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Response to Merritts et al. (2023): The Anthropocene is complex. Defining it is not

Colin N. Waters^{a,*}, Martin J. Head^b, Jan Zalasiewicz^a, Francine M.G. McCarthy^b, Scott L. Wing^c, Peter K. Haff^d, Mark Williams^a, Anthony D. Barnosky^e, Barbara Fiałkiewicz-Kozielec^f, Reinhold Leinfelder^g, J.R. McNeill^h, Neil L. Roseⁱ, Will Steffen^{j,†}, Colin P. Summerhayes^k, Michael Wagreich^l, Zhisheng An^m, Alejandro Cearretaⁿ, Andrew B. Cundy^o, Ian J. Fairchild^p, Agnieszka Gałuszka^q, Irka Hajdas^r, Yongming Han^m, Juliana A. Ivar do Sul^s, Catherine Jeandel^t, Jaia Syvitski^u, Simon D. Turnerⁱ, Jens Zinke^a

^a School of Geography, Geology and the Environment, University of Leicester, University Road, Leicester LE1 7RH, UK

^b Department of Earth Sciences, Brock University, 1812 Sir Isaac Brock Way, St. Catharines, Ontario L2S 3A1, Canada

^c Department of Paleobiology, Smithsonian Museum of Natural History, 10th Street and Constitution Avenue, NW, Washington, DC 20560, USA

^d Nicholas School of the Environment, Duke University, 9 Circuit Drive, Box 90238, Durham, NC 27708, USA

^e Department of Integrative Biology, University of California, Berkeley, CA 94720, USA

^f Biogeochemistry Research Unit, Institute of Geocology and Geoinformation, Adam Mickiewicz University, Krygowskiego 10, Poznań, Poland

^g Department of Geological Sciences, Freie Universität Berlin, Malteserstr. 74-100/D, 12249 Berlin, Germany

^h Georgetown University, Washington, DC, USA

ⁱ Environmental Change Research Centre, Department of Geography, University College London, Gower Street, London WC1E 6BT, UK

^j Fenner School of Environment and Society, Australian National University, Canberra, ACT 0200, Australia

^k Scott Polar Research Institute, Cambridge University, Lensfield Road, Cambridge CB2 1ER, UK

^l Department of Geology, University of Vienna, A-1090 Vienna, Austria

^m State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710061, China

ⁿ Departamento de Geología, Facultad de Ciencia y Tecnología, Universidad del País Vasco UPV/EHU, Apartado 644, 48080 Bilbao, Spain

^o School of Ocean and Earth Science, University of Southampton, National Oceanography Centre, Southampton, UK

^p School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham B15 2TT, UK

^q Geochemistry and the Environment Division, Institute of Chemistry, Jan Kochanowski University, 7 Uniwersytecka St, 25-406 Kielce, Poland

^r Laboratory of Ion Beam Physics, ETH, Otto-Stern-Weg 5, 8093 Zurich, Switzerland

^s Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Rostock, Germany

^t LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, 14 avenue Édouard Belin, 31400 Toulouse, France

^u INSTAAR and CSDMS, University of Colorado, Boulder, CO, USA

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ABSTRACT

Merritts et al. (2023) misrepresent Paul Crutzen's Anthropocene concept as encompassing *all* significant anthropogenic impacts, extending back many millennia. Crutzen's definition reflects massively enhanced, *much* more recent human impacts that transformed the Earth System away from the stability of Holocene conditions. His concept of an epoch (hence the 'cene' suffix) is more consistent with the strikingly distinct sedimentary record accumulated since the mid-20th century. Waters et al. (2022) highlighted a Great Acceleration Event Array (GAEA) of stratigraphic event markers that are indeed diverse and complex *but* also tightly clustered around 1950 CE, allowing ultra-high resolution characterization and correlation of a clearly recognisable Anthropocene chronostratigraphic base. The 'Anthropocene event' offered by Merritts et al., following Gibbard et al. (2021, 2022), is a highly nuanced concept that obfuscates the transformative human impact of the chronostratigraphic Anthropocene. Waters et al. (2022) restricted the meaning of the term 'event' in geology to conform with usual Quaternary practice and improve its utility. They simultaneously recognized an *evidence-based* Anthropogenic Modification Episode that is more explicitly defined than the highly interpretive interdisciplinary 'Anthropocene event' of Gibbard et al. (2021, 2022). The advance of science is best served through

* Corresponding author.

E-mail address: cw398@leicester.ac.uk (C.N. Waters).

† Deceased

clearly developed concepts supported by tightly circumscribed terminology; indeed, improvements to stratigraphy over recent decades have been achieved through increasingly precise definitions, especially for chronostratigraphic units, and not by retaining vague terminology.

The Anthropocene Working Group (AWG) of the Subcommittee on Quaternary Stratigraphy (SQS) recommended by a binding supermajority vote in 2019 (AWG, 2019) that: (1) the Anthropocene be defined as an official unit within the International Chronostratigraphic Chart (ICC), and (2) the primary guide for the base should be one of many stratigraphic signals around the mid-20th century. It similarly recommended by a binding supermajority vote in December 2022 that the Anthropocene should be accorded the rank of series/epoch. An intrinsic feature of all Phanerozoic units in the ICC is that they are defined at their base by a Global boundary Stratotype Section and Point (GSSP) that fixes a physical isochronous level for global correlation. Consequently, the AWG is assessing reference sections, with the aim of proposing a potential GSSP and auxiliary sections (Waters and Turner, 2022; Waters et al., 2023) for the base of the Anthropocene.

Merritts et al. (2023) state that the majority view of AWG members to define the Anthropocene as a geological epoch – see for example Head et al. (2022a, 2022b, 2022c), Waters et al. (2016, 2018) and Zalasiewicz et al. (2015, 2017, 2019, 2020) – is a narrower concept than Crutzen’s (2002) which arises from Earth System science. This provides a false narrative; both Crutzen and Stoermer (2000) and Crutzen (2002), in their initial proposal of the term, envisaged the Anthropocene as a geological epoch that succeeded the Holocene, although proposing the onset of the Industrial Revolution with a nominal date of 1784 CE. Subsequent investigations within the Earth System community, including contributions by Crutzen (e.g., Steffen et al., 2016), identified the mid-20th century as being the effective starting point – termed the Great Acceleration (e.g., Steffen et al., 2007, 2015; Head et al., 2022a) – for a suite of decisive planetary changes. Investigations of geological successions detailed by Waters et al. (2022), corroborated through analysis of potential candidates for a GSSP for the Anthropocene (Waters and Turner, 2022; Waters et al., 2023), have since clarified that numerous anthropogenic markers show the most abrupt and globally widespread change, and of greatest magnitude, around the mid-20th century. The concept is the same as the original proposal, but with a slightly later inception and grounded in the geological sciences. The ~1950 age for the onset of the Anthropocene was indeed already being considered as early as 2001 (Meybeck, 2001; see review in Luciano, 2022), reflecting the key date at which many indicators of human impact extended globally. By contrast, it is the proposal outlined by Gibbard et al. (2021, 2022) and supported by Merritts et al. (2023) that

markedly diverges from the original concept of the Anthropocene, by proposing that the Anthropocene represents an informal, spatially and temporally heterogeneous ‘event’, in effect recording all ‘transformative’ anthropogenic impact on the planet.

Gibbard et al. (2021, p. 4) consider the “*Anthropocene as a major transformative episode in Earth history, in keeping with similar scale events in the earlier geological record*” [our emphasis] showing conflation of terms having differing stratigraphic meaning. We argue that the long-duration, heterogeneous and time-transgressive concept of Gibbard et al. (2021, 2022) and supported by Merritts et al. (2023), removed from its social sciences contextualization, would be broadly consistent with an informal episode, one termed the ‘Anthropogenic Modification Episode’ (AME) in Waters et al. (2022) – a very different concept from a chronostratigraphic Anthropocene, but potentially complementary to it (Fig. 1). The geological evidence, detailed by Waters et al. (2022), of multiple markers showing abrupt change during the mid-20th century, which we term the Great Acceleration Event Array (GAEA), is neither mentioned nor refuted by Merritts et al. (2023).

Merritts et al. (2023) assert that “Ager (1973) ... applies the word ‘event’ to happenings of both short and long duration”. This entirely misrepresents Ager’s notion of an “event”, a term he used almost without exception in the context of rapid, sudden and catastrophic change, and attached to his “quantum sedimentation”. Ager introduced “event stratigraphy” as a method specifically to allow the recognition of near-isochronous planes of correlation that crosscut diachronous changes in lithology and biostratigraphy (figs. 7.1 and 7.2 in Ager, 1973, and fig. 1 in Head et al., 2022b). It is in this context, and that of normal Quaternary use (e.g. fig. 2 in Head et al., 2022b; Fig. 1), that we use the term “event” in its narrower, more precise, and to us more useful sense. The so-called Great Oxidation ‘Event’ (GOE), referenced by Merritts et al. (2023) as an analogue of their concept of an Anthropocene event, lasted in excess of 300 Myr and hence of longer duration than the combined Mesozoic and Cenozoic eras, comprising ~6.6% of all recorded geological time. This is surely the antithesis of rapid, sudden and catastrophic change.

Merritts et al. (2023) incorrectly state that we define episodes as “greater than approximately 1,000–10,000 years”. We provided no such absolute values to discriminate between events and episodes, but merely wished to give some guidance as to relative temporal scales, stating that events should be considered as “effectively days to thousands of years” in duration and episodes as of “tens of thousands to millions of years”

IUGS/ICS time scale with Anthropocene added

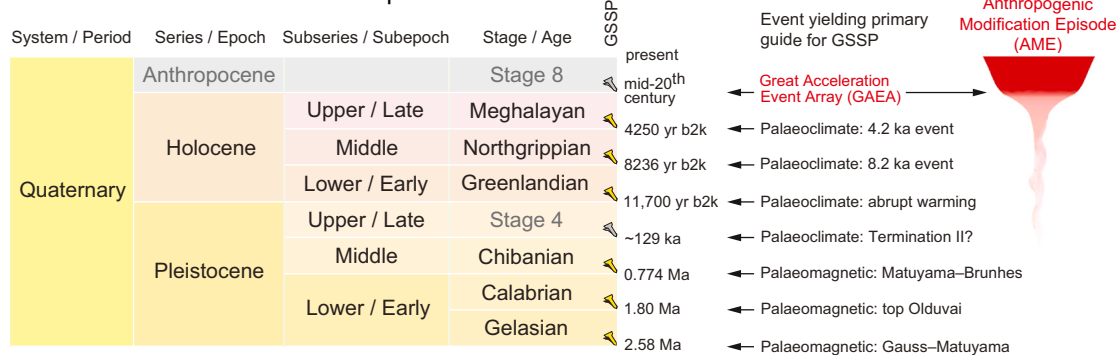


Fig. 1. Geological Time Scale for the Quaternary, but with the Anthropocene added. All units are characterised at their base by abrupt geological events, and the Anthropocene would therefore conform to standard event-stratigraphic practice with the Great Acceleration Event Array (GAEA). Our Anthropogenic Modification Episode (AME) is the geological equivalent of the interdisciplinary ‘event’ concept of Gibbard et al. (2021, 2022) and Merritts et al. (2023). Modified from fig. 1 of Head et al. (2022c).

duration (Waters et al., 2022). This aligns with the description of event stratigraphy by Rawson et al. (2002, p. 29), a source we cite but overlooked by Merritts et al. (2023), as the “stratigraphical traces of relatively short-lived events (instant to thousands of years)”.

The term ‘event’ in geology suffers because, unlike in chronostratigraphy, it is used informally, lacks precise definition and can be used (or mis-used) without regulation and clear understanding. Consequently, the term has been applied to geological phases varying markedly from at least the usual Quaternary understanding of the term. The ‘Anthropocene’ is similarly developing alternative interpretations very different to Crutzen’s original meaning of the term, partly because the Anthropocene has yet to be formally defined: the AWG must follow standard and necessarily careful and lengthy protocols in proposing formalisation. Without formal definition as a chronostratigraphic unit, the Anthropocene may well be reduced to the same level of vague usage and diminished utility that has beset the term ‘event’. In contrast, the base of the proposed Anthropocene epoch is clearly delineated by numerous proxies that record changes in Earth systems well beyond the Holocene range of environmental variability within a decade in the mid-20th century at all GSSP candidate sites (Waters and Turner, 2022; Waters et al., 2023).

Our review of deep-time examples of events and episodes provided a potential scheme to aid both authors and journals with clearer definition and more exact communication of these terms. Precise terminology is essential in science, and the enterprise of the Geological Time Scale relies upon unambiguous language and criteria. In this context, the Anthropocene is not a single prolonged and limitlessly changeable ‘event’, but a finely delineated and synchronous global phenomenon that may be usefully defined as an epoch/series via the ultra-high-resolution stratigraphy afforded by the GAEA.

In summary:

1. Events are used as chronostratigraphic markers to subdivide the entire Quaternary (Fig. 1), and there is no reason why they should not be used in this way to define the Anthropocene (Head et al., 2022b, 2022c);
2. Merritts et al. (2023) apply a term etymologically crafted for a chronostratigraphic unit at epoch-rank for a vaguely defined diachronous unit;
3. By defining and characterising their concept in interdisciplinary terms, it is unclear why these authors then consider it stratigraphically robust and call it a ‘geological’ event;
4. It is unclear why their highly nuanced interdisciplinary concept cannot be used alongside the very different, evidence-based, and potentially complementary Anthropocene epoch (Fig. 1).
5. The scale, significance and transformative effect of the Great Acceleration, representing a sharp planetary shift in the mid-20th century and uniting Earth System and chronostratigraphic definitions of the Anthropocene, appears to be denied by Merritts et al. (2023) without scientific justification.

Author contributions

All authors developed and contributed to drafts of the text as part of their voluntary AWG efforts.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Colin N. Waters and some of the coauthors report a relationship with Haus der Kulturen der Welt, Berlin, that includes: funding grants and travel reimbursement.

Data availability

No data was used for the research described in the article.

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