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Commentary

Comment on "When did the Anthropocene begin? A mid-twentieth century boundary is stratigraphically optimal" by Jan Zalasiewicz et al. (2015), *Quaternary International*, 383, 196–203

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ABSTRACT

We offer a comment on the paper: "When did the Anthropocene begin? A mid-twentieth century boundary is stratigraphically optimal" by Jan Zalasiewicz et al. (2015), *Quaternary International*, 383, 196–203. We consider this proposal in the context of the procedures and terminology employed by the International Union of Geological Sciences which underpin the formal designation of chronostratigraphic units. Our conclusion is that there is no practical value in establishing the lower boundary of a new interval of geological time in the mid-twentieth century; equally, there is no sound stratigraphical basis for designating an additional chronostratigraphic unit above the Holocene in the international Geological Time Scale.

1. Introduction

In a recent paper in *Quaternary International* (2015), Jan Zalasiewicz and members of the Anthropocene Working Group of the Subcommission on Quaternary Stratigraphy (SQS), a component body of the International Commission on Stratigraphy (ICS), outline three options for defining the onset of the 'Anthropocene': an 'early Anthropocene' some thousands of years ago; the onset of the Industrial Revolution at ~1800 CE (Common Era); and the 'Great Acceleration' of the mid-twentieth century (Steffen et al., 2007). Of these, they consider that the last named has the most pronounced and globally synchronous signal, and propose that the onset of the 'Anthropocene' be marked not by a Global Boundary Stratotype Section and Point (GSSP), as is established practice in the International Chronostratigraphic Chart of the ICS (Cohen et al., 2013) which shows the formally ratified Geological Time Scale (GTS), but rather by a Global Standard Stratigraphic Age (GSSA), in other words a particular point in time defined, in this instance, in terms of the human calendar. They suggest that the boundary be recognised in geological (specifically chemostratigraphical) records by radiogenic fall-out from atmospheric nuclear devices, and dated at the timing of the detonation of the first nuclear bomb at Alamogordo, New Mexico, USA, on 16th July 1945. Here we offer some observations on this proposal, and also consider some of the wider issues relating to the concept of the 'Anthropocene'.

2. GSSP or GSSA

As Zalasiewicz et al. (2015) note, all the units of the Phanerozoic Eon in the International Chronostratigraphic Chart are now defined, or will eventually be defined, by GSSPs or 'golden spikes'. This is because the stratigraphic record (fossil, isotopic, geochemical) is considered to provide a more secure basis for correlation than numerical ages (GSSAs). The latter have been used in the past and, as Zalasiewicz et al. point out, particularly so in the Precambrian, principally because of the absence in these ancient layers of the earth's geological record of diagnostic biostratigraphic markers. However, a consensus is now developing in the ICS that abstract period definitions based on time can no longer be sustained in the Precambrian rock record and that GSSAs must become GSSPs, using observable and correlative geological events (Gradstein et al., 2008). Indeed, the move towards the development of a 'natural'

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time scale for the Precambrian began some years ago (Bleeker, 2004), and a largely GSSP-based chronostratigraphic division of the Precambrian is now under consideration (Van Kranendonk et al., 2012). The designation of the base of the 'Anthropocene' by a GSSA would therefore be at odds with the practice now being adopted in all other parts of the GTS.

Zalasiewicz et al. also state that: *"The last unit to be defined by a GSSA, the Holocene…… has recently been replaced by a GSSP dated at 11,703 ice-layer years b2k (before 2000 CE: pg 5)"*. Strictly speaking, this statement is not correct. The base of the Holocene was never *formally* defined as a GSSA. Although the term 'Holocene' had been in common use since it was adopted by the International Geological Congress in Paris in 1885 to refer to the most recent episode of earth history, it was not until the meeting of the INQUA Holocene Commission in Paris in 1969 that it was agreed that the Pleistocene–Holocene boundary should be defined *chronometrically*, and should be placed at 10,000 ^{14}C yr BP (Hageman, 1969). At the time, it was anticipated that a boundary GSSP would subsequently be designated in a varved sequence in Sweden (Mörner, 1976) but, for a variety of reasons, this never occurred. At the INQUA Congress held in Moscow in 1982, therefore, the Holocene Commission simply reaffirmed the age-based boundary (Olausson, 1982). But, no proposal for a GSSA was ever submitted for ratification to the International Union of Geological Sciences (IUGS) via the ICS, although 26 years later the base of the Holocene was formalised by a GSSP (Walker et al., 2008, 2009). Prior to that, while the Pleistocene–Holocene boundary may have been radiometrically-based, it was not formally ratified as a GSSA in the international GTS.

3. Status and nomenclature of the 'Anthropocene'

Zalasiewicz et al. explicity state in their paper that resolution of the question regarding when the Anthropocene began is *"separate from whether the Anthropocene should be formalised or not"*, and that they are not *"…addressing the question of the hierarchical level of the Anthropocene: that is, whether it should be considered (or potentially formalized) at Epoch level"* (p. 2).

But both of these issues are intimately bound up with defining the onset of the 'Anthropocene' and, moreover, it is implicit in the text that matters have already been resolved. For example, in their discussion of the distinction between chronostratigraphy and geochronology, Zalasiewicz et al. refer only to the 'Anthropocene Series' or 'Anthropocene Epoch'. Elsewhere in the text, the 'Anthropocene' is invariably referred to as an 'epoch'. Indeed, reference is also made to the 'Holocene–Anthropocene' boundary, which carries the clear implication that the 'Anthropocene' is already accepted as a unit of series/epoch status, in other words of equivalent rank in the GTS to the Holocene, from which it is to be decoupled. No consideration is given to the possibility that the 'Anthropocene' might be designated a unit of lesser rank, i.e. of stage, age, or even sub-stage/sub-age status, and hence could become a subdivision of the Holocene (cf. Walker et al., 2012). The problem, of course, lies as much in the terminology as in the stratigraphic record, for in the formal nomenclature of the GTS the suffix '-cene' is strictly reserved for units designated to be of series/epoch rank (e.g. Pliocene, Miocene, Eocene, Oligocene). So there is no question for Zalasiewicz et al. to consider regarding the status of the 'Anthropocene'; the decision has already been taken. To a degree, therefore, the authors are being disingenuous here. By the same token, if the new chronostratigraphic unit is to be accorded 'epoch' status, then it is evident that, in due course, the proposal to the ICS will be to formalise it at this rank.

There is a further point to make regarding terminology, and the use of the suffix '-cene'. In the GTS, '-cene' derives from the Greek καιωο (Latinised to 'kainos'), meaning 'new'. Thus we find, for example, *Miocene* (Greek Latinised to 'Meion' for 'less' and 'kainos' for 'new', hence 'less new'); *Pliocene* ('Pleion' meaning 'more' and 'kainos', hence 'more new'); and *Pleistocene* ('Pleistos' meaning 'most' and 'kainos', hence 'most new'). These terms, each relating to changes in the relative abundances of molluscan taxa in Cenozoic stratigraphic sequences, had been introduced in the 1830s by Sir Charles Lyell in his magisterial *Principles of Geology* (1830–1840), and have long been established in the GTS. The term *Holocene*, first used by Gervais (1867–69) and deriving from the Greek 'holos' meaning 'whole' or 'entire' and 'kainos', therefore meaning 'wholly' or 'entirely new', has again been embedded for more than a century in the GTS. The more recently-introduced term 'Anthropocene' (Crutzen and Stoemer, 2000; Crutzen, 2002), would be written in Greek as: 'Αντηροποκαιωο'. Literally translated this means 'human-new', which makes no sense at all, as humans have been a major component of earth history throughout the Holocene (and earlier?) and, of course, it is the signature of humanity in the geological record of the last 11,700 yr that provides the justification for separating the Holocene from the Pleistocene as a chronostratigraphic unit of equal (series/epoch) rank (Gibbard and Walker, 2014). It is difficult, therefore, to see the justification for introducing a new term of dubious etymology into the international GTS.

4. A synchronous or diachronous onset for the 'Anthropocene'

In considering possible start dates for the 'Anthropocene' and the signatures of different forms of human impact in the geological record, Zalasiewicz et al. acknowledge that anthropogenic signals of, for example, agricultural origins or industrialisation, will inevitably be time-transgressive, and these will be reflected in diachronous boundaries in stratigraphic sequences. Indeed, this has been one of the pervasive problems with the 'Anthropocene' concept, and one that has repeatedly been cited by critics of the 'Anthropocene' since it was first proposed as a new interval of geological time (e.g. Autin and Holbrook, 2012; Gale and Hoare, 2012; Ruddiman, 2013; Gibbard and Walker, 2014). So it is not surprising that Zalasiewicz et al. have opted for the one potential boundary for the 'Anthropocene' that is broadly synchronous at the global scale unless, of course, the more radical (but eminently plausible) proposal of Smith and Zeder (2013) is adopted, which sees the 'Anthropocene' and Holocene as potentially coterminous chronostratigraphic units. But at the same time that the Zalasiewicz et al. paper appeared in *Scopus Early View*, a second paper was published in the journal *The Anthropocene Review* which:

> *"….presents a very different perspective to that put forward by the argument for the mid-20th century start for the Anthropocene, marked by nuclear fallout from atomic bomb tests….. It does so, crucially, not by proposing an alternative date; rather it challenges the rationale of imposing a precise and globally synchronous date onto processes that stratigraphic evidence indicates were – and still are – manifestly diachronous in onset and development"* (Edgeworth et al., 2015, p. 19).

While this paper offers an interesting archaeological perspective on the 'Anthropocene' debate, a curious fact is that three of the authors are also co-authors on the Zalasiewicz et al. paper which, of course, expresses a diametrically opposing view on the start of the 'Anthropocene'! It invites the question as to which position (the 1945 synchronous radiogenically-defined boundary, or the diachronous archaeologically-defined boundary) these authors now subscribe to? One or the other, maybe, but certainly not both!

5. Practical issues

As Eric Wolff (2014) has pointed out, we do not yet know the full extent of anthropogenic impacts on global systems, and further significant changes undoubtedly lie ahead; he therefore poses the question as to whether it is too soon to define a new geological time unit? Zalasiewicz et al. acknowledge this point, but argue that there are now sufficient manifestations in the biosphere and ocean/atmosphere system that are commensurate with period/era level changes to proceed towards formal acceptance of the 'Anthropocene'. But it nevertheless remains the case that if the 'Anthropocene' is to be formalised as a new geological unit it will, with the exception of the Holocene, be the first in the GTS to have been so ratified before the time interval has ended. With regard to the Holocene, however, fully 11,700 years of earth history have elapsed sufficient, surely, to understand the full extent of environmental, geological and human changes during the course of that epoch. That is certainly not the case with the 'Anthropocene'.

A second question relates to the practical value of a formally-defined chronostratigraphic unit that began less than a single human lifetime ago. The GTS is designed to provide a stratigraphically ordered record that provides a basis for classification, correlation and interpretation of earth history at the global scale. It is difficult to understand how demarcation of the last 70 years of the geological record (or maybe even the last ~50 yr, as suggested by Lewis and Maslin, 2015) as a discrete formalised chronostratigraphic unit enhances our understanding of that record, and aids in either interpretation or correlation. This is even more so since formal designation of the 'Anthropocene' as a new unit of geological time would apply only to one third of the planet's stratigraphic record, for a lower boundary dated to no more than 50–70 years from the present day would be effectively unresolvable in most marine sedimentary sequences (see below).

A third question is why should the 'Anthropocene' be *formalised* at all as a new geological episode? There are numerous terms, such 'Medieval Period' and 'Little Ice Age', which are employed in both historical and scientific discourse, yet are not defined as formal units of geological time (Gibbard and Walker, 2014). Similarly, in older parts of the geological record, terms such as 'Variscan', 'Grenvillian', and 'Snowball Earth' are commonly used to describe episodes of earth history, but which also remain undefined in the GTS (Finney, 2014). It is equally evident that organisms other than humans have, at particular times, impacted significantly on Earth systems. For example, both the great Ordovician diversification event, and the evolution and colonisation of vascular land plants from the late Devonian to the early Permian, left a significant stratigraphic record, yet the major global changes that ensued are not represented by formally-defined geochronological or chronostratigraphic units (Finney, 2014). Indeed, all organisms, by their very presence, modify their environments, so *"why should human impact on the Earth system be different? Might the desire to establish the 'Anthropocene' as a formal unit be anthropocentric?"* (Finney, 2014, p. 26).

6. Conclusions

We emphasise that none of the above questions the overwhelming evidence that humanity is now a major factor in global planetary dynamics. Rather, our concern is to centre the debate not on whether people are driving climate and environmental change, but rather on the proposal that these changes register sufficiently strongly and unequivocally in the Earth's stratigraphic record to warrant the recognition of a new unit in the international GTS. It is our view and, we suspect, it is also the view of many others within the geological community that a convincing case has yet to be made (Monastersky, 2015). While anthropogenic detrital material might form a discernable stratum in some depositional sequences, the reality is that a 50-year interval is unlikely to represent more than a few centimetres in these profiles, making it difficult to identify clear dateable changes and to establish correlations between sequences (Lewis and Maslin, 2015). Moreover, in localities where sedimentation rates of less than a few millimetres in a thousand years occur, such as in the deep-ocean abyssal plains, the episode will be unrecognisable, unless material such as plastics or carbonaceous particles, are present. There is no justification for recognising a high-status geological interval based on this type of evidence. While we acknowledge that, at some point in the future, geologists may look back and identify a discernable 'tipping point' reflected in the stratigraphic record which indicates the overwhelming influence of humanity, we see, at present, no practical value in establishing the lower boundary of a new interval of geological time in the mid-twentieth century. Our position remains that we continue to live within the formally-defined and ratified Holocene Series/Epoch (Gibbard and Walker, 2014), and that there is no sound stratigraphical basis for designating an additional chronostratigraphic unit above the Holocene in the international Geological Time Scale.

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