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Viewpoint

The Working Group on the Anthropocene: Summary of evidence and interim recommendations

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ABSTRACT

Since 2009, the Working Group on the 'Anthropocene' (or, commonly, AWG for Anthropocene Working Group), has been critically analysing the case for formalization of this proposed but still informal geological time unit. The study to date has mainly involved establishing the overall nature of the Anthropocene as a potential chronostratigraphic/geochronologic unit, and exploring the stratigraphic proxies, including several that are novel in geology, that might be applied to its characterization and definition. A preliminary summary of evidence and interim recommendations was presented by the Working Group at the 35th International Geological Congress in Cape Town, South Africa, in August 2016, together with results of voting by members of the AWG indicating the current balance of opinion on major questions surrounding the Anthropocene. The majority opinion within the AWG holds the Anthropocene to be stratigraphically real, and recommends formalization at epoch/series rank based on a mid-20th century boundary. Work is proceeding towards a formal proposal based upon selection of an appropriate Global boundary Stratotype Section and Point (GSSP), as well as auxiliary stratotypes. Among the array of proxies that might be used as a primary marker, anthropogenic radionuclides associated with nuclear arms testing are the most promising; potential secondary markers include plastic, carbon

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isotope patterns and industrial fly ash. All these proxies have excellent global or near-global correlation potential in a wide variety of sedimentary bodies, both marine and non-marine.

1. Background

In common usage, the Anthropocene refers to a time interval marked by rapid but profound and far-reaching change to the Earth's geology, currently driven by various forms of human impact. The term stems from Paul Crutzen's improvisation at a conference in Mexico in 2000, and subsequent publications the same year (with Eugene Stoermer, who had been using the term informally for some years previously) and 2002. Although the term arguably had significant antecedents (see Steffen et al., 2011; Hamilton and Grinevald, 2015), Crutzen's intervention marked the widespread adoption of the Anthropocene in the literature, at first among the Earth System science (ESS) community in which he is a central figure (e.g. Steffen et al., 2004), and subsequently more widely. Crutzen explicitly proposed the term as a geological time unit, with his use of the term 'epoch' and suggestion that the Holocene had effectively terminated (Crutzen, 2002), but it had not been subjected to any of the formal processes of the International Commission of Stratigraphy (ICS), which are required for inclusion within the International Chronostratigraphic Chart (=Geological Time Scale (GTS) of common usage). Indeed at that stage the stratigraphic community was not yet involved in the discussion.

Initial consideration within the stratigraphic community began in 2008, by the Stratigraphy Commission of the Geological Society of London, prompted by wider appearance of the Anthropocene in the scientific literature, often without the caveat that this was an entirely informal unit. Based on an overview of evidence, a large majority of members of this national body agreed that the term had sufficient 'stratigraphic merit' to be considered for potential formalization (Zalasiewicz et al., 2008). This led to an invitation from the Subcommission of Quaternary Stratigraphy (SQS), the relevant component body of the ICS, to establish a working group to examine the question formally. The working group, officially designated as Working Group on the'Anthropocene' (AWG) began activities in 2009 and included several of the members of the Stratigraphy Commission of the Geological Society of London who had contributed to the call for consideration of formalization (Zalasiewicz et al., 2008).

From the beginning, the AWG represented a broader community than is typical of ICS working groups, which for the most part consist mostly or entirely of stratigraphers and palaeontologists experienced in the rocks and fossils of the particular time unit under study. However, because the Anthropocene concept not only spans geological time but also involves an evaluation of human impact upon the Earth System through historical and instrumental records, it was considered appropriate to include representatives of the community working on the processes of contemporary global change including climate science, ecology, archaeology, human history and the history of science, oceanography, polar science and even international law (for which the Anthropocene had begun to be used as a framing concept: Vidas, 2011). Such breadth of expertise reflects both the potential utility of the term for a range of disciplines and communities, and, for such a recent time interval, the significant evidence from other Earth-related disciplines that can be considered in stratigraphic terms. Nonetheless, the fundamental tasks undertaken by the AWG were geological: to assess whether the Anthropocene could be considered a potential chronostratigraphic/geochronologic unit, and to determine whether it is sufficiently different from the Holocene Epoch of geological time (which began 11,700 years ago: Walker et al., 2009) to warrant establishment of a new geological epoch or indeed a unit of higher rank with global correlation potential.

The AWG follows standard stratigraphic procedures (e.g. Remane et al., 1996), rather than embracing any alternative interpretations of the Anthropocene that have emerged outside of the geological and ESS communities (e.g. Corlett, 2015; Lövbrand et al., 2015; Ruddick, 2015; Lidskog and Waterton, 2016; Bennett et al., 2016). While the AWG acknowledges keen and broad interest in the concept of an Anthropocene, as well as the significance of the term for addressing and connecting to societal questions, the role of the AWG, as constituted, is to evaluate the relevant stratigraphic evidence.

Consideration of the Anthropocene as a unit of geological time nevertheless required a wide initial approach, because the way it emerged may be said to have turned stratigraphy on its head (Barnosky, 2014). The great majority of chronostratigraphic units emerged in broad terms as a result of prolonged study of the rock record, dating back to the 19th century and even earlier, later followed by better understanding of their stratigraphic quality and more precise delineation using high-resolution biostratigraphy, technical advances in radiometric dating, cyclostratigraphy and stable isotope chemostratigraphy. By contrast, the Anthropocene of Crutzen and the ESS community (Seitzinger et al., 2015) emerged as a concept (or a mooted epoch) based on contemporary observations of Earth System processes compared to a Holocene baseline as discerned from paleoenvironmental studies, with little consideration of the recent stratal record. Hence, the early focus of AWG analysis included consideration of the range of evidence of recent global change, combined with particular emphasis on determining whether this change was associated with sufficient potential geological evidence to make the case for the Anthropocene as a new chronostratigraphic unit, and if so at what rank. There are several theoretical possibilities for rank, including that of substage/subage, series/epoch, and system/period. If the Anthropocene were considered distinct from the Holocene Series/Epoch, then it would be necessary to assess when the transition from Holocene to Anthropocene occurred. Ultimately this analysis involves establishing whether there is a stratal record that might provide chronostratigraphic support for the proposed epoch, and which stratigraphic entities might be used to characterize, correlate and define it.

The work of the group was mostly conducted via email and the sharing of manuscripts, as the basis for discussions concerning published evidence from various sources, to see if it would be possible to compile a range of lithostratigraphic, chemostratigraphic and biostratigraphic evidence in stratal archives that might represent a potential Anthropocene time interval. Four AWG meetings took place through the kind support of: the Geological Society of London (London, 2011), the Haus der Kulturen der Welt (Berlin, 2014), the MacDonald Archaeological Institute (Cambridge, UK, 2015), and the Fridtjof Nansen Institute (Oslo, 2016).

The group identified a number of changes to the Earth System that characterize the geological Anthropocene. These include: marked acceleration of rates of erosion and sedimentation; large-scale chemical perturbations to the cycles of carbon, nitrogen, phosphorus and other elements; the inception of significant change in global climate and sea level; and biotic changes including unprecedented levels of species invasions across the Earth. Many of these changes are geologically long-lasting, and some are effectively irreversible. A range of potential proxy signals emerged as potentially important during the analysis, for instance the spherical carbonaceous particles of fly ash (Rose, 2015; Swindles et al., 2015), plastics (Zalasiewicz et al., 2016), other 'technofossils' (Zalasiewicz et al., 2014a, 2016) and artificial radionuclides (Waters et al., 2015), changes to carbon and nitrogen isotope patterns (Waters et al., 2016) and a variety of fossilizable biological remains (Barnosky, 2014; Wilkinson et al., 2014). Many of these signals will