

COMMENTS AND REPLIES

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Comment

Finney & Edwards Article

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The article about the Anthropocene by Finney and Edwards (*GSA Today*, v. 26, no. 3–4, p. 4–10) is part of a wider critical commentary we have addressed (Zalasiewicz et al., 2017), and is an essential and welcome part of its analysis. We agree that any formal recognition needs clear focus on the geological evidence, separating this from policy implications. In response, we note the following:

- In current form, the Anthropocene concept entered the formal scientific literature through Paul Crutzen and the Earth System science community, effectively as a hypothesis now being explicitly tested via the stratigraphic record. Antecedents, though, are recognizable in the work of Buffon, Suess, Stoppani, Vernadsky, and others.
- The description of the International Chronostratigraphic Chart by Finney and Edwards misses an important element of the formulation of chronostratigraphic units. These differ one from another, and justify distinct names, not simply because of the lowest occurrence of a fossil species or chemical marker, but by more fundamental changes, for instance to biotic assemblages, ocean/atmospheric chemistry and sediment production, which control stratal character. We note that the periods quoted (*viz.* Ordovician, Devonian, Carboniferous, and Permian) represent major Earth System changes that are reflected in stratigraphic and paleontologic character, even if the lower boundaries are selected using the best correlatory signals. Where detached from Earth System changes, boundaries may prove unsatisfactory, and better marker levels sought—as, currently, for the Carboniferous (a time of massive accumulation and preservation of terrestrial organic matter), with proposals to replace the current conodont-based boundary with one based on multiple signals afforded by the Hangenberg Crisis, a major Earth System perturbation.
- The Anthropocene concept is based upon the stratigraphic record, with a wide range of indicators defining a distinctive body of strata (Waters et al., 2016). This includes lithostratigraphic units associated with urbanization, agriculture, landscape modification, and mineral extraction, already delineated on geological maps, as well as including distinctive components, such as plastics, metals and novel “rocks,” including concrete. Globally, sediments preserve a substantial carbon isotope anomaly, fly ash, changes in nitrogen and phosphorus abundance, persistent organic pollutants and artificial radionuclides. Organismal remains record global mixing of faunas and floras, extinctions, and blooms in the abundance of many species. These marked stratigraphical signals reflect growing human influence over boundary conditions in the Earth System, and are comparable to, or larger than, equivalent signals associated with the advent of the Holocene and its proposed subdivisions. They represent a

physical reality that is considerably more than “minimal” or “negligible.” We consider that modern successions should be treated similarly to the rest of the geologic column, and that geological time continues to the present day.

- The Anthropocene case rests on a wide array of evidence documented within existing strata that represent substantial past events, albeit of geologically brief duration. These strata have similar preservation potential to older strata, where terrestrial deposits tend to erode, and marine deposits, and those in subsiding coastal areas, to preserve; in the intervening coastal realm, deposits on subsiding crust (e.g. large delta tops) have enhanced preservation potential. Many Holocene strata are geologically unremarkable, whereas many Anthropocene sediments, especially those deposited in extensive urban areas, are distinctive in having novel materials and geochemical signatures. Ice sheets also contain Anthropocene stratigraphic signals (and the Greenland ice sheet includes the Holocene GSSP level).
- All chronostratigraphic units are defined by their base and characterized by their content. Both content and potential basal levels of the Anthropocene are being considered, as is conventional. The question of a unitary or dual geological time terminology is irrelevant to this debate: Preparation of a case for a formalized Anthropocene is explicitly in a conventional “dual hierarchy” framework, with an Anthropocene Series as a material counterpart to the temporal Epoch. The key question is not if the Anthropocene is “long enough,” but rather if it is stratigraphically distinct, and if its strata will persist over geological time scales.
- The Renaissance, describing changes in human culture and history, is detached from wider consideration of geology or the Earth System. It is thus a fundamentally different concept from the Anthropocene, which is founded on substantial changes to the Earth System recorded in marked stratal signatures. Many current changes are human-driven, but had they been produced by other means (e.g., a bolide) the geological justification would remain.
- Following standard stratigraphic procedures, a formal proposal on the Anthropocene is envisaged, based on selection of potential GSSP candidates.
- There are clearly societal and political ramifications to the Anthropocene, and to any decision made regarding it, as remains the case for global warming science. That does not disqualify it from scientific analysis, nor from potential geologic formalization. Rather it enhances the case for the rigorous scrutiny it is undergoing.
- The assembly of evidence raises a key question: Are recent changes in the stratigraphic record comparably distinct to shifts used to define and characterize other stratigraphic series/epochs? If so, and if those distinctive attributes are globally correlatable and withstand the test of time, formal recognition of the Anthropocene would be not only be warranted, but essential for communicating a scientific reality—that the magnitude of recent change in the Earth System is at least as great as the change from, for example, the Pleistocene to the Holocene.

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