The London School of Economics and Political Science

Ratifying the Anthropocene: A study of the Anthropocene Working Group's ongoing effort to formalize the Anthropocene as a unit of the Geologic Time Scale.

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A thesis submitted to the Department of Law of the London School of Economics and Political Science for the degree of Doctor of Philosophy, London, June 2021.

Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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I declare that my thesis consists of 98,910 words.

Abstract

This thesis provides an account of the ongoing effort to define the Anthropocene as a formal geological unit. Coined in 2000 by the atmospheric chemist Paul Crutzen, the term 'Anthropocene' has become symptomatic of a critical-theoretical *zeitgeist*: from a warning concerning the "deep time" effects of anthropogenic climate change, to an epistemological critique of the "human subject". It is a theme that has taken on significance in critical legal theory as well. I respond to these debates, focusing on a component of the Anthropocene thematic that is often overlooked: the political, legislative, and historical dynamics of geology as a scientific discipline. Beginning in the seventeenth century, techniques such as fossil correlation and the relative ordering of earth's material deposits have redefined understandings of scriptural authority, bringing geoscience to bear on the predominant existential reckonings of the day. Since 2008, the Anthropocene Working Group (AWG), a team of geologists, Earth System scientists, historians, and also including a lawyer, have been compiling a proposal to include an Anthropocene unit within the Geological Time Scale, the formal guide for the designation of time and space over 4.5 billion years of earth history. Folding contemporary concerns and events into transhistorical deep time, the AWG's formalization effort can be seen as an attempt to advance novel strategies of geoscientific classification in a manner continuous with contemporary social anxieties. Engaging the formalisation effort as a legislative exercise, I provide a genealogical account of the evaluative procedures in which the formalization of an Anthropocene unit is situated, and engage participant observation of the AWG, tracking the controversies, negotiations, and procedures involved in their effort to ratify a new geological unit. Ultimately, I argue that the effort to define an Anthropocene unit unfolds as a process of refiguring the significance of geoscience in society.

(296 words)

Acknowledgements

I would like to thank my supervisors Alain Pottage and Stephen Humphreys for their time, generosity, patience, and support from day one. I cannot have asked for more inspiring and caring supervisors.

Thank you to Susan Marks, Garry Simpson, Rita Astuti and the PhD Academy for providing structure and regular order in my day-to-day experience of the PhD program at LSE.

A special thank you to Jan Zalasiewicz, Colin Waters, Mark Williams, Martin Head, Francine McCarthy, Phil Gibbard, Kim Cohen, and Stan Finney from the AWG, SQS, ICS and IUGS who were exceptionally generous with their time.

The Economics & Social Research Council provided financial support during throughout the PhD, for which I am very grateful. The Modern Law Review provided further financial assistance through the *Simon Roberts Scholarship*, which was especially humbling as I remember him fondly from my time as an MSc student at LSE. The 2019 Kent Summer School in Critical Legal Theory was a wonderful and enrichening experience thanks to the organizational efforts of Maria Drakopoulou and Connal Parsley. Vaios Karavas and Steven Howe at the lucernaiuris Institute for Interdisciplinary Legal Studies provided me with an intellectual home at the University of Luzern as a pre-doctoral fellow in the calm just before the pandemic storm. I want to thank them for their hospitality and generosity. Vaios prepared me psychologically for the last two years of the PhD when he told me one day that “the only way to complete a PhD is to overcome yourself.” This was not an exaggeration in the slightest, and I have considered his advice daily ever since.

Finally, thank you to my family and loved ones: my father and sisters, nieces and nephews, who made every effort to be supportive and understanding of my choices, and to my expanded family: Lian Rangkuty, Kath Politis, Harsh Patel, Sam de Groot, Miriam Stoney, Nathan Antolik, Philipp Lossau, Adam & Sara, Hafeez Daewoo, Irene Claeys, Fatima Ahdash, Priya Gupta, Verena Gillmeier, Claudia Rech, Stefan & Marvin, Nikhil Vettukatil, Dr. Katritsis, Dave & Liv, Alex Brenchley and Maria-Vitória Vieira Capote Gonzaga (who also drew figure 1). Bernard Keenan deserves special mention for voluntarily reading my complete drafts and helping me understand my thoughts in the round during the write-up period.

This thesis is dedicated to the memory of my mother, Susan Leach.

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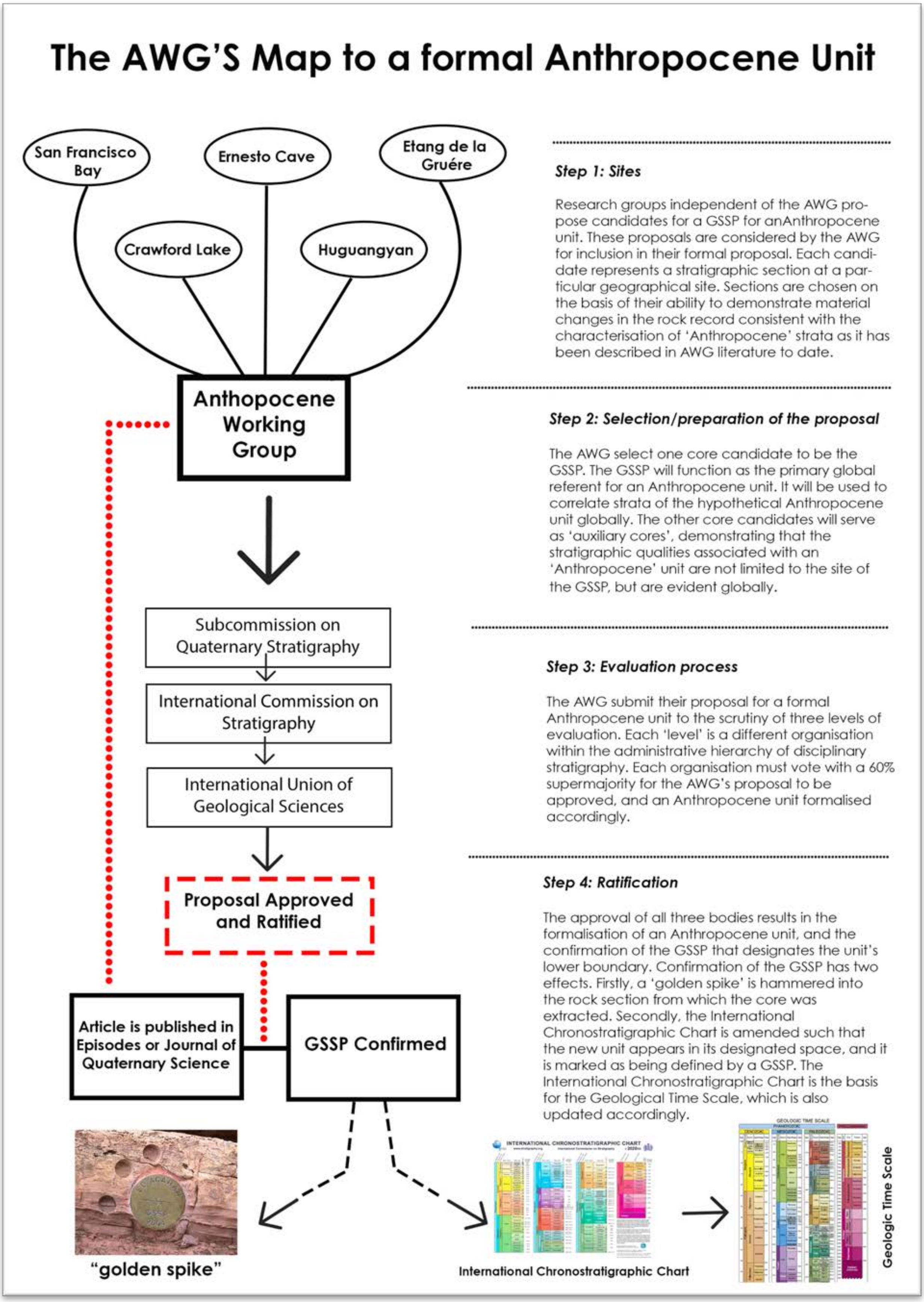

Figure 1: Map of the formalization process involved in the ratification of a formal Anthropocene unit of the International Chronostratigraphic Chart and Geologic Time Scale.

1. Introduction

> *The epoch of geological time during which human activity is considered to be the dominant influence on the environment, climate, and ecology of the earth, a formal chrono-stratigraphic unit with a base which has been tentatively defined as the mid-twentieth century.*
>
> – Oxford English Dictionary definition of 'the Anthropocene', first published in June 2014.

My thesis concerns the ongoing effort by the Anthropocene Working Group (AWG) to formalise the Anthropocene as a new geological unit. I argue that there are legislative, political, and social characteristics to the formalisation effort, according to which the Anthropocene is defined as a geological unit. The above definition is the one that is perhaps most colloquially associated with the term. However, on more than one front, it is a misleading definition. First, the Anthropocene is not yet formally a unit of geological time. It is a term whose precise geological meaning has been debated for the past two decades. There is no guarantee that the Anthropocene will be accepted by the geological community as a formal unit. Secondly, the term 'epoch' has a precise meaning in geology, which divides time into various units according to their geological magnitude. So, for example, we are currently in the Meghalayan, a geological Stage/Age that began 4200 years ago; the Meghalayan, in turn, occurs within the Holocene Series/Epoch, which geologists date to 11,700 years; the Holocene occurs within the Quarternary System/Period (approximately 2.5 million years old), which is enveloped inside the Phanerozoic Eonothem/Eon, marking the beginning of life on Earth some 541 million years ago (the reason for the dual-title of each shall be explained below).[1]

Finally, the Anthropocene Working Group, who have been developing a proposal to formalise the Anthropocene as a geologic unit since 2009, do not necessarily argue that it marks the time of humanity's dominance over "the environment, climate, and ecology of the

[1] The Meghalayan was ratified in 2018, making it both the most recent unit chronologically and also the most recently ratified unit. See Walker, M., Head, M., Berkelhammer, M., et al. 2018. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Section and Points (GSSPs) and three new stages/subseries. *Episodes* 41(4): 213-223. For an overview of all stratigraphic units, see Cohen, K., Finney, S., Gibbard, P. & Fan, J.-X. 2013 [updated] The ICS International Chronostratigraphic Chart. *Episodes* 36: 199-204.

earth." As we shall see, the idiosyncratic temporality of geology, known as *deep time*, complicates the distinctions between these already somewhat ambiguous entities. They argue, more cautiously, that the Anthropocene refers to a proposed new geologic unit at the level of Epoch/Series, wherein certain stratigraphic signals occur with a frequency that is anomalous to the envelope of Holocene conditions, with some being entirely novel altogether.[2] Initially, the AWG had gone one step further, and associated these signals with human activity. However, after an extended period of critical attention that this premise has invited, the AWG have instead narrowed their claim in such a way as to delineate, as far as they conceive it to be possible, a strictly "geological Anthropocene".[3]

The Anthropocene first appeared as a term within the context of debates concerning anthropogenic climate change. It was announced, as we shall shortly see, at a meeting of the International Geosphere-Biosphere Program, which sought to address the urgencies of a "planet under pressure" by the impact of human activity.[4] Within a decade of its announcement, a group of geologists took an interest in the term, and sought to elaborate it not as an issue of climate change, but rather as one of geological classification. My thesis concerns the means by which this conversion occurred, as well as *why*, and seeks to demonstrate the dynamics according to which the Anthropocene is currently being constructed as a new geological unit. I draw on the perspective of the AWG as they attempt to elaborate and define a strictly "geological Anthropocene" – the manner in which they approach the Anthropocene as a set of ideas, observations, and measurements that were to be drawn together into a formal stratigraphic unit – as an object of analysis itself. This requires an appreciation of the stratigraphic hypothesis of the Anthropocene as it is understood and taken up by the geologists working in the AWG. An Anthropocene unit, I intend to argue, is not *discovered* in the rock record. It is a narrative that is actively constructed through the accumulation of scientific measurements, but also in anticipation of the judgements, preferences, and procedures associated with formalising new units (what could be thought

[2] Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* 351(6269) DOI: 10.1126/science.aad2622

[3] Zalasiewicz, J., Waters, C., Williams, M. & Summerhays, C. 2019. *The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate*. Cambridge: Cambridge University Press. See especially pages 285-286.

[4] See Steffen, W., Sanders, A., Tyson, P., et al. 2005. *Global Change and the Earth System: A Planet Under Pressure (IGBP Series: Global Change)*. London: Springer.

of as the epistemic culture of stratigraphy), and finally in respect of the various financial and professional interests that become involved in the effort to formalise an Anthropocene unit.

The first part of my thesis provides a history of chronostratigraphic methodology as it relates to the effort to define an Anthropocene unit, and the manner in which this methodology is critically engaged by stratigraphers toward that effort. I also develop a genealogy of the evaluative procedures according to which the AWG's proposal shall be assessed, and ultimately either formally ratified or rejected and thereby remain an informal term within stratigraphy. In the second part of my thesis, I present participant observation conducted with the AWG as they formulate their proposal for a formal Anthropocene unit. I focus on the way they anticipate the response of the evaluative committees who will receive their proposal, and how they incorporate anticipated responses into their elaboration of the Anthropocene as a formal geologic unit.

I seek to answer three questions: why the effort to formalize an Anthropocene unit is being pursued at this moment in time; how it is happening (i.e. how it is being constructed as a geological fact); and how stratigraphic classificatory mechanisms are incorporated into the sets of challenges presented by the effort to formalize an Anthropocene unit. Because the Anthropocene is a topic that has provided occasion for critical reflection across disciplines (as we shall review shortly), how one addresses these questions is contingent on which position is adopted. I am interested in how *stratigraphers* understand the Anthropocene; not simply as a geological unit, but as a historiographic and epistemic framework for understanding their discipline and its extra-stratigraphic implications. That is, in addition to the stratigraphic considerations implied by a formal Anthropocene unit, I am interested in how the AWG engage their formalisation effort in recognition of its significance as a category of social critique more generally.

I approach the notion of the Anthropocene by drawing on two frames of reference simultaneously. My analysis is informed by literature from the history and sociology of science, science and technology studies, and epistemology. This literature informs how I observe stratigraphers at work and attempt to adopt their perspectives. In acknowledgement of the limitations of an external approach of that kind, which perceives stratigraphy as an object to be analysed, I also engage stratigraphic literature with the concerns that it lays out for itself, as evidenced by the controversy that the Anthropocene has sparked among geologists involved in the evaluative mechanisms associated with classification of geological time and space. I am interested to understand how discourse surrounding the term ‘Anthropocene’ is influenced by debates between stratigraphers, and also between members of the AWG, as a result of the effort to define the Anthropocene as a geological unit. Yet at the same time, there is no doubt, as we shall see, that the Anthropocene can be thought of as an event that happened *to* stratigraphy from “outside”: coined by an atmospheric chemist, taken up by geologists nearly a decade later, at which point it was reformulated as an issue of geological classification. I am interested to describe the dynamics according to which the AWG, and particularly those of its members who are geologists, claim authorship over the theme of the Anthropocene, and develop it as a possible geological unit by engaging some literatures and not others, alternately enrolling members and distancing themselves from others, and anticipating the feedback of the evaluative bodies that determine the formalisation of new geological units as parameters for the formulation of their proposal. The details of this interest shall be outlined shortly in this introduction. But first, where did the premise of the Anthropocene even come from?

1.1 “The… the… the Anthropocene!”

In the year 2000, a large, academic conference took place in Cuernavaca, Mexico. It was the kind of conference that fills carpeted hotel lobbies with lanyarded scientists dispensing coffee from trolleys, initiating awkward introductions with colleagues who haven’t quite finished eating their sandwiches. The topic of the conference was Earth System science, a relatively young field that combines, among other things, the insights of geology, biology, chemistry, physics, climate modelling, and mathematics.[5] Several papers presented at the conference concerned the effects of anthropogenic climate change. One presentation adopted a geological approach to this concern by invoking the Holocene. The Holocene is the geological

[5] In the words of Tim Lenton, a student of James Lovelock (the originator of Gaia theory) and poster child of Earth System science, it is a field born of the profound revelation that captured Earth’s inhabitants upon glimpsing those famous photos of the 1960’s that showed the planet from the view of outer space. Lenton, T. 2016. *Earth System Science: An Introduction*. Oxford: Oxford University Press. The book opens with the following claim:

> *“When humanity first looked back at the Earth from space, the obvious unity of the planet that supports us – and all the life that we know of – entered the popular consciousness. Earth system science is the research field born out of this revelation – it seeks to understand how our planet functions as a whole system.”*

stage or epoch (it is both a geologic stage and epoch, and the precise meaning of this terminology will be described at length below) that geologists understand the Earth to reside within for the last 11,700 years. In geological terms, the Holocene is characterised by the end of the last glacial period, and has therefore been described as an interglacial period, with an increase in air temperatures and retreating glaciers that began some 17,000 years ago.[6]

Yet even if the Holocene is characterised by a warm period in a cycle of cooling, a patter that has occurred regularly over earth history, it is argued that the current warming trends associated with anthropogenic climate change go beyond the regular parameters of the Holocene.[7] The persistent reference to the Holocene as the operating space of the planet, in spite acknowledgement of significant changes to those parameters, eventually drove one conference attendant to despair. Standing up from his seat, he exclaimed: 'The Earth is not in the Holocene anymore! We're in the... the…' and searching to find the right word, apparently on the spur of the moment, uttered, 'the Anthropocene!'[8] It is possible that this may have been an entirely inconsequential event, yet that person was Paul Crutzen, the Nobel Prize-winning atmospheric chemist, a detail which may have compelled those present to take more notice than they might otherwise, and consider a deeper significance. Crutzen was also vice-chair of the organization, the International Geo Biosphere Program (IGBP), that arranged the conference.[9] The IGBP was launched in 1987, for a fixed term of three decades, to serve as an 'internationals scientific research programme examining how Earth's biological, chemical and physical processes interact at a regional and global scale,' with an emphasis on 'how these processes affect and are affected by society.'[10] Under the motto of 'science for a sustainable planet,' the IGBP sponsored twelve chapters, dedicated to furthering scientific research on

[6] Walker, M., Head, M., Berkelhammer, M., et al. op cit.

[7] Summerhayes, C. 2019. Climate. In Zalasiewicz, Waters, Williams and Summerhayes (eds) *The Anthropocene as a Geological Unit: A Guide to the Scientific Evidence and Current Debate.* Pp. 200-218.

[8] The episode is recounted in Kunkel, B. 2017. The Capitalocene. Review of *The Birth of the Anthropocene* by Davies, J., *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* by Moore, J., and *Fossil Capital: The Rise of Steam-Power and the Roots of Global Warming* by Malm, A. *London Review of Books* 39(5): 22-28. Crutzen received the Nobel Prize in Chemsisty in 1995 for his work exposing the effects of aerosols on the deterioration of the ozone layer. He also coined the term 'nuclear winter', referring to the risks of atomic bomb detonation for planetary existence. In other words, Crutzen has a track-record of sophisticated and morally-committed interventions in scientific discourse. See Crutzen, P. & Birks, J. 1982. The Atmosphere After a Nuclear War: Twilight at Noon. *Ambio* 11: 114-125.

[9] Ellis, E. 2018. *Anthropocene: A Very Short Introduction*. Oxford: Oxford University Press. Pg. 32.

[10] See the introduction to Steffen, W., Sanderson, R., Tyson, P., et al. 2004. *Global Change and the Earth System: A Planet Under Pressure*. London: Springer.

climate and the influences thereon by human activity, as well as 'building bridges' with international policy initiatives, such as the Intergovernmental Panel on Climate Change, the UN Framework Convention on Climate Change, and the Millennium Ecosystems Assessment. Literature published by the IGBP and its members describe the Program's vision as the provision of 'essential scientific leadership and knowledge of the Earth system to help guide society onto a sustainable pathway during rapid global change.'[11] Terms such as 'sustainability' and 'planet under pressure', an emphasis on coordinating associations between scientific research and policy initiatives, position the IGBP within the discursive and epistemic field of "climate change", understood as a predominantly anthropogenic phenomenon requiring urgent political and social action.[12] The IGBP can therefore be positioned alongside initiatives such as the IPCC, which in a 2018 report warns that 'any increase in global temperature is projected to affect human health, with primarily negative consequences.'[13] Fundamentally, the IGBP sought to articulate an understanding of the planet as an integrated and responsive set of systems, in which human activity had acquired a status equivalent to earth processes that far precede the human species. IGBP publications invoke the idiom of an "Earth system," defined as 'the planet's interacting biological, chemical, physical and socio-economic processes.'[14]

Following this debut appearance of the Anthropocene, Crutzen co-authored a paper with Eugene Stoermer, a limnologist who had devised the term independently several years prior to Crutzen's announcement.[15] This paper was published in the monthly newsletter of

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[11] International Geosphere-Biosphere Program. 2010. *IGBP Strategic Vision*. Available at http://www.igbp.net/download/18.19b40be31390c033ede80001638/1376383018403/IGBPStrategicVisionpublished27September2010.pdf (accessed 05/05/2021).

[12] Regarding the emergent consensus within climate science that changes in atmospheric concentration of carbon dioxide and other greenhouse gases is an anthropogenic phenomenon, see Oreskes, N. 2004. The Scientific Consensus on Climate Change. *Science* 306(5702): 1686.

[13] See Guldberg-Hoegh, O., Jacob, D., Taylor, M., et al. 2018. Impacts of 1.5°C Global Warming on Natural and Human Systems. In Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., et al (eds). *An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. https://www.ipcc.ch/sr15/chapter/chapter-3/ (accessed 25/02/2020). The Fourth Assessment Report of the IPCC, furthermore, describes it as 'extremely unlikely that the global climate changes of the past fifty years can be explained without invoking human activities.' Alley, R., Bernsten, T., Bindhoff, N., et al. 2007. *Climate change 2007: The physical science basis: Summary for policy makers.* https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-spm-1.pdf (accessed 25/02/2021)

[14] See, for example: *IGBP Strategic Vision*: 1.

[15] Stoermer, E. & Smol, J. (eds) 1999. *The Diatoms: Applications for the Environment and Earth Sciences*. Cambridge: Cambridge University Press.

The IGBP, a significant venue for Earth System science literature.[16] The intention of their paper is to characterise a difference in the state of the planet by comparison with those qualities assigned to the Holocene. 'During the Holocene,' they explain, 'mankind's activities gradually grew into a significant geological, morphological force…'.[17] These changes include a tenfold growth in human populations over the past three centuries; tenfold increase in urbanisation over the past century; similarly unprecedented growth in emissions of sulphur dioxide, carbon dioxide, and methane; transformation of approximately half the total land surface by human activity; anthropogenic increase in species extinction rates; and pronounced human impact on marshlands, oceans, lakes, and water sources. Such phenomena are referred to by Crutzen and his colleagues as the Great Acceleration.[18] Regarding the impacts observed, Crutzen & Stoermer conclude:

> Considering these and many other major and still growing impacts of human activities on earth and atmosphere, and at all, including global, scales, it seems to us more than appropriate to emphasize the central role of mankind in geology and ecology by proposing to use the term "Anthropocene" for the current geological epoch. The impacts of current human activities will continue over long periods… climate may depart significantly from natural behaviour over the next 50,000 years.[19]

This paper was followed up with a further publication two years later, entitled 'The Geology of Mankind', which considered the geological characteristics of the Anthropocene more explicitly.[20] In this paper, Crutzen ventures a start date for the proposed new geologic unit: 'The Anthropocene could be said to have started in the latter part of the eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane.' Reasserting the role of humanity (figured in the term 'Anthropos', from the Greek word for 'human'), he continues: 'This date also

[16] Crutzen, P. & Stoermer, E. 2000. The "Anthropocene". *The IGBP Global Change Newsletter* (41): 17-18.
[17] ibid., 17.
[18] Steffen, W., Sanderson, R., Tyson, P., et al. 2004.
[19] ibid.
[20] Crutzen, P. 2002. The Geology of Mankind. *Nature* 415 (23): https://doi.org/10.1038/415023a

happens to coincide with James Watt's design of the steam engine in 1784.'[21] This is a claim that had been mentioned for the first time in his original 2000 paper.[22] In neither paper does Crutzen consider the precise procedures by which, as shall be explained, any proposal for an amendment to the classification of geologic time units are evaluated. A start date is ventured simply as a way of generating further discussion on the theme of the 'Anthropocene'. Crutzen & Stoermer explain that they are 'aware that alternative proposals can be made' concerning a start date for an Anthropocene geological unit.[23]

[21] ibid. Alain Pottage notes that this date is wrong. Watt filed several patents, however the steam engine patent was filed in 1769. The incorrect date has been re-iterated across academic literature. See Pottage, A. 2020. An Apocalyptic Patent. *Law and Critique* 31: 239-252, who notes that the incorrect 1784 date attributed by Crutzen refers to the patenting of "the parallel motion device that Watt considered to be his finest invention, which enabled the vertical motion of the piston to be converted efficiently into rotative motion, and which resulted in an engine that was compact enough to be accommodated in a smaller engine house." Yet the 1784 patent is referred to in popular literature on the Anthropocene such as Morton, T. 2013. *Hyperobjects: Philosophy and ecology after the end of the world.* Minneapolis: University of Minnesota Press.

[22] Crutzen & Stoermer, op cit., 18.

[23] ibid., 17.

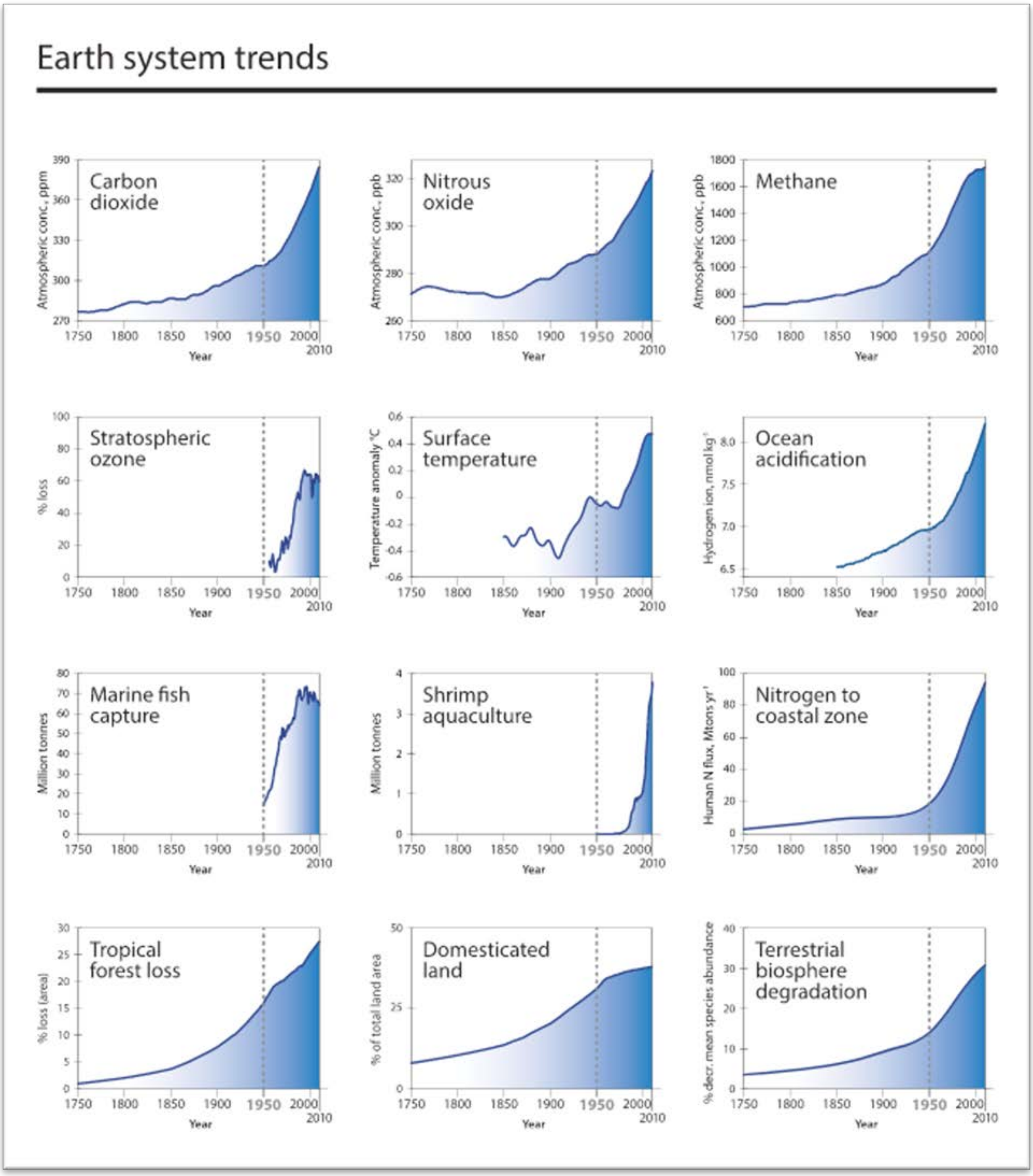

Figure 2: A version of the Great Acceleration charts, depicting Earth system trends. The dotted line marks the year 1950. From Steffen, W., Broadgate, W., Deutsch, L., et al. 2015. The trajectory of the Anthropocene: The Great Acceleration. The Anthropocene Review 2(1): 81-98. Pg. 87.

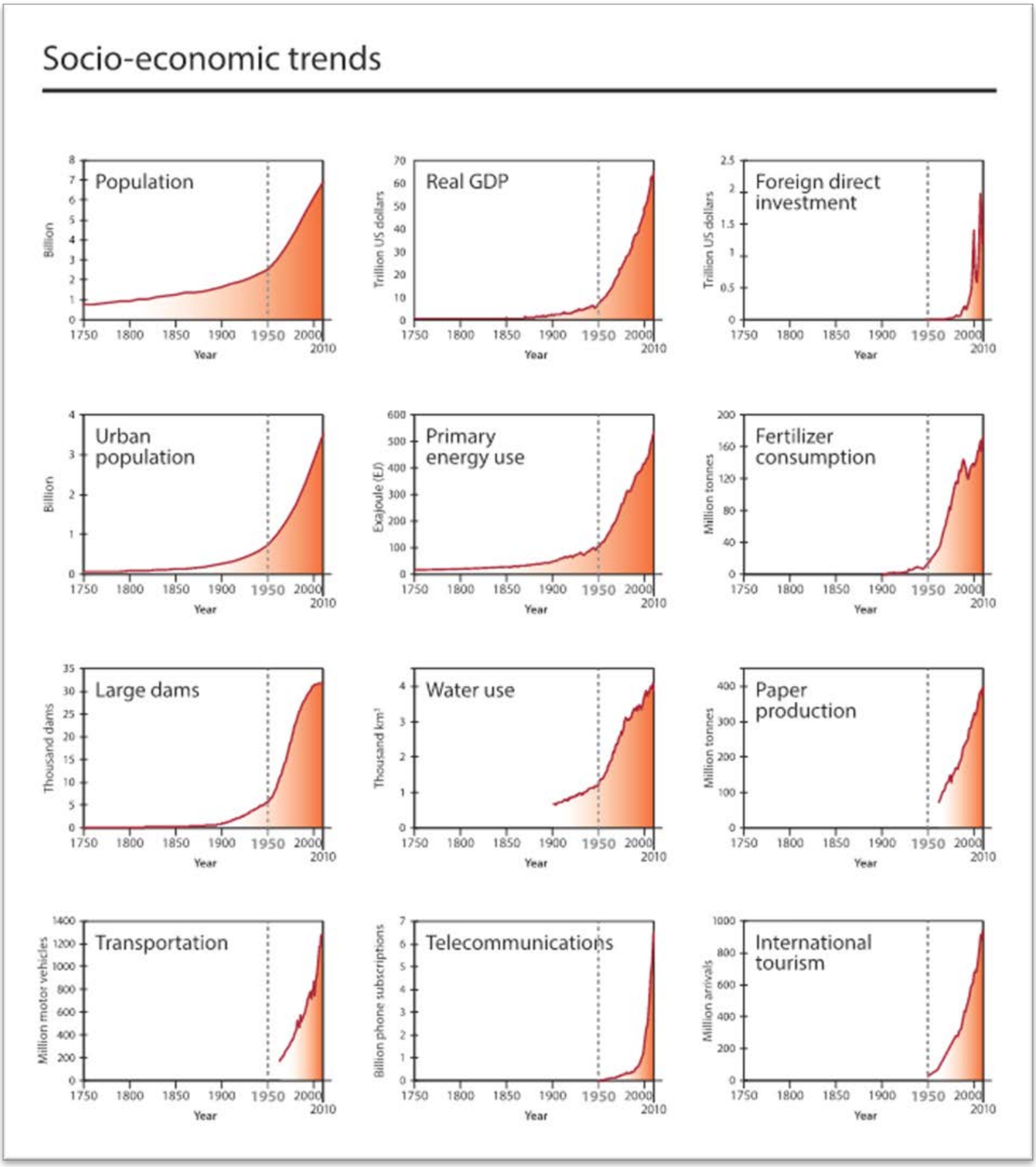

Figure 3: A version of the Great Acceleration charts, depicting Socio-economic trends. The dotted line marks the year 1950. From Steffen, W., Broadgate, W., Deutsch, L., et al. 2015: 84.

A 2007 paper, co-authored by Crutzen together with fellow IGBP member and Earth System scientist Will Steffen, as well as the historian John McNeill, sought to develop the premise of an Anthropocene chronology further. Their analysis positions the Anthropocene within a changing earth climate. They reiterate a start date for the Anthropocene 'around

1800', citing 'the onset of industrialisation… [and] the enormous expansion in the use of fossil fuels.' This proposed start date is positioned within a dramatic shift in the composition of earth's climate: 'from a preindustrial value of 270-275 ppm, atmospheric carbon dioxide has risen to about 310 ppm by 1950.'[24] Furthermore, they explain that since 1950, atmospheric carbon dioxide concentration has increased to 380 ppm. They attribute this rise to the 'Great Acceleration', a suite of exponential increases in phenomena ranging from atmospheric methane concentrations, to direct foreign investment, to the number of McDonald's restaurants worldwide.[25] Consequently, Steffen et al. argue that the Anthropocene concept can be divided into at least two "stages". The first stage begins around 1800, coinciding with the start of the industrial revolution in the United Kingdom. It lasts till the mid-twentieth century, at approximately 1945, with the beginning of the Great Acceleration, which inaugurates a second stage of the Anthropocene. As justification of this second stage, Steffen et al. note that half of the total rise in atmospheric carbon dioxide concentrations has occurred between 1997 and 2007.[26] 'Rather bravely', as Steffen puts it, he and Crutzen propose a third stage of the Anthropocene, beginning in 2015, 'based on a potential tipping point in the relationship of humanity with the rest of the Earth System.'[27] The 'tipping point' in question was anticipated by Steffen, Crutzen, and McNeill to refer to a moment of realisation wherein 'the dangers of the current trajectory of the Anthropocene would become apparent and… humanity would take decisive actions to change the trajectory from one based on exploitation of the Earth System to a pathway focused on stewardship.'[28] Writing in a recent article, Steffen contends that this anticipation was 'eerily accurate', and cites the Paris Climate Agreement and United Nations Sustainable Development Goals, both agreed in 2015, as 'landmark' moments in the relationship of humanity to the Earth system.[29]

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[24] Steffen, W. Crutzen, P., McNeill, J. 2007. The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature. *AMBIO: A Journal of the Human Environment* 36(8): 614-621.

[25] The Great Acceleration charts first appear in Steffen, W., Sanderson, A., Tyson, P., et al. 2004. *Global change and the earth system: A planet under pressure. The IGBP book series*. New York: Springer.

[26] Steffen, W., Crutzen, P., McNeill, J. 2007.

[27] Steffen, W. 2021. Introducing the Anthropocene: The human epoch. *Ambio 50th Anniversary Collection. Theme: Anthropocene*. https://doi.org/10.1007/s13280-020-01489-4

[28] ibid.

[29] Ibid

1.2 Geologizing the Anthropocene

Meanwhile, at around the same time that Steffen et al. published their 2007 paper declaring a three-stage Anthropocene, a group of geologists affiliated with the Geological Society of London were also taking an interest in the term. Their interest acknowledged the climatic positioning of the Anthropocene, but sought to assess the adequacy of the signals observed by Steffen at al., in strictly geological terms. A McDonald's restaurant, for example, could be observed as a stratigraphic marker, if one considered the imprint left in sediment by its cement foundations.[30] Such imprints could presumably be observed around the world, consistent with the global distribution of cement.[31] Plastic and other disposable packaging associated with McDonald's products could also constitute a legible stratigraphic marker, already established in the rock record.[32] Whereas Steffen et al. had originally invoked the industrial revolution as a source of changes in atmospheric carbon dioxide concentrations, these geologists took interest in fly ash emissions from the burning of coal in steam engines, which settle at the bottom of lakes and other bodies of water, thereby constituting a further geological marker.[33] Their interest, in other words, was to determine whether the phenomena that Crutzen and his colleagues had drawn on to characterise the Anthropocene, could be identified in stratigraphic terms: in the rock record globally and within a brief duration.

More specifically, the interest of the geologists lay in translating the Anthropocene idea, originally articulated as a contribution to discussions concerning anthropogenic climate change, within the discursive framework of geology, and in particular, the delineation of 4.5 billion years of earth history into units. This is a practice associated with the Geological Time Scale, a regularly published document that compiles an account of all geological units. The

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[30] The global proliferation of McDonald's restaurants was included as one of the 'Great Acceleration' charts. The McDonald's chart has been removed from subsequent publications that figure the 'Great Acceleration' charts, replaced with a chart demonstrating an exponential increase in Primary Energy Use around the mid-twentieth century. See Steffen, W., Broadgate, W., Deutsch, L., et al. 2015. Op cit.

[31] Concrete has figured prominently in the Anthropocene formalization effort as a *novel Stratotype* that indicates the novelty of Anthropocene strata. See Waters, C. & Zalasiewicz, J. 2018. Concrete: The most abundant novel rock type of the Anthropocene. In DellaSala, D., and Goldstein, M. I. (eds), *Encyclopedia of the Anthropocene*. Vol. 1. Oxford: Elsevier. https://doi.org/10.1016/B978-0-12-809665-9.09775 -5.

[32] Zalasiewicz, J., Waters, C., Ivar do Sul, J., et al. 2016. The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene* 13: 4-17.

[33] The geological record of fly ash resulting from burning fossil fuels, and its relevance for an Anthropocene unit, is described in Rose, N. & Galuszka, A. 2019. Novel Materials as Particulates. In Zalasiewicz, J., Waters, C., Williams, M. & Summerhayes, C. (eds) op cit.

Scale functions as an authoritative resource, featuring a section for each unit that describes their distinctive geological characteristics. Within the tradition of classifying geological space and time into units, the suffix 'cene' designates a geological unit of a particular rank.[34] We currently reside in the Holocene, which began approximately 11,700 years ago at the end of the last interglacial period. The Holocene is one of seven units at the rank of Series/Epoch that occur within the Cenozoic, a unit at the rank of Erathem/Era, which began sixty-six million years ago, marking the time when continents assumed their contemporary figuration, as well as when flora and fauna began to assume a form similar to what is observed today. The term 'Cenozoic' comes from the Greek *kainos* (new) and *zoe* (life). The name of each unit at the rank of Series/Epoch, within the Cenozoic, indicates a temporal reference to the present. The first Series/Epoch within the Cenozoic is called the Paleocene (from the Greek *Palaeo* "old", and *kainos*, "new"); next is Eocene (from *eos*, "dawn"); then Oligocene (from *Oligos*, "little") and so on, until we reach the Holocene (*Olos*, "all"/"entirely" new) (see figures three and four).

[34] The suffix 'cene' has held this status ever since the publication of Lyell, C. 1997 [1830-1833]. *Principles of Geology*. London: Penguin Classics. Lyell complemented Arduino's classification of the rock record into four classes (Primary, Secondary, Tertiary, and Quaternary) by adding further sub-classes. This shall be discussed in the next chapter.

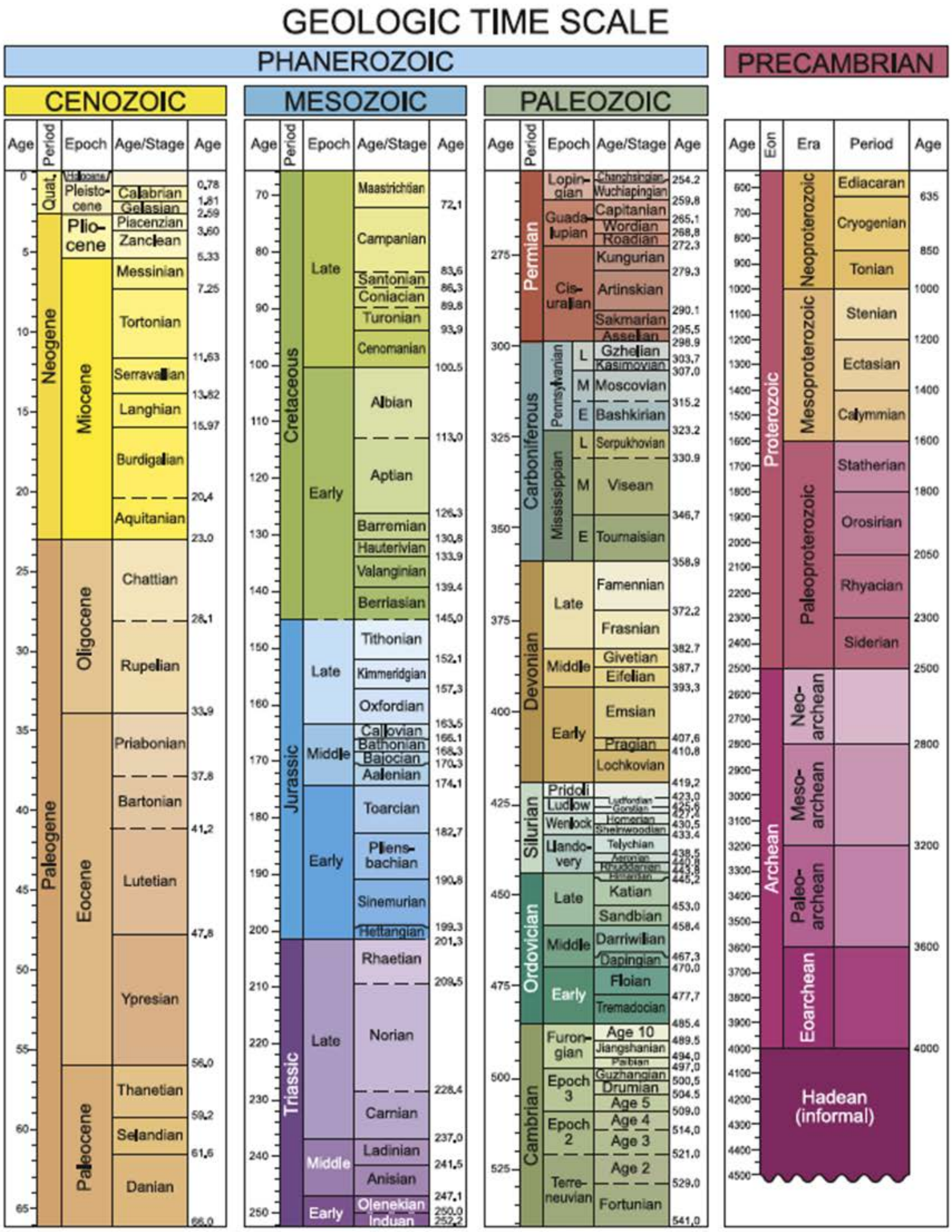

FIGURE 1.2 The new Geologic Time Scale.

Figure 4: The Geologic Time Scale. Gradstein, F., Ogg, J., Schmitz, M. 2012. The Geologic Time Scale 2012. London: Elsevier.

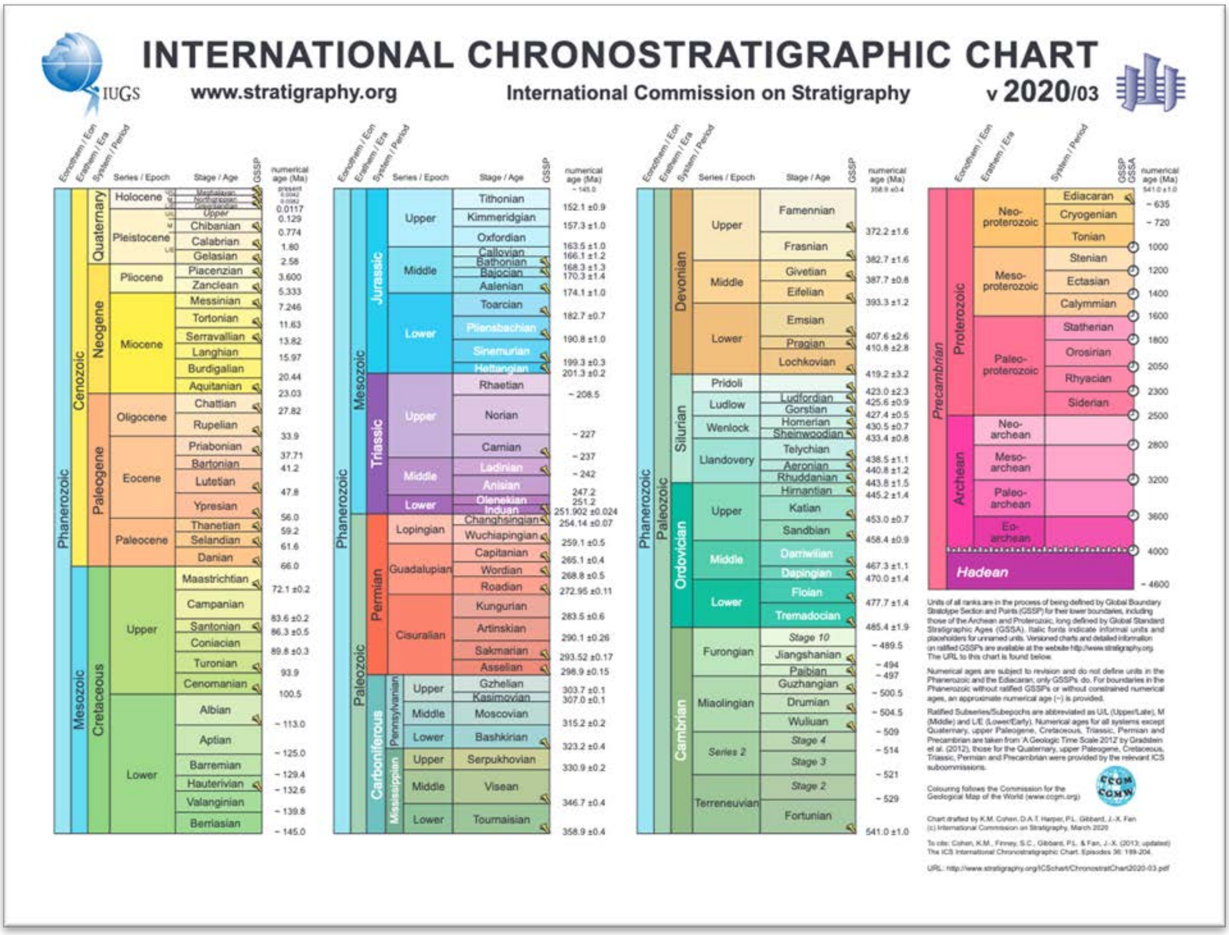

Figure 5: The International Chronostratigraphic Chart. Cohen, K., Harper, D., Gibbard, P., et al. 2013 [updated].

The dual terminology, according to which the Holocene is both “Series” and “Epoch”, and the Cenozoic both “Erathem” and “Era” refers to two simultaneous classification mechanisms that stratigraphers use (see figure five). A Series refers to *chronostratigraphic* classification, whereas an Epoch refers to a *geochronological* classification. Chronostratigraphy refers to the classification of the material record of strata, i.e. the material composition of a unit. Geochronology refers to the duration in time of a unit. Both geochronological and chronostratigraphic classifications occur in a hierarchy, intended to designate the respective significance of a unit. The two classificatory mechanisms are precisely aligned, such that all chronostratigraphic and geochronological classifications begin and end at the same point. Chronostratigraphic classification occurs alongside geochronological classification. Yet crucially, whereas chronostratigraphy refers to the material, rock record, geochronology refers to the temporal duration of units.

Why the duality of temporal and spatial references for geological units? One explanation is that, except for the Anthropocene, geologists were never alive to witness the deposition of the material evidence of events, such as the last major glaciation interval associated with the Holocene. Therefore, to posit that chronostratigraphy preserves the *evidence* of geochronological events is to presume a relationship as being self-evident, when in fact, the relationship between temporal events and material markers must be actively constructed by geologists. The material evidence of a geochronological event is not ‘discovered’. Instead, the *relationship* between a material substance referred to as ‘evidence’ and an event selected as being of geological significance, must be configured by stratigraphers: in this case, the AWG. The ‘Anthropocene’ unit must be constructed twice over: as a geochronological *event* and as chronostratigraphic *material*. The duration of an Anthropocene unit cannot be determined because, since it is being proposed as the most recent unit in the Chart and Scale, it is ongoing. Therefore, a beginning event is what is being posited by the AWG. Such an event, which would mark the “beginning” of an Anthropocene unit, is consistent with the definition of a chronostratigraphic, or material, “lower boundary,” which marks the point at which the novel rock characteristics associated with an Anthropocene unit begin to appear in the earth’s material record.

The Geological Time Scale refers, therefore, primarily to *geochronological* units, hence its emphasis on “time”. Each issue of the Scale emphasises that it is based on another reference document, the International Chronostratigraphic Chart, which lists all *chronostratigraphic* units. In the Chart, both geochronological and chronostratigraphic units are listed side by side at the top of each column, emphasising their simultaneity. The authors of the Geologic Time Scale similarly emphasise the simultaneity of the dual chronology, and hence of the Scale with the Chart: ‘the construction of a geologic time scale is the merger of a chronometric scale (measured in years) and a chronostratigraphic scale.’[35] The Geologic Time Scale and the International Chronostratigraphic Chart are therefore interchangeable insofar as their classification of the rock record is identical and coequal. Their simultaneous existence serves as a reminder of the idiosyncratic nature of stratigraphic classification.

[35] Gradstein, F., Ogg, J., Schmitz, M. 2012.

Units	Rock Units	Time Units	Examples
Discipline	CHRONOSTRATIGRAPHY	GEOCHRONOLOGY	
Main Hierarchy	Erathem	Era	Mesozoic
	System	Period	Jurassic
	Series	Epoch	Liassic
	Stage	Age	Hettangian
sub Hierarchy	Lower - **Middle** - Upper	Early - **Middle** - Late	

Figure 6: The "dual terminology" of geochronology and chronostratigraphy. From Odin, G.S., Gardin, S., Robasyznski, F., et al. 2004. Stage boundaries, global stratigraphy, and the time scale: towards a simplification. Carnets de Géologie 2: 1-12.

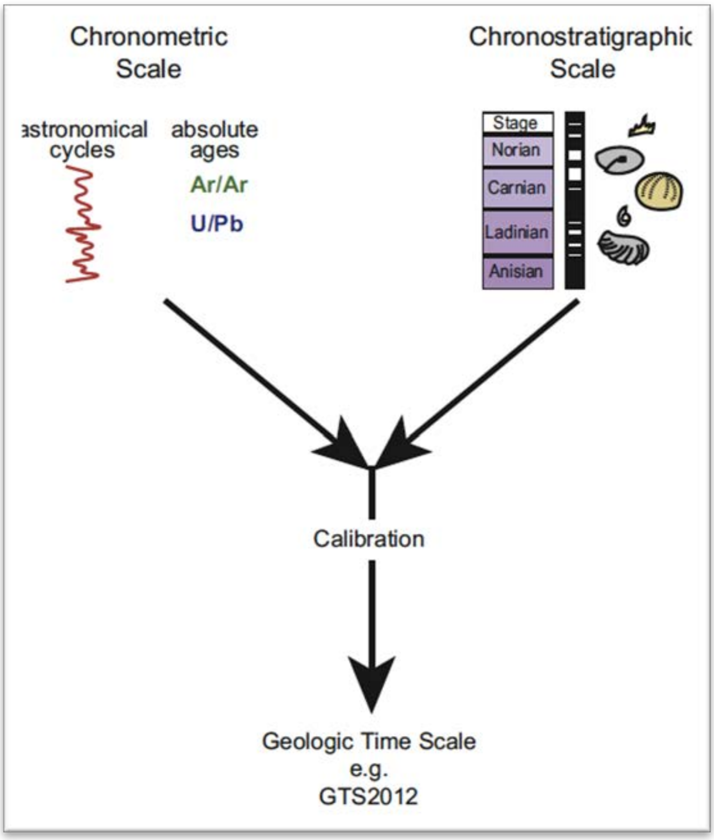

Figure 7: The Geologic Time Scale and International Chronostratigraphic Chart are constructed through the merger of temporal durations of units, measured in distinct ways (astronomical cycles or radiocarbon dating) and the designation of material units, defined by reference to palaeontology (the appearance of fossils in strata), magnetic polarity events (regular changes in the earth's magnetic polarity, which leaves varying degrees of residual magnetism in rocks that can be

materially analysed), or through analysis of the chemical composition of rocks. Source: Gradstein, F., Ogg, J., Schmitz, M., et al. 2012: 2.

The original articulations of the Anthropocene from Crutzen and Steffen served as a model with which to designate a new geological unit. As a geological unit, the Anthropocene would terminate the Holocene. Their elaboration of the Anthropocene as a theme situated within the discursive frame of anthropogenic climate change and planetary stewardship therefore presented an exercise in geological classification: terminology (Anthropo*cene*), and geochronological duration (beginning with the industrial revolution or the Great Acceleration) were already provided by Crutzen and Steffen's accounts. A question presented itself to the interested geologists: is there a sufficient material record to qualify the Anthropocene as a *chronostratigraphic* unit as well, and thereby introduce the Anthropocene into the International Chronostratigraphic Chart and Geologic Time Scale?

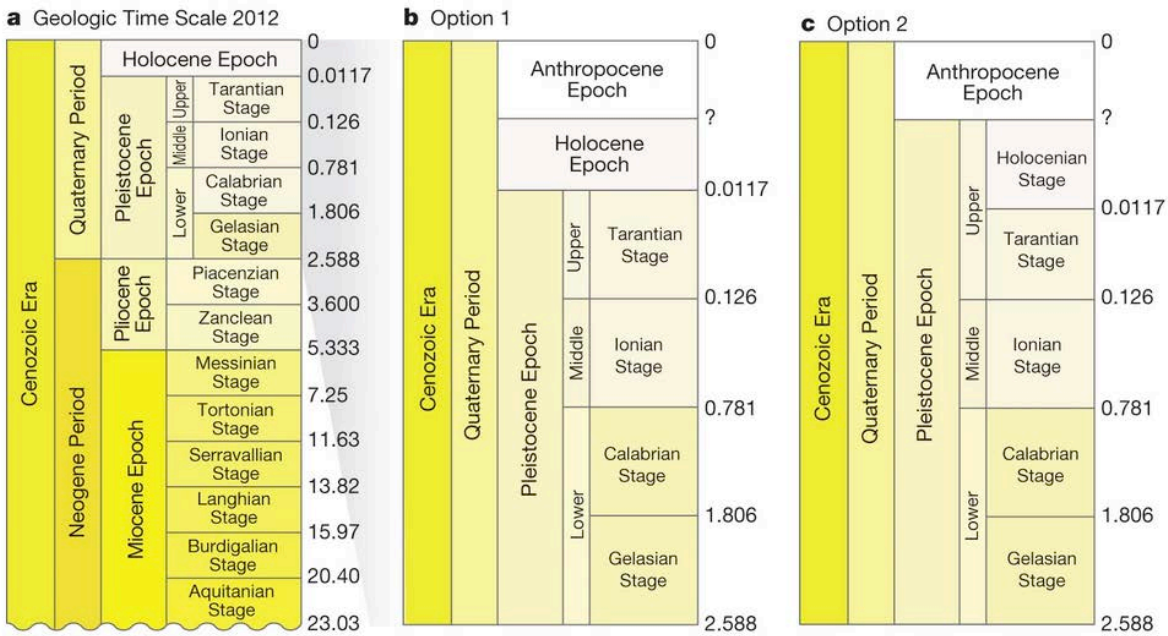

Figure 8: Comparison of the Geologic Time Scale as published in 2012 with two options for a new Anthropocene unit. The AWG is only pursuing "b Option 1", wherein the Anthropocene terminates, but does not replace, the Holocene. From Lewis, S. & Maslin, M. 2015. Defining the Anthropocene. Nature 519: 171-180.

Continued discussion among members of the Geological Society of London resulted in the publication of an article, which asked "Are we now living in the Anthropocene?"[36] The paper identifies Crutzen as the originator of the term, and notes that it 'has entered the geological literature informally to denote the contemporary global environment dominated by human activity.' The article continues by inaugurating the exploration of the term within the context of geological classification:

> 'Here, members of the Stratigraphy Commission of the Geological Society of London amplify and extend the discussion of the effects referred to by Crutzen and then apply the same criteria used to set up new epochs to ask whether there really is justification or need for a new term, and if so, where and how its boundary might be placed.'[37]

The paper posits that the effects associated with the Anthropocene are indeed sufficiently legible in material deposits 'to suggest that we are no longer living in the Holocene (as regards the processes affecting the production and character of contemporary strata).' Yet, they continue, 'it is too early to state whether or not the Quaternary has come to an end.'[38] The Holocene is a Stage/Epoch that occurs within the Quaternary System/Period. The paper, in other words, suggests that there may indeed be a sufficient supply of material deposits to define the Anthropocene as a novel stratigraphic unit at the rank of Epoch/Stage, as a new unit *within* the Quaternary System/Period, *succeeding* the Holocene Epoch/Stage. This provisional diagnosis indicated that there was believed to be a valid geological argument in the original Crutzen paper that merited further elaboration in the context of stratigraphic nomenclature and classificatory protocol. Shortly following the publication of this article, the Subcommission on Quaternary Stratigraphy (SQS), a professional body of stratigraphers specialising in Quaternary stratigraphy, commissioned the Anthropocene Working Group, to examine further the adequacy of the Anthropocene as a formal geologic unit.[39]

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[36] See Zalasiewicz, J., Williams, M., Smith, A., et al. 2008. Are we now living in the Anthropocene? *GSA Today* 18(2): 4-9.
[37] Ibid: 4.
[38] ibid., 6-7.
[39] SQS. 2009. *Annual Report 2009*. Available at: quaternary.stratigraphy.org/wp-content/uploads/2018/04/SQSAnnual-report09.doc (accessed 05/05/2021).

The Anthropocene Working Group has a unique composition among its membership. It includes the authors of the initial geological paper of 2008, with lead author Jan Zalasiewicz eventually assuming the position of Chair. Yet it also includes Paul Crutzen, Will Steffen, and John McNeill among its membership, authors of the original papers that situated the Anthropocene as an articulation of "a planet under pressure". Also among its membership are historians and philosophers of science, archaeologists, and even a lawyer.[40] The AWG have, at times, championed this diversity of expertise as necessary to the complexity posed by the idea of the Anthropocene. Yet the AWG is first and foremost concerned with the classification of the Anthropocene as a geological unit. Their commissioning by the SQS places them within a disciplinary and evaluative hierarchy that obliges them to emphasise the Anthropocene as, above all else, a geological unit. For the Anthropocene to be included in the Scale or Chart, the AWG must put together a proposal outlining the novel chronostratigraphic and geochronological qualities of the proposed unit. A unit-defining event must be proposed, along with material markers identified in stratigraphic sections. The AWG are required to present convincing arguments that such markers are *global* (rather than localised to specific areas) and *synchronous* in onset (rather than *diachronous*, or having been deposited at different points in time). Their proposal is to be submitted to the SQS, who must vote with a 60% or more majority approving the proposal. The proposal is then submitted to the International Commission on Stratigraphy (ICS), who publish the Chart, and who must also vote with 60% or more majority in favour of the proposal. It is then submitted to the International Union of Geological Sciences (IUGS), who too must vote with 60% majority in favour. At that point, the proposal would be published in the IUGS journal *Episodes*, or for Quaternary geologists, possibly the *Journal of Quaternary Science*, and included in the Scale and Chart.[41] The Anthropocene, therefore, became not just a theme within the discursive framework of climate change, but also took on valence as a potential geological unit, and to

[40] A complete list of the AWG membership is available on the AWG website: http://quaternary.stratigraphy.org/working-groups/anthropocene/ (accessed 05/05/2021). For a critical analysis of the AWG membership see Pattberg, P. & Davies-Venn, M. 2020. Dating the Anthropocene. In Dübreck, G. & Hüpkes, P. (eds.) *The Anthropocenic Turn*. London: Routledge. Pp. 126-144.

[41] The rules associated with the formalisation of a new unit are outlined in Gibbard, P. & Walker, M. 2014. The term 'Anthropocene' in the context of formal geological classification. In Waters, C., Zalasiewicz, J., Williams, M., et al (eds.) *A Stratigraphical Basis for the Anthropocene*. London: Geological Society of London Special Publication 395. Pp. 29-37. These rules and their genealogy shall be discussed in chapters three and four.

this extent, became subject to the classificatory and evaluative mechanisms associated with the Scale and Chart.

As such, the efforts of the AWG were bifurcated. In a normative register, the AWG continued to represent the views associated with Crutzen and Steffen's articulation of the Anthropocene as a warning, situated within the discursive regime of anthropogenic climate change. Early papers of the AWG consider whether climatic signals, such as variations in atmospheric concentration of carbon dioxide, might be legible in stratigraphic signals. It is argued that the 'Great Acceleration' marks a material turning point in the rock record at which the envelope within which such signals have typically varied during the Holocene have fundamentally changed. In other words, atmospheric concentration of greenhouse gases now exceeds the parameters of variability associated with typical fluctuations during the Holocene. The association of climate change and geology is rendered explicit in such accounts:

> 'The new climate driver on a planetary scale is human activity, especially the emission of greenhouse gases… Human activities also add industrially produced aerosols that reflect sunlight, and black carbon (soot), which absorbs heat. Human effects were initially small and regional. Their full impact took effect during the Great Acceleration in the 1950s as massive population growth and post-war industrial production skyrocketed and kicked off a new geological epoch – the Anthropocene.'[42]

Elsewhere, articles explained the process of formalisation, outlining the three tiers of voting bodies that must agree on a proposal for a new unit for it to be included in the Scale and Chart, situating that effort within a narrative that appears to be borrowed from the normative appeals of IGBP publications:

> [The authors wish] to examine various aspects of the Anthropocene, and to stimulate debate, both about the term itself and (more importantly) about the phenomenon it encompasses: the transformation of the Earth's surface environments by human

[42] Summerhayes, C. & Zalasiewicz, J. 2018. Global warming and the Anthropocene. *Geology Today* 34(5): 194-200.

> activity. This phenomenon is now arguably the most important question of our age—scientifically, socially and politically. We cannot think of a greater or more urgent challenge.[43]

Yet as a body that was commissioned by the institutional hierarchy that oversees the formalisation of stratigraphic units, as well as amendments to the Scale and Chart, the AWG also operated on a disciplinary and normative register. At times, the normative and disciplinary commitments were at odds with each other. A series of critical interventions by voting members of the ICS and IUGS indicated concern regarding the normative commitments evident in some AWG publications, stressing that they threatened the chances of an Anthropocene unit being formalised. These interventions stressed that normative commitments, which present the Anthropocene as a warning regarding the effects of human activity on the planet, are important, but do not justify the advent of a new geologic unit. 'Global awareness about environmental change is a separate issue from the definition of practical stratigraphic units that solve geological problems.'[44] They take issue with the perceived assumption of AWG literature, namely: that a new scale of human activity, as indicated by the Great Acceleration, merits a new geological unit. It is argued that the Holocene is itself defined in part as an acknowledgement of human activity. '[O]ne of the key justifications for defining a Holocene Series, as a separate entity from the Pleistocene, is that humans (*Homo sapiens*) reached critical numbers and began influencing natural systems from the beginning of this time period onward.'[45]

Furthermore, those signals that are associated with climatic events, such as changes in atmospheric concentrations of greenhouse gases, 'although seemingly abrupt on centennial timescales… [are] too gradual to provide useful stratigraphic markers at an annual or even decadal level.'[46] There is insufficient evidence that the Holocene Series/Epoch has been terminated. Geochronologically, the Anthropocene is too brief, and

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[43] Zalasiewicz, J., Williams, M. Haywood, A., et al. 2011. The Anthropocene: a new epoch of geological time? *Phil. Trans. R. Soc. A* 369: 835-841. Pg. 838.
[44] Autin, W. & Holbrook, J. 2012. Is the Anthropocene an issue of stratigraphy or pop culture? *GSA Today* 22(7): 60-61.
[45] Gibbard, P. & Walker, M. 2014. The term 'Anthropocene' in the context of formal geological classification. In Waters, C., Zalasiewicz, J., Willliams, M., et al. (eds) *A Stratigraphical Basis for the Anthropocene*. London: Geological Society of London Special Publications 395. Pp. 29-38. Pg. 32.
[46] Ibid: 33.

chronostratigraphically, the signals are diachronous and not sufficiently recorded in the material record. These interventions also acknowledge the origination of the term with Crutzen, situated within the context of the IGBP's interest in the Earth System science analysis of anthropogenic climate change. Yet they take this to be a weakness of the term, as far as the formalisation of an Anthropocene unit is concerned. 'The stratigraphic signal is negligible…' argues Stan Finney, Secretary and voting member of the IUGS, 'most of the stratigraphic records mentioned are potential records that might appear in the future; they are based on predictions.' They continue:

> 'Human structures, excavations, boreholes, bioturbation of soils (agriculture) and the sea floor (drag net fishing) are not strata. Made ground, refuse piles, mine dumps, and leach pads are made by humans rather than by natural sedimentation. The strata with records of anthropogenic change are speleothems, ice cores, and non-lithified sediments of rivers, marshes, lakes, coasts, and the ocean floor. In most of these depositional settings, it would be difficult to distinguish the upper few centimetres of sediment from the underlying Holocene, or sediment that has accumulated versus that that is in transit.'[47]

Clearly the differentiation of "human" and "nonhuman" sediment is a revealing choice on Finney's behalf, particularly given the commitment of the IGBP, and hence the AWG's early efforts, to undermine the distinction between human and nonhuman effects, toward the articulation of a planetary condition.[48]

The AWG are therefore pulled in two directions simultaneously. To acknowledge and act on a normative commitment to warn about the possible implications of human activity on the planet, on the one hand. On the other hand, to respect the evaluative and classificatory requirements associated with the formalization of a geological unit. As the above quotations

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[47] Finney, S. & Edwards, L. 2016. The "Anthropocene" epoch: Scientific decision or political statement? *GSA Today* 26(3): 4-10. See also Finney, S. 2014. The 'Anthropocene' as a ratified unit in the ICS International Chronostratigraphic Chart: fundamental issues that must be addressed by the Task Group. In *A Stratigraphical Basis for the Anthropocene*: 23-28.

[48] The IGBP Vision Statement defines the Earth System as: 'the planet's interacting biological, chemical, physical and socio--economic processes.' See IGBP. 2010. *IGBP Strategic Vision*. Available at http://www.igbp.net/download/18.19b40be31390c033ede80001638/1376383018403/IGBPStrategicVisionpublished27September2010.pdf (accessed 05/05/2021).

indicate, the simultaneity of these two obligations are difficult to reconcile. Responding to the preferences of critics from the voting bodies affiliated with the Scale and Chart have required the AWG to distance themselves from the normative commitments associated with Crutzen's initial articulation of the Anthropocene. This has led to schisms within the Group itself, whereby several AWG members no longer believe the chronostratigraphic method is an appropriate forum for elaboration of the Anthropocene idea.[49] In a more recent article, for example, a core group of stratigraphers within the AWG have attempted to make their prioritization of disciplinary commitments more explicit:

> 'Anthropocene as defined stratigraphically should *not* be equated with 'anthropogenic'. The Anthropocene, we stress, is not synonymous with anthropogenic activity… Had Paul Crutzen used a different term in 2000, not including an 'anthropos', then both the Earth System meaning and justification, and the stratigraphic integrity, of the term would have remained exactly the same, but the conflation of meaning may not have arisen. Equally, had the post-mid-20th century changes we associated with the Anthropocene been produced not by human actions but by, say, volcanoes or a meteorite strike, then the justification and meaning of the Anthropocene both in ESS terms and stratigraphically would also have remained similarly valid. The Anthropocene as an ESS and a chronostratigraphic unit recognizes dramatic changes to the Earth System, using the same criteria that delineates any other previous epoch – it just so happens that the cause is humans this time, rather than some other forcing factor.'[50]

Although this passage insists on the continued congruence of Earth System science perspectives on the Anthropocene with stratigraphic ones, it does so in a way that simultaneously marginalises Crutzen's original articulation of the term, of an Anthropocene

[49] See Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019. The chronostratigraphic method is unsuitable for determining the start of the Anthropocene. *Progress in Physical Geography: Earth and Environment* 43(3): https://doi.org/10.1177%2F0309133319831673

[50] Zalasiewicz, J., Waters, C., Head, M., et al. 2019. A formal Anthropocene is compatible with but distinct from its diachronous anthropogenic counterparts: a response to W.F. Ruddiman's 'three flaws in defining a formal Anthropocene'. *Progress in Physical Geography: Earth and Environment* 43(3): https://doi.org/10.1177%2F0309133319832607

as synonymous with the 'geology of mankind'.[51] Although the article insists that formalization is being pursued through joint efforts of Earth System science *and* stratigraphy, ultimately, the effort is directed toward the delineation of a chronostratigraphic unit that is distinguishable, first and foremost, from "any other previous epoch."

1.3 The GSSP

Most recently, the AWG have begun to pursue a definition of the Anthropocene unit beginning with stratigraphic signals that are associated with the onset of Plutonium isotope fallout (specifically ^{239}Pu) resulting from nuclear weapons detonation in the mid-twentieth century.[52] This is a choice that attempts to be consistent with the requirements of formalising a geological unit. But what are the precise requirements of the ICS and IUGS for units to be formalised as part of the Scale and Chart? Key among them, and one which I will focus on at some length in this thesis, is the Global Stratotype Section and Point (GSSP). The GSSP is a single level of a stratal succession, chosen as a demonstrative sample of the rock unit that it represents. The chosen stratigraphic section is called the 'stratotype.' It is the type section that demonstrates the material characteristics of the proposed unit, and how that unit can be identified in, or correlated with, rock sections around the world. It's function is to serve as a reference point for other geologists around the world who wish to see what characterises the rock of a given unit, for example, of the Holocene. GSSPs are typically designated close to the first appearance of a distinctive fossil or chemical change associated with the unit that it defines. The GSSP is a core, or long cylinder, that is extracted from the chosen model section of rock. That section is determined to be indicative of the material characteristics associated with the unit in question. The stratigraphic definition of "rock" is broad. The base of the Holocene, for example was defined in an ice core. The base of the Meghalayan (the most recent Age/Stage of the Holocene) is defined in a cave speleothem, or stalagmite.[53] The level wherein a GSSP is designated marks the "lower boundary" of the geological unit, or the point in the rock record where the palaeontological, magnetostratigraphic, or chemostratigraphic

[51] Crutzen, P. 2002. Op cit.: 23.
[52] See Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2018. Global Boundary Stratotype Section and Point (GSSP) for the Anthropocene Series: Where and how to look for potential candidates. *Earth-Science Reviews* 178: 379-429.
[53] See Walker, M., Head, M., Berkelhammer, M., et al. 2018. Op cit.

characteristics of the rock are believed to have changed sufficiently enough to inaugurate a new "species" of rock. The "lower boundary" is typically linked to a geochronological event, thought to be the cause of the chronostratigraphic change, such as a glaciation event, a mass extinction event, or in the case of the AWG's hypothesis, the detonation of the first nuclear bomb, which spread Pu_{239} particles around the world, characterising a new chemostratigraphic quality to rock ever since.[54]

Figure 9: Slide from a presentation delivered by Jan Zalasiewicz at the Max Planck Institute for Chemistry during a meeting of the AWG in September 2018. This slide shows a photograph of a sample of rock extracted from the bottom of Lake Crawford in Canada. The ruler indicates how the rock is composed of layers, or strata, that have been deposited in regular sequences. Using a ruler, it is possible to count down from the surface layer and deduce the age of each layer of strata. If, for example, one layer is deposited annually, then the layer of rock referring to the year 1950 can be counted down as the seventy-first layer from the top (if you are counting in the year 2021). Material from this layer can then be analysed, to determine its chemical and physical characteristics, as well as its contents. It is on the basis of such analysis that a particular level in the rock record can be said to refer to a specific point in time. It is how chronostratigraphic material can be correlated to geochronological events. The AWG are presently pursuing the designation of a lower boundary to an

[54] Waters, C., Syvitski, J., Galuszka, A., et al. 2015. Can nuclear weapons fallout mark the beginning of the Anthroocene Epoch? *Bulletin of the Atomic Scienctists* 71(3): https://doi.org/10.1177%2F0096340215581357

Anthropocene unit at around the mid-twentieth century consistent with measurements of Plutonium deposits resulting from nuclear weapons detonations. Zalasiewicz, J. Sep 6, 2018. Outline of Scope of Meeting. *PowerPoint Presentation.*

The purpose of the GSSP is to determine a physical point in the earth that correlates to the geochronological age of the unit. When, for example, one refers to the beginning of the Holocene, they are referring simultaneously to a period beginning approximately 11,700 years ago (its geochronological definition) and a lower boundary recorded at a depth of 1492.45 meters in an ice core extracted from the Greenland ice sheet.[55] This level is subsequently correlated with other stratal sections that demonstrate either the same chemical, biostratigraphic, or other signals (such as magnetostratigraphic, or radiocarbon dated material) associated with that unit. The objective is to trace a lower boundary for the unit, which begins at a single defined point but is elaborated through correlation of material evidence, around the planet. The lower boundary of a unit may not be visible equally in all parts of the world, and it is unlikely that the material characteristics associated with a unit will appear at the same depth everywhere in the world, for example, if one were to simply dig wherever they happened to be. Yet the GSSP is thought to demonstrate a material referent for a geochronological age, that defines the material qualities of a geological unit. The ICS Guidelines define the GSSP as:

> a unique and specific point in a specific sequence of rock strata in a unique and specific geological location… [constituting a] standard for the definition and recognition of the stratigraphic boundary between two named global standard stratigraphic (chronostratigraphic) units… a unique time signal for the world geological stratigraphic time scale.[56]

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[55] See Walker, M., Johnson, S., Rasmussen, S. O., et al. 2008. Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. *Journal of Quaternary Science* 24(1): 3-17.

[56] Cowie, J., et al. 1987. *Guidelines and Statutes of the International Commission on Stratigraphy*. Frankfurt: Commission on Stratigraphy of the International Union of Geological Sciences. Pg 5.

The GSSP therefore serves to indicate a point in the stratigraphic record where the characteristics of a section can be said to have changed substantially enough to have become a different kind of strata.[57]

Figure 10: GSSPs are often marked with a metallic nail, or "golden spike" that is hammered into the selected section. The above photo depicts the GSSP for the Ediacaran Period/System, in Enorama Creek, Australia. See Counts, J. 2017. The Adelaide Rift Complex in the Flinders Ranges: Geologic history, past investigations and relevant analogues. Adelaide: Geological Survey of Southern Australia.

A GSSP is defined by several factors. In general terms, the revised guidelines of the ICS state that the Stratotype-section chosen as the GSSP 'should contain the best possible record of the relevant marker events.'[58] More specifically its requirements include:

- Exposure of the signal over an adequate thickness of sediments

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[57] It is with a GSSP, for example, that the lower boundary of the Holocene is set at 1492.45 metres depth in the Greenland ice sheet, rather than by way of relative dating of strata, typically based on fossils or geological unconformities, as is the case in early units of the Phanerozoic or most of the Precambrian.

[58] Remane, J., Basset, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). *Episodes* 19(3): 77-81. Pg. 80. As we shall see in chapter four, these guidelines build off the effort to standardise classification techniques, consolidated in Hedberg, H. (Ed.) 1976. *A Guide to Stratigraphic Classification, Terminology, and Procedure*. John-Wiley & Sons: New York.

- The chosen Stratotype should be continuous in deposition (without gaps or disturbances, i.e. from bioactivity that disrupts the layering of sediment)
- Adequate rate of sedimentation, i.e. that the Stratotype should contain sediment that has been deposited regularly, such as once a year. These are known as 'laminations'.
- Abundance of well preserved biostratigraphic signals (i.e. fossils).
- Where possible, other methods of absolute dating should be used, such as radiometric or magnetostratigraphic, to provide as accurate a date as possible. These are in addition to the *relative* dating provided by the appearance of fossils.
- Chemostratigraphic signals are also favoured, i.e. an analysis of the chemical composition of the sediments contained in the Stratotype, to compliment its biostratigraphic definition.
- It should be easily accessible by scientists or visitors who wish to examine the Stratotype section. Access should be free of charge. Guarantees should be obtained that the site will continue to be permanently well-maintained.[59]

A proposal for a GSSP would therefore include sufficient evidence of the above points to satisfy the executive committees of the ICS and IUGS. The boundary must be named, include a 'topographic map or aerial photograph… at a scale not less than 1 : 50,000.'[60] It's location should be identified on a geological map. Thorough chemostratigraphic and biostratigraphic description of the contents of the Stratotype, together with results of radioisotopic dating of the section. An argument must be made concerning the motivation for using the chosen Stratotype, together with a demonstration of the global correlatability of the section with other sections around the world.[61]

Importantly, the GSSP is distinct from the Global Standard Stratigraphic Age (GSSA), which is a method of defining units on the basis of a numerical age. This is a method popular in older stratigraphic sections, where fossils are scarce, limiting the correlation potential of strata. GSSA definitions often use radiometric dating methods, which measure the half-lives of isotopes to provide precise dates of strata. The Archean and Proterozoic eons, defined at two and a half billion years ago, are examples of geological units marked with a GSSA rather

[59] Remane, J., Bassett, M., Cowie, J., et al. 1996: 79.
[60] Ibid.
[61] Ibid: 80.

than a GSSP. The difference of the GSSA and GSSP is significant, because it emphasises the disciplinary requirements made of the AWG. Although early efforts to define the beginning of the Anthropocene had been approximated on the basis of numerical ages (Crutzen advocated both “approximately 1800” to coincide with the beginning of the industrial revolution; Steffen later advanced “around 1950” coinciding with the Great Acceleration)[62], the committees affiliated with the Chart and Scale have made clear that a numerical age definition is not an option.[63] This insistence has pushed the AWG’s formalization efforts more stubbornly toward a strictly geological definition that, as we shall see in a later chapter, some members believe undermines their contributions, as well as the normative commitment originally articulated by Crutzen and his colleagues.

[62] Steffen, W. 2021. Op cit.
[63] Finney, S. 2014.

Figure 11: The NGRIP ice core was used as the GSSP for the lower boundar of the Holocene Epoch/Stage. Image (a) shows the ice core being tilted into position. Image (b) shows the ice core in the drill prior to extrusion. Image (c) shows the extruded ice core. Source: Walker, M., Johnsen, S., Olander Rasmussen, S., et al. 2009. Formal definition and dating of the GSSP for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. Journal of Quaternary Science *24(1): 3-17.*

The GSSP is the device that would combine an Anthropocene unit as both a geochronological *event* and chronostratigraphic *material*. It qualifies the novelty of an Anthropocene unit as both an event that took place with radical effect on the material rock of the Earth. Event and material reference each other interchangeably in stratigraphic definition. The event is recorded in strata, recognisable as a change in the material qualities of the rock. An extinction event may result in a change in the kinds of fossils preserved in the rock record. A reversal in the polarity of Earth's magnetic field provides an *event* that can be identified materially through measurement of the residual magnetism of sections of rock. A change in the chemical composition of rock sections is a material, chronostratigraphic development that can be used as a basis for identifying a geochronological event. The GSSP functions as a translation device between *temporal* and *material* descriptions of strata. It marks the "lower boundary" of a chronostratigraphic unit; effectively the *beginning* of a geochronological unit. A GSSP is recorded in material space, as a "golden spike" hammered into the section of rock that marks the 'lower boundary' of a unit; it is also indicated on the International Chronostratigraphic Chart, and the Geological Time Scale to mark the beginning of a unit, and that unit's position within the overall chronology of Earth. In material terms, the function of the GSSP is furthermore to facilitate correlation of geological units: to provide a reference section with which geologists can compare strata wherever they may be with the material characteristics associated with the section that the "golden spike" is hammered into. The GSSP therefore ultimately functions as a reference device translating between degrees of universal abstraction and local materiality.

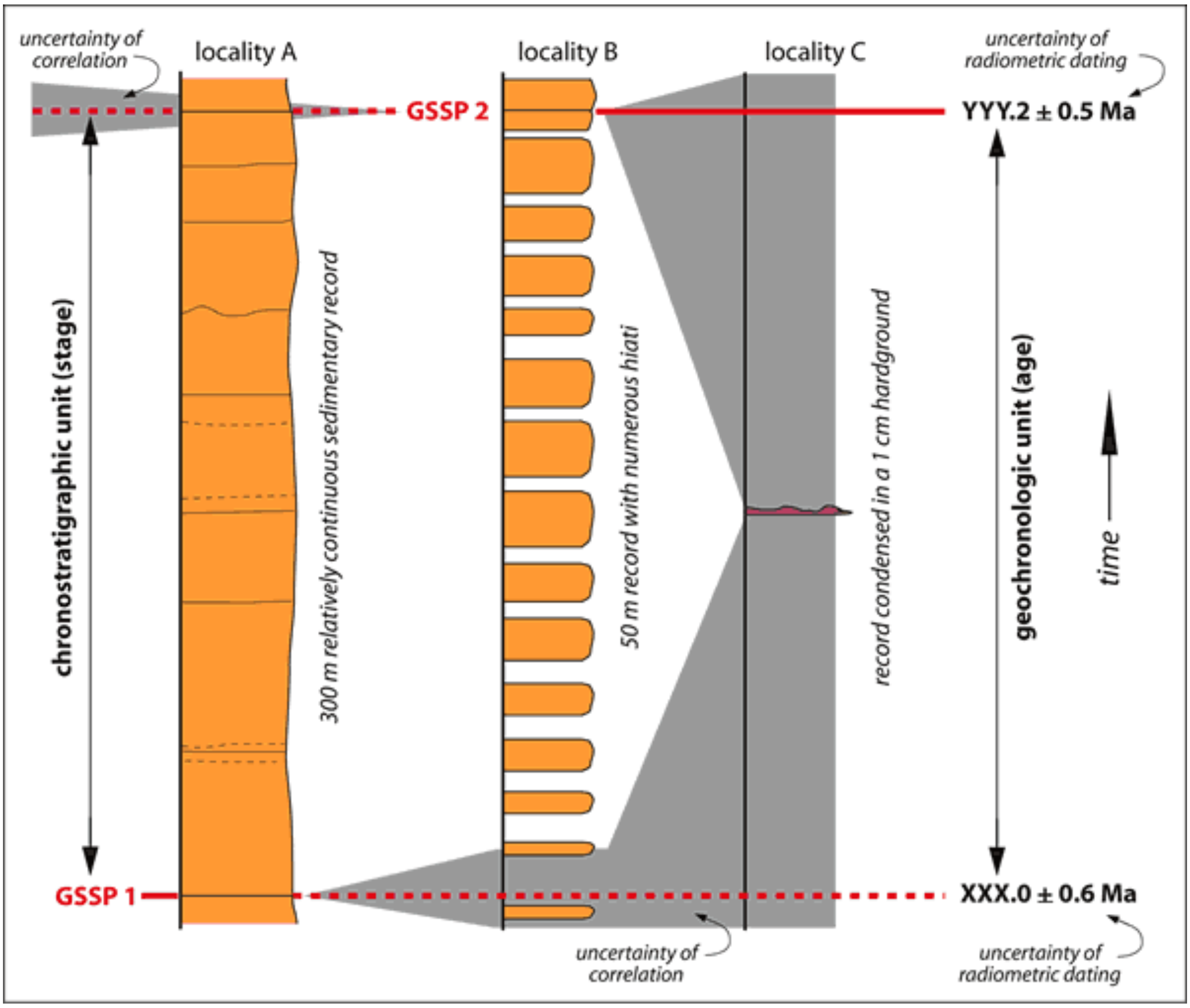

Figure 12: Diagram illustrating the relation of chronostratigraphic rock units, and geochronological time units. Source: Zalasiewicz, J., Bianca Cita, M., Hlgen, F., et al. 2013. Chronostratigraphy and geochronology: a proposed realignment. GSA Today *23(3): 4-8.*

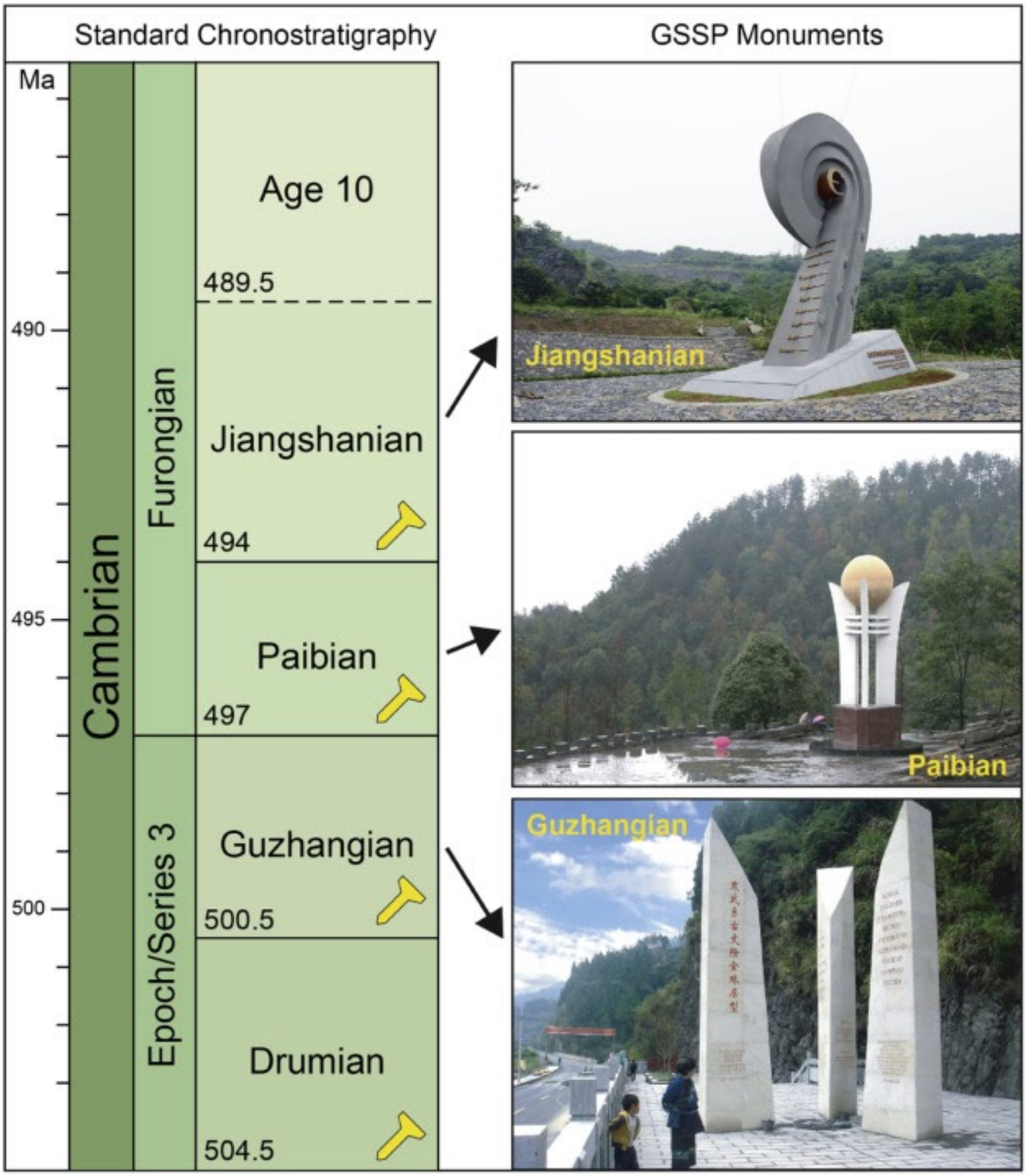

Figure 13: The above image indicates the relationship between the Chart or Scale and the site where the GSSP is physically located. In addition to a "golden spike", some GSSP sites are often accompanied by elaborate monuments. The GSSP monuments of the Jiangshinian, Paibian, and Guzhangian, together with their location on the Geological Time Chart/International Chronostratigraphic Chart. Source: Ogg, J.2019. Integrated global stratigraphy and geologic timescales, with some future directions for stratigraphy in China. Earth-Science Reviews *189: 6-20.*

1.4 Structure of this thesis

My interest in this thesis concerns the AWG's ongoing effort to formalise the Anthropocene as a geologic unit. I explore this interest in two parts. The first part of my thesis presents a genealogy of some fundamental components of geological observation: the geological unit, the evaluative mechanism associated with the Chart and Scale, and the GSSP. These overviews are presented as a way of situating the Anthropocene theme within recurrent refrains in geology. Chapter two presents a history of the geological unit, and the methods and devices of correlation with which the planet was originally apprehended as an entity that could be organised and arranged into discrete units. I argue that these are fundamentally forensic methods with which accounts are solicited from material artefacts. In the seventeenth century, the advent of the fossil facilitated a subversion of inference wherein the observer could now draw on their material environment to account for the events described in scripture. Uncoupled from religion, geological forensicality could, quite literally, unearth a novel understanding of time: *deep time*, with material artefacts such as fossils and shark teeth indicating a temporality far more vast than biblical estimates. Crucially, this deep temporality was articulated through material artefacts: rocks, fossils, and the equipment used to measure and observe them. Breaking this expansive timeline into smaller, distinct units, "geognosts" and "natural historians", as they self-identified then, sought to comprehend deep time by establishing methods to solicit accounts of events from their material remains.

Chapter three presents a brief history of efforts to establish an evaluative mechanism for the comparison and ultimately the unification of divergent practices of geological classification and correlation. I demonstrate the influence of these practices – established at the end of the nineteenth century over a series of meetings of the International Geological Congress, the first meetings of international geologists in one place – are present in the deliberative efforts of the AWG. Chapter four focuses on the GSSP as a crucial metric of stratigraphy and stratigraphic evaluative procedure. The GSSP, as we shall see, plays a crucial role in the AWG's formalization effort, to the extent that it is a formal requirement made of any Working Group exploring an amendment to the Scale and Chart. I explore how the GSSP is at once a unifying concept, to the extent that it is enforced as a disciplinary standard, while also concealing one of the discipline's most contested issues: the relationship between geochronology (or duration), sometimes referred to by stratigraphers as "time" and chronostratigraphy (material designations), often referred to as "rock". This distinction implies some overlaps that have never been fully resolved. I shall explore the extent to which the issues associated with this distinction inform the AWG's articulation of the Anthropocene as a unit, and how that debate helps the AWG anticipate the preferences of the voting bodies associated with the Scale and Chart.

With these three chapters, I seek to identify the parameters of the Anthropocene debate as it is deliberated by the AWG. The term 'Anthropocene' has been mobilised in many more ways than those demonstrated by Crutzen and his colleagues in the context of anthropogenic climate change on the one hand, and the AWG and geological classification on the other. In his "guide for the perplexed", Jamie Lorimer suggests five ways in which the idea of the Anthropocene has been mobilised: scientific question, intellectual zeitgeist, ideological provocation, new ontologies, and science fiction.[64] These mobilisations range in their intent. Some raise concern over the AWG's formalization effort, as well as Crutzen's original articulation of the Anthropocene, on the grounds that the term blankets differential culpability under the singular umbrella of 'Anthropos'. The burning of fossil fuels associated with the industrial revolution, which Crutzen posits as a possible start date of the Anthropocene, occurred primarily in the United Kingdom. The generalised figure of the 'Anthropos' conceals racialized legacies of extraction and colonial imperialism, it is argued accordingly, framing as "new" a historical condition of oppression and dispossession.[65]

Elsewhere, the Anthropocene is mobilised as an ontological theme. Within this framework, the Anthropocene is figured as a provocation to refashion the meaning of "Earth" as well as the human subject. Dipesh Chakrabarty has reflected on the implications of figuring the planet as an active, historical agent, and how a "climate of history" might be figured accordingly.[66] The Anthropocene is figured as the imperative to ecologize. Chakrabarty argues that the idea of the Anthropocene urges historians, philosophers, social scientists, to devise new accounts of history, society, the human subject, that take the active role of the environment into account. He posits the Anthropocene as the historical moment of the

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[64] Lorimer, J. 2017. The Anthropo-scene: A guide for the perplexed. *Social Studies of Science* 47(1): https://doi.org/10.1177%2F0306312716671039

[65] An argument exemplified in Yusoff, K. 2018. *A Billion Black Anthropocenes or None*. Minneapolis: University of Minnesotta Press. See also Moore, J. (Ed.) *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism*. Oakland: PM Press.

[66] Chakrabarty, D. 2009. The Climate of History: Four Theses. *Critical Inquiry* 35(2): 197-222.

planets long overdue recognition as a historical agent, calling it a "new humanist category."[67] Borrowing from Eugene Thacker, he acknowledges three facets of this new category: 'the world-for-us is simply the World, the world-in-itself is simply the Earth, and the world-without-us is simply the Planet'[68] Similarly, Donna Haraway takes up the Anthropocene theme as a call to imagine new ways of living *with* entities, such as animals, plants, and the planet, long assumed to be passive backdrops to an exclusively human agency. Haraway advocates for an ontology that 'entangles myriad temporalities and spatialities and myriad intra-active entities-in-assemblages – including the more-than-human, other-than-human, inhuman, and human-as-humus.'[69]

These are just two examples of the ways in which the Anthropocene has been mobilised as a conceptual and historiographic theme. These arguments are important and deeply compelling. Their contribution to the ongoing elaboration of the Anthropocene as a set of ideas, practices, and historiographic themes is invaluable. In their own literature, the AWG struggle to address the implications of these kinds of interventions for the formalization effort. In their own words, the AWG acknowledge that a

> 'necessary line of study is to explore more deeply the significance of formalising (and, conversely, of not formalising) the Anthropocene in the geological sciences, for the more contemporary – focused Earth System science (within which the term emerged) and for a range of other disciplines both within the physical sciences and well beyond it, extending into the social sciences, humanities and arts, all of which have taken a keen interest in the Anthropocene and have interpreted it in various ways.'[70]

And yet the consequence of this acknowledgement is to bracket those contributions. 'The AWG's emphasis,' they continue, 'concerns the 'geological Anthropocene' essentially as

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[67] Chakrabarty, D. 2019. The Planet: An Emergent Humanist Category. *Critical Inquiry* 46: 1-31.
[68] Thacker, E. 2011. *In The Dust Of This Planet: Horror of Philosophy Vol. 1.* London: Zero Books. 5
[69] Haraway, D. 2015. Anthropocene, capitalocene, plantationocene, chthulucene: Making kin. *Environmental Humanities* 6: 159–165. See also Haraway, D. 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham: Duke University Press. The notion of "inhuman ontologies" is also taken up via the notion of the Anthropocene in Clark, N. 2011. *Inhuman Nature: Sociable Life on a Dynamic Planet.* Thousand Oaks, CA: SAGE.
[70] Zalasiewicz, J., Waters, C., Williams, M,, et al. Epilogue and Forward Look for the Anthropocene. In Zalasiewicz, J., Waters, C., Williams, M,, et al. (eds). *The Anthropocene as a Geological Time Unit*. Cambridge: Cambridge University Press. Pp. 285-286.

originally intended rather than other interpretations.'[71] The contributions associated with "extra-geological" mobilisations of the Anthropocene theme constitute a blindspot for the AWG. They indicate what the AWG's formalization effort, and consequently what a formal Anthropocene unit, overlooks.

However, what Zalasiewicz et al. characterise in the above passage as the contributions from 'a range of other disciplines both within the physical sciences and well beyond', also demonstrate a blindspot in their assessment of the AWG's formalization effort. Namely, that blindspot is apparent in the assumption that the formalization effort proceeds against a backdrop of consensus within the Group. Critical reflection on the implications of the Anthropocene as it is mobilised by the AWG, can be enriched through acknowledgement of the dynamics the formalisation effort entails. In this thesis, I seek to adopt the position of those engaged in the formalisation effort, while allowing room for critical reflection on the parameters and implications of this process, for stratigraphy 'and well beyond.' I engage stratigraphic literature with the concerns it lays out for itself, as evidenced by the controversy that the Anthropocene has sparked among those concerned with a formal Anthropocene unit. I have hinted already at how the Anthropocene is a term that is translated into a set of concerns regarding stratigraphic classification. It is, furthermore, a theme that stratigraphers believe they are uniquely, and to some extent, exclusively positioned (even if through an "accident" of nomenclature), to resolve. The AWG have pursued this effort largely in avoidance of non-stratigraphic literature regarding the theme of the Anthropocene. This has been partly a tactical precaution by the AWG so as not to aggravate members of the voting bodies who have criticised their formalisation effort as irrelevant, calling it a 'political decision' and 'pop culture'.[72]

For some members of the AWG, there is no way to distinguish between the climatic *and* stratigraphic implications of an Anthropocene unit, and the political implications that precipitate from the acknowledgement of a "planet under pressure" from the activity of some (more than other) humans. Yet other members of the AWG have stated in no uncertain terms that politics and pop culture do not appear in their formalization effort.[73] There is

[71] Ibid.
[72] See Finney, S. & Edwards, L. 2016; Autin, W. & Holbrook, J. 2012.
[73] See, for example, Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* 351(6269): DOI10.1126/science.aad2622

therefore a sense that the Anthropocene is a theme that can be dealt with in exclusively stratigraphic terms. The suggestion that large bodies of literature mobilising the idea of the Anthropocene are not relevant to the AWG's formalization effort is an effort to draw a line between a stratigraphic approach to the Anthropocene, and a non-stratigraphic approach. This is a point further emphasised by claims that even though the AWG does not deal with those extra-stratigraphic concerns directly, and does not incorporate them into their formalisation effort, that effort will nevertheless prove "useful" to the wider discussions of the term "well beyond stratigraphy". The AWG argue that formalization of an Anthropocene unit 'will likely contribute to the clarify of the term and facilitate its use, at least in the geology-related sciences and hopefully more widely.'[74] I wish to understand this approach by stratigraphers as an object of investigation in itself.

In the second part of my thesis, I consider the AWG's formalisation effort by way of participant observation. Beginning in January 2018, I spent two years meeting regularly with members of the AWG. I was included in much of their correspondence, attended AWG meetings, and met at least once a month with the Chair (Jan Zalasiewicz) and Secretary (Colin Waters) at their University of Leicester offices. I draw on my participant observation of the AWG to explore how they develop their proposal for a formal unit. I seek to demonstrate the problems, themes, and commitments that preoccupy the AWG as they develop their proposal. My experience with the AWG provides insight into the formalisation process that is not necessarily apparent, or acknowledged, in the AWG's own literature concerning formalisation. Part two of my thesis focuses, in particular, on two meetings that I attended:

1. A meeting of the AWG at the Max Planck Institute for Chemistry in Mainz, Germany. This meeting took place between September 5-8, 2018.
2. A meeting of the GSSP core candidate teams, which took place at the Haus der Kulturen der Welt in Berlin, Germany, between May 28-29, 2019.

In chapter five, I recount the events of the 2018 meeting of the AWG. This was the first meeting of the AWG since a 2016 internal vote that decided on defining the Anthropocene as a geologic unit at the rank of Epoch/Stage, using a GSSP with a primary guide in the mid-twentieth century associated with the "bomb spike", or plutonium fallout from

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[74] Zalasiewicz, J., Waters, C., Ellis, E., et al. 2021. The Anthropocene: Comparing Its Meaning in Geology (Chronostratigraphy) with Conceptual Approaches Arising in Other Disciplines. *Earth's Future* 9: https://doi.org/10.1029/2020EF001896

nuclear weapons testing.[75] Several presentations were made by AWG members concerning the evaluative framework affiliated with amendment of the Scale and Chart, as well as the requirements of a GSSP definition. Interestingly, there were also several presentations by voting members of the ICS, as well as AWG members debating the appropriateness of those very same evaluative and classificatory mechanisms. The meeting therefore offers direct insight into epistemic and normative debates that occur *within* the AWG. These debates suggest that the Group's formalization effort entails the negotiation of very different commitments, wherein the original definition of the Anthropocene as a warning regarding anthropogenic climate change; the effort to define a unit in accordance with the classificatory methods particular to the Scale and Chart; as well as the various commitments represented by the diverse membership of the AWG, remain precariously unresolved.

In the final chapter, I focus on a recent development within the AWG's formalization effort: the acquisition of a grant from the Haus der Kulturen der Welt, a contemporary arts institution in Berlin. This event marks a significant milestone for the AWG, because the group has applied for funding unsuccessfully on numerous occasions (see appendix: 1). Prior to the grant, members of the AWG had conducted research either through literature reviews; by using "leftover" stratigraphic sections from field samples extracted for the purposes of non-Anthropocene research; or through efforts to translate archaeological or geographical research into an argument that could be submitted to the voting bodies of the Scale and Chart. With the one-million-euro grant, the AWG could commission the extraction of field samples (or "cores", which are large cylinders of (typically) ice or sediment) for comprehensive and original AWG analysis, thereby accelerating the completion and submission of their proposal to the voting bodies affiliated with the Scale and Chart.

The Anthropocene has yet to be formalised as a geologic unit. The AWG's formalization effort is therefore ongoing. This thesis does not (and cannot) offer a definitive conclusion regarding the effort to define the Anthropocene as a geologic unit. Instead, I seek to offer insight into the ongoing dynamics of formalisation. The term 'Anthropocene' is

[75] The circumstances and results of that vote are presented in Zalasiewicz, J., Waters, C., Summerhayers, C., et al. 2017. The Working Group on the Anthropocene: Summary of evidence and interim recommendations. *Anthropocene* 19: 55-60. On the "bomb spike", see Zalasiewicz, J. & Waters, C. 2015. Colonization of the Americas, 'Little Ice Age' climate, and bomb-produced carbon: Their role in defining the Anthropocene. *Anthropocene Review* 2(2): 117-127.

discussed in a wide variety of contexts, and is mobilised towards a set of objectives that are incommensurable. My thesis does not attempt to resolve these divergent mobilisations. Rather, I seek to emphasise the significant role of incommensurability in the construction of the ‘Anthropocene unit’ narrative. It is not often that new geological units are formalised, and none have such a dramatic effect as to provoke geologists to address issues such as capitalism, ontology, or the epistemological foundations of their discipline in as explicit a manner as has occurred since the effort to define the Anthropocene as a geologic unit commenced. In my thesis, I hope to historically situate the layers of narration and controversy that animate the AWG’s formalization effort, and to compliment that genealogy with an account of the effort “in action,” by recounting my experiences with the Group. Through invoking the methods of genealogy and participant observation, I hope to demonstrate that the effort to define a new geological unit unfolds not as an act of discovery, but as an active process of construction. To understand the dynamics of this constructive process properly entails an appreciation of multiple, simultaneous, and overlapping phenomena: scientific, legal, cultural, and political.

The AWG’s formalisation effort is legislative to the extent that the AWG must submit evidence to an authoritative body that will *judge* and enforce their decision on the stratigraphic community (and in the case of the Anthropocene, possibly beyond). It is cultural insofar as the meaning of essential methods and concepts such as the GSSP and ‘deep time’ are contested in accordance with differences in stratigraphic practice. It is political because the manner in which the AWG’s formalisation effort is engaged differs in respect of the interests of diverse AWG members and voting members of the evaluative hierarchy. In other words, the AWG’s formalisation effort unfolds in respect of a hierarchically determined (by the ICS and IUGS who ratify the International Chronostratigraphic Chart) assertion of what counts as a reliable stratigraphic observation and why. In attempting to formalise an Anthropocene unit, the AWG engage these conventions critically, and encourage an assessment of the structure and techniques of unit formalisation. The AWG’s effort is therefore simultaneously an effort to critically engage why the evaluative process in stratigraphy is the way it is: what counts as reliable knowledge and why.

2. The Original Forensic Science[76]

The activities of the AWG concern the effort to formalize the Anthropocene as a geological unit. To this extent, a good place to begin is with the question: what is a unit? Geologists currently posit that earth is four and a half billion years old. Throughout this time, events of varying magnitudes have occurred, and life has existed in as many different forms. These phenomena and variations are evident in the material records of the planet. Matter, from rocks to fossils, are deposited in regular layers that can be dated like tree rings. In addition to the temporal aspect of counting rings, the layers of the earth are often composed of different *kinds* of rock, or sediment, and may contain different kinds of fossils. Geologists draw on such differences to distinguish earth's substantial material record into distinct *units*. Among the first to do so was Giovanni Arduino, who in the mid-eighteenth century identified four major categories of strata, or units.[77] Today there are over one hundred units. Units themselves are categorised into a further hierarchy. For example, of the approximately one hundred and sixty-four units of the International Chronostratigraphic Chart are, in fact, sub units of just two units: the Precambrian (which marks the time on earth before life) and the Phanerozoic (from the Greek "appearance of life").[78] The Precambrian and Phanerozoic are units at the rank of Eonothem/Eon. Eonotohems/Eons contain Erathems/Eras, which contains Systems/Periods, in which there are Series/Epochs, which finally contain the smallest rank of unit, called Stages/Ages. The dual title of each category refers to the differentiation of geochronologic and chronostratigraphic units (roughly, the difference between the *duration* of a unit, and the *material section* it comprises. As we shall see, this difference is contested

[76] The terminology of geology as the 'original forensic science' is borrowed from Pottage, A. 2019. Holocene Jurisprudence. *Journal of Human Rights and the Environment* 10(2): 153-175.

[77] outlined in Arduino, G. 1770. Giovanni Arduino ai Provveditori Deputati sopra l'Agricoltura. Vicenza, 18 February 1769. Giornale d'Italia, 6, p. 156-174; Arduino, G. 1774. Saggio Fisico-Mineralogico di Lythogonia e Orognosia. Atti dell'Accademia delle Scienze di Siena detta de' Fisiocritici (Siena), 5, p. 228–300; Arduino, G., 1760. Due lettere [...] sopra varie sue osservazioni naturali: Al Chiaris. Sig. Cavalier Antonio Vallisnieri professore di Storia Naturale nell'Università di Padova: Lettera Prima [...] Sopra varie sue Osservazioni Naturali (Vicenza, 30 gennaio 1759): Lettera Seconda [...] Sopra varie sue Osservazioni fatte in diverse parti del Territorio di Vicenza, ed altrove, appartenenti alla Teoria Terrestre, ed alla Mineralogia (Vicenza, 30 marzo 1759). Nuova Raccolta di Opuscoli Scientifi ci e Filologici (Venezia), 6, p. 99-180. A detailed outline of Arduino's efforts is provided in Vaccari, E. 2006. The "classification" of mountains in eighteenth century Italy and the lithostratigraphic theory of Giovanni Arduino (1714–1795). In: Vai G.B., & Caldwell W.G.E., The origins of geology in Italy. Geological Society of America Special Paper411, p. 157–177; Gibbard, P. 2019. Giovanni Arduino – the man who invented the Quaternary. *Quaternary International* 500: 11-19.

[78] See Cohen, K., Finney, S., Gibbard, P., et al. 2013 (updated).

by some stratigraphers). The formalization effort of the AWG seeks to establish the Anthropocene as the latest geological unit, at the level of Series/Epoch. That means that the Anthropocene would succeed the Holocene, which marks the end of the last interglacial period approximately eleven thousand, seven hundred years ago.

In this chapter, I wish to provide a brief genealogy of the category of the geological unit. In doing so, I wish to position the formalization effort of the AWG within a broader culture of classification and evaluation in stratigraphy. The AWG's formalization effort does not proceed *exclusively* from Crutzen's understanding of the term. It responds to a set of practices, unresolved tensions, and evaluative structures. The influence of these factors on the AWG's formalization effort cannot be underestimated. Indeed, they are far more determinative of that effort than has been fully appreciated in accounts of the AWG's effort to date, and the Anthropocene theme more generally. In other words, the Anthropocene, as it has been developed by the AWG, is not simply responding to ecological circumstances, it is also framed by an evaluative and disciplinary culture that characterises the discipline of stratigraphy. In the next chapter, I will draw on Bourdieu's notion of "habitus" to elaborate this perspective further. However, first I wish to situate these circumstances historically.

A brief genealogy of the unit is a key way to approach an understanding of the requirements entailed in the formalization effort of the AWG, because it also foregrounds the practices and conventions according to which geological units are formalised. Geologists are always removed from the object of their study. Even the most recent unit, the Meghalayan, which has a lower boundary that is four thousand two hundred years old, is older than any living geologist, and precedes all known accounts of geological observation. The discipline of geology is characterised by various strategies for dealing, and overcoming, this displacement. And as we shall see, that is also the source of much controversy that continues to animate the pages of stratigraphic journals to this day. Tracing the emergence of the unit is therefore part of the preliminary work necessary to demonstrate the conventions and practices that characterise the discipline of geology, and the set of technical practices according to which geologists generate and maintain an authentic claim to knowledge. The AWG's formalization effort is a response to those incumbent practices, to the extent that the AWG must find a way to recount the arguments associated with the Anthropocene in a manner that satisfies the requirements of the ICS and IUGS executive members, who cast the final vote concerning its formalization.

2.1 The original forensic science

In seeking to situate geological formalization practices as continuous with a history of forensic observation, we may begin, as do many historical accounts of geology, with **Nicolas Steno** (1638-1686).[79] Steno was a natural historian from Denmark, who eventually traded in his scientific pursuits for a life in the clergy. Yet as we shall see, the mix of religion and science is not unusual in the history of science, indeed the two are somewhat continuous with each other as concerns their devotion to the use of objects with which to supplements stories of creation, whether in the scriptural or evolutionary sense. In October 1666, a large shark was caught by two fishermen off the coast of Italy. The Grand Duke of Tuscany ordered the head to be sent to Steno for analysis. Steno published his findings in 1667, noting a peculiar resemblance between the shark's teeth and certain objects found in stones on hilltops. These objects had been the focus of his colleagues' attention, and had acquired the name "glossopetrae" or (from Greek, meaning "tongue stones"). Even Pliny the Elder recorded these objects in his *Naturalis Historia*.[80] Yet whereas Pliny had assumed they had fallen from the moon, Steno wanted to stay with the predicament they presented, and elaborate the narrative suggested by the shark teeth. That was, namely: the possibility that these objects had not fallen from the moon, but ascended from the sea. Moreover, the glossopetrae were themselves stones. They were sharks' teeth, themselves embedded within rock.[81] The predicament was not simply how they had travelled from the seas to mountain tops, but how

[79] Examples of such accounts include Rudwick, M. 2014. *Earth's Deep History: How It Was Discovered and Why It Matters*. Chicago: University of Chicago Press; Toulmin, S. & Goodfield, J. 1965. *The Discovery of Time.* Chicago: University of Chicago Press; Rossi, P. 1984. *The Dark Abyss of Time: The History of the earth and the History of Nations from Hooke to Vico*. Chicago: University of Chicago Press, who starts with a contemporary of Steno's who came to very similar conclusion, named Robert Hooke; Gould, S.J. 1987. *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*. Cambridge: Harvard University Press.

[80] This parallel is developed in chapter one of Rudwick, M. 2014. See also Rudwick, M. 1972. The Meaning of Fossils. Chicago: Chicago University Press. Especially chapter one. See also Bek-Thomsen, J. 2013. From flesh to fossils – Nicolaus Steno's anatomy of the Earth. In Duffin, C.J., Moody, R.T.J. & Gardner-Thorpe, C. (eds). A History of Geology and Medicine. London: Geological Society of London Special Publication 375. Pp. 289-305.

[81] Stenonis, N. 1667. *Elementorum Mylogiae Specimen, seu Musculi description Geometrica. cui accedunt Canis Carcharie dissectum Caput, et Dissectus Piscus ex Canum genere*. Florentiae. An English translation is available in Garboe, A. 1958. *The earliest geological treatise (1667) by Nicolaus Steno (Niels Stensen), translated from Canis Carchariae Dissectum Caput*. London: Macmillan.

they had become encrusted within rock. These objects, in other words, suggested a peculiar temporality and spatiality that Steno wished to explore further.[82]

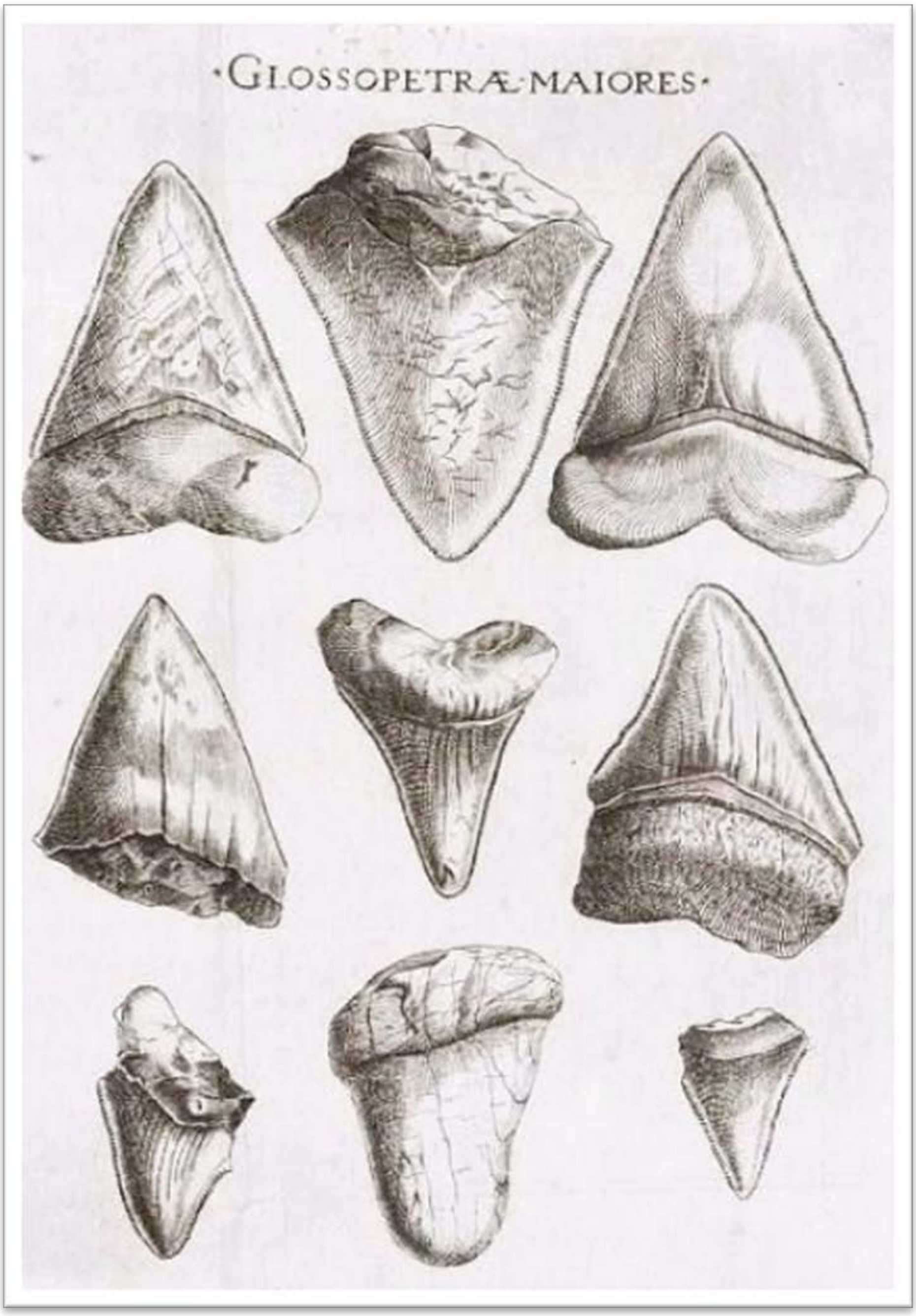

Figure 14: Steno's illustration comparing shark teeth with "glossopetrae", initially thought to be a set of stones that resembled tongues, found in solid rock. Steno argued that not only were "glossopetrae" in fact shark teeth, but that they belonged to a species of shark far larger than any known during his time, dating from an

[82] Stenonis, N. 1669. *De Solido intra Solidum naturaliter Contento Dissertationis Prodromus*. Florentiae. For a modern English translation, see Winter, J. 1968 [1916]. *The Prodromus of Nicolas Steno's dissertation concerning a solid body enclosed by process of nature within a solid*. New York: Macmillan.

early period of history. Originally published in Steno, N. 1667, Mytologia Specimen. Source: https://www.pinterest.com/pin/510243832763153091/ (accessed 9/4/2021).

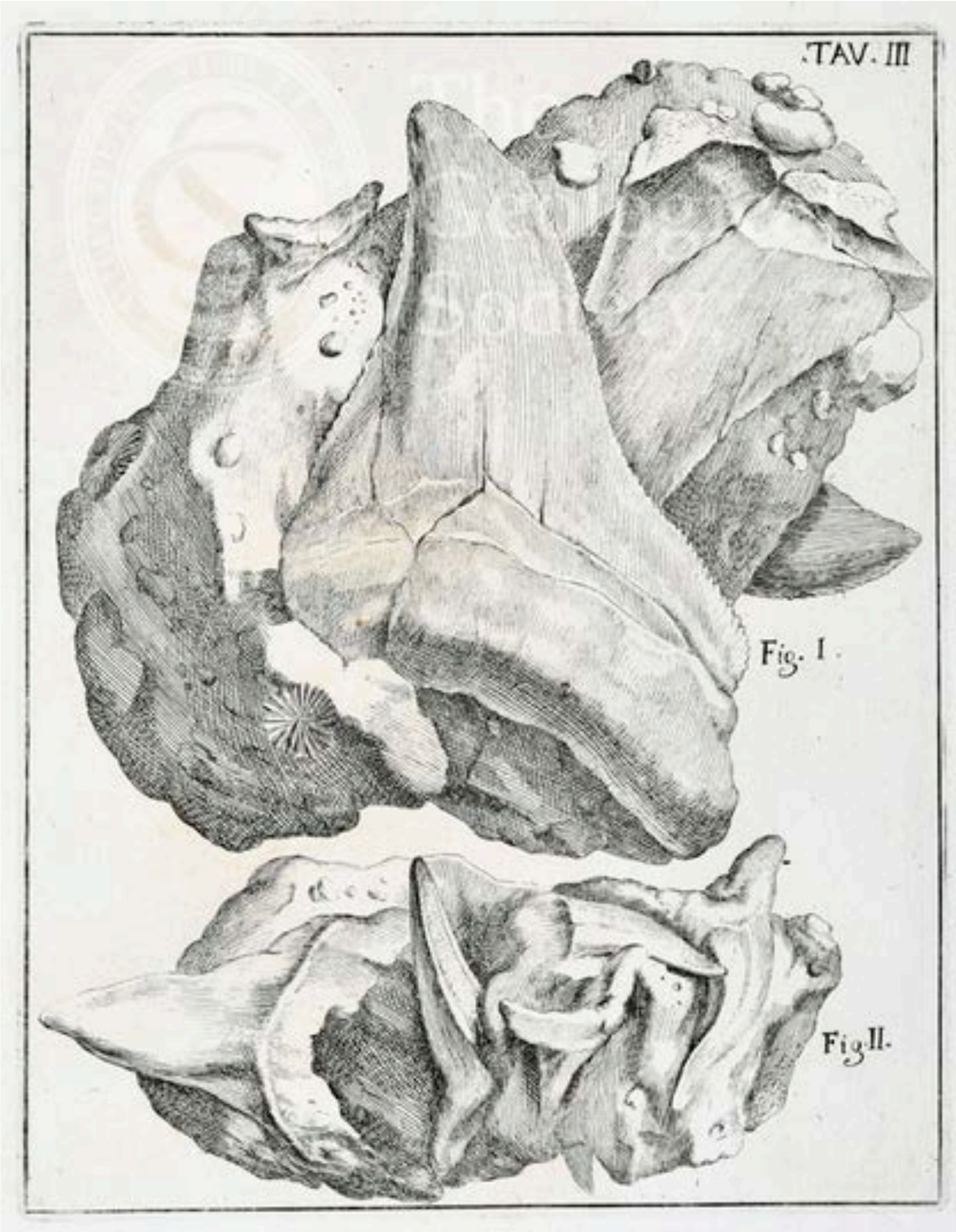

Figure 15: Illustration by Steno indicating the appearance of "glossopetrae" as encountered within rock. Originally published in Steno, N. 1667, Mytologia Specimen*. The fact that these artefacts were found encrusted in rocks was significant to Steno. It demonstrated the relative age of materials. The encrusted object must be older than the rock that encrusts it. This insight was seminal to Steno's articulation of what remain fundamental principles of geology today. Source: https://gslpicturelibrary.org.uk/glossopetrae-tongue-stones/ (accessed 9/4/2021).*

Steno called such objects "solid bodies within solids."[83] His exploration of these objects in his *Dissertationis Prodromus* of 1669 was limited – intended as a "trailer" to a more substantial work that never materialised, as Steno transitioned to a career in the Roman Catholic church – yet established a set of principles that are still key to contemporary geological practice. These principles included the law of superposition, which states that layers of strata are deposited, and therefore ordered, sequentially. The lower layers of strata are, if undisturbed by natural processes (which we shall review shortly), older than those layers closer to the surface. Steno also established the principle of unconformities, although it remained to be fully elaborated by James Hutton approximately a century later.[84] In his 1669 text, Steno posits that, following from the theory of superposition, if a body of strata cuts across another body, the cutting body must be more recent than the one it cuts across.

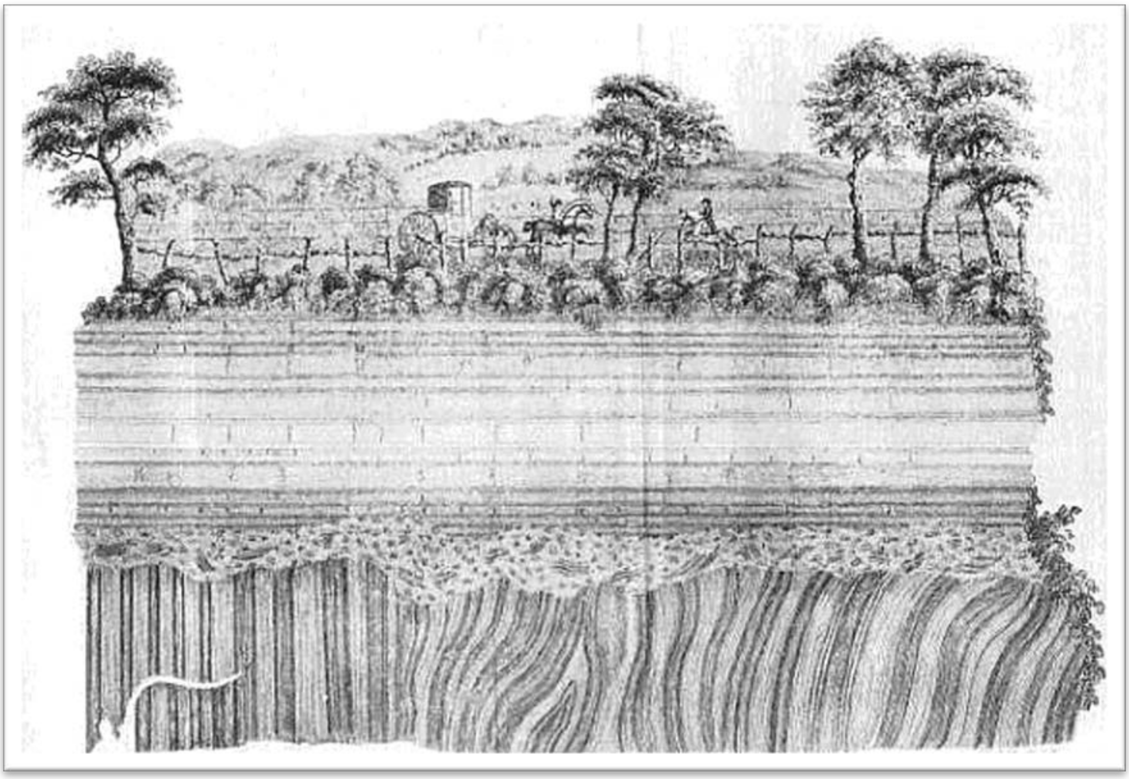

Figure 16: An unconformity observed by Hutton in Jedburgh, Scotland. This illustration, by John Clerk of Eldin, appeared in subsequent editions of Hutton's Theory of the Earth, *first published in 1785. In this illustration, the top layer cuts across the lower, vertical layer. Steno was the first to forward the general theory that it where such incisions occur, the interrupting layer must be more recent than the material that it interrupts. Source: https://commons.wikimedia.org/w/index.php?curid=2152638 (accessed 20/05/2021).*

[83] See Bek-Thomson, J. 2013.
[84] See Baxter, S. 2003. *Revolutions in the Earth: James Hutton and the True Age of the World*. London: Weidenfeld & Nicolson.

Similarly, if a shark's tooth is found *inside* another rock, the encased object must be older than the material that encases it. While these arguments may appear relatively self-evident nowadays, they presume a radical mobilization of natural materials as chronological records. With these arguments, it becomes possible to observe bodies of rock as a material record, a keeper of time and recorder of events that the observer can decode and narrativize. In effect, Steno had invented the category of the fossil, as well as the category of strata. These two categories could be used to devise a language with which to account for the history of the planet, quite separate from human history. At the very least, strata and fossils could supplement the Bible, as well as historical archives, with which the history of humanity was chronicled. Therefore, while Steno did not dispute the argument that the *glossopetrae* had been deposited on the top of mountains by the Great Flood, as recounted in the Book of Genesis – which was thought to have raised the sediments into a primordial stew before redepositing them in odd places around the planet – his research implied the possibility of another means of framing history altogether.

At around the same time, in England, Robert Hooke, the Royal Society's "curator of experiments", encountered a similar argument. Hooke had great enthusiasm for the recently invented microscope, and was excited by the vast world discovered beneath the lens. In particular, the microscope allowed Hooke to examine the peculiar structure of petrified wood and charcoal, which though processed by fire or compression, were evidently organic in origin.[85] For Hooke, such artefacts were indicative, as Steno had implied, of a planetary history that was, if not distinct from (or prior to), then certainly parallel to the temporality of human history. Hooke called such artefacts "natural antiquities," implying that they could be compared to the coins and vases with which human history was chronicled. At a lecture delivered to the Royal Society in 1668, Hooke developed this analogy further:

> There is no coin can so well inform an Antiquary that there has been such or such a place subject to such a Prince, as these [fossil shells] will certify a Natural Antiquary, that such and such places have been under the Water, that there have been sch kind of Animals and, there have been such and such preceding Alterations and Changes of

[85] Hooke, R. 1665. *Micrographia: or, Some physiological descriptions of minute bodies made by magnifying glasses : with observations and inquiries thereupon*.

> the superficial Parts of the Earth: And methinks Providence does seem to have design'd these permanent shapes, as Monuments and Records to instruct succeeding Ages of what past in preceding [ages]. And these [are] written in more legible Characters than Hieroglyphics of the ancient Egyptians, and on more lasting Monuments than those of their vast Pyramids and Obelisks.[86]

The premise that a new category of artefact, "natural antiquities," could recount a history of the planet as distinct from human history, was a subtle yet radical gesture. While the Bible had traditionally been perceived as the authoritative source on historical circumstance, these new artefacts revealed a history that was just as old as the events recounted in the Bible, if not older. A forensic strategy was therefore inaugurated, wherein the events of the Bible could be compared with the record indicated by natural antiquities. Whereas it had been traditional to use the Bible to recount the sequence of events on earth, natural antiquities could now presumably be mobilised to recount the chronology of the Bible.

The influence of this gesture is apparent in the work of subsequent chronologists. The German Jesuit scholar, Athanasius Kircher (1602-1680), drew on his collection of antiquities, both natural and civil, to develop the biblical account of the Flood. Figures such as Kircher did not seek to disprove or reject the biblical account in any way. To the contrary, it was believed that natural antiquities could confirm and strengthen religious faith by further verifying scriptural accounts. Surprised by the sheer size of some of the fossil specimens being reported, Kircher wondered just how large Noah's Ark must have been. Exactly how would it have accommodated a pair of each species? In total earnestness, Kircher drafted blueprints of the fabled vessel in his 1675 publication *Arca Noe*.

[86] This episode is recounted in Rudwick, M. 2014: 9-30. See also Rappaport, R. 1986. Hooke on Earthquakes: Lectures, Strategy and Audience. *The British Journal for the History of Science* 19(2): 129-146.

Figure 17: The building of Noah's Ark, as imagined in Kircher, A. 1675. Arca Noe. https://wellcomecollection.org/works/yn35mxqt (accessed 15/1/2021).

Figure 18: A cutaway view of Noah's Ark. Kircher, A. 1675. Arca Noe. https://wellcomecollection.org/works/yn35mxqt (accessed 15/1/2021).

The categories of fossils and strata implied a planetary chronology independent of a human-historical one. Yet in the work of Steno, Hooke, and Kircher, one does not observe an attempt to establish this chronology on its own terms. It is either not attempted, or conducted as a verification of the Bible. Towards the end of the seventeenth century, as these categories become more incumbent in the vocabulary of those who take an interest in the materiality of the planet, either for biblical reasons or otherwise, some of the earliest attempts at establishing a complete planetary chronology emerge. The work of **Thomas Burnet (1635-1715)** is a clear example of this effort. Although Burnet's work is situated firmly within a biblical reading that takes scripture literally, it is one of the earliest examples of an attempt to provide a chronology of the earth that is not simply a footnote to the Great Flood. Although Burnet did not use the terms “geology” or “geological” in his analysis, the Great Flood is assessed stylistically in the vein of contemporary geological observation, as the most significant terraforming event since the Creation of earth out of chaos.

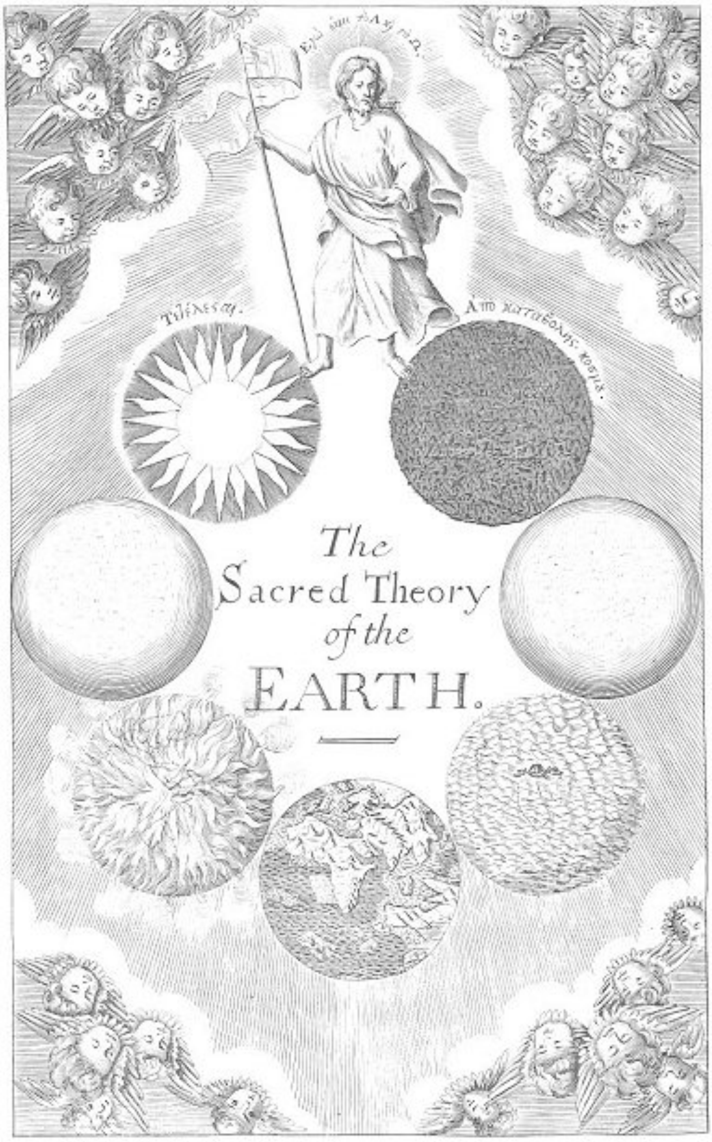

Figure 19: The frontispiece of Thomas Burnet’s The Sacred Theory of the Earth, originally published in Latin in 1681, with an English translation appearing in 1684. Image source: https://www.sacred-texts.com/earth/ste/img/front12.jpg (accessed 01/03/2021).

On the frontispiece of his 1681 *Sacred Theory of the Earth*, one sees an image of God, at whose feet the seven stages of the planet unravel. Around God’s head, like a halo, is written «εγώ είμαι το Α κι το Ω» (Greek for “I am the Alpha and the Omega”). Burnet’s is a planetary chronology that is born of God and will return to God. Burnet’s seven stages of the planet indicate a circle from the emergence of a barren planet (heaven and earth born from Chaos, as the Book of Genesis puts it), to a Great Flood that submerges the planet in its entirety, to the eventual subsidence of water to reveal the continents, followed by a period of "conflagration" that once again renders a charred and barren planet, eventually exploding into a star as the saints evacuate following a final battle with evil. Burnet's thesis attempted to verify his chronology with the Biblical account. For example, he concludes that a great body of water must have existed beneath the earth's crust. The flood, consequently, occurs when the earth's crust is cracked open. In the third sphere clockwise, on his book's frontispiece, is a planet submerged in water, with nothing but waves and a solitary Noah's Ark. There is, in other words, an attempt to reconcile the scriptural account with a "natural," planetary, and material explanation. Yet there is no account as to *where* this crack may have opened. Like many of his contemporaries, Burnet did not conduct field work. His was a speculative exercise, even though it is derivative of Hooke and Steno's forensics. Significantly, Burnet's work emphasises the possibility of a complete planetary chronology as an intellectual exercise in itself, drawing on material and biblical records equally.

This is a gesture that is extended further in another noteworthy effort published around the same time. In 1651, **James Ussher (1581-1656)** published his *Annals of the World*. In this text, Ussher presents the most sophisticated attempt at planetary chronology of his time. Although aspects of the work may seem curious by contemporary standards – such as his dating of planetary genesis at 22 October, 4004 BC (a Saturday) at approximately 18:00 – he pursues a methodology that is admirable in its own right, emphasising the significance that had been acquired by fossils and strata as records on par with the Bible and historical archives. Ussher's 4004 BC date held in religious and "natural historical" intellectual culture for several centuries. Almost three hundred years later, in the early nineteenth century, Charles Darwin would graduate from Cambridge University believing the planet to be approximately six thousand years old.

Ussher became Archbishop of Armagh at age twenty-four, and eventually became Primate of All Ireland. The professional religious context is significant to Ussher's ambition to date Earth. The premise of an original moment is a specifically Judeo-Christian, or "Mosaic" phenomenon. It is distinguishable against several religious or cultural frameworks that understood time to be cyclical. In Babylon, for example, the planets were thought to be subject to a regular period of rebirth according to a 424,000 yearlong Great Year. This Great Year was structured as a year in the more familiar sense, with a summer period in which planets burn up unto a diabolical fire, or "conflagration," and a winter period in which a great flood occurs. Yet such a framework was inconsistent with the teachings of Christianity, which held that, as St. Augustine wrote, 'Christ died once for our sins, and rising again, dies no more.'[87] Identifying an original moment of planetary genesis was not simply an intellectual, natural historical exercise, it was a matter of demonstrating, and preserving the integrity of the Judeo-Christian belief system.

Ussher read the Bible as an original document of planetary genesis. In attempting to identify the moment of genesis, Ussher sought to correlate the account provided in the Bible with historical archives. Some have claimed that Ussher used the genealogy of Adam and Eve as provided in the Book of Genesis, correlated with the Siege of Jerusalem in 70CE, to count back generations.[88] Yet other accounts argue that he did not work with estimations such as the duration of generations, but 'entirely, or almost entirely, from express and exact dates, as far as concerns the biblical material.'[89] Ussher embarked on an extensive scholarly effort, comparing editions of the Bible from around the world, including in the ancient languages of Samaritan and Chaldean when relevant excerpts appeared.[90] Ussher's attempt was therefore not simply an exercise in Biblical exegesis. As one commentator notes, 'The *Annales* are an attempt at a comprehensive chronological synthesis of all known historical knowledge, biblical and classical.'[91] The combination of various editions of the Bible, historical record, and solar and lunar patterns, as featured in the Bible, facilitate a forensic account of Biblical chronology with which Ussher could establish a "master" time scale. This time scale

[87] St. Augustine. *De Civitate Dei*. Book XII, chapter 13.
[88] Baxter, S. 2003: 20.
[89] Barr, J. 2013. Why the World Was Created in 4004 BC: Archbishop Ussher and Biblical Chronology. In *Bible and Interpretation. The collected essays of James Barr. Volume II: Biblical Studies*. Pp. 375-402. Pg. 579.
[90] Baxter, S. 2003: 20. As Barr explains, Ussher embarked on his research within an existing framework, or tradition, which dated back to at least the middle ages, that posited four thousand years between creation and the coming of Christ. Ussher, in other words, inherited this date, and sought to confirm it through reference to archival material. Anticipating the struggles of subsequent geognosts to read the stratigraphic record, Ussher encountered difficulties in his compilation of biblical references, because the Bible, like the stratigraphic record, was composed at different times by different authors, and laid down in a manner that required dedicated untangling. Barr notes, for example, that 'the Bible in itself cannot furnish us with a chronology… because the Bible does not specify the chronological distance between the Old Testament and the New. No event in the New Testament is given a precise date stating distance from any Old Testament event.' See Barr, 2013: 578-579. Barr's account of Ussher's methodology recounts in extensive detail the complexities involved in coordinating the Jewish calendar with biblical accounts and historical records.
[91] Ibid: 581.

consolidated biblical, Roman, Greek, Jewish, lunar, and "geological" (or "natural antiquarian") records.[92]

A further point regarding Ussher's effort is worth mentioning at this point. Ussher's attempt can be read within the context of the emergent "chronological sciences" of his time. As Barr explains:

> Chronology had been made a more central question through another event of the time. The church year, governed by the Julian calendar, put into effect by Julius Caesar himself, was well known to be getting out of phase; and in 1582 Gregory XIII initiated the new or Gregorian calendar, omitting ten days (the day after 4 October was taken as 15 October in that year) and correcting the future calendar (century years were in future to be leap years only when divisible by 400, thus 1600 and 2000 but not 1900, etc.). In the very next year, 1583, Joseph Justus Scaliger (1540-1609) published his *de emendation temporum*, the foundation of scientific chronology. He was a Calvinist, and professor at Geneva, later at Leiden, and an enormous scholar in classical and historical learning, in textual criticism and in the critique of sources. Incidentally, he was against the reform of the calendar, as was also Ussher himself; and it is believed that this opposition was a major reason why the Gregorian calendar was not adopted in Great Britain until much later, in fact in 1752.[93]

What this excerpt indicates is that Ussher's attempt at dating precipitates from an effort to engage dating methodologies and their consequent inscription techniques as an object of study in themselves. These efforts were as concerned with establishing a framework within which dates could be classified and ordered, as they were with understanding the causality

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[92] For example, drawing on the Jewish calendar, Ussher believed that the world would have begun on a date consistent with the first day of the Jewish year. It would, he presumed, have begun at an equinox around that time, hence the Autumn equinox. Most likely referencing Kepler's *Rudolphine Tables* of 1627, Ussher identified the Autumn equinox of October 25, 4004 BC. Consistent with the Jewish calendar, in which the God's day of rest is Saturday, Ussher established Sunday, October 23rd, 4004BC as the day of creation. His choice of six in the evening is not entirely explained, but is attributed to the "Jewish recknoning" according to which night precedes day. This is a point that Barr thoroughly disagrees with, positing the date of creation to have occurred at an unspecified time. See ibid: 592. Elsewhere, Stephen Jay Gould assumed midday to have been the precise moment of genesis. See Gould, S.J. 1991. Fall in the House of Ussher. *Natural History* 100: 12-21.

[93] Barr, 2013: 584.

of the events associated therein. The forensic strategy associated with geology, and more specifically chronostratigraphy (the sub-discipline in which the AWG's formalization effort unfolds) is as much about the history of fossils and strata as it is about chronologization efforts more generally.[94] Indeed, the way in which fossils and strata are read by these early figures amounts to a set of material practices with which geological chronology is constructed. Geology unfolds not as a specifically scientific or religious endeavour. Rather, it has always been, and remains, a relatively undifferentiated science. That degree of undifferentiated activity is an animating force in geological observation, as evaluative procedures, methodologies, and the epistemic cultures of geology more generally attempt to accommodate a wide variety of competencies and perspectives.

The efforts discussed so far indicate the basic devices and strategies according to which geological units can be distinguished and correlated. Such efforts are fundamental to the efforts of subsequent geognosts to chronicle the planet into a single, master-framework. Instances of that framework appear toward the end of the eighteenth century. Drawing on the observations of figures such as Steno and Hooke, as well as the chronological efforts of Burnet and Ussher, a shift occurs from *explanations* of planetary genesis, to *classification* of the planet's material compositions. This would indicate that any sense that the meaning of planetary genesis could be definitively explained is subsumed within a novel semantics of classification.[95]

[94] See Borst, A. 1993 [1990]. *The Ordering of Time: From the ancient computes to the modern computer*. London: Polity Press.

[95] This tendency toward classification, as a more "modern" exercise of explanation, is a substantial aspect of Foucault's work, such as in Foucault, M. 1990 [1970] *The Order of Things: An Archaeology of the Human Sciences*. London: Vintage Books; and Foucault, M. 2002 [1969]. *The Archaeology of Knowledge*. London: Routledge.

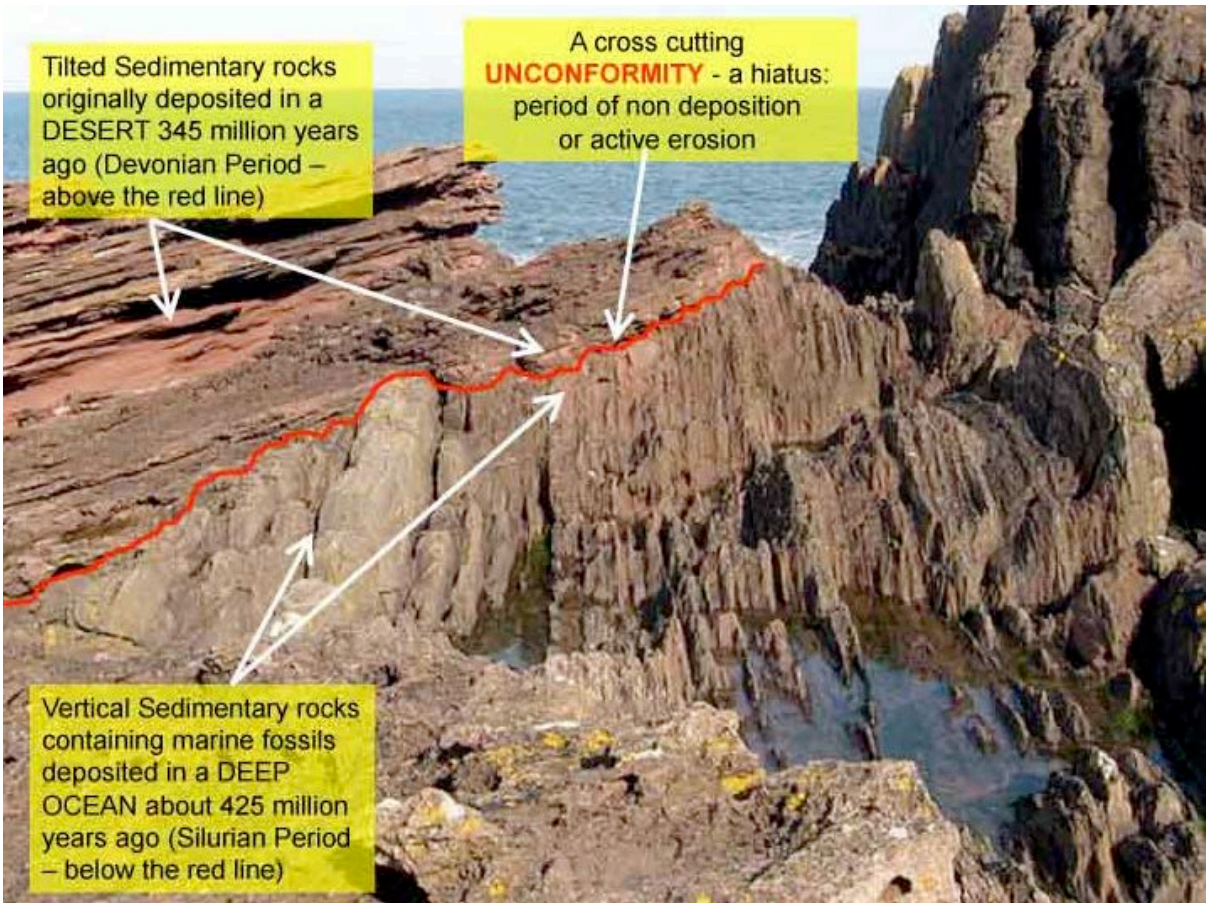

Figure 20: *The Siccar Point outcrop, in Scotland. This site was of great influence to James Hutton and partly informed his subsequent elaboration of* deep time*, as well as the division of planetary history in distinct periods, or units. Source: http://geologylearn.blogspot.com/2017/01/siccar-point-worlds-most-important.html (accessed 05/04/2021).*

Consistent with a novel emphasis on classification, as a means of definition, the late eighteenth century saw the elaboration of observations posited by Steno, Hooke, and Burnet. An interest took hold not simply in the implication of the fossil and strata in regards to a natural chronology that needed to be reconciled with the biblical account. Rather, an increased confidence in the independence of natural chronology meant that fossils and strata could be mobilised to confirm a natural chronology far more expansive than the biblically inflected 4004 BC. Figures such as **James Hutton (1726-1797)** and **Giovanni Arduino (1714-1795)** sought to establish a classificatory system appropriate to the expanded timeframe of natural chronology. For both, the key to this task lay in the organization of beds of strata. Arduino and Hutton both encountered the possibility of classifying natural chronology in "unconformities."

An unconoformity is a section of strata that has been rearranged from its original position through earth processes. These can be as vigorous as volcanic eruptions or earthquakes, which can lift whole sections of strata deposited horizontally into a vertical position, or flip them around entirely. Unconformities can also occur through gradual, persistent processes of erosion of wind or water. Observation of such unconformities indicated non-divine causation to several early architects of the geologic unit, and consequently, the Geologic Time Scale. For Hutton in 1788, it was Siccar Point on Scotland's eastern coast. For Arduino, in 1758, it was the Agno Valley, near Verona. Both sites demonstrate significant unconformities, visible in the form out "outcrops", or exposed facies that are composed of different sediments. As one commentator notes, the significance of their preoccupation with unconformities was 'to recognise that it was not a miracle that was required, that the processed of erosion and uplift that we see at work around us today are sufficient to explain everything in the rocks – sufficient, *if* they are given long enough.' Observations of fossils and stratal organization in the present, therefore, provide the observer with an account of a vast temporality through which, as Lyell famously put it, one could explain former changes to the earth by reference to causes now in operation.[96] In both instances, an attempt was made not so much to explain the origin of the mountains, either by reference to divine or natural causes, but simply to classify their sediment.

Lyell's approach, identifying historical changes as products of ongoing processes visible in the present, implied forensics of its own. Lyell's approach is a prime example of "uniformitarianism," a view of geologic time that posits continuity of processes. This is opposed to "catastrophism," which refers to the belief that geological formations visible today are the product of sudden, violent events, or catastrophes.[97] Part of the success of catastrophism resided in its ability to accommodate biblical accounts, as well as a biblical timeline. Whereas the theory of uniformitarianism indicates a vast chronology that far exceeds the biblical time-line of a four-thousand-year-old Earth, it was entirely feasible that even within such a comparatively brief duration, catastrophic events of vast magnitude had

[96] Such was the subtitle of Lyell's *magnum opus*. See Lyell, C. 1998 [1830-33]. *Principles of Geology: being an attempt to explain the former changes of the Earth's surface, by reference to causes now in operation*. London: Penguin Books.

[97] For an overview of the debate between so-called uniformitarianists and catastrophists, which characterised the interactions of specialists in the nineteenth century, see chapter four of Rudwick, M. 1972.

suddenly moulded the world into its current form. Catastrophism avoided speculation concerning the validity of scriptural accounts. Hutton's reading of the unconformity, as process visible today was the clue to observing the expansiveness of geologic time. For Hutton, in other words, geological time was not brief and turbulent, but radically vast and predictable. And if it was predictable it could also be forecasted retrospectively, acquiring a logic of its own. The possibility of classifying geological time therefore appears to be of greater interest to late eighteenth century geognosts such as Hutton, who foregoes any explanation of planetary genesis in favour of an understanding of its continuous dynamics. Geologic time is *deep time*, the Earth having, as Hutton famously put it, 'no vestige of a beginning, no prospect of an end.'[98]

Ardunio had worked from a young age in the iron mines of Klaussen and Tyrol, in Germany, and later in Northern Italy.[99] Both Arduino and Hutton had completed their studies in medicine. Indeed, Hutton develops his geognosy partly in reference to trends in medicine at the time, such as the circulation of blood. This had been a pressing topic at the time in Leiden, where Hutton completed his medical studies. Arduino, too, was part of an intellectual community at the University of Padua's department of Theoretical Medicine that eschewed the diluvial theory of sedimentary deposition for what they referred to as "the anatomy of mountains."[100] By the mid-eighteenth century, two of Arduino's colleages, Anton Lazzaro Moro and Giovanni Tagioni Tozzetti, had proposed a two-fold division of mountains:

> The "primary" mountains (*monti primari*), uplifted from the bottom of an ancient sea by subsurface (plutonic) heat, like submarine volcanoes, were composed of massive, generally crystalline rock, and they were unstratified. These mountains were considered to form the highest part of the Alps; their shape being usually illustrated and described as jagged. By contrast, his "secondary" mountains (*monti secondari*) consisted of stratified rocks deposited at the surface at differing times; the materials

[98] Hutton, J. 1997 [1788]. *Theory of the Earth*. London: Geological Society of London. A comprehensive account of this statement and its significance in geognosy of its time is provided in Dalziel, I. 1999. Vestiges of a beginning and the prospect of an end. In Craig, G.Y. & Hully, J.H. (eds) *James Hutton – Present and Future*. London: Geological Society of London Special Publication 150. Pp. 119-155.

[99] See Vaccari, E. 2007. From Tyrol to Venice: The Papers of Giovanni Arduino (1714-1795) as Valuable Sources for the Hitory of Mining and Geology. *Geo. Alp Sonderband* 1: 155-164.

[100] A term attributed to Arduino's colleague Antonio Vallisneri (1661-1730). See Gibbard, P. 2019.

> originating from volcanic eruptions derived from the former "primary" mountains. These secondary rocks frequently included fossils and debris that had accumulated on the floor of ancient sea.[101]

This classification scheme was consistent with those developed in other parts of Europe at the time. For example, in Germany, Abraham Gottlieb Werner (1749-1817) distinguished between "fundamental rock masses" and "layered rock masses." Geologists today continue to distinguish "hard" and "soft" rock.[102] Arduino's contribution was to divide these "primary" and "secondary" rocks into further units. Arduino presented his anatomy, not just of the Italian mountains, but of the entire planet, as four major bodies of strata. These include the differentiation of previously acknowledged "secondary" rocks into two further units: "tertiary" and "quaternary." Arduino described tertiary strata as characterised by "the hills of tuff and clay of Tuscany," composed of 'shells, fragments, and sands of testaceous marine animals: and fragment, pebbles, sands and fragments originated from the destruction of large portions of the primary and secondary mountains.'[103] The fourth order, according to Arduino, was composed of 'all the plains, which are also formed by layer upon layer, by floods, and deposition of material brought down from the mountains by the waters of the rivers… identified in the alluvial deposits.'[104] Significantly, Arduno held that each layer had been deposited at different moments in history, under vastly different circumstances.

Arduino's classificatory scheme remains in place to this day. The contributions of subsequent figures in geology, and especially in the sub-discipline of stratigraphy that focuses on the classification of strata into discrete spatio-temporal units, has elaborated the schema to include further divisions. In his *Principles of Geology* of 1833, Lyell elaborated the Tertiary into the Pliocene, Miocene and Eocene.[105] In other words, whereas Hutton and Arduino developed the forensicality of fossils and strata into a classificatory system, that system itself

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[101] Ibid: 13.
[102] On Werner's distinction and its relevance to contemporary geology, see Rudwick, M. 2005. *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution*. Chicago: Chicago University Press. Especially pages 90-93. This appears to be a point that even Burnet agreed on. Burnet distinguishes between a set of *montes primarii* created neither by God nor the Flood, as well as a group of *monticulos secundarios* derived from rocks formed through air and sea erosion. See Vaccari, E. 2006.
[103] This excerpt is from a letter written by Arduino in 1760, quoted in Ellenberger, F. 1994. *Histoire de la Geologie, Tome 2: La grande éclosion et ses prémices 1660-1810.* Paris: Lavoisier. 263.
[104] This quote appears in Vaccari, E. 2006, but is modified in Gibbard, P. 2019: 15.
[105] See Gibbard, P. 2019; Gould, S.J. 1987.

would subsequently evolve and further unfold into a universalizable system that could be applied to all rocks. The classificatory efforts of figures such as Arduino, Hutton, and Lyell, consolidate the technical devices articulated by other figures such as Steno and Hooke, such as the fossil, the unconformity, and strata, into an evaluative mechanism composed of discrete units. As we shall see in the next chapter, late nineteenth century geology is characterised by formalising and universalising such practices of classification and evaluation. The armoury of technical devices at the disposal of the geologist expand accordingly, both in volume and variety. In addition to fossils and unconformities there are maps, and time charts. If, as commentators have observed, the classificatory efforts associated with Arduino, Hutton, and Lyell 'replaced the hand of God with the great pressure of time, long aeons of it', a subsequent effort entailed the organization of those aeons into a universally recognisable and applied system.[106]

2.2 The referential dynamics of fossil forensics

The geological unit is a constellation of practices, techniques, and artefacts. It is a technique of bringing these diverse phenomena into association. The emergence of the unit as a category is a story of encounters by observers from different times and places with artefacts and incumbent practices of surprisingly varied origins. If you had tapped Arduino, or Ussher, or Steno, on the shoulder and told them "you are the father of geology!" they would have been most likely either bewildered or indignant. Their contributions to the geologic unit were not "for geology." Their motivation was informed by debates in biblical chronology, or interests in anatomy, chemistry, mineralogy, and other topics more contemporary to their respective times. To refer to the formalization effort of the AWG as simply an attempt to establish the Anthropocene as a geologic unit, undermines the active process that is entailed in the representation of rock as part of an overarching strategy of stratigraphic classification. Representation, such as that entailed in the designation of a geological unit, is not a passive process. Representation may precipitate the construction of a further object to which the first is related. The relation between the rock, for example, and the unit, is established through a

[106] Baxter, S. 2003: 52.

set of conventionalised practices that determines what counts as reliable in the right way.[107] In the next two chapters we shall review the evaluative procedures and standardization practices that characterise the 'conventionalised practices' of stratigraphy, and that verify and uphold the techniques of representation associated with stratigraphy. In this section I simply want to emphasise the practices of representation according to which the geologist generates accounts of geological deep time, which is realised in a material form.

Historians of science have emphasised the role of the "modest witness" in articulating objectivity. Steven Shapin & Simon Schaffer famously recount the circumstances according to which Robert Boyle forged the rules of a new method of verification, in opposition to Thomas Hobbes.[108] Boyle, who is celebrated by the Royal Society as a founding figure of epistemic methods associated with the Scientific Revolution, is credited by the authors as having furnished the modest witness with a suite of technologies:

> A *material technology* embedded in the construction and operation of the air-pump; a *literary technology* by means of which the phenomena produced by the pump were made known to those who were not direct witnesses; and a *social technology* that incorporated the conventions experimental philosophers should use in dealing with each other and considering knowledge-claims.[109]

In the case of Boyles and Hobbes, at the centre of these technologies is the air pump. The air pump was manufactured by Robert Boyle and his assistants at the Royal Society. They conducted demonstrations of its properties, employing the device as a strategy for validating the experimental method that Boyle drew on to verify his arguments. The validity of his method and argument assumed greater authority through the circulation of journals that recounted its use, documenting accounts provided by individuals held in high regard (i.e. whose accounts were deemed trustworthy). The workings of each technology depend on the

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[107] This understanding of active representation is borrowed from Van Fraassen, B. & Sigman, J. 1993. Interpretation in science and in the arts. In Levine, G. (Ed.) *Realism and Representation*. Madison: Univeristy of Wisconsin Press. Pp. 73-99. They explain, on page 74, that 'representation of an object involves producing another object which is intentionally related to the first by a certain coding convention which determines what counts as similar in the righ way.'

[108] Shapin, S. & Schaffer, S. 2011 [1985]. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton: Princeton University Press.

[109] Ibid: 25.

other and to this extent the three are not entirely distinct. The constellation of technologies, or strategies and devices, rendered an experimental system capable of yielding matters of fact.[110]

Shapin & Schaffer draw on this case study to elaborate the emergence of the experimental method as a legitimate strategy for producing objective knowledge. They explain that 'the matter of fact can serve as the foundation of knowledge and secure assent insofar as it is not regarded as man-made. Each of Boyle's three technologies worked to achieve the appearance of matters of fact as *given* items… each technology functioned as an *objectifying resource*.'[111] The consolidation of these three technologies in the air pump served a further function: to render the labour of the carefully selected witness invisible, such that human agency was factored out, and the artefact appeared as entirely neutral. 'It is not I who says this; it is the machine.'[112] Shapin & Schaffer emphasise the multiplicity of technologies that operate in, or through, the air pump, stressing that the knowledge produced cannot be located in any one place, it is an emergent property of the relation between technologies. Like the geologic unit, the air pump does not have a single historicity. Such artefacts emerge from relations between simultaneous trajectories. Shapin & Schaffer argue that the air pump appears to contain the fact itself. Yet, like the fossil, it is instead a symbol for a network that contains many more practices, artefacts, ideas, and arguments, which are not necessarily resolved.

To the extent that the fossil is a *symbol* of a greater network, there is a dynamic of representation, or reference, that is important to understand. At the time in which Steno, Hooke, Arduino, and Hutton were conducting their observations, the scientific laboratory as it is known today hardly existed. In its place, the museum was a more common site for the practice of almost all sciences, wherein artefacts and specimens were collected, arranged,

[110] Shapin & Schaffer explain that 'in Boyle's view, the capacity of experiments to yield matters of fact depended not only upon their actual performance but essentially upon the assurance of the relevant community that they had been so performed.' Shapin & Schaffer, 1985: 55. Elsewhere, Haraway has emphasised the gendered and racialized aspects of this community and the role of corresponding exclusionary practise, in consolidating experimental cultures and securing matters of fact. See Haraway, D. 1996. Modest Witness: Feminist Diffractions in Science Studies. In Galison, P. & Stump, D. (eds). *The Disunity of Science: Boundaries, Contexts, and Power.* Stanford: Stanford University Press.

[111] Shapin & Schaffer, 1985: 77.

[112] Ibid.

labelled, and displayed.[113] The concentration of specimens in a single location, the museum, facilitated their comparison, and hence their description, identification, and classification accordingly. Through a series of material practices, specimens collected in the field were converted into organised, and classifiable collections. Rocks were labelled, cut apart, ground down to determine the possible differences in their physical states; plant specimens were dried and mounted into books; shells were collected into boxes; fossils were arranged into possible skeletal arrangements. Similar to the manner in which laboratories today are often directed by a senior figure who orients the lab's research interests and the allocation of resources, European museums of the eighteenth century often functioned as private "cabinets of curiosities" of wealthy patrons.[114] These patrons often travelled, or had connections with savants in other countries who themselves travelled, and with whom they could exchange specimens, such that their "cabinet" might contain artefacts from around the world. Although by no means complete, the collection of specimens in one place, and their processing via the material practices associated with their display in museum cabinets, facilitated a process of representation whereby rocks from unique localities could be translated into more general classificatory schemes.

[113] For the particular history of geology in this context see chapters one and two of Rudwick, M. 2005. For a more general accounts, see Daston, L. 1998. Nature by Design. In Jones, C. & Galison, P. (eds). *Picturing Science, Producing Art*. London: Routledge. Pp. 232-253; Galison, P. 1998. Judgement Against Objectivity. In Jones, C. & Galison, P. (eds). Pp. 327-359.

[114] Rudwick, M. 2005: 37-41.

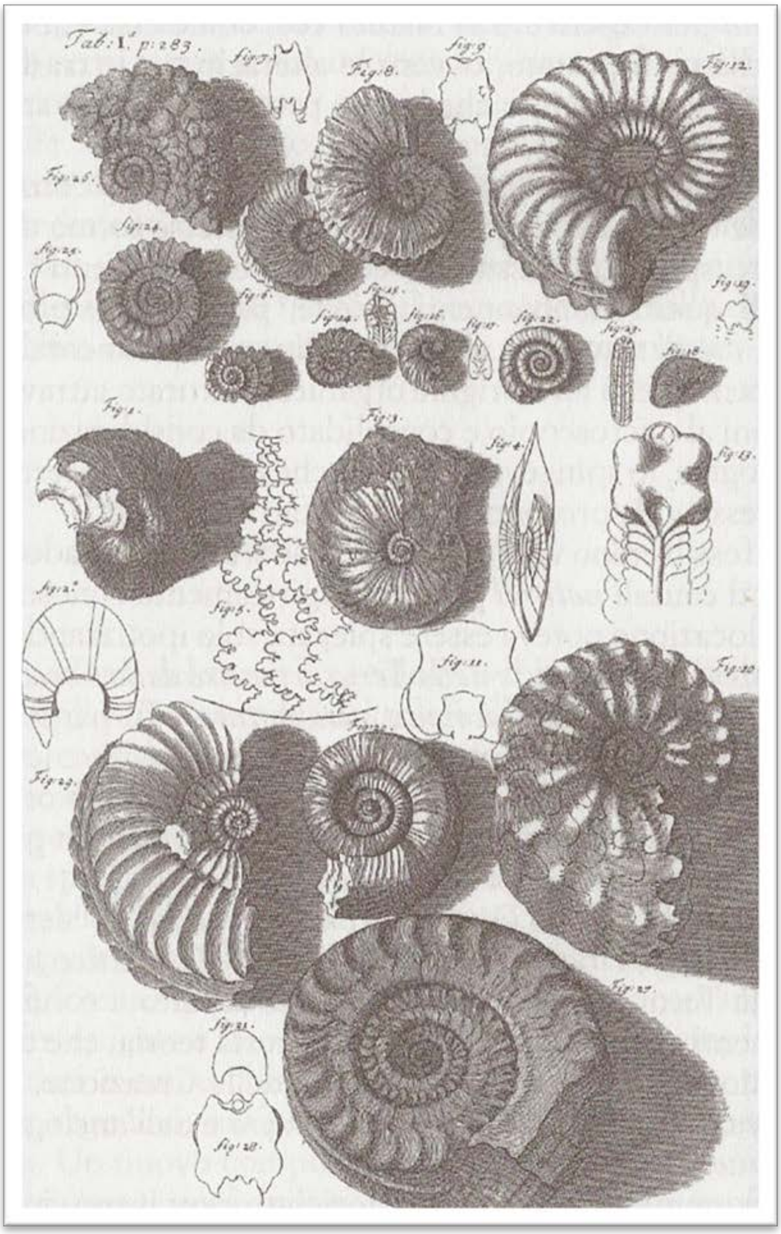

Figure 21: Ammonites drawn by Robert Hooke, featured in his Discourses of Earthquakes and Subterraneous Eruptions, *published posthumously in 1705. Source: http://historyofgeology.fieldofscience.com/2011/02/last-virtuoso-robert-hooke-and-his.html (accessed 05/06/2021).*

Hooke's skill as a draughtsman was central to compiling evidence of a resemblance between specimens, on the basis of which he could advance his own categories of classification.[115] For example, in his *Micrographia* of 1665, Hooke presents a series of illustrations of fossils examined under a microscope. He refers to these illustrations in

[115] See Kusukawa, S. 2013. Drawings of fossils by Robert Hooke and Richard Waller. *Notes Rec. R. Soc.* 67: 123-138.

advancing the observation that petrified wood and rotten oak wood are sufficiently similar to suggest that wood could be turned to stone if it absorbed enough minerals from water. His observation of shell-shaped fossils leads him to believe that shells could be turned into stone if 'fill'd with some kind of Mud or Clay, or petrifying Water, or some other substance.'[116] Such observations were not only significant in granting Hooke the conviction with which to classify a new category of artefacts, '*Natural Antiquities*,' they were also strategies by which Hooke could advance more general claims about planetary processes. From the field-site in which the rock sample was retrieved, to the illustration and text of Hooke's *Micrographia*, a process of *circulating reference* occurs that *amplifies* the localised specificity of the sample into a set of universal standards.[117] This amplification requires the loss of successive characteristics of the local sample at each stage, from excavation, to being arranged and labelled at the museum, to being examined under the microscope and patterned into Hooke's discourse. The process of reducing the rich specificity of unique samples entails a trade-off: what is lost from the artefact through reduction, is *gained* by its subsequent representation as a greater capacity for standards, circulation, and compatibility. In other words, the representation of rocks and fossils as geochronological and chronostratigraphical units, entails a chain of references, or representations, which designate discrete phenomena at each step. The specimen refers to the field-site from which it was extracted. The label in the museum display cabinet refers to the specimen, now arranged into an example of a collection. The cabinet display can be mobilised toward the articulation of a general theory about the material constitution of the earth's crust. Hooke's text itself may be a further instance of representation, according to which contemporary geological observation is validated historically.[118]

[116] Hooke, R. 1665: 92. On his comparison of fossilised and petrified materials with their modern day equivalents, see pp. 92-112 of *Micrographia*. Available at https://www.biodiversitylibrary.org/bibliography/904 (accessed 05/06/2021).

[117] The term 'circulating reference' is borrowed from Latour, B. 1999. Circulating Reference: Sampling the Soil in the Amazon Rainforest. In *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge: Harvard University Press. Pp. 24-80.

[118] I focus here on Hooke's example not as the definitive case, but as one instance of a tendency that I have attempted to adumbrate, whereby geological observations are assembled into more ambitious attempts to classify the earth's crust. Hooke, Steno, Ussher and Hutton's contributions are widely acknowledged as significant episodes in the emergence of chronostratigraphic and geochronological methodology. They delineated a set of palaeontological and lithostratigraphical practices that remain integral to geological classifications today.

Indeed, there is an intentional resonance between the way Hooke presented his observations in his publications, and his professional duties. In his employment at the Royal Society, Hooke was responsible for the Royal Society Repository, which functions as the Society's museum and cabinet of curiosities. Hooke readily admits, in his publications, that his observations are presented in a manner that is incomplete, encouraging their free interpretation by the reader. He describes the texts and illustrations in his publications as 'Essayes or Attempts only upon several Subjects which have no dependencie or coherencie one with another.'[119] He pursues a textual style of sheer accumulation, an intentionally *unmethodical* placing of artefacts alongside each other, emphasising the role of the reader, or in the case of the cabinets, the observer, in arranging what is presented to them in their own way. He describes his publications as attempts to 'inrich the Store-house of Art and Nature with choice and excellent Seed.'[120] He appears to advocate for the reader to quite sincerely tear apart his publications and mobilise the individual prints and textual accounts as they wish: 'But because they may possibly admit of some better order hereafter, I design to print them all of the same Volume, that so they may be, when ranged, either stitched or bound together, and may, as occasion requires, be referred to under the Title of their Number and Page.'[121] In this way, the manner of displacement of the "original" referent, for example the fossilised wood, or the ammonite, occurs through the medium of the literary publication, which subsequently lends itself to diverse mobilisations contingent on the objectives, interests, and ambitions of the reader. The publication is intended as a mobile version of the cabinet of curiosities, such that readers can remove pages and accumulate their own reproductions of objects in a referential chain of their own division.[122]

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[119] Hooke, R. 1674. To the Reader. In *An Attempt to Prove the Motion of the Earth*. Available at: https://royalsocietypublishing.org/doi/10.1098/rstl.1674.0007 (accessed 05/06/2021) [unpaginated].

[120] ibid.

[121] Ibid.

[122] See also Aït-Touati, F. 2008. "The Spirit of invention". Hooke's Poetics for a New Science in *An Attempt to prove the Motion of the Earth by Observation*. *Science et literature*. Available at: https://journals.openedition.org/episteme/732 (accessed 05/06/2021).

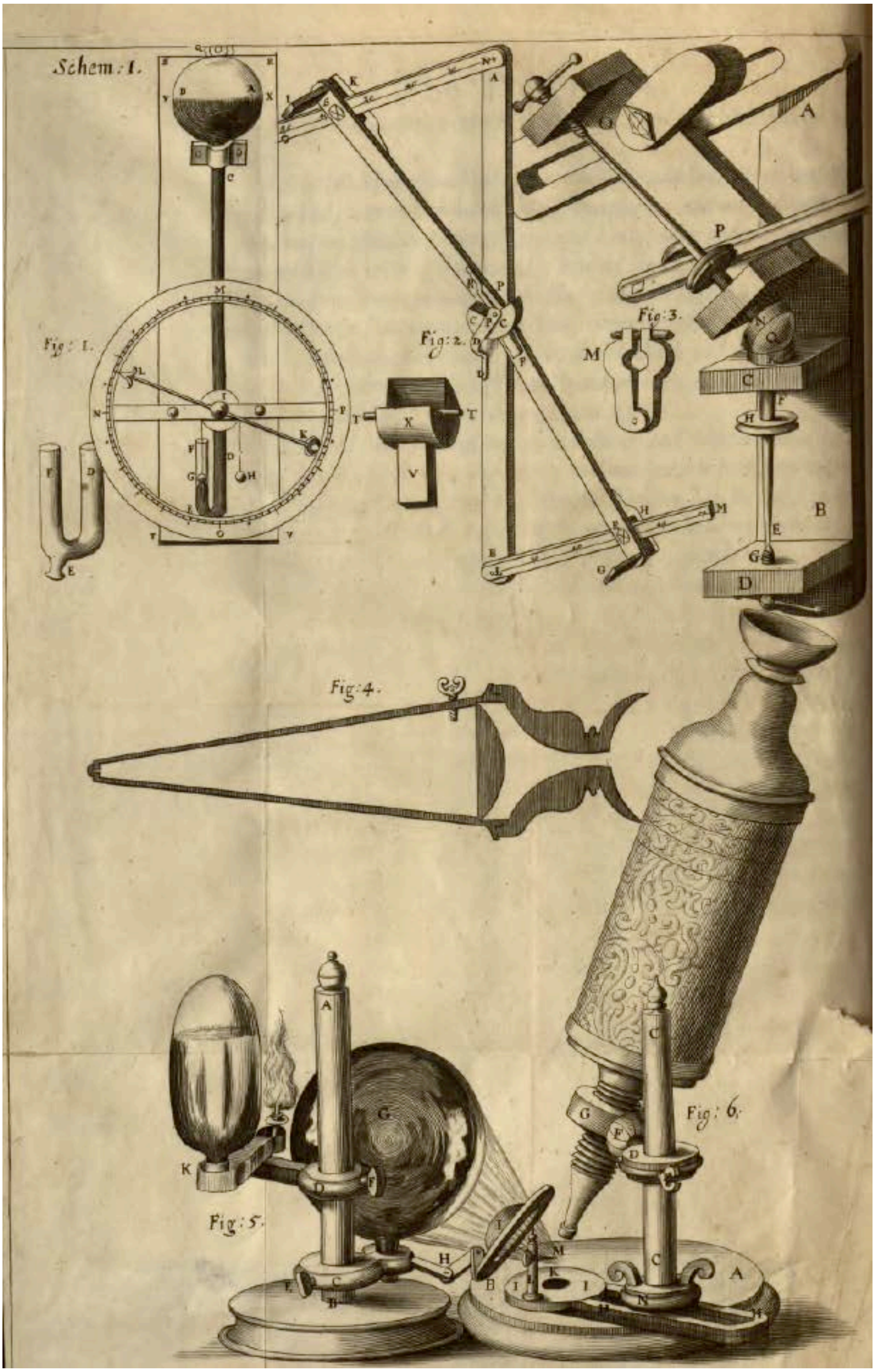

Figure 22: The microscope that Hooke used to conduct the observations presented in his Micrographia *of 1665 The microscope was central to Hooke's elaboration of a new class of artefacts: 'natural antiquities.'His examination of shells, wood, fossils, and rocks under the microscope led him to posit a historical continuity between rocks and shells, as well as petrified wood and samples from living trees. The microscope was therefore an important device with which Hooke*

elaborated an account of the fossil, as a strategy of classifying the temporality of artefacts. Source: *https://www.biodiversitylibrary.org/page/786331#page/272/mode/1up* *(accessed 05/06/2021).*

Hooke and Steno articulated the referential and representative capacity of the fossil as a strategy of geological classification, in large part through the illustration of specimens. The illustration of landscapes during field-trips plays a further role in the conversion of specific rock sections into general classificatory principles. Hutton's illustration of unconformities through Scotland is a prime example. While many geologists, particularly in England, continued to refuse fieldwork on the grounds that it obstructed their appreciation of geology as an abstract system of thought, elsewhere, fieldwork was increasingly perceived as essential for the understanding of earth processes more generally, of artefacts too large to be taken into the space of the museum or cabinet.[123] Field-expeditions, moreover, were increasingly considered an important means of verification: it was incumbent on geognosts in some regions to demonstrate that they had seen the rock section in question with their own eyes, that they had studied it first-hand. Such was a precondition to any credibility they may try to claim concerning their authority to forward their own theory concerning the constitution of the rock record.[124]

[123] Upon assuming the Woodwardian Chair of Geology at Cambridge in 1818, Sedgewick was proud to admit that 'Hitherto I have never turned a stone', which he appears to have believed made him more ideally suited to the lecturing of 'some subjects connected with the Theory of the Earth.' See Clark, J. & Hughes, T. 1890. *The Life and Letters of the Reverend Adam Sedgewick.* Cambridge: Cambridge University Press. Pg. 11.

[124] On the significance of field-work for other geologists of the late eighteenth century, see Rudwick, M. 2005: 41-44; Porter, R. 1979. Gentlemen and Geology: The Emergence of a Scientific Career, 1660-1920. *The Historical Journal* 21(4): 809-836.

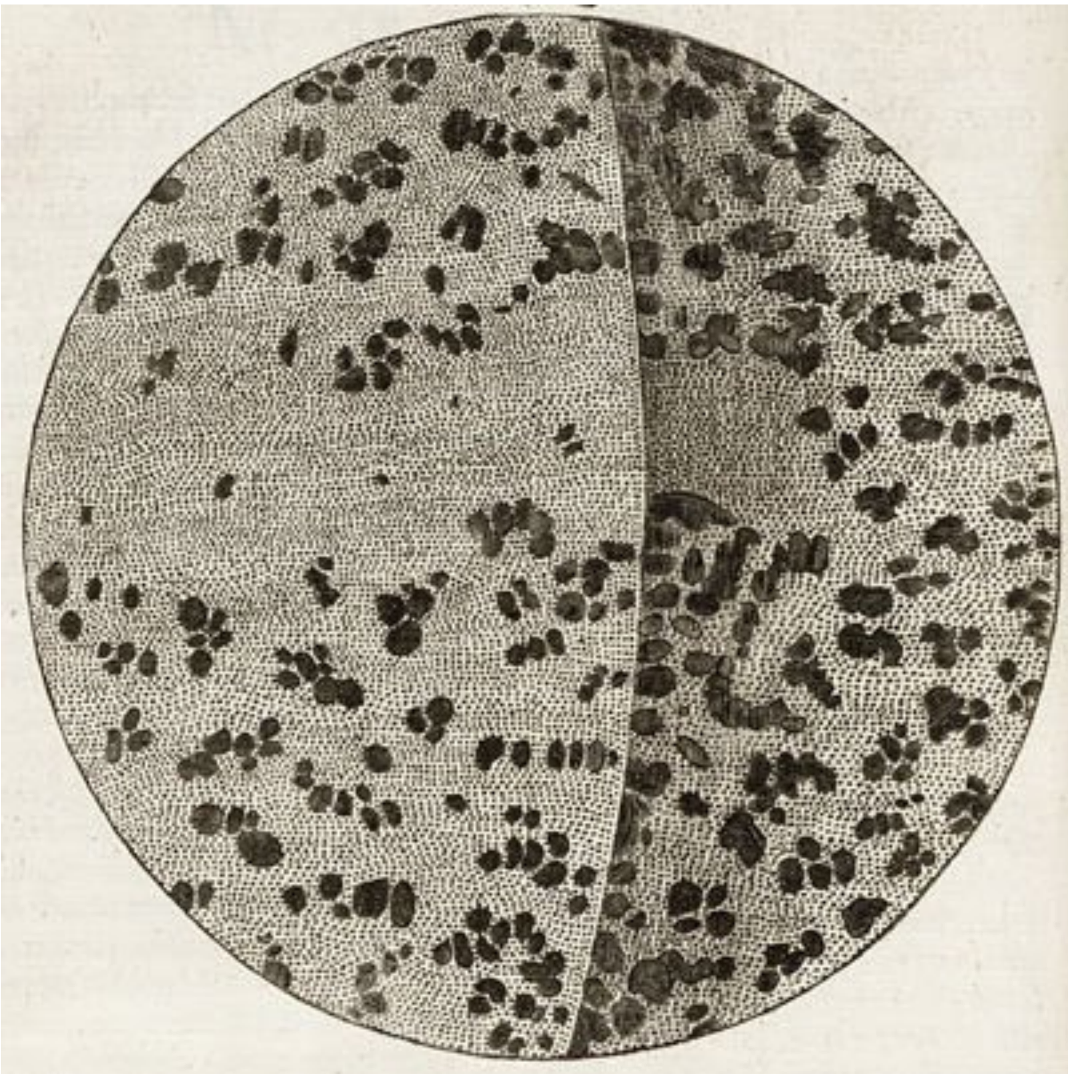

Figure 23: Illustration of petrified wood as viewed under Hooke's microscope. Hooke concluded that the structure of petrified wood, as viewed under the microscope, was sufficiently similar to that of a sample retrieved from a living oak tree, that the two must be the same material. The petrified wood indicated that material could be preserved over a vast expanse of time, and provide insight into the environment that it came from. Source: https://www.biodiversitylibrary.org/bibliography/904 (accessed 05/06/2021).

In emphasising the multiple iterations of representation and reference in the development of strategies of geological classification, I seek to foreground representation as an active and creative process. The process of labelling and arranging associated with the cabinet display, for example, entails the construction of further objects that are related to the first, through a set of conventionalised practices. Representation can refer to more than one *kind* of representation. There is symbolic representation, which refers to analogical, or hypothetical, arbitrary constructs. There are also models or simulations, or iconic representation. And thirdly, representation may be an experimental realization, or indexical, realised through the production of traces.[125] This differentiation is presented not so much to choose between one or another – they operate in parallel rather than exclusively – but instead to specify the particular dynamic of representation at play in geological classification. The conversion of specific rock samples into more generalizable classificatory mechanisms entails a situation wherein symbols are generated that refer to additional symbols created further down the chain of reference. A museum specimen is a symbol that refers to an illustration in a publication, that symbolises a geological unit, such as Arduino's *primary* unit. Amplification of local specificities of rock into more abstract, universal standards, entails an indeterminate gliding replacement of any symbol by another, to the extent that a symbol at the far end of the chain of reference returns to the beginning of the chain of representations. When a rock sample from the Jura region of France is extracted as part of a collection of rock samples from the area, and used in the definition of a new geological unit, that unit will typically refer *back* to the site from which the rock was extracted. Such is the case, for example, with the Jurassic System/Period.

[125] These three definitions of representations are borrowed from Pierce, C. S. 1955. Logic as semiotic: The theory of signs. In Buchler, J. (Ed.) *Philosophical Writings of Pierce*. New York: Dover. Pp. 98-119.

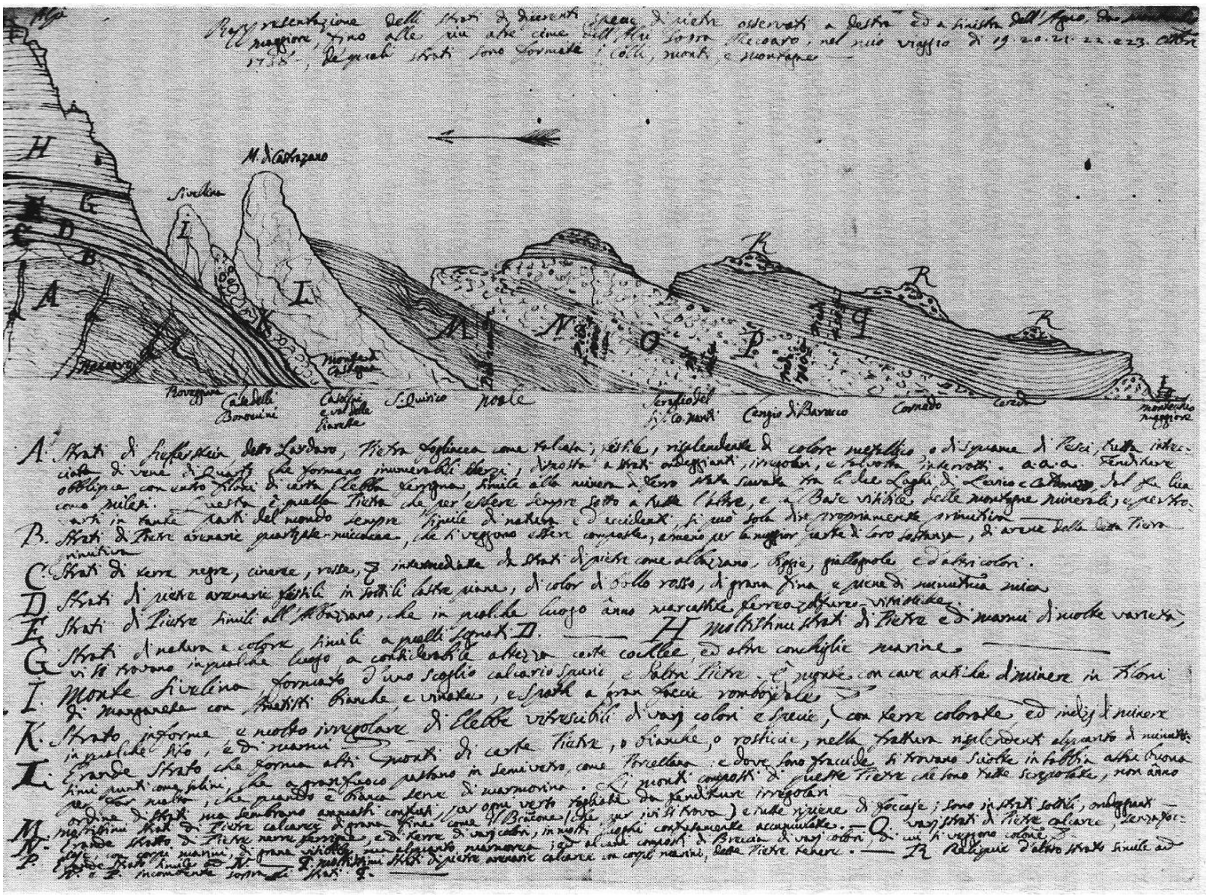

Figure 24: Cross-section of the Val d'Agno *(Agno Valley), drafted by Arduino between 19-23 October 1758, representing an exposure spanning twent-six kilometres from the Alps to the Po plain north of Verona, Italy. Below the illustration, Arduino identifies several classes of strata, whose material characteristics he delinates. Although the illustration remains a very accurate geological map of the region, Arduino's classification is inconsistent with modern-day classifications of strata. Source: Gibbard, P. 2019.*

In other words, representation entails a degree of indeterminacy. Hans-Jörg Rheinberger explains that 'anything represented, any referent, as soon as we try to get hold of it… is itself turned into a representation…' Efforts to classify rock entails an expansive chain of referents, toward a definitive symbol that is never fully attained. After Hooke and Steno, Arduino and Lyell attempt more ambitious comprehensive definitions, not simply of material in rocks, but of the entire rock record. In the next two chapters I shall review the elaboration of strategies of chronostratigraphic and geochronologic classification that precipitate from the efforts of Steno, Hooke, Hutton, Arduino, and others who perpetuated their classificatory efforts. With the increasing abundance of specimens and geological accounts of the rock record, the end of the nineteenth century sees a concerted effort to devise a method by which geological theories and accounts can be rendered comparable, and evaluated against each other. The International Commission on Stratigraphy, the International Union of Geological Sciences, and the Chart and Scale are all descendants of the effort to devise a formal evaluative framework for geological observations. Further instances of representation are devised as a way to manage the accumulation of information regarding the rock record, and the divergence of perspectives concerning its formation. As we shall see in the next two chapters, the International Chronostratigraphic Chart is an example of such a strategy of representation. The Global Stratotype Section and Point (GSSP) emerges in the twentieth century as a definitive strategy of definition. The Chart and the GSSP are further efforts to elaborate and standardise classificatory strategies in geology, but they are also responses to the 'link' of the chain of reference that immediately precedes them. This is to say, each further symbol produced in the chain of reference is generative of a further chain that refers to the previous symbol. The "original referent," i.e. the rock, becomes displaced in this chain of representations, burdened by increasingly complex representations that refer not to the "original referent," but instead to the representation that precedes them. There is no overarching telos or vanishing point at which the research dynamic could come to rest. Engaging in the production of representations means engaging in the potentially endless production of traces, where the place of the referent is always already occupied by another trace.[126] There is a radical creative activity associated, therefore, with the development of practices of representation. Representation is not a passive activity, but entails the active production of more and more referents.

Foucault describes this dynamic as 'the nomination of the visible', a quality he ascribes to the emergence of Natural History in the eighteenth century. It is a dynamic where in the distance between words and objects, or 'things and language with representation' comes to replace the exhaustive histories that characterised earlier species of "history." In these earlier versions of history, the role of the historian was to compile exhaustive lists of qualities, anatomies, and functions in a manner that removed the historian from that account. An emergent kind of history emerges in the eighteenth century wherein the historian, instead, seeks to create new modes of representation that encourage an affinity between things and language through representation. This is a gesture that is fundamental to a sense of "scientific objectivity." The air pump is an example of such representative condensation, as is the effort

[126] Rheinberger, H.J. 1997. *Toward a History of Epistemic Things.* Stanford: Stanford University Press. Pg. 104.

to produce charts that assume the existence of geologic units, and condense them to a single, tabular form.[127] Foucault illustrates this change in understandings of history:

> 'To the Renaissance, the strangeness of animals was a spectacle: it was featured in fairs, in tournaments, in fictitious or real combats, in reconstitutions of legends in which the bestiary displayed its ageless fables. The natural history room and the garden, as created in the Classical period, replace the circular procession of the 'show' with the arrangement of things in a 'table'. What came surreptitiously into being between the age of the theatre and that of the catalogue was not the desire for knowledge, but a new way of connecting things both to the eye and to discourse. A new way of making history.'[128]

This is an observation that characterises the activity of late nineteenth century geologists, as we shall review in the next chapter. The first international meetings of geological societies take place in the context of the World's Fair, where invitations to it are distributed. These meetings have as one of their most significant products, the International Chronostratigraphic Chart, which seeks to condense the various efforts to classify mountains and strata to a single table. It seeks to produce, in other words, a single document that can be circulated and referenced easily, articulating a standard of geological classification, and a set of standards for geological classification. Geologists appear acutely aware of representation as an active process, losing some characteristics of the preceding referent as it gains others through its progression. In the chapter that follows the next one, I shall therefore review the GSSP, which emerges in the twentieth century as a pre-eminent strategy of chronostratigraphic and geochronological classification. Its emergence, however, is characterised by extensive debate concerning what the GSSP ought to refer to: does it refer to a section of rock in a particular location, designating a preferential reference point, or an abstracted lower boundary that discards regional specificities in favour of a global, albeit reductive, standard?

The link between these two episodes of stratigraphy – the advent of a vocabulary with which to engage geology as an epistemic culture, and the effort to define the Anthropocene

[127] See Foucault, M. 1994 [1971]. Especially chapter five.
[128] ibid: 131.

as a formal geological unit with reference to the GSSP – can be realised by reference to a further episode concerning efforts to formalize an evaluative and classificatory system specific to geology. As figures such as Arduino and Lyell elaborated the findings of Steno and Hooke into a general classificatory system for the material deposits of the planet, that effort itself would take on a further epistemic complexity of its own. It would provide the matter with which Lyell and Arduino would attempt to develop a universal system of classification. The advent of fossils and unconformities as technical objects within the experimental system of geology is generative of unknown questions, such as how to define a unit, and how to synchronise unit definition efforts globally. Universalisation (of geological units) entails localization (of unit defining strategies, and of the material deposits to which those units refer). To elaborate this predicament, we will now turn to the advent of the first International Geological Congress, held in Bologna in 1881. If representation entails the construction of objects of reference, wherein the relation is determined through a set of conventionalised practices that stipulate what counts as reliable in the right way, then the next two chapters are intended to outline the normative point of reference: what constitutes the *right way* of referencing and, genealogically speaking, why.

3. An Evaluative Framework

In this chapter, I intend to review the process according to which geological units are evaluated and formalised by the hierarchy of evaluative institutions that oversee the Geologic Time Scale. The AWG's formalization effort is largely oriented toward the inclusion of the Anthropocene in the Geologic Time Scale, to the extent that this inclusion is necessary for the Anthropocene to be recognised as a formal geologic unit.[129] In this first part of this chapter, I will conduct a historical review of the evaluative process, using archival material. This will focus largely on the first meetings of the International Geological Congress. This was a meeting that took place every four years beginning in 1789, bringing together geoscientists from across the world. Attendants shared their practices, maps, fossils, nomenclature, and literature. However, more than just sharing information and specimens, the intention of the meeting was to consolidate a series of regional practices (or geologies) into a singular, formal discipline (or Geology). I attempt to demonstrate that the emergence of Geology as a formal discipline resides not only in the establishment of regular meetings, but also in developing specific techniques of inscription with which the proceedings of those meetings are recorded and circulated. In doing so, the discipline of Geology emerges as an evaluative method, and thereby a professional identity. Whereas the meetings provide an opportunity for differences in method or understandings to be aired, debated, and possibly (although not always) resolved, the purpose of inscription techniques is possibly more final insofar as it provides a precise and instant indication of what the consensus of the discipline is at any given moment, and what observations are permitted as properly stratigraphic accordingly. Key among these techniques is the International Chronostratigraphic Chart (which informs the Geologic Time Scale). What a formal Anthropocene unit ultimately means, or what it means for the Anthropocene to be formalised as a geologic unit, is for it to be included in the Chart (and therefore the Scale as well). The Chart, as an inscription device, entails an evaluative procedure according to which amendments to its contents are reviewed, a process which reifies a set of normative values that characterise the discipline of Geology.

The discipline of geology is characterised by the attendance of practitioners to disciplinary meetings, and their acknowledgement of, and voluntary submission to, the

[129] See Gibbard, P. & Walker, M. 2014.

standards outlined in devices such as the Scale. The history of the evaluative process of geology is therefore also the history of a discipline. To the extent that meetings and devices consolidate consensus, they also become the site of operation for a discipline. Inscription techniques, the instruments they produce, and the meetings wherein they are discussed, mediate standpoints within the discipline. There are varying opinions about how the Anthropocene should be formalized, when it began, and where its beginnings can be located in the geological record, as well as what the implications of those determinations are. Appreciating how the AWG go about drafting their proposal, which they will eventually submit for evaluation, requires an understanding of the historical emergence of the evaluative process. This is because, to the extent that the formalization process is historically situated, it informs how the AWG prepare their proposal. It is possible for the AWG to anticipate the response of the evaluative committees that will review the proposal, and factor that into the preparation of their proposal.

3.1 Present-Day Structure of the Evaluative Hierarchy of the Chart & Scale

The units of the International Chronostratigraphic Chart are amended and maintained through an evaluative hierarchy. If a group of geologists wishes to propose a new geological unit, or to amend an existing unit in the Chart, they must first be commissioned to do so. Most units at the rank of System/Period or higher have their own Subcommission. This is a group of geologists with expertise on the geochronology and chronostratigraphy associated with that unit. They work to promote geological research concerning their unit. The Anthropocene Working Group propose an Anthropocene unit at the stage of Series/Epoch, occurring within the Quaternary System/Period.

The AWG were commissioned by the Subcommission on Quaternary Stratigraphy (SQS) in 2009, following the publication of an article that acknowledged the Anthropocene term as it had been articulated by Paul Crutzen, considering whether the term had any merit as a stratigraphic unit.[130] In their annual reports, the SQS count among their objectives the promotion of Quaternary stratigraphy through the organisation of symposia, publications,

130 SQS. 2009. *International Commission on Stratigraphy Subcommission on Quaternary Stratigraphy Annual Report 2009*. Available at http://quaternary.stratigraphy.org/wp-content/uploads/2018/04/SQSAnnual-report09.doc (accessed 25/05/2021).

field expeditions, and study opportunities.[131] These efforts are intended to have immediate stratigraphic consequences, such as refining the correlation potential of Quaternary rock through elaboration of its biostratigraphic, chemostratigraphic, lithostratigraphic, or magnetostratigraphic characteristics; or the definition of GSSPs for subunits within the Quaternary. The SQS is composed of three "current officers": a Chair, a Vice-Chair, and a Secretary. These positions are appointed at the discretion of their incumbent occupiers upon retirement. The Chair commissions working groups that examine chronostratigraphic and geochronologic issues pertaining to the Quaternary Series/Epoch. There are currently four working groups commissioned by the SQS: three whose focus is the definition of GSSPs, or lower boundaries, for the Early-Middle Pleistocene, the Late/Middle Pleistocene, and the Late Pleistocene/Holocene boundaries respectively. The AWG is the fourth working group of the SQS, investigating the chronostratigraphic and geochronologic validity of an Anthropocene unit, and the possibility of a Late Holocene/Anthropocene boundary GSSP.

In addition to the "current officer" positions, any Subcommission consists of "voting members." The SQS presently consists of nineteen voting members. The voting members vote on the amendments or proposals presented to them by the SQS working groups. A comparison of the annual reports of the SQS indicates that the position of voting member does not change in any regular manner. When an SQS working group presents a proposal to the voting members, it is only approved if a 60% supermajority is obtained. If that is the case, it is passed on to the next level of the evaluative framework associated with the International Chronostratigraphic Chart, which is the International Commission on Stratigraphy (ICS).

Whereas the SQS oversees the chronostratigraphic and geochronological classification of the Quaternary System/Period, the ICS oversees the classification of all rock in geochronologic and chronostratigraphic terms, as published in the Chart. The ICS consists of an Executive Committee of elected and appointed figures, who are elected every four years by the officers of the sixteen ICS Subcommissions, which examine the major chronostratigraphic and geochronologic units of the Chart. The ICS presently consists of only three voting members, who are the executive officers themselves: the Chair, Vice-Chair, and Secretary General. Once any proposals are approved by any of the ICS Subcommissions, the

131 Most, but not all, SQS Annual Reports are available on their website at http://quaternary.stratigraphy.org/annual-reports/ (accessed 25/05/2021).

three executive officers of the ICS review the proposals again and must approve them with a 60% supermajority (meaning that two or more of the executive officers must approve). If a proposal is approved by the ICS, it is then passed on to the next, and final level of the evaluative hierarchy associated with the chart: The International Union of Geological Sciences (IUGS). The ICS receive an annual budget of approximately $40,000 from the IUGS.[132] This money is principally divided among the sixteen Subcommissions of the ICS. This amounts to approximately $2500 per Subcommission. Review of the Annual Reports of each Subcommission suggests that the majority of the money they receive from the ICS goes to expenses associated with the hosting of conferences, such as venue rental and hotel accommodation.[133] This is an important point, because it indicates that there is negligible, if any, financial interest in assuming a voting or executive position in the ICS or any of its Subcommissions. The ICS publish three journals: *Episodes* (published together with the IUGS), *Lethaia*, and *Newsletters on Stratigraphy*. The journal *Episodes* is an important venue within the discipline of stratigraphy, because whenever an amendment to the International Chronostratigraphic Chart is approved, an article, authored by the leaders of the approved proposal, must be published in *Episodes* outlining the accompanying argument and research.[134]

The IUGS is the body that provides the final approval on any amendment to the International Chronostratigraphic Chart. As a constituent body of UNESCO, the IUGS describe their aims as the production of 'authoritative scientific standards', to 'represent the geological sciences in forums and decision-makers [sic],' 'encourage and support new original ideas in basic and applied geological research,' and even to 'encourage more interdisciplinary involvement within the broad spectrum of the geosciences.'[135] Insofar as the approval of

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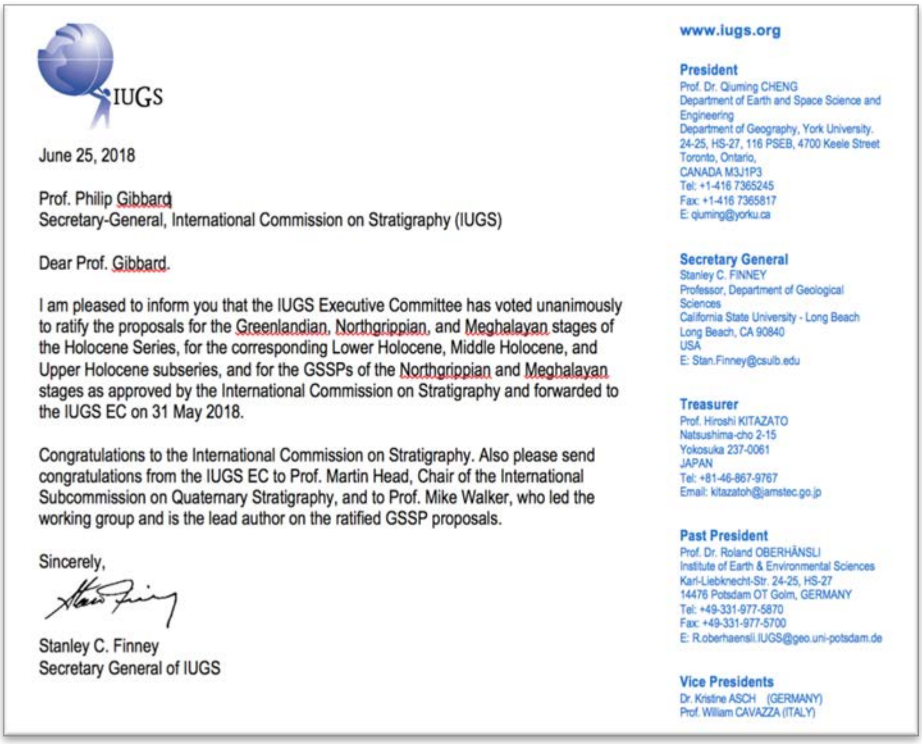
132 See International Commission on Stratigraphy. 2019. *Annual Report 2019*. Available at https://stratigraphy.org/files/ICS_AnnReport2019.pdf (accessed 25/05/2021).

133 The most recent SQS Annual Report available indicates a deposit of $3011.99 from Stan Finney, Secretary General of the IUGS. Only three payments are mentioned for that year, all of which are conference attendance fees for the SQS officers. See SQS. 2013. *SQS Annual Report 2013*. Available at: http://quaternary.stratigraphy.org/wp-content/uploads/2018/04/SQS-Annual-Report-2013.pdf (accessed 25/05/2021).

134 This requirement is outlined by the present ICS Secretary General Phil Gibbard in Gibbard, P. & Walker, M. 2014.

135 IUGS Secretariat. 2019. *International Union of Geological Sciences 2019 Report: Fosterin a global voice for the geosciences.* Beijing: IUGS. Available at https://98ca4554-1361-4fb1-a4d8-a1bb16d032e6.filesusr.com/ugd/f1fc07_36d0c8e90da341e785d2076e3a8226c2.pdf?index=true (accessed 25/05/2021).

amendments to the Chart is concerned, the IUGS, much like the ICS, consists of three Executive Committee members, known collectively as the “Bureau.” The Bureau consists of a Secretary General (currently Stan Finney), a President, and a Treasurer. The IUGS receive an annual budget from UNESCO of approximately $500,000. This budget is used to cover a variety of programs, such as conferences, educational programs, and the publication of *Episodes*. The allocation of the ICS budget is the responsibility of the Secretary General, which since 2016 has been Stan Finney.



IUGS

June 25, 2018

Prof. Philip Gibbard
Secretary-General, International Commission on Stratigraphy (IUGS)

Dear Prof. Gibbard.

I am pleased to inform you that the IUGS Executive Committee has voted unanimously to ratify the proposals for the Greenlandian, Northgrippian, and Meghalayan stages of the Holocene Series, for the corresponding Lower Holocene, Middle Holocene, and Upper Holocene subseries, and for the GSSPs of the Northgrippian and Meghalayan stages as approved by the International Commission on Stratigraphy and forwarded to the IUGS EC on 31 May 2018.

Congratulations to the International Commission on Stratigraphy. Also please send congratulations from the IUGS EC to Prof. Martin Head, Chair of the International Subcommission on Quaternary Stratigraphy, and to Prof. Mike Walker, who led the working group and is the lead author on the ratified GSSP proposals.

Sincerely,

Stanley C. Finney
Secretary General of IUGS

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Figure 25: A letter from IUGS Secretary General Stan Finney notifying ICS Secretary General Phil Gibbard of the confirmation of three new Holocene subdivisions. The reception of such a letter from the IUGS, by the ICS, confirms that a proposed amendment to the International Chronostratigraphic Chart has been accepted, or a new unit formally ratified. The implications of these subdivisions for the AWG's formalisation effort shall be discussed in the sixth chapter. Source: Head, M. May 28, 2019. The Anthropocene: Explanation of the process involved in seeking formalization. *PowerPoint Presentation.*

The IUGS Annual Report indicates that there is also an official position for the Past President, in addition to two Vice Presidents. The Past President and the Vice Presidents each have two Councillors serving them. However, only the Bureau votes on proposals that are passed to it from the ICS. The council of the IUGS, which consists of the Bureau together with the non-Bureau members, is appointed through elections every four years. The election process of the IUGS is not entirely clear. IUGS Annual Reports indicate that the council representatives are appointed ‘by the Adhering Organizations from the active IUGS member countries/regions.'[136] There are, at present, one hundred and twenty-one national members of the IUGS, indirectly representing over one million geoscientists worldwide. The IUGS was established in 1961, as an attempt to establish an organisation that could manage international research endeavours *between* the quadrennial meetings of the International Geological Congress, which since 1878 has been the venue for geologists from across the world to meet and develop a professional, and disciplinary community. The IUGS now manage the Congress, and organise its meetings every four years.[137] Informally, stratigraphers familiar with the administration of the Chart's evaluative hierarchy informed me that the Chair of each level is somewhat at liberty to select successors at their discretion. In regards to the amendment of the Chart, once the IUGS receive an approved proposal from the ICS, the Bureau must also vote with a 60% supermajority for a proposal to pass. At that point, the proposed amendment to the Chart is approved and ratified accordingly, meaning that the Chart will be updated to include the new unit, or the altered boundary of an existing unit (the two most common types of amendments). Once a unit is amended or introduced in the Chart, a ten-year moratorium is observed during which time it cannot be contested. Following the moratorium, the ICS and IUGS can once again accept proposals to change the unit or amendment.[138]

The Chart is the basis for a further map of geological divisions, the Geological Time Scale. The Geological Time Scale has been a regularly updated publication since 2004.[139] The first edition of *A Geological Time Scale*, however, was published in 1982.[140] It was edited by Brian Harland, who, as we shall see in chapter three, was part of a wider effort to promote standards of stratigraphic classification and definition. A further edition was published in 1989, also edited by Harland.[141] The subsequent edition was published in 2004, by which time the senior editorial position had been transferred to Felix Gradstein, a geologist based at Oslo University, who has edited the *Scale* ever since, together with James Ogg, a geologist at

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[136] Ibid: 3.
[137] Harrison, J. 1978. The Roots of the IUGS. *Episodes* 1(1): 20-23.
[138] Remane, J., Bassett, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of chronostratigraphic standards by the ICS. *Episodes* 19: 77-81. Specifically, section 6 on page 80.
[139] The publication history of the Scale is provided in Gradstein, F., Ogg, J., Schmitz, M., et al. 2012: xvii.
[140] Harland, B., Armstrong, R., Cox, A., et al. (eds). 1982. *A Geologic Time Scale 1982*. Cambridge: Cambridge University Press.
[141] Harland, B., Armstrong, R., Cox, A., et al. (eds). 1989. *A Geologic Time Scale 1989*. Cambridge: Cambridge University Press.

Purdue University.[142] The Geological Time Scale bases its classification in direct reference to the International Chronostratigraphic Chart.

There are therefore very few geologists who actively participate in the administration of the evaluative hierarchy associated with the Chart and Scale, particularly at the upper levels of executive positions within the SQS, ICS, and IUGS. A handful of geologists appear to be passed around from one organisation to the next. Stan Finney, for example, served as Chair of ICS from 2012-2016. He now serves as Secretary General of the IUGS, a position which will terminate in 2020. He will then occupy the position of Former Chair of the IUGS. At the time when the SQS commissioned the AWG, its Chair was Phil Gibbard (a position he served for ten years, from 2002-2012). Gibbard has been Secretary General of the ICS since 2016. Jan Zalasiewicz has been a long-time voting member of the SQS, and has served in various appointments in several of its working groups. Zalasiewicz served as Chair of the AWG from 2009 till 2019. In addition to that role, Zalasiewicz served as Secretary of the SQS. The current Chair of the SQS, Martin Head, is also a member of the AWG. There is therefore significant overlap in personnel in each of the organisations of the Chart's evaluative hierarchy.

This is an important point to emphasise because it indicates the influence of particular figures within stratigraphy. Finney and Gibbard are two figures who have been very encouraging of the AWG's formalisation effort, to the extent that Gibbard was head of the SQS when the Group was commissioned, however more recently they have expressed concern regarding the adequacy of the Anthropocene as a formal geological unit. In particular, they have accused the AWG of prioritising human activity as a geological marker, arguing that this is a) redundant given that part of the stratigraphic definition of the Holocene is as a consequence of the appearance of *Homo Sapiens*, and b) that the material, rock record is insufficient to designate an Anthropocene unit at the level of Series/Epoch (or even at the lower unit of Stage/Age).

3.2 The International Geological Congress and the Geologist

The International Geological Congress occurs every four years, and is a premiere conference for geologists and stratigraphers globally. Today it is run by the IUGS, however, it precedes

[142] Gradstein, F., Ogg, J., Smith, A., et al. (eds). 2004. *A Geologic Time Scale 2004.* Cambridge: Cambridge University Press.

the IUGS by approximately eighty years. The IUGS was founded in 1961 to provide a venue for discussion of matters pertaining to geological classification and evaluation during the interim between meetings of the Congress. It's initial circulars indicate the follow objectives of the IUGS:

- To promote and encourage the study of geological problems
- To facilitate international cooperation in geology and related disciplines
- To provide continuity in international geological cooperation
- To assist the International Geological Congress in the organisation of its regular conferences.[143]

This somewhat ambiguous list of objectives indicates much about the context of international conferences from which it emerged. In this section, I would like to review some instances of the earliest International Geological Congresses to consider the manner in which a culture of practicing geological evaluation emerges.

The first International Geological Congress was held in Paris in 1878. The end of the 19th Century was, at least for some, a moment of great optimism. This was a period that, in some parts of the world, was characterised by socio-technical opportunity. The advent of railways and telegraphy meant that those who benefited from such developments perceived the world as both smaller and more immediate than ever before.[144] This was also the period of 'global events', such as the World's Fair. The World's Fairs had begun in the late 18th century as an opportunity for the French and Prussian empires to demonstrate their manufacturing abilities. By the mid 19th Century, countries across Western Europe and the Americas were hosting their own World's Fairs towards similar ends. These were both an opportunity to demonstrate the industrial and manufacturing competencies of individual nations, as well as an occasion of international interest. Accordingly, the World's Fair hosted in Philadelphia in 1876, on the 100th anniversary of the declaration of independence, was both an opportunity to demonstrate America's mining capabilities as well as to advocate for an international network of geological expertise. Thirty-seven nations attended the World's

[143] See Harrison, J. 978: 23. See also International Union of Geological Sciences. 2012. *IUGS Book of Facts, 1961-2011.* Beijing: IUGS Secretariat, which contains an appendix of the statutes approved at the IUGS Constitutive Assembly, held in Paris in 1961.

[144] See Krajewski, M. 2014. *World Projects: Global Information Before World War I.* Minneapolis: University of Minnesota Press.

Fair in 1876, including representatives from various sectors within each nation. Moreover, attendance to the World's Fair that year was just over nine million.[145] These conditions made the event a suitable venue to pursue the agenda of disciplinary internationalisation. At a meeting of the American Association for the Advancement of Science held later that year, invitations to which had been distributed at the Fair, a committee of international attendants declared:

> That a committee of the Association be appointed by the Chair to consider the propriety of holding an International Congress of Geologists at Paris, during the International Exhibition of 1878, for the purpose of getting together comparative collections, maps and sections, and for the settling of obscure points relation to geological classification and nomenclature.[146]

Consequently, the first International Geological Congress was held in Paris in 1878. Those in attendance included representatives of the geological unions of Great Britain, Russia, Sweden, Norway, Austria, Spain, Italy, and France. The memory of the Franco-Prussian War, which ended in 1871, is alleged to be the reason for Germany's absence from the meeting, despite its significant geological expertise.[147] The primary topic of discussion at the first IGC was the "standardization of geologic maps and reports with regard to nomenclature and symbols."[148] The International Exhibition, which the Congress was held in parallel to, featured an exhibition of rocks, fossils, geologic maps and sections brought by the international participants. A commentator notes that "the real contribution of the Congress to the important theme of nomenclature standardization appeared less in what was said and discussed in the session than in the sincere willingness that was expressed to launch a true effort toward reaching a statement."[149] The meeting, in other words, provided a survey of

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[145] Gross, L. & Snyder, T. 2005. *Philadelphia's 1876 Centennial Exhibition*. Mount Pleasant: Arcadia Publishing.

[146] Ellenberger, F. 1999. The First International Geological Congress: Paris, 1878. *Episodes* 22(2): 113-117. Page 113.

[147] Vai, G.B. 2002. Giovanni Capellini and the origin of the International Geological Congress. *Episodes* 25(4): 248-255.

[148] The topics discussed at the meeting are outlined in the official minutes of the event. See Anonymous. 1882. Séance du 27 Septembre. In Anonymous (Ed.) *Congres Geologique International: Compte Rendu de la 2me Session, Bologne, 1881.* Pg. 15.

[149] Ellenberger, F. 1999:: 114

geological practice at the time. Methodologies, artefacts, and regional classificatory standards were demonstrated and shared. An aspiration to unite these regional practices into a single, unified standard is demonstrated as well.

The willingness demonstrated in Paris was acted upon more resolutely at the next International Geological Congress, held in Bologna in 1881. Whereas the first congress secured consensus regarding a standard, universal nomenclature for geology, the second congress intended to come up with one. Minutes from the meeting indicate that this occurred by allowing each national representative an opportunity to outline the nomenclature employed in their respective geological organization. Subsequently, one party would suggest a term to represent a particular category or region of strata, with another party dissenting, only to be resolved through the intervention of the 'Commission', or hosts. The French and British delegations, for example, disagreed as to whether the term *formation* should carry a chronological implication or not, which was resolved when the Commission suggested restricting the term to lithology and mode of origin.[150]

Efforts to establish consensus between the various geological societies towards a satisfactory nomenclature occurred through lengthy discussions. In these discussions, many, but not all, attendants spoke, presenting their argument for a particular term or classificatory logic. Eventually, the leader of the session would call for a vote to be held to determine which argument, and therefore which term, to adopt. The minutes and reports of the first several International Geological Congresses reveals the precise method by which terminology was surveyed, discussed, and formalised.[151] This happened with remarkable efficiency, to the extent that much nomenclature still in use was formalised by the end of the second Congress. While nomenclature continued to be reviewed from then on, the basic structure informed by the decisions of these earliest Congresses remains more or less intact. This is particularly evident in the persistence of the dual hierarchy of geochronology and chronostratigraphy.

[150] Like the Fair where it was first proposed, the International Geological Congress would regularly feature exhibitions of artefacts and specimens brought by attendants from around the world. Although for reasons of space the details of these exhibitions cannot be developed sufficiently, the display of specimens and artefacts indicates a continuity between the forensic method outlined in the previous chapter and the aspiration to a formal evaluative procedure that characterises the advent of the Congress. Gross, L. & Snyder, T. 2005; Ellenberger, F. 1999.

[151] Anonymous, 1882: 15-25.

What is immediately evident from the proceedings of the early Congresses is that the objects of geology, such as rocks and strata, although present at the Congress exhibition hall, were not directly discussed.[152] Rather, the establishment of a singular, universal framework for geology drew attention to systems of reference, such as map-making and nomenclature. Given that the Congresses were the first occasions for geologists from around the world to meet and share their best practice, these were primarily administrative meetings. Definitions of material artefacts were not pursued in any substantial depth: such as what unit a given rock belonged to, or how old a certain fossil was. Rather, the primary focus of the Congress concerned the advancement of ways of talking about, or referring to, material artefacts within an abstracted, evaluative system.

The Congress was attended primarily by geologists acting on behalf of geological societies of which they were members. Many of these societies were well established by the time of the Congress, with the oldest, the Geological Society of London, having been established in 1807.[153] Many of these societies, therefore, had established not only their own nomenclature, but distinct methodologies according to which their nomenclature was justified.[154] Yet at the Congresses, these regional traditions became subject to a new normative order: that of global communicability.[155] For example, one attendant explains that:

> [S]cience has everything to gain by popularizing itself as much as possible, that is to say by being able to be understood and cultivated by the greatest number; however, this result will only be achieved by eliminating words whose comprehension requires too specific knowledge.[156]

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[152] Vai, G.B. 2002.

[153] See Herries Davis, G. 2007. *Whatever is Under the Earth: The Geological Society of London 1807 to 2007.* London: The Geological Society of London.

[154] To provide one example, the Swiss delegates advocated for the adoption of Greek terminology for all formal nomenclature, with terms such as “analithes” (ανά λίθος, or over rocks) and “katalithes” (κάτα λίθος, or under rock) to refer to patterns of deposition; while Italian delegates tended to advocate for more accessible and readily understandable language to be used, as per the below featured quote, which the anonymous minute keeper attributes to the Monsieur de Stefani of the Italian Geological Society. See de Chancourtois, M.B. 1882. Tableau de Classificaiton Lithologique. In Anonymous (Ed.) *Congres Geologique International: Compte Rendu de la 2^me^ Session, Bologne, 1881.* Pg. 112-113.

[155] By global it was meant, more properly, Euro-American, for the nomenclature was to be partial to French and English as the international languages of science. The only non-European attendants were from the USA and Russia.

[156] Anonymous. 1882: 90.

The objective of the meetings on nomenclature are explicit about their effort towards a single, international language of geology. Participants appear to be so dedicated to this cause as to disregard their own proposals on occasion. For example, in relation to the term "System", the committee on nomenclature discuss:

> Mr. de Moeller [of the Russian delegation] believes that since it was a question of creating an international language, preference should be given to words which could easily be translated into all languages; however, that of the "terrain", in this respect, is one of the least fortunately chosen…
>
> M. Dewalque [of the Belgian delegation] recognizes the correctness of M. de Moeller's observation and accepts the substitution of the word "system" for that of "field."
>
> M. Renevier [of the French delegation] thinks that if we do not decide to make some concessions to each other, the Congress will not succeed. For his part, his quite prepared to abandon the word "terrain" as well as that of "formation"… That the French, among whom [the term "terrain"] is most used, are prepared to abandon it, and the Germans, on their side, will sacrifice the term "formation" which they have used until now in a different sense than that established by the Congress.[157]

A vote follows this discussion, wherein "System" easily secures a majority vote. Of course, not all proceedings are so smooth. And as we shall see in the next chapter, the confirmation of a definition at one moment does not preclude scrutiny in the future; indeed, developments tangential to stratigraphy, such as in technology or archaeology, may feedback into renewed consideration of "settled" discussions.

An example of discussion requiring "external" arbitration appears in a subsequent committee meeting regarding maps. Just as significant as verbal representation, i.e. nomenclature, is visual representation in the form of geologic maps. Map making becomes a site of constructing normativity in geology precisely insofar as it seeks to condense geological observation to a set of common parameters. This too was discussed in great depth during the

[157] Ibid: 94-95.

initial Congresses, and each Congress had a particular meeting reserved specifically for discussion of map making procedures. The exhaustive account provided by the minute keeper for the American Committee indicates that discussion over the five days of the third Congress held in Berlin in 1885 focuses on two main themes: visual representation in maps and linguistic representation in nomenclature.[158] In an exchange from the first day of proceedings, disagreement emerges concerning the appropriate colour with which to represent the Silurian on maps. In response to a request by the Congress to adopt a resolution whereby 'the colour of the "Siluric" system is left to the choice of the committee on the map,' an English representative explains that in England the group of rocks referred to in the proposal were in fact materially distinct from each other, and could therefore not be addressed as a single system. Accordingly, he claims, 'English geologists would never consent to this union.'[159] This comment provokes a prolonged debate:

> Prof. Dewalque (Belgium), objected to the use of the term Siluric in the 4th section [of the committee report], on the grounds that the question of the limitation of the Silurian was to be brought up hereafter.
>
> Prof. Renevier [France] said he used the term "Silurique" in order not to bring up the Silurian question, and moreover, he had said "Siluric, Cambrian included." He called the attention of M. Dewalque to the fact that *it was impossible for him to discuss things without applying to them names, but that he did so in a manner that he thought would commite the committee and Congress in the last possible degree.*
>
> Professor Hughes [England] energetically protested against the use of the word "Siluric." He had not found the Cambrian in the region of the Silures.
>
> M. Jacquot (France) allied himself warmly with Professor Hughes in protesting against the use of the term Silurique, at least for the measures in France. One can recognize distinctly the differences between the Silurian and Cambrian in every part of the extended contact in this country, in the Pyrenees and in various other places they are never to be confounded.

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[158] Anonymous. 1888. *Congres Geologique International: Compte Rendu de la 3me Session, Berlin, 1885.* Berlin: A.W. Schade's Buchdruckerei. Pg. 15.
[159] ibid: 19.

> Professor Renevier said, it is not a question of confounding them, but it is simply a question of using one general color-base for a column of measures which have certain points of analogy and are usually found together. They could be easily distinguished from each other by difference of tint or other means.
>
> M. Jacquot replied that he could not see any reason for uniting two things that are distinct.[160]

At this point the Secretary of the Committee intervenes:

> "Gentlemen, we must get on, and I ask as a personal favour on behalf of the committee on the map of Europe that the members repose a certain amount of confidence in it. It is not intended to prejudge any questions or force upon the delegates any views other than those they desire to support." He suggested that the fourth article might be so altered as to allow the committee to adopt provisionally according to their choice, a scheme for colours for convenience, and that this choice should not decide the scientific question connected therewith at all.
>
> M. Jacquot accepted this suggestion of the Secretary, and thereupon action four was adopted.[161]

This passage is remarkable because it indicates the extent to which the Congress were concerned not with the objects of geology directly, but with developing a system of reference by which those objects could be rendered comparable and evaluated. The Congress was convened, in other words, not to talk about geology, but to talk about *how to talk about* geology. The primary means of representation in geology, namely: map making and nomenclature, emerge through a careful deliberative process, according to which each divergent view is presented, assessed, and concluded through a popular vote. Where necessary, an appointed figure intervenes to arbitrate in the interests of ensuring the primary objective of the Congress is retained: to establish a framework for a universal discipline. As we shall see in the subsequent chapter, this is a strategy that endures in stratigraphy to this

[160] ibid: 20
[161] ibid: 20-21.

day. The Anthropocene will ultimately be decided by the popular vote of the Subcommission on Quaternary Stratigraphy, the International Commission on Stratigraphy, and the International Union of Geological Sciences. Ever since the AWG was commissioned in 2009, the Anthropocene concept has unfolded as a forum of divergent views and evidence. The wealth of these views, and the many thousands of pages on the topic, shall be mediated by the decision-making hierarchy via the medium of the Geologic Time Scale, and more specifically the GSSP. These are techniques of geological mediation whose genealogy can be traced back to the Congress, as we shall discuss in the next chapter. For now, I simply wish to emphasise that the Congress, as an international venue for geologists who aspired to the establishment of a universal discipline of their own, is the starting point for the deliberative process that ultimately encompasses the formalisation effort of the AWG.

A further purpose of the meeting, and one whose significance cannot be understated, was to establish a professional network. In bringing practitioners of common interest together, it becomes possible for those present to self-identify *as geologists*. The social function of the congress, is therefore also a disciplinary one. As one commentator of the time observes:

> Practically the chief inducement to nine members out of every ten [of the congress] is the be found in the social pleasures of such a meeting. The members are coming together to make the acquaintance of their fellow workers from distant lands; to exhibit specimens, compare notes, and exchange opinions; to visit the objects of scientific attraction… and to join in the geological excursions which are being organized on their behalf.[162]

The task of assembling Geology as a unified, international discipline concerns both a standard nomenclature, or method, as well as an identity. It concerns both meanings of the word 'subject', as analytical space and identity, to the extent that those present agree to subject themselves to a set of international standards *despite* variations that may exist between it and their own regional practices. An international discipline of geology emerges through a

[162] Editorial. 1888. The International Geological Congress. *The Athenaeum, London* 3175 (September 1st): 295-295.

common agreement amongst those present to abide by the judgement of others. This willingness to subject oneself to the judgement of their colleagues is what qualifies them as part of a community, and therefore their status to likewise submit others, their colleagues, to their own judgement. Their expertise, on the basis of which they can vote on the proposals of their colleagues, is qualified by their willingness to submit their proposals likewise to the judgement of their colleagues. The reciprocal dynamics through which the subject of geology emerges, both as a professional identity as much as the analytic space in which the Earth was considered geologically, is a topic I will now review in further depth.

3.3 On the dynamics of disciplinary geology

The Congress is devoted to establishing an evaluative framework within which geological observations can take place, and be compared and assessed against each other. If geological observation occurs as a strategy not of directly observing the earth, but of devising media with which to do so, then the Congress proceeds not by discussion of those media, but of developing a framework within which those mediated observations can be evaluated and universalised. There are several theoretical frameworks within which the significance of this gesture could be elaborated. The above description indicates a tendency wherein geological observation proceeds from a piece of rock (material earth itself), toward an abstracted, generalizable, evaluative framework. There is a transition, in other words, from local and specific instances, to universal and more general frameworks or theories. And yet, this universalising tendency collects in it a greater variety of local observations, such that the move towards universal frameworks is simultaneously an intensification of localisation. The geological unit refers both to a local, material rock section, as well as an abstracted entity that functions to facilitate correlation of that material globally. The rock can be further associated with an event, thought of as the cause for changes in the Earth's rock record. The event itself can then function as a further means for correlation rocks globally, such that geologists can speak of a global geological record. The unit is therefore an early geological strategy with which to abstract local material into a more generalizable set of standards within the discipline of geology; a reference system that has the effect of rendering specific and unique localities comparable with each other, subject to a common standard of evaluation. This is the dynamic of 'circulating reference' discussed in the previous chapter. The efforts toward the construction of a universal framework, such as at the International Geological Congress, encourages local observations. The effort to devise a universal framework for evaluation, structures geological observation and encourages a professional identity, which aids in the designation of further descriptions of strata, fossils, maps, etc. There is therefore a simultaneous directionality toward universalisation and localisation with each operation. Latour invokes reference in the etymological sense, "to bring back." 'Is the referent what I point to with my finger outside of discourse, or is it what I bring back inside discourse?'[163] It is both. A closed operation articulates an open structure, pointing to what is outside, and in doing so modifies the structure, encourages further instances of the operations, bringing back inside.

A closed operation articulates an open structure. The use of fossils as correlation devices with which to trace geological units around the world is a simplification of the complexity of earthly sediments. It is unlikely, for example, that a unit defined by a glaciation event, such as the Holocene, will be legible in the same way everywhere in the world. The premise of global units is therefore something of a fiction with which geologists project local observations into universal facts. Fossils, strata, GSSPs, Charts and Scales, constitute the material repertoire with which geologists translate the complexity of planetary phenomena into neat and comparable observations. There are a discrete number of operations that the geologist has at hand with which to conduct such acts of translation. The translation of planetary phenomena into geological discourse via fossils or strata therefore entails a simplification, a reduction of complexity. Geologists can produce an effective system for analysing the complexity of planetary phenomena, but it entails a conspicuous reduction of complexity through the use of a limited number of methods particular to geology. As more and more such operations accumulate an increasing number of geological observations, the complexity of those observations increases, 'within' the discipline of geology. Even though in rendering external phenomena geologically relevant, a process of simplification is entailed, the abundance of geological observations assumes its own complexity, 'within' geological observation. The advent of a system with which to render all of these observations comparable with each other; to overcome variations in regional practices of geology with a single, universal, evaluative framework, appears as a strategy by which to manage and

[163] Latour, B. 1999: 32.

regulate this internal complexity. Representational practices are therefore contingent on media such as fossils and rock specimens, which were brought from around the world and put on display for the duration of the Congresses, as well as a social capacity according to which geologists shared specimens, and reviewed the legitimacy of accounts that were constructed on the basis of those specimens.

The case of the International Geological Congress, however, is also historical and disciplinary. It is not simply a story of media technologies. It's invocation in this chapter is intended to foreground the emergence of a particular set of practices and dispositions that orient geologic observation subsequently. The Congress indicates the emergence of geology as a discipline, which is to say as a set of conventions and practices that determine what counts as reliable knowledge. This is a theme that bears some resemblance to Bordieu's notion of "habitus." Bourdieu's elaboration of this term is sufficiently broad as to have been designated "complex and often obscure."[164] This is somewhat paradoxical, given that the theory attempts to elaborate an account of knowledge as a thoroughly *practical* phenomenon, i.e. as being constituted through practices and habits. 'The habitus is precisely this immanent law, *lex insita*, inscribed in bodies by identical histories, which is the precondition not only for the co-ordination of practices but also for practices of co-ordination.'[165] There are several consequences of this observation for my account of the International Geological Congress. First of all, the notion of "habitus" emphasises a sense in which the discipline of geology emerges as a set of rules and techniques that attendants of the Congress voluntarily submit themselves to. Habitus is in this sense, 'understood as a system of dispositions common to all products of the same conditionings.'[166] Geology is established as a set of standardized techniques of observation and description. The geologist emerges as a professional identity to the extent of their ability to demonstrate a mastery of a common code. This is why the proceedings of the Congress, as discussed already, tend toward the delineation of a common nomenclature and method. This is also a disciplinary technology, to the extent that the geologist acquires that title, or professional designation, insofar as they can continually adapt to, or oblige by, the requirements made of them as a

[164] Bruce, S. & Yearly, S. 2006. Habitus. In *The SAGE Dictionary of Sociology*. London: SAGE. Pg.190.
[165] Bourdieu, P. 1990. *The Logic of Practice*. Stanford: Stanford University Press. Pg. 59.
[166] Ibid.

consequence of their participation in the habitus. The habitus is both a 'savoir-faire', the demonstration of know-how, as well as submission to abide by the "rules of the game."[167]

The second aspect of habitus relevant to this thesis is a kind of blind spot that precipitates from inhabiting a professional or disciplinary field. Mastery of the rules of conduct associated with a professional identity may entail a de-sensitization to other stimuli. Bourdieu describes the "habitus" as 'embodied knowledge.' Other stimuli may therefore not necessarily be ignored, but are likely to be understood primarily in terms already anticipated by a disciplinary disposition. 'The habitus makes questions of intention superfluous, not only in the production, but also in the deciphering of practices and works.'[168] Latour explains how the prevalence of certain technological artefacts, or instruments, in scientific research, entails a "black-boxing" according to which the controversies or other possible ways of doing things are obscured by the techniques or assumptions designated by the instrument.[169] Bourdieu's

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[167] Bourdieu explicitly references Wittgenstein in developing his theory of "habitus." The purpose of this theory, for Bourdieu, is to explore the limitations of prevalent discourses concerning the nature of knowledge. Bourdieu wishes to emphasise the extent to which knowledge of the world does not pre-exist techniques of observation by which it is demonstrated as such. Bourdieu explains:

> 'The theory of practice as practice insists, contrary to positivist materialism, that the objects of knowledge are constructed, not passively recorded, and, contrary to intellectualist idealism, that the principle of this construction is the system of structured, structuring dispositions, the *habitus*, which is constituted in practice and is always oriented towards practical functions.'

See ibid: 52. 'How am I able to follow a rule?' asks Wittgenstein, 'if this is not a question about causes, then it is about the justification for my following a rule the way I do. If I have exhausted the justifications I have reached bedrock, and my space is turned. Then I am inclined to say: 'This is simply what I do.' Wittgenstein, L. 2009 [1953]. *Philosophical Investigations: Fourth Edition*. London: Wiley-Blackwell. 217 (pg. 93). "Habitus," in other words, is a way of accounting for the non-idealist, non-rationalist, character of knowledge; what is practiced routinely within a discrete group. Yet to the extent that Bourdieu identifies a set of "rules" that oblige the actor in a certain way, and not others, his account of "habitus" does acknowledge a structure according to which knowledge unfolds. That is to say, Bourdieu's account of "practice" as opposed to "idealism" does not imply that knowledge is only ever a material practice (compare Bourdieu, for example, with Kittler's media theology. See Winthrop-Young, G. 2000. Silicon Sociology, or, Two Kings on Hegel's Throne? Kittler, Luhmann, and the Posthuman Merger of German Media Theory. *Yale Journal of Criticism* 13(2): 391-420.) Rather, Bourdieu appears to acknowledge a certain dialectic between structure and agency (see Bourdieu, P. 1990: 61 for a key example of this), wherein that structure is constructed and maintained in accordance with the evolution of material practices. This is a point I shall return to later in this chapter by way of Biagioli's "anthropology of incommensurability," which I believe addresses some of what remains ambiguous in Bourdieu's notion of "habitus."

[168] Bourdieu, P. 1990: 58.

[169] Latour defines blackboxing as 'the way scientific and technical work is made invisible by its own success', a phenomenon that has the paradoxical effect obscuring the dynamics of scientific activity the more successful it becomes. Latour, B. 1999: 304. The term blackbox is particular to science and technology studies, the affiliated authors of which perceive their work as an "opening" of the box. See Pinch, T. & Bijker, W. 1987. The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. In Bijker, W., Hughes, T. & Pinch, T. (eds) *The Social Construction*

notion of "habitus" implies a pre-artefactual iteration of such black-boxing. Inhabiting a particular perspective, or culture of practice, can make one blind to the possibility of doing things otherwise. Seeking to emphasise this reflexive-limitation implied by "habitus," Bourdieu invokes the analogy of class:

> '[c]lass (or group) *habitus*, that is, the individual habitus in so far as it expresses or reflects the class (or group), could be regarded as a subjective but non-individual system of internalized structures, common schemes of perception, conception and action, which are the precondition of all objectification and apperception; and the objective co-ordination of practices and the sharing of a world-view could be founded on the perfect impersonality and interchangeability of singular practices and views.'[170]

This is a dimension of "habitus" that will be useful when we consider the divergence of views concerning the Anthropocene within the AWG itself. Some stratigraphers take issue with the Anthropocene because it is thought not to sufficiently acknowledge the requirements of their discipline. Their contention is articulated in terms of the formalization procedure according to which units are ratified into the Geologic Time Scale. These critiques do not contest that human activity has influenced the planet in significant ways, some of which are geologically legible already. Rather, it abstracts the Anthropocene as a disciplinary, methodological issue concerning the parameters of formalization particular to chronostratigraphy.[171]

Significantly, the premise that the Geological Congress establishes disciplinary geology as a set of rules, according to which Geological observation is evaluated and formalized as a "game", need not presume a teleology. If the Geological Congress does articulate a "habitus", as I have suggested, then it is a phenomenon that occurs of its own momentum. Many of the issues presented and discussed during the International Geological Congresses remain unresolved by the end of the meeting, despite having been agreed on in a formal capacity. The application of a formal decision through a majority vote, or the preference of the

of Technological Systems: New directions in the sociology and history of technology. Cambridge: MIT Press. Pp. 17-51.

[170] Bourdieu, P. 1990: 60.

[171] Examples of such arguments appear in the contributions by Gibbard & Walker, and of Finney in Waters, C., Zalasiewicz, J., Williams, M., et al. (eds). 2014.

conference organiser, does not resolve the differences in methodology particular to each geological society present. Nor does it address differences in the way geology is taught in each country, practiced professionally, or variations in outcrops visible in each location according to which respective geological societies have staked their interests. A decision to side with England on the issue of the Silurian, for example, does little to resolve differences in practice between England and those who hold different preferences regarding the body of rock that, from the Bologna Congress onwards, becomes designated, at least for a period, as Silurian. Rather than resolve differences, decisions made at the Congress can emphasise difference, and provoke controversy, which becomes a topic for discussion in subsequent meetings of the Congress. The evaluative mechanism devised at the Congress, which characterises the discipline of geology as a “habitus”, is generative of its own authority, as well as the issues that it is subsequently called on to intervene in and resolve. It is, as Francois Jacob said of his own “habitus”, biology, a *future making machine*.[172] The scope for involvement as an evaluative framework is also the horizon of future controversies that justify further involvement. One way to explore this observation is by considering parallels between the proceedings of the International Geological Congress and the manner in which the Anthropocene unfolds as a theme for geological consideration. That is the focus of the next section.

3.4 The Anthropocene as forum

On what basis should the Anthropocene be included in the Chart and Scale? This is one way of understanding the debates concerning how best to define a lower boundary, or GSSP, which have characterised a significant portion of the Anthropocene literature over the last decade. The question of how the Anthropocene could be defined geologically was present in the first articles by Crutzen, but it did not consider the formal requirements of a GSSP or GSSA to mark the lower boundary of a geological unit. It simply considered the premise of a ‘beginning’ in a relatively abstract sense. With the first intervention of geologists, from a 2008 article authored by Jan Zalasiewicz and several colleagues, the majority of whom would compose the membership of the Anthropocene Working Group beginning the following year,

[172] Jacob, F. 1988. *The Statue Within: An Autobiography.* New York: Basic Books.

the GSSP is already a concern.[173] The authors ask whether a GSSP is required to formalise the Anthropocene, or whether a numerical date, or GSSA, would be sufficient given the high resolution available for such recent deposits. The question is also asked as to whether a GSSP could be defined by way of CO_2 markers in strata, or whether plutonium fallout from nuclear weapons testing would be more appropriate for a GSSP. The issue of diachronous beginnings is also raised at this early stage of the geological investigation into the Anthropocene, as the authors state that CO_2 markers, although abundant, may be too gradual to constitute a global and synchronous boundary as would be required of a GSSP. I shall review the history of the GSSP in the following chapter, along with the lively debate it has provoked concerning whether it is a useful marker. What frames this chapter, however, is the influence that the history of geology's deliberative procedures, as well as its charts, scales, and suite of inscription and correlation techniques, have had on the articulation of the Anthropocene as a geologic unit.

This influence is visible in two ways:

a) <u>Anticipatorily</u>: the deliberation of the executive, and the preferences that will inform their reception of any proposal, frames which arguments the AWG pursue, what evidence is drawn on, and how. As we shall see, one reason why the AWG can anticipate the response of the executive is because they have publicly communicated their scepticism and its causes. It is not therefore the case that geological normativity is *diffusive*, proceeding from a central point, fatalistically.[174] The AWG must simply become proficient at *translating* between the various interests elaborated by the Anthropocene, and the specific requirements of the ICS and IUGS.

b) <u>Figuratively (or structurally)</u>: the deliberative process of the executive is mirrored internally by the AWG. They too commission proposals from scientists who wish to propose a rock section or core for the lower boundary, or GSSP of an Anthropocene unit, which are evaluated by the AWG who vote on which GSSP candidate is most likely to be approved by the ICS and IUGS.[175]

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[173] Zalasiewicz, J., Williams, M., Smith, A., et al. 2008.

[174] Latour, B. 1984. The powers of association. *The Sociological Review 32(1): https://doi.org/10.1111%2Fj.1467-954X.1984.tb00115.x*

[175] Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2018.

3.4.1 Structural resemblance of AWG to IGC

In the context of the effort to formalise the Anthropocene as a geologic unit, the decision-making, or disciplinary procedures established at the International Geological Congress are once again rehearsed. This is because the AWG was commissioned by the Subcommission on Quaternary Stratigraphy, which is a constituent body of the International Commission and hence the International Union of Geological Sciences. There is a parallel in the way that the AWG formulate their proposal and how the IUGS conduct their evaluation. Each level of the hierarchical decision-making process (which passes through the SQS, ICS, and IUGS) involves a final vote to determine the adequacy of a proposal. The main decisions, however, are made at the level of the AWG and the IUGS, i.e. at the lowest and highest rank of the hierarchy. Although the majority of the AWG's efforts have been oriented toward the final decision of the IUGS, most the attention on the Anthropocene has concerned the decision ultimately to be made the by the AWG themselves.

When the AWG was established in 2009, its objective was to assess the adequacy of the Anthropocene as a formal geologic unit. By this it is ultimately meant a unit of the International Chronostratigraphic Chart, on which the Geologic Time Scale is based. The initial article of the AWG is open-ended in its consideration of an Anthropocene unit. It considers the possibility of either a GSSP (a material rock section) or a GSSA (a numerical date) to mark the lower boundary of an Anthropocene unit. It considers Crutzen's initial proposal, which marks the lower boundary of the Anthropocene at the beginning of the industrial revolution, as well as indicating an openness to other possibilities. They furthermore solicited proposals from anyone who wished to contribute a GSSP candidate.[176] A further sense in which the Anthropocene hypothesis is unique in geology, beyond the AWG being comprised of non-geologists, is that the Group actively solicited engagement from beyond geology for the purposes of its geological delineation.

In 2016, the 35th International Geological Congress took place in Cape Town, South Africa. Typically, Working Groups are given a period of eight years to submit a proposal. It was therefore expected that, seven years having elapsed since their founding, the AWG would

[176] See Zalasiewicz, J., Waters, C., Summerhayes, C. 2017.

present its proposal at Cape Town. However, in a discipline that moves as slowly and cautiously as geology, which bears the weight of 4.5 billion years of Earth history, no one is penalised if the process takes longer (until recently with little success, see appendix: 1). Add to this that the AWG is responsible for securing its own funding. Although a proposal was ultimately not submitted, there were several meetings dedicated to the Anthropocene, and a meeting of the Anthropocene Working Group was held.[177] At this meeting, a vote took place that was intended to determine what was to be the primary signal for a formal Anthropocene unit, as well as how it was to be recorded (by GSSA or GSSP). The options for a guiding principle, or primary signal, included all the proposals that had appeared in scientific literature up until then. Specifically, the proposals voted on, by date, and result, were:

3.4.1.1 Orbis Spike: 0 votes

The geographers Simon Lewis and Mark Maslin posited their own GSSP proposals in 2015.[178] They are not members of the AWG. The first of these proposals was the Orbis spike, which marks a significant slump in carbon dioxide levels beginning in 1520, with its lowest point in 1610. The authors attribute this slump to arrival of European colonial forces to the Americas in 1492. This arrival led to the death of fifty million indigenous inhabitants, and the destruction of huge areas of agricultural land. The genocide perpetrated by the colonial forces led to an increase in tree growth across the Americas, growing in previously cultivated lands. As a result, carbon dioxide was metabolised at much greater rates than had been the case in preceding decades. This slump is indicated in the Law Dome Antarctic ice core from the West Antarctic. The ice core contains layers that are deposited regularly, and therefore provide a remarkably accurate guide to fluctuations in the concentration of atmospheric gases and other climatic factors over regular time intervals.[179]

[177] This meeting and the results of the vote that took place are recounted in ibid. See also Subramanian, M. 2019, May 21. Anthropocene now: influential panel votes to recognize Earth's new epoch. *Nature*: https://www.nature.com/articles/d41586-019-01641-5 (accessed 23/1/21).

[178] See Lewis, S. & Maslin, M. 2015. Defining the Anthropocene. *Nature* 519: 171-180; Lewis, S. & Maslin, M. 2018. *The Human Planet: How We Created the Anthropocene*. London: Pelican Books.

[179] Lewis, S. & Maslin, M. 2015.

3.4.1.2 7ka: 0 votes

The archaeologist William Ruddiman has proposed a start date for the Anthropocene beginning seven thousand years ago.[180] Ruddiman argues that significant anthropogenic change to the earth's surface begins with anthropogenic deforestation for the purposes of rice paddy irrigation. Such early agricultural activity was so extensive that carbon dioxide levels, which up until then were steadily declining, begin to increase. A similar reversal occurs in methane levels five thousand years ago. Ruddiman attributes these anomalies to greenhouse gas emissions resulting from early farming. Subsequent research has indicated that at least eighty percent of methane emissions from this time can be attributed to human agricultural activity.[181]

3.4.1.3 3ka: 1.3 votes

The proposal for an Anthropocene lower boundary placed at approximately three thousand years ago derives from deposits left by early metal mining and smelting, as well as anthropogenic modification of soil. Both metalwork and soil modification indicate a general expansion in the scope and reach of trade between human societies around the world. Trace-metal pollution from human activity around that time has left traces in geological archives including lake sediments, ice cores, peat bogs, estuarine sediments and coastal sediments.[182] Greek-Phoenician mining and Roman metal production have left signals in Southern European lake sediments that can be correlated with ice cores from the Antarctic.[183] Around Polynesia, extensive trading of shells, among other objects, occurred over a wide area consistent with significant expertise in sea navigation. These circumstances are similarly recorded in soil

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[180] See Ruddiman, W. 2003. The anthropogenic greenhouse era began thousands of years ago. *Climate Change* 61: 261-293; Ruddiman, W., Ellis, E., Kaplan, J., et al. 2015. Defining the epoch we live in. *Science* 348(6230): 38-29; Fuller, D. 2015. Earth transformed. *Holocene* 25(7): 1193-1194.

[181] Elsewhere, the AWG have expressed scepticism over the attribution of carbon dioxide and methane level rises *solely* to human activity. They argue furthermore that the inflexion of carbon dioxide levels in the ice core that Ruddiman references is too gradual to distinguish any particular point for a GSSP. Furthermore, they argue that an Anthropocene start date of seven or five thousand years ago would "not rest comfortably" with the existing divisions of the Holocene, which have boundaries placed at 8.2 (the Northgrippian Age/Stage of the Holocene Epoch) and 4.2 (the Meghalayan Age/Stage of the Holocene Epoch) thousand years ago. See Zalasiewicz, J., et al. 2019: 247-248.

[182] See Zalasiewicz, J., et al. 2019: 248.

[183] See Garcia-Alix, A., Jimenez-Espejo, F., Lozano, J., et al. 2013. Anthropogenic impact and lead pollution throughout the Holocene in Southern Iberia. *Science of the Total Environment* 449: 451-460; Krachler, M., Zheng, J., Fisher, F., et al. 2009. Global atmospheric As and Bi contamination preserved in 3000-year-old Arctic ice. *Global Biogeochemical Cycles* 23: GB3011.

sediments, and can be correlated with mining and smelting activities of Southern Europe. Although this proposal received 1.3 votes when it was taken to vote at the 35th International Geological Congress, the AWG have argued that these signals are too diachronous and regional to provide a synchronous, global marker such as is required for a GSSP designation.[184]

3.4.1.4 1800: 0 votes

As explained in the introduction, Crutzen & Stoermer's initial proposal for an Anthropocene start date was the end of the 18th Century.[185] This date marks the beginning of the industrial revolution, they argued. The year in which James Watt's most sophisticated version of the steam engine, 1787, was chosen as a proxy symbolising the industrial revolution in what some take to be its most significant contribution.

3.4.1.5 1950: 28.3 votes

The 1950 proposal designates the variety of signals associated with The Great Acceleration as a lower boundary for an Anthropocene unit.[186] As explained in the introduction, The Great Acceleration refers to a period of exponential growth across a wide range of phenomena, from human population to ocean acidification, fertilizer consumption to atmospheric concentrations of methane. This argument is illustrated with the aid of a series of charts demonstrating a sharp spike at approximately 1950.[187] The likely primary signal would be the onset of plutonium-239 (^{239}Pu) isotopes resulting from persistent nuclear weapons testing, beginning in 1945.[188] The Great Acceleration is an attractive proposal for the AWG because, in providing a range of signals, there is greater opportunity for correlation across events and place. This means that in addition to whatever signal is chosen as the GSSP, there will be a

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184 Zalasiewicz, J., et al. 2019: 248-250; Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.

185 Crutzen, P. & Stoermer, E. 2000; Crutzen, P. 2002.

186 Zalasiewicz, J., Waters, C., Williams, M. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383: 204-207. See also Waters, C., Zalasiewicz, J., Summerhays, C. 2017. Global boundary Stratotype section and point (GSSP) for the Anthropcoene series: Where and how to look for potential candidates. *Earth Science Reviews* 178: 379-429; Zalasiewicz, J., Waters, C., Wolfe, A. 2017. Making the case for a formal Anthropocene Epoch: An analysis of ongoing critiques. Newsletters on Startigraphy 50(2): 205-226.

187 For the latest version of these graphs see the IGBP website at http://www.igbp.net/globalchange/greatacceleration.4.1b8ae20512db692f2a680001630.html (accessed 01/12/2020). These graphs are also reprinted in the AWG's definitive account of the Anthropocene as a geological unit. See Zalasiewicz, J., et al. 2019: 256-259.

188 Waters, C., Syvitski, J., Galuszka, A., et al. 2015.

variety of other deposits that can serve as ‘auxiliary cores’. The Great Acceleration proposal thereby offers greater possibility for satisfying the requirement that a GSSP indicate a global and synchronic event.

3.4.1.6 1964: 1.3 votes

In addition to the Orbis spike proposal, Lewis & Maslin also proposed a 1964 lower boundary, or start date, for an Anthropocene unit. The 1964 proposal is based on deposits resulting from nuclear fallout following persistent nuclear weapons testing beginning in 1945. This nuclear fallout leaves isotopes, including ^{239}Pu, iodine-129 (^{129}I), and carbon-14 (^{14}C), which can be dated in absolute terms, to the year. Lewis & Maslin suggest ^{14}C, detectible in tree rings.[189] The age of the tree rings can be correlated to the half-life of the isotope. The choice of 1964 is intended to emphasise the peak of carbon-isotope concentration relative to global standards.[190]

3.4.1.7 Diachronous beginnings: 4 votes

It is perhaps one of the more interesting details of the formalisation process so far that the AWG has, among its members, individuals who hold that the Anthropocene should not be formalised as a geologic unit. These members believe that “an anthropogenic era now exists”[191], but that by formalising a lower boundary, the Anthropocene will undermine evidence of anthropogenic impact that occurs ‘prior’ to (or lower than) that boundary. A lower boundary set at 1950, for example, would render an event from 1949 to be of the Holocene, while a similar event from 1951 would be enveloped in the narrative of the

[189] See also Turney, C., Palmer, J., Maslin, M., et al. 2018. Global peak in Atmospheric Radiocarbon Provides a Potential Definition for the Onset of the Anthropocene Epoch in 1865. *Scientific Reports* 8(3293): DOI:10.1038/s41598-018-20970-5

[190] The AWG have dismissed this proposal for two reasons. Firstly, it is argued that trees are not long-lasting enough to constitute a reliable archive of the geological record. There are no units dated in tree rings. Although the Holocene was dated using what was then a novel kind of geologic record (ice cores), it is thought that trees are even less archivable than ice, which has now become a fairly common-place type of geologic archive. Secondly, the AWG argues that it is inconsistent with “normal stratigraphic practice,” to place a GSSP at the peak of a trend. Rather, the placement of boundaries at the inception or onset of a signal is favoured. See the AWG’s response to the Lewis & Maslin proposals: Zalasiewicz, J., Waters, C., Barnosky, A., et al. 2015.

[191] Ruddiman, W. 2018. Three flaws in defining a formal ‘Anthropocene’. *Progress in Physical Geography* 42(4): 451-561. Pg. 451.

Anthropocene.[192] These members therefore hold that while an Anthropocene unit is worthwhile in recognising the extent of human impact on the planet, it is not something that came about all at once, as a global, synchronous, lower boundary would indicate. Rather, the emergence of what Crutzen calls a "geology of mankind" was a gradual, iterative process.

They fear, moreover, that the placement of a lower boundary would be an obstacle to further research on the history of anthropogenic impacts on the planet. They voice concern that "journal editors will henceforth treat the Anthropocene in the same way they treat the Holocene and Pleistocene: as formal time units, the boundaries of which have specific dates, not open to redefinition by individual authors."[193] The categorisation of time will, in this view, supersede the attention given to what took place therein. Finally, there is scepticism concerning the possibility of global synchronicity. Authors of this proposal argue that the effects associated with the Anthropocene, in other words, began *gradually* and *somewhere*, rather than everywhere at once. They explain:

> It goes without saying that all stratigraphic evidence is diachronous to some degree. There is, in general, no such thing as a truly globally synchronous event, or isochronous boundary in the ground… even the Cretaceous/Tertiary bolide impact [which famously caused the extinction of dinosaurs] and its effects had some duration, albeit relatively short… in that sense, the terms 'diachronous-synchronous' roughly correspond to the terms 'near-far' – not actually absolute terms with fixed meanings at all, but relative terms that can be applied to the same thing when viewed from variable distances away in time.[194]

The argument to recognise the diachronous beginnings of the Anthropocene is in direct contravention to the IUGS's requirement of a GSSP, which is defined on the basis of a globally correlatable and synchronous signal. The authors of this particular proposal are certainly aware of this requirement.[195] The position appears therefore to be an effort to

[192] Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019.
[193] ibid: 341.
[194] ibid: 338.
[195] The majority of authors of the paper arguing for a diachronous beginning of the Anthropocene are members of the AWG, and one, Phil Gibbard, was Chair of the SQS when it commissioned the AWG, and now remains a voting member of the ICS.

highlight, what is in their view, the AWG's unnecessary pursuit of IUGS-approved unit formalization. If the Anthropocene is already in extensive use beyond stratigraphy, and there is a general understanding of what the Anthropocene refers to, even by stratigraphers who do not think the term should be formalized, then what's the use of a formal Anthropocene unit?

This is a question I shall return to later in this thesis. For now, suffice to say that these proposals were the options presented to the AWG members at the 35th International Geological Congress. The members voted with a clear majority in favour of the 1950, or mid-twentieth century Great Acceleration proposal.[196] There were no abstentions or undecided votes. In addition to a vote on where the Anthropocene began, there was also a vote on how to mark this beginning: with a GSSP (physical location) or GSSA (numerical date). The Group voted overwhelmingly for a GSSP. Finally, a vote was held on which signal to pursue as the primary guide. Consistent with the selection of a mid-twentieth century lower boundary, the use of plutonium fallout resulting from nuclear weapons detonation was identified as the primary marker for an Anthropocene unit GSSP.[197]

3.4.2 Anticipatory resemblance of AWG to IGC

The effect of this vote appears to have been the consolidation of the Anthropocene from a forum for cross-disciplinary discussion, to the execution of a technical task. That task, specifically, entails defining a GSSP core along with a suite of auxiliary cores to demonstrate the global and synchronous beginning of an Anthropocene unit. This transition indicates the success of the ICS and IUGS in orienting the efforts of the Anthropocene Working Group. As evidence of this, the Anthropocene Working Group write, in the conclusion of a 2019 publication that serves as the definitive, up-to-date account of the formalisation effort so far:

> The AWG's emphasis concerns the 'geological Anthropocene' essentially as originally intended rather than other interpretations overall, the Anthropocene has emerged as a concept that has provided not only a particular perspective on Earth history but also a remarkable and positive catalyst for cross-disciplinary discussions. These will

[196] Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.
[197] See Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.

> continue to generate wider insights, even as the specific work of examining the Anthropocene in technical geological terms continues.[198]

The wider, non-geological threads of the Anthropocene are acknowledged, but as a means of cordoning off the effort of the Working Group therefrom. They are acknowledged, in other words, to demonstrate their differentiation from the work of unit formalisation. The AWG assemble their proposal in anticipation of the preferences of the ICS and IUGS. Their efforts are increasingly oriented exclusively towards those preferences.

The requirements of the IUGS and ICS come at the expense of a wealth of competencies that have contributed to the elaboration of the Anthropocene, and ultimately, its generativity as a cross-disciplinary forum. Although these contributions were once welcomed by the majority of the AWG, in their response to the above allegations, the rest of its membership take a decisive approach:

> Ruddiman asks the question: how can the significant pre-industrial anthropogenic signals from deforestation, mammal extinction and so on be excluded from the Anthropocene, to the extent that locally the terms are conflated, as in the 'Anthropocene Working Group' and 'pre-Anthropogenic time'? The answer is 'very easily', as Anthropocene as defined stratigraphically should *not* be equated with 'anthropogenic'. The Anthropocene, we stress, is not synonymous with anthropogenic activity. Ruddiman's conflation of 'Anthropocene' with 'anthropogenic era' does not recognize this important point, nor does it recognize the developing understanding of the Anthropocene as a potential epoch, a more modest unit than an era.[199]

The AWG anticipate the rebuttal they would face from the ICS and IUGS if they submitted a proposal that was at all sympathetic to a diachronous onset of an Anthropocene unit. Such a position would be at odds with the requirement for a global, synchronous lower boundary. They move from a position of openness towards diverse understandings of the Anthropocene to the narrow, more strict approach required if the Anthropocene is to be included in the

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[198] Zalasiewicz, J., et al. 2019: 286.
[199] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 325. Emphasis in original.

Charty and Scale. The AWG continue to make reference to various arguments that elaborate an expanded sense of the Anthropocene theme, but primarily to differentiate the predominant view of the Group from a set of views that are hence presented as 'fringe'. The majority of the Group wishes to distinguish those views from the primary objective of GSSP definition. They continue to invoke the original sense of the Anthropocene-as-cross-disciplinary-forum, but as a way to signpost their overall commitment to, and prioritisation of, the requirements of unit formalisation as outlined by the ICS and IUGS:

> A mounting body of evidence now indicates that the Anthropocene as originally proposed by Crutzen and Stoermer, adopted and developed by the Earth System sciences (ESS) community, and more recently analysed in stratigraphic terms by the AWG is clearly distinct from the Holocene. It represents the marked *intensification* of anthropogenic change, taking the Earth System beyond the envelope of Holocene conditions.[200]

In Crutzen's original articulation of the Anthropocene, the "age of Man" can be said to refer to both human impact on the planet, as well as the ability of that same, obscurely defined 'Anthropos' to respond to this challenge.[201] Yet as the Anthropocene becomes increasingly posited as a search for a GSSP candidate, the imperative to respond is substituted by the obligation to identify that effect in the geological record.

3.4.3 From response to assignment

The initial polemicism of Crutzen's intervention, which sought to stir the geoscientific community to the challenge of substantial planetary modification in the wake of a "geology of mankind" had also to be refashioned as chronostratigraphically consistent, or altogether dropped. Consider an early account of the Anthropocene as described by its president, Jan Zalasiewicz:

[200] ibid: 324.
[201] Crutzen, P. & Stoermer, E. 2000.

> The Anthropocene is here treated as a geological phenomenon, comparable to some of the great events of the Earth's deep past. But, the driving force for the component global changes is firmly centred in human behaviour, particularly in social, political and economic spheres.[202]

In the same year that the above account was published, a special issue of *Nature* on the Anthropocene opened with an editorial on what it termed *the human epoch*:

> Official recognition of the concept would invite cross-disciplinary science. And it would encourage a mind-set that will be important not only to fully understand the transformation now occurring but to take action to control it… But the first step is to recognize, as the term Anthropocene invites us to do, that we are in the driver's seat.[203]

These provocations were, not altogether unreasonably, received as an open invitation to engage the Anthropocene concept. Lewis & Maslin's proposal is explicit in this regard, seeking to envelope within the Anthropocene 'a deeply uncomfortable story of colonialism, slavery, and the birth of a profit-driven capitalist mode of living being intrinsically linked to long-term planetary environmental change.'[204]

However, the conviviality of the Anthropocene concept is also its most problematic aspect, as far as the executive of the ICS and IUGS are concerned. In their articles, the executive members of the ICS and IUGS are unanimously dismissive of any reflections on the Anthropocene that are not firmly located within the framework of formal chronostratigraphic procedure. The attention that the Anthropocene has received from beyond that framework appears to have bewildered ICS and IUGS voting member. They ask, consequently, whether the Anthropocene is in fact an artefact of 'pop culture'[205], or a 'political statement'[206]. "Most articles on the Anthropocene [do] not consider the mission of the International Commission

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[202] Zalasiewicz, J., Williams, M., Haywood, A., et al. 2011.
[203] Nature editorial. The human epoch. 2011. *Nature* 473: https://doi.org/10.1038/473254a
[204] Lewis, S. & Maslin, M. 2018: 326-327.
[205] See Autin, W. & Holbrook, J. 2012:60-61.
[206] See Finney, S. & Edwards, L. 2016.

on Stratigraphy," argue Finney & Edwards, "nor [does] it present an understanding of the nature of the units of the International Chronostratigraphic Chart on which the units of the geologic time scale are based."[207] The Anthropocene is addressed squarely within the framework of ICS procedure, the requirement of a GSSP for formal ratification into the Chart.

A normative order is enforced via reference to a disciplinary and evaluative framework. This is described as a requirement, citing the weight of tradition within the discipline in chronostratigraphy that calls on the AWG to act in accordance with the 'terminology and concepts presented in all stratigraphic guides and codes, even in first year historical geology textbooks, [which] date to the 2nd International Geologic Congress in Bologna in 1881.'[208] Accordingly, Finney reframes the research agenda of the AWG: 'human impact is immense and potentially increasing. But the question is: Should the Anthropocene be approved by the ICS and ratified by the IUGS as an official unit of the ICS International Chronostratigraphic Chart?'[209] Such passages reveal the extent to which the Anthropocene theme is received by the ICS and IUGS as a purely procedural, and disciplinary matter. They do not question anthropogenic planetary modification. Their concern is whether the discourse surrounding the Anthropocene theme adequately acknowledges what they perceive to be an obligation towards the formalities of disciplinary chronostratigraphy. The ICS and IUGS are thereby presented as the exclusive arbiters of an Anthropocene unit, by merit of its association with the evaluative procedures of stratigraphy as a Working Group of the ICS (via the SQS), and as the arbiters of the Chart and Scale.

In other words, where a solution does not immediately present itself in the stratigraphic record, geologists have devised a system to bring about a resolution. Stratigraphers can effectively outsource their problems to be resolved in a manner that retains authority within their practice, as both scientifically legitimate and final. The ability to outsource problems in this way can be said to characterise the stratigraphic process. The evaluative procedure is intended to secure the integrity of stratigraphy. It remains possible to adjust the decisions generated by this process if subsequent research falsifies the

[207] ibid: 5.
[208] ibid.
[209] ibid: 6.

decision.[210] This system was developed in response to early aspirations of universality, seeking to consolidate a series of regional geological practices into a singular, unified discipline. Through this deliberative process, a formal nomenclature was developed, enabling the systematic codification of strata. This includes, as we have seen, the distinction of chronostratigraphic and geochronological units, which underlies the categories of the International Chronostratigraphic Chart, which is the basis of the Geologic Time Scale. The Chart and Scale are managed through the deliberative process delineated at the Bologna Congress of 1881. The committees that review proposals and vote on proposed amendments to the Chart/Scale retain exclusivity in their power to do so.

In our first interview in 2016, AWG President Jan Zalasiewicz insisted that they were "spoiled for choice" as far as geological markers for the Anthropocene were concerned.[211] Already at that point, Zalasiewicz could point to a mass of literature in support of his claim, across several disciplines and journals. That the AWG was nevertheless no closer to a formal Anthropocene unit, emphasises the significance of procedural evaluation and judgement in geology. The stratigraphic evidence is secondary to its approval by the executive of the ICS & IUGS, and their judgement. Formalisation of an Anthropocene unit, in other words, refers first and foremost to approval from the three-tiered hierarchy of the SQS, ICS, and the IUGS. This hierarchy is the medium through which stratigraphic controversies are resolved. In order to deliver judgement, a proposal is required, which the AWG have yet to submit, despite the significant body of literature outlining the characteristics of an Anthropocene unit.

Literature from the stratigraphic community that dismisses the adequacy of the Anthropocene as a formal unit does not necessarily disagree with the evidence presented in literature favourable to a formal Anthropocene unit. Instead, it argues that such claims are procedurally insufficient. Stan Finney, Chair of the IUGS commission on stratigraphy from 2008-2016, is explicit on this point:

> There's this huge, huge media tsunami wave in both scientific publications and the media. The question I raise in my papers is 'where's the stratigraphic record?' They've produced a large number of articles in high profile journals, including *Science*. I cite

[210] Although, of course, the requirement of an external system of arbitration implies that somebody will always hold that any decision is already wrong to begin with.

[211] Zalasiewicz, J. 2017, February 2. Personal interview.

> those papers, asking 'where is the stratigraphy?' We've been asked, as the commission on stratigraphy, to consider the Anthropocene, but *we have never received a formal proposal*. And nothing can be done until a formal proposal is submitted. Yet I've been contacted so many times by journalists asking 'when are you going to consider it?' Well, once we have the proposal. And what that needs is for the stratigraphy to be shown.[212]

Finney's claim that the stratigraphy has yet to be shown is at odds with his admission that he has engaged the AWG's account of the stratigraphic characteristics of an Anthropocene unit. In his response to such accounts, Finney criticises the semantics of time demonstrated by the AWG. He asks how an Anthropocene unit can be justified given that some units have boundaries whose margins of error are many-fold greater than the entire duration of the Anthropocene.[213]

The scepticism demonstrated by voting members of the ICS and IUGS, such as Finney, who are the ones who will ultimately approve the AWG's proposal for a formal Anthropocene unit, may be the reason for a marked shift in the tone of the AWG. Whereas in 2011 they were confident that "the driving force for the component global changes is firmly centred in human behaviour, particularly in social, political and economic spheres", in their 2019 response to their own members' scepticism regarding the utility of a defined lower boundary, they are keen to distance themselves from Crutzen's original polemicism:

> Had Paul Crutzen used a different term in 2000, not including an 'anthropos', then both the Earth System meaning and justifications, and the stratigraphic integrity, of the term would have remained exactly the same, but the conflation of meaning may

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[212] Quoted in Voosen, P. 2016. Anthropocene pinned to postwar period. *Science* 353(6302): 852-853. Pg. 852.
[213] See Finney, S. & Edwards, L. 2016. As they explain:

> The stratigraphic record of the Anthropocene is minimal, especially with its recently proposed beginning in 1945; it is that of a human lifespan, and that definition relegates considerable anthropogenic change to a "pre-Anthropocene." It's concept is fundamentally different from the chronostratigraphic units that are established by ICS in that the documentation and study of the human impact on the Earth system are based more on direct human observation than on a stratigraphic record.

This criticism resembles arguments that would be made slightly later by AWG members who feel a 1945 lower boundary marginalises non-stratigraphic understandings of the Anthropocene, described earlier.

> not have arisen. Equally, had the post-mid-20th century changes we associated with the Anthropocene been produced not by human actions but by, say, volcanoes or a meteorite strike, then the justification and meaning of the Anthropocene both in ESS terms and stratigraphically would also have remained similarly valid. The Anthropocene as an ESS and a chronostratigraphic unit recognizes dramatic changes to the Earth System, using the same criteria that delineates any other previous epoch – it just so happens that the cause is humans this time, rather than some other forcing factor.[214]

'The Anthropocene' is a term that overlaps with a wide range of incommensurable interests. Even restricted to its designation as a chronostratigraphic unit, it is mobilised alternately to various ends. For some, the formalisation of the Anthropocene is an opportunity to address the severity of human impact on the planetary environment. For others, it is an opportunity to elaborate existing understandings of that impact. Presenting their Orbis spike hypothesis, Lewis & Maslin mobilise geoscience to elaborate 'a deeply uncomfortable story of colonialism, slavery, and the birth of a profit-driven capitalist mode of living being intrinsically linked to long-term planetary change.' They conclude: 'what we do to each other matters, as well as what we do to the environment.'[215]

I have sought to indicate how the AWG establish a position from which the Anthropocene theme is observed. The location from which observation is possible is both defined ad hoc, responding to competing interests that delineate the parameters of their research efforts, and determined in advance. It is ad hoc in the sense that early publications of the AWG demonstrate an enthusiasm for cross-disciplinarity and the potential of defining a geologic unit through the encounter of various competencies in one place, in a manner entirely novel to stratigraphy. It is determined in advance both by the traditions and procedures of unit definition that were set in stone beginning with the first International Geological Congresses, as well as the strict requirements and evaluative procedures associated with the Chart and Scale; but also by the concern and scepticism of the executive members of the ICS and IUGS who see their role as a safeguarding of those traditions. A

[214] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 326.
[215] Lewis, S. & Maslin, M. 2018: 327.

history of the AWG could observe a transition from a period of initial enthusiasm, in which, as Crutzen originally proposed, the geoscientific community is called upon to respond to the challenges presented by anthropogenic planetary modification, to a period wherein the formalisation effort of the AWG distances itself from previously allied arguments, narrowing its efforts toward the satisfaction of the evaluation process associated with the Chart and Scale.

3.5 Contingentism of the Anthropocene

What does the dynamic outlined above reveal about the formalisation effort of the AWG? Various solutions have been presented concerning the definition of an Anthropocene unit. None of these suggestions are categorically false. The AWG does not dispute the truth-value of any of the proposals. On the contrary, it has supported their elaboration, and presented them for selection among its members. Presumably, if a 3ka start date, for example, had been selected by the majority of members, the AWG would direct their efforts in the same way they pursue a 1950 primary marker now. The chronostratigraphic method does not determine that any position is wrong. It only determines a preference. There is nothing inevitable about the outcome of the AWG's efforts. When numerous options are considered equally, such that a vote must proceed to decide among them, then we are no longer in the domain of *rationalism*, wherein we could posit that anyone who thought seriously enough about it would eventually reach the same conclusion.[216] Clearly many different conclusions were reached. As the one who coined the term, Crutzen had been thinking about it longer than anyone else, and yet his proposal for an 1800 start date was dismissed by the AWG without a single vote.

And yet it does not therefore stand that the effort to define an Anthropocene unit is an instance of *relativism*. The vote determines one position. The AWG may initially have welcomed the concerns of various disciplines, and invited proposals from them, but this was ultimately toward the end of adopting one position that was as comprehensive as possible, at the exclusion of all other possible positions. The position adopted by the AWG (namely that the Anthropocene *is* a legitimate unit at the rank of Epoch/Stage, which should have a lower boundary defined by a GSSP using the mid-twentieth century signals associated with the

[216] Shapin, S. & Schaffer, S. 1985.

Great Acceleration as a primary guide) is not by any account the *best* of all possible options, but simply that which succeeded in accordance with disciplinary protocol the AWG are subject to as a constituent body of the ICS and SQS. This indicates as much about the preferences of a majority of AWG members as it does about the ecological niche the AWG has adapted to, i.e. the preferences of the current ICS and IUGS executive members who have indicated their preference for a particular kind of chronostratigraphic definition, which the AWG subsequently seek to incorporate into their own decisions by choosing a primary marker that is most likely to satisfy those preferences.

The parallels with the events of the congress are evident. The Congress gathered geologists from around the world, each of whom was pursuing their own regional variation of the study of Earth's material constitution and history. It was the intention of the Congress, and most the participants, to forge a single and unified discipline out of this variability. The meetings of the Congress were vital towards this end because they accommodated a position from which all the options could be surveyed and compared. Inevitably this was never to the satisfaction of all involved. However, compromise was accepted as a condition of realising a universal set of standards that would characterise the discipline of geology. Yet there was nothing inevitable about the way this universal Geology unfolded. The authority of the hosts in coordinating discussions, and refereeing debate, indicates that all that prevented a different outcome was the diplomatic and negotiating style of the participants. The nomenclature and preferences adopted through the early meetings of the Congress, which have informed geological observation ever since, were not necessarily the best of all possible outcomes, but rather the ones that were agreed upon at that time. And yet they were, to some extent, determinative of what constituted reliable geological observation subsequently. The notion of "habitus" lends itself to the tendency to perceive structures such as the formal evaluation procedure of stratigraphy, as delineated at the IGC and which guides the AWG's formalization process, as a static entity. Latour's notion of "circulating reference" acknowledges a degree of recursivity such that we can perceive formal structures as dynamic, not static, but it does so with an emphasis on technical devices. I wish to argue that the social element of geologists meeting each other and sharing best practice is necessary to maintain, *alongside* an emphasis on media technologies. How might this simultaneity be preserved toward a more appropriate articulation of the formalization procedure the AWG currently pursue?

The account provided in this chapter, which adopts neither a rationalist nor a relativist position, recalls what Mario Biagioli calls *contingentism*, which highlights the recursive and contingent dimension of “habitus” as discussed earlier.[217] Contingentism addresses what Biagioli views as an impasse that beguiles historians of science between relativism and rationalism. If rationalism is the claim that the present state of affairs has emerged because it is the best of all possible options, and to that extent was always, already inevitable; and if relativism posits that it is possible to view everything but at the same time to be nowhere at all, then both views profess a similar bias. They are two sides of the same ‘God trick’ coin; a kind of teleological a priori that is figured in advance of the problem posed.[218] Attempting to demonstrate the commitments of contingentism, Biagioli invokes evolution as a metaphor. To appreciate the dynamics according to which one position is adopted against the background of all other possible outcomes, one must relinquish any appeal to ‘true’ or ‘false’, ‘good’ or ‘bad’. Rather, if we take as an example the prevalence of one nomenclatural tradition over another, or more recently, one proposal for the Anthropocene lower boundary over another, it is not necessary for a claim to be falsified for another to be adopted. This is

[217] A position which he develops in Biagioli, M. 1996. From Relativism to Contingentism. In Galison, P. & Stump, D. J. (eds). *The Disunity of Science*. Stanford: Stanford University Press. Pp. 189-206. In this paper, Biagioli is developing what he calls ‘the anthropology of incommensurability’, which is a theme he first posits in his account of Galileo’s encounter with Aristotelian philosophers. See Biagioli, M. 1993. *Galileo, Courtier: The Practice of Science in the Culture of Absolutism*. Chicago: Chicago University Press. Especially pages 211-244. In his account, Biagioli does not hold that Galileo’s account prevailed because it was inherently better, nor because it was the strongest competitor in a world where scientific truth is ultimately about the dynamics of power, as Latour’s reliance on agonistic metaphor would imply. Rather, Biagioli insists that it is impossible to write history from the perspective of the moment of its unfolding. The precise circumstances according to which one option prevails and another does not, is always inaccessible. For Biagioli, this admission is a means of practicing reflexivity; of appreciating both the partial perspective from which history unfolds (as recounted by historians), as well as one’s own partiality in recounting history. In coining the term ‘contingentism’, Biagioli appreciates that any historical account unfolds *relative to the inaccessibility of the subject or period one describes.* As context for this argument, Biagioli is responding to what he calls “routine bashing of whiggish history of science” which was nevertheless, at the time, making a comeback. Biagioli sought to address the very possibility of making judgements about historical trajectories, positing that it was equally redundant to assume judgement could be made as it was to denounce the possibility of judgement altogether. Rather, the premise that history is inevitable, to the extent that subsequent events always respond to previous ones, but that does not mean it is teleological. See also Schaffer, S. 1986. Scientific Discoveries and the End of Natural Philosophy. *Social Studies of Science* 16(3): 387-420, where Schaffer takes up a similar argument in regards to the discovery of photosynthesis, claiming on page 397: “We can say that the research of the early nineteenth century produced the discovery of photosynthesis in the late 1770s.” In other words, not only is discovery historically situated, but so is any account of discovery. He continues, “It seems simultaneously unnecessary, ill-mannered, and impossible to find a mark of discovery separate and superior to the locally generated rules of communities of natural philosophers.”

[218] This notion of relativism and rationalism as two versions of the ‘God trick’ is developed in Haraway, D. 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14(3): 575-599.

indicated above all by the exercise of political procedures in stratigraphy, such as the constant reference to majority votes, and the role of arbiters who determine the classification of geochronological and chronostratigraphic units in the Chart and Scale. The views that do not receive a majority vote may continue to be supported and elaborated by their proponents. Indeed, the vote in 2016 appears to have led to an increase in publications by AWG members holding minority positions (such as support for diachronous beginnings).[219] Their persistence may likely have been the impetus for a second AWG vote, held in 2019, on precisely the same issues as the 2016 vote, and which returned the same decision as in 2016.[220] It remains to be seen whether those views will fade as the efforts and resources of the AWG are turned exclusively toward a mid-twentieth century GSSP designation. A history of such marginalised views is often hard to conduct, given that one consequence of a view becoming marginalised is precisely its absence from the historical record. In the case of the International Geological Congress, for example, the record focuses on those views that are upheld by the participants, not those that are decided against. It is in this context that Biagioli invokes the metaphor of evolution:

> Like species that die off not because they are directly eliminated by others but because they no longer fit the environment, paradigms can come to an end not because they are replaced or refuted by others but because they no longer fit the ecological niche – that is, the reward system of science and the socioinstitutional context in which they are located… Local contingencies (rather than the hidden hand of rationality) have a lot to do with it… The success of a representation is not necessarily achieved by having it chosen and adopted by all competing groups. Rather, it may simply be that a paradigm or set of practices appears to have been adopted by everybody simply because the groups that did not adopt it became professionally extinct. In short, intergroup justification of beliefs is not generally necessary. Somebody belonging to a given scientific group does not necessarily need to justify his or her beliefs to members of other groups.[221]

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219 See Ellis, E., et al. 2017; Ruddiman, W. F., 2018; Edgeworth, M., et al. 2019.

220 The results of this vote are listed on the AWG website. See http://quaternary.stratigraphy.org/working-groups/anthropocene (accessed 1/12/2020).

221 Biagioli, M. 1996: 198.

The AWG have had the best of all possible worlds, in some ways. The first paper that considered the Anthropocene as a chronostratigraphic unit, authored by members of the AWG before the Group was commissioned, indeed took up Crutzen's call to the geoscientific community to *respond* to a *crisis*. Crutzen's call hinted at a seductive polemicism that attributed a sense of urgency out of step with the careful deliberative procedures that characterise chronostratigraphic investigation. That urgency, as well as the sense of complexity that was thought to be endemic to the Anthropocene condition as characterised by Crutzen, justified the recruitment of a wide range of non-geological expertise to the effort of formalising an Anthropocene unit; hence the unusually diverse disciplinary affiliations that constitute the AWG membership. In the initial articulations of a potential Anthropocene unit, circumstances unfolding in the present, a geological deep past, and a moral imperative toward the future, were intricately interlaced. The Great Acceleration hypothesis illustrated the unfolding of a set of unique circumstances in the present; the chronostratigraphic perspective sought to situate those circumstances as a part of geological deep time; and the Promethean dimensions of Earth System science's initial articulation of the Anthropocene appeared to be searching for a way to intervene in what it perceived to be a desperate set of circumstances, to enact a trajectory of technoscientific 'planetary stewardship'.[222] In this way, the Anthropocene theme assumed a kind of novelty that attracted the attention of various disciplines, as well as popular outlets such as in journalism, the arts, popular science and economics.[223] This widespread interest provided the AWG with a platform unprecedented for

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[222] Crutzen & Stoermer conclude their account of the Anthropocene thus:

> To develop a world-wide accepted strategy leading to sustainability of ecosystems against human induced stresses will be one of the great future tasks of mankind, requiring intensive research efforts and wise application of the knowledge thus acquired in the noösphere, better known as knowledge or information society. An exciting, but also difficult and daunting task lies ahead of the global research and engineering community to guide mankind towards global, sustainable, environmental management.

See Crutzen, P. & Stoermer, E. 2002: 23. Such aspirations have not appeared in any AWG communications. Yet it is interesting to consider that the Anthropocene was first uttered both to refer to the 'stresses' induced by anthropogenic modification of the planet, but also as an opportunity for further anthropogenic modification to ease those same 'stresses'. The argument against fighting fire with fire characterises much of the more sceptical reflections on the formalisation effort of the AWG, and the notion of the Anthropocene more generally. See Haraway, D. 2016; Yusoff, K. 2018; Neyrat, F. 2016. *The Unconstructable Earth: An Ecology of Separation*. New York: Fordham University Press. Especially pp. 25-70.

[223] In 2013, The Haus der Kulturen der Welt together with the Max Planck Institute for the History of Science initiated the Anthropocene Curriculum, a cross-disciplinary platform intended to explore the various

a Working Group of any stratigraphic commission. This attention was, furthermore, the impetus for a premature interest in the efforts of the AWG by voting members of the ICS and IUGS; that is, well before any proposal had been submitted. These interventions can be attributed to the extra-geological interest in the Anthropocene, which lead those voting members to accuse the AWG of conflating issues of geological definition with 'politics', or 'pop culture'.[224]

Following the cautious scepticism of the executive of the ICS and IUGS, a majority of AWG members began distancing themselves from accounts of the Anthropocene that did not demonstrate an explicit commitment to the evaluative procedures associated with the Chart and Scale, especially in articles and publications authored by senior AWG members. The AWG therefore benefited from the early involvement of non-geologists in promoting their effort and receiving a platform unprecedented in chronostratigraphy. The AWG's formalisation effort benefited from pursuing the Anthropocene as a 'response' in the sense that Crutzen had initially proposed. Yet the AWG also benefited in the subsequent stage of the AWG, which, responding to the cautions of voting members of the ICS and IUGS, refashioned the formalisation effort as a legislative exercised assigned by the ICS and IUGS. The 2016 and 2019 votes indicate that the AWG was eager to distance itself from those aspects of their effort that were less favourable to the preferences of the ICS and IUGS executive, as they had been outlined in literature sceptical of extra-geological accounts of the Anthropocene theme. Accordingly, the efforts of the AWG were guided exclusively towards the designation of a GSSP with a mid-twentieth century markers as a lower boundary, which they have attempted to enforce on all their members by recourse to a majority vote: a technique that characterised the proceedings of the very first International Geological Congresses. We have reviewed the disappointment felt by AWG members who were consequently marginalised, and how a majority of AWG members more disciplinarily aligned with the ICS and IUGS (such as AWG

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consequences of the Anthropocene hypothesis. In 2011, *The Economist* ran a cover story considering the Anthropocene and its meaning. This was the first of several appearances the Anthropocene has since made in popular news outlets. See The geology of the planet: Welcome to the Anthropocene. 2011, May 26. *The Economist*: https://www.economist.com/leaders/2011/05/26/welcome-to-the-anthropocene (accessed 1/12/2020). The popular economist Jeffrey Sachs has focused on the Anthropocene in a series of lectures and publications. See Sachs, J. 2018. We Are All Climate Refugees Now. *Project Syndicate*: https://www.project-syndicate.org/commentary/climate-change-disaster-in-the-making-by-jeffrey-d-sachs-2018-08 (accessed 1/12/2020).

[224] See Autin, J. & Holbrook, W. 2012; Finney, S. & Edwards, L. 2016; Gibbard, P. & Walker, M. 2014.

president Jan Zalasiewicz and Secretary Colin Waters) then went so far as to dismiss the significance of 'anthropos' altogether.[225]

However, the AWG was only able to pursue this effort of formalisation because of the interest attracted during their previous stage of recruitment, or 'response'. In 2019, the AWG secured a one million euro grant from the Haus der Kulturen der Welt, intended to support the extraction and analysis of cores, to designate a GSSP. This was something of a lifeline for the AWG, who up until then had been unsuccessful in securing any funding for their research whatsoever.[226] On their website, the HKW describe the Anthropocene as 'a concept of contested terrain and therefore any approach to it must be adaptive, exploratory, and useful for everyday concerns in this new age.' They define their relation to the Anthropocene, and the efforts of the AWG as bringing together:

> heterogeneous knowledge practices, inviting academics, artists, and activists from around the world to co-develop curricular experiments that collectively respond to this crisis of the customary. It does this by producing experimental co-learning situations and research possibilities for transdisciplinary collaboration that are capable of explicitly tackling the epistemic and geo-social dimensions of knowledge that are at stake in this new epoch.[227]

We will review the relationship of the HKW to the AWG extensively later in this thesis, but for now, suffice to say that although the AWG increasingly seek to distance themselves from non-geological understandings of the Anthropocene, moving towards an exclusively chronostratigraphic definition of an Anthropocene lower boundary, they nevertheless retain the benefits of the earlier period of engagement with non-geological concerns.

The AWG, therefore, have been very good at negotiating the various interests in the Anthropocene theme in a manner that has ultimately worked to their advantage. The

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[225] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 326.

[226] The AWG have unsuccessfully applied for funding to the Natural Environment Research Council (NERC), the leading public funder of natural science research in the UK, and were denied support from their host university (Leicester University) in previous funding applications. Zalasiewicz, J. 2017, February 2. Personal communication. See Appendix to chapter five.

[227] See the website of the Anthropocene Curriculum of the Haus der Kulturen der Welt, at https://www.anthropocene-curriculum.org/about (accessed 10/12/2020).

Anthropocene has yet to be formalised, but it is safe to say that no other chronostratigraphic unit has attracted the kind of attention that the Anthropocene has. Meanwhile, through the two rounds of voting in 2016 and 2019, the AWG have confirmed a position concerning the direction of their formalisation effort that demonstrates a willingness to conform to the preferences of the ICS and IUGS. While this has often been a problem for the AWG, attracting criticism from the executive members of the ICS and IUGS, who ultimately decide whether an Anthropocene unit is formalised, they have been successful in recruiting expertise and financial support such that they are now able to carry out their own, independent research, as is required of any formal proposal.

3.6 Conclusion

In this chapter I have attempted to describe the emergence of geology as a formal discipline through the articulation of a uniform set of practices, including map making, nomenclature, and techniques of hierarchical classification. As we have seen (and shall explore further in the subsequent chapter with the specific case of the GSSP), this is an illicit process, to the extent that it attempts to simplify the complexity of regional specificities into an overarching, universal uniformity. The effort to consolidate these regional practices into a single discipline, reveals the reverse, namely: the cohabitation of diversely interested groups within the disciplinary space referred to as Geology. The International Geological Congress begins (and continues) as an effort to render these differences comparable, so that they can be evaluated (against each other), thereby resolving controversy and disagreement. Invoking "discipline" flattens these differences when the uncomfortable tension between them is what is generative. In other words, how might the circumstances of the Congress and the evaluative framework in which the Anthropocene is implicated, be understood without assuming the unity of geology, and indeed without assuming the unity of science?

The effort to resolve controversy can lead to its own (further) disagreements. Biagioli's account of *contingentism* demonstrates that to assume unity is to assume a teleological progression. It implicates the observer in one side of a distinction that they have imposed on their environment. The assumption of unity is a blindspot. The account provided in this chapter seeks to demonstrate that devices such as the Chart and Scale, or issues of nomenclature, proceed in full recognition of incompatibility of the different communities that are party to the articulation of a theme, the definition of a concept, or the designation of a *fact*. Beyond differences in nomenclature specific to each region, minutes of the Berlin meeting in 1885 differentiate between a "nationalist" contingent of geological societies who sought to preserve regional differences, and those that are in favour of unification. Where the two groups disagreed, the minutes indicate that the council would intervene to negotiate a deal.[228] Such deals, like the council members, favoured the internationalist project of unification. In other words, some groups of geologists were better able to satisfy internationalism, that "ecological niche" in which the Congress took place.[229] This does not mean that their arguments or methods were any "better." We cannot know how things may have turned out otherwise. It is irrelevant to consider unrealised trajectories. But in considering the contingency of realised trajectories, our attention is drawn to the mechanisms and procedures that frame the subsequent unfolding of geological observations, including the ongoing effort to define an Anthropocene unit.[230]

The AWG's formalisation effort entails adherence to a historically situated evaluative procedure. The events of the Second International Geological Congress indicates that the Congress refrains from any conclusive decisions regarding the object of deliberation, namely: the rocks themselves. Rather, the purpose of the meeting is to devise an evaluative

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[228] Anonymous. 1882. Séance du 27 Septembre. In Anonymous (Ed.) *Congres Geologique International: Compte Rendu de la 2me Session, Bologne, 1881.* Pg. 70-90.

[229] Efforts to describe this ecological niche, of "internationalism" as a general phenomenon of the late nineteenth century, not specific to geology, can be found in Krajewski, M. 2014. *World Projects: Global Information Before World War I*. Minneapolis: University of Minnesota Press. Krajewski is interested in the "world as prefix" as mediated by "media *a priori*". For example, the advent of telegraph communications and rail transit to a much wider Euro-American public in the late nineteenth century means that the world can be apprehended in a new way to those who can make use of such technologies. Telecommunications and transit technologies condense the space and time of the experience of the "world". Krajewski argues that this technologically mediated apprehension of the "world picture" (Krajewski draws generously on the writings of Heidegger) becomes something of a generalised tendency or pursuit in-itself towards the end of the nineteenth century. His book explores, for example, attempts to create a universal currency, a universal language (Esperanto), and universal standards for paper sizes (A4) and classification systems (such as the Dewey decimal system). "World" in this sense becomes apprehensible through technological media, as various instances of standardization and unity. Not all of these attempts are successful, and one may surmise accordingly that the object understood as "World" in each instance is in fact the processual exercise of standardization strategies. Ultimately Krajewski's argument may be an attempt to engage a comparison of the work of Friedrich Kittler and Niklas Luhmann vis-à-vis the ontological status of media, or communication. See Winthrop-Young, G. 2000. Silicon Sociology, or, Two Kings on Hegel's Throne? Kittler, Luhmann, and the Posthuman Merger of German Media Theory. *Yale Journal of Criticism* 13(2): 391-420; Geoghegan, B. 2013. After Kittler: On the Cultural Techniques of Recent German Media Theory. *Theory, Culture & Society* 30(6): 66-82.

[230] Biagioli explains that 'today's scientific knowledge cannot be said to be the best possible in any general sense. It is good only in the (important) sense that it made it to the present.' Biagioli, M. 1996. 201.

framework wherein differences can be rendered comparable. The unity of stratigraphy cannot be understood in the absence of this initial disunity. Efforts toward an evaluative framework, according to which geology can be characterised as a discipline, must encounter the simultaneity of disunity and unity as mutually reinforcing conditions of possibility. Disunity is therefore constitutive of geology as a unified discipline. Yet this would necessitate that unity is somehow constitutive of a general disunity in the practice of stratigraphy as well. This is a premise that I shall develop in the subsequent chapter, in regards to the GSSP. The propensity of attempts to secure unity to result in further disunity is already apparent in the proceedings of the Congress and the formalization effort of the AWG likewise. Disagreement occurs at every step of the way in the Congress, from the vocabulary used to the preferred colour for a section on geological maps, an incommensurability that is echoed in the AWG's ongoing effort to designate a lower boundary for an Anthropocene unit.

The effort to establish a single, authoritative evaluative procedure that geologists voluntarily submit to exposes disagreement between regional practices of geology, while at the same time aspiring to consensus. The effort to formalise and unify regional practices raises awareness concerning the extent of differences between the practices of, say, the Geological Society of London and that of Moscow, as well as the imperative of their common interests in a unified discipline. Likewise, the extent of disagreement between members of the AWG appears to have become more apparent as the task of formalization, and its adherence to the unifying procedures of evaluation and unit designation that it entails, is further realized. The unity of geology as a discipline would therefore appear to be constituted by continual changes that seek to accommodate the activity of the diverse interests that participate in, and comprise the scope of, its evaluative framework.

Behind closed doors, the AWG have considered whether it may be worth waiting till the present executive members of the ICS and IUGS retire, at which point the positions may be filled by stratigraphers more favourable to the AWG's formalization effort, and the Anthropocene more generally. This would indicate that the power according to which the present executive members of the IUGS could refuse the formalization of the Anthropocene as a geologic unit is itself contingent, an ecological niche. When new executive officers of the ICS and IUGS are eventually appointed, they may be more favourable to the AWG's efforts. Yet what is far less likely to change in this time is the centrality of devices such as the Chart and Scale, fossils, or the GSSP. These devices provide a means of representation and classification that orient the research activity of geologists. That is not to say that the GSSP *determines* certain outcomes. The effort of the AWG would entail quite the contrary, that the activity of constructing an Anthropocene GSSP can be radically innovative. The requirement of a GSSP for the formalisation of an Anthropocene unit lends itself to a great variety of research activity, not all of which is compatible, even if the GSSP requirement simultaneously constrains the work of stratigraphers who must take the evaluative framework on whose behalf the device speaks, into account in their own work. In other words, creative work often begins with the setting of certain limiting parameters.

This is why it is worthwhile to consider the events of the Congress and draw a parallel with the ongoing effort of the AWG. The evaluative framework established at the Congress does not determine the effort of the AWG. But the outcome of the early meetings of the Congress are inherited by the AWG as they develop their effort to formalise the Anthropocene as a geological unit. The effort to formalize an Anthropocene unit is also an instance of recounting the narrative of stratigraphic unity and disunity anew. As we shall see in the next chapter, it is possible to trace certain precursors to the effort to define a GSSP for an Anthropocene unit, and the creative thinking that effort requires in respect of evaluative procedures and requirements, as continuous with earlier debates within stratigraphy. Some of these debates, as we shall explore, will subsequently be seen to have been validated if the Anthropocene is formalized, even though they were dismissed at the time. Furthermore, the effort to formalize the Anthropocene is an attempt to retell the narrative of Earth history, which the Chart and Scale, the GSSP, fossils, and other stratigraphic inscription devices attempt to tell. So these devices are not entirely determinative, but are creative as well. In other words, incongruence and difference is generative of novelty. In the next chapter, I shall elaborate this claim through a genealogical account of the GSSP. In this chapter I simply wish to recount a brief genealogy of the evaluative framework within which unity is practiced (not in a way that overcomes disunity, but which even encourages it) in the interests of demonstrating some key factors according to which the AWG's formalization effort unfolds.

4. **Biography of the GSSP**

The formalisation effort of the AWG refers primarily to the Geologic Time Scale. Their objective is to have the Anthropocene included in the Scale as a formal unit. Through internal votes they have decided that the Anthropocene amounts to a new unit at the level of Epoch/Stage.[231] The Anthropocene would therefore occur within the Quaternary System/Period, but would succeed the Holocene Epoch/Stage. If inclusion in the Scale is the objective of the AWG, the GSSP is informative of the process by which the AWG attempt formalization of the Anthropocene. It shapes the horizon of possibilities within which the AWG operate, by setting out in advance the parameters of their research. The history of the GSSP is far more recent than the Chart or Scale, yet it too precipitates from early efforts to establish an evaluative framework. In this chapter I wish to recount the history of the GSSP, considering how it at once facilitates greater uniformity within stratigraphic observations today, while simultaneously encouraging further controversy. This tension of uniformity and controversy, or unity and disunity, I will argue, anticipates aspects of the AWG's formalization effort today.

In developing this argument, I wish to capture the stakes that the Anthropocene poses *for stratigraphy*. I develop this argument as a juxtaposition to the predominantly social scientific, humanistic, or otherwise generally non-stratigraphic senses in which the Anthropocene theme is engaged. Of course, as already discussed, the AWG demonstrate a blindspot of their own, to the extent that blindspots are an inevitable characteristic of all observation (including this one, as concerns my effort to speak *for stratigraphy*). To an extent, this has already been touched on, or at least implied, in the previous chapter's description of the voting results. Suffice to say, however, that literature by the AWG has often demonstrated an insufficient grasp of the significance of the kinds of arguments rehearsed in literature that critiques the Anthropocene on the grounds of blanketing differential culpability under the singular umbrella of 'Anthropos'.[232] While I keep these arguments in mind as I develop my thesis, I am here interested to explore the set of problems that the effort to define an Anthropocene unit poses for stratigraphers. Doing so indicates that the AWG's effort emerges

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[231] For an overview of the 2016 internal vote, see Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.
[232] For a review of the various ways in which the Anthropocene has been framed, see Lorimer, J. 2016; Quenet, G. 2017.The Anthropocene and the Time of Historians. *Annales HSS (English Edition)* 72(2): 165-197

from incumbent epistemic and methodological issues in stratigraphy that have never been fully resolved, an aspect that non-stratigraphic accounts of the Anthropocene theme often overlook. The GSSP, as we shall see, is central to situating the AWG's formalisation effort in this manner.

As has already been noted, the GSSP designates both the 'lower boundary' of a geological unit, or the point at which the material characteristics of rock change substantially enough to constitute a new "species" of rock. Yet the GSSP simultaneously designates the 'beginning' of that unit as it appears on the Chart and Scale. It is possible to date the material section in which the GSSP appears, either through counting down layers of rock from the surface (which are typically deposited at regular intervals) or through absolute dating techniques such as radiometric dating. Consequently, two corresponding hierarchies exist alongside each other on the Chart and Scale, such that each unit is defined temporally and spatially. This distinction is known as the 'dual hierarchy', wherein the temporal definition of strata is known as *geochronology*, while spatial classification belongs to the domain of *chronostratigraphy*. Confusingly, both terms appear to be composed of the same composite terms: time (chrono; chronology) and space (geo; stratigraphy). As we shall review, this is not a coincidence that has escaped the critical gaze of practicing geologists. In fact, I will argue that debate concerning the purpose of a dual hierarchy anticipates many of the themes that arise during the early stages of the AWG's formalization effort. Implicit in this argument is an understanding of the GSSP as a framing device for the AWG's formalization effort, because the GSSP has been realised as a device that marks both the temporal and material beginning of a unit. It satisfies both sides of the dual hierarchy, and to that extent serves as an enforcement of the arguments that constitute the dual hierarchy and its perseverance in geological classification. The GSSP therefore informs what a unit formalisation effort must include, what it ought not to include, and presents an obstacle that must be taken into consideration if the AWG wish to realize the Anthropocene as a formal geological unit.

This chapter seeks to reflect on how practices associated with the GSSP become incumbent, and in doing so, inform the commitments of subsequent research activity within stratigraphy. As the GSSP becomes an incumbent stratigraphic practice, it informs the kinds of disputes that emerge consequently. The GSSP too, is informed by the incumbency of other practices, namely the differentiation of geochronology and chronostratigraphy, beginning with the second meeting of the International Geological Congress of 1881, where the dual hierarchy was formalised.[233] This is to say that the GSSP is both the final product of the AWG's formalization process as well as its driving force. Attainment of the GSSP entails abidance to a normative order that informs the range of possibilities according to which it can be formalized. A formal Anthropocene unit cannot be conceived independently from the media and disciplinary conventions through which it is obtained.[234] Formalization procedures in stratigraphy are both iterative and recursive. A theme emerges, is either dropped or adopted, and subsequently reappears in the subsequent concerns it inspires. To this extent, the emergence of an effort to define an Anthropocene unit is no surprise at all. Although the Anthropocene thematic was not announced by a geologist, the manner in which it was taken up by stratigraphers is continuous with the epistemic preoccupations of stratigraphers throughout the twentieth century: to determine with ever-greater precision *what* the GSSP refers to. If the GSSP is an attempt to clarify the relationship between spatial and temporal categories in stratigraphy, (i.e. the purpose of the dual hierarchy), then the AWG's formalisation effort seeks to test the limits of this relationship in articulating a geological description of the past seventy years.

To say that stratigraphy is iterative and recursive recalls the premise of *contingentism*, explored in the last chapter. Even though the term Anthropocene did not exist until 2000, in exploring the idea, stratigraphers were aware of certain precedents for the premise of

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[233] Although, as reviewed in the previous chapter, the specific terminology of which the dual hierarchy is comprised was the subject of extensive deliberation, the same cannot be said for the dual hierarchy. The minutes from the Bologna Congress, as well as the sub-committee reports, indicate that the dual hierarchy was a principle already used by the majority, if not all, geological societies present. It was readily accepted by the various geological societies who attended the Bologna Congress, and therefore the subsequent ones, that a dual hierarchy for referring to time and space respectively, was very useful. What remained to be debated was nomenclature. See for example a conclusion of the sub-committee report from the Bologna congress that states:

> The Sub-Commission considers it useful to retain the division for these geological witnesses in the evaluation of time and space. It accepts for the subdivisions of time the following terms: period, epoch, and century to express any duration shorter than an epoch. The Sub-Commission accepts to express the subdivisions of space, and thereby stratigraphy, with the following terms: group, system, division, stage.

Although not all these terms were retained by the end of the Congress, the basic premise of a dual hierarchy was. See Anonymous. 1882: 529.

[234] This position borrows from a familiar set of arguments in the history of science and media studies, which posit that, as one commentator recently put it, 'the objects at stake cannot be conceived and thought of independently from the means and the media with and through which they are being shaped.' See Rheinberger, H-J. 2018. Epistemics and aesthetics of experimentation: Towards a hybrid heuristics? In Sormani, P., Carbone, G. & Gisler, P. (eds). *Practicing Art/Science: Experiments in an Emerging Field*. London: Routledge.

anthropogenically modified planet. In an earlier chapter I reviewed how, as early as 1788, Hutton posited a theory of the Earth as a superorganism, adapting insights derived from his participation in The Circulation Society, which examined human physiology and blood circulation, by thinking of reciprocity of atmospheric gases such as oxygen and plant, or animal, life.[235] Further antecedents to the Anthropocene theme have been explored by AWG members themselves.[236] These include the 'anthropozoic era' coined in the late nineteenth century by the Italian geologist Antonio Stoppani[237]. The list the publication of texts, around the same time, with revealing titles such as *The Earth as Modified by Human Action*[238], and *Man as Geological Agent*[239]. They also include the 'noösphere', referring to the influence of human activity on planetary processes, as proposed by the Austrian geologist Eduard Suess in 1875[240], and extrapolated by the Russian polymath Vladimir Vernadsky, together with Henri Bergson in the early twentieth century.[241]

The Anthropocene theme is not simply a problematic to be solved within the social sciences and humanities, but refers to methodological and conceptual debates within chronostratigraphy that remain unresolved. The persistence of such debates anticipates the advent of the Anthropocene as a problematic within chronostratigraphy, because the AWG's formalisation effort revives certain controversies, encouraging more detailed definition of the relation between rock material and temporal narratives of the Earth. In providing a "biography of the GSSP," The GSSP method harbours unresolved methodological and epistemic issues that indicate the simultaneity and persistence of very different approaches

[235] For an outline of Hutton's theory of superorganism, and its striking contemporary relevance, see Lovelock, J. 1989. Geophysiology, the science of Gaia. *Review of Geophysics* 17: 215-222. Hutton's theory of Earth as superorganism anticipates almost exactly Lovelock's theory of Gaia, which itself has provided a framework with which some prominent thinkers have approached the Anthropocene. See Latour, B. 2017. *Facing Gaia*. London: Polity.

[236] See Steffen, W., Grinevald, J., Crutzen, P., et al. 2011. The Anthropocene: conceptual and historical perspectives. *Phil. Trans. Roy. Soc. A.* 369: 842-867.

[237] Stoppani, A. 1873. *Corso di geologia. Vol. II.* Milan, Italy.

[238] Marsh, G.P. 1885. *The Earth as Modified by Human Action: A Last Revision of Man and Nature*. New York: Charles Scribner's Sons.

[239] Sherlock, R. & Woodward, A. 1922. *Man as Geological Agent: An account of his action on inanimate natute.* London: H., F. & G. Witherby.

[240] Suess, E. 1875. *Die Entstehung der Alpen*. Wien: W. Braunmuller.

[241] The account of these variations, which are little more than a list in the manner I provided above, appears in Steffen, W., Grinevald, J., Crutzen, P., et al. 2011; See also Vernadsky, V. 1998 [1929]. Trans. Langmuir, D.B. *The Biosphere: Complete annotated edition*. New York: Copernicus Press; Guillaume, B. 2014. Vernadsky's philosophical legacy: A persepective from the Anthropocene. *The Anthropocene Review* 1(2): https://doi.org/10.1177/2053019614530874

to the practice of stratigraphy. The AWG's formalisation effort rehearses those differences and controversies that arise between them. The effort responds to methodological and conceptual problems within stratigraphy itself; in particular, the requirement of a GSSP definition for any proposal to add a new unit to the Chart and Scale.

4.1 What's wrong with the GSSP and why does it matter?

The Global Stratotype Section and Point (GSSP) is a point identified in a stratal section that designates the lower boundary of a geologic unit. Although that point refers to one location, the GSSP is in effect a reference point. That point is "correlated by" a suite of biostratigraphic, chemostratigraphic, magnetostratigraphic, and radioisotopic signals in other locations. These are known as 'secondary signals'. The primary signal, which is typically the point designated by the GSSP, is usually, but not always, a biostratigraphic datum, that is, the lowest occurrence of a fossil in a stratal section. Due to geological unconformities, wherein stratal sections are physically adjusted by geologic events (for example because of tectonic activity, or the force of a volcanic eruption, or the compression effect of ice, etc), the lowest occurrence of a fossil may not be the earliest instance of its appearance (what stratigraphers call 'first appearance datum'). Yet as we shall review, part of what makes the GSSP so interesting is that despite its reputation as having introduced "one single set of standard world-wide stages"[242], it is acknowledged as a somewhat imperfect measure.[243] Hollis Hedberg, who is generally recognised by the stratigraphic community to be, for better or worse, the architect of the GSSP[244], acknowledges that "palaeontological evidence of time in rocks is always imperfect," and that as far as accurate geological divisions are concerned, "it

[242] Following Hedberg, H. 1968. Some views on chronostratigraphic classification. *Geological Magazine* 105: 192-199. Pg. 193

[243] Even the ICS *Statutes and Guidelines*, which formalised the GSSP concept in stratigraphic procedure, admitted as much. 'In a world which is not ideal it is most unlikely that all selected stratotype points can meet all the ideal requirements and stratigraphy must be a practical subject and responsive to the needs of working geologists.' Cowie, J., et al. 1986. *Guidelines and Statutes of the International Commission on Stratigraphy (ICS)*. Frankfurt: Cour. Forsch. Inst. Senckenberg.

[244] This is acknowledged in the *Guidelines and Statutes* of the ICS, where the GSSP was formalised. See Cowie, J., Ziegler, W., Boucot, A., et al. 1987. *Guidelines and Statutes of the International Commission on Stratigraphy (ICS)*. Frankfurt: IUGS. See also Walsh, 2005. The role of stratotypes in stratigraphy. Part 2. The debate between Kleinpell and Hedberg, and a proposal for the codification of biochronologic units. *Earth-Science Reviews* 70: 47-73.

is doubtful that their division points are marked by 'natural breaks' in the fossil record."[245] Hedberg was of the opinion that universality is a more important objective than total accuracy, the latter being an unrealistic abstraction in any case, given that the inability of the stratigarpher to directly observe their object of investigation makes the geologic record always and inevitably incomplete.

Controversially, the GSSP has often been referred to as a 'necessarily arbitrary marker.'[246] In his landmark textbook on stratigraphy, included in many first-year university stratigraphy courses in the UK to this day, Derek Ager explains: "it does not matter where the golden spike is hammered… so long as we can make an arbitrary decision, stop arguing about words and get on with the much more difficult (but much more rewarding) task of correlation."[247] Similarly, in his historical account of the GSSP, former ICS chairman Stephen Walsh describes GSSP-defined units as "classificatory pigeonholes, analogous to the arbitrarily defined grain-size pigeonholes."[248] This approach was adopted in the 2004 Geologic Time Scale, wherein the Precambrian was divided into equal two-hundred-million year intervals.[249] The base of each unit was defined by a Global Standard Stratigraphic Age, or GSSA.[250] The support for arbitrary GSSPs, and the arbitrary placements of GSSAs in the Precambrian, led some stratigraphers to the conclusion that the two methods were interchangeable. Chronostratigraphic units refer to stratified rock successions that are assigned to geologic times. Geochronologic units refer to units of geologic time that have a

[245] Hedberg, H. 1948. Time-stratigraphic classification of sedimentary rocks. *Bulletin of the Geological Society of America* 59: 447-462. Pg. 447.

[246] By 'arbitrary', it is not meant that a decision is made at random, but rather that it is contingent on the discrestion of a judge, tribunal, or in this case, a three-tiered committee. See Walsh, S. 2004. Solutions in chronostratigraphy: the Paleocene/Eocene boundary debate, and Aubry vs. Hedberg on chronostratigraphic principles. *Earth-Science Reviews* 64: 119-155 especially pp.145-147 where the notion of 'arbitrary' is discussed in the context of stratigraphic classification. This is an admission made by Hedberg, as well as more recent stratigraphers. See. Hedberg, H. 1968; Remane, J. 2003. Chronostratigraphic correlations: their importance for the definition of geochronologic units. *Palaeogeography, Palaeoclimatology, Palaeoecology* 196: 7-18 – Remane is the author of the updated edition of the *Statutes and Guidelines* of the ICS. He shares the acknowledgement of arbitrariness of the GSSP with Stephen Walsh, former chair of the ICS, who upholds an acknowledgement of the arbitrariness of the GSSP in his history of the GSSP, see Walsh, S., Gradstein, F. & Ogg, J. 2004. History, philosophy, and application of the Global Stratotype Section and Point (GSSP). *Lethaia* 37: 201-218. For an excellent overview of arbitrary nature of the GSSP, see Lucas, S. 2018. The GSSP Method of Chronostratigraphy: A Critical Review. *Frontiers in Earth Science* 6. https://doi.org/10.3389/feart.2018.00191 (accessed 20/12/2020).

[247] Ager, D. 1981. *The Nature of the Stratigraphic Record*. London: Wiley. Pg. 79.

[248] Walsh, S., Gradstein, F. & Ogg, J. 2004: 205.

[249] See Gradstein, F., Ogg, J., Smith, A. (eds). 2004. Especially pp. 129-146.

[250] Robb, L., Knoll, A., Plumb, K., et al. 2004. The Precambrian: Archean and Proterozoic eons. In Gradstein, F., Ogg, J. & Smith, A. (eds) *A Geologic Time Scale 2004* Cambridge: Cambridge University Press: 129-140.

parallel and exactly corresponding stratigraphy.[251] The Holocene, for example, is both a chronostratigraphic Series and a geochronologic Epoch.[252] All geologic units have dual classification in this way. The dual hierarchies are exactly aligned in the Geologic Time Scale. The purpose of this dual hierarchy is to allow geologists to distinguish between strata and time, i.e. to indicate whether they are talking about a property of strata or an event that occurred during a period of time. Yet some stratigraphers have questioned the necessity of this method.

In 2004, Jan Zalasiewicz led an article titled 'Simplifying the stratigraphy of time' which advocated 'ending the distinction between the dual stratigraphic terminology of time-rock units (of chronostratigraphy) and geologic time units (of geochronology).'[253] Their argument is that the GSSP had rendered the dual hierarchy redundant. Invoking Hedberg's popular analogy of the stratigraphic record as like sand pouring through an hourglass, they argue that the GSSP renders the stratigraphic record "not so much the sand pouring through an hourglass, as the capture of successive instances of time as sand grains hit the base of the hourglass."[254] Admittedly, the difference between these two analogies is negligible, except to

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[251] Zalasiewicz, J., Smith, A., Brenchley, P., et al. 2004. Simplifying the stratigraphy of time. *Geology* 32(1): 1-4. Pg.1.

[252] See Cohen, K., Finney, S., Gibbard, P., et al. 2013 (updated).

[253] Zalasiewicz, J., et al. 2004: 1.

[254] ibid: 3. Hedberg's hourglass analogy appears in his 1976 *International Stratigraphic Guide*, wherein he states:

> Each interval of stratified rocks represents a certain interval of geologic time. Accordingly, each chronostratigraphic unit (interval of rock strata) has a corresponding geochronologic unit (interval of geologic time)… Because geochronologic units are units of geologic time – an intangible property – while stratigraphic units are tangible material units composed of rock strata, geochronologic units are not in themselves stratigraphic units. To illustrate the difference, a chronostratigraphic unit can be likened to the sand that flows through an hourglass during a certain interval of time, while the corresponding geochronologic unit can be compared to the interval of time during which the sand flows. It may be said that the duration of the sand flow measures a certain interval of time – an hour, for instance – but the sand itself cannot be said to be an hour.

Hedberg, H. (Ed). 1976. *International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology, and Procedure*. New York: John Wiley & Sons. Pg. 11. In their proposal to simplify the dual hierarchy, Zalasiewicz et al invoke Hedberg's analogy as a canonical text, suggesting a slight alteration: 'Hedberg's (1976) ingenious hourglass analogy is thus not altogether apt, for the stratigraphic record reflects not so much the sand pouring through an hourglass, as the capture of successive instants of time as sand grains hit the base of the hourglass.' Zalasiewicz, J., et al. 2004: 3. It is not clear what the difference is between these two accounts of the sand and the hourglass, however as we shall see, the invocation of Hedberg in the context of acknowledging the predominance of the GSSP indicates a disciplinary and procedural affiliation that is not pre-given. Invoking Hedberg may be more a way to signal where the authors sit in terms of pre-existing debates than to serve any purpose as far as arguing for a consolidated hierarchy is concerned.

emphasise that any measurement of stratigraphic space is always also a measure of stratigraphic time. Because the GSSP defines a unit by designating a point in a stratal section that serves as the reference point for the rest of the unit, there is concern that this approach, known as lower-boundary, overlooks the stratigraphic nuances throughout the rest of the unit (i.e. the strata between the lower boundary and the GSSP of the next unit, which in indicating the lower boundary of *that* unit also indicates the upper boundary of the preceding unit). Yet geochronologic units designate the entirety of a unit, not just its lower boundary, but only in temporal terms; not in material, chronostratigraphic terms. Zalasiewicz's proposal to consolidate the dual hierarchy could therefore be understood as an attempt to resolve the shortcomings of chronostratigraphic and geochronologic metrics by reducing them to a single measure.

As I shall review in this chapter, the premise that the GSSP is essentially reducible to a temporal designation is disputed by some prominent stratigraphers. Inevitably, those same stratigraphers, however, have their own problems with the GSSP, and the classification of geologic units more generally. When reviewed collectively, the diversity of positions concerning the GSSP point to a common grievance concerning the problem of measurement, and the commitments, or directions, established by formal nomenclature. Specifically, the concern regards the ability of existing techniques of measurement to accurately convey the stratigraphic record. The flip side of these grievances is that the stratigraphic record is nothing other than the techniques of measurement that comprise it. Consequently, the events of the Congress as well as the debates surrounding the GSSP indicate the extent to which debates about geology are actually debates about practices of measurement and evaluation. This is an important point to emphasise because for many geologists, the effort to formalise an Anthropocene unit indicates a further misunderstanding of chronostratigraphic methodology. Zalasiewicz insists that the proposal to consolidate the dual hierarchy of chronostratigraphy and geochronology is an entirely separate issue from the AWG's formalisation effort.[255] However, there are clear overlaps, insofar as a historical period, encapsulated in the historical account of The Great Acceleration, is formally acknowledged by the AWG as the primary guide for a lower boundary of an Anthropocene unit. The slippage between a historical event and a material section has been the cause of much spilled ink in

[255] Personal communication, 2016.

the debates surrounding the AWG's formalisation effort, with geologists arguing that in designating a historical event first, and *then* looking for a material record, the AWG are conducting stratigraphy the wrong way round.[256] However, the extent to which the GSSP remains somewhat unresolved as the standard classificatory mechanism of stratigraphy has allowed the AWG to maintain the adequacy of the Anthropocene as a stratigraphic unit, arguing that those arguments against the formalisation of an Anthropocene unit are in fact misunderstandings concerning disciplinary procedure. To this extent, we might say that from the perspective of stratigraphers, the AWG's formalisation effort is primarily a methodological dispute. To understand this argument, it is worth reviewing some episodes in the history of the GSSP.

4.1.1 Where does the GSSP come from?

The GSSP appears for the first time in 1986, in the *Guidelines and Statutes of the International Commission on Stratigraphy*. The *Guidelines* were a culmination of the effort began at the International Geological Congress, namely: to establish a set of standards in stratigraphy according to which theoretical trajectories and arguments could be evaluated, if not defined. Indeed, the International Commission attributes its origins to the International Geological Congress. The ICS was founded at the eleventh meeting of the Congress, in Stockholm, 1910, as the Commission on a Lexicon of Stratigraphy. It assumed its present name at the 1952 Congress, as a consolidation of the Commission on a Lexicon of Stratigraphy and the Subcommission on Stratigraphic Nomenclature.[257] The ICS was adopted as a Subcommission

[256]This argument is made most recently in Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019.

[257] On the significance of this event, see Hedberg, H. 1954. Procedure and terminology in stratigraphic classification. *19th International Geological Congress, Algiers, section 13, fascicule vol. 13*: 205-233. On page 230, Hedberg explains:

> In view of the complex nature of stratigraphic nomenclature, the existing differences and inconsistencies in usage, and the resulting confusion in the international exchange of geological observations and ideas, it is here recommended that the 19th International Geological Congress take steps toward the creation of an International Commission to establish principles and harmonize practice in stratigraphic nomenclature and terminology.

On the basis of this suggestion, the IUGS set up the International Subcommission on Stratigraphic Terminology in 1952 (which would later become the International Commission on Stratigraphy in 1965). Hedberg presided as president until 1977. See Walsh, S., Gradstein, F. & Ogg, J. 2004.

of the International Union of Geological Sciences in 1965[258], and as such was assigned the task of instructing the formal parameters according to which stratigraphic procedure is undertaken. The ICS, like the International Geological Congress, provides a forum for the establishment of stratigraphic standards. They have sought to formalise nomenclature through publications that drew on earlier efforts at formalisation and consolidated them into a single set of *Guidelines and Statutes*, as the title suggests.[259]

Key among these efforts is a series of earlier texts that defined the 'boundary stratotype'.[260] The boundary stratotype, along with the Stage, were posited as the essential unit of the International Chronostratigraphic Chart, and therefore the Geologic Time Scale. The boundary stratotype is the section of strata that defines where a geologic unit begins in the rock record, thereby acting as a border between the upper part of the previous unit, and the beginning of the subsequent one. The Stage is the smallest unit into which stratal sections can be divided, which occurs between its own boundary stratotype and the boundary stratotype of the subsequent Stage. The boundary stratotype of a Stage is the most important, because it also defines the lower boundary of large, divisible units, up to the Phanrozoic Eonothem/Eon, and even the Precambrian Supereon, which begins with the formation of the Earth.[261] The 'boundary stratotype', in other words, is an effort to derive a *type* in stratigraphy, in an almost taxonomic sense. We have seen how the early Congresses had established formal nomenclature, such as Stage, Formation, Period, etc. The purpose of a *stratotype*, however, was to formalise a means of defining units by reference to a single stratal section. The chosen section would function as the reference, indicating the key characteristics of the unit to which it belonged. It was therefore not simply a way of categorizing geologic time and space (as is the Stage, Period, etc.), but of defining those units stratigraphically.

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[258] The IUGS too emerges from the regular meetings of the Congress. The Union was founded in 1962, as an attempt to further coordinate geological research. It was intended as 'a mechanism… to take action on global geological problems between the International Geological Congresses, traditionally held every four years.' See Harrison, J. 1978. The Roots of IUGS. *Episodes* 1(1): 20-23.

[259] See Cowie, J., et al. 1986. *Guidelines and Statutes of the International Commission on Stratigraphy*. Frankfurt: Commission on Stratigraphy of the International Union of Geological Sciences; and the updated version: Remane, J., et al. 1996. Revised Guidelines for the Establishment of Global Chronostratigraphic Standards by the International Commission on Stratigraphy. *Episodes* 19(3): 77-81.

[260] The documents of Cowie et al and Hedberg, along with others that shall be reviewed shortly, being key examples of such literature.

[261] See Cohen, K., Finney, S., Gibbard, P., et al. 2013 (updated).

In 1950, during the eighteenth meeting of the International Geological Congress, the British geologist William Bernard Robinson King made what is perhaps the earliest proposal for establishing a practice of *types* in stratigraphy, or *stratotypes*: 'In stratigraphy as in palaeontology it is advisable to have a "type locality" as it is to have a "type specimen." It gives a definite basis to which argument of a theoretical nature can be related.'[262] King's proposal was met with resistance, with one geologist explaining:

> The practice of establishing a type section for a rock-stratigraphic unit has merit, for it allows the original observations to be repeated and verified or elaborated. But the type section is only a sample of the unit as defined by the original describer, and at best it is "typical" only in terms of the exposures seen by him. Subsequent investigations may dictate a modified definition of the unit, a practice that has been by no means uncommon, but there has been persistent reluctance to change limits that were clearly set originally at a type section.[263]

Yet in 1952, only two years later, at the 19th International Geological Congress, The International Commission on Stratigraphy was established. It only adopted this name in 1965. When it was founded in 1952, it was named the International Subcommission on Stratigraphic Terminology. It was then, and remains today, a constituent body of the IUGS, who cast the final vote on the ratification of new units, or any adjustment to the International Chronostratigraphic Chart, on which the Geologic Time Scale is based.[264] They will cast the final vote as to whether the Anthropocene is formalised as a geologic unit. By the time of the 21st International Geological Congress, the ICS were publishing circulars asserting that 'the basis for definition of a series should be a specifically designated and delimited type or

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[262] King, W.B.R. 1950. The Pliocene-Pleistocene boundary: introduction. *18th International Geological Congress (Great Britain), part IX, Proceedings of Section H, the Pliocene-Pleistocene boundary*: 5. Although Hedberg develops this point more consistently over an even greater span of time. As early as 1937, Hedberg had articulated a notion of global chronostratigraphic units: 'The unit in the time-stratigraphic [i.e. chronostratigraphic] category is the *stage* which is independent of lithologic, paleontologic, or mineralogic variation and comprises the sediments deposited in a region during a specific time interval – the geologic age [i.e. geochronologic unit].' Hedberg, H. 1937. Stratigraphy of the Rio Querecual section of north-eastern Venezuela: *GSA Bulletin* 48: 1971-2024. Pg. 1976.

[263] Bell, W.C. 1959. Uniformitarianism or uniformity. *American Association of Petroleum Geologists Bulletin* 43: 2862-2865. Page. 2864.

[264] See Gradstein, F., Ogg, J, Schmitz, M., et al. 2020. *Geologic Time Scale 2020*. Amsterdam: Elsevier.

reference sequence of strata… The basis for definition of a system should be a specifically designated and delimited type or reference sequence of strata.'[265] The notion of boundary stratotypes was consistent with established practice throughout Europe, however there remained doubt about the ability to expand the premise to the global scale. Although a stratal section could provide a model for a particular region, this premise was complicated significantly when expanded over larger areas, where stratigraphic variation was inevitable.[266] Yet the purpose of the ICS was to establish definitions within stratigraphy, towards the end of improving communication between stratigraphers. What was therefore required was not simply a stratal section that could provide a reference type for a section, but also the guarantee that this reference would remain unchangeable. Only in this way, it was held, could stratigraphy establish a universal, singular vocabulary:[267]

> Consequently, the best ultimate standard of reference for the boundary of a System appears to be a designated horizon in a specific type section of continuously deposited strata. From this type of section (stratotype) the boundary may be extended around the world, by means of palaeontology or any other useful supplementary methods of time correlation, to achieve as nearly as possible the ideal of an isochronous boundary, while at the same time maintaining *a fixed and immutable standard of reference* in the stratotype.[268] (Emphasis added).

The boundary stratotype was written into the constitution of stratigraphy when it appeared in Hedberg's 1976 *International Stratigraphic Guide*. In this publication, the stratotype is defined accordingly:

> '[T]he original, or subsequently designated, type representative of a named stratigraphic unit or of a stratigraphic boundary, identified as a specific interval or as

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[265] International Subcommission on Stratigraphic Terminology. 1961. Statement of principles of stratigraphic classification and terminology. *21st International Geological Congress, Copenhagen, Part XXXV*: 1-38. Pp. 25-26.
[266] See Walsh, S., Gradstein, F. & Ogg, J. 2004: 203.
[267] This vocabulary, moreover, could ideally be *about stratigraphic sections themselves*, rather than, as had been the more modest objectives of the early Congresses, about how to talk about stratigraphic sections.
[268] This quote is from internal circulars of the ICS, quoted in Walsh, S., Gradstein, F., Ogg, J. 2004: 203.

a specific point in a specific sequence of rock strata, and constituting the standard for the definition and recognition of that stratigraphic unit or boundary.'[269]

A year later, in 1976, the first Standard Global Geochronologic/Chronostratigraphic boundary was placed in Klonk, Czech Republic, demarcating the lower boundary of the Devonian Period/System.[270] This was effectively the first instance of a GSSP to be approved internationally. The boundary is marked by the lowest occurrence of a trace fossil associated with graptolites.[271] Yet the GSSP was only formalised as an official procedure with the publication of the *Statutes and Guidelines of the international Commission on Stratigraphy* in 1986. In that publication, the GSSP is defined in the following manner:

> Global Boundary Stratotype sections and points (GSSP) allow maximum flexibility with the use of multiple hypotheses to give minimum ambiguity and the greatest likelihood of stability. It is essentially a unique and specific point in a specific sequence of rock strata in a unique and specific geographical location. This Boundary Stratotype Section and Point is the designated type of a stratigraphic boundary identified in published form for the definition and recognition of the stratigraphic boundary between two named global standard stratigraphic (chronostratigraphic) units.[272]

The *Statutes and Guidelines* outline the requirements of a GSSP proposal, as well as the process of GSSP formalisation. These are the same requirements and processes that the AWG are subject to in their ongoing formalisation effort today. These include, for example, the hierarchical evaluative procedure, according to which an ICS Subcommission, the ICS, and then the IUGS must each vote on a proposal with a majority of at least 60% in order for an amendment to the International Chronostratigraphic Chart to be ratified. The document also outlines the requirements of any such proposal. These include the designation of a boundary stratotype; a convincing argument for the choice of that stratotype that considers lithologic,

[269] Hedberg, H. 1976: 4.
[270] This definition is formalised in McLaren, D. 1977: The Silurian-Devonian Boundary Committee: a final report. In Martinsson, A. (Ed) *the Silurian-Devonian Boundary*. Stuttgart: International Union of Geological Sciences Series A, no. 5. E. Schweizbart'sche Verlagbuchhandlung: 1-34.
[271] See Walsh, S., Gradstein, F., Ogg, J., 2004.
[272] Cowie, J., et al. 1986: 5.

magnetostratigraphic, palaeontologic, and chemostratigraphic factors; and perhaps most importantly, demonstration of the correlation potential of that stratotype. The document goes so far as to claim that 'correlation must precede, and accompany, definition of a boundary.'[273] In addition to biostratigraphic, radiosiotopic, magnetostratigraphic, chemostratigraphic, and geologic requirements, the *Statutes and Guidelines* also hold that the GSSP should be geographically accessible with 'free access for research and permanent protection of the site.'[274]

At present, seventy-four of one-hundred-and-two Phanerozoic stages have a ratified GSSP. One Precambrian stage has a GSSP. This is a remarkable achievement given that there is no biostratigraphic evidence in the Precambrian. It is also an indication of developments in stratigraphic methods that facilitate lower boundary definition by other means. The overwhelming majority of GSSPs in the Phanerozoic are defined biostratigraphically, i.e. with fossils. At either end of the Scale, however, the means of definition change.[275] The sole Precambrian GSSP, for example, is defined with both carbon isotopes, and by reference to the appearance of distinct cap carbonates, i.e. geologically. In the Quaternary, which is the most recent Period of the Chart, beginning 2.58 million years ago, only two of six GSSPs have a biological definition. Both are accompanied by other definitions (magnetostratigraphic, and sedimentologic). The four most recent stages have GSSPs that are defined *climatically*. The Holocene, the geologic Epoch in which we currently reside, and which the Anthropocene would terminate, is defined by a GSSP marking the end of the Younger Dryas ice age, as

[273] ibid: 6. As we shall review, this is a particularly contentious premise, as far as some stratigraphers, known as the "Berkley school" are concerned. See Walsh, S. 2005. The role of stratotypes in stratigraphy. Part 3. The Wood committee, the Berkeley school of mammalian stratigraphic palaeontology, and the status of provincial golden spikes. *Earth-Science Review* 70: 55-71.

[274] Remane, J., Bassett, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). *Episodes* 19(3): 77-81. Pg. 80.

[275] The *Statutes and Guidelines* of the ICS state that:

> Because of the multiplicity of criteria involved and the variation in circumstances through the geological time scale it would be unwise (or impossible) to specify which criteria are essential and which are desirable up and down the scale. Expert assessment must be the responsibility of the appropriate experts in that field of study. It is unlikely that all boundary stratotypes will possess all criteria and some compromise must be expected.

See Cowie, J., et al. 1986: 8.

recorded in the NGRIP2 Greenland ice core.[276] The other two stages of the Holocene are also defined with GSSPs by reference to climatic events: a sudden decrease in global temperatures that lasted four centuries, and an aridity event.[277]

The GSSP has proved a remarkably effective means of defining and correlating stratigraphic units. It has been held up by its proponents as the key to achieving a common language for a universal geology.[278] This is because the GSSP renders a boundary stratotype permanent (unless it is challenged following the ten year moratorium). It is held that the GSSP is 'the only place where we actually know (by definition) that time and rock coincide within our classification.'[279] However, that is not all the GSSP does. In his exhaustive historical account of the boundary stratotype, Walsh identifies three functions of the stratotype: they are bases for boundary definitions, standards of comparison, and 'fixed thicknesses of strata to which names are attached'.[280] These functions are not always compatible. The prevalence of the GSSP has revealed contradictory assumptions implied by these different functions concerning the relation of time and space. Although the GSSP is generally (although sometimes reluctantly) accepted as a central technique in stratigraphy, stratigraphers diverge over whether geologic time derives from the stratigraphic record, or whether stratigraphic units are a product of historiographic periodisation. Some stratigarphers, furthermore, argue this difference is insignificant, and that with the introduction of the GSSP chronostratigraphic and geochronologic units become interchangeable.[281] Although this is a debate that has gone on for decades in geologic literature, I wish to argue that the emergence of the Anthropocene as a problem of geologic classification indicates that it is a debate that continues to inform the work of stratigraphers today. To this extent, the debate surrounding the effort to

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[276] See Walker, M., Johnsen, S., Rasmussen, S.O., et al. 2009. Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. *Journal of Quaternary Science* 24(1): 3-17.

[277] See Walker, M., Head, M., Berkelhammer, M., et al. 2018. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Sections and Points (GSSPs) and three new satges/subseries. *Episodes* 41(4): 213-223; Head, M. 2019. Formal subdivision of the Quaternary System/Period: Present status and future directions. *Quaternary International* 500: 32-51.

[278] This aspiration is apparent in the stratigraphic literature. See Basset, M. 1985. Towards a "common language" in Stratigraphy. *Episodes* 8(2): 87-92.

[279] Holland, C. 1984. Steps to a standard Silurian. Proceedings of the 27th International Geological Congress, Moscow 4-14 August 1984. *Stratigraphy* 1: 127-156. Pg. 149.

[280] Walsh, S. 2005. The role of stratotypes in stratigraphy. Part 1. *Earth Science Reviews* 69(3-4):307-332. Pg. 311

[281] See Zalasiewicz, J., Smith, A., Brenchley, P., et al. 2004. Simplifying the stratigraphy of time. *Geology* 32(1): 1-4.

formalise the Anthropocene unfolds as a further attempt to address the problem of the relation bewteen geochronology and chronostratigraphy, or the dual hierarchy.

4.1.2 The Schenck & Muller Antecedent

The two views – that chronostratigraphy (or stratal units) derives from geochronology (or the period of time that has elapsed between the lower and upper boundary of a stratigraphic unit), and vice versa – have common origins. Their two primary proponents, Kleinpell associated with the former, Hedberg with the latter, completed their PhD's together, and under the same supervisor, in the early twentieth century.[282] Both had completed their PhD research under the supervision of Hubert Schenck. In 1941, Schenck co-authored a paper that advocated a 'three-fold arrangement' of geologic units: lithogenetic, time-stratigraphic, and time units.[283] Lithogenetic units refer to 'concrete rock units' that can be represented on maps without consideration of time, or the ages of the rock. Time-stratigraphic units, which Schenck & Muller refer to as 'the task of the biostratigrapher':

> [T]he biostratigrapher deals with units of a standard column which are delimited by fossils regardless of kind of rock and thickness of strata. Since the fossils usually serve as our nearest approach to time-markers, it follows that the units of this standard column are stratal units defined by time.[284]

The third category, time units, refers to the sequence of events that correspond to the rock record. This tripartite classification greatly influenced the ongoing efforts of the stratigraphic community to establish a single, universal language for their discipline. Even today, although geologists tend to speak of a 'dual hierarchy', formally a tripartite division is retained. There are three kinds of chronology used in definition of the Phanerozoic time scale: chronostratigraphic, geochronologic, and geochronometric; the latter referring to the measurement of time in years as numerical ages. Geochronometry differs from

[282] Walsh, S. 2005. Part 2.
[283] Schenck, H. & Muller, S. 1941. Stratigraphic terminology. *Geological Society of America Bulletin* 52: 1419-1426.
[284] ibid: 1420.

geochronology only in that the former is entirely abstracted from the geologic record, whereas the latter is said to have a 'parallel and exactly corresponding stratigraphy'.[285]

Most importantly for the purpose of this discussion is Schenck & Muller's conflation of biostratigraphy with chronostratigraphy. As Walsh has shown, this was not merely an oversight. He quotes a subsequent article in which Schenck explains: 'I was pleased to read Professor John Rodger's rejection of the popular distinction between time-stratigraphic and biostratigraphic categories of units.'[286] Their argument that biostratigraphy and chronostratigraphy are the same justifies a further omission from their classificatory scheme, namely: stratotypes. We have seen how stratotypes play a fundamental role in the formal procedures that have been adopted by the International Commission on Stratigraphy, and hence the stratigraphic community at large. The boundary stratoype is a notion central to Hedberg's procedural philosophy, and is to that extent the progenitor of the GSSP.[287] Hedberg's notion of boundary stratotype did accommodate, and indeed often rely on, biostratigraphy, to the extent that a boundary stratotype could be defined at the lowest occurrence of a fossil index. Even today, biostratigraphic markers (especially in marine sediments) are often chosen as boundary stratotypes of early Phanerozoic units. These provide the sites of GSSPs and are thereby an integral part of chronostratigraphic unit formalisation, and the International Chronostratigraphic Chart. Yet in Schenck & Muller's account of chronostratigraphy, the conflation of biostratigraphy and chronostratigraphy is an argument *against* the need for a boundary stratotype. Whereas Hedberg's GSSP makes use of biostratigraphic markers to define a single, global, permanent (lower) boundary stratotype,

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[285] This division is formalised in Hedberg, H. 1976. In practice few stratigraphers refer to geochronometry, finding it to be largely redundant. Indeed, recent proposals to consolidate the dual hierarchy into a single hierarchy do not even take geochronometric scales into consideration, indicating how little consideration it is given. Yet the existence of a three-part hierarchy is retained from the original contribution of Schenck & Muller. See Zalasiewicz, J., et al. 2004.

[286] Schenck, H. 1961. Guiding principles in stratigraphy. *Journal of the Geological Society of India* 2: 1-10. Pg. 7. Quoted in Walsh, 2005. Part 2: 49.

[287] Hedberg, H. 1976. In the updated version of Hedberg's *Guide*, it is written that the stratotype is:

> [t]he original or subsequently designated standard of reference of a named layered stratigraphic unit or of a stratigraphic boundary. A stratotype is a specific interval or point in a specific sequence of rock strata and constitutes the standard for the definition and characterization of the stratigraphic unit or boundary being defined.

Salvador, A. (Ed). 1994. *International Stratigraphic Guide, 2nd ed*. Boulder: International Union of Geological Sciences and the Geological Society of America. Pg. 24.

Schenck & Muller's 'time-rock' units are collections of local groups of fossils that are correlated with units of the Geologic Time Scale. In other words, whereas Hedberg's notion of boundary stratotype assumes the possibility of a globally mappable stratotype section, Schenck & Muller assume that one can only correlate local units with pre-agreed global units, whose very globality is an artefact of the geologists narrative of deep time.[288] Underlying this difference is a disagreement concerning which measure (chronostratigraphic or geochronologic) logically precedes the other. This is a debate that continues to this day, even if it is not addressed directly. It re-appears in the early efforts of the AWG to formalise an Anthropocene unit on the basis of the mid-twentieth century marker by way of a GSSA, or numerical age.[289] 'Where is the stratigraphy?' responds ICS chair, Stan Finney.[290] The subsequent effort of the AWG to identify a GSSP indicates one way in which the indeterminate nature of the relationship between geochronology and chronostratigraphy continues to influence the work of stratigraphers to this day.

4.1.3 The Kleinpell Antecedent

The other classificatory method that stands out in relation to ongoing debates in stratigraphy is most commonly associated with the geologist Robert Kleinpell. Kleinpell and Hedberg were both students of Schenck's. They both worked towards the formulation of a universal

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[288] Under the section 'Time-Stratigraphic Units', Schenck & Muller explain:

> The biostratigrapher strives to correlate the local mappable units with those of the standard scale in order that the physical and biologic phenomena read from a local study of the formations may be fitted into the general sequence of geologic events of a wider region.

Schenck & Muller, 1941: 1420. That physical rock units are always and inevitably local as far as they are concerned is indicated in a table of stratigraphic terminology that appears in their article. It identifies lithogenetic (what would today be called lithologic) terms as 'for units of more or less local extent'. The purpose of 'time terms' accordingly, is to facilitate a set of universally recognised geologic units. While those global units facilitate communication between geologists, Schenck & Muller appear resigned to the opinion that global units are nothing more than a communicative artefact, and to that extent are not mirrored in the physical rock record, which is inevitably always local. See Figure 1.

[289] See Zalasiewicz, J., Williams, M., Smith, A., et al. 2008. Are we now living in the Anthropocene? *GSA Today* 18(2): 4-8. This is the first publication from a geological group, the Stratigraphic Commission of the Geological Society of London, who would eventually form the Anthropocene Working Group. In this paper, a GSSP and GSSA are considered as equally permissible. This has subsequently been rebuked by the executive of the ICS and IUGS, and the AWG have since adopted a very narrow focus on a GSSP definition. See Zalasiewicz, J., Waters, C., Williams, M., et al. 2019. *The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate*. Pp. 284-286.

[290] See Finney, S. & Edwards, L. 2016.

language for geologists. Yet whereas Hedberg pursued this objective via the notion of a permanent and global stratotype section, Kleinpell prioritised a palaeontologic approach that assumed flexibility of more generally defined biostratigraphic *zones*. This approach is illustrated in a passage by Kleinpell concerning the middle Tertiary as observed in California:

> The California middle Tertiary stages in reference in the present work, are, in principle, stages such as those recognized by Albert Oppel more than a century ago, although based on the organic evolution and stratigraphic distribution of benthonic small foraminifers rather than nektonic ammonites. These stages thus correspond, both qualitatively and in magnitude, to the "Zonengruppen" of Oppel. That is, each stage is a group of two or more of Oppel's zones, grouped together and distinguished from each other, almost, though not entirely, as a matter of convenience in handling and communication; yet both the zones and the stages are recognized on the basis of the same principles.[291]

The zone, as defined by the German palaeontologist Albert Oppel, refers to the span of diagnostic taxon, or fossil, in a rock succession.[292] Unlike the GSSP, the 'zone' concept appreciates that subsequent fieldwork may uncover additional fossils of the same taxa. The zone is therefore a flexible concept that is not intended to define a *type* for global and permanent application, but rather to refer to a local instance of a group of fossil indexes.[293] Kleinpell therefore adopted the zone as the fundamental unit of stratigraphy. This was a local and flexible definition of strata. Hedberg, by contrast, and as we have seen, adopted the lower boundary stratotype of the stage, a permanent and global definition, as the fundamental unit of stratigraphy. In adopting the zone as such, Kleinpell could argue that the GSSP was a

[291] Kleinpell, R. 1980. *History of stratigraphic paleontology of West Coast Tertiary. The Miocene stratigraphy of California revisited. Vol. 11*. Tulsa: American Association of Petroleum Geologists Studies in Geology. Pp. 15-16.

[292] Oppel, A. 1856-1858. *Die Juraformation englands, Frankreichs und des südwestlichen Deutschlands*. Stuttgart: Verlag von Ebner & Seubert.

[293] The zone is developed in Oppel, A. 1856-8. *Die Juraformation: Englands, Frankreichs und des Sudwestlichen Deutschlands.* Stuttgart: Verlag von Ebner & Seubert. An overview of the history of the zone concept is presented in Page, K. 2017. From Oppel to Callomon (and beyond): building a high-resolution ammonite-based biochronology for the Jurassic System. *Lethaia* 50(3): 336-355; Walsh, S. 2000. Eubiostratigraphic units, Quasiobiostratigraphic units, and "Assemblage Zones". *Journal of Vertebrate Palaeontology* 20(4): 761-774.

contradiction in terms, because both Stage and Zone were, as far as he was concerned, 'restricted to particular faunal provinces.'[294]

As Walsh has demonstrated, Kleinpell acknowledged Hedberg's stratotype concept, but insisted on the predominance of biostratigraphy as the medium of stratigraphic definitions.[295] Whereas Hedberg understood 'type section' to indicate the single stratal section that would determine the lower boundary of a unit worldwide, for Kleinpell, a 'type section' meant something more like an exemplary section:

> The type for an Oppelian stage or zone is simply such a biostratigraphic sequence, selected from one of many throughout a province, in which the congregation diagnostic for a time-rock unit of such magnitude seems best in evidence. Even in the selected type section for such a time-rock unit the boundaries remain to some extent fuzzy owing to causes that are inherent, philosophically much the same as in a group of organisms constituting a species, from which group a single organism is selected as morphologically the most similar.[296]

In other words, biostratigraphy is the *de facto* means of stratigraphic definition. Given that palaeontological research in any location is always ongoing, stratigraphic definitions must remain open to change, or 'fuzzy' as Kleinpell puts it. This is a markedly different approach from Hedberg's, for whom all sub-branches of stratigraphy (e.g. magnetostratigraphy, chemostratigraphy, etc., in addition to biostratigraphy) must be considered in the definition of a GSSP, given its permanence. As we shall see, the subsequent predominance of Hedberg's approach over Kleinpell's remains a point of contention for Kleinpell's various students at University of California, Berkeley, known as the 'Berkeley school'.[297] We may now proceed to the views held by some of those associated with this school of thought, which emphasises

[294] Phillips, F. 1972. Age and correlation of the Eocene Ulatisian and Narizian stages, California: discussion. *Geological Society of America Bulletin* 83: 2217-2214. Pg. 2218.
[295] See Walsh, S. 2005. Part 2: 51-53.
[296] Kleinpell, R. 1980: 41.
[297] See Berry, W. 2008. Robert M. Kleinpell: Founder of the Berkeley School of Stratigraphic Palaeontology. Earth Sciences History: *Journal of the History of the Earth Sciences Society* 27(1): 100-112; Walsh, S. 2005. Especially pages 75-101.

flexible, local, biostratigraphic definitions over permanent, global, GSSPs, as we lead up to its impact on a hypothetical Anthropocene unit.

4.2 Definition, correlation, and the dual hierarchy

Kleinpell's approach to stratigraphy is evident in recent debates concerning the relation of definition and correlation. Formulating stratigraphic classification in terms of 'correlation' and 'definition' is relatively recent. In the revised *Guidelines and Statutes* of the ICS, it is stated that 'correlation precedes definition'.[298] This presents a significant contention for those who hold that units should be determined on the basis of locally recognisable fossil indexes, rather than globally defined sections. In a series of papers published in the tail end of the 1990's, several stratigraphers. These stratigraphers hold that the GSSP is essentially the same as the boundary stratotype concept. The only difference is that whereas the boundary stratotype has been used for years to differentiate regional, predominantly biostratigraphic successions, the GSSP is a global and permanent commitment. The success of the GSSP has been received by these stratigraphers as a marginalisation of their views. Continuing Kleinpell's partiality towards flexible, regional, biostratigraphically defined sections over the global and permanent GSSP, Marie-Pierre Aubry, a prominent figure affiliated with the 'Berkeley School' states: 'There is not a single, straight, unequivocal interpretation of stratigraphic sequences, but alternative interpretations.'[299] This view undermines the entire project of the ICS to enforce the GSSP as the fiat of global stratigraphy. For Aubry and her colleagues, there has not been much need to adjust the global geologic time scale as it was devised by Charles Lyell. In his *Principles of Geology*, Lyell divided Earth history into four units.[300] Lyell's system has been sufficient as a general guide for stratigraphers who have since worked to refine the rock record through the discovery and correlation of regional units. The GSSP undermines the significance of what Aubry and her colleagues call 'historical priority', by which is meant the prevalence of previous scales, such as Lyell's, on the basis of which observations have

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[298] Remane, J., Basset, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). *Episodes* 19: 77-81. Pg. 78.

[299] Aubry, M.P. 1995. From chronology to stratigraphy: interpreting the Lower and Middle Eocene stratigraphic record in the Atlantic Ocean. In Berggren, W., Kent, D., Aubry, M.P., et al. (eds) *Geochronology Time Scales and Global Stratigraphic Correlation*. SEPM Special Publication 54: 213-274. Pg. 221.

[300] Lyell, C. 1997 [1830-1833].

accumulated. They argue, consequently, that stratigraphy is 'being disconnected from its roots… [as well as] the wealth of data that were collected and interpreted based on' previously established frameworks.[301] Aubry refers to the GSSP as 'no more than pegs meant to validate' new time scales that would otherwise lack the authority of historically verified frameworks for stratigraphic classification. Aubry goes so far as to dismiss the objectives of the ICS altogether: 'it is irresponsible of the ICS to deprive chronostratigraphy of its roots by insisting that historical priority has no ground in setting its subdivisions'.[302]

The GSSP presents a further methodological problem: it undermines the historical significance of biostratigraphy in the classification of stratigraphic units.[303] This position implies that other branches of stratigraphy, such as chemostratigraphy, or magnetostratigraphy, emphasise the correlation potential of stratal units, at the expense of their material (and primarily palaeontological) constitution. This is referred to as the problem of correlation preceding definition.[304] This is perhaps best demonstrated by the approach Aubry and her colleagues have taken towards the Quaternary. I had previously mentioned that the Quaternary is unique to the extent that the majority of its boundaries are defined with climatic markers, rather than exclusively biostratigraphic markers, as is typical of most other units. For Aubry and her colleagues, this is an indication of stratigraphy subsumed by the methodologies of other geoscientific disciplines. They argue that the stages of the Quaternary, like almost every other stage, should be defined biostratigraphically: 'Once biotic change becomes the medium of measurement, then logic dictates that the measured units

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[301] Aubry, M.P., Couvering, J.., Berggren, W., et al. 2000. Should the Golden Spike glitter? *Episodes* 23(3): 203-210. Pg. 207.

[302] Ibid: 206.

[303] Hedberg's call for a 'freezing of the units by which we measure' was apparently on Cowie's mind when inaugurating the GSSP in the original ICS *Guidelines and Statutes* of 1986. The authors of those guidelines took some care to provide a more definite form to the GSSP. They did not explain what kind of classificatory mechanism the GSSP is. Rather, keeping in mind the overwhelming influence of palaeontology to date, and the need to rebalance stratigraphic nomenclature in light of the increased relevance of other methods such as the emergent radiometric dating and magnetostratigraphy, they outline what it is best *not* associated with:

> It is considered preferable not to use parabiological analogies which imply unsound analogies and cause confusion (e.g. holostratotype or parastratotype) but to confine nomenclature, for ICS candidates, to two categories of stratotype: (a) global stratotype section and point (GSSP) and (b) auxiliary stratotype point (ASP)… designations like "para" or "hypostratotype" should be avoided as diluting and clouding the value of the GSSP.

See Cowie, J., et al. 1986: 5.

[304] ibid: 207.

be exclusively framed in these terms to avoid miscommunication and conflict.'[305] Given that units have traditionally been defined in reference to palaeontological deposits, the GSSP is redundant, according to this view. Proponents of the Quaternary argue that the appearance of the genus Homo approximately twenty-four million years ago is a palaeontological marker specific to the Quaternary, 'but at the biotic rather than the emotional level,' argue Van Couvering et al, 'this event is almost invisible.'[306] The Quaternary introduced alternative, non-biostratigraphic markers as legitimate 'mediums' of stratigraphic classification. This has opened the project of stratigraphic classification to manipulation. It means, in their words, 'a profound change in the organizing principles of the standard time scale… abandoning the fossil; record as the uniform guiding standard for the geologic time scale.'[307] As part of their critique of the Quaternary, Van Couvering et al argue against the a formal Anthropocene unit. They consider the suggestion of an Anthropocene unit as an inevitable consequence of what they call the "holistic" approach of Quaternary stratigraphers. This involves the use of signals that were traditionally used to correlate regional stratotypes, such as palaeomagnetic reversals or isotope peaks, to *define* units in the Quaternary. 'In this "holistic" scenario, decisions as to the nature and boundaries of units in the standard time scale would move entirely, and not just partially as now, into the realm of politics, where various disciplines would back their favourite time units.'[308]

Both these arguments concern the relationship of time and space in geological classificatory mechanisms. As we have seen, this has been the case since the first meetings of the International Geological Congress. In the dual hierarchy, stratigraphy remains simultaneously an issue of time and of space. Aubry and her colleagues argue that the proper place indicated by stratigraphic classification are regional stages marked by fossil indexes that set an example for recognising similar successions in other areas, which nevertheless retain their locality, and hence the possibility of being recognised differently according to new discoveries. Accordingly, it is argued that regional definitions can change, and thereby reflect

[305] Van Couvering, J., Aubry, M.P., Berggren, W., et al. 2009. What, if Anything, is Quaternary? *Episodes* 32(2): 125-126. available at https://www.researchgate.net/publication/48323979_What_if_Anything_is_Quaternary/citations (accessed 05/01/2021). Pg. 126.
[306] This quote appears in a version of Van Couvering, J., et al. 2009: 5.
[307] ibid: 6.
[308] ibid.

the evolving nature of stratigraphic discovery, unlike the GSSP, which artificially fixes definitions at the global level. This is a geologic time scale that is at once anchored to previous frameworks, such as Lyell's or Arduino's, yet dynamic in the present, insofar as beyond those original frameworks, nothing is permanently or absolutely defined. The time and space of stratigraphy are in this sense, immanent. On the form of geologic time that emerges from this approach, Aubry writes:

> The measurement of past time is not a blue ribbon dotted with check marks every so many million of years depending on the availability of datable radioactive elements in rocks. Its measurement is a web of interconnected (correlated) stratigraphic horizons and units, each endowed with a precise significance, contributing to a mixed calendar of relative and numerical time, just as in a calendar of years and holidays.'[309]

The chronological record is an artefact of stratigraphic definitions. It is a chronology that precipitates from the correlation of defined, material, stratigraphic units. But ultimately, and as Aubry emphasises, 'we do not date events: we date strata!'[310]

4.2.1 Time-rock and rock-time: anticipating the Anthropocene debate?

Paradoxically, the dual hierarchy is intended to unite geology by making a distinction: between geochronology and chronostratigraphy. Hedberg characterised the difference of geochronology and chronostratigraphy to an hourglass:

> Each interval of stratified rocks represents a certain interval of geologic time. Accordingly, each chronostratigraphic unit (interval of rock strata) has a corresponding geochronologic unit (interval of geologic time)… Because geochronologic units are units of geologic time – an intangible property – while stratigraphic units are tangible material units composed of rock strata, geochronologic units are not in themselves stratigraphic units. To illustrate the difference, a chronostratigraphic unit can be likened to the sand that flows through an hourglass during a certain interval of time, while the corresponding geochronologic

[309] Aubry, M.P. 2009. Thinking of deep time. *Stratigraphy* 6(2): 93-99. Pg. 97.
[310] Aubry, M.P. 2007. Chronostratigraphy beyond the GSSP. *Stratigraphy* 4(2/3): 127-134. Pg. 129.

> unit can be compared to the interval of time during which the sand flows. It may be said that the duration of the sand flow measures a certain interval of time – an hour, for instance – but the sand itself cannot be said to be an hour.[311]

The sand that flows through the hourglass represents chronostratigraphy (i.e. the Quaternary System), while the time interval represents geochronology (i.e. the Quaternary Period). The distinction of time and rock has served to accommodate different geologic methods. One difference between Kleinpell and Hedberg, for example, concerns whether fossils are the exclusive means of characterising strata and recording the passage of time, or whether palaeontology is just one among several methods in the geologist's armoury. This debate precedes Kleinpell and Hedberg. It can be identified in the proceedings of some of the first International Geological Congresses. The term 'zone', appears without capitalization in 1850 with the work of French geologist d'Orbigny, synonymous with Stage, or 'Etage'. It was taken up by Edmund Hubert, President of the first International Geological Congress of Paris (1878), who encourages an exclusively palaeontological definition of the term, invoking the 'Zone a *Ammonites primordiales*.'[312] These early invocations do not designate a precise definition, although they indicate a palaeontological characterisation of rock successions. Despite the apparent influence of Hubert on the early Congresses, having been president of the first meeting, when 'zone' was adopted as formal nomenclature, the definition it retained was indebted to its development by the Austrian geologist Alfred Oppel. Oppel defined zones as 'distinct horizions [which] through constant and exclusive occurrence of certain species, mark themselves off from their neighbours.'[313] When it was introduced into formal nomenclature at the Eighth International Geological Congress of 1900, it was ranked below Stage, as 'a group of beds, of an inferior status, characterized by one or several special fossils which serve as indices.'[314] This was an indication of the largely informal way it was used, typically to refer to

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[311] Hedberg, H. 1976: 11.

[312] Hebert, E. 1857. *Les Mers Anciennes et Leurs Rivages dans Le Bassin de Paris, ou Classification Des Terrains Par Les Oscillations Du Sol: Premiere Partie - Terrain Jurassique*. Paris: Librarie de L. Hachette Et Co. Pg. 23.

[313] Oppel, A. 1856-58. Quoted in Teichert, C. 1950. Zone concept in stratigraphyi. *Geological Notes* 34(7): 1585-1588. Pg. 1585.

[314] See O.H.F. 1900. The Eighth International Geological Congress at Paris. *Science* 21(12): 440-442; Puche Riart, O., Mazadiego Martinez, L., Kindelan Echevarria, P. 2008. The VIII International Geological Congress, Paris 1900. *Episodes* 31(3): 336-343.

regional successions; a trend that was out of touch with the Congresses' aspiration of a singular, universal nomenclature.

The official inclusion of 'zone' was short-lived, and by 1933 was absent from the code of the Committee of Stratigraphic Nomenclature. Yet it persisted in informal usage to refer to regional appearances of fossils. Hence it continued to appear in stratigraphic literature, and continued efforts were made to refine a common understanding of the term, even if zones were not included in the Geologic Time Scale. 'Zones are units of more restricted function than stages', explains one stratigapher in 1946. 'Attempts to give them universal application are misdirected; such attempts merely make zones synonymous with subdivisions of stages and at the same time deprive them of their special qualities as the basis of correlation from one province to another.'[315] The zone, in other words, is designated outside of the official nomenclature of global stratigraphic charts, precisely for its ability to designate regional, palaeontological varieties of strata.

Although usage of the term remained relatively consistent across the English-speaking world, and France, where it was coined, German stratigraphers invoked a different definition. The German definition of 'zone' understood the term exclusively as a time unit. In Germany, the zone is defined as the 'the average duration of a mutation of the more common marine animals', 'the time duration of a species', and 'the time-unit for the duration of a certain fossil'.[316] Seen in this light, the scepticism expressed by Aubry and her colleagues is easier to understand. Their concern regards the correct use of stratigraphic terminology, against the tendency of some stratigraphers to muddle terms of the dual hierarchy respectively.

As radiometric dating techniques developed throughout the twentieth century, it appeared to demonstrate a corrective to the problem of diachronous beginnings that resulted from correlating bodies of rock over great distances. The boundary stratotype, as proposed by Hedberg, saw no reason to limit stratigraphic definitions to palaeontology alone. The boundary stratotype method allows for the definition of a boundary by reference to the first instance of a chemostratigraphic, magnetostratigraphic, or biostratigraphic marker, without requiring that signal to have appeared at the same instance in all other strata around the world. It sets the first instance of the chosen marker in the chosen section as an artificial

[315] Arkell, W. 1946. Standard of the European Jurassic. *Geological Society of America Bulletin* 57(1): 1-34. Pg. 10.
[316] See Teichert, C., 1950, for an overview of the German approach to zones as time-unit.

boundary; artificial to the extent that it is imagined to traverse the entire planet like a giant belt, even if the stratigraphic record will indicate that it is slightly more staggered in reality. 'In a world which is not ideal', explains the ICS *Guidelines and Statutes* that formalised the GSSP method, 'it is most unlikely that all selected stratotype points can meet all the ideal requirements, and stratigraphy must be a practical subject and responsive to the needs of working geologists.'[317] The boundary stratotype method therefore aimed to facilitate communication between geologists internationally. But does communication occur at the expense of accuracy? That is precisely the charge of Aubry and her colleagues.

While Aubry and her colleagues have been particularly forceful in combating complacency in the reception of stratigraphic methods of classification, they are certainly not alone in thinking that way. At times it appears that few stratigraphers are completely satisfied by the dual hierarchy of chronostratigraphy and geochronology. The dual hierarchy appears to offer more opportunity for disagreement than consensus, by nature of the simultaneous authority of what are in fact two quite different ways of conducting stratigraphic classification. Following this line of thought, and as previously mentioned, some stratigraphers have called for the consolidation of the dual hierarchy; that is, to make it singular. Many of the co-authors of the 2004 paper that proposed the consolidation would go on to participate as members of the Anthropocene Working Group.[318] They developed some themes that Aubry found deeply problematic, namely the inference of stratigraphic divisions from historical events, or definition from correlation potential. However, rather than arguing for or against the GSSP, they simply posit that since the GSSP is the predominant method of stratigraphic classification, adopted by the ICS, it is no longer certain that a dual nomenclature is necessary:

> We consider that the practice of chronostratigraphy today defines the time framework of geochronology, because intervals of geologic time are now being precisely defined within rock successions by GSSPs… The effect of this is that chronostratigraphy and geochronology (in the sense of time-rock stratigraphy and geologic time stratigraphy, respectively) should become on and the same thing… For

[317] Cowie, J., et al. 1986: 3.
[318] Zalasiewicz, J., et al. 2004.

> this discipline, we propose to keep the name "chronostratigraphy," which in the sense of this paper is the definition and application of a hierarchy of eons, eras, periods, and ages.[319]

According to this view, chronostratigraphy would come to refer to both the material point in a rock succession, as well as a geochronologic event. This is a diplomatic effort to resolve disagreement within the stratigraphic community concerning the very issues raised by Aubry and her colleagues. The proposal that the dual hierarchy simply be consolidated overlooks the complicated issues of whether to prioritise historical event or material section, stratotype section or groups of fossil indexes, biostratigraphic markers over the variety of other methods.

Response from the stratigraphic community to this proposal was mixed. One reply argues that 'many of the supposed drawbacks of the current system are only problematic to those unwilling to distinguish between the fundamentally different entities of rocks and time,' and that 'utilization of GSSPs is fraught with problems.'[320] A further response agrees with the article's position. It argues that a consolidated hierarchy is an opportunity to expand the applications of stratigraphy. Consolidation is seen as 'an opportunity to extend the geochronological terminology to the commonly used anthropological time scale… [such as] millennium, century, year and so on.'[321] Yet another reply argues that the authors demonstrate a complete misunderstanding of stratigraphic terminology, and that 'their adoption would create major disruption to established procedures.'[322] It is worth noting that this last comment is authored by some of those behind the ICS *Guidelines and Statutes*, which formalised the GSSP method. Beyond the formal replies, the article prompted some debate within the broader stratigraphic community, including a special issue on the topic in the journal *Stratigraphy*.[323] The articles therein largely rehash the positions discussed above,

[319] ibid: 4.
[320] Heckert, A. & Lucas, S. 2004. Simplifying the stratigraphy of time: Comments and reply: COMMENT. *Geology* 32(1): 58.
[321] Gong Y.-M., Yin, H.-F., Zhang, K.-X., et al. 2004 Simplifying the stratigraphy of time: Comments and reply: COMMENT. *Geology* 32(1): 59.
[322] Basset, M., Cope, J., Hancock, J., et al. 2004. Simpifying the Stratigraphy of time: Comments and reply: COMMENT. *Geology* 32(1): 59-60. Pg. 60.
[323] See the introduction to the special issue, McGowran, B. 2007. Beyond the GSSP: New developments in chronostratigraphy. *Stratigraphy* 4(2): 81-82.

wherein permanent stratotype definitions were opposed to flexible palaeontological ones, the precedent of historical frameworks to new kinds of scales, and correlation to definition. A conference of the Geological Society of America held a special conference on the topic. Yet in a display of their predominance, a 2010 meeting of the ICS held a formal ballot and confirmed, with an 88% majority, to maintain the dual hierarchy.[324]

Whereas Zalasiewicz and his colleagues at the Geological Society of London have argued that the dual hierarchy is rendered obsolete by the GSSP, others criticise the GSSP on grounds that it undermines the favourable aspects of the dual hierarchy. Here again, Aubry has argued convincingly for the need to re-assess chronostratigraphic practices of measurement, and the GSSP in particular. Her argument begins with a fundamental distinction between two models of the relationship between time and rock:

> 'the *rock-unit model*, in which *stratigraphic horizons* define the boundaries of specific stratigraphic units (the stratomeres) representative of specific temporal units (the chronomeres), to the *time-rock model*, in which *points* are selected in the rock as representative of pre-selected events.[325]

The time-rock model takes as its premise something rather different from the GSSP, namely that 'no stratigraphic horizon can be traced continuously over long-distance, let alone globally.'[326] Despite the best intentions of the GSSP, rock formations are too discontinuous, diachronous, and messy to provide a reliable framework of reference. Even minerals that could be absolutely dated with isotopes are not always found near enough to a boundary, or in sufficient abundance to provide a reliable age. The GSSP overlooks these issues by using a single signal as a global boundary, thought to be rendered correlatable by reference to other single signals, known as auxiliary cores. Aubry presents a reading of the GSSP as deeply problematic, because the rock itself does not need to be dated. Instead, an event can be used

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[324] For details of the workshop, see Zalasiewicz, J., Cita, M. B., Hilgen, F., et al. 2013. Chronostratigraphy and geochronology: a proposed realignment. *GSA Today* 23(3): 4-8. Especially page 5.

[325] Aubry, M.P. 2007: 127.

[326] ibid: 128. On this particular reading of the GSSP, see also Harland, W.B. 1978. Geochronologic Scales. In Cohee, G., Glaessner, M. & Hedberg, H. (eds) *Contirbutions to the Geologic Time Scale. American Association of Petroleum Geologists Studies in Geology* 6: 9-32; Walsh, S., Gradstein, F., Ogg, J. 2004.

as a palliative in the absence of absolute measurements such as isotopes that can be radiometrically dated. For Aubry, the GSSP abstracts time from rock:

> 'The age of events are deduced from the (estimated) age of the strata that contain them. Further the reliability of the ages is only as good as the reliability of the interpretation of the stratigraphic sequence that records then. This is because of the discontinuous nature of the stratigraphic record… Whereas events belong to the time domain, the discovery of their succession and age proceeds from the rock-time model, not the time-rock model.'[327]

According to this view, the GSSP is too reductive in its compromise. It relieves stratigraphic classification to the discretion of executive committees, rather than in the analysis of stratal sections themselves.[328]

For Aubry, this compromise amounts to a conflation of strata and time. Her contention is that the geological community have sacrificed accuracy in favour of communicability, such that stratigraphy refers to its own 'artificial' references rather than strata itself. This is a contention that is mirrored in differences between attempts to define what the GSSP measures. Hedberg described the function of the GSSP thus:

> If we fix the basis of a system, or a series, or a stage, as a designated section (or sections) of rock strata, then we all have a common standard of reference which in its type can mean only one specific interval in the time scale to any of us regardless of our ever-changing interpretation of history. *This is not a freezing of what we measure, as some have claimed, but a freezing of the units by which we measure*. And I think this constancy is what we want in any standard of measurement.[329]

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[327] ibid: 129.
[328] Aubry, M.P., 2007 cites Harland on this point: \For those who do not wish to face or resolve this conflict, it is possible to manage with a compromise wording which accepts that both [geochronology] and [chronostratigraphy] are derivate from the reference points.'. See Harland, 1978: 24.
[329] Hedberg, H. 1961. The Stratigraphic panorama. *Geological Society of America Bulletin* 72: 499-518. Pg. 510.

The 1996 *ICS Guidelines and Statutes* posit that the 'GSSP cannot be compared to the holotype of Zoological Nomenclature; it corresponds rather to a standard of measure in physics.'[330] The editors of the Geologic Time Scale reflect on these divergent definitions:

> [W]e would reformulate [Aubry's view] and agree that the actual duration of any Standard Global Age defined by two GSSPs is uncertain, and as such is not comparable to, for example, the standard second in physics… [the GSSP can be] more profitably refarded as classificatory pigeonholes… these standard pigeonholes of the geologic time scale provide a stable, theory neutral framework for expressing similarity in age, regardless of our every-changing interpretation of history.[331]

Consequently, Aubry's characterisation of the GSSP as a muddled metaphor appears somewhat sympathetic, as does her observation that it confuses time and strata. Although the ICS vote formally decided against the consolidation of the dual hierarchy, it could not prevent further efforts towards an elaborated definition of the relation of geochronology and chronostratigraphy. Zalasiewicz has insisted that the question of consolidating the dual hierarchy has been put to rest.[332] However, the effort to formalise the Anthropocene as a geologic unit could be seen as a revival of debate over these issues. In the first collection of AWG essays, the Group suggested that a formal Anthropocene unit might be defined by reference to a Global Standard Stratigraphic Age, or GSSA.[333] A GSSA is a numerical age, which unlike a GSSP, uses a historical event to mark the beginning of a geologic unit. It is traditionally reserved for Precambrian units, wherein the palaeontologic record is scarce; although with more recent advances in alternative dating methods, such as isotope dating, even Precambrian units are gradually being assigned GSSPs.[334] The AWG argued that a GSSA would

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[330] Remane, J., Bassett, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). *Episodes* 19: 77-81.

[331] Walsh, S., Gradstein, F., Ogg., J. 2004: 204.

[332] Zalasiewicz, J. December 2, 2017. Personal correspondence [personal interview].

[333] See Zalasiewicz, J., Williams, M., Fortey, R., et al. 2011. Stratigraphy of the Anthropocene. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Science* 369(1938): 1036-1055. This is a more decisive statement than what was ventured in the first stratigraphic paper on the Anthropocene, wherein Crutzen's initial proposal for a Watt-dated start was considered alongside a GSSP, with no specific proposal for a start date/location proposed. See Zalasiewicz, J., Williams, M, Smith, A. 2008.

[334] See Strachan, R., Murphy, J.B., Darlin, J. 2020. Chapter 16 – Precambrian (4.56-1Ga). In Gradsein, F., Ogg, J., Schmitz, M., et al. (eds) *Geologic Time Scale 2020*. Amsterdam: Elsevier. Pp. 481-493. On the requirement of a GSSP made of the Anthropocene, see the contributions from Stan Finey and Phil Gibbard in Waters, C.,

be appropriate given how young Anthropocene deposits are compared to those of the more typical time frames that geologists work with. Furthermore, a GSSA would recognise the geological significance of the Anthropocene while leaving open the question of which physical marker is most substantial.[335] This argument was repeated in a 2015 article arguing that an absolute date would facilitate more optimal correlation than relative, palaeontological methods favoured by the GSSP. An exact date could be defined, they argue, by measuring the half-life of artificial radionuclides deposited following prolonged nuclear weapons testing. Radionuclides appear globally, on both poles and on every continent. They argue that the Anthropocene could begin with the detonation of the first atom bomb, known as the Trinity test, providing a start date that is accurate to the second: New Mexico, 1945, July 16th, 05:29:21.[336]

The proposal provoked strong backlash. In a reply to the 2015 article, several executive (voting) members of the ICS commented:

> [A] consensus is now developing in the ICS that abstract period definitions based on time can no longer be sustained… and that GSSAs must become GSSPs, using observable and correlative geological events… 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 Geologic Time Scale.[337]

Given that the nuclear fallout proposal already emphasised correlation potential, it was not so difficult for the AWG to shift the emphasis towards a chronostratigraphic definition of that signal when the GSSA was rebuffed by the ICS executive. Commenting on the results of a 2016 internal vote, the members of the AWG posit that the primary marker of a unit, or GSSP, 'is not always the most widely useable proxy…. However, the primary marker is ideally correlatable widely.' Although regional biostratigraphic markers may be referenced as

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Zalasieicz, J., Williams, M., et al. 2014. *A Stratigraphical Basis for the Anthropocene.* London: Geological Society Special Publication 395.

335 Zalasiewicz, J., et al. 2011: 1050.

336 See Zalasiewicz, J., Waters, C., Williams, M., et al. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383: 196-203.

337 Walker, M., Gibbard P., Lowe, J. 2015. Comment on "When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383: 204-207.

auxiliary markers of the Anthropocene, the radionuclide signals (primarily Pu_{239} isotopes) provide 'the sharpest and most globally widespread signal.'[338] In turning towards the GSSP, the AWG indicate an allegiance with the chronostratigraphic programme of the ICS. The AWG are explicit in attributing comments from the ICS executive to their shift in attention towards the GSSP, citing an article written by the former ICS-chair as indication that 'the geological community as a whole is more comfortable with a GSSP,' and that 'therefore, the AWG is currently working towards candidate GSSP selection.'[339] The shift towards a GSSP definition indicates furthermore the acceptable parameters of involvement in the formalisation effort of the AWG. We have already discussed in the previous chapter how efforts to formalise the Anthropocene with a 1610 marker were dismissed, together with diachronous events, or generally any event that could not accommodate a GSSP definition. Even Lewis & Maslin's proposal for a 1964 beginning, based on nuclear fallout, is dismissed because it departs from 'normal stratigraphic practice' insofar as it places the beginning at the peak of the signal, rather than the beginning or on onset of the spike in measurements of sedimentary plutonium deposits.[340] Although the AWG acknowledge the influence of non-geological studies on their formalisation effort, particularly from the Earth System science community, they argue that the phenomena identified by that community (such as the Great Acceleration trends), are not sufficient to define a GSSP in and of themselves. They must be represented chronostratigraphically, that is, using the nomenclature and methods outlined by the ICS.[341]

In this way, the GSSP exercises a normative disciplinarity onto the AWG's formalization effort. It constrains the horizon of possible options, yet in doing so, also renders formalization more attainable, as long as the AWG are prepared to acknowledge the preferences of the ICS

[338] Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.
[339] ibid: 57.
[340] Waters, C., et al. 2015: 53.
[341] See Zalasiewicz, J., Steffen, W., Leinfelder, R., et al. 2017. Petrifying Earth Process: The Stratigraphic Imprint of Key Earth System Parameters in the Anthropocene. *Theory, Culture & Society* 34(2-3): 83-104. On pp. 5-6, they explain:

> Rather than take the stratigraphic signals and ask if they correspond to environmentally significant events, one may take the environmental trends picked out as of major significance to contemporary global change by the [Earth System science] community and consider whether or not they will leave a recognizable signal within strata that may then be used as a basis to create chronostratigraphical units.

They emphasise further that the insights of Earth System science are considered 'in the context of the potential alignment of the modifications to the Earth System to the multiple environmental signals proposed to indicate the transition to an 'Anthropocene state'.'

executive. While this would appear to preclude formal inclusion of extra-stratigraphic concerns into the AWG's proposal, it need not determine the way in which the formalization effort, and formalization itself, is acted upon by everyone other than the ICS. In other words, there is the belief that the formalisation effort of the AWG can proceed in isolation from the greater discursive and historiographic framework of the Anthropocene. The past two chapters have attempted to illustrate how that separation is perceived by the AWG, how the parameters of their formalisation effort are apprehended and articulated in stratigraphic terms. Yet the following two chapters attempt to demonstrate the precise dynamics by which those extra-stratigraphic considerations take part in the formalisation effort of the AWG, and how the evaluative dimensions of that effort are influenced accordingly.

4.3 Conclusion

In this chapter I have recounted a brief history of the GSSP in the twentieth and twenty-first Century. I have done so largely by focusing on the disagreements that emerged in relation to the GSSP. Each disagreement is, to some extent, prefigured in the disputes that come before it. The differences in stratigraphic classification articulated by Kleinpell and Hedberg respectively emerge from the historical process of nomenclature formalisation in geology. These disagreements, concerning, for example, correlation versus definition, or palaeontology versus what Aubry dismissively calls a 'holistic' approach to stratigraphy, reappear, and partly determine, the issues raised by Aubry and her colleagues concerning the stratigraphic relevance of the GSSP. In attempting to resolve discrepancies in chronostratigraphic and geochronologic classification, Aubry highlights the difference of time and rock, and in doing so participates in the opening of an analytic space wherein further proposals are possible, such as consolidating the dual hierarchy. That space exists separate from, and regardless of, the complete intentionality of an author. Aubry may develop her arguments as a way of undermining the significance of the GSSP. However, as those arguments are picked up in the consolidation of the dual hierarchy, they are appropriated towards a total obedience towards the GSSP as the unquestioned standard of stratigraphy.

In his account of contingentism, Mario Biagioli explains that its effects do not necessarily occur chronologically. Continuing his evolutionary metaphor, Biagioli posits that a species of argument may reappear at different times. The survival of an argument at any time is contingent on whether or not it satisfies an ecological niche. Ultimately, the arguments set forth by Aubry and her colleagues appear to have been outdone by the sheer determination to establish the GSSP as the standard of stratigraphic classification. The AWG appear fully aware that the success of a formal Anthropocene unit is similarly contingent on their ability to render its compatibility with the GSSP program. Demonstrating compatability entails shedding certain affiliations. As mentioned above, the influence of Earth System science is slowly distilled from the various Great Acceleration trends, which once even included the worldwide number of McDonald's restaurants[342], to the GSSP potential of Pu_{239} fallout. Clearly then, arguments emerge through processes of elimination, reduction, appropriation, and elaboration. Aubry's argument that a palaeontological interpretation of Hedberg is more historically authentic than the ICS's global stratotype species of "Hedbergarianism" is largely non-existent beyond their own circle, despite attempts to appropriate elements of her critique of time towards a 'simplified' dual hierarchy.[343]

In the next chapter, I would like to focus on this process of contingentist argument formation in real time, i.e. not as reconstructed by reference solely to existing literature. I will take a meeting of the AWG at the Max Planck Institute of Mainz as my sample, and use the discussions held there as a spring board into various artefacts that the AWG have assembled in the manner of a bricolage towards the acceptance of the formal Anthropocene hypothesis. The 'technofossil', which attempts to bridge the palaeontological tradition of stratigraphic definition, and the diverse interests of AWG members, with the ICS's requirement of auxiliary stratotypes in support of a GSSP, is a prime example of the formation of arguments visible in the AWG literature. In this way, the biography of the GSSP conducted in this chapter serves as an opportunity for further reflection on the manner in which the AWG pursue their formalisation effort.

[342] Steffen, W., Grinevald, J., Crutzen, P., et al. 2011: 851.
[343] Simplified in the sense imparted by Zalasiewicz, J., et al. 2004.

5. The AWG meeting of Mainz, September, 2018.

Since their founding in 2008, the AWG have held semi-regular meetings.[344] These meetings are essential for discussion of research, as well as for developing a strategy towards formalisation of the Anthropocene as a geologic unit. Given the international reach of AWG membership, the majority of communication is conducted via email, resulting in lengthy email threads.[345] In 2018, the AWG secured the Max Planck Institute for Chemistry, in Mainz, Germany, as a meeting venue.[346] The meeting took place between September 5-8. Paul Crutzen served as Director of the Atmospheric Chemistry Department of this institute from 1980 until his retirement in 2000, and has since held the position of Emeritus Scientific Member. This was the first meeting of the AWG since their internal vote of 2016, which determined their intention to pursue formalisation of the Anthropocene by GSSP, at the level of Epoch, with a mid-twentieth century primary guide.[347] Over the course of three days, members of the AWG, the Max Planck Institute, and the International Commission on Stratigraphy (ICS), delivered presentations on literature and research surrounding the effort to formalise the Anthropocene as a geologic unit. Through these presentations, and the subsequent Q&A sessions, a strategy was outlined regarding the designation of a GSSP for an Anthropocene unit, together with a suite of auxiliary cores. This strategy relied just as much

[344] In a 2017 article, it is noted that four meetings of the AWG had taken place. These were at the Geological Society of London in 2011, at the Haus der Kulturen der Welt in 2014, the Cambridge University MacDonald Archaeological institute in 2015, and the Fridtjof Nansen institute, Oslo, in 2016. See Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017. The Working Group on the Anthropocene: Summary of evidence and interim recommendations. *Anthropocene* 19: 55-60. In 2018, the AWG held a meeting at the Max Planck Institute in Mainz, Germany. Since then a further two meetings have been held, however these have generally concerned the teams that have proposed GSSP sections, not all of whom are AWG members. Minutes from these meetings are available on the AWG website.

[345] In a jointly written article, the AWG membership explains:

> '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.'

See Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017: 56.

[346] Max Planck Institute for Chemistry. 2018, September 5. Scholars discuss the formalization and implication of the Anthropocene. Available at: https://www.mpic.de/4392246/anthropocene-working-group (accessed 10/5/21).

[347] Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017: 58-59. The results of the 2016 vote have already been outlined in chapter three.

on those presentations that were favourable to the formalisation effort as those that were not (of which there were a few, as we shall see). Presentations that were sceptical of the formalisation effort warned the AWG of potential pitfalls in their pending proposal, which they could subsequently seek to accommodate or resolve. Like the proceedings of the International Geological Congresses discussed in an earlier chapter, the meeting was a survey of the full extent of positions and arguments. Whereas the Congresses sought to establish formal, unifying nomenclature, in the instance of the Mainz meeting it was the formalization of the Anthropocene as a geological unit that discussion sought to resolve. As we shall see, however, the question of formalization draws on, and proceeds from, some unresolved issues of nomenclature. To this extent, the AWG's formalisation effort unfolds partly as an attempt to resolve previously unsettled contentions characteristic of stratigraphic practice.

In this chapter, I review the proceedings from the 2018 AWG meeting. This provides an opportunity to reflect on the articulation of the Anthropocene as a formal unit, emphasising the political, diplomatic, and legislative qualities of the AWG's formalisation effort. The contributions of various members of the AWG are negotiated by more senior members, and particularly those who are familiar with the process of unit formalisation particular to the Chart and Scale, in preparation for the drafting and submission of a formal proposal to the ICS. They must find ways to translate arguments from archaeologists, Earth System scientists, and geographers in a manner that is consistent with the strict preferences of the ICS and IUGS voting members. This effort results in the creation of new categories of earth material, and novel narratives of earth history and geological methodology, as AWG members seek to justify an Anthropocene unit by reference to the precedent of previously defined units.

One example I shall focus on is the incorporation of palaeontological methods into the AWG's narrative of an Anthropocene unit. In an effort to demonstrate the substantial material record that has accumulated since the proposed mid-twentieth century beginning, argued by some to be too brief for there to be any geologically significant record, the AWG pursue the figure of the 'technofossil', a composite of the 'technosphere.' Technofossils, as the idea is advanced by AWG members, are the material remains of socio-technical activity, ranging from the cement foundations of office buildings to plastics laid down in stratigraphic deposits.[348] The technosphere hypothesis amounts to a strategy by which the AWG seek to incorporate the Earth System science definition of the planet as 'interlacing biological, chemical, physical and *socio-economic* processes'[349] in a manner that is in keeping with the established significance of palaeontology for chronostratigraphic definition, such as in the requirement of a lower boundary 'stratotype' or GSSP, often defined by the first appearance of a novel kind of fossil. Arguments such as the *technofossil*, as we shall see, are a demonstration of the AWG's effort to render arguments for a formal Anthropocene unit favourable to the ICS and IUGS voting members, which would otherwise be met by them with disapproval.

Yet the AWG's commitment to the preferences of these voting members also introduces a schism within the Group itself, with some non-stratigraphers feeling that their contributions, and the scientific characterisation of an Anthropocene unit more generally, are being marginalised in favour of the approval of a niche and obscure formalisation procedure whose significance they come to find questionable. In their effort to remix the various contributions of their membership into a single proposal that will satisfy the requirements of unit formalisation, and the preferences of the ICS and IUGS voting members, a contingent of the AWG comprised of geologists, who are familiar with the formalisation process, risk aggravating non-geologist members of the AWG, who feel that an important opportunity is being missed by defining an Anthropocene unit in strictly stratigraphic terms. We shall see, therefore, how in the aftermath of the AWG's meeting at Mainz, a series of papers are published by some AWG members, arguing *against the chronostratigraphic classification of an Anthropocene unit*. The response from those AWG members who are committed to formalisation of the Anthropocene as a unit of the Chart and Scale, indicates a fundamental shift in the priorities of the AWG, from an affiliation with a more general sense of the Anthropocene term as it was invoked by Crutzen (an opportunity for scientist-led *planetary stewardship*; an ethical commitment ignited by anxiety of a changing planet) to a more narrowly defined sense of the Anthropocene as a chronostratigraphic unit (informed by

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[348] See Zalasiewicz, J., Williams, M., Waters, C., et al. 2014. The technofossil record of humans. *The Anthropocene Review* 1(1): https://doi.org/10.1177%2F2053019613514953

[349] See the definition provided in IGBP. 2010. *Strategic Vision*. Available at: http://www.igbp.net/download/18.2709bddb12c08a79de780002812/1376383208857/IGBPDraftvision27September.pdf (accessed 10/05/2021). This definition of Earth System is repeated and expanded in Steffen, W., Sanderson, R., Tyson, P., et al. (eds.) 2004.

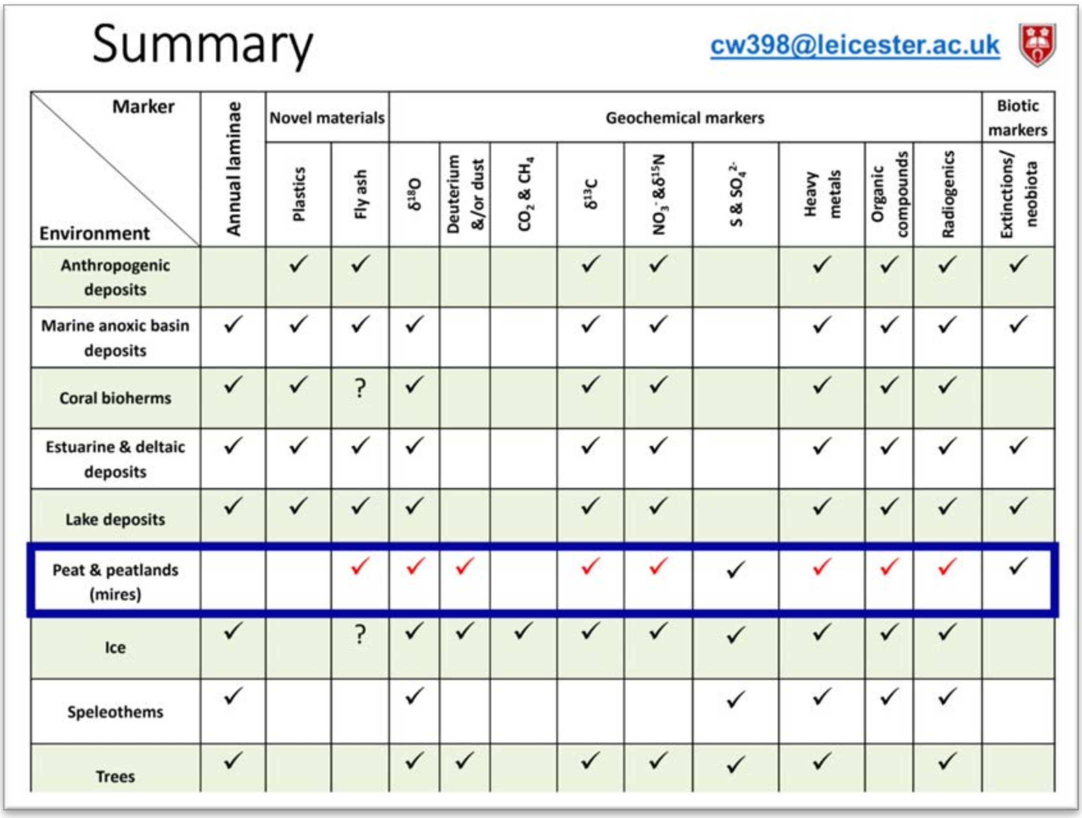
concern from the ICS and IUGS that a hypothetical Anthropocene unit would be a baseless politicisation of the formalisation process associated with the Chart and Scale).

The Mainz meeting together with its aftermath demonstrate the informal economy according to which the AWG develop their proposal for a formal Anthropocene unit. By "informal economy", I refer to two aspects. Firstly, how the AWG construct a proposal for an official unit by soliciting input from diverse sources, chronostratigraphic and otherwise, only to subsequently tailor those contributions to a narrative that anticipates the preferences of ICS and IUGS members. This is a political process to the extent that it foregrounds the importance of anticipating interests and appealing to the preferences of an authoritative group. It is a legislative process to the extent that it must consider the primacy of a particular procedure that dictates the manner in which the stratigraphic characteristics of an Anthropocene unit are to be presented. Secondly, an informal economy is evident in the AWG's effort through the manner in which resources are managed in the absence of substantial or long-term institutional backing and funding. The AWG have made numerous attempts to secure funding from bodies such as the Natural Environment Research Council (NERC) that would traditionally fund geological research, but to no avail (see appendix: 1). As we shall see, an important shift occurs at the Mainz meeting in regards to this second point. Shortly after the Mainz meeting, the AWG confirm a one million euro grant from the Berlin based Haus der Kulturen der Welt. This grant shall greatly influence the trajectory that the AWG continue on today.

5.1 The Presentations: Auditioning the GSSP

Following a dinner on the fifth of September, two days of PowerPoint presentations, Q&A and discussion sessions commenced. We may review some of the proceedings to understand how the AWG developed their strategy for formalisation. The purpose of the presentations was to audition various sites and sections of rock to determine the most appropriate GSSP candidates, together with a suite of auxiliary cores that would support the primary GSSP core. The events of the first day of presentations were largely dedicated to the protocol of unit definition procedures, and the preferences of the ICS and IUGS executive members who would vote on the AWG's proposal. The implications of these presentations shall be considered shortly. First, however, I would like to review some of the presentations concerning the GSSP and auxiliary core candidates, which provide a sense of how the GSSP is defined stratigraphically. It is important to note that while the GSSP is required to be defined in a rock sample, the precise definition of *rock* is flexible in stratigraphic classification. The lower boundaries of the Holocene sub-units, for example, are defined in speleothems and ice. The important point, in other words, is for the GSSP to be defined in regularly deposited material, such that it can be correlated with a geochronological event in time.[350]

Each presentation on a core candidate was delivered by a different member of the AWG, in accordance with their regional and methodological expertise. There were presentations both on specific sites where it was believed a suitable candidate could be extracted, as well as the benefit of particular kinds of stratigraphic signals (i.e. biostratigraphic, chemostratigraphic, etc.). The majority of these presentations included a slide that demonstrated the relative suitability of each core candidate as compared against each other.



Summary

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Marker / Environment	Annual laminae	Novel materials		Geochemical markers									Biotic markers
		Plastics	Fly ash	$\delta^{18}O$	Deuterium &/or dust	CO_2 & CH_4	$\delta^{13}C$	NO_3^- & $\delta^{15}N$	S & SO_4^{2-}	Heavy metals	Organic compounds	Radiogenics	Extinctions/ neobiota
Anthropogenic deposits		✓	✓				✓	✓		✓	✓	✓	✓
Marine anoxic basin deposits	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓
Coral bioherms	✓	✓	?	✓			✓	✓		✓	✓	✓	
Estuarine & deltaic deposits	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓
Lake deposits	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓
Peat & peatlands (mires)			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Ice	✓		?	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Speleothems	✓			✓					✓	✓	✓	✓	
Trees	✓			✓	✓		✓	✓	✓	✓		✓	

Figure 26: A slide featured in numerous presentations concernings GSSP and auxiliary core candidates. The row concerning 'Peat & peatlands (marshes)' is highlighted in this slide because it is from the presentation concerning the site at Etang de la Gruére, which is a marshland. The slide indicates how cores are auditioned for inclusion in the AWG's proposal, which has

[350] Head, M. 2019.

yet to be finalised. Waters, C. & Shotyk, B. September 6, 2018. Session 3: GSSP/auxiliary section proposals. Peat & peatlands: Etang de la Gruére. *PowerPoint Presentation.*

In the case of a presentation concerning a marshland in Switzerland, a case is made for the suitability of marshland environments for the designation of a lower boundary for an Anthropocene unit. Marshlands, for example, make up a total of 4.4. million square-kilometres, or approximately 5% of total land mass.[351] The global distribution of marshlands, extending around the globe, is presented as justification for their suitability as markers of a global change in rock composition.

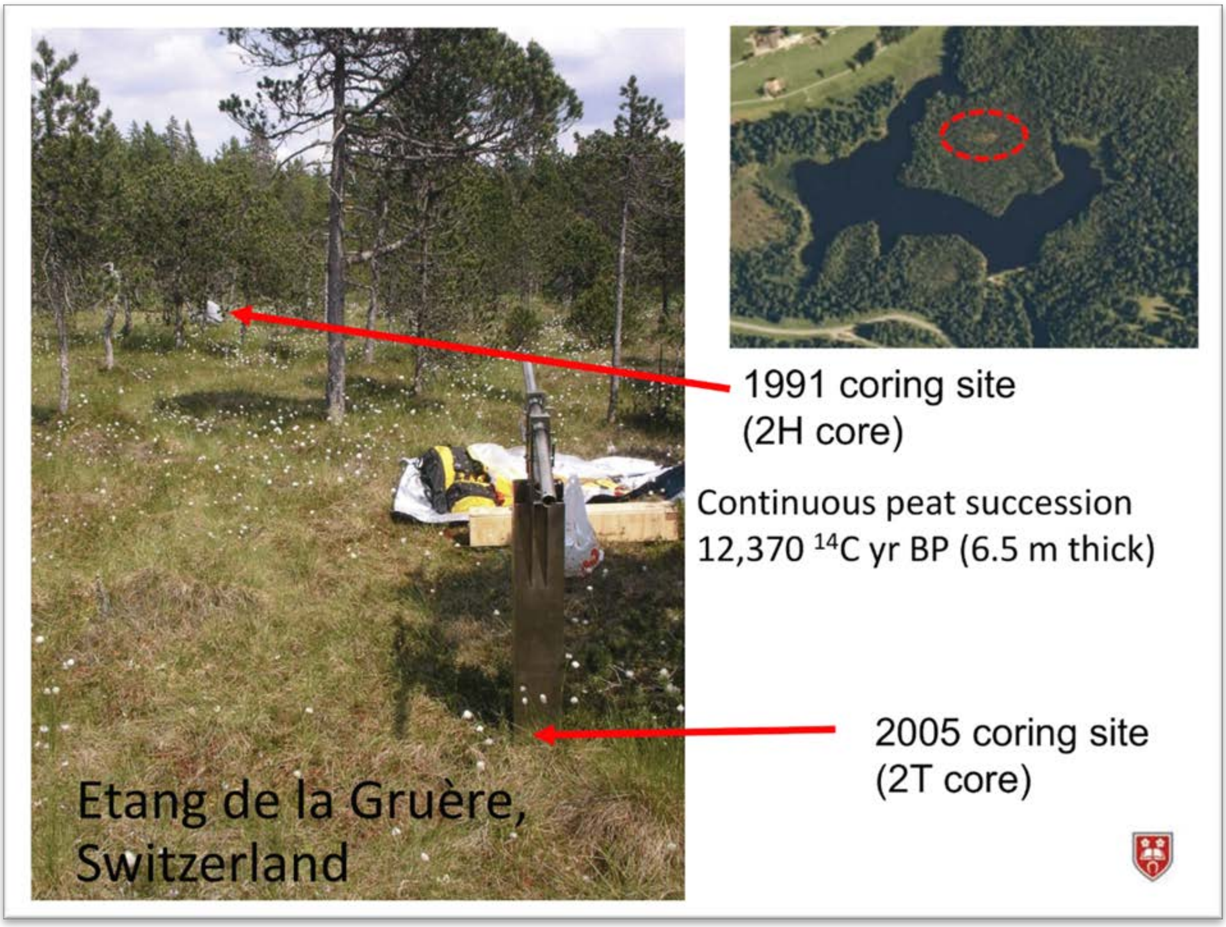

Figure 27: Photograph of the site from which the two cores have been extracted. In the photograph on the left, the device that is used to extract the core is present.

[351] Yu, Z., Loisel, J., Brosseau, D., et al. 2010. Global peatland dynamics since the Last Glacial Maximum. *Geophysical Research Letters* 37(13): https://doi.org/10.1029/2010GL043584

Figure 28:Close-up of the 2T core extracted from the marshland in 2005. The material is deposited in regular sequences, such that a simple ruler can translate the section into a record of geochronological events. The layer that was deposited in 1960 can be analysed to demonstrate changes in the chemical composition of the marshland that could qualify the AWG's proposal for a new Anthropocene unit.

Cores had already been extracted from some sites that were being proposed. In the case of Etang de la Gruére, cores had been extracted in 1991 and 2005 for the purposes of geological research unrelated to the AWG's formalisation effort. Existing studies on core sections from these sites could therefore be used toward their recommendation as a possible GSSP or as an auxiliary core. In a previous chapter, I discussed the role of *circulating reference* in the translation of local rock specimens into a generalised theory of biostratigraphy, and geological *deep time*, i.e. into *geological facts*. These practices were formalised through venues such as the International Geological Congress, and new media such as the Chart and, of course, the GSSP. These are conventions that determine what counts as a *reliable* relation in each stage of the conversion from local and specific samples to allegedly universal and general facts. Presentations such as the one on the Etang de la Gruére core demonstrate the persistence of representaitonal practices in geological classification strategies today. They demonstrate, furthermore, the precise manner in which the AWG attempt to render recent sediments as *geologically* significant, i.e., within the context of a temporality that is far greater than the seventy years or so that have elapsed since the deposition of the strata being presented as a candidate for an Anthropocene GSSP. An account is provided of the various artefacts that are inserted between the unique specificity of an area of marsh in Switzerland, and an Anthropocene unit that is being constructed as a globally correlatable unit of the Chart and Scale. Photographs of field expeditions wherein cores were extracted indicate some of the instruments that take part in the elaboration of geological facts. This includes, for example, the device used to extract cores from the ground. It also includes a simple ruler, which is all that is needed to convert the material core into a record of elapsed geochronological events. Layers of strata, which are often visible to the naked eye, indicate regular deposition of materials. In some samples, a new layer of strata may be deposited once a year. In other environments, new layers may deposited every three months. Radiocarbon dating can be used to determine the precise age of each layer, measuring the half-lives of carbon isotopes. The layers of the core can thereby serve as a reliable, and regular account of the passing of time, the chemical or biological composition of each layer of strata serving as an account of elapsed geochronological events, such as extinction events, or nuclear weapons detonation.

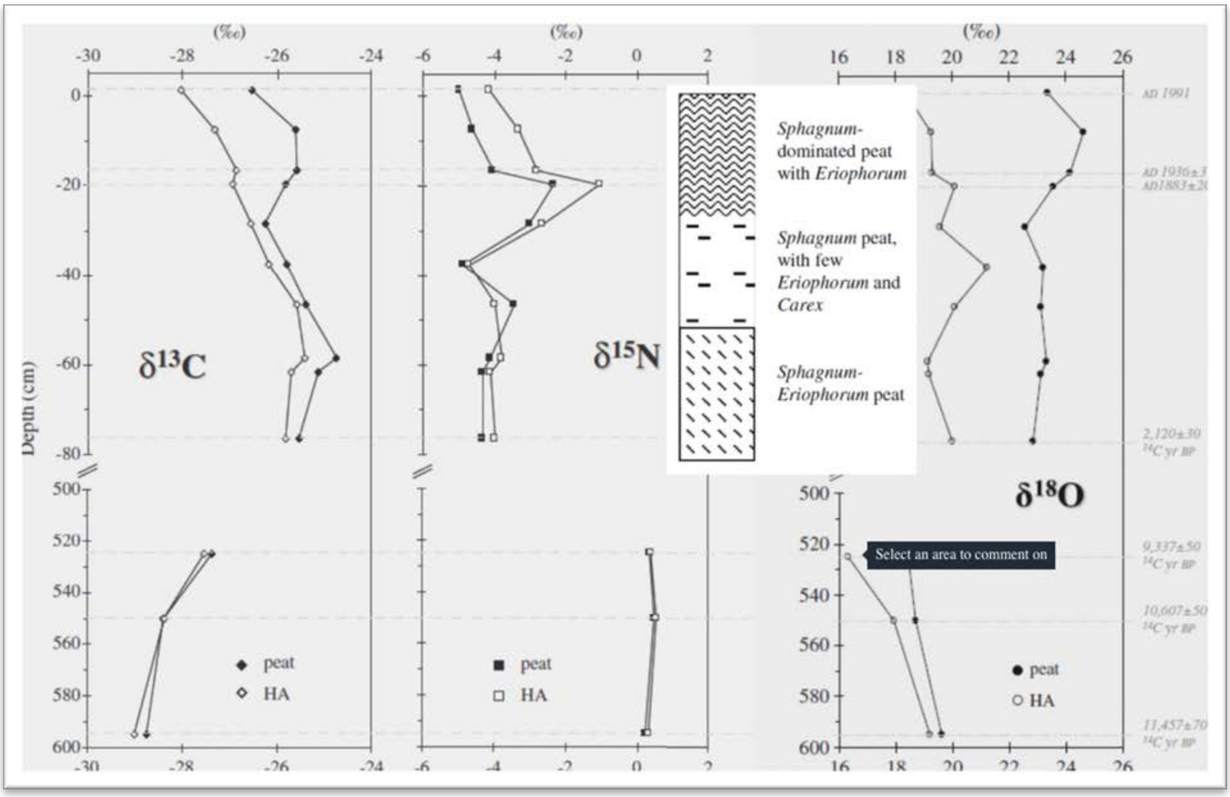

Figure 29: This graph demonstrates the presence of radionuclides that can be carbon-dated to indicate the precise age of each layer of the core. One reason that the Etang de la Gruére is unlikely to provide a GSSP is because it does not demonstrate a clear enough "spike" across different types of radionuclides. Another study regarding the Plutonium content of the Etang cores corroborates this claim. Nevertheless a core from Etang will likely be used as an auxiliary core in the AWG's proposal. This image was featured in the Mainz presentation, but is sourced from Zaccone, C., Casiello, G, Longobardi, F., et al. 2011. Evaluating the 'conservative' behaviour of stable isotopic ratios in humic acids and their reliability as palaeoenvironmental proxies along a peat sequence. Chemical Geology *285: 124-132.*

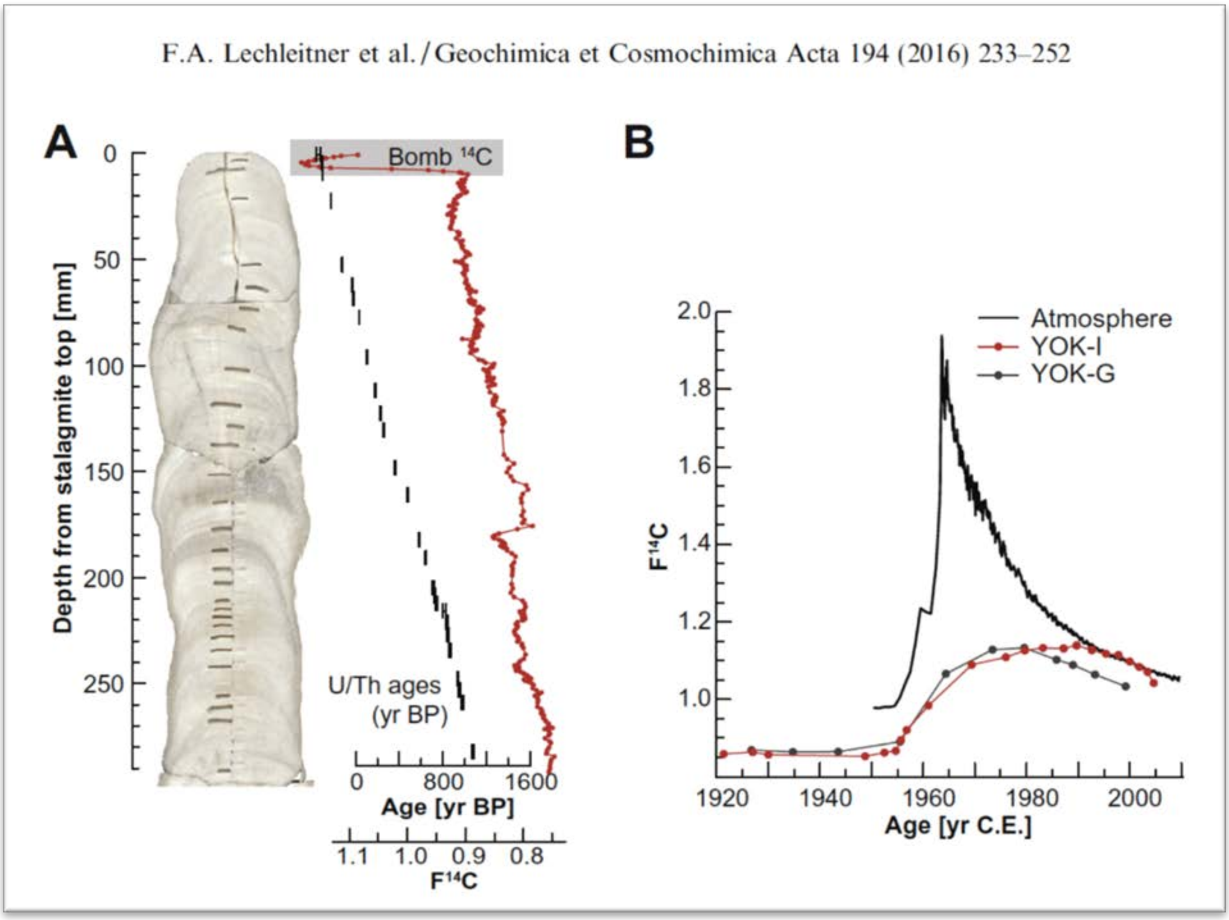

Figure 30: Slide from a presentation delivered at the AWG meeting in Mainz concerning the legibility of nuclear weapons fallout in the rock record using radiometric dating techniques further illustrates the conversion of local rock specimens into chronostratigraphic descriptions, linked to geochronological events. A stalagmite from the York Balum Cave in Southern Belize, Brazil, is superimposed on the a graph depicting changes in ratios of radiocarbon isotopes, with a sharp spike appearing in the stratum deposited in 1950. Source: Hajdas, I. September 7, 2018. 'Bomb Peak' ^{14}C - a time marker. *PowerPoint Presentation.*

Photographs of the site of the core candidate, and the core itself, are placed alongside graphs demonstrating various analyses of the core samples. The cores have been carefully divided into pieces and delivered to laboratories around the world according to the equipment and expertise required by the analysis. The cores are spliced along their vertical axis (because strata accumulate vertically) similar to the way dry spaghetti is removed from its packaging. If one laboratory is not able to conduct all the analyses, either for lack of equipment or relevant expertise, the core will be divided further, as much as its dimensions allow, and be transported accordingly. The membership of the AWG has been composed so as to facilitate an appropriate division of expertise. Irka Hajdas is head of a laboratory at a Zurich university where she can conduct radioisotopic dating analysis. Juliana Assunção Ivar do Sul is completing a post-doctorate at a German university conducting analysis of microplastics in sediment samples. Because the AWG have not received funding with which to conduct any original analysis on cores of their own, they have so far relied on meticulous literature reviews, assembling data from extant studies that could lend themselves to identifying appropriate core sites for an Anthropocene GSSP and auxiliary cores. As we shall see, if funding can be obtained, as it eventually is, members of the AWG will, it is hoped, be able to draw on the resources available to them to accelerate a proposal for a formal Anthropocene unit.

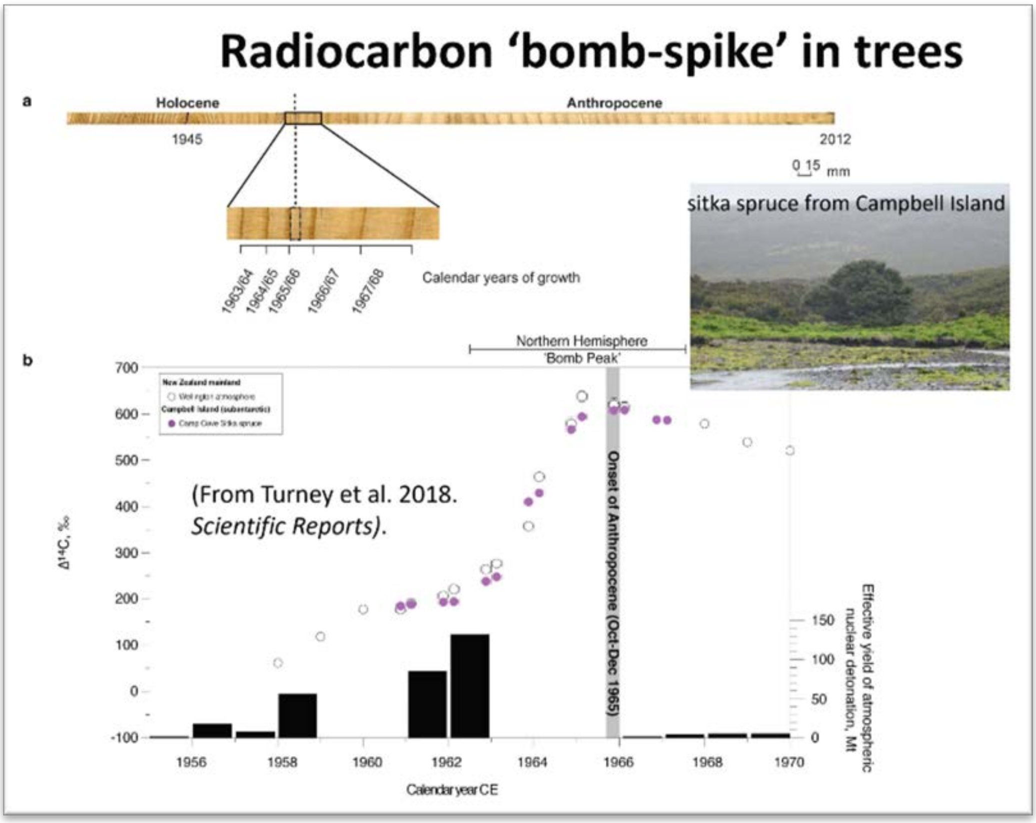

Figure 31: Slide from a presentation delivered at the AWG meeting in Mainz that proposed a tree sample as a possible auxiliary core. The sample is taken from the 'loneliest tree in the world', planted on Campbell Island by Lord Ranfurly, the appointed governer of colonial territories in New Zealand at the turn of the twentieth century. The sitka spruce is not indigenous to Campbell Island. It is thought to be appropriate as an auxiliary core because it demonstrates the global reach of the 'bomb spike' signal, demonstrating a clear spike in radiocarbon isotope ratios resulting from nuclear weapons detonation in the mid-twentieth century, despite being the only tree in a particularly remote location. However, there is no precedent for using living organisms, such as a tree, as a GSSP or auxiliary core for a geological unit, and for that reason may not be included in the AWG's proposal. Source: Waters, C. & Winter, A. September 7, 2018. Session 3: GSSP/auxiliary section proposals: Trees*. PowerPoint Presentation.*

The presentations also audition the core candidates on the basis of other characteristics that are expected of the GSSP. As a boundary Stratotype, the GSSP should ideally contain an abundant and well-preserved biostratigraphic signal (i.e. fossils). It should be sufficiently thick so as to demonstrate a clear and precise change in the stratigraphic record consistent with the preferred geochronological event, which in the case of the AWG, is the onset of a spike in Plutonium isotope ratios in strata (specifically ^{239}Pu) resulting from nuclear weapons detonation.[352] It should have layers that have been deposited relatively frequently and regularly (i.e. preferably once a year, or what are called ‘annual laminations’).[353] However, there are further requirements stipulated of an ideal GSSP. These include, primarily, that the site of the GSSP, or “golden spike”, be easily accessible. The original ICS Guidelines stipulate that ‘if the Stratotype is to fulfil the role of a standard, it should be situated in an area geographically accessible to all who are interested, regardless of political or other circumstances.’[354] This is a requirement that is duly observed in some presentations. A presentation on the Crawford Lake site in Ontario, Canada, emphasises that the site is located in a World Biosphere Reserve, which is generously funded by the International Union for Conservation of Nature, and carefully maintained. It is noted that the site is within one-hundred kilometres of Toronto and Hamilton, ‘both serviced by international airports.’[355]

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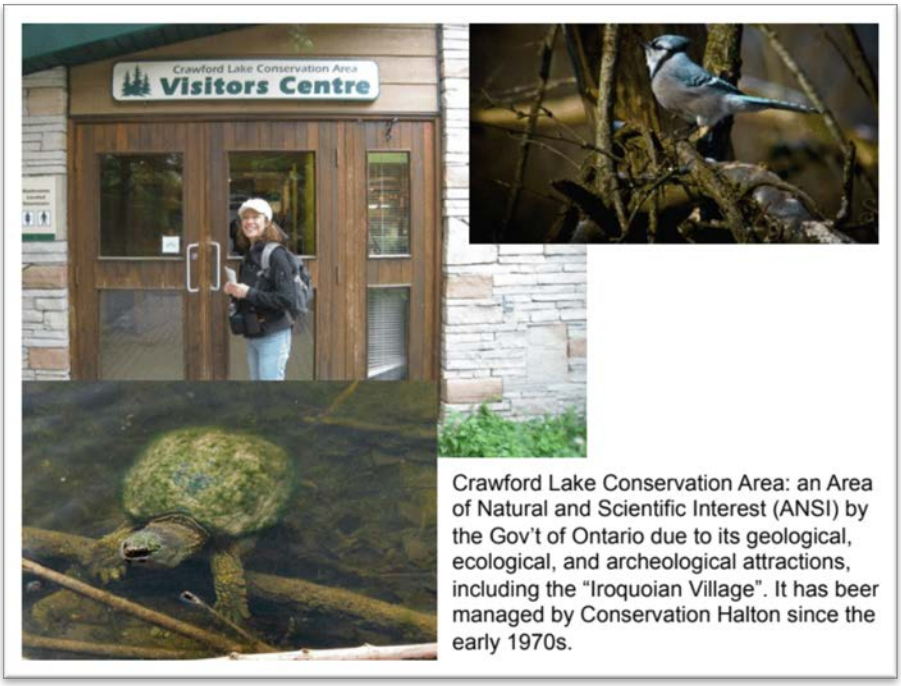
[352] See Waters, C. 2019. Artificial Radionuclide Fallout Signals. In Zalasiewicz, J., Waters, C., Williams, M., et al. (eds). 2019: 192-199.

[353] These are some of the preferences outlined in the ICS Guidelines, most recently in Remane, J., Bassett, M., Cowie, J., et al. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). *Episodes* 19(3): 77-81.

[354] Hedberg, H. (Ed.) 1976: 29.

[355] Head, M. & McCarthy, F. September 7, 2018. *Crawford Lake, Ontario, Canada: a prospective GSSP candidate for the Anthropocene Epoch*. PowerPoint Presentation.



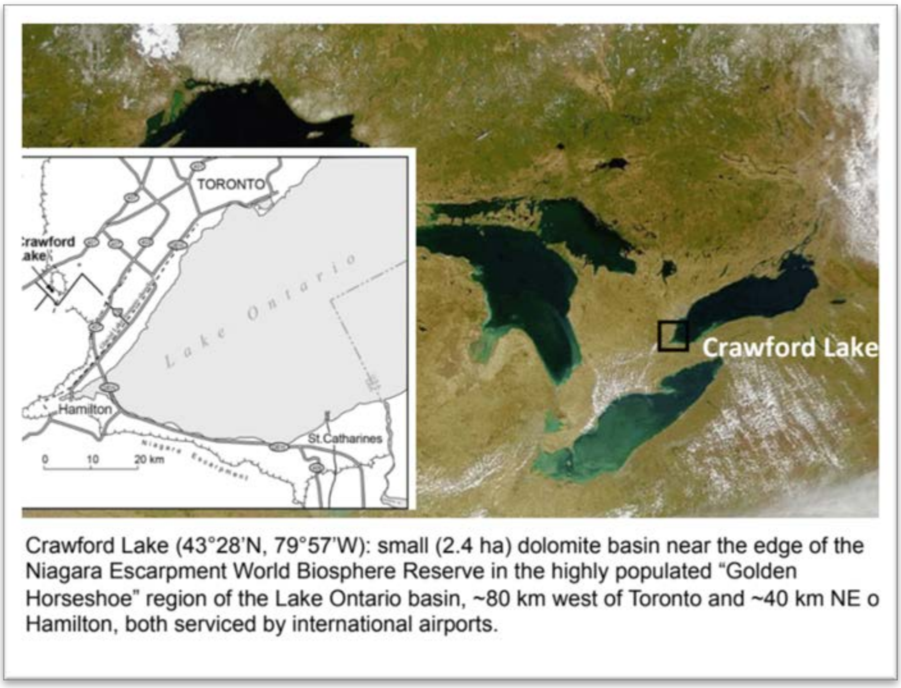


Figure 32:Slides from a presentation delivered at the AWG meeting in Mainz on the suitability of the Crawford Lake site for an Anthropocene GSSP. In addition to demonstration of the chemostratigraphic, lithostratigraphic, and biostratigraphic properties of lake sediments that make Crawford Lake a suitable site, attention was also paid to its accessibility, which is a further preference for a GSSP site according to the ICS Guidelines. Source: Head, M. & McCarthy, F. 2018. PowerPoint Presentation.

Each presentation concluded with a table demonstrating the pros and cons of the respective section candidate. In this way, the meeting was not intended to determine which core would be selected as a GSSP. Rather, the intention was to provide survey of the options that AWG researchers were considering. Waters and Zalasiewicz, the Secretary and Chair of the AWG at the time, stressed that the AWG remained open to new proposals for GSSP and auxiliary core candidates.

Marine Anoxic Basins

For:	Against:
• Undisturbed laterally extensive varves	• Restricted extent (~0.7% of oceans)
• Common environment within which other GSSP sections have been hosted	• Possibility of missing/additional laminae in near-coastal settings due to turbidites
• No/little benthic bio-/anthro-turbation	• Thin strata, e.g. last 75 years e.g. <20 cm for Santa Barbara Basin
• Modification of fluvial input to oceans	• Potential decadal time delay for Pu/metal contaminants to reach sea-bed (peak is more perturbed than onset)
• Clinker ash from steam-powered ships ~1850-1950; microplastics post-1950	• Difficult/costly environment to collect samples without disturbing youngest laminae
• Coastal eutrophication since mid-20th century	
• High organic and clay components scavenge metals, radionuclides, POPs	
• Global radionuclide signal (e.g. ^{239}Pu, ^{14}C)	
• Planktonic foraminifera and diatoms as bio/geochemical signals	

Figure 33: Example of the table that was featured at the end of each core candidate presentation. No definitive decision was taken at the meeting concerning which section would be pursued as a GSSP. Source: Waters, C. September 8, 2018. Session 5: GSSP/auxiliary section proposals – Marine Anoxic Basins: Santa Barbara Basin. *PowerPoint Presentation.*

5.2 The Presentations: Procedural parameters

One of the first presentations at the Mainz meeting was by the Secretary General of the ICS, Phil Gibbard.[356] They did not comment directly on the Anthropocene. Rather, the formal,

[356] Gibbard, P. September 6, 2018. *ICS protocols and key concerns regarding formalisation*. PowerPoint Presentaiton. For the full program and details of the meeting, see Zalasiewicz, J., Waters, C., Damianos, A.

decision making hierarchy of the Geologic Time Scale was outlined. This includes the three rounds of voting by executive committees described in the introductory chapter. The AWG internal vote held in 2016 was acknowledged, but not verified. No formal proposal has been submitted to the first chain in the evaluative hierarchy, the SQS, so there was no place for the Secretary General of the ICS to judge what had been decided at that vote. However, for any unit to be ratified, it must be formalised at a particular rank (Stage, Epoch, etc). What evidence would justify the decision of the AWG to pursue formalisation of the Anthropocene at the level of Epoch? With this comment, Gibbard concluded his presentation on the role of the ICS in the formalisation of geological units.

The formalisation procedure did not come as news to any members of the AWG. However, it served as a reminder that the term 'Anthropocene' could mean whatever anyone wanted it to, but to become a unit of the Chart and Scale, the AWG would need to adhere to the procedure associated with the evaluative hierarchy of the ICS and IUGS.[357] The remainder of the day's sessions presented GSSP and auxiliary section proposals. These presentations outlined the suitability of different sites, from peat bogs to lake deposits, tree rings to noebiota, for procuring sections that could constitute a GSSP candidate for an Anthropocene unit. Not all presentations were favourable toward their object. For example, a presentation on the use of anthropogenic deposits, such as the cement foundations of buildings, or underground train networks, concluded that although such deposits can complement more traditional cores, there has yet to be made a compelling argument for their inclusion in any proposal for stratigraphic unit formalisation.[358] Yet other presentations delivered summaries of ongoing research concerning sites that indicated stratigraphic markers of 'cultural eutrophication', or anthropogenic manipulation of lake sediments[359], as well as of the bomb

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(eds). 2018. *Newsletter of the Anthropocene Working Group*. Vol. 8. http://quaternary.stratigraphy.org/wp-content/uploads/2018/12/Anthropocene-Working-Group-Newsletter-Vol-8.pdf

[357] This procedure is outlined in chapter three of Gradstein, F., Ogg, J., Schmitz, J. 2020. *Geologic Time Scale 2020*. Oxford: Elsevier; largely building off the procedure and requirements established in Cowie, J., Ziegler, W., Boucot, A., et al. 1986. *Guidelines and Statutes of the International Commission on Stratigraphy*. Frankfurt: Courier Forschungsinstitut Senckenberg; as well as Herberg, H. (Ed.) 1976. *International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology, and Procedure*. London: John Wiley & Sons.

[358] It is explained that such deposits 'are unlikely to provide the time resolution needed for an Anthropocene GSSP candidate.' See Zalasiewicz, J., Waters, C., Williams, M. (eds). 2019: 278.

[359] Sediments from Crawford Lake in Ontario, Canada, 'record seasonal changes in the water column… allowing two intervals of cultural eutrophication to be accurately dated.' More recent layers of strata from the same cores 'since 1950 reflect higher mass accumulation rates of calcium carbonate… and total organic carbon.'

spike.[360] In other words, while neither complete nor exhaustive, the presentations were a genuine attempt to satisfy the ICS executive's request for a justification of the Anthropocene as proposed at the level of Epoch/Series. They sought to respond to the concern raised by some executive members of the ICS, regarding whether the Geologic Time Scale is an appropriate venue in which to recognise the impact of human activity on the planet.[361]

In a Q&A session following these presentations, the ICS executive raised concern regarding the placement of the Anthropocene within the Geologic Time Scale. 'The elephant in the room is whether the Anthropocene can be justified at Series status. I personally don't think so. I think it's pointless to create stages and sub-epochs of the Anthropocene.' The ICS executive did not acknowledge the reliability of the arguments from the presentations. They indicated that the arguments may be sufficient for the purposes of unit formalisation, but that what remained to be determined was the rank of an Anthropocene unit, i.e. what kind of unit? A circularity therefore occurs: the AWG are compelled to demonstrate the stratigraphic qualities of an Anthropocene unit, determined to be at the rank of Epoch/Stage. Yet having demonstrated Anthropocene stratigraphy, the AWG are compelled to justify the rank they have assigned to those characteristics.

What deeper dynamics of the AWG's formalisation effort does this indeterminacy reveal? Formalisation of the Anthropocene as a geologic unit entails a careful balancing act on more than one front. Firstly, it entails a balancing act between novelty and redundancy. The AWG hold that with the Anthropocene, Earth has entered a new Epoch in which the material constitution of the planet is fundamentally altered as a result of activity that can be

Waters, C., Fairchild, I., McCarthy, F., et al. 2018. How to date natural archives of the Anthropocene. *Geology Today* 34(5): 182-188. Pg. 183. See also Ekdahl, E., Teranes, J., Guilderson, T., et al. Prehistorical record of cultural eutrophication from Crawford Lake, Canada. *Geology* 32: 745-748.

[360] A stalagmite (called ER77) in north Italy has layers that accumulate regularly every year. These layers have been analysed individually, indicating a sharp peak in radiocarbon isotope ^{14}C, associated with nuclear weapons fallout, beginning shortly after 1950. See Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2018. Global Boundary Stratotype Section and Point (GSSP) for the Anthropocene Series: Where and how to look for potential candidates. *Earth-Science Reviews* 178: 379-429; Fairchild, I. 2018. Geocehmical records in speleothems. In DellaSala, D., Goldstein, M. (eds) *Encyclopaedia of the Anthropocene*, Vol. 1: 205-212.

[361] See Finney, S. 2014. On page 27, Finney states that 'the most fundamental question that must be addressed is whether or not the International Chronostratigraphic Chart/Geologic Time Scale is appropriate for application to chronometers of recorded and future human history.' This is a premise that has motivated much of the work of the AWG, both to determine that the Anthropocene can be defined at a scale consistent with the organization of the Time Scale, and that the impacts recorded are not merely chronological but also stratigraphic.

associated with human activity.[362] Yet to be formally recognised as a unit of the Geologic Time Scale, the Anthropocene must, to some extent, resemble other units of the Scale. The phenomena associated with an Anthropocene unit are therefore both unprecedented and potentially capable of being categorised as a unit of the Chart and Scale. It is proposed as an Epoch/Series, and therefore of far less significance than higher ranking units, such as the Quaternary System/Period. An Anthropocene unit would therefore be novel by comparison with the Holocene Epoch/Series, which an Anthropocene unit would terminate; yet it is presumably redundant within the Quaternary System/Period, within whose envelope of variable parameters it resides.[363] The technofossil and technosphere provide one solution to this paradox, as we shall see, wherein recent anthropogenic deposits are rendered consistent with palaeontological markers, despite not being "paleo", or old, in the geological context of a four and half billion year old planet. The GSSP also provides a central strategy for formalising the Anthropocene despite scepticism. Like fossils, the GSSP is figured as a neutral arbiter of classification, even though these artefacts are open to constant recombination. For example, as shall be discussed shortly, the formalisation of three new sub-units of the Holocene at Stage/Age rank, with GSSPs, provides a further strategy for the Anthropocene to be posited as both unique and yet similar to existing precedent within stratigraphy.

The second balancing act that is required of the AWG is between encouraging contributions from diverse disciplines and remaining in accordance with the strict requirements of stratigraphic classification. The AWG boasts of the diversity of disciplines that

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[362] In their first article on the topic, Zalasiewicz and his colleagues at the Geological Society of London write that 'since the start of the Industrial Revolution, Earth has endured changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene or of previous Pleistocene inter-glacial phases, encompassing novel biotic, sedimentary, and geochemical change.' See Zalasiewicz, J., Williams, M., Smith, A., et al. 2008: 4.

[363] The AWG initially proposed the Anthropocene at the level of Series/Epoch because of the suffix 'cene' that had been attached to it by Crutzen on a spur of the moment announcement. They have stated that they wished to test Crutzen's hypothesis by considering whether there the scale of the modifications was adequate to that rank, thereby terminating the Holocene. Yet in the same paper, they also posit that the Anthropocene could 'arguably be of Period/System scale', i.e. at the rank of Quaternary, which is one rank higher than the Holocene. This is not a suggestion that has been pursued further, most likely because the proposal for the Anthropocene at Series/Epoch level is contentious enough as far as most chronostratigraphers are concerned. See Waters, C., Zalasiewicz, J., Williams, M., et al. 2014. A Stratigraphical basis for the Anthropocene? In Waters, C., Zalasiewicz, J., Williams, M., et al. (eds) *A Stratigraphical Basis for the Anthropocene*. London: Geological Society of London Special Publication 395: 1-22. As we shall review further down, a primary reason the proposal to terminate the Holocene with the Anthropocene is thought to be contentious, is because the Holocene is partly defined in recognition of the humans as 'influencing natural systems'. See Gibbard, P. & Walker, M. 2014.

comprise its membership.[364] These affiliations have been crucial in refashioning deposits, as well as diverse phenomena, from McDonald's restaurants to energy consumption, as possible stratigraphic markers.[365] Yet they have also attracted criticism from executive members of the ICS and IUGS, who argue that the AWG is conflating the preoccupations of historians, sociologists, and climate change scientists with the distinct work of stratigraphic classification.[366] Scepticism from the stratigraphic community has led executive ICS and IUGS members to reiterate that the Anthropocene can have whatever meaning one wishes, yet to achieve formalisation, the AWG must acknowledge that, in the words of one executive member, 'the definition of the base of the Anthropocene must conform to the same stratigraphic principles [as those that determined the Holocene GSSP].'[367] In response to these warnings, the AWG have adopted greater determination towards the definition of a

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[364] See, for example, the contribution of some senior AWG members to the most recent Geologic Time Scale publication, which dedicates a chapter to the Anthropocene as an informal term. The AWG membership is described thus:

> The AWG developed as a considerably more diverse body than is typical of ICS working groups, as the Anthropocene time interval is one where geological processes overlap not only with a range of human forcings but with an increasingly detailed and sophisticated observational record of both human-drive and Earth processes: hence it includes not only stratigraphers but [Earth System] scientists, oceanographers, historians, archaeologists, geographers and even an international lawyer, to include consideration of questions of potential wider societal relevance.

See Zalasiewicz, J., Waters, C., Williams, M. 2020. The Anthropocene. In Gradstein, F., Ogg, J, Schmitz, D., et al (eds) *Geologic Time Scale 2020*. Oxford: Elsevier. Pp. 1257-1280. Pg. 1258.

[365] McDonald's restaurants and energy consumption were both featured among the many Great Acceleration charts, demonstrating a sharp spike around 1950. These charts have featured in the AWG's literature since their first collection of essays with the Royal Society in 2011. In the AWG's internal votes of both 2016 and 2018, it was decided that a mid-twentieth century signal would be the primary guide for an Anthropocene GSSP. The most recent analysis of the AWG, similarly, has emphasised energy consumption as a further key index of the Anthropocene. See Steffen, W., Grinevald, J., Crutzen, P., et al. 2011. The Anthropocene: conceptual and historical perspectives. *Phil. Trans. Roy. Soc. A.* 369(1938): 842-867, especially pp. 851-852; Zalasiewicz, J., Waters, C., Williams, M., et al. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383:196-203; Syvitski, J., Waters, C., Day, J., et al. 2020. Extraordinary human energy consumption and resultant geological impacts beginning around 1950 CE initiated the proposed Anthropocene Epoch. *Communications Earth & Environment* 1(32): 1-13.

[366] See for example Finney, S. & Edwards, L. 2016.

[367] The full quote reads:

> If a Holocene/Anthropocene boundary is to have the same credibility, then it must be underpinned by anthropogenic events that are as globally significant as the natural events that form the basis for the proposed Holocene GSSPs. In other words, the definition of the base of the Anthropocene must conform to the same stratigraphic principles.

Gibbard, P. & Walker, M. 2014: 33.

GSSP. We have already reviewed the limitations of the GSSP method, which requires a single stratigraphic section to determine the lower boundary of a unit, both globally and synchronously. Such strict requirements do not necessarily accommodate the contributions made to the AWG's formalization effort by non-stratigraphers, such as archaeologists, or geographers, for whom a mid-twentieth century boundary poses serious problems: does that mean that anything pre-1950 is not properly associated with an increase in anthropogenic modification of stratigraphic deposits? Those members of the AWG have responded to the limitations of the GSSP method by criticising the need for a stratigraphic definition of the Anthropocene at all; i.e. undermining the fundamental effort of the AWG, exposing the Group to further criticism both from within and externally, from the stratigraphic community at large.

We shall return to this predicament further down. For now, this is raised to indicate that the events of Mainz were a display of the strategies devised by members of the Group to navigate the balance between novelty and redundancy, the disciplinarily diverse appeal of 'the Anthropocene' as a discursive theme, and the strict limitations of stratigraphy. The purpose of this chapter is therefore to demonstrate how the AWG craft a description of an Anthropocene unit in response to, or in anticipation of, the formalisation procedures mapped out by the evaluative committees associated with the Chart and Scale. Of course, it is not possible to fully anticipate something that has yet to occur. As the archaeologist-led internal fraction of the AWG indicates, any attempt to act in anticipation of an envisioned outcome generates further unanticipated outcomes of its own. In this chapter, we shall review the unfolding of these efforts, to attempt to understand why the AWG addresses the problems it faces in the manner it does, and what consequences arise therefrom.

5.3 The technofossil: Fossil forensics

In the previous chapter, we examined the significance of palaeontological markers, such as fossils, for defining geological units, as well as in negotiating stratigraphic normativity. We established that in adopting the boundary stratotype method, the GSSP encourages additional approaches, such as chemostratigraphy or radiometric dating, in addition to biostratigraphy. This is evident in GSSP definitions of more recent units, which tend to be defined with climatologic or chemostratigraphic markers, in addition to (although sometimes even without) biostratigraphic signals.[368] Nevertheless, palaeontology remains central to the Geologic Time Scale.[369] Most GSSPs are defined by biostratigraphic markers.[370] This is because geologists have traditionally been reliant on fossils to provide them with accounts of their object of study. A hypothetical Anthropocene unit aside, geologists have not had access to the events that they describe. They piece together an account of the gradual changes that Earth has endured over millions of years by soliciting accounts from their material remains. The technofossil reverses this temporality. The technofossil provides geologists with an account of a chronostratigraphy that is ongoing into the future. In anticipation of the ICS & IUGS executive judgement, it is therefore important to be able to refer to palaeontological markers, even if they are for an auxiliary, not the primary GSSP, core.

In an earlier chapter, I developed a brief history of how the fossil emerged as a forensic medium. The fossil facilitated the articulation of historiographic frameworks, to tell, and retell, the history of earth; both overall and by reference to discrete episodes. I described how in 1668, following Steno's example, Robert Hooke devised a novel category of artefacts: 'natural antiquities.' These artefacts were 'natural' as distinguished from the general category of antiquities associated with the history of human civilization, such as vases, swords, or coins. Observers used these artefacts to fabricate a historical account of human and societal time. Shells and petrified wood, on the other hand, suggested something apparently of genuine novelty: The Earth itself had endured a history of its own, 'outside' human activity. Like the artefacts of antiquity, it was possible to solicit a historiographic account from them

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[368] Such as the recently defined subdivisions of the Holocene. See Head, M. 2019. Formal subdivision of the Quaternary System/Period: Present status and future directions. *Quaternary International* 500: 32-51.

[369] Members of the AWG acknowledge the continued significance of biostratigraphy, stating:

> Fossils are used in geology for two main reasons. Firstly, abundant, diverse and well-preserved fossil successions are sought, in unbroken sedimentary successions, to provide abundant evidence not only directly for ecological and evolutionary change but also for use as proxies for climatic, oceanographic and other types of planetary change. Scondly, fossils are used routinely to date natural exposures or borehole succssions of sedimentary deposits and to allow those to be correlated with each other by being placed in the chronological framework of the Geological Time Scale.

See Williams, M., Barnosky, A, Zalasiewicz, J., et al. 2019. Fossils as Markers of Geological Boundaries. In Zalasiewicz, J., Waters, C., Williams, M., et al. (eds) *The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate*. Cambridge: Cambridge University Press. Pp. 110-115. Pg. 111

[370] A full list of GSSPs and their definitions is available on the ICS website at https://stratigraphy.org/gssps/ (accessed 23/1/21).

concerning changes in the material constitution of Earth and life, or planetary genesis. Equating these two artefacts was a subtle yet radical gesture. The notion that Earth had a history independent of humanity was not consistent with the religious framework according to which the earliest efforts to date the planet, and recount elapsed earth processes, proceeded. The attempts of figures such as Ussher and Burnet indicate a gradual evolution of forensic techniques with which a general sense of geologic *deep time* was articulated and represented.

Material artefacts, and the demonstrative method, provide naturalists with a way out of exclusive reliance on scripture. They provided a means of understanding the material environment where the Bible was unable to fill increasingly apparent gaps in an emergent narrative of an independent history of the Earth, even before the appearance of humanity. This method has proved especially prescient for geologists. In attempting to determine the age of the Earth, and following from Newton's theory that the Earth was once a fragment of the Sun, George-Louis LeClerc heated metal spheres to see how long it would take until they were too hot to touch. He deduced from these experiments that seventy-five thousand years had passed since a molten globe, which would become Earth, chipped off from the Sun after a meteorite impact. Acknowledging significant margins of error, he posited this figure as a conservative estimate. Although one reason for this conservatism may have been less concerned with humility and more concerned with wishing to save face in light of the predominant belief in the validity of the Bible's accounts of an Earth far younger than today's accepted age of 4.5 billion years. Nevertheless, experiments of this kind provide the impetus for a narrative of Earth history wherein a literal interpretation of scripture was replaced by an interpretation of material artefacts informed, but not determined, by the Bible. The radical nature of such gestures is evident in naturalists' willingness to grant priority to that which is observed in their own material environment, such as the heating of a sphere, or the appearance of fossils in the earth. These observations were now the starting point with which to *verify* scripture, a significant transition from the time of earlier naturalists, such as Burnet[371], for whom scripture was the ultimate referent according to which a narrative of Earth history could unfold.

[371] Thomas Burnet's 1681 *Sacred Theory of the Earth* took the Bible as the sole reliable account of the history of the planet. It was even believed that there existed an 'unbroken line of records or memories stretching back

5.4 The Technofossil: Palaeontology of the present

I recall the above episodes again here to contextualise the technofossil, to present it as a further elaboration of the forensic capacity of the fossil. Within the AWG's formalization effort, the technofossil is mobilised as a device with which to anticipate an unfolding stratigraphy. Whereas the fossil, or natural antiquity, constituted a strategy with which to gain access to an otherwise inaccessible past, the technofossil facilitates a mode of stratigraphic observation that is *anticipatory*. The technofossil is furthermore a prime strategy by which the AWG seek to characterise an Anthropocene unit in a manner that is consistent with the requirements of formalisation stipulated by the ICS and IUGS.

The term 'palaeontology' comes from the Greek *palaeo*, meaning old, and *ontologia*, the study of being or existence. Within the context of geologic deep time, palaeontology may refer to remains that are several billion years old.[372] The AWG currently propose that the Anthropocene began in the mid-twentieth century, less than a century ago. There is therefore nothing "old" about the Anthropocene, geologically speaking. Nevertheless, AWG have developed a strategy to apply the biostratigraphic principles of palaeontology to recent deposits. Neobiota-biostratigraphy, or fossil remains from invasive species, are an exemplary material with which to elaborate a palaeontology of the present, providing novel biostratigraphic markers for an Anthropocene unit.[373] In San Francisco Bay, for example, research has been conducted over the past two hundred years indicating an accelerating trend of new species being introduced that accelerate the extinction of incumbent species,

to Noah and his family, who had been on board the Ark and had witnessed the Flood first hand.' Rudwick, M. 2014: 20. Accordingly, Burnet divides the planet into seven stages, in accordance with the Bible's account of the seven days of creation. On the frontispiece of his book, one sees an image of God, at whose feet the seven stages of the planet unravel, and around whose head, like a halo, is written, «εγώ είμαι το Α κι το Ω» (I am the Alpha and the Omega). As Stephen J. Gould remarks, 'the necessary concordance of God's words and works established harmony between physics and scripture as necessary *a priori*.' Any account of the planet, in other words, beings and ends with divinity. See Gould, S.J. 1986: Pg. 28.

[372] McGowran, B. 2008. *Biostratigraphy: Microfossils and Geological Time.* Cambridge: Cambridge University Press, especially chapters one and three.

[373]Noebiota are defined by the AWG as 'species that have extended beyond their pre-anthropogenic geographical range as a result of deliberate or accidental human introduction; for example, the widespread introduction of the Pacific rat across the isalnds of Polynesia.' ibid: 118. This is a trend that is accelerated with global transport of goods, and the unexpected castaways that travel with commercial vessels; for example, marine life that sticks to the bottom of boats, or creatures hidden in the vessels.

rapidly changing the fossil ingredients of the stratigraphic record.[374] It is argued, moreover, that the biostratigraphy of neobiota are preferable to stratigraphic markers of extinction, because the latter are locally distributed by comparison with neobiotic invasion resulting from international exchange of goods, which is consequently global and confined to a (geologically speaking) brief interval of post-World War II boom in global trade.[375]

The fossil therefore remains a central medium with which the AWG develop their proposal for an Anthropocene unit; its urgency emphasised. However, the AWG have also developed a more ambitious discursive strategy with which to designate an Anthropocene unit. The technofossil extrapolates from the categorical logic of the fossil, and biostratigraphy, in service of the AWG's formalisation effort. It fashions a geological temporality that accommodates the comparatively brief duration of a potential Anthropocene unit. It facilitates the articulation of an Anthropocene lower-boundary consistent with the requirements of the GSSP, using materials that have not previously been used in that context, such as plastics, or styrofoam. This is a politically prudent gesture from the AWG given that most GSSPs are defined in biostratigraphic markers. Whereas it has been argued that geochronological events associated with an Anthropocene unit are simply too recent to justify a new unit (given that many geologic boundaries have margins of error far greater than the total elapsed time an Anthropocene unit would have endured to date), the technofossil indicates that there is nevertheless the appropriate material, or *chronostratigraphic*, evidence to support the stratigraphic expression of a mid-twentieth century event. The AWG, after all, only seek to define the lower boundary, or "beginning" of an Anthropocene unit, not its duration.[376] And yet, the fossil provides a medium with which to imagine a geological

[374] ibid: 124-126. See also Cohen, A. & Carlton, J. 1998. Accelerating invasion rate in a highly-invaded estuary. *Science* 279: 555-557. It was discussed at the Mainz meeting that if a core could be extracted from 'neobiota-based stratigraphies' such as the San Francisco Bay and other discussed in Williams, M., et al., 2019 they could be included as auxiliary cores in the Anthropocene GSSP proposal.

[375] ibid: 118. The broiler chicken provides a further, compelling example. It is argued that with the beginning of the Chicken-of-Tomorrow Program, a program of the United States Department of Agriculture that sought to encourage the cultivation and consumption of chickens, the anatomy and abundance of chickens changed rapidly. Chickens were genetically modified to provide more meat, and their consumption increased globally to such an extent that there is a global, synchronous record of chicken bones from landfills around the world that exhibits high-resolution correlation potential. See Bennett, C., Thomas, R, Williams, M. et al. 2018. The broiler chicken as a signal of a human reconfigured biosphere. *R. Soc. open sci.* 5: 180325. https://doi.org/10.1098/rsos.180325.

[376] See Zalasiewicz, J., Waters, C., Williams, M. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383: 196-203.

temporality wherein the events and material associated with an Anthropocene unit *will be geologically significant*, as if by extending an Anthropocene unit into the future we can already appreciate a duration of geological proportions that has yet to occur. Anticipating the geological record of the Anthropocene, Crutzen notes:

> Imagine our descendants in the year 2200 or 2500. They might liken us to aliens who have treated the Earth as if it were a mere stopover for refuelling, or even worse, characterize us as barbarians who would ransack their own home. Living up to the Anthropocene means building a culture that grows with earth's biological wealth instead of depleting it. *Remember, in this new era, nature is us*.[377]

Of course, even five hundred years is geologically negligible. Yet the point is that the technofossil captures the sentiment expressed in this passage, and renders it such that it can be delivered as a stratigraphic observation.

The technofossil is an artefact that is said to derive from the 'technosphere', which the AWG define as the 'interlinked set of communication, transportation, bureaucratic and other systems that act to metabolize fossil fuels and other energy resources… with similarities to the lithosphere, atmosphere, hydrosphere and biosphere.'[378] The notion of 'spheres' has an iterant, discontinuous history. 'Atmosphere' is the earliest of the spheres to have been coined, in 1638. It was initially observed as a phenomena not of Earth, but of the moon. The English clergyman, natural philosopher, and co-founder of the Royal Society, John Wilkins, claimed: 'That there is an Atmo-sphaera, or an orbe of grosse vaporous aire, immediately encompassing the body of the Moone.'[379] 'Lithosphere' and 'biosphere' appear for the first time in the writings of the geologist Eduard Suess. Both terms are coined, almost in passing,

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[377] Crutzen, P. & Schwägerl. 2011. Living in the Anthropocene: Toward a New Global Ethos. *Yale Environment 360*. https://e360.yale.edu/features/living_in_the_anthropocene_toward_a_new_global_ethos (accessed 15/01/2021).

[378] Haff, P. 2014. Technology as a geological phenomenon: implications for human well-being. In Waters, C., Zalasiewicz, J., Williams, M., et al. *A Stratigraphical Basis for the Anthropocene*. London: Geological Society of London Special Publications 395. Pp. 301-310. Pg. 301. See also Haff, P. 2014. Humans and technology in the Anthropocene: Six rules. *The Anthropocene Review* 1(2): https://doi.org/10.1177%2F2053019614530575

[379] Wilkins, J. 1638. *The Discovery of a World in the Moone.* London: Michael Sparl & Edward Forrest. Pg. 138

in the context of a geological account of the Swiss alps.[380] In this book, Suess develops an account of multiple spheres referring to distinct domains that correspond and interpenetrate:

> [O]ne thing seems to be foreign on this large celestial body consisting of spheres, namely, organic life. But this life is limited to a determined zone at the surface of the lithosphere. The plant, whose deep roots plunge into the soil to feed, and which at the same time rises into the air to breathe, is a good illustration of organic life in the region of interaction between the upper sphere and the lithosphere, and on the surface of continents it is possible to single out an independent biosphere.[381]

In subsequent publications, Suess attempts a far more ambitious task of accounting for the geological features of the entire 'face of the Earth', as the book's title proclaimed.[382] His analysis shares an interest in fossils and correlation developed by Hooke and Steno, yet he integrates his observations via the idiom of the 'sphere'; i.e. situates them in a continuous process rather than observing them as one off events that must be forensically recounted. Suess posits that oceanic activity, such as the rise and fall in sea levels over millennia, leaves a stratigraphic record that can be correlated across the planet. Key in this method of correlation is the presence of fossils, which appear in layers that reveal the passing of time as both regionally variable and yet ultimately globally consistent.[383]

The technosphere follows up on both traditions of sphereology. It seeks to insert itself as an emergent dynamics of earth system processes, building on the vocabulary of Earth System Science to which the formalisation effort of the AWG remains indebted. In doing so it lays claim to its own class of artefacts, which appear all over the world and thereby demonstrate global correlation potential. This strategy of appropriating characteristics of

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[380] See Suess, E. 1857. *Die Entstehung der Alpen.* Vienna: Wilhelm Braumüller.

[381] Quoted in Smil, V. 2002. *The Earth's Biosphere: Evolution, Dynamics, and Change.* Cambridge: MIT Press. Pg. 2. Suess's attempt to articulate the interpenetration of various spheres was visionary for his time, but retrospectively reads quite conservative, for example he entirely omits marine life or microbial life from his description of the spheres. Some fifty years would pass before Suess's notion of biosphere was developed more extensively by the Russian scientist Vladimir Vernadsky. See Vernadsky, V. 1998 (1926); Guillaume, B. 2014.

[382] See Suess, E. 1904 (1899). *The Face of the Earth*. Oxford: Clarendon Press. Suess uses this term to refer to 'the whole of the animal world'. See pg. 210.

[383] See for example, chapter three of Volume II from *The Face of the Earth*, wherein the layering of fossils is used to construct a geological account of the entire Pacific region. ibid: 143-157.

"spheres" to articulate attributes of the Anthropocene thought to be both self-evident and yet entirely novel, is apparent:

> The technosphere comprises the interconnecting technological systems that underpin modern human civilization, and is a phenomenon that has now reached a scale sufficient to perturb the natural physical, chemical and biological cycles of the Earth… we suggest that the incoming of certain materials (e.g. mass-produced plastics and aluminium) and the objects made from them (cans, bags) may provide useful marker levels. Given the rate of technological progress, technostratigraphic divisions may encompass as little as a decade. The middle of the 20th century has seen a change from local technostratigraphies to, essentially, a global one, enhancing the potential of this time level as an appropriate and perhaps formal Anthropocene beginning.[384]

The technosphere is developed as a rhetorical strategy with which to pattern the technofossil, and sediment of the recent past, within the procedural and evaluative requirements associated with the Chart and Scale.

Technofossils, which the AWG elaborate as derivative of the technosphere, are those materials and objects that provide useful markers, and take on global correlation potential within the condensed timeframe of the late Twentieth Century. Considerable thought is given to the elaboration of this category. Technofossils, as the AWG explain them, are not just the "material and their objects": they imitate palaeontological fossils to the extent that they can also appear as *trace fossils*, or anything that indirectly indicates the presence of those materials in a stratigraphic section. And yet, technofossils of all kinds remain distinct by virtue of the entirely novel material from which they are made. Bees, for example, leave a trace in the form of honey-comb wax hives. Spiders produce distinctive silk webs. 'In all of these cases, however', argue the AWG, 'the diversity of composition consists almost exclusively of organic materials.'[385] Furthermore, the variety of materials associated with fossils from bees, either their bodies or traces, remains limited in scope. By contrast, technofossils are traces of, or are themselves, 'artefacts from materials that are either very rare in nature (uncombined iron,

[384] Zalasiewicz, J., Williams, M., Waters, C., et al. 2014: 40-41.
[385] ibid: 36.

aluminium and titanium) or unknown naturally (uncombined vanadium, molybendum).'[386] Consistent with the Great Acceleration thesis, moreover, both the variety of such materials and their total mass is growing, and typically increases exponentially shortly after 1950.[387]

The notion that material such as aluminium, titanium, or sytrofoam are 'unnatural' is a decision of the Anthropocene Working Group, which aspires to justify the novel category in the context of stratigraphic discursive strategy. The technofossil argument posits a distinction between "natural" and "unnatural" material, the consequence of which is to fashion recent deposits as stratigraphically relevant. Plastic, Styrofoam, and refined metals (to name a few), are fashioned as forensic indices of Anthropocene stratigraphy. The gesture of the technofossil is to fold recent history into geological deep time by reference to the anticipated longevity of contemporary deposits. This produces a kind of conceptual whiplash: we are used to thinking of a plastic cup, for example, for only as long as it takes to consume its contents; the technofossil situates such items within the expansive temporality of 4.5 billion years of Earth history. The paradox of consolidating these two temporalities into a single class of artefacts is indicative of the forensic capacity of artefacts to illicit radical narrative accounts. Whether the technofossil presents as radical a gesture as Hooke and Steno's "natural antiquities" is, in the case of a formal Anthropocene unit, for the IUGS to decide. Yet the reoccurrence of this gesture is not a coincidence. If geologists are especially skilled at refashioning artefacts to become witnesses of vertigo-inducing temporalities, it is because they have traditionally been at the mercy of these silent witnesses. Geologists almost never directly observe that which they study. Even the most recent geological unit, the Meghalayan Stage/Age, began over four thousand years ago. What is perhaps so compelling about the hypothesis of an Anthropocene unit is that it interrupts this trend. Hypothetically, we are all witnessing the Anthropocene, and many have witnessed the *beginning* of the Anthropocene, i.e. the mid twentieth century (which is the primary guide for an Anthropocene GSSP). The

[386] ibid.

[387] For example, the number of motor vehicles, telephones, and McDonald's restaurants are included among the Great Acceleration charts, all of which spike shortly after 1950. These are entities that require materials so heavily processed, such as plastics or refined metals, thereby falling in the category of 'technofossil' that is at once formally familiar to stratigraphers and yet compositionally novel. See Steffen, W., Grinevald, J., Crutzen, P., et al. 2011: 851-852.

technofossil implies that our bodies and our habitual activities contribute to what will have been the beginning of an Anthropocene unit, if approved.[388]

The technofossil is therefore an integral ingredient in the effort towards formalising an Anthropocene unit, insofar as it functions to quell the anxieties of the ICS and IUGS that the Anthropocene is not properly stratigraphic. It does this by advancing a stratigraphic account of the contemporary, casting it into the idiom of the fossil, and consequently of geological deep time. This is an effort that appears to be constructed with the preferences of the ICS and IUGS executive in mind, given the longstanding precedent of fossil markers, and palaeontology more generally, in the evaluative practices of stratigraphy. Yet does the technofossil, tied as it is to the mid-twentieth Century Great Acceleration spikes, emerge only at 1950? What of the global networks of telegram cables and railway lines of the late nineteenth century, which some have argued were the advent for the kinds of "universalising" initiatives that characterised the inauguration of the International Geological Congress?[389] That is to say, what does the technofossil narrative *conceal*? There are some members of the AWG who worry that the technofossil narrative undermines the significant record of human activity buried in the earth, which dates back many thousands of years before the present. It is an example, in other words, of all that the Anthropocene narrative *overlooks*, or *conceals*, in the AWG's effort to satisfy the conventions enforced by the IUGS. The concern of these AWG members was apparent at the Mainz meeting in September 2018, and led to a significant internal schism with the publication of articles, authored by AWG members, that opposed the Group's formalization effort. We shall now turn to this episode.

5.5 The Anthropocene formalization effort as erasure

In the summer of 2018, three sub-units of the Holocene Epoch (each at the level of Stage/Age), were formally ratified. A further point that the ICS and SQS executives present were keen to emphasise was that the recent subdivisions of the Holocene had no bearing whatsoever on the AWG's formalisation effort. Popular reporting at the time, which followed

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[388] Although in this chapter I stay with the AWG's strategy, elsewhere, Landecker develops this theme further than the AWG. See Landecker, H. 2016. Antibiotic Resistance and the Biology of History. *Body & Society* 22(4): https://doi.org/10.1177/1357034X14561341. Antibiotics use leads to antibiotics resistance, encouraging 'physical registration of human history in bacterial life'.

[389] See Krajewski, M. 2014.

from interest in the Anthropocene, reported on the formalisation of the Meghalayan as a polemical move that came out of nowhere to undermine the AWG's formalization effort.[390] However, AWG president Jan Zalasiewicz, who also served as Secretary of the SQS at the time of their formalisation, voted in favour of formalizing the Holocene sub-units. The effort to subdivide the Holocene was also mentioned approvingly in an early collection of essays by the AWG.[391] An article announcing the new sub-divisions, authored by the Chair of the Subcommission on Quaternary Stratigraphy, states that 'the presently undefined term Anthropocene is already used extensively and, like Holocene subdivisional terms, its functionality will be enhanced by formal definition.'[392] In other words, there was understanding amongst the stratigraphic community that the subdivisions of the Holocene could support the argument for a formal Anthropocene unit.

This interpretation is somewhat at odds with the position of ICS executive member Phil Gibbard, who argues that 'one of the key justifications for defining a Holocene Series, as a separate entity from the Pleistocene, is that humans reached critical numbers and began influencing natural systems from the beginning of this time period onwards.'[393] Were it not for the presence of *Homo Sapiens*, there would be no need to define the Holocene as anything other than a typical Pleistocene interglacial event, they continue.[394] In the same article, Gibbard acknowledges the legitimacy of the Meghalayan GSSP, recorded in a stable isotope record in an archived stalagmite from Mawlmuh Cave in India. It is further acknowledged that

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[390] The Atlantic published two articles that presented the Meghalayan as a rebuttal of the Anthropocene, which failed to acknowledge the role of AWG members in the formalisation of the Holocene sub-units. See Meyer, R. 2018, July 20. Geology's Timekeepers are Feuding. *The Atlantic*. https://www.theatlantic.com/science/archive/2018/07/anthropocene-holocene-geology-drama/565628/ (accessed 10/01/2021); Meyer, R. 2018, September 20. Geologists Are Feuding About the Collapse of Civilization. *The Atlantic*. https://www.theatlantic.com/science/archive/2018/09/the-geologist-mega-drama-about-an-ancient-mega-drought/570508/ (accessed 10/01/2021). The reference to the collapse of civilization does not refer to the Anthropocene but instead to the aridity event, thought to have led to global civilizational decline, that is marked by the Meghalayan GSSP. See Walker, M., Head, M., Lowe, J. 2019. Subdividing the Holocene Series/Epoch: formalization of stages/ages and subseries/subepochs, and designation of GSSPs and auxiliary stratotypes. *Journal of Quaternary Science* 34(3): 173-186.

[391] See Gibbard, P. & Walker, M. 2014.

[392] Head, M. 2019: 32.

[393] Gibbard, P. & Walker. 2014: Pg. 32.

[394] ibid. The Pleistocene is the Series/Epoch that precedes the Holocene. The AWG have responded to this concern, positing that human impact on the environment from the late Pleistocene to throughout the Holocene 'have largely been local to regional in nature and are also highly diachronous in tiem from one region to another.' Vidas, D., Zalasiewicz, J., Steffen, W. 2019. The Utility of Formalisation of the Anthropocene for Science. In Zalasiewicz, J., Waters, C., Williams, M., et al. 2019. *The Anthropocene as a Geological Time Unit*. Cambridge: Cambridge University Press. Pp. 31-41. Pg. 33.

this record refers to a global aridity event that was pronounced in low, middle, and high latitudes. These characteristics are in keeping with the requirements of a GSSP section as outlined by the ICS.[395] Gibbard may therefore acknowledge the legitimacy of the Meghalayan as a GSSP defined unit of the International Chronostratigraphic Scale, but would apparently strongly disagree that it sets a precedent for an Anthropocene unit. A geologic unit defined on the basis of human modification of Earth already exists, he argues: the Holocene.[396] There is no reason to define a further unit, because geology is ultimately a planet-focused discipline, not an anthropocentric discipline.

It is hard to be sure where the executive of the ICS and IUGS stand on the relevance of the Meghalayan for the Anthropocene. Although Gibbard appears dismissive of the Meghalayan's relevance for an Anthropocene unit, his reflections on the Meghalayan were co-authored with Mike Walker, who was lead author on the article that formalised the Holocene subdivisions.[397] Walker delivered a presentation together with SQS Chair Martin Head at the Mainz meeting of the AWG in September 2018.[398] Their presentation reiterates that the formalisation of the Meghalayan is an entirely separate matter from the formalization of an Anthropocene unit and does not bear on it at all. They conclude their presentation by listing three ways in which the formalisation of the Meghalayan supports the case for a formal Anthropocene unit. Firstly, as has been discussed, it synchronises stratigraphic boundaries with a timeline of archaeological, even "cultural" history. Secondly, the stages of the Holocene are some three to four thousand years in duration; far smaller than most geological units. This provides a precedent for short yet significant geologic units, which is a concern that some stratigraphers hold over the AWG.[399] Third, they claim that the Holocene has been subdivided 'for convenience alone, justified only by desirability to

[395] See Cowie, J., Ziegler, W., Boucot, A., et al. 1986; Gradstein, F., Ogg, J., Schmitz, D. 2020.
[396] See Gibbard, P. & Walker, M. 2014; Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019.
[397] That article is Walker, M., Head, M., Berkelhammer, M., et al. 2018.
[398] Walker was absent, so the paper was delivered solely by Martin Head, who at the time was Chair of the Subcommission on Quaternary Stratigraphy. Head, M. 2018. SQS progress for Holocene stage definitions. Paper presented at the fourth meeting of the AWG. See the *Anthropocene Working Group Annual Newsletter*. Vol 8: http://quaternary.stratigraphy.org/wp-content/uploads/2018/12/Anthropocene-Working-Group-Newsletter-Vol-8.pdf (accessed 1/2/2021).
[399] For example, some prominent stratigraphers argue that the Anthropocene refers to sediment that has yet to be adequately deposited: 'Should the 'Anthropocene' be ratified as a formal unit of the ICS Chart/Geologic Time Scale given that much of the 'Anthropocene' relative to Earth's history is really in the present and future…' See Finney, S. 2014: 27.

formalize terms already used extensively.'[400] To demonstrate this point, Head has elsewhere drawn on citation metrics. He refers to the number of results returned for the Anthropocene by comparison with Holocene, Pleistocene, Pliocene, Neogene and Silurian. He demonstrates that in some cases, the Anthropocene returns more results than other long-standing geologic units. Given that the ICS has as one of its mandates to facilitate communication in stratigraphy[401], Head takes these citation metrics as an argument for formalising the Anthropocene: 'Given the now wide use of the term Anthropocene, in geological contexts but also within the social sciences and beyond, there is a growing imperative to define this term promptly and reduce further confusion.'[402] Formally defined boundaries facilitate precise communication, he argues.[403] It is therefore desirable, argues Head, to formalise the Anthropocene as a geological unit, given that the term is already in wide circulation, but has yet to be formally defined in stratigraphic terms.

The recent subdivisions of the Holocene arguably provide further precedent for an Anthropocene unit. Firstly, the Holocene sub-units occurred very recently, by geological standards. The Meghalayan began only four thousand, two hundred years ago.[404] This supports the AWG's claim that the relative brevity of an Anthropocene unit to date would not detract from the case for its formalisation as a geological unit. Secondly, the Meghalayan GSSP is defined in a speleothem from the Mawmluh Cave in Meghalya, India. The speleothem

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[400] Head, M. & Walker, M. September 6, 2018. *SQS progress for Holocene stage definitions* PowerPoint Presentation.

[401] The most recent statue of the ICS includes the 'communication of major stratigraphic data to the global earth-science communication' as one of its purposes. See the ICS website at https://stratigraphy.org/statutes (accessed 15/1/21).

[402] Head, M. 2019: 49. He continues on the page 50:

> The recent subdivisions of the Holocene answers the fair question of whether defining a formal Anthropocene serves any real use. The rationale for formally subdividing the Holocene was that the terms, early, middle and late, were already widely used and that formal definition would simply increase their utility. The same justification clearly applies also to the Anthropocene.

This statement is especially significant given that it comes from the former Chair of the SQS, who was co-author on the successful proposals to ratify two new GSSPs for the three Stages/Ages of the Holocene (the third GSSP, of the Holocene base, has already been defined for some years now – Head was also involved in this effort).

[403] 'the presently undefined term Anthropocene is already used extensively and, like Holocene subdivisional terms, its functionality will be enhanced by formal definition.' Head, M. 2019: 31.

[404] The lower boundary of the Greelandian Stage is coincident with the lower boundary of the Holocene, with a numerical age of approximately eleven thousand, seven hundred years. The lower boundary of the Northgrippian Stage has a numerical age of eight thousand, two hundred years. That of the Meghalayan is four thousand one hundred years. See Walker, M., Head, M., Lowe, J. 2019.

shows evidence of a significant reduction in rainfall at the time the GSSP definition marks. This aridity event has been referred to as the '4.2ka climatic event'. It initiated a drought that lasted two hundred and fifty years, forcing 'synchronous societal collapse, habitat-tracking, and eventual resettlement and reorganization across Spain, Greece, Egypt, Palestine, Mesopotamia, Indus, and China.'[405] As such, the Meghalayan provides a precedent for an Anthropocene unit, insofar as the entanglement of climatic and human history are acknowledged in the definition of its GSSP.[406]

These comments provoked scepticism from members of the AWG who study similar objects to geologists in the context of different time frames.[407] '[A]rchaeology and geology are related disciplines,' explains archaeologist and AWG member Matt Edgeworth.[408] They often work on the same physical sites. Geologists take as their frame of reference the modification of sites through natural processes over hundreds of thousands, even millions of years. Archaeologists work with reference to a time frame of thousands of years, sometimes tens of thousands of years, using anthropogenic deposits to piece together an account of what happened. An Anthropocene unit would imply that these temporalities have merged. That merger has proved useful insofar as elaborating the stratigraphic impacts of human activity since 1950 are concerned.[409] A majority of the AWG that is in favour of a GSSP definition have made use of the overlap of interests between stratigraphy and archaeology.

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[405] Walker, M., Gibbard, P., Head, M., et al. 2019. Formal Subdivision of the Holocene Series/Epoch: A Summary. *Journal of the Geological Society of India* 93: 135-141. Pg. 138. This article is a summary of the official declaration of the Holocene subdivisions. See Walker, M., Head, M., Berkelhammer, M. et al. 2018. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Sections and Points (GSSPs) and three new stage/subseries. *Episodes* 41: 213-223. Publication of an article in *Episodes* is a traditional requirement of any GSSP formalisation, as per the stipulations of Cowie, J., Ziegler, W., Boucot, A., et al. 1986: 1-14.

[406] Which for some observers, is the defining gesture of Anthropocene discourse. See Chakrabarty, D. 2009.

[407] Although this episode has been partially recounted in chapter three, I revisit it here to illustrate its influence on the more recent trajectory of the AWG's formalisation effort.

[408] Edgeworth, M. 2014. The relationship between archaeological stratigraphy and artificial ground and its significance in the Anthropcene. In Waters, C., Zalasiewicz, J., Williams, M., et al. *A Stratigraphical Basis for the Anthropocene*. London: Geological Society of London Special Publciation 395. Pp.55-90; See also Edgeworth, M., Richter, D., Waters, C. 2015.

[409] For example, the geoscientist Erle Ellis contributed a chapter to the first collection of essays by the AWG, wherein he presents a series of arguments that 'human transformation of the ecosystems have already irreversibly altered the terrestrial biosphere at levels sufficient to leave an unambiguous geological record different substantially from that of the Holocene or any prior epoch.' See Ellis, E. 2011. Anthropogenic transformation of the terrestrial biosphere. *Phil. Trans. R. Soc. A.* 369(1938): 1010:1035. See also the contribution by archaeologist and AWG member Matt Edgeworth to a subsequent AWG collection of essays: Edgeworth, M. 2014.

It is an opportunity to indicate what makes Anthropocene sediment novel, while still being in accordance with the requirements of stratigraphic definition. As they explain:

> Evidently, the Anthropocene is different from the rest of the geological column in being the first envisioned chronostratigraphic unit that spans written and instrumentally documented human history, as well as being one that covers an interval in which we have a more or less complete understanding of the operation of the many different parts of the Earth System. To some, this is an argument against defining the Anthropocene as a chronostratigraphic unit, because it is based more on direct human observation than on a stratigraphic record. In contrast, a response might be that by searching for a GSSP using standard stratigraphic protocols, the analysis of the Anthropocene is uniquely aided by the overlap of geological and historical time and by access to detailed instrumental records.[410]

Yet as the AWG work towards defining a GSSP, they have argued that pre-industrial human impacts of the kind elaborated by the archaeologists and geographers among the ranks of the AWG, are ultimately too 'strongly time-transgressive' and therefore inappropriate for further consideration.[411] As a result, some AWG members have expressed doubt concerning the purpose of formalising an Anthropocene unit.[412] In a paper authored together with several AWG members, they ask:

> Does it really make sense to define the start of a human-dominated era millennia after most forests in arable regions had been cut for agriculture, most rice paddies had been irrigated, and CO_2 and CH_4 concentrations had been rising because of agricultural and industrial emissions?[413]

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[410] Waters, C. 2019. Potential GSSP/GSSA Levels. In *The Anthropocene as a Geological Time Unit*. Pp. 269-285. Pg.284

[411] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 320.

[412] This is reflected in the 2016 AWG internal vote, wherein there were three votes against formalising the Anthropocene, and subsequently four votes for diachronous beginnings (rather than a single GSSP or GSSA beginning). See Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.

[413] Ruddiman, W., Ellis, E., Kaplan, J., et al. 2015:39.

It is elsewhere concluded that 'the AWG strategy would relegate the vast pre-industrial (and pre-1950s) alterations of this planet to the 'pre-Anthropocene'.[414]

In light of the increasingly marginalised position of non-stratigraphic contributions to the AWG's formalisation effort, the Group has appeared to split. This schism was confirmed in an exchange of articles published shortly following the September 2018 meeting of the AWG in Mainz. In early 2019, an article was authored by a combination of archaeologists, geographers, as well as geologists (one from the executive of ICS), all of whom are either AWG members or have participated in the AWG's formalisation effort. They argue that the chronostratigraphic method is unsuitable for determining the Anthropocene:

> It is important to clarify that we are not questioning the validity of chronostratigraphy in the division of time on long-term geological time-scales. The accomplishments of that method in providing an essential framework for understanding four and a half billion years of Earth history, as encapsulated in the International Chronostratigraphic Chart, are widely acknowledged. What is being questioned here is the suitability of the chronostratigraphic method for the division of time on archaeological and historical timescales, which are several orders of magnitude shorter. Our critique applies with particular force to the proposed start of the Anthropocene because of its extreme proximity in time.[415]

Determining the lower boundary of an Anthropocene unit with a GSSP has the effect of dividing and parcelling time in a manner that is unsuitable for the historiographic frameworks of archaeology and history. The technosphere (together with technofossils) is recognised by the authors as an effective idiom with which to delineate the highly defined and long-lasting stratigraphic imprint of human activity. Yet by insisting on a GSSP definition, the insights made

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[414] Ruddiman, W. 2018: 456. This is a concern that is echoed in several disciplines. See Periman, R. 2006. Visualising the Anthroopcene: human land use history and environmental management. In Aguire-Bravo, C., Pellicane, P., et al. (eds) *Monitoring Science and Technology Symposium: Unifying Knowledge for Sustainability in the Western Hemisphere Proceedings RMRS-P-42CF.* Fort Collins: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pp. 558-564. On page 558 they argue that 'by defining the Anthropocene as a geological epoch beginning only 200 years ago, Crutzen and Stoermer truncate thousands of years of human interaction with the global environment.'

[415] Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019: 335.

available by archaeological timescales would be fundamentally undermined. Geological deep time has typically worked in isolation from archaeological, or historical, timescales: millions, even billions of years before the temporalities of archaeology and geography 'commence'. In attempting to apply geological deep time to the present, or recent past, a shared temporal domain is encountered that a GSSP definition would fail to appreciate. 'The only way the [chronostratigraphic] method can deal with time-transgressive signals in strata is through the placement of isochronous timelines upon them, splitting them up into separate time units on either side.'[416] Chronostratigraphic methodology assumes sole occupation of temporalities that are in fact shared with archaeological, geological, and historical observations (among others).

The authors claim, furthermore, that the GSSP misunderstands the material characteristics of strata. Here again it is argued that the wealth of archaeological research concerning pre-industrial human impact on the planet is disregarded by stratigraphers as too diachronous and regional.[417] The detracting members of the AWG again take issue with the GSSP on this point:

> The crux of the matter is that, in seeking to impose a globally isochronous timeline to mark the start of the proposed new interval – as a formal prerequisite in chronostratigraphical classification – anything that is not synchronous at a global scale is regarded as peripheral to the central task of fixing the boundary. Since all formations of anthrpogenic strata are highly diachronous on human timescales, these are largely taken out of the equation.[418]

The intensification of the formalization effort, marked by a determined commitment to the GSSP, is intended to satisfy the evaluative framework of the IUGS. However, in doing so, a schism emerges within the AWG itself that leaves the formalisation effort vulnerable both to

[416] ibid.

[417] Archaeological literature on the hypothesis of an Anthropocene unit is extensive, and cannot be adequately represented in the scope of this thesis. Some examples include Edgeworth, M., Benjamin, J., Clarke, B., et al. 2014. Archaeology of the Anthropocene. *Journal of Contemporary Archaeology* 1(1): 73-132; Boivin, N., Zeder, M., Fuller, D., et al. 2016. Ecological consequences of human niche construction. *PNAS* 113(23): 6388-6396.

[418] ibid: 336.

internal and external criticism. This is because as the GSSP is pursued with greater determination, the strict parameters of the chronostratigraphic method, and the evaluative procedure associated with the Chart and Scale, become increasingly apparent as the predominant orientation of the AWG's formalisation effort. Indeed, those AWG members who co-authored the dissenting paper argue that it is unclear why the chronostratigraphic method needs to be pursued at all. For example, with the advent of radiometric dating beginning in the 1950's, many geologists no longer pay attention to the arcana of chronostratigraphic classification.[419] They can determine the age of a stratigraphic section using radiometric techniques and proceed without reference to the Chart or Scale at all. Some members of the AWG who are not stratigraphers have sought clarification on the precise requirements of unit formalisation. Together with non-AWG members who nevertheless maintain a disciplinary interest in the formalisation effort, they have argued:

> The formalization of the Anthropocene must be more transparent and have wider input and assessment. The criteria for assessing the sciences of the new epoch need to be published and peer reviewed, rather than agreed in private meetings. An open online platform could host the full range of proposals and research papers as well as feedback and discussion.[420]

The requirements of a GSSP proposal have not changed since the publication of the ICS *Statutes and Guidelines* some forty years ago. Yet the interventions of ICS executive members at Mainz, together with the three levels of supermajority votes (by the SQS, ICS, and IUGS) required for a unit to be included in the Geologic Time Scale, indicates the central role of

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[419] This is one of the three flaws identified by Ruddiman, W. 2018. He outlines the debates surrounding the definition of the Pleistocene Series/Epoch, which lasted almost sixty years:

> Meanwhile, most paleoclimatologists had simply ignored this ongoing debate and adopted an age of 2.7 or 2.6 million years for the start of the Pleistocene ice-age cycles based on the North Atlantic evidence… Practical scientists were not paying much attention to the slow process of formally approved designations.

Interestingly, this argument was partially upheld in the subsequent paper by Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019. This is especially interesting given that one co-author, Phil Gibbard, is also an executive member of the ICS and co-author of the International Chronostratigraphic Chart.

[420] See Ellis, E., Maslin, M., Boivin, N. 2017. Involve social scientists in defining the Anthropocene. *Nature* 540(7632): 192-194.

judgement in the evaluative procedures associated with the Chart and Scale, which the AWG is subject to. The emergence of a faction from within the AWG, which speaks out *against* the chronostratigraphic method as a suitable means of defining an Anthropocene unit, foregrounds that role further. Together with discursive strategies such as the technofossil argument, this schism suggests that the AWG's formalisation effort is not solely a *scientific* endeavour. The description of material sections, the publication of research papers, and the characterisation of guiding geochronological events, is intimately associated with a keen awareness of the preferences of voting members of the ICS and IUGS. Those preferences actively shape what information is included in the AWG's formalisation effort, and how that information is presented. It also influences what arguments or perspectives are marginalised. The AWG express the marginalisation of archaeological perspectives by countering that such markers are too diachronous to be geologically significant. But of course, this does not disprove that such markers exist. To the extent that a proposal has yet to be completed by the AWG, it is not clear in what sense the diachroneity of archaeological markers compares with other markers that senior AWG members believe to be more likely to achieve formalisation of an Anthropocene unit. Yet most significantly, the disagreement between these two sides of the AWG demonstrates the political character of the AWG's formalisation process, because the reason the preferences of the ICS and IUGS voting members shapes the AWG's effort so significantly is because of their authority in relation to the Chart and Scale.

The definition of an Anthropocene GSSP is therefore a disciplinary and formally legislative exercise. That is why it is becoming increasingly apparent that this endeavour is indifferent to the contributions of *other* disciplines beyond stratigraphy. This was clearly not always the case, as the wealth of contributions from non-geologists in earlier publications affiliated with the AWG indicates.[421] Yet as the strict preference for a GSSP in line with IUGS-determined protocol becomes apparent, the AWG changes tack, increasingly eager to distance itself from cross-disciplinary encounters that were previously held to be the impetus for the AWG's founding in the first place.[422] This is a change in orientation, in other words,

[421] Regarding the encouragement of diverse disciplinary contributions to the AWG's formalisation effort, see footnote 12.

[422] The formal Anthropocene unit hypothesis, for example, is framed as an insight of the Earth System Science community in the very first article by AWG stratigraphers on the Anthropocene. See Zalasiewicz, J., Williams, M., Smith, A., et al. 2008.

that occurs in anticipation of the formal decision making procedure associated with the Geologic Time Scale. Those involved in that procedure, i.e. the executive members of the ICS and IUGS, have demonstrated their scepticism of the AWG's openness to other disciplines, and accordingly questioned the purpose of formalisation at all.[423] They have made it clear that either the AWG propose a formal definition of the Anthropocene that is fully in line with "established stratigraphic principles", or else it will not obtain the favourable majority from the ICS or IUGS that it requires.[424]

5.6 Practicality, utility, and definition of the Anthropocene for stratigraphy and beyond

The prospect of being marginalised has led those less immediately involved in the formalisation effort of the AWG to question precisely how formalisation takes place. Formal requirements of the GSSP are outlined in the ICS *Statutes and Guidelines* and reiterated in the regularly published *Geologic Time Scale.* They indicate that a GSSP proposal must include a primary marker and correlation event of adequate thickness above and below the boundary signal; have a suite of supporting auxiliary cores; and occupy a site that will be preserved and adequately maintained.[425] It is also known that a decision requires a 60% or more majority among the executive members of the SQS, ICS, and IUGS.[426] Yet these guidelines do not indicate how one candidate is selected against other possible primary markers. What criteria inform the selection of the primary marker when more than one could be said to satisfy these guidelines?[427] Seeking to obtain clarity on the deliberative process, and failing to find it in the

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[423] See Gibbard, P. & Walker, M. 2014; Finney, S. 2014.

[424] See for example this statement by ICS executive Phil Gibbard:

> If a Holocene/Anthropocene boundary is to have… credibility, then it must be underpinned by anthropogenic events that are as globally significant as the natural events that form the basis for the proposed Holocene GSSPs. In other words, the definition of the base of the Anthropocene must conform to the same stratigraphic principles.

See Gibbard, P. & Walker, M. 2014: 33.

[425] Cowie, J., et al. 1986; Gradstein F, Ogg, J., Schmitz, M. 2012.

[426] This is a requirement of the GSSP formalisation procedure since the first statutes of the ICS. See Cowie, J., et al. 1986: 6.

[427] For example, the geographers Simon Lewis and Mark Maslin were among the first to suggest a GSSP proposal. Indeed, they proposed two. They used the 'minimum GSSP requirements' as outlined in *The Geologic Timescale 2012* as the framework to develop their proposals. Both were dismissed by the AWG in subsequent articles, even though, as Lewis & Maslin state, the AWG articles do not disagree with the choice

literature to date, Simon Lewis and Mark Maslin, two geographers who are not AWG members, propose their own framework:

1. 'Are there at least six stratigraphic deposits spanning the low-, mid- and high-latitudes, Northern and Southern Hemispheres, and from terrestrial, marine and polar environments, showing globally correlated changes? (Following the example of the Holocene Epoch GSSP ratified proposal)
2. Are each of these six or more stratigraphically complete, that is with adequate thickness before and after the event, and show no obvious hiatuses across the boundary? (Following the most important criticism of utilising GSSPs for boundaries: incompleteness of records)
3. Are each of these six stratigraphic deposits preserved and accessible to researchers? (Following a second criticism of some past GSSP decisions)
4. Select the boundary that includes the clearest long-term change that is near-permanent on the scale of millions of years (to identify changes on geological timescales relevant to epochs).'[428]

The AWG have not responded to Lewis & Maslin's attempt to define a formal framework for deliberation of GSSP candidates. Instead, while continuing with their effort, the AWG have sought to argue that a formally defined Anthropocene unit would clarify all discussion of the

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of which primary guide to use (radionuclide fallout from mid-twentieth Century atom bomb detonations) but rather *where* to place the marker therein: 'Zalasiewicz et al do not disagree that the Great Acceleration is a possible beginning of the Anthropocene, but that the first detection of the radionuclide marker out to be used.' The AWG argue instead that the onset should be used, rather than the beginning. See Lewis, S. & Maslin, M. 2015. A transparent framework for defining the Anthropocene Epoch. *The Anthropocene Review* 2(2): 128-146. Their two GSSP proposals appear in Lewis, S. & Maslin, M. 2015. Defining the Anthropocene. *Nature* 519: 171-180. The "dismissive" response from the AWG appears in Zalasiewicz, J., Waters, C., Williams, M., et al. 2015. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* 383: 196-203; see also Zalasiewicz, J. & Williams, M. 2015, January 30. First atomic bomb test may mark the beginning of the Anthropocene. *The Conversation*. https://theconversation.com/first-atomic-bomb-test-may-mark-the-beginning-of-the-anthropocene-36912 (accessed 16/01/2021).

[428] Lewis & Maslin, 2015. A transparent framework: 138. The sources quoted are left in to indicate that Lewis & Maslin propose their framework with reference to what they hold to be authoritative accounts within stratigraphy. Those accounts are the article that formally defines the Holocene GSSP, see Walker, M., Johnsen, S., Rasmussen, S., et al. 2009. The other source is an account of the GSSP from a Special Publication of the Geological Society of London. See Smith, A., Barry, T., Bown, P., et al. 2014. GSSPs, global stratigraphy and correlation. *Geological Society of London Special Publication* 404: 37-67.

Anthropocene theme more generally, even those indifferent, or opposed, to the stratigraphic context. This was an argument that came up during the Mainz meeting, both in regard to the precedent set by the Meghalayan, as well as in response to scepticism voiced by non-stratigraphers. This argument has been made by way of a particular idiom that may itself provide greater insight into chronostratigraphic, deliberative process than indeed the *Statutes and Guidelines* of the ICS or the GTS: 'utility'.

"Utility" is a term mentioned frequently at the meetings of the AWG, as well as in literature both in favour and against formalisation. There is no technical, stratigraphic definition of 'utility'. The absence of a comprehensive definition of 'utility' may provide the decision-making procedure with the ambiguity required to uphold the authority of its judgements. Proposals such as Lewis & Maslin's are carefully assembled in respect of the established criteria for a GSSP, but are nevertheless disregarded on the grounds of being too 'time transgressive' or 'regional'. Lewis & Maslin assert that the AWG have misunderstood their arguments. The AWG have, furthermore, foregone peer-review of their rebuttals to Lewis & Maslin, issuing replies in the non-peer-reviewed correspondence section of journals instead.[429] This suggests that Lewis & Maslin believe that if the AWG did submit their criticisms concerning the adequacy of the Orbis Spike or 1964 definition, their claims would be disputed.

At any rate, in the absence of a sufficiently transparent framework concerning the AWG's selection of a GSSP candidate, and the formulation of their proposal to the SQS, the ambiguity of what we might call, in keeping with the theme of the GSSP, "auxiliary terms" such as 'utility' and 'practicality', is indicative of how the AWG seek to navigate critical reception of their research. In this way, the AWG adapt their progress to the ecological niche most receptive to their formalisation effort. Utility is figured both in terms of stratigraphic procedure (i.e. that a formal Anthropocene unit would be *useful* for the purposes of

[429] Lewis & Maslin explain:

> 'We note that AWG members chose not to submit a comment to *Nature* which would have been peer-reviewed, but instead chose to write to the non-peer-reviewed correspondence section of *Nature*. The second response, submitted to the Perspectives and Controversies section of this journal [*The Anthropocene Review*], likewise avoided formal peer-review.'

See Lewis & Maslin. 2015: 129.

facilitating communication and hence correlation of strata globally[430]), as well as concerns wider adoption of the Anthropocene term "beyond" stratigraphy (i.e. that a formal Anthropocene unit would provide a formal reference, or "anchor", from which to develop non-stratigraphic research concerning the Anthropocene "theme"[431]).

For example, the AWG justify their dismissal of Lewis & Maslin's proposal to define the Anthropocene GSSP at the 1964 peak in radionuclide fallout[432] by stating that 'it is more conventional and usually more practical in terms of worldwide correlation, to place a boundary based on chemical or isotopic excursion at the beginning rather than the peak, of such a major geochemical change in strata.' However, the units of the Geologic Time Scale indicate otherwise. The GSSP that defines the lower boundary of the Paleogene System/Period, for example, correlates the peaks in several signals associated with the unique stratigraphic composition of that section.[433] A peak in the appearance of oxygen isotopes is also used for correlation of ice-core records used in the definition of the Holocene GSSP.[434] Lewis & Maslin consequently quip that 'practicality' is a 'rarely defined term, but often meaning better correlation potential.'[435] More appropriately, 'practicality' is a strategy that affords the AWG the flexibility to adapt their argument to the prevalent ecological niche. It is a way for the AWG to justify the dismissal of a proposal that they believe would not be favoured by the evaluative committees. Although the AWG provide explanations for their

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430 'The presently undefined term Anthropocene is already used extensively and, like Holocene subdivisional terms, its functionality will be enhanced by formal definition.' Head, M. 2019: 32.

431 Referring to the disciplinary diversity of their composition, the AWG remark that '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.' Zalasiewicz, J., Waters, C., Summerhayes, C. 2017: 56.

432 Lewis, S. & Maslin, M. 2015. Defining the Anthropocene. Lewis & Maslin explain that, in particular among radionuclide fallout signals, ^{14}C was chosen 'in temperate tree rings, as this event has global correlation, can be dated to an unambiguously annual resolution, and provides the best correlation potential with other radionuclide species.' See Lewis & Maslin. 2015. A transparent framework: 140.

433 See Molina, E., Alegret, L., Arenillas, I., et al. 2006. The Global Boundary Stratotype Section and Point for the base of the Danian Stage (Paleocene, Paleogene, "Tertiary", Cenozoic) at El Kef, Tunisia – Original definition and revision. *Episodes* 29(4): 263-273. See especially page 266. This is noted as an error in the AWG's response by Lewis & Maslin, who explain that that 'boundary is defined by the red clay layer which containes the iridium peak, *not* the start of the rise in iridium as Zalasiewicz et al. claim.' Lewis & Maslin, 2015. A Transparent framework: 141.

434 'The location of the double ECM peak inside the $\delta^{18}O$ minimum around 8200 year BP constitutes a unique time-parallel marker horizon for correlation all Greenland ice-core records.' See Walker, M., Johnsen, S., Rasmussen, S.O. 2019. Formal definition and dating of the GSSP (Global Boundary Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. *Journal of Quaternary Science* 24(1): 3-17. Pg 12.

435 Lewis & Maslin. 2015. A transparent framework: 138.

refusal that frame their rejection on chronostratigraphic grounds, Lewis & Maslin point out that there has not been sufficient comparison of their proposal with the other available options under the AWG's consideration. Recall that the AWG determine which marker to follow through an *internal vote*, and that the process leading up to that vote entails a month of internal communication among the AWG via email, followed by a month of consideration during which no further discussion of the options is permitted. Lewis & Maslin's argument indicates the extent to which the AWG's proposal for an Anthropocene unit is constructed through political and processual means, with an eye toward the anticipation of the preferences of the evaluative committees associated with the Chart and Scale, rather than through transparent discussion of all available options for a GSSP candidate.

The AWG dismiss extra-stratigraphic interest in their formalisation effort as inconsistent with the requirements of the strict process of unit formalisation. Yet at the same time, they mobilise interest in the Anthropocene term from other disciplines as a justification for a formal Anthropocene unit. This mobilisation of extra-stratigraphic interest in the hypothesis of a formal Anthropocene unit is also addressed through the idiom of 'utility'. It is argued that formalisation of an Anthropocene unit serves would benefit analysis of the Anthropocene theme more generally, even if it does not share an interest in the chronostratigraphic concerns of the AWG. The utility of the Anthropocene for other disciplines is figured in terms of the 'users' of the term from beyond the natural sciences.[436] Here, utility functions both to register interest in the term from beyond stratigraphy as a relevant component of the formalisation effort, but also to contain the manner in which that effort is mobilised by observers from beyond stratigraphy.

The AWG boasts of its diverse disciplinary composition. It is argued that such a composition is necessary given the types of changes the planet is undergoing. The Anthropocene is therefore uniquely relevant beyond geology, it is implied, and this presents chronostratigraphers with an obligation to those extra-disciplinary considerations. Prime among these obligations is that to Earth System science. Just as the term Anthropocene is noted as 'where the Anthropocene as a term originated,'[437] following the interest by the stratigraphic community, and the efforts of the AWG, it is incumbent on the stratigraphic

[436] See Vidas, D., Zalasiewicz, J., Steffen, W., et al. 2019.
[437] ibid: 34.

community to formalise a definition, to "give back". The two disciplines are integrated in this sense: 'it seems clear that the use of the term [Anthropocene] will continue in this community, but formalisation may nevertheless bring benefits, such as stabilising the term with a meaning that is consistent with the way that it is understood in Earth System science.'[438] The term Anthropocene is also widely used in other disciplines 'beyond Natural Sciences', and while some of those disciplines have already established customary ways of deploying the term, it is argued that formalisation as a chronostratigraphic unit would anchor those non-stratigraphic references to the term. It might therefore be reasonable to assume that a formal stratigraphic definition would undermine those other uses of the term, but the AWG do not believe this to be the case. They invoke the examples of articles published in journals on international law and public health, wherein it is argued that the Anthropocene has come to refer to the premise that 'it can no longer be expected that our global environment background will remain stable, as was the case for much of the Holocene', and to formalise the Anthropocene would promote the affiliated agendas and areas of research.[439]

Utility may also be invoked by the AWG to constrain the range of associations between themselves and the various mobilisations of the Anthropocene theme. We have reviewed the ways in which the AWG discount the concerns of archaeologists regarding an Anthropocene GSSP, which would render everything before the designated point as belonging to the Holocene Epoch/System, i.e. not indicative of human-impacted Anthropocene strata. Those members of the AWG who, together with non-AWG members sharing this apprehension, have responded directly to efforts to discount their concern. Similarly, although the AWG are eager to recite their cross-disciplinary affiliations, as well as the prevalence of the Anthropocene term beyond stratigraphy, they are careful not to let such admissions be used against them by members of the stratigraphic community who accuse the AWG of misunderstanding the parameters of classification:

> [T]he AWG focuses on the Anthropocene as a potential chronostratigraphic/geochronologic unit, using standard stratigraphic criteria, so that

[438] ibid.
[439] ibid: 35.

> it can be compared directly with, and on the same terms as, other units of the GTS. This emphasis is important, as since the formation of the AWG, the use of the Anthropocene has increased enormously in the literature not least because it has been widely adopted as a concept by disciplines well outside of the Earth sciences, and ranging across the social sciences, humanities and arts. Interpretation has also expanded, well beyond original [Earth System science] meaning and its chronostratigraphic interpretation (which are essentially congruent…) into a broader range of "human-centred" meanings. These wider meanings of the term are often not consistent with chronostratigraphic definition…[440]

In such passages, extra-stratigraphic interest in the Anthropocene is acknowledged simultaneously to argue for formalisation of the term as a chronostratigrahic unit, as well as to constrain their significance for stratigraphy. Those extra-stratigraphic interests are presented as a reason for the unit to be formalised, even if the correlative arguments are dismissed. Indeed, the AWG have gone so far as to dismiss the relevance of 'anthropos' to the Anthropocene:

> Had Paul Crutzen used a different term in 2000, not including an 'anthropos', then both the Earth System meaning and justification, and the stratigraphic integrity of the term would have remained exactly the same, but the conflation of meaning may not have arisen. Equally, *had the post-mid-20th century changes we associate with the Anthropocene been produced not by human actions but by, say, volcanoes or a meteorite strike, then the justification and meaning of the Anthropocene both in ESS terms and stratigraphically would also have remained similarly valid*. The Anthropocene as an ESS and a chronostratigraphic unit recognizes dramatic changes to the Earth System, using the same criteria that delineates any other previous epoch – it just so happens that the cause is humans this time, rather than some other forcing factor.[441]

[440] Zalasiewicz, J., et al. 2020. The Anthropocene: 1258.
[441] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 325. Emphasis added.

Both species of argument regarding utility are included in recent accounts by the AWG that seek to demonstrate why the Anthropocene should be formalised as a unit of the Chart and Scale. They are included largely via the idiom of 'utility' and 'practicality'. In the most recent collection of essays on the AWG's formalisation effort, a tentative definition of "utility" is provided. This definition is presented in the context of the benefit that a formally defined Anthropocene unit could have both for stratigraphy as well as to coordinate the various ways in which the term "Anthropocene" has been mobilised in diverse disciplines both in the natural sciences and beyond:

> Why and how could the formal Anthropocene in geology be useful for science (including social science)? – that is the question of *utility for science*, which the AWG is addressing and aims at providing some clarification towards. What is the point of the formalisation exercise for the society at large? – that is the question of *societal relevance*, which is beyond the scope of, and independent of, the AWG mandate.[442]

"Societal relevance" is distinguished from "utility for science". This differentiation would appear to overlook the significance the Anthropocene theme has taken on in the work of certain prominent contributors from "social science", even though the article attempts to acknowledge those contributions as an indication of the need for formal Anthropocene unit: a formal definition would be useful for those concerned with the 'societal relevance' of an Anthropocene unit.[443] These AWG members arguing for the expanded benefit of a formalised Anthropocene unit cite mention of the term in international legal journals, wherein it is

[442] Vidas, D., et al. 2019: 39.

[443] The article begins, for example, with an acknowledgement of the influential works of Dipesh Chakrabarty and Bruno Latour on Anthropocene discourse:

> the Anthropocene concept has become increasingly used also in the social sciences and humanities (e.g., Chakrabarty 2009; Vidas 2010; Latour 2015) to designate the time when humans began to decisively influence the state, dynamics and future of the Earth System… Yet there remains no formal acknowledgement, through appropriate scientific analysis, that we now live in a new and distinct geological time interval, the Anthropocene.

ibid: 31. Indeed, although the AWG implies an involvement with these "social scientific" adaptations of the Anthropocene, it would appear that they do not incorporate the substance of those arguments, but rather recognise their enthusiasm for the term as tacitly consenting to the AWG's own, rather distinct, work of unit formalisation. (Gibbard for example mentions something much more like the Capitalocene argument than AWG ever have). On the "influential works", see Chakrabarty, D. 2009; Latour, B. 2017.

argued that discourse in international law benefits from having a revised account of the planet as the assumption underlying its constructs; in acknowledgement of a planet whose parameters are uncertain and changing.[444] In public health discourse, similarly, it is argued that the Anthropocene enables a revised understanding wherein 'planetary health is the health of human civilisation and the state of the natural systems on which it depends.[445] Yet already these acknowledgements complicate the differentiation of "utility for science" and "societal relevance". 'Public health is also political', the AWG acknowledge.[446] Yet even more revealingly, although the formalisation of the Anthropocene entails a differentiation of science and society, the same cannot be said, it is argued, if the Geological Time Scale were to remain as it currently stands, i.e. if the Anthropocene were not formally ratified:

> Decision either way, be it 'Holocene preserving' or 'Anthropocene introducing', can be expected to have political resonance. An explicit decision denying formalisation of the Anthropocene and resulting in the formal continuation of the Holocene would be as much a politically relevant statement as would be the inclusion of the Anthropocene as a new time interval in the Geological Time Scale.[447]

The way this argument develops would indicate that 'utility' can be deployed in a manner that both immunizes the AWG's formalisation effort against accusations of political motivation, while also designating any argument *against* its formalisation as politically consequential. Utility and practicality, in other words, are strategies with which the AWG manage the traffic of meaning associated with the Anthropocene term, towards their formalisation effort, which is required to oblige by the stipulations of the ICS and IUGS. These are strategies for directing

[444] Some examples of this style of international legal scholarship on the Anthropocene include Vidas, D. 2011. The Anthropocene and the international law of the sea. *Phil. Trans. Roy. Soc. A.* 369: 909-925; Vinuales, J. 2016. Law and the Anthropocene. *C-EENRG Working Paper 2016-5*. Cambridge University; Scott, K. 2013. International law in the Anthropocene: Responding to the geoengineering challenge. *Michigan Journal of International Law* 34: 309-358; Kotze, L. 2014. Rethinking global environmental law and governance in the Anthropocene. *Journal of Energy & Natural Resources Law* 32: 121-156.

[445] See Whitmee, S., Haines, A., Beyrer, C., et al. 2015. Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation – Lancet Commission on planetary health. *The Lancet* 386: 1973-2028.

[446] Vidas, D., et al. 2019: 40.

[447] ibid.

interest in the Anthropocene (whether stratigraphically or in its various “expanded” senses) towards formalisation, and specifically, a GSSP definition.

5.7 AWG anxieties: what kind of normativity? (an aside)

The events of the Mainz meeting indicate that although the evaluative procedure in stratigraphy may be centralised, the AWG’s formalization effort is not. A GSSP is pursued as a minimum requirement for an Anthropocene unit, as mandated by the IUGS. The events of the Mainz meeting suggest that the formalization effort is not solely a matter of formulating a GSSP definition that caters to the preferences of the voting members affiliated with the Chart and Scale, but also concerns the ongoing negotiation of values, commitments, and aims within the AWG itself. Far from proceeding against a backdrop of consensus, the formalization effort of the AWG is itself subject to change, and is contingent on the changing disposition of its membership. What precisely the Group is referring to in its invocation of “the Anthropocene” is actively negotiated and evolving, even during the process of its definition as a formal unit.

The common acceptance of the necessity of a GSSP for unit definition can be understood by reference to themes such as *habitus*, and in particular, *doxa*, or ‘a set of inseparably cognitive and evaluative presuppositions whose acceptance is implied in membership.’[448] The common acceptance of a set of fundamental premises, rules, or conventions that are taken to be indisputable, constitutes the *habitus* of chronostratigraphy. Bourdieu advances a taxonomy of organizational practice (a *logic of practice*) in reference to Pascal, who states that ‘custom creates the whole of equity, for the simple reason that it is accepted. It is the mystical foundation of its authority; whoever carries it back to its first principle destroys it.’[449] The acceptance of certain conventions as indisputable and necessary is fundamental to the constitution of a *habitus*; in this case: the discipline of chronostratigraphy. To historicise conventions is to reveal that they are not self-evident, because it indicates that things could have turned out otherwise.[450] And yet, with the

[448] Bourdieu, P. 2000. *Pascalian Meditations*. Stanford: Stanford University Press. Pg. 100.
[449] Quoted in ibid: 94.
[450] Rheinberger, H.J. 2021. On the Narrative Order of Experimentation. In Carrier, M., Mertens, R. & Reinhardt, C. (eds). *Narratives and Comparisons*. Bielfeld: University of Bielfeld Press. 86-97. Rheinberger refers to the acknowledgement of historicity as ‘narrative’: ‘a narrative is a narrative only as long as one can imagine that

publication of a series of papers shortly following the Mainz meeting[451], a faction emerges that would appear to disrupt this consensus. It is a highly revealing instance, wherein a group that is working toward the formalization of the Anthropocene as a chronostratigraphic unit contains a sub-group that argues an Anthropocene unit should not be defined chronostratigraphically. The *habitus* might thereby be broken further into two (or more) *fields*, or distinct yet mutually responsive areas of interest each representing a different point of view, along with a consequent set of objectives that they pursue.

However, if a *habitus* can become fragmented, then how can it retain the status of a unity of observation concerning a set of values and customs taken to be indisputable? Bourdieu acknowledges that the continued belief in the indisputability of *habitus*-defining customs (a practice he calls *doxa*) is often a paradox. *Habitus* is the unity of opposing views. Those with opposing views are united by a common acceptance of the object they disagree over. '[A]gents have to share a common acceptance of [beliefs] to be able to fight over them'.[452] Common beliefs may not be advocated to the same extent; however, the occupation of a common *habitus* is entailed to the extent that even those who disagree, do so *through* a common medium, i.e. the object of their disagreement. This would suggest that the "engine" of scientific research is not the prevalence of consensus, but rather of incommensurability. Such was my argument in reference to the evolution of evaluative frameworks, such as during the International Geological Congresses of the late nineteenth century. Similarly, the generative dynamics of research through incommensurability are part of what was observed at the Mainz meeting.

An important question remains: if the two emergent *fields* within the AWG appear to disagree on such a fundamental issue as the relevance of a GSSP (a chronostratigraphic unit cannot be defined chronostratigraphically without a GSSP – and yet Edgeworth et al. argue that the Anthropocene *should* be *defined*, but not chronostratigraphically), what did they agree on in the first place? What led to their cohabitation within the AWG's formalization effort? As a Subcommission of the SQS, which is itself part of the ICS and IUGS, the AWG exists

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it might have been otherwise. Narration therefore comes with an intrinsic quantum of potential plurality, and therefore with an unavoidable amount of concreteness and circumstantiality.' Pg. 97.

[451] These are the papers discussed above, namely: Ruddiman, W. 2018; Ruddiman, W. 2019; Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019; Zalasiewicz, J., Waters, C., Head, M., et al. 2019.

[452] Bourdieu, P. 2000: 100.

to define an Anthropocene GSSP, or else not attempt to define an Anthropocene unit at all. It is possible that those AWG members who eventually spoke out against a GSSP definition had anticipated something different of the formalization process. Edgeworth et al. state that 'application of the [chronostratigraphic, i.e. GSSP] method hinders rather than helps understanding of the role of human impact on Earth System change; it leads to a loss of the bigger picture…'[453] The 'bigger picture' provides a clue as to why Edgeworth and his colleagues began to disagree with the methodological approach of the AWG, but also why they became involved in the first place. They subsequently explain that 'recognition of humans as geological agents needs to be accompanied by recognition of the distinctive traces of human agency in the ground, which are unprecedented in the stratigraphic records of earlier geological time periods.'[454] Recognition of the scale of human influence of planetary processes would therefore appear to be the 'bigger picture' to which these authors refer.

To the extent that Edgeworth and his colleagues, who authored the paper arguing against the appropriateness of the chronostratigraphic method for defining the Anthropocene, perceive the acknowledgement of an unprecedented scale in the influence of human agency on the planet as the 'bigger picture' of their research commitments, we can presume that their dissent was triggered by a sense that the AWG did not share a common understanding of the implications, or meaning of an Anthropocene unit. They explain that the chronostratigraphic method threatens to:

> 'further divide researchers and scientific disciplines that ought to be working together. [The formalization of an Anthropocene unit] would encourage scholars and the public to conceptually separate contemporary climate change from its incipient prehistoric origins, making it more difficult to discern long-term trajectories and evaluate accelerating trends, collapsing the possibility of multi-scalar analyses of climate impacts. It would predispose archaeologists and geologists to perform similar operations on strata, hiving off the post-1950 examples of humanly modified ground from larger stratigraphic sequences of which they are part, constraining ability to see

[453] Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019: 334.
[454] ibid.

> [sic] the wider picture of accumulating effects and the spread and transformation of materials through time.'[455]

It is possible to read into this account a certain anxiety on the behalf of its authors about the purpose of their research commitments. Before articulating precisely what the parameters of this anxiety are, it is worth repeating that the authors of this article include *both* archaeologists and geographers who believe the insights of their disciplinary environments have been undermined in the AWG's formalization process, *as well as* a senior member of the ICS who will cast a deciding vote at the ICS level concerning the formalization of the Anthropocene. Accordingly, the article describes both a need to see a "bigger picture" concerning the "geological agency of humanity" on the one hand, while also expressing concern that the Anthropocene imposes a geochronological (i.e. temporal and historical) assumption *onto* the material, chronostratigraphic sections, where in fact no such evidence exists. The common thread between these two positions is an opposition to the Anthropocene being defined as a formal chronostratigraphic unit. They explain:

> Recognition of humans and human social formations as geological agents (together with their 'camp followers' of domesticated animals and plants, not to mention earth-moving machines) must surely be accompanied by recognition of the distinctive marks and traces of that agency in the ground, unparalleled in the stratigraphic records of earlier geological time periods. These missing strata need to be taken into account in any formulation of the start of the Anthropocene.[456]

The authors argue that the strata that the AWG point to from the mid-twentieth century is not yet sufficient to constitute a new chronostratigraphic unit. Meanwhile, the far greater material record that refers to many thousands of years of earth-modifying human activity, elaborated by archaeological and geographical research, is discounted as too diachronous and localised for the purposes of a GSSP. In other words, there are two species of anxiety that can be observed side by side in this paper. The duality of this anxiety can be expressed as a paradox: scientific research, of the kind entailed in the AWG's formalization effort, is

[455] ibid: 341.
[456] Ibid.

simultaneously insufficiently *and* prohibitively normative. It is prohibitively normative to the extent that the obligation to abide by the conventions of a discipline, to demonstrate habitation of a *habitus*, can be experienced by scientists as a constraint on the exercise of their ethical commitments. Paul Robbins & Sarah Moore identify this kind of anxiety as *anthropophobia*: anxiety of loss through excessive human influence on the planet.[457] Anthropophobia is characterised by the anxiety that scientists could be doing more in their professional capacity as researchers to address the problems associated with human influence on the planet, i.e. that it could be *more normative* in the sense of advancing a certain idea of what is "good" and "bad." Anthropophobia is therefore anxiety that science is *too normative* in a disciplinary context (the obligation to acknowledge disciplinary norms), and *not normative enough* in an ethical capacity (about what is a 'good' way to act).

In opposition to *anthropophobia* is *autophobia*. Autophobia is defined by Robbins & Moore as a fear of ethically normative assumptions folded into scientific observation. Autophobia therefore refers to anxiety regarding the loss of "scientific objectivity" through excessive concern on scientists behalf regarding their ethical commitments. Following Lacan, Robbins & Moore define anxiety as the fear of loss. It is not loss itself, but the fear that something may be lost that characterises the *autophobic* anxiety concerning overly-politicised research activity. Both autophobic and anthropophobic anxiety are a fear of loss through insufficient normativity. Both varieties of anxiety are rooted in a desire for *more normativity*. Anthropophobia understands normativity as a political aspiration that can be encouraged through more direct involvement of the sciences in social concerns (a "progressive" normativity), whereas autophobia invokes normativity as a scientific value, "passionate disinterest", that needs to be maintained to preserve claims to objectivity (a "conservative" normativity).

Robbins & Moore understand both these anxieties as constitutive of a single condition: Ecological Anxiety Disorder. They recognise this Disorder and its symptoms as fundamentally bound up with the broader theme of the Anthropocene:

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[457] Robbins, P. & Moore, S. 2013. Ecological anxiety disorder: diagnosing the politics of the Anthropocene. *Cultural geographies* 20(1): https://doi.org/10.1177/1474474012469887

> Anthropocene phobia articulate themselves over the symbolic crisis born of the end of nature, understood here as an imaginary or cosmological state and order that provides the grounding orientation point for adjudicating interventions and actions in the world. It is not necessarily a form of Cainotophobia that prevails therefore in the Anthropocene – a fear of change or novelty itself – but rather a fear of lacking a normative way to judge human actions and decisions in a world condition without precedent. In the absence of an organizing moral compass for protecting ecosystems from human action or directing human interventions, a role historically filled by a reconstructed or imaginary past, it is little wonder that the core experience of ecologists would be one of disorientation, really *a fear of getting lost*.[458]

In its "original" formulation, Crutzen's Anthropocene encourages *more normativity* of scientists. 'A daunting task lies ahead for scientists and engineers,' warns Crutzen, 'to guide society towards environmentally sustainable management during the era of the Anthropocene.'[459] Crutzen elaborates the Anthropocene as a response to anthropophobia, and positions "scientists and engineers" firmly at the helm of any solution to "a world condition without precedent." For Crutzen, this means considering options such as geo-engineering. Although the 'preferred way to resolve the policy makers' dilemma is to lower the emissions of the greenhouse gasses… attempts in that direction have been grossly unsuccessful.'[460] The idiom of the Anthropocene as recognition of the geological agency of "mankind" is borrowed from Crutzen (it was the name of his first solo article on the topic[461]) This sense of the Anthropocene as an opportunity for scientists to act on ethical

[458] ibid: 10. This scientific variety of anxiety and desire is borrowed by Robbins & Moore from Lacan, J. 2006 [1966]. The Subversion of the Subject and the Dialectic of Desire in the Freudian Unconscious. In *Ecrits*. London: Norton. Pp. 671-702.

[459] Crutzen, P. 2002.

[460] He acknowledges, furthermore, that 'although by far not the best solution, the usefulness of artificially enhancing earth's albedo and thereby cooling climate by adding sunlight reflecting aerosol in the stratosphere might again be explored and debated as a way to defuse the Catch-22 situation… [and] counteract the climate forcing of growing CO_2 emissions.' See Crutzen, P. 2006. Albedo enhancement by Stratospheric Sulphur Injections: A Contribution to Resolve a Policy Dilemma? *Climatic Change* 77, article number: 211. Available at https://link.springer.com/article/10.1007/s10584-006-9101-y (accessed 25/02/2021). Anthropophobic anxiety is evident in Crutzen's diagnosis, and while some scepticism about the consequences of geo-engineering is evident, it is outweighed by a sense that something needs to be done at all costs.

[461] Crutzen, P. 2002.

commitments, provoked by anxiety of human devastation of the planet, motivated to use their expertise to *make good* of an urgent crisis, is retained in Edgeworth et al.'s intervention: to "see the bigger picture." And that intention is acknowledged in the response of Zalasiewicz et al., which seeks to distance itself from Crutzen's terminology, to render the *anthropophobia* Crutzen expresses in terms that do not provoke *autophobia*: 'it just so happens that the cause is humans this time, rather than some other forcing factor.'[462] Even more recently, the AWG have acknowledged 'considerable congruence between the meaning of the Anthropocene as originally devised and used in the Earth System science community and the Anthropocene as considered geologically, as a chronostratiraphic unit.'[463] And yet, they continue to explain:

> An effective Anthropocene boundary does not need to be based, say, on the earliest significant traces of human activity (for example, the wave of large mammal extinctions beginning in the Late Pleistocene) or even those that may be regarded as of most transformative significance (some 10,000 years ago, for instance, as agriculture started). Instead – and especially as *the geological Anthropocene is in essence Earth centred (and strata based) rather than human centred* – it should provide the clearest, most recognisable, most nearly synchronous geological division. The boundary, indeed, need not be based on a human-made signal. Had there been, say, a globally recognisable volcanic ash layer from some particularly violent single eruption somewhere within the boundary interval… then that might have served admirably as a candidate boundary. Similarly, it is more important that the boundary allows the best tracing of a single time plane around the world than that it exactly coincides with the timing of greatest global change, and there are a number of boundaries of the Geological Time scale where the two (time plane and time of greatest change) are significantly offset. In the case of the Anthropocene, there is in fact reasonably close congruence between the boundary considered most optimal…

[462] Zalasiewicz, J., Waters, C., Head, M., et al. 2019: 325. Emphasis added.

[463] Zalasiewicz, J., Summerhayes, C., Head, M., et al. 2019. Stratigraphy and the Geological Time Scale. In Zalasiewicz, J., Waters, C., Williams, M., et al. (eds) *The Anthropocene as a Geological Time Unit*. Cambridge: Cambridge University Press. Pp. 11-17. Pg.16.

> and the change in trajectory of major parts of the Earth System (perturbations to the carbon and nitrogen cycles, for instance).[464]

Contributions from Crutzen, Steffen, and other Earth System scientists to the formalization effort of the Anthropcoene are therefore acknowledged as being stratigraphically relevant, while the *anthropophobic* tone of those contributions are dismissed.

The notion of Ecological Anxiety Disorder suggests one way we may understand what might have brought the two factions of the AWG together in the first place, or how they may have commenced a working relationship despite apparent divergences in their objectives. Of course, any attempt to account for the motivations or intentions of AWG participants is speculative. Yet reading their accounts through the lens of anxiety foregrounds the political and diplomatic negotiations that occur within the AWG's formalisation effort. Recalling Bourdieu's notion of *doxa*, the two groups may have converged with the belief that the other shared their 'cognitive and evaluative presuppositions'. This shared belief in a common perspective was fundamental to the elaboration of the formalization effort, as a *habitus*, articulating a specific mode of thought: unit formalization – the unit being their common object of construction. Yet as this effort was further elaborated, and commented on critically by voting members of the ICS and IUGS, differences in the respective modes of observation, of Edgeworth et al. on the one hand, and Zalasiewicz et al. on the other, rendered the continued collaboration problematic. Whereas the former group was committed to defining the Anthropocene as an instrument of critical reflexivity, toward realising the ethical commitments of a set of researchers, the latter were obliged to abide by the requirements of chronostratigraphic formalization, which entailed the preservation of certain customs *against* the "burden" of a set of concerns thought to be "non-stratigraphic." That distinction is described by Zalasiewicz et al. as "Earth centered" and normative in a disciplinary sense, rather than "human centered" and normative in the sense of designating culpability.

The publication of a set of papers, shortly following the Mainz meeting, indicates that However, the intervention of a faction from within the AWG who contest the suitability of the chronostratigraphic method for elaborating the significance of rapid and long-lasting human influence on the planet, suggests that there is greater room for dispute within the AWG. The

[464] ibid: 16-17. Emphasis added.

emergence of a group of AWG members who take issue with the relevance of the chronostratigraphic method demonstrates that even within the Group, the formulation of a proposal for an Anthropocene unit entails the negotiation of divergent research interests and even ethical commitments. While their competencies are involved in a common effort to formalize the Anthropocene as a geological unit, the members affiliated with the Edgeworth et al. paper of 2019 would appear to be doing so for quite different reasons. We can recall Biagioli's argument, discussed in chapter three: that developments in scientific fields often occur *as a result* of incongruity, rather than through consensus. As mentioned in an earlier chapter, the AWG appear to be aware of this contingency, to the extent that, behind closed doors, they have considered postponing the submission of their proposal for a formal Anthropocene unit until a new Chair of the IUGS is assumed. This could be beneficial for their purposes, given that the current Chair, Stan Finney, has expressed concern over the relevance of a formal Anthropocene for the rest of the Scale.[465] Elsewhere, Bourdieu's notion of *habitus* can help us account for the schism that emerges from the Mainz meeting. 'Every field is the institutionalization of a point of view in things and in habitus,' explains Bourdieu.[466] The habitus of chronostratigraphy is characterised by a common mode of thought, or observation, which takes certain values, instruments, and conventions as undisputable. The formalisation effort of the AWG unfolds partly as an attempt to negotiate between two forms of anxiety, *anthropophobic* and *autophobic*, in a manner that is determined by the established preferences of the current ICS and IUGS executive officers.

5.8 Conclusion

How does the AWG's take on utility and practicality fair in light of more recent intensification of the AWG's relationship with non-stratigraphic interest in the Anthropocene? In late 2018, the AWG secured a one million euro grant from the Haus der Kulturen der Welt. Their involvement with the HKW dates to 2013, when they hosted a public meeting of the AWG. Indeed, since 2013, the HKW have been running an ongoing series of programs called The Anthropocene Curriculum.[467] As part of this program, contributors from across disciplines are

[465] Finney, S. 2014.
[466] Bourdieu, P. 2000: 99.
[467] See the Anthropocene Curriculum website, at https://www.anthropocene-curriculum.org/ (accessed 16/1/21), which describes itself as 'a global network of initiatives developing and testing experimental and

invited to reflect on the various themes associated with the Anthropocene. In October 2020, as part of the Anthropocene Curriculum, the HKW hosted *The Shape of a Practice: Negotiating Context in the Anthropocene*, a week long program of talks, screenings, and online exhibitions bringing 'together over 100 researchers, scientists, artists and activists to share their fields and methods of work on everything from water pollution and disaster management to an interrogation of the new geological era's colonial histories.'[468] In 2019, the HKW held a meeting of the AWG in New Orleans as part of the Anthropocene Curriculum program, for a project called *Mississippi. An Anthropocene River*. Their project 'explored how the river – as ecology and human habitat – has been reshaped over time, understanding its present as a product of a history of human-environmental interaction, but also violent intervention.'[469]

The HKW's grant is a lifeline for the AWG's formalisation effort. Since they were commissioned in 2009, the AWG have made numerous unsuccessful attempts for funding.[470] As the AWG turned increasingly towards a GSSP led formalisation effort, the lack of funding posed a problem. A GSSP requires detailed analyses of cores. The absence of funding meant that such analyses could not take place. Most AWG studies to date do not refer to original research, but rather to existing literature, for example on analysis of cores extracted for other purposes, such as towards the definition of the Meghalayan. The extraction of new cores from sites around the world is a costly and time-consuming endeavour. It's analysis within the appropriate laboratories (those that have the required equipment and personnel) entails subsequent costs. The final day of the Mainz meeting saw a session devoted specifically to the distribution of jobs relating to GSSP designation *in the absence* of exclusive AWG cores. These discussions outlined an informal economy with which the AWG pursued the designation of a GSSP for an Anthropocene unit in the absence of institutional support or adequate funding. For example, AWG members discussed colleagues they knew of who were conducting research in some of the sites mentioned as possible GSSP candidate locations.

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experiential approaches to co-learning and co-producing knowledge in a rapidly changing planetary situation.'

[468] See *The Shape of a Practice* website at https://www.hkw.de/en/programm/projekte/2020/the_shape_of_a_practice/the_shape_of_a_practice_start.php (accessed 22/1/21).

[469] See the website of *Mississippi. An Anthropocene River* at https://www.anthropocene-curriculum.org/project/mississippi (accessed 22/1/21).

[470] Zalasiewicz, J. 2019. Personal correspondence. See Appendix.

Would those colleagues be willing to contribute sections of their own cores, extracted for non-Anthropocene related research? And if they could, would anyone be able, or know someone who could, conduct the appropriate analysis on those sections, if not for free, then for as little as possible? Would it be possible to combine the kind of analysis that would need to be conducted on a core section for AWG purposes *with another ongoing* research project that would already be using the laboratory equipment anyway? In this way, the AWG proceeded with their efforts toward designating a GSSP through asking favours of colleagues who had access to resources and were willing to assist in the AWG's research efforts. Informally, it was discussed that in exchange for helping conduct laboratory analysis, or lending a section of an existing core, those who assisted could be listed as co-authors in the resulting research papers.

The need for both a GSSP and funding to extract cores and assess them towards that end were mentioned frequently at the Mainz meeting. It appeared that the stringent requirements of the GSSP came as a surprise to many of the meetings attendants who were not directly affiliated with the AWG. Yet it was in this capacity that the director of the HKW, Bernd Scherer, appeared to acknowledge the significance of the GSSP, and the materiality of its method of designation: a metal nail, or "golden spike," hammered into the section that serves as the lower boundary of the geologic unit, and the point of reference for correlating that unit globally.[471] Scherer could be observed typing furiously into a tablet device, paying

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[471] The term 'golden spike' to refer to the GSSP has an unclear history. The two terms are used interchangeably, with 'golden spike' the vernacular version. ICS executives at Mainz, following the view held by the prominent chronostratigrapher Charles Holland (Holland, C. 1986. Does the golden spike still glitter? *Journal of the Geological Society of London* 143:3-21), claimed that the term derives from the use of golden spikes to ceremoniously mark the completion of North American railway lines. How railway lines and unit boundary markings are relevant to each other remains unclear, but to the extent that it continues to be repeated, it is a commonly held myth within the discipline. Elsewhere, however, Stephen Walsh et al provide a more plausible explanation, quoting another chronostratigrapher Sylvester-Bradley, who explains:

> The concept of marker points is not, of course, a British invention. I became acquainted with it in 1961 during a session of the International Field Institute in Britain, held under the auspices of the American Geological institute. I was leading a party of American geologists over the classic localities of the Jurassic System in England. Dr. W. C. Bell, a member of the American Stratigraphic Commission, had brought with him a 'golden pick'. At each type locality, the pick was driven into the section at the base of the formation, and a photograph of it and the type section was taken. Now, many British stratigraphers feel that marker points should be physically inserted in type sections as permanent records, only to be altered by decision of an International Commission.

Sylverster-Bradley, P.C. 1967. Towards an international code of stratigraphic nomenclature. In Teichert, C. & Yochelson, E. (eds). *Essays in Palaeontology and Stratigraphy: R.C. Moore Commemorative Volume*.

close attention to the proceedings. During the discussion on the final day, where the AWG's absence of resources became particularly apparent, one could almost observe a light bulb going off above Scherer's head. Could the absence of funding be an opportunity for his museum, which had already demonstrated its interest in the AWG's formalisation effort, and the Anthropocene theme more generally?

The one-million-euro grant was offered to the AWG by the HKW within months of the Mainz meeting. This grant confirmed the central role of the HKW in the AWG's formalisation effort. The HKW would be the site of the subsequent meetings of the AWG, and accelerate the formalisation effort by narrowing meetings down not to the total membership of the AWG, but instead to groups of teams, not all of whom are AWG members, who could extract cores and analyse them as GSSP, or auxiliary core, candidates. In the next chapter I wish to pick up from that point, beginning with a close reading of the first meeting of core candidate teams at the HKW in May 2019, less than a year after the Mainz meeting. How is the AWG's strategy, of invoking terms such as 'utility' to constrain the way in which the Anthropocene is deployed, effected in light of their increased dependency on the HKW? What consequences does their collaboration have for the formalisation strategy of the AWG? These questions will inform the trajectory of the next chapter.

Kansas: University of Kansas Special Publication 2: 49-56. Pg. 53. With the involvement of the HKW, the theme of material markers of unit designations, or monuments, shall take on a more important meaning, which we shall review in the next chapter.

6. The HKW and AWG: A conclusion

How might one conclude a thesis whose object of study remains ongoing and incomplete? This chapter concerns a key development in, and the current stage of, the AWG's formalization effort: the acquisition of a one-million-euro grant, to be used toward the extraction and analysis of cores for an Anthropocene unit GSSP. This money was granted by the Berlin based Haus der Kulturen der Welt (HKW). The HKW describes itself as an institution that 'creates a forum for the contemporary arts and critical debate.'[472] It is housed in a large, multi-roomed Congress Hall, built as the USA's contribution to the INTERBAU international architectural exhibition of 1957. The HKW is a branch of the Kulturveranstaltungen des Bundes GmbH (KBB), or the German Federation for Cultural Events Ltd. Together with the Berlinale Film Festival, and the Berlin Festspiele, or "Festival Hall," the HKW is part of the KBB's 'platform for international cultural work'.[473] In practice, the HKW operates as a contemporary arts space, hosting exhibitions that aspire to attend to what it identifies as the predominant artistic, scientific, and political challenges and 'upheavals' of the day.[474] The Haus has demonstrated a keen interest in the Anthropocene for several years already. Since 2013, the HKW has hosted a program called the Anthropocene Curriculum, which they describe as a forum for discussion of the Anthropocene theme and its implications within stratigraphy, as well as what the HKW's director Bernd Scherer likes to call its "social, political, cultural" implications.[475] The second meeting of the AWG took place as part of an Anthropocene Curriculum schedule, at the HKW in 2014.[476] The grant is a significant milestone in the AWG's effort, given their lack of success in securing funding from more

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[472] See the HKW's website at https://www.hkw.de/en/hkw/ueberuns/Ueber_uns.php (accessed 10/05/2021).

[473] This quote is taken from the KBB's web page, available at: https://www.kbb.eu/de/ueber_uns/die_kbb/dieKBB.php (accessed 10/05/2021).

[474] See the HKW's 'About Us' page, which, in lieu of a traditional self-description, poses the following question:

> 'in the midst of profound global and planetary transformation processes, HKW re-explores artistic positions, scientific concepts, and spheres of political activity, asking: How do we grasp the present and its accelerated technological upheavals? What will tomorrow's diversified societies look like? And what responsibilities will the arts and sciences assume in this process?'

ibid.

[475] See Robin, L., Avango, D., Keogh, L., et al. 2014. Three galleries of the Anthropocene. *The Anthropocene Review* 1(3): https://doi.org/10.1177%2F2053019614550533. See also the Anthropocene Curriculum website, at https://www.anthropocene-curriculum.org/ (accessed 5/5/2021).

[476] Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017: 56.

traditional sources of funding for geological research, as discussed at the end of the last chapter.

In focusing on this development (the grant), I am ultimately interested in understanding how the HKW's involvement influences the AWG's formalisation effort. I seek to develop an understanding of the circumstances surrounding the HKW's grant, and how the involvement it entails is received by the AWG within the context of their ongoing effort to formalise an Anthropocene unit, and designate a GSSP. I argue that, in the same way the AWG have adapted their position on their formalisation effort in reference to the preferences of the ICS and IUGS (shifting from a perspective that considered both a GSSA and GSSP definition, to one that focused exclusively on a GSSP definition and that prioritised chronostratigraphic interest in the hypothesis of a formal unit), the involvement of the HKW signals a similar effort to adapt their position accordingly. The AWG are consequently obliged to manage two sets of interests at once: those of the ICS & IUGS, and those of the HKW. These interests, as I shall explain, are not entirely compatible. It is therefore of great interest to observe how the AWG develop their formalisation effort in a manner that satisfies the strict, procedural requirements concerning unit formalisation and GSSP designation, with the far more eclectic interests of the HKW's commitment to the Anthropocene theme.

I address these questions in two parts. Firstly, I review a contract that has been drafted by the HKW with each of the eight GSSP core teams. I provide an overview of the language therein, which presents the grant as an artists' commission, wherein the AWG are being commissioned to provide the GSSP to the HKW, as an artist would provide an artwork, for the purposes of an exhibition. The contract presents a novel development in the AWG's formalization effort: it outlines a relationship in which the HKW *commission* the AWG to provide an artefact of their formalisation effort, preferably the GSSP itself once defined, for display at an upcoming exhibition, currently in development, on the AWG's formalisation effort, to be hosted at the HKW. The GSSP thereby takes on a new significance as the means for unit definition. It is to function both as a means of chronostratigraphic classification consistent with the requirements imposed by the evaluative bodies associated with the Chart and Scale on the one hand. On the other hand, it is to serve as an artefact at the centre of an exhibition within a contemporary arts space, the HKW.

I contrast the representation of the HKW's involvement with the AWG that appears in the contract with one that emerges from a series of meetings that took place at the HKW between May 28-29, 2019. Some of these meetings were between members of each of the GSSP candidate research teams and the HKW to discuss the contracts that had been drafted. Another meeting was between senior members of the AWG and HKW, together with members of the German press. In these meetings, one observes each side (the HKW on one hand, the AWG on the other) presenting their understanding of the formalisation effort, marking the differences in the way that effort is perceived, understood, and formulated. Despite the HKW's financial backing of the AWG's formalisation effort, and particularly the designation of a GSSP, the meetings indicate that the two organisations have quite different understandings of what the formalisation effort accomplishes. In the press meeting, the HKW stresses that there are significant "cultural, social, political" implications to the AWG's formalisation effort that not all AWG members fully appreciate. The proceedings of the contract meetings indicate that some GSSP candidate research teams are unclear as to how the HKW intend to present the AWG's work in a contemporary art context. These differences in understanding are an occasion for each side to discern what the other expects of them, and how to adapt accordingly. The differences in the way the HKW perceive the formalisation effort is an occasion for the AWG to adapt their explanation of the significance of a formal Anthropocene unit in a way that can satisfy the HKW's interests in the Anthropocene theme, while still satisfying the requirements of an official geological unit. This is an important point, because it demonstrates the extent to which the AWG continue to elaborate their formalisation effort in political and diplomatic terms. That is to say, the AWG's formalisation effort does not *discover* an Anthropocene unit, simply delineating its characteristics in a passive manner. It actively constructs the unit, adapting its position as to its meaning and significance as the formalisation effort proceeds, and as diverse interests shape and position the AWG's formalisation effort accordingly.

The notion of the AWG being "positioned", and of external interests (ie those developed by non-AWG members and organisations) shaping the position of the AWG, is a significant theme in my conclusion. It is a theme that helps to understand the ways in which the AWG have changed their position in relation to the strategies and the significance of the formalisation effort, since that effort began in 2009. To speak of the AWG's formalisation effort as "positioned" emphasises its continual evolution in response to the diverse interests according to which the AWG attempt to define a formal Anthropocene unit. Much of the AWG's adaptability in response to external interests, such as those of the IUGS or HKW, centre on the GSSP. The GSSP intervenes in the initial effort to define the beginning of an Anthropocene unit by reference to a numerical age, or GSSA (which the voting members affiliated with the Chart and Scale made clear would not be sufficient for the purposes of unit formalisation). The GSSP demarcates the boundaries between the various factions *within* the AWG, who vote for the GSSP's designation at very different points in the geological record, or according to very different historical events, each with their own remarkably distinct set of social and epistemic implications. The GSSP becomes a point of contention within the AWG, furthermore, when a sub-section of members determine that the GSSP indicates the *wrong way* for an Anthropocene unit to be defined, as discussed previous chapters.

In this chapter, we shall review how external interest in the GSSP, from the HKW, is the impetus for the AWG to be granted crucial funding. Yet this funding entails a further set of interests in the formalisation effort, that the AWG are obliged to respond to, and incorporate into their effort. The AWG must acknowledge the interests of the HKW, and reconcile them with the preferences of the ICS and IUGS, toward the ratification of a formal Anthropocene unit. The HKW take interest in the AWG's formalisation effort more specifically as they seek to designate an artefact, the GSSP core, which can be fashioned as a pretext for a contemporary arts exhibition. The ICS and IUGS have a very different appreciation of the GSSP, as a disciplinary standard that must be consistent with the other units of the Chart and Scale. The AWG pursue the GSSP toward the validation of their research efforts over the past twelve years, since the AWG was founded in 2009. The GSSP is therefore the site of negotiation between the various interests in the AWG's formalisation effort, providing insight into the political, diplomatic, and legislative components of the that effort.

6.1 The grant

In early 2019 informal discussions with AWG members indicated that the HKW had secured one million euros for the purposes of extracting and analysing a set of cores for a GSSP definition of an Anthropocene unit. This was a significant development because it would enable the AWG to commission and finance the retrieval of their own cores. Up until now, the AWG have conducted research on stratigraphic sites and sections, which they believe could be used in a proposal for an Anthropocene unit, either by way of extensive reviews of existing literature (whose primary concern is geological research not related to the AWG), or through the generosity of colleagues who extract cores for their own, non-Anthropocene purposes, but conduct Anthropocene-relevant analysis on the leftovers of their own research. The HKW grant therefore facilitates more efficient and dedicated research of the kind that the AWG need to designate a GSSP and conclude a successful proposal for the inclusion of an Anthropocene unit in the Chart and Scale.[477]

Following confirmation of the grant, the AWG held a formal and binding vote among its members, 'to affirm some of the key questions that were voted on and agreed at the IGC Cape Town meeting in 2016.'[478] That meeting had seen a first round of voting as to whether the Anthropocene was worth pursuing as a formal geological unit, as well as when it could be said to have begun.[479] That vote, which found that a majority of AWG members agreed that the Anthropocene merited formalization at the level of a geologic Epoch/Stage, with an optimal lower boundary (or beginning) in strata from the mid-twentieth century, had been the occasion for a wealth of reflection on the consequences of this decision. As we reviewed in previous chapters, this led to increased involvement, and the publication of further literature, from archaeologists, geographers, and social scientists, among other fields.[480] Much of that literature criticised what was seen as an exclusively stratigraphic approach to time, ignoring the contributions of other disciplines in favour of adhering to IUGS criteria. Critics argued that it was not clear what the relevance of such a narrowly defined Anthropocene unit would be, especially given that beyond the sub-field of

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[477] Elsewhere, Zalasiewicz et al. explain that the 'work of the group [has been] 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 possible Anthropocene time interval.' Zalasiewicz, J., et al. 2017. The Working Group on the Anthropocene: Summary of evidence and interim recommendations. *Anthropocene* 19: 55-60. Pg. 56.

[478] See Zalasiewicz, J. & Waters, C. 2019. *Newsletter of the Anthropocene Working Group. Volume 9*. http://quaternary.stratigraphy.org/wp-content/uploads/2020/09/Anthropocene-Working-Group-Newsletter-Vol-9-final.pdf (accessed 10/01/2021).

[479] For full details on this vote, see 'Media note: Anthropocene Working Group' available at: https://www2.le.ac.uk/offices/press/press-releases/2016/august/media-note-anthropocene-working-group-awg (accessed 01/10/2020).

[480] See Marwick, B., et al. 2019. Surveying archaeologists across the globe reveals deeper and more widespread roots of the human age, the Anthropocene. *The Conversation*. https://theconversation.com/surveying-archaeologists-across-the-globe-reveals-deeper-and-more-widespread-roots-of-the-human-age-the-anthropocene-122008 (accessed 01/10/2020); Lewis, S. & Maslin, M. 2015. Defining the Anthropocene; Ellis, E., Maslin, M., Boivin, N., et al. 2016.

chronostratigraphy, few geologists or geoscientists are concerned with the preferences of the IUGS or the classifications of the Chart or Scale.[481]

What precisely was being decided in this new round of voting? On March 19th, 2019, an email was circulated to all AWG members. They were asked to vote on two questions:

- Should the Anthropocene be treated as a formal chronostratigraphic unit defined by a GSSP?
- Should the primary guide for the base of the Anthropocene be one of the stratigraphic signals around the mid-twentieth century of the Common Era?

The group was allowed one month for open discussion via email, followed by an additional month to cast a vote, during which time no further discussion was permitted. The final vote was published on the AWG website on the 21st of May, 2019. 88% voted in favour of both points (twenty-nine out of thirty-four members). Four votes were cast against both points. There were no abstentions.[482] Given that only 60% majority was required for a resolution to pass, the AWG could now adopt the favourable position as the official stance of the AWG. This decision was to guide any subsequent analysis and research activity. The vote was a demonstration of decisiveness by the AWG. It signalled a change in narrative, from a unit with numerous possible lower boundaries and start dates, to a proposed unit of a single definition. A general area for a chronostratigraphic section and geochronological event had been chosen. It remained to be determined which precise section and event would be selected as most likely to satisfy the preferences of the voting members affiliated with the evaluative procedure of the Chart and Scale. The definition of a GSSP requires a suite of supporting, auxiliary cores. One material section is chosen as the primary reference with which rock belonging to an Anthropocene unit would be correlated worldwide. The other core candidates comprise the "auxiliary cores" which are intended to support the GSSP by indicating sample reference points in other parts of the world.[483]

One week after the results of the vote were confirmed, a meeting took place at the HKW. This meeting was not aimed at all AWG members. Rather, it was for the members of

[481] See the article, authored by some members of the AWG, published around the same time the vote was taking place. Edgeworth, M., Ellis, E., Gibbard, P., et al. 2019.

[482] Details of the vote can be found on the AWG website: http://quaternary.stratigraphy.org/working-groups/anthropocene/ (accessed 10/01/2021).

[483] See Zalasiewicz, J., Waters, C., Summerhayes, C., et al. 2017.

each of the core candidate teams associated with an Anthropocene GSSP. There are scientists working on proposals for an Anthropocene GSSP who are not themselves members of the AWG. Although most teams include one AWG member, not all of them do, and it is not necessary to be an AWG member to propose an Anthropocene GSSP.[484] Each proposal identifies a site, or material body of rock from which a core can be extracted. The proposal explains why the site is appropriate for a GSSP definition. This can include descriptions of the material characteristics of the section, such as the presence of certain fossils, *technofossils*, chemostratigraphic signals, but also the preservability and accessibility of the site. Such points of emphasis are consistent with the guidelines of the ICS, which, in addition to identifying material qualities such as ‘a single point in a designated sequence of rock strata, serving to indicate the position of the boundary horizon at one place’, emphasise that any GSSP section ‘should be situated in an area geographically accessible to all who are interested, regardless of political or other circumstances.’[485] All of the GSSP candidates are likely to be included in the proposal that the AWG will eventually submit to the SQS.

However, only one candidate will be designated as the GSSP. The other candidates will be included as ‘auxiliary cores’, or cores that support the GSSP, demonstrating that the characteristics associated with it, both geochronologically and chronostratigraphically, are identifiable in other parts of the world as well, and can be correlated. The various proposals are therefore ideally collected from different parts of the world, and from different kinds of rock. The majority of the candidates are from deep sea or lake deposits. This is because marine sediment tends to accumulate in the most regular and undisturbed manner, especially if it is from an “anoxic basin” (a basin that is low in oxygen content, and therefore marine life that could “disturb” sediment deposition). However, there is also a core candidate that has been extracted from a speleothem in a cave in Italy, as well as an ice core extracted from Greenland, and two coral samples from the Great Barrier Reef and Little Cayman Island. The geographical span of these candidates is intended to demonstrate that the characteristics associated with the primary GSSP core are not specific to its region (that it does not

[484] See Waters, C., Zalasiewicz, J., Williams, M., et al. 2014. The chronology of the vote and meeting suggests that the AWG executive had begun accepting proposals for the Anthropocene even before the vote had taken place. See also Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2018. Global Boundary Stratotype Section and Point (GSSP) for the Anthropocene Series: Where and how to look for potential candidates. *Earth-Science Reviews* 178: 379-429.

[485] Hedberg, H. (Ed.) 1976.

demonstrate characteristics that are particular to its locality), but are rather a local indicator of a stratigraphically global phenomenon. The auxiliary cores, furthermore, are intended to demonstrate that the characteristics associated with the primary core are material markers of a geochronological event that had a global impact within a discrete period of time, as opposed to demonstrating a gradual onset (allowing for an acceptable degree of diachroneity, consistent with, for example, the time required for nuclear fallout to disperse from the site of its detonation to another part of the planet). In other words, the auxiliary cores function to support claims that the GSSP designates the material markers of a global and synchronous event. [486] The requirement of globality, a condition of any proposal for a GSSP defined unit, entails the demonstration of synchronicity. An event is associated with material change in the rock record that, consistent with the ICS Guidelines, the AWG are obliged to indicate as having occurred globally within a brief period.[487] The AWG's internal vote decided, first in 2016 and then again in 2019, that this event was the detonation of the first atomic bomb in July 1946. This event led to the rapid spread of nuclear isotopes, specifically ^{239}Pu and ^{14}C around the world, still evident in rock records around the world today.[488] Seeking to satisfy the requirement of synchronicity, AWG members argue that the presence of these materials is evident in deposits globally by 1952 and 1954 respectively.[489]

The sessions of each day of the HKW meeting were opened and closed by HKW curators and/or the director Bernd Scherer. They framed their interest in the Anthropocene theme by reference to the Anthropocene Curriculum, an ongoing program of the HKW that began in 2013.[490] Under the auspices of this program, the HKW hosted the first meeting of the AWG in 2014.[491] The impetus for their continued interest in the Anthropocene theme was presented by Scherer as a desire to reflect on a "profound social paradigm shift," characterised by reference to the dissolution of the boundary between society and nature. Scherer explains, for example, that:

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[486] See Waters, C., Syvitski, J., Galuszka, A., et al. 2015; Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2016.
[487] Hedberg, H. 1976: 24-29.
[488] Waters, C., et al. 2015.
[489] See Waters, C., Zalasiewicz, J., Summerhayes, C., et al. 2018.
[490] Scherer, B. 2020. When Humans Become Nature. In *The Anthropocenic Turn: The Interplay Between Disciplinary and Interdisciplinary Responses to a New Age*. London: Routledge.
[491] For details of this meeting, see Waters, C. & Zalasiewicz, J. 2014. *Newsletter of the Anthropocene Working Group. Volume 4.* http://quaternary.stratigraphy.org/wp-content/uploads/2018/08/Anthropocene-Working-Group-Newsletter-Vol-4-Final.pdf (accessed 10/01/2021)

> 'the Anthropocene not only refers to the aforementioned phenomena such as climate change, the decline in biodiversity, etc.; but more significantly, it stands for a fundamental paradigm shift in our understanding of the world and of humankind… the ostensibly clear dividing line between nature and culture is giving way to a dynamic interweaving of cultural and natural processes, a development which is not manifesting itself in the increasing naturalization of various areas of human life.'[492]

Accordingly, while the involvement of an institution such as the HKW, particularly as a funding body, is unprecedented within stratigraphy, the relation is presented as consistent with the themes that the HKW associate with the term 'Anthropocene.' At the meeting it was announced that as part of the HKW's funding of the AWG's GSSP designation effort, the HKW would host an exhibition, exploring the "social, cultural, political" ramifications of the Anthropocene theme more generally. The AWG's search for a GSSP candidate would provide the framing device justifying this new relationship with the HKW, as well as the context for the exhibition. There was one problem with this plan. According to German federal law, a cultural institution such as the HKW is not allowed to fund basic scientific research. Sections 23 and 44 of the Federal Budget Code (Bundeshaushaltsordnung) state that federal grants may only be administered outside of federal agencies 'if the Federal Government has a substantial interest in the fulfilment by such agencies which cannot be satisfied, or cannot be satisfied to the extent necessary, without the grants.' This implies that the HKW, a branch of

[492] Scherer, B. 2020: 148-149. In this same essay, Scherer quotes a now famous essay concerning the Anthropocene, to situate his concern: 'Humans have become geological agents very recently in human history. In that sense, we can say that it is only very recently that the distinction between human and natural histories – much of which had been preserved even in environmental histories that saw the two entities in interaction – has begun to collapse.' Chakrabarty, D. 2009: 207. This work, in part, builds on now canonical attempts to situate human relations to the environment historically and philosophically. This is a gesture perhaps most readily attributable, at least in recent times, to Latour, B. 1994. *We Have Never Been Modern*. Cambridge: Harvard University Press, and more explicitly politicised in the more recent Latour, B. 2017. The bibliography of Scherer's writings concerning the HKW's involvement with the AWG demonstrates a proficiency in science and technology studies and its perceived ability to address the historicity of the distinction between nature and society. This is a theme that, as we shall see, is foundational to Scherer's descriptions of the AWG's formalization effort and the place of the HKW therein. See Robbin, L., Avango, D., Keogh, L., et al. 2014. Three galleries of the Anthropocene. *The Anthropocene Review* 1(3): https://doi.org/10.1177/2053019614550533 (accessed 12/4/2021); Swanson, H.A., Bubandt, N. & Tsing, A. 2015. Less Than One But More Than Many: Anthropocene as Science Fiction and Scholarship-in-the-Making. *Environment and Society: Advances in Research* 6: 149-166.

the German Federation for Cultural Events (Kulterveranstaltungen des Bundes), are not allowed to forward the federal funding they receive to another organisation to perform their own tasks. The HKW must render the end to which the funding is being applied such that it appears to be directly relevant to the HKW. The AWG's formalization effort would therefore need to be fashioned as an *artists' commission*, in order for the HKW's funding to be permissible. The HKW were now commissioning the AWG to provide them with the GSSP, much as they might commission an artist to provide an artwork. How was this relationship articulated formally?

6.2 The contracts

In parallel to the candidate core presentations, a series of meetings were taking place at the HKW between candidate-team leaders, HKW staff, and the AWG Secretary. The purpose of these meetings was to determine how much money each team needed, what would be the most useful analyses to run on the core(s), as well as to establish a time-line for their research activities. The meetings were also an opportunity for the HKW to explain their approach to the researchers, as the following excerpt from one meeting demonstrates:

> **HKW Liaison**: … we are not a funding body. We are a cultural institution which gets the money from the state to do cultural projects. And we managed to define the Anthropocene project as a cultural project because we see it from our perspective…
>
> **Core team leader**: Yes, yes.
>
> **HKW Liaison**: And that is the interesting thing in this whole project. So the work we are financing, we are financing with regard to the results which are going to be presented to the public in 2021. And this has to be part of the project, for us to make this possible. And what do we mean when we say 'results'? We are not doing a scientific presentation here. We are going to engage curators and artists who will develop formats by which your scientific work is going to be communicated to the public.

> **Core team convenor**: Ah, very nice!
>
> **HKW Liaison**: This is what we do as a cultural institution. Now, how this event is going to be structured, or what part the science is going to take, this all has to be developed. But for us, it is necessary that in the contract we have a clause that we get the usage rights of your work and maybe, if it's possible, and this is what the curators want, the right to exhibit the core in Berlin. I don't know if this is feasible, if you can get the cores transported over here, how much this costs. But this would be the direction in which we would define the contract.

It is interesting to observe how, in those moments, members of the AWG and core-candidate teams made sense of the AWG's description. What does the curatorial knowledge advanced by the AWG have in common with the situation of the AWG researcher? How do the researchers accommodate the HKW's interests within their own experience, activities, and frame of reference? Two examples occurred during my observation of the proceedings. Trying to wrap their head around the description of the contractual relationship outlined by the HKW Liaison, one core-candidate team researcher suggests:

> 'So it's a bit of a cross between an ODP, an Ocean Drilling Program participation, and working under contract somewhat. Because it's a bit of both. We're working under contract to HKW who are funding the analysis, but we're also part of a Working Group and we have to include all of the relevant people on all of the fronts… yeah that makes sense to me. It's really starting to take shape, because it was a very nebulous concept initially and now that I see where we're going with it…'

"Working under contract" is a relatively common form of geological research, especially for those who work in the private sector, such as with resource extraction or large infrastructure projects.[493] But the HKW contract is also similar to a grant contract, wherein researchers work

[493] Much could be said regarding the influence of commercial geological research on practices of geological classification and definition. These range from some of the earliest efforts at unit definition, which were funded by "canal companies" in the UK, transporting coal across the country, to more recent significance of resource extraction for definition of geological phenomena such as continental drift. In the interest of

toward research objectives and include each other on the subsequent publications and other research output. A senior AWG member present at this meeting expands on this point:

> 'The other aspect is that it would be the case that the artist would have access to the data as it's being collected, with the understanding that it's not presented in a way that anybody could reinterpret the data before it's published. So we need to make sure that we as scientists get the first opportunity to publish the data. But bearing mind that the presentation is going to be sometime in the Fall of 2021, the artists need access to the data, but we need to make sure that doesn't go outside of their workshop and that they don't release that data as raw information. So, we have the ownership of that as scientists. And the idea would be that you lead on the basic paper describing the Crawford Lake succession. Any spinoff papers with the work you're talking about regarding the non-anoxic successions, by all means, you go ahead and publish those as well. Perhaps the ordering of things might be worth discussing with us as Working Group spinoff papers: do you publish them before the main paper; is it going to detract from the results by doing that or does it actually help that we don't have to then, in the main paper, discuss that in any detail. So, we need to be involved in that discussion as and when you decide to publish, but we're accepting your lead on this. So, if you wish to have other papers talking about things… and you think that's worth doing as a separate paper, then again… all these spinoffs are possible, but it's communicating with everyone in the team to make sure that you don't leave any of the core offers out.'

This comment provides a glimpse of how parts of the AWG make sense of the HKW. The aspiration to work together is realised through the mutual fulfilment of respective ambitions. It also emphasises a key component of the HKW's work with the AWG: *data*. The HKW liaison acknowledges that even though the exhibition would ideally figure the GSSP as the centre

retaining focus I have not included these chapters of geological history in my thesis. Some interesting sources on this topic include Oreskes, N. 1999. *The Rejection of Continental Drift: Theory and Method*. Oxford: Oxford University Press; Winchester, S. 2001. *The Map That Changed the World*. London: Penguin, which focuses on William Smith's drafting of one of the first geological maps of the UK, and Shafiee, K. 2018. *Machineries of Oil: An Infrastructural History of BP in Iran*. Cambridge: MIT Press.

piece of an exhibition on the AWG, this may not be possible. And yet, an exhibitable artefact is required of the AWG to validate the grant: to show that it is not an instance of funding basic scientific research. The slightly ambiguous term 'data', which nevertheless appears prominently in the above understanding of what the AWG have left to do, appears prominently in the contract as well. The relationship is approached as an opportunity to promote the AWG's incumbent strategy of producing literature and developing proposals for an Anthropocene lower boundary.[494] This strategy is thought to be relevant to the artists involved, but separate. The researchers and artists do not work together, in this understanding of the situation, but do share the same material: "data."

The contract provides a blueprint for the dynamics of the HKW and AWG's relation. In emphasising the duality of the GSSP and the AWG's research effort as a material with which to develop exhibitable artefacts, the historicity of the formalization effort is foregrounded. That is to say, the sense that the GSSP could be manifested equally as a series of art works as it could an IUGS-approved core, contrasts from the AWG's effort to narrow the possibilities of the GSSP through the vote. Put simply, thinking about the GSSP as an artwork, and not only a stratigraphic method, emphasises the contingency of the overall effort, and the work that is required to establish the GSSP and formalize the Anthropocene as a geologic unit. 'Data' can be understood equally as a noun as it can a verb.[495] As such, the manner in which the term 'data' is invoked in discussions between the AWG and HKW mirrors the dynamic according to which the GSSP is articulated, toward a formal designation. The contract makes this analogy explicit when it invokes the terms "data", "works" and "object of agreement" interchangeably. The "object of agreement" refers to 'generated data in raw as well as in plotted form… accompanied by an analysis report and a short scientific report, in which the results are described and evaluated.' In their discussions with the HKW, the AWG as well as

[494] A strategy that is entirely consistent with the predominant activity of scientists, who have traditionally been observed by science & technology studies scholars to be devoted to the writing and publishing of articles. See Latour, B. & Woolgar, S. 1986 [1979]. *Laboratory Life: The Construction of Scientific Facts.* Princeton: Princeton University Press. A more recent account of the dynamics of this culture of literary production is provided in Biagioli, M. & Lippman, A. 2020. Metrics and the New Ecologies of Academic Misconduct. In Biagioli, M. & Lippman, A. (eds). *Gaming the Metrics: Misconduct and Manipulation in Academic Research*. Cambridge: MIT Press. Pp.1-23.

[495] See Gitelman, L. & Jackson, V. 2013. Introduction. In Gitelman, L (Ed.) *"Raw Data" Is an Oxymoron*. Cambridge: MIT Press. 'Raw data' is an oxymoron, in their sense, because it is not *discovered*, but rather ''collected', 'entered', 'compiled,' 'stored,' 'processed,' 'mined,' and 'interpreted.'' The adjective 'raw', implying 'discovered', overlooks the question of 'how different disciplines have imagined their object and how different data sets harbour the interpretive structures of their own imagining.' (Pg.3).

the core candidate teams have raised some hesitations regarding the possibility of transporting whichever core is chosen as the GSSP, to the HKW for exhibition. Cores are fragile artefacts, and there is uncertainty as to whether the HKW have the necessary facilities to ensure whichever core is chosen to designate the GSSP can be safely stored at the museum for the duration of the exhibition.[496]

"Data", "works", and "object of agreement" are therefore place-holder terms. They designate the ongoing contingencies associated with the definition of an Anthropocene GSSP. They also indicate the epistemic promiscuity of the GSSP. Although the GSSP is an established metric in stratigraphic practice, it can refer to very diverse kinds of material. So far, GSSPs have been designated in ice cores (as in the Holocene/Pleistocene boundary), speleothems (as with the Meghalayan/Northgrippian boundary), and rock sections (as in the Silurian/Devonian boundary). GSSPs can be designated with reference to very different methods as well, from palaeontological to magnetostratigraphic. The ambiguity of the terms "data", "works", and "object of agreement" in the HKW's contract, attempt to encompass the full variety of what an Anthropocene GSSP *might be*. These are terms that acknowledge the contingency associated with the AWG's formalization effort, while seeking to confirm that the effort will indeed go ahead, that something will result from it. These are terms that, in this instance, imply a noun as much as they do a verb. They refer to the process in which they are invoked: a contractual agreement in which something is being exchanged; a stratigraphic formalization process in which something is being formalized. The definition of what that 'something' *is*, is delayed, implying a material artefact yet unfolding as part of an ongoing and indeterminate process. In effect, it is that indeterminacy that the HKW is interested in, more than the material artefact of an eventual GSSP (which even in stratigraphic parlance would also be a processual practice of reference and not *solely* an artefact). Invoking such place-holder terms as "data" and "object of agreement", the contract demonstrates the joint act currently being undertaken by the AWG together with the HKW of imagining a GSSP for an

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[496] The recently formalised Meghalayan Stage/Age has already lost an auxiliary core to its GSSP core. The arctic ice core, one of three cores that collectively designated the lower boundary of the Meghalayan (two auxiliary cores and one GSSP core) melted when a freezer malfunction occurred at the University of Alberta in Edmonton. See Walker, M., Head, M., Lower, J., et al. 2019; Kassam, A. 2017. 22,000 years of history evaporates after freezer failure melts Arctic ice cores. *The Guardian*. Available at https://www.theguardian.com/environment/2017/apr/16/arctic-ice-cores-melt-university-alberta-canada (accessed 10/05/2021).

Anthropocene unit. Indeed, the contract frames the exhibition as aiming to 'create a public forum for the scientific, cultural and social political impact of the geochronological research carried out by the international GSSP-research projects on the Anthropocene.' The contract shares with the GSSP effort the quality of being determined by an object that remains as-of-yet undefined. The contract designates both organizations participation in a common *process*: the effort to designate a GSSP for an Anthropocene unit.

"Data", "works" and "object of agreement" stand to indicate what the AWG and HKW have in common: an interest in the designation of a GSSP for an Anthropocene unit. The contract presents an image of the relationship between the two groups as harmonized through the assertion of such common artefacts. However, more accurately, the relationship between the two groups is an ongoing process that both sides are attempting to accommodate into their own, more familiar, activity. They do not fully understand each other: rather, each side understands their own activity, and projects it onto the other. The HKW, for example, must find a way to fashion the AWG's research effort as an *artists' commission*, consistent with the parameters of their funding under German federal law; while the AWG search for ways to apprehend the HKW's interest in their research through the more familiar idioms of geological research, as well as to embrace the HKW's involvement in a manner that will not contradict the interests of those members of the Chart's evaluative hierarchy who will ultimately vote on an AWG proposal. In the next section I will explore how the description presented in the contract differs from that demonstrated by the HKW and AWG in a "public-facing" context, namely: at a press conference announcing the upcoming exhibition.

The existence of a contract in the first place indicates that if there is consistency of interests, there is also a difference. The purpose of any contract, arguably, is to manage that boundary. It therefore implies that the AWG's formalization effort is now subject to the interests of the HKW. Their formalization effort stands to be influenced by the HKW's interest, specifically in articulating a sense of the Anthropocene theme as they find it to be "culturally, socially, politically" implicated. The interest of the HKW is simultaneous with the incumbent interests of the ICS and IUGS, the voting bodies affiliated with the Chart and Scale. In the previous chapter I demonstrated ways in which the AWG acknowledge the interests of the ICS and IUGS, and develop their formalization effort in anticipation of those interests and expectations. The involvement of the HKW, therefore implies a further set of interests and expectations that the AWG must acknowledge as they develop their proposal. These interests are applied materially: the contract indicates that the HKW distribute their grant at milestones whereby funding is released to the core teams in accordance with the completion of tasks. These tasks include the publication of peer-reviewed articles, the extraction of a core, or the performance of specific analyses on those cores. Yet the interests of the HKW are also explicitly conceptual in a way that may have more significant limitations on the development of the AWG's formalization effort.

6.3 The press conference

The contract is a private agreement between the two organizations. How do the organizations reflect on their relationship publicly? In addition to the various presentations and meetings that took place during the May meeting, there was also a press conference. This meeting took place at the end of the first day, following a full morning and afternoon of presentations and meetings. It was held in a large, wood-panelled room directly above the conference hall in which the presentations took place. A long, slightly oval table ran across the middle of the room. Along one side of the table were various personnel of the HKW's press and curatorial teams, as well as two AWG members. A wall at the end of the table was lit by a projector. AWG Chair Jan Zalasiewicz was not able to attend the meeting. Sitting across from the HKW and AWG team were approximately ten journalists from various German newspapers, seated behind name cards. Following a round of introductions, one of the two AWG members was invited to provide some context for the journalists by explaining the formalization procedure that the AWG are pursuing, as well as the GSSP technique. The AWG member begins a detailed history of the ICS and the IUGS, as well as the formalization procedures entailed in the definition of a GSSP. They outline the division and classification of geological units from Hutton to Arduino. A journalist becomes slightly confused:

> **Journalist**: Sorry, what is the GSSP again?
>
> **AWG member**: It's the reference point we would use to define the base of the Anthropocene. And then that point, it's the point itself that fixes the definition. Not the signal, but the point itself. So if it were to later be established because of more sensitive instrumentation that the signal actually starts a few years before, well you

don't move the definition of the Anthropocene down. The Anthropocene definition is based upon that point, which would be in a particular year that you have already defined within that Stratotype section.

Journalist: A particular year and a particular location, right?

AWG member 1: A year and a location, yes. The year you can determine by counting down from the top.

HKW Affiliate: So you start out with objective science and you end up with a normative… you make a practical decision in reference to what is the Anthropocene. I think this is a very important point. It's also referring to what [journalist] is asking. Basically, we are at the point where the collection of data is getting transformed into a normative decision. And the normative decision will define, so to say, a natural science fact.

AWG member 1: Yes.

HKW Affiliate: And will be the reference point for discussion. And if you now contextualise the natural sciences and society, they're defining, so to say, what nature is. That becomes then, a reference point also for political, social, and cultural discourse. So we are exactly at that point where the collection of data worldwide leads to a decision, pragmatic decision, which becomes normative. And this is a very important transition which is going to take place here. Because the normative, the normativity in the concept then inbuilt, has impact on the social, political discussions in society.

AWG member 1: Correct.

HKW Affiliate: Because it becomes a reference point for politicians to say, "yeah…" And this is so important to see. That this is taking place on the basis of your work at the moment. And just in order to make a, more or less in the end, I mean I don't want to interrupt further questions, but what is the role of HKW? When we finance this, to some extent, we give a budget to make this possible as Colin explained, for me it's like a kind of cultural production. As we would give money to an artist, or intellectuals to develop a project, so we give money to the AWG and to this whole research project in order to come up with a normative concept that allows to be mobilised in the cultural, social, and political fields. And this is crucial, for me, the crucial strategy which is going on at the moment. And what is interesting is that people like you, and Jan, who cannot unfortunately be with us, he is very conscious of this kind of cooperation between the cultural institution and the scientific research stuff.

AWG Member 2: What you tend to find is that…

HKW Affiliate: And perhaps, just to say, from an outside perspective, I am not a scientist or geologist or natural scientist; for me some of the fact you are dealing with, I mean, it's dry science! [laughter] I must say! But the implications of what you are doing, I mean, they are tremendous. This is really so important to see.

AWG Member 2 raises eyebrows and folds arms.

AWG Member 2: I think also, scientists these days are very much tuned to the fact that they have to present their science outside of their own community. And this provides us with a wonderful opportunity for not only doing our strict stratigraphical assessment, which we were tasked to do, but also then explaining that science. And that can be done through publications. But also it can be done by how people can interpret our work. And as part of that study, in 2021, HKW will be presenting our information, perhaps in way we might find unusual, but at least we have to appreciate that some people can understand concepts visually perhaps in ways that maybe scientists would not find the easiest way of understanding. You know, we show lots of graphs. People look at graphs and just close off. But if someone else can present that data in different ways, they can visualise it…

> **HKW Curator**: But it's not just translating your findings! What I think our task is, is to mobilise the meanings inbuilt into the concept which you, on a scientific level, are not mobilising. In the cultural and political field. It goes beyond much of what you're saying. Because you want to be as objective as possible, and objectivity in this sense means to decontextualize your findings from the political, from the social, from the cultural, and we are recontextualising it. So, this is our task, not just a translation 1:1 from the science part into the society part. But to, so to say, yeah… articulate what are the social, political, cultural implications into the concept you propose.

What is the "political, social, cultural" triptych to which the curator persistently refers? What is the difference that it draws between the work of the HKW Affiliate and the AWG Member, of the HKW and the AWG? What does their insistence – to communicate something *more* than what the AWG members perceive – reveal about what the relationship performs for the HKW? To address these questions, we may look to literature authored by senior HKW personnel.

In his contribution to a volume of essays entitled *The Anthropocenic Turn: The Interplay between Disciplinary and Interdisciplinary Responses to a New Age*, HKW director Scherer situates the HKW's involvement within a new, interdisciplinary paradigm:

> 'The Anthropocene not only refers to the aforementioned phenomena such as climate change, the decline in biodiversity, etc.; but more significantly, it stands for a fundamental paradigm shift in our understanding of the world and humankind. As a result, the ostensibly clear dividing line between nature and culture is giving way to a dynamic interweaving of cultural and natural processes, a development which is now manifesting itself in the increasing naturalization of various areas of human life.'[497]

The idiom of 'interweaving', invoked by Scherer, is therefore both a gesture of hybridity, insofar as it indicates the historicity of distinctions such as those between "nature" and "culture"; but also a distancing gesture, insofar as the HKW distinguishes itself and its role vis

[497] Scherer, B. 2020. When Humans Become Nature. In Dürbeck, G. & Hüpkes, P. (eds). *The Anthropocenic Turn: The Interplay between Disciplinary and Interdisciplinary Responses to a New Age*. London: Routledge. Pp. 145-151. Pg. 148.

a vis the characterisation of the AWG's work as "dry" and *decontextualizing*, as opposed to the "recontextualising" effort of the HKW.

The AWG's formalisation effort is therefore clearly performing some epistemic work on the HKW's behalf. The involvement of the HKW with the AWG's effort positions the HKW in a way that they find desirable, insofar as it demonstrates their fluency in, and commitment to, a *zeitgeist*: the 'Anthropocene'. In the next section, I would therefore like to address the relationship of the HKW and AWG, and how it may stand to influence the unfolding of the AWG's formalisation effort, the other way around, by advancing some thoughts on what the formalization effort does for the HKW. In doing so, I hope to emphasise the degree to which the various mobilisations of the Anthropocene theme respond to each other and influence their mutual unfolding accordingly.

6.4 The HKW's interest in the AWG's formalisation effort

To some extent, each invocation of the Anthropocene theme is its own refashioning of the term more generally. When Crutzen used the term, it was intended as a rallying cry to geoscientists to guide an ambiguously figured 'humanity', through a scientist led 'planetary stewardship,' in response to a 'planet under pressure.' The AWG's understanding of the term Anthropocene refers to something different, namely, an exercise in the designation of a GSSP that identifies the chronostratigraphic markers affiliated with a geochronological event: primarily the detonation of the first nuclear bomb in 1946. The fluidity with which the term 'Anthropocene' is mobilised is itself the object of critical reflection, with commentators positing their own versions of the term accordingly, such as 'Capitalocene' or 'Plantationcene' in an attempt to both criticise the assumptions that underlie the invocation of the term 'Anthropocene' in diverse contexts, as well as to distinguish between the particular normative commitments entailed in each invocation.[498] In this section, I wish to outline what the HKW attach to the term Anthropocene, and specifically the AWG's effort to define a formal Anthropocene unit of the Chart and Scale.

In a text on the "Anthropocenic turn," Scherer reflects on the Anthropocene theme as a technological issue. Citing the work of a prominent commentator on the Anthropocene theme, Dipesh Chakrabarty, Scherer posits the Anthropocene as the advent of humanity as a

[498] See Haraway, D. 2015.

geological agent.[499] Inaugurating an event on the theme of the Anthropocene, the HKW defined the term in the following manner:

> Nature as we know it is a concept that belongs to the past. No longer a force separate from and ambivalent to human activity, nature is not an obstacle nor a harmonious other. Humanity forms nature. Humanity and nature are one, embedded from within the recent geological record.[500]

For Scherer, the insertion of human history into the expanded temporal framework of geological *deep time* is a technological phenomenon, because it occurs through a set of technological conditions that made the extraction of fossil fuel possible, and the subsequent use of those fossil fuels ubiquitous. The 'capacity' of humans to 'generate planetary transformations' is 'in great part a result of the planet's accumulated "deep time" entering the "now" of humankind in the form of fossil fuels.'[501] This occurs, Scherer argues, through processes of refining raw fossil products that can be used by humans in the creation and use of new technologies that 'contribute to the large scale transformation of the world,' condensing planetary time into human time twice over: first through the contrast of the enormous temporality of fossil products that took millions of years to accumulate being extracted and consumed in comparatively brief durations; and secondly through the insertion of geological markers that Scherer argues result from those practices of consumption, such as plastics and increases in atmospheric concentration of greenhouse gases. In other words, for Scherer, the climatic reading of the Anthropocene, as the theme was developed by Crutzen – a "geology of mankind" – is indistinguishable from the AWG's strictly chronostratigraphic articulation of the Anthropocene as a hypothetical unit of the Chart and Scale.

For Scherer, on the contrary, climatic factors such as atmospheric concentration of greenhouse gases, and chronostratigraphic factors such as the advent of novel fossil types,

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[499] Dipesh Chakrabarty comments that 'it is only very recently that the distinction between human and natural histories – much of which had been preserved even in environmental histories that saw the two entities in interaction – has begun to collapse.' Chakrabarty, D. 2009: 207.

[500] Scherer, B. & Klingan, K. 2013. *The Anthropocene Project: An Opening January 10-13, 2013.* Berlin: HKW. Pg. 2.

[501] Scherer, 2020: 145.

either in the form of neobiota or "technofossils" such as plastics and Styrofoam, are constitutive of a common set of infrastructures that 'form the nature of the Anthropocene world.'[502] Fossil fuel consuming technologies changed the world, as well as human experience of it, to the extent that, Scherer argues, a 'second nature' emerged. 'During this transformation of the planet,' Scherer claims, referring to the advent of telecommunications technologies such as the Internet, and transport technologies such as airplanes and freeways, 'the main goal of cultural activity seems to be the creation of a second nature through technology.'[503] Scherer does not define the precise meaning of "cultural activity" as he invokes it. However, in addition to transportation and communication technologies, Scherer adds the 'monetary economy' as a further instance of technologically-assisted planetary transformation:

> 'The monetary economy is a precursor to other disruptive technologies of today that drive the dynamics of the Anthropocene… the monetary economy is… disruptive in that it connects various areas and spheres from completely different categories. Inventions, discoveries or cultural achievements can be compared via monetary abstraction. In this process of abstraction, cultural acts themselves take the form of objects and are thus naturalized.'[504]

Although again here, the precise sense of the term 'culture' remains unclear, 'abstraction' emerges as a key concept. 'Abstraction processes… are… fundamental to the use of digital technologies whose disruptive nature further fuels the dynamics of the Anthropocene,' explains Scherer.[505] As an example, Scherer recounts the example of a father in the US that learned of his daughter's pregnancy before she had told him, after receiving targeted advertisements for pregnancy related products. As a result of the daughter's online browsing and shopping activity, the US retailer Target had identified her as being pregnant, and targeted ads for pregnancy-products began appearing when others used the same computer

[502] ibid: 146.
[503] Ibid.
[504] ibid: 147.
[505] Ibid.

the daughter had used to browse products online.[506] For Scherer, this is indicative of a particular dynamic wherein 'information is not just abstracted from a concrete and complex life, but is also… injected into it, exercising its influence.'[507] The story is indicative, for Scherer, of a situation in which 'objective and subjective categories are mixed up.' Technologies such as the targeted advertisement algorithm 'form the basis for the planet-wide removal of local limits to human modes of acting and experiencing within the Anthropocene.'[508] Abstraction, in the sense in which Scherer invokes the term, refers to the process according to which difference is reduced to objects of comparative value. Scherer identifies the process of abstraction as common to the sciences more generally: 'the production of knowledge in the sciences is itself being subjected to the aforementioned processes of economization and naturalization. Standardization is aimed at making distinct scientific products comparable, thus turning research into a product.'[509]

At this point, certain overlaps with the AWG's formalisation effort are implied. The GSSP entails the transformation of a material area of rock into a universal referent. Recalling Latour's notion of circulating reference described in an earlier chapter, we can say that the AWG's designation of a geological unit entails a correspondence between an entirely unique locality and a universally generalizable fact. The GSSP is both at once. It is the "golden spike", hammered into the material section that designates the lower boundary of a unit, as well as the unit on the Chart or Scale, enforcing a normative order that characterises the discipline of stratigraphy. The designation of a GSSP proceeds from a piece of rock somewhere on Earth to a universal fact of the Chart and Scale. A site is identified, an area is sectioned off, a core is extracted, carefully returned to a laboratory, where as many varieties of analysis are conducted as a research budget allows, providing a set of data with which scientific illustrations and texts may be drafted and submitted to the evaluative hierarchy of the ICS and IUGS, who approve the proposal through a vote, and, hopefully, ratify the associated unit into the Chart and Scale. At each step of this process, the material specificity of the rock

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[506] Hill, K. 2012. How Target Figured Out a Teen Girl Was Pregnant Before Her Father Did. *Forbes Magazine*. Available online at: https://www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/ (accessed 01/06/2021).

[507] Scherer, 2020: 147. Scherer has a particular interest in the social effects of algorithms. See Scherer, B. (Ed.) 2016. *Die Zeit der Algorithmen.* Berlin: Matthes & Seitz.

[508] Scherer, 2020: 148.

[509] Ibid.

section is lost, or reduced, and an abstract, universal property is amplified. And yet, each further degree of abstraction entails a return to the material specificity referenced, such that the ratification of a unit in the Chart is associated with the "golden spike" hammered into the "original" rock section.

Abstraction is an active practice, an emergent property of the scientific, legislative, and political processes that characterise the AWG's formalisation effort. Likewise, in Scherer's articulation of the Anthropocene theme, abstraction processes are figured as a social practice:

> 'We live in times where the pressure to innovate is so immense that the ability to make something all too quickly leads to de-facto-level manufacturing. Production in the name of science thus often inadvertently leads to the transformation of reality. A new technology is founded on the facticity of manufacturability. Yet normativity can only be negotiated in societal discourse.'[510]

As the director of a prominent German contemporary arts institution, Scherer advances the role of artists in elaborating a more inclusive practice of abstraction:

> 'Instead of the classic laboratory in which trained experts conduct research, we need rehearsal stages for the new phenomena, on which subjective, social, technological and cultural phenomena are woven together. On these stages, social actors, scientists and artists may rehearse together.'[511]

The role of the artist is here clearly identified as encouraging relationality. It is thought to be the role of the artist to generate media and circumstances wherein this relationality can be exercised.[512] The mention of "trained experts" implies that Scherer is interested in looking beyond differentiated specialization, encouraging what might be thought to be a more

[510] Scherer, 2020: 149.
[511] ibid: 149.
[512] Elsewhere Scherer and colleagues have referred to a 'principal of inclusive reflexivity' as a way of articulating a "grounded" elaboration of the implications derived from the AWG's formalization effort. See Robbin, L., Avango, D., Keogh, L., et al. 2014.

generalized response that is more inclusive. The role of artistic production is cast here as the means with which differences can be reconciled and "woven together."

Yet it is important to contrast Scherer's aspiration to facilitate a strategy of active participation in the various processes of abstraction (what we might call 'active abstraction') that characterise his interest in the Anthropocene theme with the actual processes according to which the HKW's relation to the AWG is formulated. For example, although Scherer advances a program of 'active abstraction,' the details of the contract between the HKW and the various GSSP candidate research teams indicate that the possibility of the grant is contingent on the common subsumption of GSSP research, whether scientific or artistic, into "data." As already noted, the figure of 'data' plays a central role in the contract, as a nexus between the otherwise divergent research interests and objectives of the AWG on the one hand, who seek to define a formal Anthropocene unit, and the HKW on the other hand, whose primary objective is to put together an exhibition. The contributions of HKW affiliates at the press conference would seem to imply that the HKW hold that the AWG are not capable of adequately articulating the full implications of their research. In this sense, not all kinds of participation in abstraction processes are equivalent. Within the context of the HKW exhibition, the HKW referee the various mobilisations of the Anthropocene theme. The justification for the HKW's intervention in the AWG's construction of an Anthropocene unit is figured in terms of a 'general population' who lack expertise. 'The crucial factor is making knowledge developed by experts comprehensible to third parties,' concludes Scherer's contribution to *The Anthropocenic Turn*. 'There are those who know, the experts; and those who do not know, the general population. The phenomena of the Anthropocene, however, as demonstrated, demand an entirely new concept of knowledge and expertise. We need rehearsal stages for the creation of knowledge and our world, on which those affected by the development of the Anthropocene become actors.'[513]

6.5 Whose values?

Scherer advocates relations, a "rehearsing together", as a strategy for intervening in the 'social, political, and economic consequences' of the Anthropocene theme, and the AWG's

[513] Scherer, 2020: 150.

formalisation effort more specifically.[514] Yet as I have suggested at the end of the last section, conviviality can be a strategy of obfuscation. Frederic Neyrat questions whether an emphasis on relationality conceals the articulation of *values*, i.e. how consequences of relationality are framed by the preferences of observers. Developing a critique of the sociological meaning of relations, Neyrat draws almost exclusively on the work of Bruno Latour. In particular, Latour's recent writings on the Anthropocene theme, which are also a source of inspiration and legitimation of the HKW's position on the idea of the Anthropocene as well.[515] For Latour, the popularity of the Anthropocene theme is yet a further instance of the dissolution of category thinking such as those implied by the differentiation of the old 'modernist tropes' of Nature and Culture.[516] Phenomena such as climate change and global pandemics introduce a degree of complexity that cannot be resolved by recourse to a single set of expertise. 'Rare now are topics where you do not see scientists publicly disagreeing among themselves on what they are, how they should be studied, financed, portrayed, distributed, understood, cast. Facts have become issues.'[517] For Latour, this presents an opportunity: 'to compose the common world from disjointed pieces instead of taking for granted that the unity, continuity, agreement is already there, embedded in the idea that "the same nature fits all."'[518] Such thinking is necessary, for Latour, if a way is to be found to address problems of ever-increasing complexity.[519]

Neyrat questions what this enthusiasm for relations achieves. What does the imperative to "compose the common world" mean in the context of the AWG's effort to legislate a new epoch of geological time by reference to novel planetary strata? How might we consider this command *through* Crutzen's early, and similarly bold declaration, to mount "planetary stewardship", understood as further integration of scientific expertise into planetary processes through geo-engineering, as an appropriate response to the challenges he associated with his version of the Anthropocene? Latour has provided a partial answer in

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[514] Ibid: 148.

[515] Latour has spoken at the HKW on several occasions as part of the Anthropocene Curriculum. For a list of events that Latour participated in at HKW, see https://www.hkw.de/en/programm/projekte/veranstaltung/p_140211.php (accessed 18/4/2021).

[516] An argument advanced in Latour, B. 1994.

[517] Latour, B. 2010. An Attempt at a "Compositionist Manifesto". *New Literary History* 41(3): 471-490. Pg. 485.

[518] ibid.

[519] See also Haraway, D. 2016, who asks 'what happens when human exceptionalism and bounded individualism, those old saws of Western philosophy and political economics, become unthinkable in the best sciences, whether natural or social? Seriously unthinkable: not available to think with.'Page 30.

his proposition to "love our monsters".[520] Technology already exists with which the effects of increases in global temperatures may be temporarily subdued. Crutzen was an early proponent of large-scale "Earth modification". 'Although by far not the best solution,' explains Crutzen,

> 'the usefulness of artificially enhancing earth's albedo and thereby cooling climate by adding sunlight reflecting aerosol in the stratosphere might again be explored and debated as a way to defuse the Catch-22 situation just presented and additionally counteract the climate forcing of growing CO2 emissions. This can be achieved by burning S2 or H2S, carried into the stratosphere on balloons and by artillery guns to produce SO2.'[521]

The proposal that "we" "love our monsters" has been read by some commentators as a call to accept responsibility for "our" actions. The dangers associated with the release of huge plumes of sulphur into the atmosphere are many. There is no way to comprehensively anticipate the risk of doing so. The uncertainty of those predicaments must be matched with equally uncertain solutions. To ignore the possible solutions such risky technologies may provide, is to indulge the fantasy that whatever it is imagined would be preserved by *not* using them, still exists. For Latour, there is nothing left to lose; or rather, there is *everything* left to lose by not acting dramatically *now*. Latour does not make a normative judgement; he does not discuss whether it is *good* or *bad* to use such risky technologies as geo-engineering. Rather, he invokes the story of Frankenstein, advocating that we embrace the monsters that have been created, rather than rejecting them, and pretending they do not exist, as Dr. Frankenstein does in Shelley's famous novel:

> 'Let Dr. Frankenstein's sin serve as a parable… At a time when… we, our technologies, and nature can no more be disentangled than we can remember the distinction

[520] Latour, B. 2011. Love your monsters. In Nordhaus, T. & Shellenberger, M. (eds) *Love Your Monsters: Postenvironmentalism and the Anthropocene*. Oakland: Breakthrough Institute. See also Latour, B. 2007. It's the Development, Stupid! or How Can we Modernize Modernization. Available at http://www.bruno-latour.fr/node/153.html (accessed 01/06/2021).
[521] Crutzen, P. 2006: 212.

> between Dr. Frankenstein and his monster – this is the moment chosen by millions of well-meaning souls to flagellate themselves for their earlier aspiration to dominion, to repent for their past hubris, to look for ways of diminishing the numbers of their fellow humans, and to swear to make their footprints invisible?... The real goal must be to have the same type of patience and commitment to our creations as God the Creator, Himself. And the comparison is not blasphemous: we have taken the whole of Creation on our shoulders and have become coextensive with the Earth.'[522]

In other words, Latour's suggestion that critique be replaced with enthusiastic pursuit of further relations, amounts, for Neyrat, to substituting a critical, reflexive approach concerning the motivation behind action. Latour's position, argues Neyrat, 'renders impossible its preventative action, that is, the possibility of *not realizing* a technology… To call into question [*remmetre en cause*] should mean, theoretically, to *return to its cause* [*ramener à sa cause*], to interrogate causes.'[523] Latour's argument for pursuing the consequences of our actions, rather than abandoning them, does not address the complicated question of who is the "we" that speaks for "our" actions. 'Unexpected consequences are *attached* to their initiators and have to be followed through all the way.'[524] In pursuing what he calls a "political ecology" of *more* relations, Latour overlooks the fundamental question of *who* mediates relations, and who makes the decisions whose consequences are then to be dealt with.[525]

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[522] Latour, 2011: 2.

[523] See Neyrat, F. 2017. Elements for an ecology of separation: Beyond ecological constructivism. In Hörl, E. & Burton, J. (eds) *General Ecology: The New Ecological Paradigm*. Pp. 101-128. Pg. 114.

[524] Latour, 2011: 8.

[525] Elsewhere, Chakrabarty describes this unequal distribution as a fundamental normative challenge of the Anthropocene. If the cause of the Anthropocene can be more accurately attributed to Western industrial expansion and colonialism, which occurred largely at the expense of everyone and everywhere else, then might the calls for equal efforts to address climate change appear as a continuation of western exceptionalism? How does the Anthropocene, in other words, square with the project of emancipation as explored in post-colonial literature? Charkabarty explains:

> That earnestness [of the effort to lift the populations of China and India out of poverty] transforms into authoritarianism and bad faith with later leadership but – and this is my point – a legacy of "obligation to the masses" remains central to the legitimization that both the Chinese and Indian regimes seek internally. And the rhetoric of the appeal "we need fossil fuel to move millions out of poverty" has a global force because of the pull Planet Emancipation is still capable of exerting on the conscience of the privileged.

Chakrabarty rightly raises this as a blind spot of Anthropocene discourse, and a problematic that has not yet been fully attended to. See Latour, B. & Chakrabarty, D. 2020. Conflicts of planetary proportions – a

This oversight is also characteristic of initial efforts to define an Anthropocene unit. Elaborating the consequences he perceived of 'the Anthropocene', Paul Crutzen proclaimed that 'it is no longer us against "Nature." Instead, it's we who decide what nature is and what it will be.'[526]

Emphasising relationality and interconnections between diverse phenomena, can therefore function as a strategy of exclusion. Crutzen draws connections between 'scientific, legal, ethical, and societal issues,' and advocates the building of trust 'between scientists and the general public' as a way to emphasise 'large-scale climate modification' as the last remaining option. 'The very best would be if emissions of the greenhouse gases could be reduced so much that the stratospheric sulphur release experiment would not need to take place. Currently, this looks like a pious wish.'[527] The extent to which diverse competencies are bound up in the predicament that Crutzen identifies is stressed as a way of advocating for a 'planetary stewardship' that for him, characterises an Anthropocene Epoch in which 'socio-economic processes' are inextricably bound up with 'the planet's biological, chemical [and] physical… processes.'[528]

Similarly, Scherer emphasises the drawing of connections between diverse competencies. He suggests that practices of abstraction need to be inclusive. Building on his model, mentioned previously, of the inclusive "rehearsal stage" that replaces the "classic laboratory" of "trained experts", Scherer explains:

> 'On the one hand, the rehearsal stages are places of practice in which world sections are created. On the other hand, they are places of the imagination in the sense of artistic practice. The rehearsal stages are not about creating facts but about providing a blueprint for possibilities in order to rehearse various options in a social process, to experiment with ways of thinking or ways or perceiving, before something is actually realized.'[529]

conversation. *Journal of the Philosophy of History* 14(3): 419-454. https://doi.org/10.1163/18722636-12341450

[526] Crutzen, P. & Schwagerl, C. 2011.
[527] Crutzen, 2006: 217.
[528] IGBP. 2010: 2. Crutzen was Chair of IGBP at the time this report was published.
[529] Scherer, 2020: 150.

Yet in the press conference, as I have recounted in an earlier section of this chapter, there is scepticism concerning the AWG's ability to properly appreciate the implications of their research, and of a formal Anthropocene unit. It is stressed that the HKW plays a central role in "recontextualising" the "dry science" that characterises their formalisation process. This would suggest that the conviviality of the "stage rehearsal" model is contingent on the authority of a mediating actor that can translate the significance of the AWG's work *on behalf of a* 'general population… who do not know.'[530] The vocabulary of the HKW's contract with each of the GSSP candidate teams, furthermore, indicates a narrowing of the different ways that the HKW and AWG perceive the GSSP to the common figure of "data." When the conviviality of the "rehearsal stage" is contrasted to the "classic laboratory" of "trained experts," the extent to which controversy characterises scientific expertise is underestimated, even within the AWG itself. It could therefore be argued that an idiom of collaborative, proactive abstraction is invoked that encourages *more relations* between different actors, but in such a way as to position the HKW as the *stage*, as the site where relations are made, as the arbiter that decides which relations are most important for the "general population" to understand.

I stress that this kind of "relational thinking," which characterises much interest in the Anthropocene theme can, somewhat counterintuitively, function as a strategy of exclusion, not to criticise the HKW or Crutzen, but rather as a way to consider the consequences of such arguments for the AWG's formalisation effort. Despite the divergent interests that meet in the AWG's effort, the Group's objective remains the same: to formalise an Anthropocene unit at the rank of Epoch/Series with a GSSP designation. The HKW's involvement is a crucial step in the AWG's formalisation effort, given that it makes available financial resources without which the AWG would struggle to execute their proposal. Yet it comes with the further problem, for the AWG, of how to justify the HKW's enthusiasm for the 'social, political, and economic consequences' of an Anthropocene unit in a way that does not agitate the executive members of the ICS and IUGS, who have expressed concern over the AWG's formalisation effort as a "political statement" or an artefact of "pop culture", rather than a properly stratigraphic concern.[531]

[530] ibid.
[531] Finney, S. & Edwards, L. 2016; Autin & Holbrook, 2012.

In response to these divergent interests, and as a way to conclude reflection on the dynamics of unit formalisation that the AWG have engaged to date, I would like to argue that the AWG takes on a mediating role – a balancing act – in which they are obliged to engage relational thinking directly, acknowledging the various mobilisations of the Anthropocene theme, yet in a way that preserves their primary interest in the formalisation of an Anthropocene unit. The AWG do so through an intensification of an approach discussed in the last chapter: presenting a formal Anthropocene unit, defined in a manner entirely consistent with the preferences of the ICS and IUGS, as a "practical" and "useful" contribution to all other mobilisations of the term. The GSSP figures prominently in this balancing act. It operates, as we shall see, as a strategy with which the diverse interests in the AWG's formalisation effort are negotiated.

6.6 The GSSP: A common language?

The GSSP mediates the diverse interests in the AWG's formalisation effort. The GSSP relates the diverse commitments of the three entities immediately involved in that effort: the HKW's interest in formulating a successful exhibition; the ICS & IUGS's interest in preserving the integrity of the chronostratigraphic method; and the AWG's commitment to the formalisation of an Anthropocene unit. The GSSP is a material reference for chronostratigraphy, as well as a disciplinary standard that designates a unit of the Chart and Scale, as it is a medium with which the Anthropocene theme continues to be elaborated. It is simultaneously discovered and constructed. To the extent that the GSSP negotiates the different interests and mediates the different commitments in the AWG's formalisation effort, it is ultimately constructed *and* discovered, depending on which position one adopts among these three.

Throughout this thesis, I have attempted to describe the AWG's formalisation effort not as a passive act of discovery, but as an active process of construction and association; an ongoing and emergent dynamic. As of the time of writing (June 2021), the AWG have yet to submit their proposal for a formal Anthropocene unit to the SQS. Given that the formalisation effort cannot be concluded at this point in time, I will instead conclude my thesis by reference to the most recent iteration of this dynamic of responsiveness through which the proposal for a formal Anthropocene unit emerges. The position of the AWG on the formalization of an Anthropocene unit, and the manner in which they pursue that effort, is contingent on the relations that the AWG engages with other entities. Their strategy adapts to the AWG's environmental conditions: what interests are directly involved in their effort and the manner in which those interests are exercised, critically, financially, or otherwise. This includes the ICS and IUGS, whose senior executive members have stated their preferences concerning how a unit is to be formalised: a GSSP must be designated, serving as a reference section for other strata around the world. The GSSP, moreover, must be designated in a manner that is consistent with other geological units, as discussed in a previous chapter, regardless of the problems some AWG members may identify in the epistemic assumptions of the GSSP method. These preferences were stated as a caution in light of the AWG's consideration of a numerical age definition, or GSSA. It was posited that to define an Anthropocene unit by reference to a numerical age would be inconsistent with established practice of chronostratigraphy, which favours definitions 'based on the existence of a rock body (the Stratotype), which differs from underlying rocks and defines a clear stratigraphic boundary… the local expression of a global phenomenon.'[532] Such comments came from executive members of the ICS and IUGS committees, who would ultimately vote on the AWG's proposal for a formal unit.[533] Their interventions were not simply a suggestion, they were received by the AWG as a warning, outlining the condition of success of any proposal they would write. The AWG would *need* to designate a GSSP if their proposal was to be successful, and an Anthropocene unit formalised accordingly. The AWG are explicit in attributing comments from the ICS executive to their shift in attention towards the GSSP, citing an article written by the former ICS-chair as indication that 'the geological community as a whole is more comfortable with a GSSP,' and that 'therefore, the AWG is currently working towards candidate GSSP selection.'[534]

Responding to these concerns, the AWG began to emphasise the GSSP as a central component of their formalisation effort, distancing themselves from Crutzen's original proposal for a date-oriented definition, such as the beginning of the industrial revolution, or that of the Great Acceleration event. Although the AWG are currently pursuing a GSSP

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[532] Rull, V. 2017. The "Anthropocene": neglects, misconceptions, and possible futures. *EMBO Reports* 18(7): 1056-1060.

[533] Such as Phil Gibbard, secretary of the ICS, and Stan Finney, Chair of the IUGS. Gibbard, P. & Walker, M. 2014; Finney, S. 2014.

[534] ibid: 57.

designated at a mid-twentieth century boundary, it must be defined in terms of the material evidence (a chronostratigraphic definition), rather than by reference solely to an event (geochronology). This entailed a further distancing of the AWG's narration of their formal effort from the term 'anthropos'. The invocation of 'human activity' as a marker of a new stratigraphic unit was further criticised by ICS member Phil Gibbard for being incompatible with the stratigraphic definition of the Holocene, because, in Gibbard's words, 'one of the key justifications for defining a Holocene Series/Epoch, as separate from the Pleistocene, is that humans (*Homo sapiens*) reached critical numbers and began influencing natural systems from the beginning of this time period onwards.'[535] The AWG demonstrate their willingness to adapt their position in relation to these concerns is clear in subsequent literature they authored, such as when they state, as quoted above, that a formal Anthropocene unit would have very little to do with the figure of the 'Anthropos'.:

The AWG's position on a formal Anthropocene unit is therefore defined by phenomena that are external to their operations. The AWG had been adamant that a numerical age definition, or GSSA, could be pursued as a possible avenue for formalising the Anthropocene as a geological unit *prior* to these criticisms.[536] Recently, the AWG have explained that in response to the concern of ICS and IUGS members, 'the current focus of the AWG is on identifying potential GSSP candidate sites within suitable kinds of sedimentary archives… all in preparation for a formal proposal to the ICS.'[537] And in regard to the problem of the 'Anthropos' as a stratigraphic marker designating the onset of human activity, part of the reason why themes such as the *technofossil* are problematic is because it occupies two positions at once: it is consistent with Crutzen and Steffen's understanding of human activity as a component of the Earth System, understood as 'the planet's interlacing biological, chemical, physical, and socio-economic processes,'[538] as well as an attempt to "declimatise"

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[535] Gibbard, P. & Walker, M. 2014: 32. They continue, 'without this unique record of human impact there would be no justification for the Holocene being anything other than an interglacial, in common with all others in the Pleistocene.' Consequently, 'If the human dimension is accepted as a reasonable basis for a separate Holocene Series, as distinct from the Pleistocene, the activities of humans cannot then be used again in support of a discrete Anthropocene division.'

[536] Such as in their first paper, see Zalasiewicz, J., Williams, M., Smith, A., et al. 2008.

[537] Grinevald, J., McNeill, J., Oreskes, N., et al. 2019. History of the Anthropocene Concept. In Zalasiewicz, J., Waters, C., Williams, M. (eds.) *The Anthropocene as a Geological Time Unit*. Cambridge: Cambridge University Press. Pp.4-11. Pg. 11.

[538] IGBP. 2010. *A vision for integrative global-change research for a sustainable future*. Available at: http://www.igbp.net/download/18.2709bddb12c08a79de780002812/1376383208857/IGBPDraftvision27September.pdf (accessed 15/05/2021). See also Steffen, W., Sanderson, A., Tyson, P., et al. 2004.

their formalisation effort, and render it in the idiom of fossils and palaeontology more generally; albeit a palaeontology of the present, rather than in Crutzen's initial terms of increases in concentration of atmospheric gases such as carbon dioxide.

The involvement of the HKW signals the possibility of the AWG having to adjust their position on a formal Anthropocene unit further. Although HKW director Bernd Scherer was adamant during the May 2019 meeting that the HKW would not interfere in the AWG's research process, the HKW's position on the general significance of a formal Anthropocene unit differs radically from that of the ICS and IUGS. The HKW regards the Anthropocene theme as an indication of 'humanity as a geological force.'[539] The HKW's interest in the figure of the 'Anthropos' is at the centre of their commitment to the theme. They introduce their interest in the Anthropocene theme through a series of questions: 'who exactly is the Anthropos that brought about this new geological era? What epistemological foundations have made it possible to transform and exploit the planetary flows of energy and materials? And how are responsibility and agency distributed in the Anthropocene?'[540] In a report on their engagement with the Anthropocene theme, Scherer explains that any response to these questions needs to be approached *collaboratively*:

> However, Anthropocene processes have set in motion a series of developments that require, in particular, new forms of working-together (*Zusammenarbeit*) and thinking-together (Zusammendenkens) of natural sciences, humanities, and social science methods, as well as artistic research.[541]

Scherer stresses the terms 'Zusammenarbeit' (a compound verb of "together" and "work") and 'Zusammendenkens' ("together" and "thinking") as crucial methods with which to articulate responses appropriate to the Anthropocene, understood as a situation in which

[539] See the preface to the collection edited by HKW curators and director: Klingan, K., Sepahvand, A., Rosol, C., et al. (eds). 2014. *Textures of the Anthropocene: Grain Vapor Ray*. Cambridge: MIT Press.

[540] From *The Anthropocene at HKW* page on the HKW website. Available at https://www.hkw.de/en/programm/themen/das_anthropozaen_am_hkw/das_anthropozaen_am_hkw_start.php (accessed 15/05/2021).

[541] Scherer, B. 2014. Ein Bericht – Einführung. *Report: The Anthropocene Project*. Berlin: HKW. Pg. 9. The original quote reads as follows: 'Durch die anthropozänen Prozesse sind aber Entwicklungen in Gang gesetzt worden, die insbesondere neue Formen der Zusammenarbeit und des Zusammendenkens natur-, geistes- und sozialwissenschaftlicher Methoden sowie einer künst-lerischen Forschung notwendig machen.' All translations of this text are my own.

'what we have understood as nature up to now is made by people [and] dualisms such as nature/culture or subject/object no longer function in their traditional way.'[542] There is an explicitly normative aspiration to the HKW's line of questioning. 'A new sense of amazement at the wonder of the Earth is required,' explains Scherer and fellow HKW curators, 'what can we do and how can we know—and to what extent are these two questions connected? With what means, methods, and senses can we encounter the world of our own creation?'[543]

Elsewhere, as we have seen, Scherer exercises this collaborative approach through suggestions to AWG members concerning the significance of their work. What HKW affiliated describe above, during the press conference, as the "recontextualising work" whereby the "cultural, social, political" implications of the AWG's formalisation effort are articulated, suggests an intimate involvement. The HKW works *with* the AWG, financing the formalisation effort, overseeing the execution of GSSP and auxiliary core research, as well as elaborating the significance of those findings and the effort overall. The HKW positions itself *between* the AWG's formalisation effort, and a "wider public" that is to understand the significance of that effort in a manner that is not simply 'dry science'.

The AWG therefore finds itself in a position of having to satisfy two sets of interests at once, those of the HKW on the one hand, and the ICS and IUGS on the other. Although both sets of interests are ultimately registered in terms of a formal Anthropocene unit, their investment in that objective unfolds along different discursive trajectories. Those interests determine the position of the AWG on the formalization effort accordingly. The concerns of stratigraphers affiliated with the ICS and IUGS caused the AWG to distance itself from an explicit commitment to those pursued in the original, IGBP articulation of the Anthropocene theme, characterised by a preoccupation with human activity as a geological marker in and of itself.[544] The concerns of the HKW, more recently, compel the AWG to acknowledge arguments that they had begun to distance themselves from in an effort to satisfy the preferences of the ICS and IUGS. Evidence of the AWG's attempt to satisfy both sets of interests simultaneously are evident in their most recent literature. A 2021 article recognises two *levels* to the Anthropocene theme. They call this characterisation of the term in reference

[542] ibid: 4.
[543] MIT Press. 2015, February 25. *Five Minutes with the editors of Textures of the Anthropocene*. Available at: https://mitpress.mit.edu/blog/five-minutes-editors-textures-anthropocene (accessed 15/05/2021).
[544] Steffen, W., Sanderson, R., Tyson, P., et al. 2004.

to levels "the integrative Anthropocene concept *sensu lato*."[545] They identify, accordingly, *analytical levels*, which are comprised of 'the Anthropocene Earth System', characterised by the earlier articulations of the Anthropocene by Crutzen and Steffen, and the 'Anthropocene Epoch', which refers to the effort to formalise an Anthropocene unit by reference to novel stratotypes.

The other level they identify is the 'Consequential Metalevel.' In the authors' characterisation, this level refers to 'The Responsible Anthropocene', an umbrella term for mobilisations of the Anthropocene that are not exclusively committed to the Earth System science, or geological interests in the Anthropocene theme. Justifying this distinction of levels, the authors explain:

> "Anthropocene" in the humanities and social sciences is a synthetic, less precise term that hints at an understanding of human responsibility. Instead of being an issue of precise definition, it begets criticism and debate… in order to understand more fully the deeper (i.e. political, ethical, cultural, and epistemic) implications of the diagnosis inherent in the scientific term. Formalization of the term is one side of the debate, and it will form an important point of reference for the humanities and social sciences to engage with the science. On the other hand, the humanities/social sciences aim at a more differentiated and thus more flexible understanding of the Anthropocene as a human-influenced state of the Earth System and as a cultural threshold. This wider understanding should be seen as *complementary* to the very precise, strict understanding in geology/ESS. While the scientific term is descriptive and analytical with regard to a given state of affairs, the humanities term is either normative (what should we do now?) or narrative ("how did we get here?), or both ("why did we get there?").[546]

The strategy of the AWG thereby appears to be to satisfy the simultaneous yet conflicting interests of the HKW and ICS/IUGS by adopting the role of mediator of divergent mobilisations

[545] Zalasiewicz, J., Waters, C., Ellis, E., et al. 2021. The Anthropocene: Comparing Its Meaning in Geology (Chronostratigraphy) with Conceptual Approaches Arising in Other Disciplines. *Earth's Future* 9: https://doi.org/10.1029/2020EF001896

[546] ibid: 9.

of the Anthropocene theme. This mediating role is pursued through a simultaneous effort to appreciate the complementarity of divergent invocations of the Anthropocene theme, while emphasising their role as distinctly chronostratigraphic, and in line with the task of identifying a GSSP for a formal Anthropocene unit of the Chart and Scale. The AWG have adopted this position on their formalisation effort *in response to* the simultaneous, yet conflicting interests of the two organisations they are responsible to: the HKW on the one hand, who provides crucial financial support, and the ICS and IUGS on the other, who are the gateway to inclusion of an Anthropocene unit in the Chart and Scale. The AWG describe this predicament not as the mediation of interests that are simultaneous yet conflicting interests, but rather 'overlapping but distinct.'[547]

A further indication of the mediating strategy that the AWG have assumed in response to the interests of the HKW and ICS/IUGS is evident in their appeal to the 'utility of the chronostratigraphic (geological) Anthropocene beyond geology.'[548] The AWG argue that formalisation of the Anthropocene as a geological unit would serve all other mobilisations of the term, whether or not they are supportive of the AWG's effort. Formalisation, they argue, would facilitate clearer communication. A single definition would function as an anchor, which any invocation of the Anthropocene theme could reference as *the primary definition*. They stress the need for a 'common language' between the diverse invocations of the term, while emphasising their prioritisation of a chronostratigraphic definition. 'Formalisation of the geological meaning of the Anthropocene in stratigraphy – if that becomes the case – will likely contribute to the clarity of the term and facilitate its use, at least in geology-related sciences and hopefully more widely.' Such claims amount to a calculated diplomatic effort of the AWG, to negotiate the interests of the two bodies they are responsible to, emphasising their continuity where they might otherwise be perceived as incompatible. The AWG seek to demonstrate that the effort to define a formal Anthropocene unit remains open to the 'consequential metalevel', as a resource for critical discourse 'beyond geology', while continuing to acknowledge its obligations on the 'analytical level', as a yet-to-be-approved geological unit of the Chart and Scale. Any effort towards the establishment of a common

[547] Ibid: 18.
[548] Ibid.

language between the various mobilisations of the Anthropocene theme are pursued by the AWG toward the ultimate, and exclusive, goal of designating a GSSP.

What are the strategies with which such a common language may be realised? Focusing on the relationship of the HKW and AWG, what does a mutual form of working together (or *zusamenarbeit*/*zusamendenkens* in Scherer's idiom; the resolution of 'overlapping but distinct interests' in the AWG's idiom) look like in practice? How is the GSSP, an essential component of any proposal for a formal Anthropocene unit, figured in this accommodating effort? There is precedent for thinking of the GSSP as a combinatory process of artistic and chronostratigraphic observation/construction. The sites of GSSP designations often feature elaborate monuments, such as sculptures or plaques that indicate the significance of the site, both for geology but also often in a cultural or diplomatic capacity as well. Artists have taken the tradition of constructing monuments at the site of GSSPs as a cue for reflection on the process of formalizing geologic time. In 2014, at Les Abattoirs Museum of Contemporary Art in Toulouse, France, hosted *Anthropocéne Monument*. The event brought together artists and intellectuals and was organised by Bronislaw Szerszynski and Bruno Latour.[549] As the co-organizer of that event explains, the notion of a sculpture or park to monumentalise the GSSP, itself a monument of its own already, combines the multiple, overlapping temporalities at play in geological time. Szerszynski invokes the distinction of 'natural monument' and 'intentional monument' to illustrate the simultaneity of different temporalities and semiotic systems, of history, geology, nationhood, and culture.[550]

The artists involved in the *Anthropocéne Monument* event proposed their own monuments to accompany a potential Anthropocene GSSP site. For example, Thomas Saraceno's work *Towards an Anthropocene Monument* (2014) is composed of a series of "flying sculptures" made from plastic bags stitched together, the sculpture itself growing with the addition of further plastic bags at every location it is exhibited in. Other "flying sculptures" (the artist's terminology) are composed of cable and string the hangs from the walls and

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[549] See Szerszynski, B. 2017. The Anthropocene monument: On relating geological and human time. *European Journal of Social Theory* 20(1): 111-131. A full program of the event is available at http://www.bruno-latour.fr/sites/default/files/downloads/TOULOUSE-11-12-DEROULE%2bANTHROPO_0.pdf (accessed 20/04/2021).

[550] A theme explored further in Dittmer, J. 2017. *Diplomatic Material: Affect, Assemblage, and Foreign Policy*. Durham: Duke University Press. For an example relating to geology more specifically, see Shen, G.Y. 2013. *Unearthing the Nation: Modern Geology and Nationalism in Republican China*. Chicago: University of Chicago Press.

ceiling of the gallery space, figuring a model of the "network" of divergent competencies and nodal points that allow the work to, literally, hang together. Consequently, it is 'the room' and not the work itself, that according to one description 'documented Saraceno's exchange with scientists from diverse fields who contributed to the project.'[551] However, initiatives such as the *Anthropocéne Monument* take the AWG's formalisation effort as a starting point for critical, artistic generativity. They do not assume a position *within the formalisation effort itself*. Thomas Saraceno's work takes the Anthropocene theme as a point of departure, not as a strategy for defining a GSSP for an Anthropocene unit, or as a way of managing the divergent interests of the HKW, the ICS and the AWG. The HKW's involvement in the AWG's formalisation effort is different because they are funding the most crucial part of that effort: the designation of a GSSP. They therefore stand to influence the AWG's effort itself, rather than to reflect on the formalisation of an Anthropocene unit quite apart from the work of the AWG.

The GSSP, in its peculiar materiality, lends itself both to the unit-definition efforts of the AWG and the curatorial interests of the HKW. The meaning of its materiality is animated by the various concerns that characterise the curatorial and unit-defining interests that are presently involved in it. The routine material practices through which scientific objectivity is pursued entail both the perceived reliability of routine procedures as well as the variation entailed in each instance of such a procedure. In more recent reflections, Hans-Jörg Rheinberger posits that both art and science proceed 'in taking advantage of the options that become available – or are felt to be foreclosed – as a consequence of the shafts that have already been dug, and less by ignoring them in the alleged thin air of the anticipations of a genius.'[552] Artistic and scientific research is characterised by a perpetual indeterminacy, in which any assertion of teleology only occurs after the fact.[553] Research entails a "tinkering"

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[551] For images and details of the work, on display during the *Anthropocéne Monument* event, see https://www.estherschipper.com/exhibitions/282-anthropocene-monument-with-tomas-saraceno/ (accessed 20/04/2021). The invocation of the room, rather than the work, demonstrates an awareness of the context in which a work takes place, a theme we shall return to shortly.

[552] Rheinberger, H.J. 2018: 239.

[553] Elsewhere this similarity has been described as the experimental process common to both science and art. See Sormani, P., Carbone, G. & Gisler, P. 2019. Introduction: Experimenting with 'Art/Science'? In Sormany, P., Carbone, G., Gisler, P. (eds) *Practicing Art/Science: Experiments in an Emerging Field*. London: Routledge. 'Both, scientists and artists,' explains Rheinberger, 'are after the unprecedented, and both know very well that they cannot just conjure it out of their heads.' Rheinberger, H.J. 2018: 248. The GSSP offers the material medium with which to 'conjure' that which is unprecedented.

of 'arrangements that are not set up for the purpose of repetitive operation but for the continuous re-emergence of unexpected events.'[554] The AWG, for example, undertake their formalization effort in such a way that what is required of them is both entirely apparent (a GSSP) and unknowable (i.e. what the GSSP will be).

This observation may point to a further commonality between the art object and the scientific artefact, a relationship that will become more important in the AWG's formalisation henceforth. The GSSP is not the final object of research. As soon as it is defined it is folded into the ongoing research efforts of chronostratigraphy more generally. If it is ever defined, it will take a place in past, current, and future stratigraphic research accordingly, and be mobilised as a resource for future research activity, just as the AWG have mobilised geological research to validate their narrative of an Anthropocene unit. The GSSP, as a form of stratigraphic research, as well as in the specific case of an Anthropocene GSSP, is both a historical entity but also an animating force of stratigraphic research. Rheinberger calls this the 'intrinsic temporality of objects of art and of objects of science.'[555] The GSSP, as both art object and scientific artefact, points to the future of artistic and scientific research, while also being framed by a history of the art object and artistic self-presentation, as well as chronostratigraphic strategies of correlation and definition.

Rather than making the relation of the HKW and the AWG about how to emphasise the unique position of each – i.e. how the AWG are to use the funding for their own literature and then pass on whatever remains to the artists in their "workshops", or how the HKW are to realise the "social, cultural, political" implications of the AWG's formalization effort, which would otherwise go unarticulated – the more interesting route may be to address the common practices of both, and how the activity of each, respectively, shapes that of the other. The GSSP offers an opportunity to do so. The contracts, drafted between the HKW and the GSSP groups, provide a medium of common articulation for the GSSP more than any of the public descriptions of the relationship have to date. The contract offers a medium with which to elaborate the common interests, and more importantly, the common practices, of the HKW and AWG. Unlike the rhetoric deployed at the press conference, the contract does not discriminate between an exclusively "cultural, social, political" discourse, thought to be

[554] Rheinberger, H.J. 1997: 32-33.
[555] Rheinberger, H.J. 2018: 240.

particular to the HKW, and the "dry, decontextualizing" science of the AWG. The contract adopts Rheinberger's sense of artistic and scientific process as always under-determined, working towards an object that is both entirely present and yet undefined (the GSSP, which is central to the entire effort, but has yet to be designated). The conversation at the press conference betrays the novelty and significance of the relationship articulated in the contract. I believe the reason for this is that the HKW, as a cultural institution, must constantly demonstrate its relevance to the interests of the contemporary art and theory community. This is both in the interests of preserving a position of authority as a cultural institution, in keeping with the *zeitgeist*, as well as the support of the public and its other patrons. Similarly, the AWG must constantly demonstrate its relevance to the requirements and preferences of the IUGS and the stratigraphic community, and to this end, downplays the significance of their relationship in the interests of outlining a publication timeline and strategy. In other words, the HKW and AWG aspires toward an integrated process of articulating the GSSP but this occurs *in spite of* the public presentation of the HKW and AWG relation. This suggests that enacting a participatory model of *zusammenarbeit* and *zusammendeken* requires participants to relinquish the assumptions that inform their sense of self, vis-à-vis differentiation from the "other" (in this case, art as other than science, and vice versa). Otherwise, the effort to establish a different kind of relationship proceeds as a promotional strategy, which although effective, remains unrealised as anything else.

6.7 Conclusion

Despite having yet-to-be formalised, the Anthropocene theme continues to be the topic of regular publications, both by the AWG, and as a more generalised set of themes and problems explored in various disciplinary contexts.[556] The AWG, meanwhile, continue their effort toward formalization.[557] Yet the formalization effort of the AWG revels a set of dynamics that

[556] The AWG have recently authored a review of literature concerning the Anthropocene, within stratigraphy and in other disciplines. They do so to present their own definition of the Anthropocene, arguing that all discussions of the term would benefit from a single, formal, chronostratigraphic definition. See Zalasiewicz, J., Waters, C., Ellis, E., et al. 2021.

[557] Paul Crutzen passed away in January of 2021, at the age of 87. In an obituary published in the Financial Times, the Earth System scientist Will Steffen, a colleague of Crutzen's as the International Geosphere-Biosphere Program who is also an AWG member, predicts that the Anthropocene will be formalized as an official geologic unit 'within three or four years'. Clark, P. 2021. Paul Crutzen, scientist, 1933-2021. *The Financial Times* February 5th. Available at https://on.ft.com/3cH0zfa (accessed 20/04/2021).

are significant whether or not the Anthropocene is ever formalized. Studying the AWG's formalization effort before its conclusion facilitates a view that abstains from the tendency of scientific work to be concealed by its own success. The AWG's formalisation effort indicates that such moments of 'blackboxing' are not conclusive, but are an occasion for the elaboration of further discursive trajectories. The so-far indeterminate nature of the formalization effort therefore provides less distilled, and therefore more instructive insight into the dynamics of scientific research as a socially situated phenomenon.

Of course, the example of the AWG cannot be said to account for the "dynamics of scientific research" as a whole. The description of the AWG's formalization effort that I have presented in this thesis is a case study. Case studies demonstrate a metonymic character to the extent that their narration points beyond themselves. They seek to present a lesson that can be applied beyond themselves. Making a metaphor of a metonym, Hans-Jörg Rheinberger has analogised the function of the case study to that of the individual experimenter: 'Each and every experiment is a concrete, singular event. But it is only accepted as an experiment worth [sic] of consideration if it can be looked at as an instantiation of a more general state of affairs. Otherwise one would not take it to be more than just fancy.'[558] By focusing on the AWG's formalization effort, and the controversies, negotiations, and procedures that it entails, as an object of study, the role of *practice* is emphasised. The term "Anthropocene", whether conceived of specifically as a proposed geological unit, or more generally as a discursive theme, varies in meaning according to the practices it is aligned with. This is another way of saying that in the term 'Anthropocene', we witness the demonstration neither of *relativism*, wherein it's meaning is entirely contingent on the context in which it is evoked, or *rationalism*, according to which we must all acknowledge one essential meaning. Rather, I have presented a narrative of the formalization effort in this thesis that positions 'the Anthropocene' as a dynamic emerging between positions.

This aesthetic recalls Donna Haraway's account of "situated knowledge".[559] Haraway argues for an account of knowledge that does not fall back to the binary of relativism and

[558] Rheinberger, H.J. 2021. On the Narrative Order of Experimentation. In Carrier, M., Mertens, R. & Reinhardt, C. (eds). *Narratives and Comparisons*. Bielfeld: University of Bielfeld Press. 86-97. Pg. 92.

[559] Haraway, D. 1991. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. In *Simians, Cyborgs, and Women: The Reinvention of Nature*. London: Free Association Books. Pp. 183-202.

rationalism. Both, she argues, are sides of the same 'God trick' coin, according to which knowledge is thought of as something that occurs in a disembodied, and essentialist manner. Totalising rationalism assumes the position of a knowledge that exists monumentalised and absolutely in one fixed place for all of time, as an inevitability. Relativism is everywhere and nowhere at once. Both are all-seeing, and fail to account for the dynamics of evolution through which what counts as knowledge *changes*. Geology is a discipline that is ripe with examples of this evolutionary dynamic: from the use of fossils as a material counterweight to scriptural accounts of planetary genesis, to ongoing controversies concerning the relationship of time and rock, which the GSSP both silences and exacerbates in its materiality. Furthermore, geology is a discipline that has never fully differentiated. Geological observation has historically taken place through the lens of the preoccupations and *zeitgeist* of its day, whether that be Hutton's interest in anatomy and circulation, or the set of concerns and anxieties associated with the Anthropocene theme.

Haraway's notion of situated knowledge seeks to pave a way through the binary of rationalism and relativism by stressing the extent to which 'politics and ethics ground struggles over knowledge projects in the exact, natural, social, and human sciences.'[560] At the beginning of this thesis, I explained that I sought to address the effort to formalise an Anthropocene unit as an object of study in itself. I have attempted to analyse the effort to formalise the Anthropocene as a geologic unit, or what we might now call "the stratigraphic position", within the context of its historical genealogy, that is: as a position that is itself the result of numerous previous controversies, negotiations, and incommensurable ideas, and which itself now stands among several other similarly historical positions within the *field* of the 'Anthropocene'. The remarkable popularity and generativity of the term is therefore an effect of the incommensurability of the various ways in which it is mobilised. The AWG benefit from the continued variability of mobilisations of the term, even if they are now *simultaneously* encouraged to adopt a specifically chronostratigraphic definition. Indeed, they appear to be pursuing both trajectories at once.

The debate about how to formally define, or legislate an Anthropocene unit, unfolds as a debate about those very same definition procedures. It is a debate about the definition and classificatory procedures that geological observation is submitted to. To that extent, the

[560] Ibid: 193.

effort to define an Anthropocene unit is a debate about what precisely constitutes geological observation. What is *the position* of geological observation? And what are the devices with which geological observation occurs? What are the instruments that are used in maintaining and negotiating that position, vis a vis other forms of situated knowledge? This is a question that geological classificatory mechanisms may struggle to resolve by themselves. We have seen, for example, how the efforts of the first International Geological Congresses stopped short of defining geological entities in themselves, such as the material substance of a particular unit, but instead circled around such questions by setting out evaluative procedures. The objective was not to define geological entities, but rather to define methods and procedures for evaluating competing proposals for entities. The objective was not to establish *definitions*, but *procedures* for evaluating proposals, for rendering different positions comparable. The debates concerning the GSSP are similarly inconclusive. The diverse understandings of the meaning of time and rock respectively, and their relationship, are never fully resolved, and the silencing of that debate by a vote of an ICS Prague Workshop in 2010 does little to assure the epistemic and methodological anxieties that animate such debates.

Procedures of geological classification, evaluation, correlation, and measurement, or what amounts to "geological observation", has historically occupied a position, or been defined, *in relation* to other positions. In the seventeenth century, geological observation was apprehensible in relation to scriptural accounts of genesis. Scriptural accounts of planetary genesis and various stages of earth history presented an opportunity for the development of a set of practices and arguments that were specifically geological (although at the time they were acknowledged as "geognostic" or "natural historical"). The effort to define an Anthropocene unit is approached *against* the commitments of some of its members (and early proponents) to the theme of anthropogenic climate change. The formalization effort of the AWG borrows from that effort, but also distinguishes itself against it. Phenomena such as increases in atmospheric concentrations of greenhouse gases are *translated* by geologists into chronostratigraphic markers, such as the presence of plutonium markers resulting from nuclear weapons testing. The Great Acceleration charts, first published and elaborated within the context of the IGBP's program to respond to a "planet under pressure", provide the AWG with an opportunity to elaborate a specifically *geological position* for the 'Anthropocene', one that allows them to "declimatize" the effects associated with anthropogenic climate change, situating those concerns within the context of geological classification. I repeat a passage from a recent defence of the chronostratigraphic method as a means of defining an Anthropocene unit is indicative on this point:

> 'Anthropocene as defined stratigraphically should *not* be equated with 'anthropogenic'. The Anthropocene, we stress, is not synonymous with anthropogenic activity… Had Paul Crutzen used a different term in 2000, not including an 'anthropos', then both the Earth System meaning and justification, and the stratigraphic integrity, of the term would have remained exactly the same, but the conflation of meaning may not have arisen. Equally, had the post-mid-20th century changes we associated with the Anthropocene been produced not by human actions but by, say, volcanoes or a meteorite strike, then the justification and meaning of the Anthropocene both in ESS terms and stratigraphically would also have remained similarly valid. The Anthropocene as an ESS and a chronostratigraphic unit recognizes dramatic changes to the Earth System, using the same criteria that delineates any other previous epoch – it just so happens that the cause is humans this time, rather than some other forcing factor.'[561]

The formalisation effort is positioned in relation to the ESS interest in the Anthropocene theme, which means simultaneous complementarity and difference. In the previous chapter, I elaborated the position of the HKW vis-à-vis the AWG's formalization effort. This was to draw attention to the way in which distinct mobilisations of the Anthropocene respond to each other. The theme of the 'Anthropocene' emerges as an aggregate of changing interactions between its various mobilisations: as a geological unit, as a theme for an exhibition, as an indication of the insufficiency of historical research that has marginalised the responsiveness of human activity to environmental conditions. If the AWG's formalization effort is itself dynamic, changing with each encounter and according to ongoing controversies and negotiations *within the group itself* as well as *in relation* to external parties who are themselves mobilising the Anthropocene theme in their own way, then an account of the

[561] Zalasiewicz, J., Waters, C., Head, M., et al. 2019.

formalization effort may be elaborated by considering how one such external party develops *its own* sense of the Anthropocene vis-à-vis the AWG's effort to designate a GSSP.

I have attempted to emphasise the role of material devices in the ongoing trajectory of a formal Anthropocene unit. The GSSP has been a key device with which to identify the situatedness of the various mobilisations of the Anthropocene term. It intervenes in the initial efforts to define the beginning of the Anthropocene by reference to a numerical age (which the voting members affiliated with the Scale and Chart made clear would not be sufficient for the purposes of formalisation). It demarcates the boundaries between the various factions *within* the AWG, who vote for its designation at very different points in time and space, each with its own remarkably distinct set of social and epistemic implications.[562] The GSSP becomes a point of contention within the AWG, furthermore, when a sub-section of members decide that the GSSP indicates *the wrong* way for an Anthropocene unit to be defined.[563] Most recently, the GSSP provides a crucial funding opportunity for the AWG, as the HKW take an interest in its materiality as an entrance point for further involvement. The HKW's interest in the GSSP situates the AWG's formalization effort within a further, novel context: that of contemporary art, and the host of anxieties and concerns that are entailed therein. At each point, the trajectory of the AWG's formalisation effort is shifted accordingly. And yet, despite the remarkable influence the GSSP has on the effort to define an Anthropocene unit, it remains perpetually undefined and absent, both materially and conceptually, to the extent that it has yet to be decided *what and where* the GSSP is. The GSSP is both an anticipated result of the AWG's formalisation effort, as well as the record of that process. It is in this sense that the GSSP, much like the formalisation effort of the unit it would define, is perpetually under-determined. Even if a GSSP were to be designated, and an Anthropocene unit defined, the mobilisation of that unit would proceed in subsequent discursive trajectories, in much the same way that the AWG have sought to enrol the formalisation of other geological units as a justification of their own effort.

A conclusion, such as this one, cannot resolve what a formal Anthropocene unit *will be*. Rather, the dynamic of formalisation is highly contingent, the formalisation effort is itself changing to the extent that AWG members are themselves continuing to adjust their position

[562] Zalasiewicz, J., Waters, C., Summerhayes, C. 2017
[563] Edgeworth, M. Ellis, E., Gibbard, P. 2019.

in relation to *each other*, and the Group's overall strategy has adapted to the criticisms and concerns of the ICS and IUGS voting members, as well as the availability of resources. These dynamics are not resolvable. Even if the Anthropocene were to be defined as a formal unit, there can only be speculation as to what that will mean and for whom. If ever formalised, an Anthropocene unit will be incorporated variably into further efforts, either of geological classification (Anthropocene sub-units, perhaps), or folded into the discursive regime of anthropogenic climate change, an artistic imperative, and any number of other mobilisations. This is to say, the effort toward definition implies a stoppage, when it more accurately reveals the under-determined dynamics of knowledge production. That is because there is a fundamentally processual, legislative, and political component to the production of geological knowledge.

Appendix

1. Personal correspondence with Jan Zalasiewicz regarding funding applications of the AWG.

Zalasiewicz, Jan A. (Prof.) 28 August 2019 at 21:58 JZ

Re: Question about AWG

To: Damianos,A (pgr)

Hi Alex

apologies for the delay in replying. Yes, we have tried to get funding from some of the more usual sources. Perhaps not as much as we could have done, but then each application represents a lot of effort, which is usually and in our case always (before the HKW) wasted effort. The effort we put into direct work was much more effectively spent.

It would take a bit of digging into the files to get the details, but we applied to NERC in 2011 (turned down) the Belmont Forum in 2017 (turned down), to the Leverhulme in 2017 (did not get supported by Leicester University), to Resarch England in 2018 (did not get supported by Leicester University), I tried for a Leverhulme fellowship in 2018 (turned down). Some of the bids were for basic geological research, others more broad-based.

I hope that helps

all best

Jan

2. Schedule for the 2018 meeting of the Anthropocene Working Group, Max Planck Institute for Chemistry, Mainz, September

AGENDA FOR:
Mainz meeting of the Anthropocene Working Group
5-8 September 2018, hosted by the Max Planck Institute for Chemistry

Wednesday, 5 September 2018
- accommodation at Intercity and Advena Hotels

20:00: evening reception/meeting at Proviantmagazin* http://www.proviant-magazin.de/ ;

Thursday, 6 September 2018
(meeting held at the MPI)

8:55 – 9:00 Gathering at hotel lobby; walk/bus to the Institute (ca 20 min)

9:30 Welcome to the Max Planck Institute for Chemistry
- Words of welcome by Institute director, *Ulrich Pöschl*

9:40 – 11:05 **Session 1: Introductions and ICS business**
9:40 Introductions by the meeting attendees
9:50 Outline of scope of meeting (*Jan Zalasiewicz*)
10:10 SQS progress for Holocene stage definitions (*Martin Head)*
10:30 ICS protocols and key concerns regarding formalisation (*Phil Gibbard)*
10:50 Discussion

11:05 – 11:20 *Break (coffee, tea, refreshments)*

11:20 – 13:00 Session 2: Max Planck Institute for Chemistry expertise
11:20 Climate Geochemistry Department (Gerald Haug)
11:40 Organic Isotope Geochemistry Group (Alfredo Martinez-Garcia)
12:00 Organic Isotope Geochemistry Group (Nicolas Duprey – Awardee 2018 of the Nobel Laureate Paul Crutzen Fellowship)
12:20 Multi Phase Chemistry Department- Climate and Health in the Anthropocene (Uli Pöschl)
12:40 Discussion

13:00 – 14:00 *Lunch**

14:00 – 15:40 Session 3: GSSP/auxiliary section proposals
14:00 Anthropogenic deposits: Vienna (*Michael Wagreich*)
14:20 Peat deposits: Etang de Gruère (*Colin Waters & Bill Shotyk*)
14:40 Trees (*Colin Waters & Angus Winter*)
15:00 Discussion

15:20 – 15:40 *Break (coffee, tea, refreshments)*

15:40 – 17:40 Session 4: GSSP/auxiliary section proposals (continued)
15:40 Crawford Lake, Ontario, Canada: a prospective GSSP candidate for the Anthropocene Epoch (*Martin Head & Francine McCarthy*).
16:00 Lake deposits: Huguangyan Maar (*An Zhisheng*)
16:20 Neobiota signals for biostratigraphy (*Mark Williams*)
16:40 Speleothems: Ernesto Cave (*Colin Waters & Ian Fairchild*)
17:00 Discussion

17:40 *End of the meeting at MPI; return to the hotels*

19:15 **Gathering at hotel lobbies**
19:45 **Dinner*** – at Heilig Geist http://www.heiliggeist-mainz.de/
**** Lunch/catering will be arranged by Max-Planck-Institute for Chemistry, all dinners will have to be paid for individually.***

Friday, 7 September 2018
(meeting held at the MPI)

09:00 – 10:20 Session 5: GSSP/auxiliary section proposals (continued
9:00 Ice (*Colin Summerhayes*)
9:20 Marine anoxic basins (*Colin Waters*)
9:40 Corals (*Reinhold Leinfelder*)
10:00 Radiocarbon bomb peak (*Irka Hajdas*)
10:20 Discussion

10:35 – 10:50 *Break: coffee/tea, refreshments*

10:50 – 13:00 Session 6: 'Scientific utility' and 'societal (political) relevance'
10:50 Introduction and overview (*Davor Vidas*)
11:10 Utility to Earth sciences (*Jan Zalasiewicz)*
11:30 Utility of the Anthropocene to the Earth System science community (*Will Steffen*)
11:50 Utility Challenges of an Anthropocene Epoch for Ecology, Archaeology, and Geographic Science (Erle Ellis)
12:10 Connection between public health and climate change (*Jos Lelieveld, Atmospheric Chemistry Dept., MPI*)
12:30 Utility beyond physical and natural sciences: the example of international law theory development (*Davor Vidas*)
12:50 Discussion

13:05 – 14:00 *Lunch**

14:00 – 16:05 Session 7: Anthropocene in the social sciences and arts
14:00 Preview of Anthropocene film from Mercury film
14:10 Two fundamental misconceptions as primary causes of global human impacts: Open cycling of matter and the myth of unlimited growth (Max von Tilzer).
14:25 Archaeology and the Anthropocene (*Nicole Boivin, MPI Jena*)
14:45 The Anthropocene and global environmental history (*Franz Mauelshagen*)
15:05 The Anthropocene in culture and art: HKW example (*Bernd Scherer*)
15:30 The Anthropocene Surge, tracking the life of data in modified ground (*Katrin Hornek*)
15:45 Discussion

16:00 – 16:20 *Break: coffee/tea, refreshments*

16:20 – 17:40 Session 8: Funding, future plans and meeting conclusions
16:20 Summary of recent and potential funding bids (*Davor Vidas & Jan Zalasiewicz*)
16:45 Summary from a journalist's perspective and communicating the Anthropocene to a non-academic audience (*Nicola Davison*)
17:00 Future plans and logistics of the AWG programme of work for 2019 and 2020 (*Jan Zalasiewicz)*
17:20 Conclusions (*Jan Zalasiewicz)*

19:00 **Gathering at hotel lobbies**

19:30 **Dinner*** – Weinhaus Wilhelmi www.weinhaus-wilhelmi.de

Saturday, 8 September 2018

- *For those who do not have to return on Saturday, organised visits*:
- Temple of Isis, Mainz (small donation to cover cost of English-speaking guide)
- Scientific market
- Either wine tasting at the river side near Rathausplatz or on the market square, lunch nearby

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3. Schedule for the GSSP core candidate meeting at the Haus der Kulturen der Welt. May 27-29, 2019.

AGENDA FOR: **Anthropocene GSSP project meeting at the Haus der Kulturen der Welt, Berlin**
28-29 May 2019, Conference Room (K1)

Attendees:
Bernd Scherer, Katrin Klingan, Carlina Rossée, Niklas Hoffmann-Walbeck, Evi Chantzi, Christoph Rosol, Colin Waters, Martin Head, Neil Rose, Francine McCarthy, Tony Barnosky, Elizabeth Hadly, Allison Stegner, Han Yongming, Stephen Himson, Jens Zinke, Irka Hajdas, Jerome Kaiser, Juliana Ivar do Sul, Michael Wagreich, Reinhold Leinfelder, Alex Damianos, Elvan Kaiser
Film Team Armin Linke

Monday, 27 May 2019

- Accommodation at Hotel Motel One- Bellevue, Paulstraße 21, 10557 Berlin

20:00: meet at Balikci Ergün (Turkish Fish Restaurant, Lueneburger Str. 382) for informal dinner (at own expense).

Tuesday, 28 May 2019

8:30 Depart from hotel lobby; walk to HKW (ca 15 min)

9:00 Welcome to the HKW by Director, *Bernd Scherer*

9:20 – 11:05 **Session 1: Introductions and GSSP process**
- 9:20 Introductions by the meeting attendees
- 9:35 Outline of scope of meeting (*Colin Waters*)
- 9:45 Explanation of the process involved in seeking formalization (*Martin Head)*
- 10:10 Review of suitability of diverse environments (*Colin Waters)*
- 10:30 The Anthropocene at HKW and MPIWG – project genealogy, strategies and outlook (*Katrin Klingan, Christoph Rosol*)
- 10.50 Discussion

11:05 – 11:20 *Break (coffee, tea, refreshments)*

11:20– 13:00 **Session 2: Analytical techniques**
- 11:20 ^{210}Pb dating and ^{137}Cs & ^{241}Am from gamma spectroscopy *(Neil Rose)*
- 11:40 Radiocarbon (*Irka Hajdas*)
- 12:00 Microplastics *(Juliana Ivar do Sul)*
- 12:20 Spheroidal Carbonaceous Particles (*Neil Rose*)
- 12:40 Discussion

13:00– 14:00 *Lunch*

14:00 –15:30 **Session 3: GSSP/auxiliary section proposals**
- 14:00 Crawford Lake, Ontario, Canada (*Francine McCarthy & Martin Head*).
- 14:25 Huguangyan Maar Lake, China (*Han Yongming & An Zhisheng*)
- 14:50 Searsville Reservoir, Jasper Ridge Biological Preserve, California (*Allison Stegner, Tony Barnosky & Elizabeth Hadly*)
- 15:15 Discussion

15:30 – 15:45 *Break (coffee, tea, refreshments)*

15:45 – 17:30 **Session 4: GSSP/auxiliary section proposals (continued)**
- 15:45 Corals- Cayman Islands and Great Barrier Reef (*Jens Zinke, Kristine DeLong & Janice Lough*)
- 16:25 Palmer Antarctic Ice core (*Colin Waters & Liz Thomas*)
- 16:40 Ernesto cave, Italy (*Colin Waters & Ian Fairchild*)
- 17:00 Discussion

17:15 *End of the meeting at HKW; return to the hotels*

18:00-19:00 Internal: press meeting with 2-3 representatives of AWG, Bernd Scherer, Katrin Klingan, Christoph Rosol, Anne Maier

19:30 **Dinner** – as guests, dinner will be at HKW

Wednesday, 29 May 2019

9:15 – 11:00 **Individual meetings** (in parallel; schedule will be announced)
Interviews: Journalists interview AWG members and analysts
HKW: on administrational procedures, contractual agreements
Armin Linke: filmed interviews discussing personal involvements in study

11:00 – 11:15 *Break (coffee, tea, refreshments)*

11:15 – 13.00 **Session 5: GSSP/auxiliary section proposals (continued)**
11:15 Baltic Sea, Sweden (*Jerome Kaiser*)
11:40 San Francisco Bay, California (*Stephen Himson*)
12:05 Etang de la Gruère, Switzerland (*Colin Waters & Bill Shotyk*)
12:20 Vienna Anthropogenic deposits (*Michael Wagreich*)
12:45 Discussion

13:00 – 14:00 *Lunch*

14:00 – 15:15 **Session 6: Project organisation HKW-AWG**

14:00 Public presentation of material evidences and research results (*Bernd Scherer, Katrin Klingan, Christoph Rosol*)
14:20 General proceedings, working structures and next steps (*Bernd Scherer, Katrin Klingan, Christoph Rosol*)
14:40 Future meetings (*Colin Waters, Christoph Rosol, Bernd Scherer*)
14:55 Conclusions (*Bernd Scherer & Colin Waters*)

15:15 – 15:30 *Break: coffee/tea, refreshments*

15:30 – 17:00 **Individual meetings continued** (in parallel; schedule will be announced)
HKW: on administrational procedures, contractual agreements
Armin Linke: filmed interviews discussing personal involvements in study

17:00 *End of the meeting at HKW*

19:00: meet at Angkor Wat (Paulstraße 22) for informal dinner (at own expense)

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