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Correspondence

The Anthropocene as an epoch is distinct from all other concepts known by this term: a reply to Swindles et al. (2023)

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Swindles *et al*. (2023) correctly point out there are many conceptions of the 'Anthropocene' in use, and they argue that this vagueness in terminology is desirable. We agree that the multiple uses of this term have stimulated much scholarly debate, but we contend that precision in terminology is far more desirable than vagueness, and promotes more productive communication. We also emphasize that an evidence-based approach in defining the Anthropocene strongly argues for its formal definition as a geological epoch with an onset in the mid-20th century. As members of the Anthropocene Working Group (AWG), the body charged with investigating the Anthropocene as a new unit of geological time, we offer alternative perspectives to key assertions made by Swindles *et al.* (2023). In the interest of brevity, we quote each assertion, followed by our view.

- "*Researchers have strong* [i.e. different] *opinions over where the base of the Anthropocene, as a new geological epoch, should be set*".

No alternative timing for the inception of the Anthropocene as an epoch, requiring an isochronous base rigorously supported by stratigraphic evidence, has been formally advanced as a credible option. The Anthropocene, as conceptualised by the AWG, aligns with its understanding in Earth System science to recognise planet Earth's sharp departure from Holocene norms in the mid-20th century, the so called 'Great Acceleration' (Steffen *et al*., 2016; Head *et al.*, 2022a). This essentially agrees with its original conceptualization (Crutzen and Steffen, 2003; Waters *et al*., in press). The inception of this Anthropocene is marked by a wide array of stratigraphic markers clustered around the mid-20th century (Waters *et al*., 2016, 2023; Fig. 1) known as the Great Acceleration Event Array (GAEA; Head *et al.*, 2022b; Waters *et al*., 2022).

- "*It is important that this debate draws from ideas and commentaries beyond the Earth and environmental sciences, because the term 'Anthropocene' is already being used widely across social science and humanities literature*"

Prominent scholars in the humanities have already embraced the Anthropocene in its timescale (chronostratigraphic) sense (e.g. Thomas, 2022; Latour, 2017; Chakrabarty, 2021) and we agree that extending this discourse will lead to the discovery of new alignments between the sciences, social sciences, and humanities consequent on the enormous social, political, and economic upheavals that followed the Second World War. The AWG has benefitted from a unique 10-year collaboration with the Haus der Kulturen der Welt and Max Planck Institute for the History of Science, both in Berlin, which has served as a model of multi-disciplinary discourse and creativity (Rosol and Rispoli, 2022). The AWG has expertise to assess when the chronostratigraphic Anthropocene might begin, but integrating data and concepts from the socio-historical record helps ground and interpret the resulting stratigraphic signals that are crucial to its conceptualization and definition.

- "*The Anthropocene should be used as a purely informal concept to describe our planet's recent history, as characterised by an increasing prevalence and potential dominance of human activities and impacts on the Earth system*"

Rather than aggregating the *increasing prevalence* of human activities and impacts, transformational or otherwise and potentially across tens of millennia, under a single concept and term, we suggest it far preferable to recognise and name many concepts, their range reflecting the complexity, subtlety, and agency of humans and their influence on the planet. Some of these concepts are diachronous with respect to time, whereas for others time is barely relevant. But scholarship moves forward by logical analysis and clarity of thought, and precise terminology is key to this process (Waters *et al*., in press). We therefore assert that scholarship is best served by adopting separate terms (e.g. Hallé and Milon, 2021; Testot and Wallenhorst, 2023) for different concepts, and that the chronostratigraphic Anthropocene, in having an isochronous beginning aligned with a transformational shift of the Earth System, is *immediately*

distinct and conceptually separable from all other concepts. Its strength relies on absolute consistency and wide and systematic application, with an onset intersecting all other interpretations of the Anthropocene as a pragmatically sharp and unyielding boundary in time. This concept is best served by a unique name, and what better than the term Anthropocene, as originally conceived and coined, and bearing the suffix '*cene*' which explicitly affixes this term to an epoch of the Cenozoic Era within the international geological time scale.

- "*Rushing to formalise the Anthropocene as an epoch may … be an exercise in haste. The Earth system continues to change as anthropogenic impacts expand and proliferate*."

As Swindles *et al.* (2023) suggest, future changes to the Earth System may indeed lead to a period-rank (or greater) transition rather than the epoch rank proposed by the AWG, given current rates of change. However, recognition of this would be eased, not hindered, by formal recognition of an Anthropocene epoch justified by our present assessment that the Earth System state has decisively exceeded Holocene norms but not yet those of the Quaternary (Waters *et al*., 2016). Should it do so, future geologists would most likely reason that an Earth System trajectory sharply redirected by overwhelming human impacts in the mid-20th century represents the crucial turning point in this evolving transition. A new period might then be introduced in the future to terminate the Quaternary, though with its base aligned with that of the Anthropocene epoch (Fig. 2). This would require minimal modifications to the time scale, and successive changes could be accommodated by new subdivisions within the Anthropocene. Introducing the Anthropocene as an epoch now would not limit future options, but instead yield the many immediate benefits of formalization. Furthermore, Swindles *et al*. (2023) wonder "*how can the Anthropocene be defined … with only two thirds of the information (past and present)"* and no agreement on its future. But units of the Geological Time Scale are defined only by their base, and the top of the Holocene is presently undefined. As Zalasiewicz *et al*. (2017) pointed out, defining a base for the Anthropocene will provide completeness for our understanding of the highly stable Holocene, with both top and base defined, in contrast with the uncertain planetary boundary conditions that characterize the Anthropocene.

- "*A formalised Anthropocene epoch may provide little geochronological benefit either, as in the absence of an unambiguous and widespread 'golden spike' marking its onset, we remain reliant on several approaches to date young sediment successions …*"

Numerous studies by the AWG (e.g. Zalasiewicz *et al*., 2019; Waters *et al*., 2022, 2023) have highlighted the many stratigraphic indicators that can be used to trace the base of the chronostratigraphic Anthropocene with strikingly high precision (a decade to a few calendar years in some cases), on a global scale, and in a wide range of sedimentary settings (Waters *et al*., 2018; Waters and Turner, 2022; Fig. 1). Within this event array, the primary guide to the GSSP is likely to be the plutonium isotopic signal, which reflects nuclear weapons testing from 1945 onwards (Waters *et al*., 2015, 2019). This signal has a detectable global upturn in the stratigraphic record beginning around and soon after the year 1950 (Han *et al*., in press;

McCarthy *et al*., in press; Waters and Turner, 2022; Waters *et al*., 2023; Fig. 1) and in a range of stratigraphic settings.

- "*The debate regarding the Anthropocene has been useful in: highlighting the proliferating negative human impacts on the planet; fostering interest among non-geological scientists in the Earth system; making geology relevant to climate change issues; and providing the media with a useful and marketable name*."

We agree but the AWG is tasked merely with exploring the Anthropocene as a potential formal chronostratigraphic unit and, if justified, to propose its definition. This remains its focus, with the Anthropocene being treated for definitional purposes as any other ongoing unit of geological time, with an agreed inception in the mid-20th century, and a substantial and strikingly distinctive stratal content documented on a global scale. At present, it has a relatively short duration, nearly 75 years. But its consequences are now certain to reverberate far into the geological future. For example, ongoing rapid and irreversible biotic changes such as accelerated extinctions and translocations evident in the sediment record since the mid-20th century will translate into an even more dramatic change in palaeontological patterns in the future (e.g. Williams *et al*., 2022). Moreover, forward-modelled climate projections at various time scales from a few centuries (Arias *et al*., 2021) to tens of thousands of years (Ganopolski *et al*., 2016; Talento and Ganopolski, 2021) indicate a suspension of the normal glacial–interglacial climate pattern continuing 50 kyr or more into the future (Zalasiewicz *et al*., in prep.). In all projections, this emerges as a climate state sharply different from the relative stability of the Holocene, or at best a human-managed Earth pathway leading to a "super-Holocene" state (Steffen *et al.*, 2018). The future is not yet geological time but these projections contribute to a larger picture that is firmly supported by the stratigraphic evidence.

Formalizing an Anthropocene epoch would not detract from continued debate about anthropogenic impacts on the planet. Indeed, highlighting the punctuation mark caused by the Great Acceleration, which guides the onset of the proposed Anthropocene Epoch, would continue to stimulate healthy and productive debate across disciplines about the role of humans on planet Earth.

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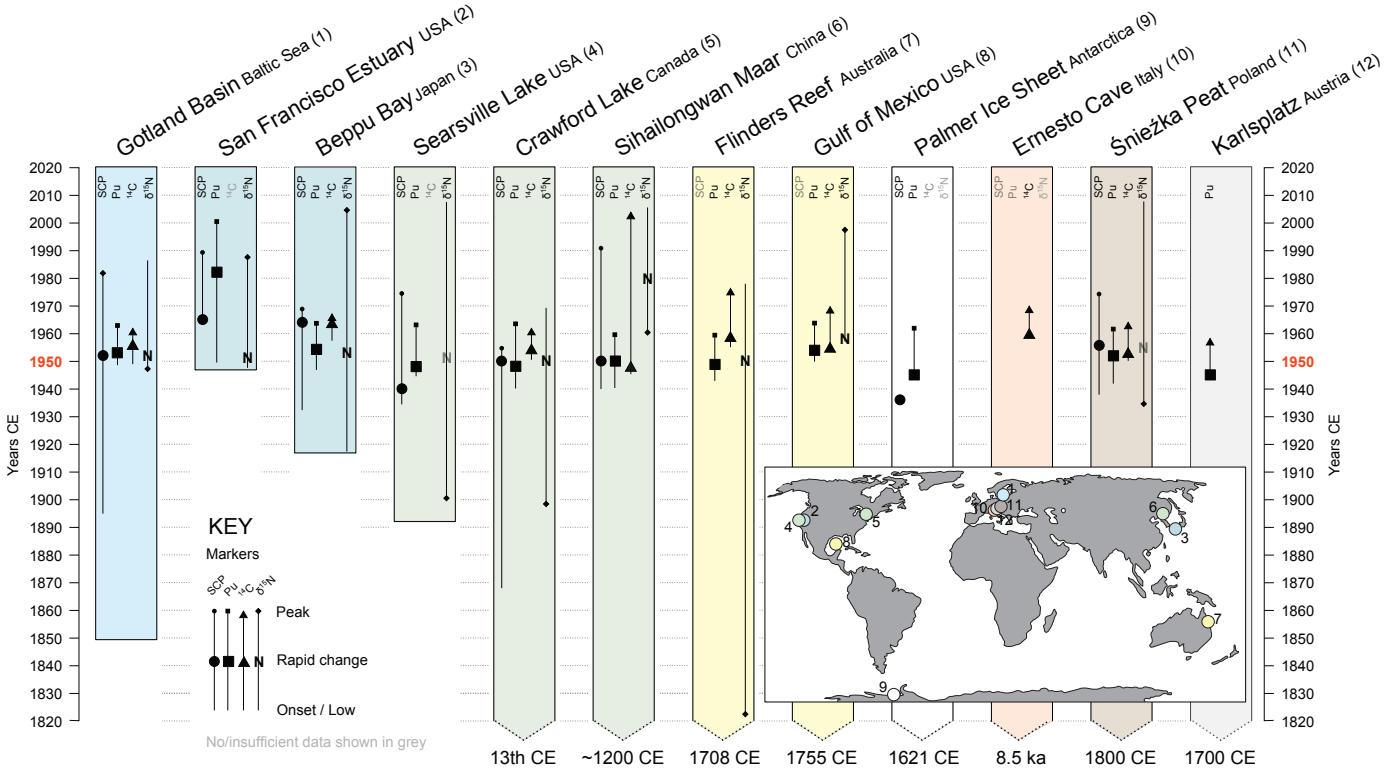
Figure captions

Fig. 1. Candidate GSSPs and other reference sections for the Anthropocene epoch showing the close correlation of significant shifts in, or appearances of, markers between sites clustered around the year 1950 and corresponding to the mid-20th century Great Acceleration Event Array. Colour reflects environment of formation: light blue: anoxic marine basin; blue-green: estuary/coastal; green: lake; yellow: coral; white: ice sheet; pink: speleothem; brown: peat; and grey: anthropogenic. SCP: spheroidal carbonaceous particle; Pu: plutonium; ^{14}C: radiocarbon; ^{15}N: stable nitrogen isotopes (modified from fig. 2 of Waters *et al*., 2023). [Color figure can be viewed at wileyonlinelibrary.com].

Fig. 2. a) Geological time scale for the Quaternary, as sanctioned by the International Union of Geological Sciences/International Commission on Stratigraphy, but with the Anthropocene added as a proposed new series/epoch. Ratified boundaries are identified by a golden spike symbol (indicating a Global boundary Stratotype Section and Point; GSSP); pending and proposed boundaries are marked by a grey spike symbol (from Head *et al*., 2022b). A new stage name (replacing Stage 8) would be based on the locality of the GSSP also defining the Anthropocene. b) A hypothetical future scenario as suggested by Swindles *et al*. (2023) in which the Earth System trajectory has fully departed from Quaternary norms, and might justify the introduction of a new system/period. The planetary response to overwhelming human impacts in the mid-20th century would represent the key turning point at this hierarchical level too. [Color figure can be viewed at wileyonlinelibrary.com].


Gotland Basin Baltic Sea (1)
San Francisco Estuary USA (2)
Beppu Bay Japan (3)
Searsville Lake USA (4)
Crawford Lake Canada (5)
Sihailongwan Maar China (6)
Flinders Reef Australia (7)
Gulf of Mexico USA (8)
Palmer Ice Sheet Antarctica (9)
Ernesto Cave Italy (10)
Śnieżka Peat Poland (11)
Karlsplatz Austria (12)
Years CE
2020
2010
2000
1990
1980
1970
1960
1950
1940
1930
1920
1910
1900
1890
1880
1870
1860
1850
1840
1830
1820
SCP
Pu
^{14}C
δ^{15}N
N
KEY
Markers
Peak
Rapid change
Onset / Low
No/insufficient data shown in grey
13th CE
~1200 CE
1708 CE
1755 CE
1621 CE
8.5 ka
1800 CE
1700 CE

a) IUGS/ICS time scale with Anthropocene added

System / Period	Series / Epoch	Subseries / Subepoch	Stage / Age	GSSP	
					present
Quaternary	Anthropocene		Stage 8		mid-20th century
	Holocene	Upper / Late	Meghalayan		4250 yr b2k
		Middle	Northgrippian		8236 yr b2k
		Lower / Early	Greenlandian		11,700 yr b2k
	Pleistocene	Upper / Late	Stage 4		~129 ka
		Middle	Chibanian		0.774 Ma
		Lower / Early	Calabrian		1.80 Ma
			Gelasian		2.58 Ma

b) Potential future configuration

System / Period	Series / Epoch	
		future
New Period	Anthropocene	mid-20th century
Quaternary	Holocene	
	Pleistocene	