



The Past as a Mirror: Deep Time Climate Change Exemplarity in the Anthropocene

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Abstract

During the past decades, notions of Earth dynamics and climate change have changed drastically, as anthropogenic CO₂-emissions are linked to measurable Earth system changes. At the same time, Earth scientists have discovered deep time climate changes triggered by large scale and natural release of CO₂. As the understanding of past climatic changes improved, they were used to envision what might happen in the near future. This article explores the use of deep time climate examples by analyzing publications on a 56-million-year-old greenhouse gas-driven rapid global warming event, the Paleocene-Eocene Thermal Maximum (PETM). We explore how the PETM is framed and used as an example of “extreme climatic warming” in four cases across different scientific genres. The scientific knowledge about the PETM is considered too uncertain to draw conclusions from, but our analysis shows that, by being presented as an example, the PETM may still contribute to the scientific understanding of ongoing climate change. Although the PETM is regarded as too uncertain to guide present day climate change modeling, it is still considered morally significant, and is allowed to influence public opinion and policy making. We argue that the PETM is used as an example in ways that have formal similarities with the early modern *historia magistra vitae* topos. The PETM example highlights the ambivalence that characterizes the Anthropocene as a temporal conception. The Anthropocene is “completely different”, but at the same time pointing to the similarity between the present and the deep past, thereby allowing for comparison to past geological events. Thus, the Anthropocene is not so “completely different” after all. Just a little bigger, a lot faster, and a lot scarier to humans.

Keywords: temporality, historicity, *historia magistra vitae*, exemplarity, Anthropocene time, the PETM, deep time climate change

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1. Introduction

1.1 Past climates and their relevance for understanding contemporary and future climate change

The Earth sciences, in particular aspects related to deep time rapid climatic and environmental changes, have gained a renewed interest. Part of the reason is the improved methods for reconstructing past climates, and proxies that can make climate models more certain. Moreover, the Anthropocene concept has roots in Earth science and the geological timescale, where, by definition, ongoing Earth system changes are compared to past events in order to be better constrained and understood. Since climate change is an integral part of Earth system science, it has implications for how we think about the present and the future. In this sense, Earth system science has had an impact on contemporary scholarly, popular and, indirectly, political debates on entanglements between human actions and geological processes, such as anthropogenic climate change.

Research on past climates used to focus on the origin of the ice ages in the last 2–3 million years. The term *deep time* is used when investigating the state of the Earth millions of years ago, providing a spatial analogy that may help understand Earth history on timescales vastly exceeding the human experience. The ice ages were believed to represent cold dips from a normal and steady warm climate state. The greenhouse effect and its theoretical basis has been known for more than a century, but no natural mechanisms were believed capable of releasing sufficient quantities of CO₂ to the atmosphere to trigger global warming (e.g. Brooks 1926, Schwarzbach 1963). Climate change was thus restricted to processes such as the changing positions of continents over time, elevation changes of the Earth's crust, or shifts in the Earth's orbit around the Sun (ibid.). However, during the past three decades, Earth scientists have discovered deep time rapid climatic changes, and developed models for their initiation and development (e.g. Summerhayes 2015), building on the theoretical and methodological insights from present day climate studies.

Many of the deep time examples involve natural release of carbon dioxide (CO₂) or methane (CH₄), and these climate changes are recorded as geochemical anomalies in the so-called sedimentary archives, both in organic matter deriving from continents and the oceans, and as mineralogical changes. The best understood deep time climate change is the Paleocene-Eocene Thermal Maximum (PETM), that took place 56 million years ago, and was triggered during a short time period (2,000–5,000 years). This was followed by almost 200,000 years of elevated global average temperatures (e.g. Sluijs et al. 2007). Studies of sedimentary archives from this time period, at numerous localities across the world, have shown that in addition to the global temperature increase, the global hydrological

cycle changed, leading to increased erosion and runoff from the continents. Moreover, the climate change resulted in the extinction of deep marine species, coral reef disappearance, ocean acidification, reduction in body size of terrestrial mammals, and potentially a complete destruction of vegetation in equatorial regions, as the average temperature soared to 36–37 degrees Celsius (Frieling et al. 2017).

The PETM was discovered in the late 1980s and was early on suggested to represent a period of warm climate that was caused by the release of methane from gas hydrates stored in the shallow seafloor (e.g. Dickens et al. 1995). Gas hydrates are marine equivalents of terrestrial permafrost. Several other hypotheses have been put forward to explain the PETM, including degassing of volcanic CO₂ and metamorphic CH₄ following the eruption of an enormous volcanic province in the North East Atlantic (Svensen et al. 2004), and comet impacts (Schaller et al. 2016). There is, however, currently a consensus in the Earth science community about a greenhouse gas trigger of the PETM, and that the source of the carbon was not gas hydrates or permafrost. Topics that are still debated include the magnitude of the carbon release during the ca. 200,000 year duration of the PETM (the CO₂ emissions per year), and the climate sensitivity (that is, the temperature response following a doubling of the atmospheric CO₂ concentration). Moreover, the potential catastrophic aspects of the PETM are still poorly understood; for example, the environmental stress in various parts of the paleo-world, including the tropics. Despite these uncertainties, the PETM is still the most studied and best understood deep time greenhouse gas-related climate change (cf. Summerhayes 2015) that may provide knowledge about how the Earth responds to large and rapid injections of carbon from the Earth's crust into the atmosphere.

1.2 Notions of temporality and historicity in the Anthropocene

Over the last decade, it has been frequently argued that the possibility of the Anthropocene as a new geological epoch has fundamental implications for contemporary notions of temporality. A main argument has been that the recognition of humankind as a geological force, implied in the concept of the Anthropocene, also means that the modern distinction between historical and geological timescales has collapsed. The Anthropocene has inscribed humankind into a long geological time span (Chakrabarty 2009, 2018, Latour 2017, Robin & Steffen 2007, Robin 2013). The human present must be seen in relationship with the deep past and the far future. This also has implications for the notion of history and historicity. According to one of the leading historians on theorizing Anthropocene temporality, Dipesh Chakrabarty “[t]he discussion about the crisis of climate change can [...] produce affect and knowledge about collective human pasts and futures that work at the limits of historical understanding” (Chakrabarty 2009: 221). This

might be the case, yet, it is still to be empirically investigated. What does this claim imply? How are deep time geological events relevant for the present and the future? How are deep time geological events made relevant for the contemporary society, and how are such events used to anticipate a climate-changed future?

1.3 The aim of this contribution

The main objective of this article is to investigate how the PETM throws light on notions of historicity concerning anthropogenic climate change. In the 2007 IPCC Fourth Assessment Report, *The Physical Science Basis*, the PETM was referred to as “a striking example of massive carbon release and related extreme climatic warming” (Jansen et al. 2007: 442). In this article we examine how the PETM is used as such an example, with the 2007 IPCC report as a starting point. In addition to this report, we examine a modeling paper comparing past and present CO₂ emissions (Zeebe et al. 2016), the short-format review article “A heated mirror for future climate” (Alley 2016), and the popular science book *The Storms of my Grandchildren* by James Hansen (2009).

We discuss how the PETM is framed and used as a climate event with relevance for contemporary climate change research, and how it might inform predictions of a climate-changed future. By doing so, this article will contribute to the discussion of notions of temporality and historicity in the Anthropocene.

2. Approach and theoretical background

2.1 Perspectives on historicity

Historic understanding is normally understood as how the past, the present and the future are seen in relation to each other. Reinhart Koselleck has used the terms *space of experience* and *horizon of expectations* to describe this relationship. He describes experience as:

[...] present past, whose events have been incorporated and can be remembered. Within experience a rational reworking as included together with unconscious modes of conduct which do not have to be present in awareness. There is also an element of alien experience contained and preserved in experience conveyed by generations or institutions (Koselleck 1985: 272).

Expectations on the other hand, is defined by Koselleck as “the future made present; it directs itself to the not-yet, to the non-experienced, to that which is to

be revealed” (Koselleck 1985: 272). None of these categories are understood as individual. Koselleck is instead concerned with experiences and expectations on a societal and cultural level. His theoretical claim is that the relationship between “present past” and “the future made present” is not fixed, but historically changing (Koselleck 1985: 272).

Koselleck claims that, in early modern Europe, the *space of experience* and *horizon of expectations* were more or less overlapping categories. The future was not regarded as fundamentally different from the past, and expectations of the future were based on past experiences, regardless of age. The world was changing chronologically, but the fundamental problems and challenges that humans were facing were regarded as constant (cf. Eriksen 2017: 184). The notion of historical progress and development had not yet emerged, and the timescale of the world was fixed within the framework of God’s plan. In this period of time, history was not regarded as a temporal process, but as a collection of narratives to learn from. Koselleck argues that the early modern notion of history could be summed up in the formula *historia magistra vitae* (Koselleck 1985: 22). This formulation, borrowed from Cicero, emphasized the authority of history; it was regarded to be instructive as a ‘teacher of life.’ Textbooks in history were, for instance, structured as collections of good and virtuous examples. These were presented as model examples, meant to instruct the students in how to handle similar situations (Eriksen 2017). Historical examples also informed political theory and political decisions. For instance, both Queen Christina of Sweden and Charles XII of Sweden mirrored their life and work on the life history of Alexander the Great (Hellerstedt 2009: 128). History was a resource for “repeat[ing] the successes of the past instead of committing earlier mistakes in the present” (Koselleck 1985: 22).

However, this way of thinking was not exclusive to that which today is regarded as human history. The distinction between human history and the history of the Earth emerged in the latter part of the 18th century. Up until then, Genesis was the starting point of both human and natural history. Natural history was explored through the notion of exemplarity. Biblical narratives were used to interpret geological observations, as well as astronomical phenomena and weather events. And events in nature were also used as instructive examples for human behavior. For instance, the 17th century Uppsala University Professor Johannes Schefferus included natural occurrences as examples to learn from in the collection of examples *Memorabiliū Sueticae gentis exemplorum liber singularis* (A Book about the Memorable Examples of the Swedish People) (Schefferus [1671] 2005: 45). His book demonstrates how exemplarity was a way of thinking and reasoning that exceeded what later became a distinction between the ontological spheres of nature and culture (cf. Latour 1991). Thus, natural phenomena were regarded as parts of God’s plan, and the overlapping of the *space of experience* and *horizon of*

expectations also counted for early modern understandings of geology and natural phenomena (Kverndokk 2019).

A tension between *the space of experience* and *the horizon of expectation* emerged in the mid-18th-century, according to Koselleck. He relates this to the decline of the early modern eschatological world view, and the appearance of a new, open future without a fixed end (Koselleck 1985: 276–277). The emergence of this open future was paired with the new notion of progress, that set history in motion, so to speak. At the same time, natural history was excluded from the notion of history. The history of the earth was no longer regarded as being incorporated into a human space of experience. The idea of geological flux was introduced in the mid-18th century, and uniformitarianism gradually replaced catastrophism as the dominating geological doctrine (Rappaport 1997; Eriksen 2007). The biblical timescale was questioned by scientists like Buffon. The calculations of the age of the world became a scientific issue, and the idea of what is today termed “deep time” eventually developed.

The historian Francois Hartog has argued that the emerging awareness of a global ecological crisis during the 1980s and 1990s changed Western notions of historicity, yet, his argument is seemingly different from Chakrabarty's. Hartog argues that the present and future are now considered fundamentally different from the past. We live in an omnipresent present, he argues, where the past seems to be irrelevant for contemporary lives and future predictions. The past is evaluated by using the present as the standard. This also counts for how the future is evaluated, he argues. Concerns about the future are transformed into present concerns and demands for immediate political action. The present is transformed into a commenced future, or the future is approached as an extended present. In this way, he has argued that the tension between *space of experience* and *horizon of expectation* has come to a breaking point (Hartog 2015: 203–204). Drawing on Koselleck, Hartog depicts a linear description of the development of Western notions of historicity, from an early modern to a late modern one.

Chakrabarty, on the other hand, argues that the emergence of the Anthropocene might again change notions of time and historicity. The intertwining of geological and historical timescales that are implied in the notion of the Anthropocene also implies a change in how expectations and experiences are related. In his article “Anthropocene Time”, Chakrabarty seems to recognize Hartog's presentism as a social phenomenon. He refers to Hartog to criticize scholars claiming that that the *Anthropocene* should rather be replaced by terms such as the *Capitalocene* or *Econocene* (cf. Malm & Hornborg 2014; Moore 2016). According to Chakrabarty, such attempts are narrowing down the complex concern reflected in the term Anthropocene to “more immediate factors” – the capitalist system (Chakrabarty 2018: 11). When Chakrabarty claims that the discussion about a climate crisis

produces “knowledge about collective human pasts and futures that work at the limits of historical understanding”, however, he implies a severe expansion of the human *space of experience* and *horizon of expectation*, by also including geological timescales (Chakrabarty 2009: 221). He does not, however, show empirically how the geological past works as a space of experience.

In this article, we use the categories *space of experience* and *horizon of expectations* as a methodological approach for exploring how the PETM is used in climate change discourse.

2.2 Examples and exemplarity

Inspired by how the PETM was coined by the IPCC (“a striking example of massive carbon release and related extreme climatic warming”, Jansen et al. 2007), we read four selected cases of studies on the rhetoric of examples and exemplarity. Aristotle calls the example a rhetorical induction, that is, an argument based on a number of similar cases, and they are used today for the same reasons that Aristotle used them; to illustrate a point, to explain something, and, first and foremost, to persuade someone (Aristotle *Rhetoric*: Chap. 2). However, the problem with keeping such a view of examples is that since antiquity, there have existed two different ways of applying them; the Platonic, where the example is used as an ideal, and the Aristotelian, where the example is used as an illustration, and examples always contain an innate ambivalence between the two functions (Gelley 1995: 1). Examples, including those that are meant to have an illustrative function, hover between being an illustrating element among many, and being a unique model (Eriksen et al. 2012: 9).

In early modern Europe, with the understanding of history as a collection of narratives for instructing people on the present, examples provided the empirical basis for science as well as theology and politics. Although, in the 18th century exemplary reasoning in the natural sciences was replaced with numerical reasoning, statistics and mathematical probabilities, Eriksen (2016: 214, 2018: 37) has shown how numerical arguments remained entangled with arguments from exemplarity into the 19th century. Thus, the exemplary way of thinking lingered when both a “quantifying spirit” and instrumentalism were well established. The transfer went both ways; individual cases, that is, examples, were used as evidence and calculations could be turned into metaphors and transferred to an exemplary context (Eriksen 2016: 215). Today, exemplary reasoning has seemingly vanished from the natural sciences. The exemplary way of thinking, however, has remained explicit in political, pedagogical and vernacular discourses, and examples are still important parts of the rhetorical mode of such texts.

Gelley (1995: 5) has argued that exemplarity constitutes an “answer position”

that has been kept on despite the fact that the rhetorical and religious reasoning behind it has disappeared. This means that the authorization of the example, the “why” it can teach us something, is to a certain degree left unexplained in the contemporary use of examples, while the texts still draw authority from them. Because of this, examining the way the PETM is used as an example can give important empirical information on the notions of historicity at play in the Anthropocene.

Rhetorically, examples can be understood as parts of a text that are made to stand out of the text and point towards reality (Lyons 1989: 28), but although the examples seem to be just pieces of reality added into the conversation, they are, of course, artificial. They are created, shaped, and chosen in a process where the example is “transformed from ‘itself’ into an ‘example of’” (Lyons 1989: 33). One of the aspects of this transformation process is that examples are taken out of one context and placed into another (Lyons 1989: 31). Only parts of the current knowledge about the PETM are brought into the texts that comprise the source material of this article. Both the question of what parts are considered relevant and the contexts or frames they are placed in will vary from text to text, affecting whether and how deep time historical knowledge is made relevant to the present.

2.3 The empirical cases

The choice of literature is based on 1) contributions from leading scientists in their fields; 2) scientific contents or methods that are not controversial but reflect the research front; and 3) genres representing different knowledge platforms, from a scientific consensus report (Jansen et al. 2007) to a popular science book (Hansen 2009). Although three of the selected texts have first authors from the USA, we stress that the PETM represents an international research topic.

The four selected texts are all based on scientific knowledge, and are produced by well-renowned scientists. However, the choice of selecting publications produced within different genres is based on an assumption that different genre conventions imply different ways of arguing, and might also facilitate slightly different conclusions. Both a review article such as Alley (2016) and the 2007 IPCC report are syntheses of a range of scientific texts. Yet, a review article is not restricted by the obligations to inform policy making in the way an IPCC report is. While the task of an IPCC report is to present scientific consensus, the review article is a genre that sums up the best available and relevant research, something that is not necessarily equal to consensus. A review article also, to some extent, allows for claims in ways that are impossible in a report format. While the IPCC report operates as an interface between science and politics, the review article is supposed to inform a scientific audience about the research front. Popular science is a less restricted genre. It not only allows for catchy formulations, but also for personal nar-

ration, balancing scientific knowledge with personal claims. This is the case with Hansen's book. It transforms science into a well-told story, appealing to a general audience. The peer-reviewed scientific article by Zeebe et al. (2016) is different from all of these forms. It is the only text written within a strict scientific genre, implying that it is driven by a research question and is methodologically stringent. Hence, the four publications cover a wide range of possible ways to argue and to use the PETM as an example in climate change discourse.

3. Analysis

3.1 *The PETM and climate sensitivity*

The 2007 IPCC report included, for the first time, a separate chapter dedicated to lessons from paleoclimate research (Jansen et al. 2007). The work was led by Eystein Jansen, Professor of Geoscience at the University of Bergen, Norway, and includes 15 co-authors. The paleoclimate presentation is thematically organized in four parts, starting with the pre-Quaternary climate (i.e. prior to 2.6 million years ago), the climate of the ice ages, the Holocene climate, and ending with the climate evolution of the past 2,000 years. Part of the motivation behind the paleoclimate chapter is to use lessons from the past to better understand future changes in the climate system. The report claims that:

[A]n examination of how the climate system has responded to large changes in climate forcing in the past is useful in assessing how the same climate system might respond to the large anticipated forcing changes in the future. (Jansen et al. 2007: 438)

One of the challenges in climate modeling is to evaluate the model performance for CO₂ concentrations much higher than at present. The climate sensitivity is poorly constrained and may not be constant as CO₂ concentrations continue to increase. This is where the PETM becomes relevant for the IPCC 2007. Can the PETM be used to improve the understanding of the climate sensitivity, as the PETM background CO₂ concentration was much higher than the pre-industrial level of 280 ppm? When reviewing the available reconstructions of CO₂ concentrations before, during, and after the PETM, Jansen et al. (2007) stress that the reconstructions are highly uncertain, and give values across the 300 to 3,000 ppm range. The reason for this is that CO₂ reconstructions are very challenging, and the results are highly dependent on which methods are used.

Although the PETM is argued to be relevant because of “some similarity with the ongoing rapid release of carbon into the atmosphere by humans”, and the

magnitude of released carbon is comparable, there is still a poor match between data and model output. The conclusion of Jansen et al. (2007) is that more work is needed to obtain more accurate information from the PETM, but at the same time, that the PETM has something to offer. The full quote, from which we used an excerpt in our introduction, is:

Although there is still too much uncertainty in the data to derive a quantitative estimate of climate sensitivity from the PETM, the event is a striking example of massive carbon release and related extreme climatic warming. (Jansen et al. 2007: 442)

The PETM is relevant because it represents a striking example of an event from the past that may happen again in the future.

In the following IPCC report, published in 2013, the PETM is mentioned as one of several interesting paleoclimate events (Masson-Delmotte et al. 2013). Even though new estimates about the PETM emissions and the temperature response is better constrained compared to the status in 2007, the PETM is still regarded as too uncertain to be of use as a quantitative case: “Uncertainties on both global temperature and CO₂ reconstructions preclude deriving robust quantitative estimates from the available PETM data” (Masson-Delmotte et al. 2013: 339).

What does it mean that the PETM is an example, yet, there is “still too much uncertainty in the data to derive a quantitative estimate of carbon sensitivity”? The noun “example” might in this case mean one possible scenario of extreme climate warming. Yet, the use of the adjective “striking” indicates that it is not understood as just one of a range of possible scenarios. It could be understood as the best available case in the paleoclimatic history for “assessing how the same climate system might respond to the large anticipated forcing changes in the future”. Another possibility is that it is a qualitatively useful example (cf. Eriksen 2018). Regardless of the uncertainties, the way it reveals climate sensitivity of the Earth system might still work as a warning of what might possibly be the consequences of the anthropogenic emissions of CO₂ and other greenhouse gases. This is left open for interpretation by the IPCC working group.

3.2 The current “no-analogue state”

The starting point for the study of Zeebe et al. in their article from 2016, entitled “Anthropogenic carbon release rate unprecedented during the past 66 million years” is that “geologic analogues from past transient climate changes could provide invaluable constraints on the response of the climate system to such perturbations” (Zeebe et al. 2016: 325). The authors, Richard E. Zeebe, Andy Ridgwell, and

James C. Zachos are the leading experts in their fields (carbon cycle- and paleoclimate modeling, and temperature reconstructions). Zachos is one of the scientists behind the iconic sea surface temperature reconstruction for the past 66 million years (the so-called Zachos-curve).

Both the abstract and the main text start with evoking the present, stating that anthropogenic carbon release rates reached a record high in 2014, and that rapid reductions in these carbon emissions seems unlikely. Thus, the starting point for the investigation is not the PETM in itself, but its value in making future climate projections.

The sentence cited in the beginning of this section continues as follows: “but only if the associated carbon release rates can be reliably reconstructed.” Thus, Zeebe et al. set up a limitation for the possible use of geologic analogies. In the introduction, they state such a limitation specifically for the PETM, claiming that “[d]etermining the release rate is critical” for drawing future inferences from this event (Zeebe et al. 2016: 325).

The approach of Zeebe et al. (2016) is to make new estimates of how much carbon was emitted into the atmosphere during the first phase of the PETM (the first 4,000 years), and to compare the results with the anthropogenic carbon release. Since the PETM is the largest global warming event for the past 66 million years, it represents a benchmark example for the applicability of deep time climate change. When estimating the PETM carbon flux, the results are about ten times less compared to the anthropogenic situation, that is, about 1 gigaton of carbon per year (PETM), compared to ca. 10 gigatons of carbon per year (anthropogenic). The overall conclusion is that the current carbon release rate is “unprecedented during the past 66 million years.” As a consequence, Zeebe et al. use the term ‘no-analogue state’ for the anthropogenic carbon emission scenario, resulting in “a fundamental challenge in constraining future climate projections.”

Zeebe et al. discuss whether or not the PETM could pose a state that is analogous to the present or near future. They are concerned with the process of figuring out what would make it applicable as science, and state early on that the key is the CO₂ emission rates. If these are not comparable, there is no analogy. When Zeebe et al. conclude that CO₂ emission rates during the PETM must have been much lower than present day emission rates, they conclude that the present is a no-analogue state, it cannot be inferred from the past. Thus, it would seem that the authors of the article postulate the present and near future as a breach, not only from human history, but also from geological history (as far back as 66 million years). This would seem to imply that there are no direct lessons to be learned from Cenozoic climate change.

However, after drawing this conclusion, Zeebe et al. still seem to consider the PETM useful. Although the PETM cannot be used for constraining future climate

projections, the no-analogue state of the near future means that the consequences of the anthropogenic emissions will likely be more severe than what happened during the PETM, and Zeebe et al. (2016: 328) state that:

Regarding impacts on ecosystems, the present/future rate of climate change and ocean acidification is too fast for many species to adapt, which is likely to result in widespread future extinctions in marine and terrestrial environments that will substantially exceed those at the PETM. (Zeebe et al. 2016: 328)

A similar view is also stated in the abstract, where Zeebe et al. (2016: 325) state that “future ecosystem disruptions are likely to exceed the relatively limited extinctions observed at the PETM”.

Thus, in the last few sentences of the article and the last sentence of the abstract, the PETM is used in another way than in the rest of the article. It is not used as an analogy or as a non-analogy, but as an Earth history experience to learn from. What we can learn is that ecosystems are going to become more disrupted than they have been during the last 66 million years, and that there will be more species extinctions than during the PETM. Zeebe explains this himself following the publication of the paper, in an interview in the newspaper, the *New Zealand Herald*:

The analogy between the PETM and the present, then, is less than perfect – and our own era may be worse in key ways. “The two main conclusions is that ocean acidification will be more severe, ecosystems may be hit harder because of the rate of carbon release”, says Zeebe. (New Zealand Herald 2016)

The uniqueness of the anthropogenic climate-changed future is argued by the use of deep time data, but at the same time this uniqueness is used for presenting the PETM as something to learn from. In the terminology of examples, this discrepancy is the result of two different ways of “cutting out” the PETM in the same article. When the analogue state is discussed, the PETM is framed quantitatively, focusing on emission rates, while in the last sentences of the article, the PETM is instead presented as a qualitative example of a past extinction event caused by climate change. Thus, the future can be a no-analogue, and at the same time deep history can be relevant. In the qualitative “extinction” frame, the uniqueness of the present and near future consists only of it being “worse”, and the changes “more severe”.

3.3 *The PETM as a mirror for near future changes*

In 2016, Richard Alley wrote a short summary paper in *Science* about the PETM and what is known about the climate change and the resulting environmental changes (Alley 2016). Alley is a climate scientist with a focus on ice age climates and ice core research in particular. The basis for the summary is a reading of the key literature about the PETM, and the motivation is apparently to understand what may happen in the future following massive anthropogenic CO₂ emissions:

The possible effects of rapid carbon dioxide (CO₂) release may be clearest from the Paleocene-Eocene Thermal Maximum (PETM) about 55.9 million years ago, when a large, natural CO₂ release drove strong warming that caused amplifying feedbacks, dwarfing of large animals, ecosystem disruptions, soil degradation, water-cycle shifts, and other major changes. (Alley 2016: 151)

Like the 2007 IPCC report, Alley raises the question about past climate sensitivity, and he uses new results to imply that the climate sensitivity during the PETM may have been higher than previously believed. If so, this has implications for the future, as “temperatures may rise more than currently projected” (Alley 2016: 151). Thus, knowledge about past climates where the background CO₂ concentration was higher than today may be used to modify our understanding of future climates. Alley still considers the uncertainties related to reconstructions of the climate during the PETM as problematic, but claims research is on the right track for improvements.

Like Zeebe et al., Alley starts his article with a reference to the present and future: “Climate has always changed naturally, and this is not good news when contemplating a human-forced future”, he writes, before turning to discuss the PETM (Alley 2016:151). The main point is whether the past can help us to understand the present. Also like Zeebe et al., Alley evaluates whether the PETM example is relevant by stating similarities and differences between the PETM and the present situation. However, while for Zeebe et al. the specific aim of their article is to contribute to such an evaluation of whether the PETM is relevant, restricting other descriptions of the PETM to the last few lines of the article, for Alley, this consideration is a starting point for a much broader presentation of what the world looked like during the PETM. Thus, while Zeebe et al. (2016) use most of their article to present the PETM in a way that makes similar rates of CO₂-emissions the crucial factor for it being a useful analogy, Alley, as illustrated by the title of this review article, regards the PETM as a “heated mirror for future climate”, stating that “Climatic changes 55.9 million years ago resemble those expected in the future” (Alley 2016: 151).

The way Alley starts with the present, combined with the title of the article “A heated mirror for future climate”, and the descriptions of nature during the PETM, show that he considers this information relevant for understanding the future. He uses words like “confirming”, “suggests” and “likely” when describing knowledge from the PETM applied to present conditions. The CO₂ emission rates pose a constraint for what the PETM can be used for, but does not seem to suggest very much on the possible use of it, and there is no mention of a no-analogue state.

However, Alley also underlines the fact that the future will probably be different from the PETM. The difference consists in an enhanced severity, compared to the PETM: “Hence, the biological impacts of the PETM were likely less severe than those of human-caused emissions under a business-as-usual scenario,” Alley writes (2016: 152). This is also highlighted in the caption following the article’s only illustration. This caption starts with a question “Clues to the future?”. The question mark indicates an uncertainty as to whether the future will be like the past, and like in Zeebe et al. it is the CO₂ rates that are the cause of the question mark: “Today, greenhouse gas concentrations are rising even faster than they did then”, Alley writes (2016: 152). Still, the past does represent a mirror, in which we can look and see the future, he claims.

As a summary paper, Alley’s article does not have to subscribe to the strict requirements of a scientific article, and the descriptions of the PETM from the scientific references are extremely detailed in some points: “PETM plant leaf fossils from the Bighorn Basin are almost twice as likely to show insect damage as the average from before and after; one PETM leaf shows 10 different types of damage” (Alley 2016: 151). Although Alley does not use the word ‘example’ for the PETM, he uses the PETM in a way that is recognizable as an example – that is, as a concrete instance to support a general statement. The PETM is claimed to be a mirror for future climate, presenting an event, not from traditional history, but from geological history, that we can learn from, although biological impacts in the future will probably be more severe. During the PETM, there could be ten different types of insect damage on one leaf – in the future we may expect worse.

In the last sentence of the article, there is a change in focus from nature and science to humans: “The history of the PETM shows that our decisions will have large and long-lasting consequences” Alley states, (2016: 152), and in the text he also argues for the direct use of the PETM in policy making:

Narrowing the uncertainties about this important climate event and other similar features in the geologic record could provide additional valuable insights to inform decisions on our energy future. (Alley 2016: 152)

Here, Alley uses the PETM as a typical historical example, an instructive narrative

from which it is possible to draw lessons, and which should inform political decisions. Thus, the PETM is not only a mirror in which to see future climate change, but a mirror in which we humans can see ourselves. The term “mirror” highlights a similarity between the use of the PETM and the medieval and early modern rhetorical practice of using stories about the life and work of historical persons as models for contemporary political depictions – as “*historia magistra vitae*”. In this tradition, “the mirror” was used as a metaphor equal to “the example”. The mirror metaphor was, for instance, used in the medieval and renaissance literary genre of “mirrors for princes”, from which young rulers were meant to learn how to conduct themselves by historical examples (Kjus et al. 2011: 59–63, Koselleck 1985: 24–25).

There are, in other terms, similarities between the way Alley argues and the *historia magistra vitae* topos. One major difference is that the relevant example is offered by deep geological history. Although early modern examples could be non-human and even be taken from the early history of the Earth, there were still no distinction between human history and Earth history. They both had the biblical Genesis as the starting point, and were intertwined from the start. In the way Alley perceives the PETM, however, the example from which humans may learn is taken from a past millions of years before human history began.

3.4 *The concerned environmentalist and the climate crisis*

In 2009, the director of the NASA Goddard Institute for Space Studies, James Hansen, published the popular science book *Storms of my Grandchildren* as an introduction to climate change research. It is a highly personal account of climate research and his career as a climate scientist, activist and government advisor. The different chapters vary between depictions of his experiences from Senate hearings, reflections upon American climate politics, and popular natural science. In chapter 8, entitled “Target Carbon Dioxide: Where Should Humanity Aim?” he is discussing the appropriate target level of CO₂ in the atmosphere. In this chapter, he discusses the PETM and the relevance of the PETM for today’s global climate crisis (Hansen 2011: 140–171).

The question concerning the appropriate target level for CO₂ was addressed to him by the profiled environmentalist Bill McKibben in 2007. McKibben himself had suggested 450 ppm. His plan was to open a website called 450.org to emphasize the importance of such a target level, and wanted to check with Hansen if the number was correct. Hansen promised that he would have an answer for him by the end of the year (Hansen 2011: 140, 164). The chapter “Target Carbon Dioxide: Where Should Humanity Aim?” is formed as a story that leads the readers through how he finally got an answer for McKibben.

The number 450 ppm was not taken out of thin air, it was based on a scenario study published by Hansen and his colleagues in 2000 (Hansen et al. 2000). This paper concluded that 450 ppm would give an additional rise of 1 degree Celsius, compared to the average global temperature at the turn of the millennium (Hansen 2011: 140–141). Hansen wanted to give McKibben an updated answer, yet, also wanted to “have a good science rationale – otherwise the number would have little meaning” (Hansen 2011: 140). To get this answer, Hansen turned to paleoclimatic research on the relationship between global climate fluctuations and atmospheric CO₂ fluctuations during the last 66 million years, and combined this data with data on ice cap melting and rising sea levels. At the time he got the question from McKibben, Hansen and his colleagues worked on a new paper that concluded that 450 ppm was a more dramatic target limit than previously presumed (Hansen et al. 2008). “A striking conclusion from this analysis is the value of carbon dioxide – only 450 ppm, with estimated uncertainty of 100 ppm – at which the transition occurs from no large ice sheet to a glaciated Antarctica” (Hansen 2011: 160). Hence, it would be “foolish and dangerous” to have 450 ppm, as a target goal for climate politics.

After using several pages on discussing changes in climate during the Cenozoic era, he introduces the PETM by suddenly addressing his readers:

Okay, I know, this is getting long, but for the sake of your children and grandchildren, let’s look a little more closely at another story in figure 18 [the Zacherl-curve], one that is vitally important. I refer to the PETM, the Paleocene-Eocene thermal maximum, the rapid warming of at least 5 degrees Celsius that occurred about 55 million years ago and caused a minor rash of extinctions, mainly of marine species. (Hansen 2011: 161).

There are several interesting aspects in the way he introduces and frames the PETM as a paleoclimatic event “that is vitally important”. Hansen explains that one reason why the PETM is of such vital importance is that it was caused by a carbon release, which, according to Hansen, was “almost as much as the carbon in all of today’s oil, gas, and coal” (Hansen 2011: 161). This comparison makes it meaningful in a contemporary context. However, the phrase “for the sake of your children and grandchildren” still stands out compared to the timescale and scientific content in the rest of the paragraph. The entanglement of scale between deep time and generational time and family concerns is typical for the rhetorical use of generational time in Hansen’s book. It is however, more than a rhetorical device. The phrase “for your children and grandchildren” is an efficient way to dramatize Hansen’s message; that the current situation is severe. And, even if not explicit-

ly explained by Hansen, it is also an illustration of the radically different rate of today's emissions, compared to the natural emissions of carbon in earlier Earth history and during the PETM. Even though the emissions that caused the PETM happened at a much faster pace than average in Earth's history, they were still much slower than the contemporary human-made emissions. Thus, the reference to children and grandchildren is also a description of entangled timescales and an acceleration of Earth processes.

It is implied in Hansen's argument that if the PETM should work as a relevant comparative scenario, it has to be calibrated for the differences of duration. In other words, in order for the PETM to work sufficiently as "present past" in the Earth history, as a geological experience of relevance for contemporary climate research, activism and politics, its pace has to be turned on turbo. The fossil resources of the world might all be burned in just a few decades, releasing a total amount of carbon that more or less equals the quanta that caused the PETM (Hansen 2011: 161). In this way Hansen demonstrates how deep time and human time entangle in the 21st century (cf. Chakrabarty 2009).

Another point that gives the PETM additional contemporary relevance to Hansen is that paleoclimate data "unambiguously point to the methane releases [that caused the PETM] being a [climate] feedback" (Hansen 2011: 162). In other words, that a warming climate caused additional release and accelerated the global warming. The contemporary warming of the climate may again cause such a feedback reaction if global temperatures get too high: "[I]t is practically a dead certainty that business-as-usual exploitation of all fossil fuel would cause today's frozen methane to melt – it is only a question of how soon" (Hansen 2011: 162). Hansen claims this to be the point of no return, and also states that the Earth's methane reserves today are larger than they were before the PETM (Hansen 2011: 162–163), indicating that in the long run, anthropogenic climate change could even be more dramatic than the PETM.

At the end of the chapter, Hansen reveals what he eventually answered McKibben; it was not 450 ppm, but 350 ppm. The conclusion was partly based on the paleoclimatic knowledge on the likely target level for a glaciated Antarctica, and partly on the PETM research, with an emphasis on climate feedback reactions. Although the data did not give an exact answer, Hansen, based on a precautionary principle and the wish to find a level that ensures avoiding feedback mechanisms, regarded the number to be way under 450 ppm. Also taking contemporary data on ice melting into account, he concluded that the number had to be less than the contemporary level of 387 ppm, and landed on 350 ppm (Hansen 2011: 164–166). McKibben responded by opening the webpage 350.org and starting an international environmental organization also entitled 350.org, which has as its goal to reduce the concentration of atmospheric CO₂ to 350 ppm (350.org).

In this way, paleoclimatic knowledge is used as a space of experience that is paired with knowledge of contemporary climatic phenomena and processes. Data on the PETM does not give an exact quantitative answer to McKibben's question, but it informs the answer qualitatively, as a historical demonstration of how a warmer climate might cause methane feedback effects. The uses of deep historical data in Hansen's book, and the way a paleoclimatic analysis works as a basis for climate activism demonstrate clearly how deep time and historical time, natural phenomena and technical processes, the ontological zones of culture and nature are intertwined in climate activism and politics (cf. Latour 2017). It demonstrates how the climate crisis requires knowledge that "work at the limits of historical understanding" (Chakrabarty 2009: 221). This case not only demonstrates that the climate crisis challenges the limits for historical understanding, it also exceeds every possible human experience. Just like in Alley's article, the historical experience is far beyond human history, the analysis demonstrating how the climate crisis establishes a non-human space of experience to model possible human futures.

4. Conclusion

The four publications examined in this article are produced within four different genres. Some of their striking differences are due to genre conventions and the audiences they are addressing. The starting points for all of the four publications are, however, similar. They are all discussing the usefulness of the PETM in informing knowledge production on anthropogenic climate change, thus investigating how the deep geological past can inform the present and the future. Even though the conclusion in Zeebe et al. (2016) is different from the others, in that they consider the near future a no-analogue state, the starting point is the same: to investigate if paleoclimatic data and past climatic events in Earth history might contribute to the understanding of anthropogenic climate change. When Zeebe et al. state that the future is a 'no-analogue' state compared to the PETM and any other climate event the last 66 million years, they do not reject that the past might inform the current situation. The conclusion concerning the uniqueness of the anthropogenic carbon release is itself a result of a systematic comparison of climatic events in Earth history. Finding that there is no analogous event in the last 66 million years of Earth history leaves the scientific community and humankind with no comparable Earth experiences to draw future expectations from. "It's a bit scary", to quote from the interview with Richard Zeebe. The past is regarded as a valuable authority; the "scary" part is that the proportions and pace of the current situation exceeds this authority. The past can no longer inform, just warn.

The scientific uncertainty is discussed in all of the publications. Neither Alley

(2016) nor Hansen (2009) question that the quantitative data are uncertain, or that the current carbon release rate seems to be much higher than during the PETM. Yet, in line with the 2007 IPCC report, the PETM is used in all the three other papers as an event informing the current situation, not quantitatively, but qualitatively: The biological impacts of anthropogenic climate change may be “more severe” than during the PETM (Alley 2016: 151), and a future climate feedback due to methane releases similar to the PETM is “practically a dead certainty” (Hansen 2011: 162). The qualitative information is, however, not only of a scientific nature. To Alley and Hansen, the PETM also has the power to inform human actions. The PETM “could provide valuable insights to inform decisions on our energy future” (Alley 2016: 152) and thus ought to inform international policy making; while in Hansen’s text, the insight the PETM gives on the severity of feedback effects gives a background for his evaluation of an appropriate CO₂ target level. The lesson Hansen professed to learn from the PETM has directly influenced international environmentalism through the founding of 350.org.

It is not surprising that paleoclimatologists look at past events to understand the current situation and future development of the Earth system. The physical and chemical principles of the climate system are the same. Yet, it is interesting to note that, although not sufficiently well studied to inform climate change modeling, the PETM is regarded not only as qualitatively significant, but as morally significant as well. This is spelled out in the concluding sentence by Alley: “The history of the PETM shows that our decisions will have large and long-lasting consequences” (Alley 2016: 152). The PETM then, has become a deep past experience, and as such has become “present past” in the terms of Koselleck. Earth history is configured as a space of experience, or more precisely, a reservoir of events that has the potential to teach the international community about climate change processes. Thus, the PETM is used as an example, in ways that have formal similarities with the early modern *magistra vitae topos*. In both Alley and Hansen, the PETM is used as an example in the Platonic sense, as a narrative that can inform humans in making the right decisions, and navigate us away from a disastrous future. Thus, deep geological history provides the authority necessary to authorize the example as an “answer position” similar in both form and function to early modern historical examples. The history again works as an authority to consult. Our analysis shows that practices of arguing by examples have not vanished from the natural sciences. When scientific knowledge is too uncertain, examples may still be used, not as data and models, but to warn and to inform.

The entanglement of human-historical and geological timescales in the Anthropocene facilitates a range of ways of engaging with the past and the future. New ways of understanding the relationship between the past, present and future may occur, but as we have argued in this article, old ways of engaging with the

past might just as well be actualized. Rather than thinking about the history of the notion of historicity as a linear developing process, as Koselleck and Hartog both do, where “the rise of new forms of engagement with the past implies the fall of all that came before”, we argue in line with the historian Judith Pollmann, that it is more productive to regard it as “a cumulative process” (Pollmann 2017: 72).

The four publications on the PETM show that different ways of engaging with the past exist side by side in the Anthropocene. The climate crisis and the emergence of the Anthropocene as a geological epoch has added a geological layer of not only time, but also of Earth history, to human timescales and historicity. While presentism might characterize a number of societal fields, as Hartog convincingly has shown, the notion of the Anthropocene opens up a more ambivalent conception of historicity. On one hand, the Anthropocene epoch is completely different from before, a no-analogue state, with humans cast as a geological force. On the other hand, as geological time, the Anthropocene points to the similarity between the present and the deep past, thereby opening up to comparison with past geological events. One implication is that since humans make up the threat, the PETM provides a moral lesson as well as a scientific one. Thus, the Anthropocene is not so completely different from the PETM after all. Just a little bigger, a lot faster, and a lot scarier to humans.

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