminifera...), (micro)flora (e.g. algae...) or organisms of uncertain affinity (e.g. acritarchs...).

It should be noted that stage boundaries may correspond to a major tectonic phase (collision or readjustment of tectonic plates), such as the Messinian crisis in the Mediterranean, which is recognized worldwide ([Aslanian et al. 2019](#)) or other indicators (e.g. geochemical ...)

The basic unit of geology is the **Stage** with a duration of 5 to 6 Ma (sometimes more, sometimes less, see Figure 1) and its base is fixed by a limitotype (if the data are sufficient, see Figure 1) whose age is known within ± 1 Ma (sometimes more,

sometimes less, see Figure 1) or without any precision yet being given (*id.*). **We can therefore see that the key to understanding geology on the largest useful scale is the million years or a few million years. Trying to create a specific nomenclature for events quickly leads to inconsistencies and even conflicts.**

Just look at the importance given to the appearance of Man at the origin of the word '[Quaternary](#)', which until recently was wrongly considered to be an **Era**, even though its duration is shorter (officially 2.58 Ma, the **Gelasian or Upper Pliocene**) than that of a geological stage ([Gibbard and Head, 2009](#)), since the last decision published in Episodes on 29 June 2009. **Since 2009, the Quaternary is no longer an Era and has been attached to the Cenozoic or Tertiary Era.** The subdivisions of the Quaternary are still the subject of much debate and conflict ([Episodes](#)). The rank of the [Holocene](#) geological unit, which marks the last epoch of the Quaternary, **alias isotope stage 1 (MIS 1)**, and therefore of the Cenozoic, shows just how different this unit, which currently lasts 11700 years, is from all the units on the international chronostratigraphic scale. For Quaternarists, this isotopic unit corresponds to the last interglacial in progress. Figure 1 shows that the Holocene contains three geological stages and corresponds to the rank of a Series/Epoch. Let us therefore consider three geological stages for 11700 years instead of 15 Ma, taking an average duration of 5 Ma for each stage (see Figure 1). Holocene stratigraphy is particularly complex and is based on numerous proxies.

5. ANTHROPOCENE

Given that the Quaternary is also shorter than a geological stage, with a highly detailed stratigraphy, **and that the Holocene represents virtually nothing in terms of time on a geological scale (0.2% of an average stage)**, is the proposal to add a new 'unit', the Anthropocene, reasonable? First, it should be remembered that, according to the rules of stratigraphy, proposing a limit for the base of the Anthropocene is de facto tantamount to defining the upper limit of the preceding stage (in this case the [Meghalayan](#), Figure 1). If the Anthropocene were defined and began with a geological stage (the Crawfordian, see below), we would know neither the upper limit of the Anthropocene as a Series/Epoch, nor that of this new stage that is yet to come! If it is not a correctly defined geological stage (and here it cannot be), then it cannot appear on the international chronostratigraphic chart, and makes no geological sense since the purpose of this chart is to present global units. **The introduction of the Anthropocene only accentuates the incoherence of the definition and the place taken by the Quaternary.** However, it is part of the same logic, i.e. that of the appearance of Man on Earth, but whereas for the Quaternary there was no judgement on this appearance, for the Anthropocene, on the contrary, there is a judgement, Man being considered as a geological agent in his own right, manifesting himself mainly through his destructive side of the Planet, especially since the Industrial Revolution. Some people even want to replace the Anthropocene with the Capitalocene (*sic*), reflecting the degradation of the Planet by capitalism.

We can discuss this aspect endlessly, but it is beyond the scope of (good) stratigraphic logic, which has been applied since the Archean period, that this proposition makes no sense. So, let's look at the Anthropocene and see where it leads us. It was Paul Crutzen, atmospheric chemist, and Nobel Prize winner, who announced at a symposium in Mexico in 2000: *'No! we are no longer in the Holocene but in the Anthropocene, we need to add a new age to our stratigraphic scales ... to indicate that Man as a species has become a major geological force'* ([Crutzen and Stoermer, 2000](#)). In 2002, in an article in *Nature*, he proposed that this new age should begin in 1784, the date of James Watt's patent on the steam engine. This shows how little we know about the concept of age in relation to its meaning in geology. At the 34th IUGS Congress, held in Brisbane in 2012, it was decided to set up a working group on the proposal (see the history of the various developments of the International Quaternary Stratigraphic Subcommission [Waters et al., 2018](#), [Head et al., 2023](#), [Episodes, 2024](#)).

The date of the start of the 'Anthropocene' is immediately raised, and various considerations linked to human activity (the nitrogen cycle, the phosphorus cycle, the increase in lead levels, which peaked in Roman times (52 ± 300 AD), the exploitation of hydrocarbons by the Mesopotamians in the Bronze Age, etc.) are quickly intertwined; mercury in the soil, which led the Mayans to abandon the vast site of Tikal in 1520 AD because of mercury pollution, changes in biodiversity at the very beginning of the Holocene, especially with the clearing of land in the Neolithic period, nuclear explosions and artificial radionuclides...), climatic events propagated by the IPCC (CO₂ cycle, CH₄, NO₂ ... acidification ...) and still other phenomena also linked to human activity (e.g. (micro)plastics and new polymers, pesticides, soot and flue dust from combustion, 'techno-minerals', concrete, ...).). **So where exactly does the Anthropocene begin?** With the appearance of *Homo sapiens* around 300 ka ago ([Smith et al. 2007](#)), or earlier, with the appearance of the *Homo* genus around 3.0-2.0 Ma, with its use of fire, hunting and toolmaking in Africa ([Gibert et al. 2022](#)), or again around 5,000 years ago, when deforestation, rice paddies and livestock farming (greenhouse gases?) became intensive ([Ruddiman, 2003](#))? Numerous proposals have been considered... ([Yusoff, 2018](#), [Wallenhorst, 2021](#)).

The Anthropocene was finally rejected by the IUGS as a unit of Series/Epoch by 12 votes to 4 on 5 March 2024 ([here](#) and [Witze, 2024](#) in *Nature*, Figure 2, also [Hansen, 2024](#)). If the proposal had been accepted, the Holocene beginning 11700 years ago would have been succeeded by the Anthropocene in 1952 in the sediments of an industrially contaminated lake at Crawford, near Toronto in Canada ([Witze, 2023](#)). The Crawfordian stage would then be the first stage of the Anthropocene, and the GSSP that defines it is located at the base of a black lamina or varve deposited in 1952 and present at 17.0 cm in hole CRA23-BC-1F-B drilled in the lake. Numerous chemical changes occurred in this lamina, including a rapid increase in ^{229/240}Pu and ¹⁴C following atomic testing in the 1940s-1950s ([Waters et al., 2023](#)). Nine other sites had been approached because they also recorded the first manifestations of human activity on a global scale ([Prillaman, 2022](#)). Proponents of the Anthropocene were

disappointed by the IUGS's refusal and wish to continue the fight 'For now, the SQS and the ICS will sort out how to handle Zalasiewicz and Head's request for a vote annulment. Meanwhile, scientific, and public discussions about how best to describe the Anthropocene continue ... "By voting 'no', they [the SQS] have made a stronger statement,' Ellis says: "that it's more useful to consider a broader view - a deeper view of the Anthropocene." ([Witze, 2024](#)). It should also be noted that it is impossible to draw a precise temporal boundary between the Holocene and the Anthropocene, since the activity of 're-modelling' the Earth by humans is by its very nature diachronic.

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Geologists reject the Anthropocene as Earth's new epoch – after 15 years of debate

But some are now challenging the vote, saying there were 'procedural irregularities'.

Figure 2. Rejet par la Sous-Commission Internationale Stratigraphique du Quaternaire de la proposition de créer une nouvelle Epoque (l'Anthropocène) qui suivrait l'Holocène ([Witze, 2024](#) in Nature).

The reasons for rejecting (and discussing) the vote are reported in the [New York Times](#) (Zhong, March 5, 2024).

6. CONCLUSION

Our lengthy explanation of stratigraphy and its rules, which geologists have been applying for decades, shows just how incoherent this proposal is: we start with an Epoch, the Anthropocene, and then give it a minimum age, the Crawfordian ([Waters et al., 2024](#)), and its duration is unknown. This is enough to confuse any geologist, whether a field geologist or a geochemist! From a geological point of view, this proposal is incoherent, as the International Quaternary

Stratigraphic Subcommittee rightly pointed out, and the decision was endorsed by the highest stratigraphic body, the IUGS. The stratigraphy of the Quaternary is not a simple matter, as shown by the stratigraphy of the [Mediterranean regions](#).

So, what about the Anthropocene? We believe, as do many others, that it represents a particular event on Earth that is strongly tinged with sociology, and even **with guilt about man's actions on Earth**, in the manner of J. Lovelock's Gaia hypothesis ([SCE, 2022](#)). This event also supports the catastrophic scenarios linked to the climate alarmism that is constantly being put forward today. Finally, the Earth has undergone several events that have 'shaped' it, such as the appearance of bacteria that enabled an oxygenated atmosphere to emerge in the Proterozoic (= [Great Oxidation Event](#)), the [conquest of continental \(= cratonic\) areas by vegetation](#) in the Silurian, the emergence of vertebrates from the waters in the Devonian, and so on. Also, the 'Snowball Earth' of the Cryogenian, end of the Precambrian.... These are processes that have significantly transformed our planet and whose action takes place within a Stage, Epoch or other unit depending on their duration. We also speak of the 'Era of the Fishes', the 'Era' of the dinosaurs, etc. without this having the slightest formal meaning. **In formally (= 'officially') rejecting this proposition, the term Anthropocene does not depart from the common-sense rule of geology, namely that a few specific events can be reported without a formal nomenclature being created for each of them.** So, we can simply talk about 'the era of modern man'. But is this useful? Perhaps for anthropologists and sociologists... It could correspond to the Optimum of skyscrapers or thermo-industrial *Era*...!

Let's conclude with Hansen's conclusion ([Hansen \(2024\)](#)): *"The Anthropocene is, at its very best, a propaganda term invented by the environmental movement. It is always used to imply the negative consequences of the rise of Humans and their civilizations.*

I am heartened that The Geologists, even if for the wrong reasons, have rejected, so far, enshrining this basically anti-human propaganda term in the Geological History of the planet.

There is no doubt that humans have become a or the major biological force on Earth, altering their environments to their liking and their own purposes. Humans have certainly been successful. Darwin might have said this means humans are "the fittest".

.. et "At this moment, the Anthropocene is one of the following: 1) Dead, 2) Postponed, or 3) Pending (Figure 3).

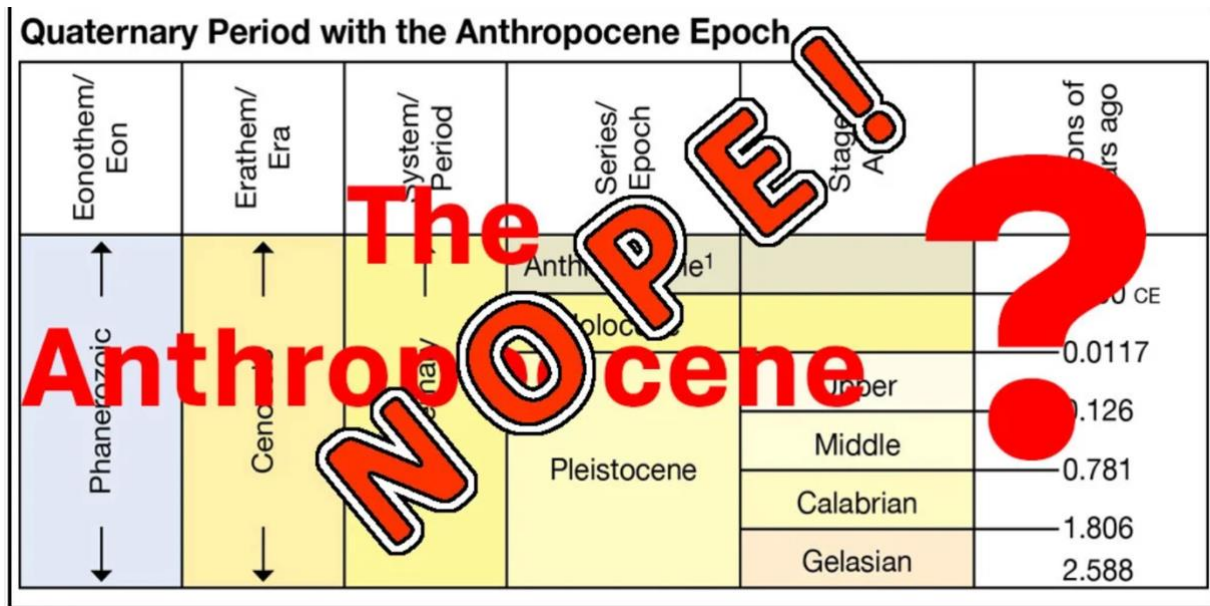


Figure 3. At this moment, the Anthropocene is one of the following: 1) Dead, 2) Postponed, or 3) Pending ([Hansen \(2024\)](#)).

Of course, we do not dispute the impact of man on the planet, but we believe that it is not appropriate to mix 'feelings or sentiments' within the rigorous framework of the rules of stratigraphy. **It seems to us that the Anthropocene is more a new 'Geoethical' unit than a 'Geological' one.** When the rules of stratigraphy are not formally validated (by the IUGS), a unit can be used informally but has no place in the international chronostratigraphic scale. In this context, the Anthropocene is just one event among many in the Holocene. Many events, even extraterrestrial ones, have had an impact on our planet. Once again, they have not been formally defined ([Stein, 2024](#)).