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Opinión

The Anthropocene, should it be a new geological time unit?

El Antropoceno, ¿debería ser una nueva unidad geológica de tiempo?

Carlos Jaramillo[1], Andrés Cárdenas[2], Germán Bayona[3]

[1] Smithsonian Tropical Research Institute, Panama City, Republic of Panama
[2] Universidad Eafit, Bogotá, Colombia
[3] Corporación Geológica ARES, Bogotá, Colombia

Geologists divide the history of the Earth into chronostratigraphic units, each characterized by a unique set of Earth's biota, geochemistry, and climate. These units form the basis of the International Geological Time Scale (IGTS), which defines the geological periods, epochs, and ages (**Figure 1**). The International Commission on Stratigraphy (ICS), which is part of the International Union of Geological Sciences (IUGS), approves the IGTS. The base of each chronostratigraphic unit requires the definition of a "global boundary stratotype section and point" (GSSP). This is a specific site in the planet where the event that defines the onset of the unit is pinpointed in the rock or sediment with a "golden spike", literally, a nail stuck in the rock. For instance, the GSSP for the Eocene/Oligocene boundary is located in a small outcrop called the Massignano Section on the Adriatic coast

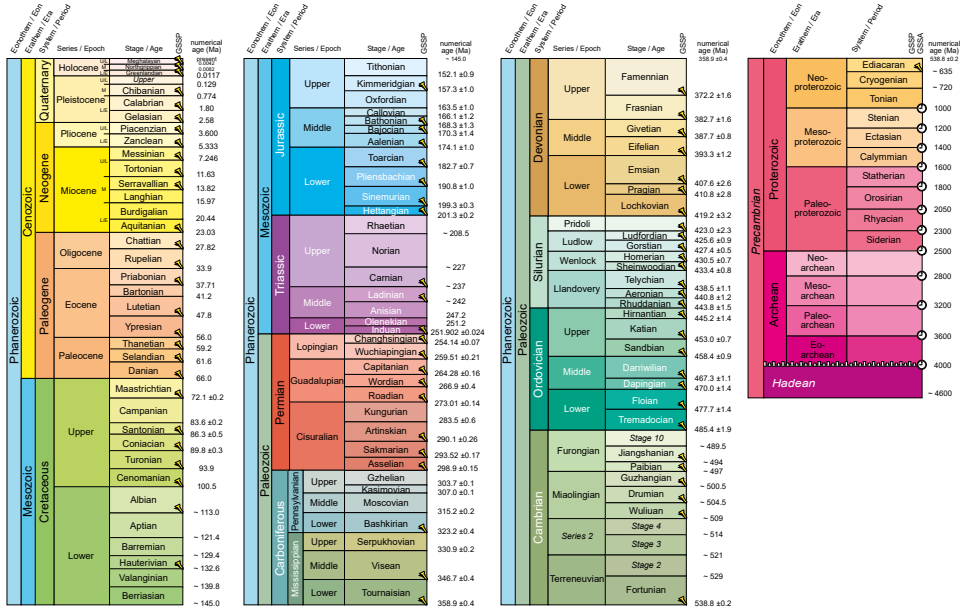

Figure 1. International Chronostratigraphic Chart taken from the International Commission on Stratigraphy (**Cohen *et al.*,** 2013; www.stratigraphy.org/ICSchart/ChronostratChart2022-02.pdf). The units of all the ranks are being defined by the Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries including those of the Archean and Proterozoic eons long defined by the Global Standard Stratigraphic Ages (GSSA). Italic fonts indicate informal units and placeholders for unnamed units. Numerical ages are subject to revision and do not define units in the Phanerozoic and Ediacaran eons, only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

of Italy (**Figure 2**). The GSSP should contain an event recognizable in other rocks around the world. Whenever a geologist says: "this rock accumulated during the early Oligocene", it means that it correlates to the corresponding rock unit in Massignano and that both accumulated simultaneously. Geologists set up committees that oversee the decisions on where to place GSSPs, a meticulous process that can take many years. For example, the committee that decided on the GSSP for the Paleocene-Eocene boundary took more than three decades to reach a decision because, besides purely scientific reasons, many other details were considered as usually happens when a group of people is involved (some of the experts may want to have the GSSP in her/his own country, or in a geological setting related to their research interests).

We are in the Holocene series/epoch belonging to the Quaternary System/Period (**Gradstein *et al.,*** 2020), whose base is 11700 years b2k (before the year 2000), and its GSSP is located in the NGRIP2 Greenland ice core. Over the past few years, geologists have been tinkering with the idea that a new chronostratigraphic unit is needed. This new series/epoch would be part of the Quaternary. It has been called Anthropocene and although the term was not defined by scientific methods, it is broadly used both in scientific and non-scientific literature, and is popular among politicians because the general public associates it with the present time more than any of the other geological periods.

Is it worth all that effort?

There is no question that our species has produced massive transformations of the terrestrial and marine environments and the life that inhabits them at a speed that no other species has done since life originated on the planet. This change can easily be observed in the geological record as there are massive changes whenever humans arrive in a region or increase in population (e.g., the extinction of the megafauna in the Americas, the deforestation of the Yucatán Peninsula during the Mayan urban expansion, the extinction of bird faunas in eastern Pacific islands, and all the impacts of the industrial revolution over the past 200 years). However, the question is not about the changes themselves but how permanent they will be in the geological record.

Figure 2. Golden spike for the Global boundary stratotype section and point (GSSP) of the Eocene/Oligocene boundary located in a small outcrop called the Massignano Section on the Adriatic coast of Italy (Photo by C. Jaramillo)

We geologists cluster together the most recent deposits in geological maps under the Quaternary Period and we subdivide them according to their geological processes, never their age (Holocene, Pleistocene). In some specific cases, we document the age of deposits to determine, for example, earthquake frequency, or to have evidence of climate change in the most recent geological record, always at the scale of tens of thousands of years with an error margin of hundreds of years depending the dating method and the material obtained for age control. In continental environments where humans have had a major impact, the spatial implication of these results is usually local, as Quaternary deposits are spatially restricted. There are few places in our continental environments where no human activity has taken place, therefore, it is necessary to search for sites where (1) sediment deposition has been, is, and will be continuous by natural processes over a range of several thousands of years (e.g., bottom of a lake); (2) human activity has not altered, is not altering, and will not alter the natural environment directly (e.g., farming, construction), and (3) the environment has a regional context (i.e., it can be found in several places in our planet).

With the new subdivision, the Anthropocene, the time scale resolution would change to decades with an error margin of years. This requires state-of-the-art control techniques that only a few laboratories will be able to implement to carry out the analysis with the resolution required to define the Anthropocene time boundary in the sedimentological record at a few millimeters level so it would reflect an event in the history of human activity affecting effectively the Earth system. In summary, the age boundary (a year) would have no significance in the geological record (> 4.500.000.000 years) and the location of the golden spike would correspond to a place that humans would not be able to visit, which means that only a few geologists would see it, and exclusively in an unconsolidated sediment core (more probably in ice, which dissolves rapidly in geological terms), and never in a rock.

Defining a time boundary for the future

Let's say a geologist from another planet comes to Earth in 20 million years. We will be long extinct by then, but will the alien geologist be able to identify the Anthropocene? That is a difficult question. It is hard to imagine that our species could last another 10,000 years without a massive collapse in population density, so let's assume that we will go extinct ten thousand years from now. Consequently, our activity will no longer be, and there is a high probability that many biogeochemical cycles (e.g., carbon, nitrogen) will function again as they did before humans modified them. If that is the case, the extraterrestrial geologist would identify the Anthropocene as a spike of many different variables (e.g., CO_2 and nitrogen concentrations, presence of micro-plastics, etc.). Still, that spike would only last 1,000 to 10,000 years, meaning that this amount of time would be represented by only a few millimeters of rock. Therefore, it would be almost impossible for extraterrestrial geologists to find out that we existed or identify the effects we produced on the planet. That alone would imply that naming a new geological stage after us is useless.

However, the alien geologist would find a layer in the rock record where thousands of species went extinct, a mass-extinction level like that of the meteorite that impacted the Yucatán Peninsula 66 million years ago. Our extraterrestrial geologist would also find a diversity recovery interval a few million years after the extinction event occurred, something that we have identified throughout the last five mass extinction events over the previous 542 million years. Extinction is permanent; once a species goes extinct, it does not return. Therefore, it is worth naming a new series/stage to mark the only long-lasting impact we humans will have on this planet, a human-induced mass extinction.

As discussed above, two criteria need to be determined to define the Anthropocene: what is the event and where it can be observed. The Anthropocene Working Group (AWG), a group of 23 voting members from the International Commission on Stratigraphy, has been discussing when the Anthropocene began focusing around the mid-20th century. There are already several candidates for the event (**Waters & Turner,** 2022): the onset of the 1952 plutonium spike produced by the beginning of the hydrogen bomb tests (a magnificent example of one of our most outstanding scientific achievements, the creation

of a tool to destroy life in the entire planet); the acute increase in CO_2 levels over the past 200 years; the massive postwar use of fertilizers (whose effect can be seen in the Earth's nitrogen cycle); the abundance of microplastics; the profuseness of pesticides; the excess of chicken bones, and several other possibilities. Twelve sites have already been shortlisted including lake beds in the US and China, sediments in the Baltic Sea or the Mediterranean Sea, and growth layers in the Australian coral reef.

Once the AWG reaches a decision, it will have to be approved by the Subcommission on Quaternary Stratigraphy, then by the International Commission on Stratigraphy, and lastly by the International Union of Geological Sciences. This process will have to be completed before or at the international geological congress to take place in South Korea in 2024 when the AWG expires. Hard to tell if this will be possible; stay tuned!

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