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The Anthropocene Event as a Cultural Zeitgeist in the Earth-Human Ecosystem

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Abstract

In 2000-2002 a climate scientist and limnologist recommended that the Anthropocene become a human-influenced Geological Time Scale addition. In 2009 an Anthropocene Working Group was mandated by the International Commission on Stratigraphy's Subcommission of Quaternary Stratigraphy to investigate it. Developments unfolded in several phases. In 2015 as Future Earth announced an acceleration of Earth System and socioeconomic trends since the mid-20th century, the Working Group anticipated that mid-20th century atomic bomb testing fallout would define the base of a new Anthropocene epoch, an approach it affirmed in 2019. During 2022-2023 it coordinated a search for an optimal Global Boundary Stratotype Section and Point and another group of geoscientists announced a different Anthropocene definition focused on the intensifying impacts of humanity on environments and climates since the Late Pleistocene. In March 2024 the Working Group's proposal was declined by the Subcommission, a decision ratified by both the Commission and International Union of Geological Sciences. Manifesting the pure to applied transformation of the geoscience profession with its commitment to ethical approaches, the Anthropocene Event's dovetailed geological, archaeological and historical realities offer a stimulus for an Earth-human ecosystem mindset, a zeitgeist integrating nature and humanity, and governance of the polycrisis with new partnerships.

Keywords: Applied geoscience; Earth-Human Ecosystem; Anthropocene Event; Cultural zeitgeist; Earth governance

1. Prologue

The Anthropocene, an Earth System concept proposed in 2000-2002 [Crutzen and Stoermer 2000; Crutzen 2002], gained traction in 2009 when the Anthropocene Working Group (AWG) was mandated by the Subcommission on Quaternary Stratigraphy (SQS) and International Commission on Stratigraphy (ICS) to investigate it [Zalasiewicz et al., 2017]. In 2015 the AWG anticipated a mid-20th century Anthropocene epoch/series with a fixed base defined by atomic bomb testing fallout [Waters et al., 2015]. Confirmed as its only goal in 2019 [Subcommission on Quaternary Stratigraphy, 2019] and with multidisciplinary interest in the Anthropocene concept growing, the AWG then considered 12 potential Global Boundary Stratotype Section and Point (GSSP) sites [Waters et al., 2023]. Its choice of a varved sequence in Crawford Lake, near Toronto, Canada was a major news story [e.g. Mitchell 2023]. International coverage surged again in March 2024 when the SQS declined the AWG's proposal, a decision soon ratified by the ICS and International Union of Geological Sciences (IUGS)[1]. The already proposed and differently intended Anthropocene Event definition [Gibbard et al., 2022a] removes the problem that would have occurred if the Anthropocene had been formally defined as the AWG proposed by encompassing humanity's adverse environmental and climate impacts since the Late Pleistocene to provide a holistic framework for a new global zeitgeist in an Earth-human ecosystem context. In the same vein, Henderson and Vachula [2024] concluded: "We urge reconsideration of geologically rigid definitions (of the Anthropocene) in the spirit of recognizing holistic identification of human impacts to the Earth System, while also addressing the gaps in global influence with this pressing concept."

With geoscience as the progenitor of the Anthropocene concept and because now is a critical juncture in Earth history, our context is the pure to applied transformation of geoscience. With a geoethical stance, we offer a synthesis of its development as a vital geoscience-and-society movement. Surely more than ever, our profession

[1] https://www.iugs.org/_files/ugd/f1fc07_ebe2e2b94c35491c8efe570cd2c5a1bf.pdf (accessed 30 March 2024).

should maximally leverage its insights about once pristine environments everywhere, climate and sea-level changes, biodiversity loss and ecosystem disruptions, natural hazards, finite energy and mineral resources, and in particular natural versus human-caused rates of change. We anticipate that the dimensions of the Anthropocene journey with enduring relevance will include its discontinuity from traditional Geological Time Scale (GTS) considerations, responsibility to reflect on the fast growing spectrum of related professional, public and news opinions, moral imperative to cease unemotive mingling of atomic bomb test legacies with geoscientific advances, and obligation to splice its knowledge with Earth System planning efforts via concerted approaches to transdisciplinarity and citizen science. Because of how pervasively Crutzen and Stoermer [2000] and Crutzen [2002] stimulated research and opinions about the Anthropocene during the last 15 years, we recall, as a foundation to our synthesis, what they did say to clarify what they did not say when launching the concept.

2. Transforming science

James Hutton (1726-1797) — lauded as the discoverer of deep time [Fisher, 2023] — framed his 'present is the key to the past' theory of uniformitarianism with this haunting statement: "This globe of the earth is a habitable world, and on its fitness for this purpose, our sense of wisdom in its formation must depend… the result, therefore, of our present inquiry is that we find no vestige of a beginning, no prospect of an end" [Hutton, 2010]. While research into 'a beginning' thrives in astrophysics, imagination with a geological outlook about 'an end' — or at least a post-human end — made Zalasiewicz [2008] and Gormley [2021] rare voices. However, a decade before the Anthropocene concept emerged, a multidisciplinary assessment entitled *Planet under Stress* began with this declaration: "The human being is an animal that has moved out of ecological balance with its environment… We are now faced with a task that is more difficult than anything ever contemplated: to decide how we may continue to live on this small planet" [McLaren, 1990].
Stephen Jay Gould (1941-2002) — "a paleontologist, evolutionary biologist, and historian of science (who was) one of the most influential and widely read authors of popular science of his generation"[2] — assessed that "most working scientists are notorious for their lack of interest in history" [Gould, 1987]. Similarly, Stanley Schumm (1927-2011) — "a leading force in transforming geomorphology from a descriptive science to a dynamic quantitative science" [Ethridge et al., 2012] — considered that

[2] https://en.wikipedia.org/wiki/Stephen_Jay_Gould (accessed 1 October 2023).

"most earth scientists do not find philosophical discussions of their field very interesting" [Schumm, 1991]. These views emphasize the extent to which geology — in its classic sense, defined straightforwardly as the scientific study of the Earth — has transformed from a pure discipline to an applied discipline at the frontline of the world's 21st century needs. Here, the pure and applied qualifiers are used in the sense described by the Encyclopedia of Science, Technology, and Ethics [2023].

Schumm [1991] pointed out that in 1972 the purpose of the American Geological Institute (AGI) was "the explanation of present conditions and the interpretation of history". The succeeding AGI stated in 2023 that it "represents the geoscience community by providing collaborative leadership and information to connect Earth, science and people" with a vision "of a world that understands and trusts the role of the geosciences in fostering creative solutions for the Earth and humanity"[3]. In the United Kingdom, today's mission of The Geological Society of London (GSL) is "to connect science, the profession and society" with a vision that includes "addressing global challenges"[4]. In its umbrella role, the IUGS "aims to promote development of the Earth sciences through the support of broad-based scientific studies relevant to the entire Earth system; to apply the results of these and other studies to preserving Earth's natural environment, using all natural resources wisely and improving the prosperity of nations and the quality of human life; and to strengthen public awareness of geology and advance geological education in the widest sense"[5].

The journal *Earth's Future* was launched by the American Geophysical Union (AGU) in 2013. Clearly, today's more nuanced geoscience profession has experienced several connected trends, primarily a focus on the geological present, stewardship of the human-altered planet, and a holistic view of the Earth System. In steps just two decades apart, the Anthropocene concept has been a major influence on the ethos and profile of geoscience. First came, as this century began, the urging by an atmospheric scientist and limnologist that geoscience and engineering focus on humanity's disruption of the Earth's atmosphere and environments. Then came a 4 March 2024 decision by the SQS, promptly ratified by the ICS and executive committee of the IUGS, that the Anthropocene not be defined as an epoch since the mid-20th century as proposed by the AWG. The *de facto* outcome was that a preceding concept to define the Anthropocene as a diachronous and ongoing event comprising humanity's disruption of climates, environments and ecosystems since the Late Pleistocene became the new and widely beneficial vanguard of Earth history. Spanning those milestones came the United Nations' (UN) 2000-2015 *Millennium*

[3] https://www.americangeosciences.org/strategy-for-the-future/ (accessed 1 October 2023).

[4] https://www.geolsoc.org.uk/About/Strategy-and-Values (accessed 1 October 2023).

[5] https://www.iugs.org/history (accessed 30 March 2024).

Development Plan with eight goals[6]; the concept of nine operating limits for humanity [Rockström et al., 2009]; the *Great Acceleration* synthesis of the International Geosphere-Biosphere Programme (IGBP) comprising 12 Earth System trends and 12 socio-economic trends intensifying since the mid-20th century [Future Earth, 2015]; and the UN's 2015-2030 *Transforming our World* plan with 17 Sustainable Development Goals[7] [United Nations, 2015]. An anthropologist offered this reflection: "The complex set of human-driven global, social, technological, and environmental changes intensifying dramatically since 1950… represents a radical shift in our collective relationship to each other as well as to the Earth system as a whole" [Shoshitaishvili, 2021]. Among the most comprehensive news profiles on the developing Anthropocene concept, one which also aired the definitional controversy and included an illustrated online resource, was that by Zhong [2022].

3. "The Earth in Our Hands"

Before the Anthropocene concept, GTS matters seldom attracted attention outside the geoscience profession. Exceptions were the Jurassic and Cretaceous: named in the 1820s, they became familiar words in the 1990s when commercial film makers seized the box office draw of dinosaur-themed science fiction. By providing an evidence-based framework for the Earth's natural history — the evolution of biodiversity and ecosystems, the changing geography of continents and oceans, the geography and causes of natural hazards, the origins and distribution of energy and mineral resources — the GTS provides geoscience with its organizational spine. The Anthropocene is, however, utterly different from all pre-human chapters in the Earth's history. In the view of Edgeworth et al. [2019], chronostratigraphic principles developed for the classification and division of ancient strata are unsuitable for use in archaeological and historical timescales. Finney and Edwards [2016] had already opined that "most articles on the Anthropocene misrepresent the nature of the units of the International Chronostratigraphic Chart, which is produced by the International Commission on Stratigraphy and serves as the basis for the geologic time scale". Subsequent articles, including Edgeworth et al. [2023], Gibbard et al. [2022b], Walker et al. [2023], and Swindles et al. [2023], reinforced this position: the AWG refuted their conclusion [Zalasiewicz et al., 2023].

Following the AWG's start in 2009, editorials in The Economist[8] and *The New York Times*[9] announced the Anthropocene as shorthand for humanity's environmental

[6] https://www.un.org/millenniumgoals/bkgd.shtml (accessed 1 December 2023).

[7] https://sdgs.un.org/2030agenda (accessed 1 December 2023).

[8] https://www.economist.com/leaders/2011/05/26/welcome-to-the-anthropocene (accessed 1 December 2023).

disruptions and Koster [2011] positioned it as an opportunity to advance the unique relevance of geology to societal and environmental needs. Moore [2015] reported: "The Anthropocene is everywhere in academia. There are Anthropocene journals, Anthropocene courses, Anthropocene conferences, Anthropocene panels, Anthropocene podcasts, and more. It is very safe to say that the Anthropocene is having a moment. But is this just a case of fifteen minutes of fame, name recognition, and bandwagon-style publishing? The authors in this issue of ARES think not". By 2016 published scientific articles on the Anthropocene approached 500 per year [Mahli, 2017]. Additionally, public exhibitions and films about the Anthropocene became widely popular [Möllers et al., 2015; Hill 2020; Isager et al., 2021].

The pioneering *Welcome to the Anthropocene: The Earth in Our Hands exhibition* (Figure 1) was at the Deutsches Museum in Munich, Germany, from 5 December 2014 to 30 September 2016[10]. Rated a breakthrough by the Museum, the purpose as described by its Director-General was "to shape how this pressing topic [the Anthropocene] is thought about in the future" [Hechl, 2015]. Opened five years after the AWG formed, it was surprising that it did not include any stratigraphic considerations. The exhibition was about utilizing and altering the environment through agriculture, trade, transportation and industry. An independent critique by history of technology and the environment staff at two Swedish universities considered that "it offers a relatively benign vision of a changing planet. The change is not pictured as threatening, in spite of being rapid. The exhibit says 'Welcome to the Anthropocene, not Goodbye to the World You Knew' [Jørgensen and Jørgensen, 2016].

It is interesting to note that both humility and hubris were among the early emotional responses to the Anthropocene idea [Mittman, 2018; Schwennesen, 2020]. Boivin et al. [2024] summarized what they viewed as the beneficial consequences of the AWG's epoch proposal being rejected: "… a wealth of opportunities to expand our views on the Anthropocene… the wide cultural currency of the term Anthropocene… a clearer understanding of the links between human action and environmental change [and] the global inequities that lie at the heart of these dynamics": we concur with these sentiments. Growth indicators of the Anthropocene concept have been the array of scholars with opinions on its meaning (Table 1) and the volume of related concerns by the public (Table 2).

[9] https://www.nytimes.com/2011/02/28/opinion/28mon4.html (accessed 1 December 2023).

[10] The first author of this paper participated in an invited tour and discussion.

Figure 1. *The iconic image of the exhibition Welcome to the Anthropocene: The Earth in Our Hands at the Deutsches Museum (https://www.carsoncenter.uni-muenchen.de/events_conf_seminars/exhibitions/anthropocene/index.html - accessed 1 December 2023) in collaboration with the Rachel Carson Center for Environment and Society as well as for its digital companion [Möllers 2014].*

"The Anthropocene represents a new phase in both humankind and of the Earth, when natural forces and human forces become intertwined, so that the future of one determines the fate of the other" [Zalasiewicz et al., 2010].

"Is the Anthropocene a specific subdivision in the continuum of time, or is it a holistic concept that includes time but is not defined by it? Which decision will serve us best?" [Edwards, 2015].

"The concept of planetary health is based on the understanding that human health and human civilization depend on flourishing natural systems and the wise stewardship of those natural systems. However, natural systems are being degraded to an extent unprecedented in human history" [Whitmee et al., 2015].

"… the geological discussion, while vital, is not nearly as important as the wider discourse that has emerged around the word and its implications… Reflecting on all that has passed and is to come, I see the prospect of slow but substantial and productive shifts in the human enterprise" [Revkin, 2016].

"The Anthropocene is a key theme in contemporary speculations about the meaning of the present and the possibilities for the future… How the Anthropocene is interpreted, and who gets to invoke which framing of the new human age… matters greatly for both the planet and for particular parts of humanity" [Dalby, 2016].

"… until recently, I had not met an alternative concept that would redefine spatial and time coordinates as well as the right type of agency… This is what the definition of the Anthropocene could do: it gives another definition of time, it describes what it is to stand in space, and it reshuffles what it means to be entangled with animated agencies [Latour, 2017].

"Unlike prior intervals of geological time, the proposal to mark the interval in which humans have become a 'great force of nature' has exploded across the scholarly world and beyond" [Ellis, 2018].

"The consequences of human actions are not the coordinated synchronous product of a global humanity but rather result from heterogeneous activities rooted in situated sociopolitical contexts that are entangled with environmental transformations at multiple scales" [Bauer and Ellis, 2018].

"A subtler point for geologists is that the idea of the Anthropocene represents a fundamental break with the philosophical underpinnings of the field, established by Hutton and Lyell... the exact start of the Anthropocene matters less than the idea behind it" [Bjornerud, 2018].

"The Anthropocene discussion focuses attention on a fundamentally Humboldtian observation: humanity and nature are deeply intertwined… nature would persist in the absence of humanity, but humanity cannot exist without nature" [Jackson, 2019].

"In our period, the grand challenges are encountered in their aftermath... We can no longer categorically segregate culture from nature but must face the fact that these spheres are inescapably mingled" [Renn 2020]. "… by not acknowledging the ontologies, philosophies and cultural histories of non-Western people, the Anthropocene in the museum is at risk of becoming a colonizing concept that should be rejected" [Isager et al., 2020].

"With every degree of temperature increase, roughly a billion people will be pushed outside the zone in which humans have lived for thousands of years… Migration is not the problem; it is the solution" [Vince, 2022].

"For people working in philosophy and literary criticism, in the arts, in the humanities, the sciences, I think it's [the Anthropocene Event] far more meaningful… than any attempts by stratigraphers could have made to restrict or define it in some narrow sense" (Jacquelyn Gill quoted in Adam [2024]).

"Many people in the humanities who are using the [the Anthropocene Event] phrase find… the articulation of a particular year, based on a deposit in a particular lake, a ridiculous way of framing the concept of a human-altered planet" (Chris Thomas quoted in Adam [2024]).

"The wide cultural currency of the term Anthropocene offers a rich opportunity to engage a global audience with issues that are relevant to all of us" [Boivin et al., 2024].

Table 1. A chronological selection of geological and other disciplinary opinions about the significance of the Anthropocene concept since the AWG was formed.

"Given that it appears that our own era might be rather short, we probably need to get on with naming it before the onset of our own extinction."

"The key question is not did we change things and when, but what will the next few centuries/millennia look like as a result of our actions and what can we do to minimize adverse consequences."

"Humans with their big brains and big egos have a fatal flaw. They have escaped natural interaction with the Earth. We have insulated ourselves from the natural process of interdependency with nature that historically had balanced any population."

"Nature is dying at our hands. Our beautiful blue Earth is in the intensive care unit, mostly past the point of being saved, due to the stubborn failure of humans to admit that we are the most destructive force to hit the planet since the asteroid destroyed the dinosaurs."as we possibly can."
"I like the suggestion to refer to what we're doing as an 'event' and not classify it as a geologic period, whether age or epoch. We are simply too close to the onset, and the changes are coming too fast and too furious to know how long we'll be lasting in this mode… A little-noticed problem with wide adoption and formalization of 'Anthropocene' as an epoch is an unintended flattering of our species' vanity, and a bolstering of our complacency. Telling ourselves that our current mode of choices is a geologic age just solidifies the ethos we need to overcome. Better to recognize our situation as The Anthropic Event. It's a more behavioral classification, which is more accurate, and more amenable to turnaround and recovery."
"We are in this mode as part of an ethos of dominance and control over nature and we are not going to survive this mode without changing that ethos to one of felt connection with and lived reverence toward the more than human world."
"Looking at the grand sweep of this history, the evolution of life on this planet, the organization of sentience in the human mind, the emergence of the complex forms of consciousness, awareness and self-conceptions, it's so painful to look at what we have done with the genius of our species."
"I love my family and friends and acknowledge the many amazing and beautiful things humans have created and achieved, but considering the toll of our brutality, hate and destruction of the earth and every being on it for millennia, maybe the human race has run its course."
"All this talk about 'rocks' seems quaint, and perversely academic—an intellectual enclave for a handful of persons who fetishize rigor over urgency."
"… If we consider the entire planet as one big living organism, this species, the human species, is like a cancer that is killing the current ecosystem."
"We don't know how our end will come, but we seem to be trying our hardest to meet it as soon as we possibly can."

Table 2. A sample from almost 300 online comments by readers of 'For Planet Earth, this might be the start of a new age' in The New York Times [Zhong, 2022].

4. Crutzen's contribution revisited

Paul Crutzen (1933-2021), Mario Molina (1943-2020) and Frank Rowland (1927-2012) were awarded the Nobel Prize in 1995 for their work on atmospheric chemistry and specifically for efforts in studying the formation and decomposition of the atmospheric ozone. In *The New York Times*, climate activist and former US vice-president Al Gore remarked that "his life's work continues to inspire us to take responsibility for how that force affects our planet's ecological integrity" [Shwartz, 2021]. Authors of his obituary in the *Bulletin of the American Meteorological Society*

[Fishman et al., 2023] referred to a book entitled *Health of People, Health of Planet and Our Responsibility* [Al-Delaimy et al., 2020] which surmised: "the well-being of humans and the integrity of our environment are closely coupled, as expressed by the term 'planetary health'" and "the integration of scientific knowledge with societal considerations will help to solve the challenges and grasp the opportunities of the Anthropocene for the well-being of humanity, now and for future generations". The obituary in *Nature* included a little-known fact — one relevant to a later section of this paper — that Crutzen was "the first to warn of the possibility of what came to be known as nuclear winter" [Lelieveld, 2021].

Interviewed about the origin of his interest in the Anthropocene, Crutzen recalled: "At an Intergovernmental Geosphere Biosphere Program (IGBP) in Mexico in the year 2000… the chairman mentioned the Holocene again and again as our current geological epoch. After hearing that term many times, I lost my temper, interrupted the speaker, and remarked that we are no longer in the Holocene. I said that we were already in the 'Anthropocene'. My remark had a major impact on the audience… After my talk I looked to see whether the term Anthropocene had been used before. Indeed it had, by a limnologist of the University of Michigan, Eugene F. Stoermer... I came up with the idea independently and I think that my impetus made it possible for the Anthropocene idea to take off in the public and scientific arenas. I contacted Stoermer and we published a paper together in the IGBP Newsletter" [Schwägerl, 2013].

Asked whether the Anthropocene idea was purely a scientific hypothesis or was it more, Paul Crutzen projected that the Anthropocene "develops into a metaphor about the relationship between nature and humankind" and assessed that "it is not a single entity… but a huge variety of possibilities that cannot be ranked" [Schwägerl, 2015]. Asked about whether scientists and engineers have a central role in solving humankind's problems, Paul Crutzen responded: "Ultimately politicians will have to make some bold decisions to change course. Scientists and engineers can help but their real power lies in making positive innovations possible, not in decision making... The Anthropocene idea is now animating many people in many places in new ways" [Schwägerl, 2015].

We respectfully differ from Jan Zalasiewicz in his Anthropocene Curriculum interview[11] that "Right from the very beginning, from Paul Crutzen's improvisation of the term or concept, the Anthropocene was never meant to capture the full range, extent, and history of human impacts". It was after all Crutzen and Stoermer [2000] who predicted that "To develop a world-wide accepted strategy leading to

[11] https://www.anthropocene-curriculum.org/contribution/conversation-with-jan-zalasiewicz (accessed 1 December 2023).

sustainability of ecosystems against human induced stresses will be one of the great future tasks of mankind" and Crutzen [2002] who anticipated that "a daunting task lay ahead for scientists and engineers to guide society" with "appropriate human behavior at all scales… in *terra incognita*". Notwithstanding these expressed needs, the AWG surprisingly pursued its SQS mandate [Zalasiewicz et al., 2018] with sole consideration of chronostratigraphic criteria [Zalasiewicz et al., 2008; 2011] and a concerted reliance on mid-20th century atomic bomb testing fallout [Working Group on the Anthropocene, 2019; Koster, 2023a].

Looking back, the Anthropocene concept began as a spontaneous Earth System-scale emotion by a non-geologist who immediately and importantly urged that scientists leverage it to help address humanity's mounting climatic and environmental impacts. However, the concept was pursued assiduously only in a chronostratigraphic context during a period in which, arguably, geoscience as a whole should have been proactive with its knowledge about the deteriorating state of the Earth. Herein lies the topical value of the Anthropocene Event approach as a holistic platform for new science-and-society thinking and action. Profoundly, this approach facilitates geology, archaeology, anthropology, prehistory, history and sociology being a seamless continuum of perspectives about the development of *Homo sapiens* as the sole surviving and remarkably influential member of the human family [Wong, 2018; Waring et al., 2023].

5. Anthropocene Event

Focused on the Anthropocene, Robin and Steffen [2007] noted that global history had become the business of more than just historians. The AWG began accordingly. Its first chair recalled: "it seemed sensible to take on board archaeologists, historians, and even an international lawyer, to look at the wider implications of the kind of work that was being done… I think the business of establishing these transdisciplinary kinds of understanding have given the [AWG] a sense of inspiration which has been quite unique — at least within geology — and has helped enormously the work of the group"[12]. We concur with that intent but following developments cast doubt over its results. Challenges surfaced as published opinions, including Edgeworth et al. [2019], Finney and Gibbard [2023] and Walker et al. [2023], and as resignations from three (following two previously) AWG members. Ellis [2023] opined: "Dividing Earth's human transformation into two

[12] https://www.anthropocene-curriculum.org/contribution/conversation-with-jan-zalasiewicz (accessed 1 December 2023).

parts, pre- and post-1950, does real damage by denying the deeper history and the ultimate causes of Earth's unfolding social-environmental crisis… Choosing to systematically ignore the overwhelming evidence of Earth's long-term anthropogenic transformation isn't just bad science, it is bad for public understanding of the causes of these changes and for action to address them".

The International Association for Promoting Geoethics (IAPG)[13] calls upon research about human activities interacting with the Earth System to be mindful of appropriate behaviors and practices. Apropos, the Anthropocene Event (Figure 2) spans the Late Pleistocene Subepoch and the entire Holocene Epoch of the ongoing Quaternary Period with the human species continuing to disrupt the natural workings of the Earth's atmosphere, hydrosphere, cryosphere, biosphere and surface and near-surface environments as summarized by Koster [2021; 2022].

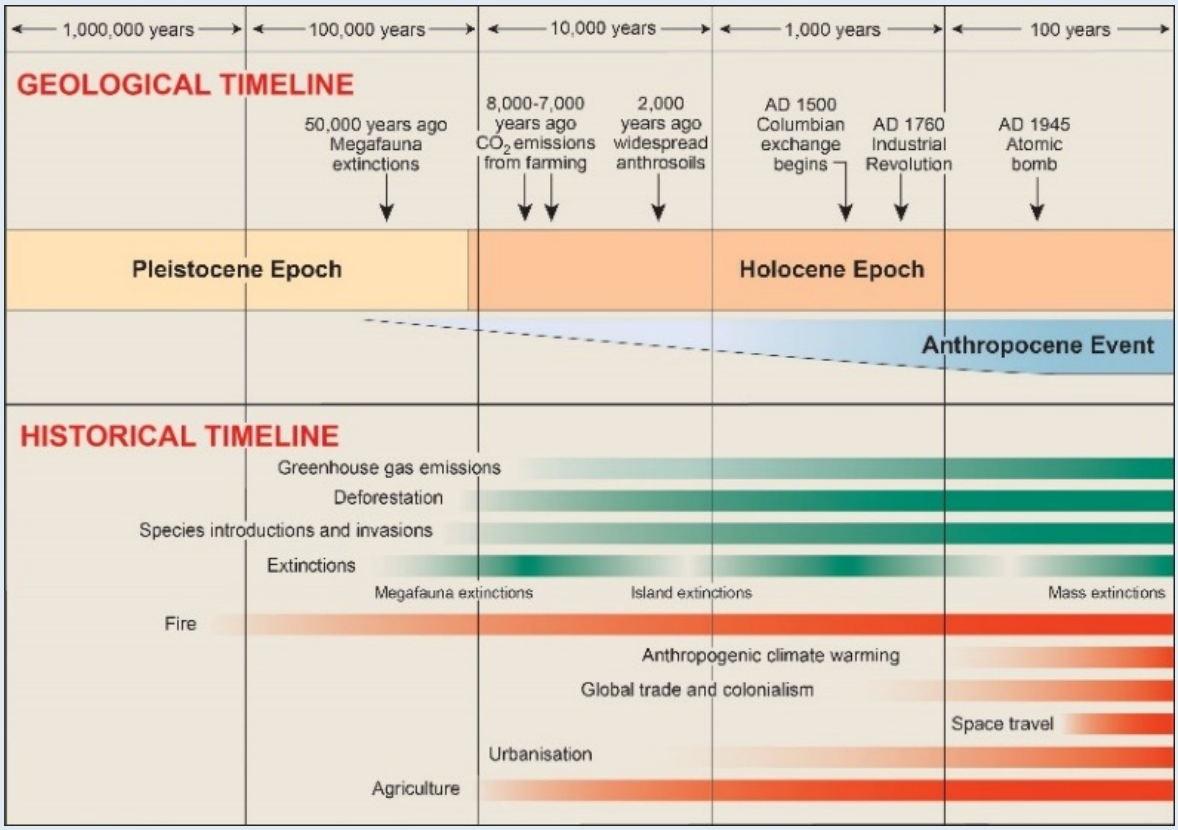

Figure 2. *The Anthropocene Event with its geological and historic contexts [Koster et al., 2023].*

[13] https://www.geoethics.org (accessed 22 June 2023).

Evidence that people have shaped most of terrestrial nature for at least 12,000 years was presented by Ellis et al. [2021] with the increasing impacts of agricultural, irrigation, engineering and technological activities on rivers chronicled by Gibling [2021]. Walker et al. [2023] concluded: "the idea that human impact on the Earth system can be understood in terms of an effectively instantaneous transition from the Holocene Series/Epoch to an Anthropocene series/epoch specifiable to a moment in time in the mid-20th century ignores the time-transgressive transformative complexity and progressively amplified development that is evident in the material records. When this stratigraphical and other evidence are analysed objectively and without imposing a rigid chronostratigraphical framework, the picture emerges of a much more diachronous set of transformations, speeding up significantly in the 20th and 21st centuries, and that are most appropriately characterized as an unfolding and intensifying Anthropocene Event."

The AWG's epoch view at the Fourth International Conference on Stratigraphy (STRATI) in Lille, France on 11-13 July 2023 was revelatory. Its five presentations included understanding event stratigraphy in the context of chronostratigraphy and the signature of the acceleration in the varved succession of Crawford Lake[14] with its implications for the Anthropocene as a series/epoch. In *The Washington Post* [Kaplan et al., 2023], Francine McCarthy who led the Crawford Lake research team remarked: "The Earth itself is playing by a different rule book. And it's because of us" with Jacquelyn Gill of the University of Maine clarifying that "Formalizing the Anthropocene creates a hard and bright line, and you either exist on one side or the other. But really, it's been a long gradient, a long process of changing how we live". In *Nature*, Zoe Todd, an anthropologist with Métis ancestry, observed that "European scientists seem to be quite captivated that this time period starts very recently. For Indigenous and other displaced and dispossessed peoples who were impacted by massive forms of violence that characterize the last 600 years, everything that leads up to what makes this global shift starts much earlier" [Witze, 2023]. In their reports on the AWG's epoch proposal, *The Guardian* quoted Alexander Farnsworth, a global environment researcher, that "We are but a ripple in the river of gene flow through time" [Carrington, 2023] and *The New York Times* ended its update with a summary of the ongoing definitional dispute [Zhong, 2023].

The sensational tendency of epoch-cancelled news headlines from the 4 March 2024 decision [e.g., Kaplan, 2024] likely made the Anthropocene term more widely known, perhaps also with a sense that it is no longer a useful term [e.g., Adam, 2024]. A *Nature* editorial alleged that "News of the vote, and the ensuing controversy,

[14] https://globe2go.pressreader.com/article/281706914147384 (accessed 12 July 2023).

has created both confusion and concern"[15] and a former SQS chair remarked that "the IUGS ruling means that the Anthropocene will confusingly continue to represent widely different concepts" [Carrington, 2024]. But quite the reverse — that the Anthropocene Event has become a topically meaningful term well suited to unified knowledge [Christian, 2019] — now needs to be widely grasped. As Finney and Gibbard [2023] pointed out, "the Anthropocene Event needs no GSSP, it needs no start date; it needs no approval, nor does it require ratification by ICS and IUGS. It leaves the door open and extends the welcome mat to all disciplines in the sciences and humanities." Boivin et al. [2024], among others, promptly pointed out the advantages of this approach. In hindsight, it is also interesting to recall that Brannen [2019], opining for an influential magazine, likened human civilization to a geologic event, not an epoch.

Already from two big-picture perspectives, the Anthropocene Event looms as a breakthrough science-and-society opportunity. The first builds upon the view of the president-elect of the International Sci[e]nce Council (ISC) with her integrated vision of an "Earth-Human system"[16]. The second builds upon the outlook of Mahli [2017], an ecosystem scientist at the University of Oxford, that "the Anthropocene has spilled out of its natural sciences origins to become a cultural zeitgeist… about how to understand and respond to human domination of the Earth". In turn, these are enveloped by a cultural barrier and a global breakthrough. The barrier is a detachment of Western cultures from their cumulative damage to climates and environments[17]. Cajete [2000] pointed out that "Western and Native science traditions are very different in terms of the ways in which people come to know, the ways in which knowledge or understanding is shared, how knowledge is transferred from one generation to another, and how knowledge is handled legally, economically, and spiritually". The breakthrough is a prominent public endorsement[18] of the above-noted concept of nine operating limits for humanity, six of which have already been surpassed [Richardson et al., 2023].

[15] https://www.nature.com/articles/d41586-024-00815-0 (accessed 20 March 2024).

[16] https://council.science/current/blog/integrated-science-understanding-the-earth-human-system/ (accessed 1 December 2023).

[17] https://www.unicef.org/stories/young-climate-activists-demand-action-inspire-hope (accessed 30 March 2024).

[18] https://time.com/collection/100-most-influential-people-2023/6269887/johan-rockstrom/ (accessed 1 December 2023).

6. Uncoupling geoscience from nuclear warfare

Accentuated by the OSCAR winning 2023 film *Oppenheimer*[19], much of the world remains familiar with the horrifying images of mushroom clouds and mass annihilation from World War II and the Cold War and is newly fearful of nuclear warfare scenarios. To be clear, the purpose of this section is not to question the correlatory precision of quasi-isochronous fallout of radionuclides from mostly mid-20th century atomic bomb tests (over 2,000 were carried out around the world, 1,032 of them by the USA). The essential point of this section is as follows.

If a stratigraphic Anthropocene proposal with a basal boundary GSSP centered on mid-20th century atomic bomb tests never resurfaces, the ethical concern voiced in this section of our paper becomes moot. However, because nuclear warfare began more than three generations ago, because the AWG relied on the remains of atomic bomb tests as the core of its evidence — but we note never also on the use of atomic bombs — and because of today's fears about a new nuclear age [*The New York Times,* 2024], we feel compelled to recount for the record what transpired in terms of some geoscientific research and nuclear warfare developments becoming comingled. Because unemotive mentions of a historical event with a horrendous impact may be construed as an indifferent attitude, we earnestly recap the following pertinent facts:

- 16 July 1945, New Mexico, USA | The United States conducted the first test detonation of a nuclear weapon at its Army Trinity Test Site at Los Alamos[20].
- 6 and 9 August 1945, Japan | The United States dropped atomic bombs on Hiroshima and Nagasaki killing an estimated 145,000 and 78,000 people[21]. As Setsuko Thurlow, a survivor from Hiroshima, implored when accepting a Nobel Peace Prize in 2017, "Each person had a name. Each person was loved by someone. Let us ensure their lives were not in vain"[22].
- December 1945 | "Founded in 1945 by Albert Einstein and the University of Chicago scientists who helped develop the first atomic weapons in the Manhattan Project, the *Bulletin of the Atomic Scientists* created the Doomsday Clock two years later… to convey threats to humanity and the planet… [it] is set every year by the Bulletin's Science and Security Committee in consultation with its Board of Sponsors which includes 10 Nobel laureates. The Clock has become a universally recognized indicator of the world's vulnerability to global

[19] https://en.wikipedia.org/wiki/Oppenheimer_(film) (accessed 1 September 2023).

[20] https://podcasts.apple.com/us/podcast/outside-in/id1061222770?i=1000621735834 (accessed 1 December 2023).

[21] https://www.nationalww2museum.org/war/articles/atomic-bomb-hiroshima (accessed 28 July 2023).

[22] https://www.icanw.org/hiroshima_and_nagasaki_bombings (accessed 18 August 2023).

catastrophe caused by manmade technologies" [Mecklin, 2023].

- 24 January 1946, London, United Kingdom | "The United Nations General Assembly adopted by consensus its very first resolution… which established a commission of the UN Security Council to ensure: 1) the control of atomic energy to ensure its use only for peaceful purposes, and 2) the elimin[a]tion from national armaments of atomic weapons and all other major weapons adaptable to mass destruction"[23].
- 15 May 1946, Princeton, New Jersey, USA | Albert Einstein sent a telegram to several hundred American leaders and politicians warning that the "unleashed power of the atom has changed everything save our modes of thinking and we thus drift toward unparalleled catastrophe" [Powell, 1998].
- 1964, New York City, USA | "The world has averted catastrophe; no nuclear weapons have been used in anger since Nagasaki. But four nations have spent $50 billion in amassing nuclear arsenals and in developing a large family of nuclear weapons. Many times this amount of money has been committed to developing and producing the aircraft and missiles for delivering nuclear bombs and warheads. A vast uranium-mining industry has sprung up" [*The New York Times,* 1964].
- 1980 and 1994, Washington, DC, USA | The press office of the US Department of Energy initially issued 'Announced United States Nuclear Tests, July 1945 through December 1979' with the first three listed as the Trinity Test, Hiroshima and Nagasaki, but its edition 14 years later was revised to distinguish the tests from the attacks [Solomon, 2023].
- 2013 | In an interview [Schwägerl, 2013] associated with the 2014-16 exhibition titled *Welcome to the Anthropocene: The Earth in Our Hands* at the Deutsches Museum, Paul Crutzen was asked "what are the key political and economic changes that need to happen for a "Smart Anthropocene"? He answered: "I still think that one of the most important tasks is to abolish or hinder the spread of the 'ABC' weapons: the atomic, biological, and chemical weapons. If that does not happen, they will be used eventually. Together with colleagues I have researched intensively how disastrous a nuclear winter—caused by the large amounts of black smoke produced by the many wartime fires, which block out sunlight—would be. My research findings haunt me".
- January 2015 | "We propose an appropriate boundary level… to be the time of the world's first nuclear bomb explosion, on July 16th 1945 at Alamogordo, New Mexico; additional bombs were detonated at the average rate of one every 9.6 days until 1988 with attendant worldwide fallout easily identifiable in the

[23] https://www.unfoldzero.org/time-to-implement-un-resolution-1-1/ (accessed 1 December 2023).

chemostratigraphic record. Hence, Anthropocene deposits would be those that may include the globally distributed primary artificial radionuclide signal, while also being recognized using a wide range of other stratigraphic criteria [Zalasiewicz et al., 2015].

- 1 May 2015 | The above-noted *Bulletin of the Atomic Scientists* published 'Can nuclear weapons mark the beginning of the Anthropocene Epoch?' [Waters et al., 2015]. They anticipated that "nuclear sciences are likely to be critical to the definition of the Anthropocene… fallout from nuclear weapons testing appears most suitable".
- 16 July 2018, Canberra, Australia | This inaugural, but not continued, public proclamation of *World Anthropocene Day* marked "a moment in the year when humanity reflects on the existential nature of our engagement with the Earth system that sustains us" [Fenner School of the Environment and Society, 2018]. Speakers were from the National Museum of Australia and Australian National University, including Will Steffen (1947-2023) who had been a lead advocate for the Great Acceleration concept [Future Earth, 2015; Steffen et al., 2015].
- 21 May 2019 | Following SQS and ICS guidance, the 34-member AWG completed binding votes to affirm some of the key questions that were voted on and agreed at the 2016 International Geological Congress. These were "Should the Anthropocene be treated as a formal chrono-stratigraphic unit defined by a GSSP?" and "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?" [Subcommission on Quaternary Stratigraphy, 2019].
- 2022 | The AWG considered twelve GSSP sites [Waters et al., 2023]. Given the above-cited paper by Waters et al. [2015] that "a site to define the Anthropocene… would ideally be located between 30 and 60 degrees north of the equator, where fallout is maximal, within undisturbed marine or lake environments", it was unsurprising that a lake in Canada at 43.5°N and a lake in China at 42.2°N were the finalists.
- 20 May 2022, Berlin | Referring to an AWG meeting which he attended online, Koster [2023a] was "surprised by a seemingly unemotive, almost clichéd, use of 'bomb spike' (cf. 'golden spike') in many of the presentations", adding that the AWG "does not consider itself publicly accountable for research decisions and that a link with atomic bomb tests could be helpful to society were dismaying".
- 15 November 2022, Nairobi, Kenya | Referring to an annual meeting of the UNESCO-IGCP *Language of the Anthropocene* Project which he attended online,

Koster et al. [2023] noted: "With frequent reference to plutonium — in marked contrast to the frequent references to atomic bomb tests and bomb spikes at the earlier Berlin meeting — each mid-20th century GSSP proposal had a multi-proxy high-resolution correlation approach". It seemed that the AWG had decided to soften the language of its reliance on nuclear bomb testing.

- 11-13 July 2023, Lille, France | At the Fourth International Conference on Stratigraphy, the ethics of inventions capable of mass destruction were a recurring theme in the news coverage, including CBC News [Chung, 2023] and *The Guardian* [Carrington, 2023]. In *The New York Times*, Zhong [2023] noted that "using nuclear bombs to mark a geologic interval strikes some scientists as abhorrent, or at least beside the point": he quoted Erle Ellis that "Radionuclides are a convenient global marker, but they say nothing about climate change or other human effects".

Immerwahr [2022] surmised: "We cannot drive nuclear war to extinction by ignoring it. Instead, we must dismantle arsenals, strengthen treaties and reinforce nuclear norms. Right now, we're doing the opposite". Our contention is that it would be morally desirable for geoscience to play its part on the grounds that safeguarding human health is not responsibly divorced from safeguarding environmental health as Whitmee et al. [2015] emphasized. A global study by Prăvălie [2014] provided this poignant warning from another frontier of scientific research: "The indirect transfer of radionuclides into the geospheres and their accumulation in living cells, by way of the food chain, was yet another form of radioactive contamination of the marine and terrestrial ecosystems… In terms of human exposure, the increase in the thyroidal cancer incidence in many areas of the globe (strongly affected by the radioactive contamination with the ^{131}I radionuclide) is the one among the worst consequences of nuclear testing".

In refuting the seven challenges by Finney [2014] to the AWG's approach, Zalasiewicz et al. [2023] countered that the Anthropocene was "conceptualized prior to the search for its chronostratigraphic definition". Indeed, intervals differentiated within the GTS have typically arisen from stratigraphic evidence exhaustively debated in accordance with established practices. The AWG's recommendation appears however to have arisen, six years after the SQS launched the AWG, as a fait accompli centered on the legacy of humanity's most abhorrent invention. 2015 was when the Great Acceleration concept was defined with its mid-20th century start and when the AWG's most recent chair projected in the Journal of the Atomic Scientists [Waters et al., 2015] that the Anthropocene's GSSP would be centered on the fallout of radionuclides from mid-20th century atomic bomb tests. In this regard, we are intrigued by psychological research into competing in-group and out-group

behaviors when one group believes it is exceptional and deserves special treatment [Cislak and Cichocka, 2023].

Writing for the American Association for the Advancement of Science, David Cassidy, author of *J. Robert Oppenheimer and the American Century*, opined: "I think it's important for the public to be reminded often of what massive nuclear destruction really entails, especially so today when the potential for nuclear war is greater than at almost any time in the past" [Boyer, 2023]. Presently, nine countries possess nuclear weapons — China, France, India, Israel, North Korea, Pakistan, Russia, the United Kingdom, and the United States. "Together, these states have 12,700 nuclear warheads, of which 9,400 are in active military stockpiles…While this is a significant decline from the approximately 70,000 warheads owned by the nuclear-armed states during the Cold War, nuclear arsenals are expected to grow over the coming decade and today's forces are vastly more capable"[24]. "The US and Russian arsenals eclipse all others, with roughly 90% of the world's nuclear warheads between them" [Global Zero, 2023].

To close this section, we echo an evocative assessment by a Commonwealth scholar at the University of Cambridge who became a lecturer at Australia's RMIT University: "The atomic bomb created the conditions of contingent catastrophe, forever placing the world on the precipice of existential doom. But in doing so, it created a philosophy of acceptable cruelty, worthy extinction, legitimate extermination. The scenarios for such programs of existential realisation proved endless. Entire departments, schools of thought, and think tanks were dedicated to the absurdly criminal notion that atomic warfare could be tenable for the mere reason that someone (or some people) might survive. Despite the relentless march of civil society against nuclear weapons, such insidious thinking persists with a certain obstinate lunacy" [Kampmark, 2023].

7. Approaches for progress

Actualizing the Anthropocene Event behooves its researchers to know about and ideally apply some proven approaches for optimizing individual and group behavior. Overall, anthropological psychology finds that the best way for the public to grasp science-and-society challenges is learning what science has discovered, why it matters and what remains to be learned, rather than attempts at persuasion with science-says-fill-in-the-blank styled exhortations [Kendall-Taylor, 2023]. This section profiles four approaches. In the Anthropocene, 'science' ideally hinges on an

[24] https://www.icanw.org/nuclear_arsenals (accessed 18 August 2023).

amalgam of geology, anthropology and social psychology and 'society' ideally embraces the principles and practices of diversity, equity, accessibility and inclusion. As an example, Lövbrand et al. [2015] positioned the social sciences as an asset to expansive Anthropocene thinking.

7a. Mindsets

Mindsets are patterns of thought that underlie entrenched attitudes and opinions. Being able to pinpoint and potentially modify a mindset requires an understanding of how everyone thinks and reacts to current and different circumstances. Repositioning of a mindset can enable a depolarization of a prevailing culture.

7b. Generative thinking

An organization's most consequential work is when stakeholders discern its most pressing challenges and opportunities. This step builds an intellectual agenda as the organization's backbone of meaning and direction. Solving questions requires an orderly reflection of 'why?', 'how?' and 'what?' — respectively, matters of vision, strategy and operations.

7c. Citizen Science

A desirable coupling of science and society began in 1959 with the widely quoted 'two cultures' perspective of the British essayist Charles Percy Snow (1905-1980) [Krauss, 2009; American Physical Society, 2017]. This has been a specialized discipline since 1989 (International Network on Public Communication of Science and Technology - PCST[25]) and was advanced by the 'third culture' perspective of Brockman [1995]. In the above-cited *Planet under Stress* book, Franklin [1990] importantly concluded: "The task of the future is to build knowledge and understanding among and between citizens and scientists, so that the distinction between the two groups vanishes — so that *both* become citizen scientists, potentially able to solve our problems together". This was proposed to the Smithsonian Institution by Koster [2017].

[25] https://www.pcst.network/ (accessed 1 October 2023).

7d. Transdisciplinarity

Rigolot [2020] opined that "when transdisciplinarity is taken as *a way of being*, the need for knowledge and know-how for integration and implementation extends far beyond the scope of research projects and appears constantly and ubiquitously in real life". Distinguishing the meanings of multidisciplinarity, interdisciplinarity and transdisciplinarity is important. Choi and Pak [2006] clarified that common synonyms are additive, interactive and holistic, respectively, but "with their own specific meanings, these terms should not be used interchangeably". They further explained: "Multidisciplinarity draws on knowledge from different disciplines but stays within their boundaries. Interdisciplinarity analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole. Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries". Concerning the Anthropocene, Zalasiewicz et al. [2021] "encouraged cross-disciplinary discussion… to help resolve issues of meaning and communication in this area".

8. Applications of Earth System Governance

On 19 September 2023, an imagined renewal of the UN's 1945 Charter emphasized that "management of the Earth System" needs to be the response "to the biggest governance gap today" which is at "the global level where the environmental risks of catastrophe are the most threatening and the least managed" (Global Governance Forum 2023/2024].

The increasingly familiar term polycrisis, first mentioned in Homeland Earth by Morin and Kern [1999], applies "when crises in multiple global systems become causally entangled" [Lawrence et al., 2022]. 'Evolution and Sustainability: Gathering the Strands for an Anthropocene Synthesis' was the theme of the January 2024 issue of the *Philosophical Transactions of the Royal Society B*. 'Polycrisis in the Anthropocene' is the theme of a forthcoming special issue of the journal *Global Sustainability* and the theme of the 2024 forum of Earth Science Governance, an organization focused on the social sciences, is 'Re-imagining Earth System Governance in an Era of Polycrisis'.

The momentous task of bringing a new vision of Planet Earth to life has been attempted by the UN, the world's only potentially capable body. In hindsight, and on par with the World Meteorological Organization which is a UN agency, geoscience could have regularly contributed its Earth System insights to UN deliberations: Koster [2023b] was a recent example. As background to a cohesive worldview

arising from the Anthropocene Event approach, we summarize relevant UN and NASA developments and imagine their adaptive future roles.

8a. United Nations (UN)

In 2015, as a successor to its eight human-focused Millennium Development Goals in 2000, the UN a[n]nounced its *Transforming Our World* plan of 17 more balanced Sustainable Development Goals (SDGs) comprising 169 targets[26]. Caballero and Londoño [2022] recalled that on 25 September 2015 "an historic meeting of the UN General Assembly… burst into jubilant applause when the resolution was adopted without a single objection or abstention". Their highly ambitious statement was: "We resolve, between now and 2030, to end poverty and hunger everywhere; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote gender eq[u]ality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources"[27]. However, the journey toward these goals soon encountered pessimism [e.g., Sriskandarajah, 2017], then calls for their replacement [e.g., Pavicevic et al., 2022], and recently became a dire situation. Challenges also flowed from the diffuse meanings of sustainable development [Bendell, 2022; Castro, 2022; Initiative on Communication and Sustainability, 2022] and a survey that most people are unable to name one SDG[28].

Toward a Rescue plan for People and Planet was the title of a special UN report in April 2023[29]. "It's time to sound the alarm. At the mid-way point on our way to 2030, the SDGs are in deep trouble. A preliminary assessment of the roughly 140 targets with data show only about 12% are on track; close to half, though showing progress, are moderately or severely off track and some 30% have either seen no movement or regressed below the 2015 baseline… If ever there was an illumination of the short sightedness of our prevailing economic and political systems, it is the ratcheting up of the war on nature… the potential for science, technology and innovation to be applied to the SDGs is vastly untapped and institutional" [Sustainability Times, 2023; United Nations, 2023a].

Imagine the successor plan to the UN's 2015-2030 plan, *Transforming Our World 2.0*

[26] https://www.mdgmonitor.org/the-sustainable-development-goals-a-new-framework-to-address-development-goals/ (accessed 1 December 2023).

[27] https://sdgs.un.org/2030agenda (accessed 1 December 2023).

[28] https://www.nature.com/articles/d41586-023-01989-9 (accessed 20 June 2023).

[29] https://sdg.iisd.org/news/un-secretary-generals-report-outlines-rescue-plan-for-people-and-planet/ (accessed 1 December 2023).

is our proposed title for it, replacing the siloed SDG approach with a holistic one-world framework in which its atmosphere, hydrosphere, cryosphere, biosphere and surface lithosphere sub-systems became the first order organizing parameter for amelioration of the humanosphere. Imagine too the benefits of policy deliberations of annual UN Conferences of the Parties (COP) "to build the science and knowledge that allow us to tackle the causes and threats of climate change" (United Nations - Climate Action[30]) being integrated with the transdisciplinary Anthropocene Event context.

8b. National Aeronautics and Space Administration (NASA)

Referring to NASA's *Apollo 8, 11* and *17* missions in 1968, 1969 and 1972, Poole [2008] vividly noted: "The sight of the whole Earth, small, alive, and alone, caused scientific and philosophical thought to shift away from the assumption that the Earth is a fixed environment, unalterably given to humankind, and towards a model of the Earth as an evolving environment, conditioned by life and alterable by human activity". Some 600 million people, a fifth of the world's population, watched NASA's 1969 lunar landing live and heard astronaut Neil Armstrong exclaim "One small step for man, one *giant leap for mankind*". Initially focused on affirming US supremacy in space exploration, looking back at the Earth did not become a NASA interest until the 1972 *Apollo 17* mission which took the now famous *Blue Marble* photograph (Figure 3).
Already though, US Senator Gaylord Nelson had stimulated, and an environmentally concerned public had avidly supported, annual *Earth Day* celebrations around the globe. Those began in 1970 (Figure 4) with Cosgrove [1994] recalling that "The Apollo Earth photographs… have been enormously significant… in altering the shape of the contemporary geographical imagination".
Just 622 humans have so far reached Earth orbit and only 24 have orbited or walked on the Moon. Upon return, almost every astronaut and cosmonaut remarked on a cognitive shift from the experience of viewing the whole Earth, profoundly affecting the perceptions of themselves and of t[h]e planet [White, 1987; World Peace Through Technology, 2013; Beaver, 2016]. In coopera[t]ion with six partner space agencies, NASA's robotic and human *Artemis*[31] program is planning for the first return to the Moon by astronauts since *Apollo 17*[32] in 1972. The *Artemis 3* mission is a crewed Moon landing currently scheduled for late 2026 with a long-term goal of a base for human missions to Mars. Meanwhile, the United Nations [2023b] has emphasized that "Outer space, a province of humankind that benefits us all, requires agile and

[30] https://www.un.org/en/climatechange (accessed 1 October 2023).
[31] https://www.nasa.gov/humans-in-space/artemis/ (accessed 1 December 2023).
[32] https://www.nasa.gov/mission/apollo-17/ (accessed 24 1 March 2023).

multi-stakeholder governance responses". As made clear in a report on memorial payloads of human rem[a]ins in space missions including potentially to the Moon [Sullivan, 2024], planning demands respectful consultation of all involved parties.

Figure 3. *The Earth System with its swirling atmosphere over a blue-g[r]een biosphere with an estimated 8.7 million species dominated by the lone surviving species of the genus Homo [Blue Marble, 7 December 1972, NASA].*

Based on the *Apollo 11*[33] audience and because of the quantum leap in the volume and accessibility of broadcast screens since 1969, it is plausible that more than one billion people will witness *Artemis* on the Moon. In 2026 the human population is projected to be 8.26 billion, more than twice the 3.62 billion in 1969. As the UN's 2015-2030 *Transforming the World* plan approaches its concluding stage, there will be no bigger bully pulpit than commentary from the Moon while peering over its horizon toward the Earth. Imagine the NASA Administrator addressing the UN's 2024 *Summit for the Future: Multilateral Solutions for a Better Tomorrow* conference [United Nations, 2023c] and then the UN Secretary-General speaking with *Artemis 3* astronauts while they are on their way to or on the Moon about the Earth's needs

[33] https://www.nasa.gov/mission/apollo-11/ (accessed 1 Mach 2023).

which have become exponentially more pressing than almost six decades earlier when *Apollo 11* astronauts exuberantly declared "one *giant leap for mankind*".

Figure 4. *The inaugural Earth Day celebratory crowd on Fifth Avenue in New York City on 22 April 1970 (from TIME).*

9. Earth-Human Ecosystem as a cultural zeitgeist

Building on the view of Peppoloni and Di Capua [2023], we view the Anthropocene Event as a powerful transdisciplinary construct that embraces the shifting scope of geoscience from the *Earth* to the *Earth System* to the *Earth-Human System*. "Basic science that unravels the relationship between the Earth system and Biological system needs to be understood in mid-to-long-term spatiotemporal scales... The great challenge is for basic science and society to transcend the invisible barriers and to co-create a new vision of the *Earth-Human system* in an integrated manner"[34]. As an even more meaningful scholarly and societal term, we propose that the *Earth-Human Ecosystem* best conveys the planet's competing natural and unnatural forces as well as its default ecologically balanced state.

[34] https://council.science/current/blog/integrated-science-understanding-the-earth-human-system/ (accessed 1 December 2023).

Finney and Edwards [2016] observed that the terms Anthropocene and Renaissance have similar characteristics: "Both refer to richly documented, revolutionary, human activities... Both carry significant connotation. Although precise dates are not specified for the Renaissance, the term is established and conveys a singular meaning of the content of that period, where it began, how it evolved, and how it spread". The hallmark of the Middle Ages Renaissance, the most known example, was its abundance and influence of visionary philosophers, artists, scientists, authors and statesmen. "The sociologist Philip Abrams once argued that an event is not simply 'a happening there to be narrated' but rather 'a happening to which cultural significance has successfully been assigned'. In other words, events do not just happen. They are created partly in hindsight, shaped by processes of retrospection and commemoration" [Lyon, 2017]. In the cᵒntext of this paper, "cultural significance" comprises societal and environmental dimensions.

A grammatical cousin of renaissance, the increasingly popular term zeitgeist[35] connotes the defining spirit or mood of a particular period as shown by its driving ideas and beliefs. An already-cited prescient perception by Mahli [2017] bears reiterating — "the Anthropocene has spilled out of its natural sciences origins to become a cultural zeitgeist, a catalyst for numerous cultural, philosophical, and political debates about how to understand and respond to human domination of the Earth". We join with Mahli in choosing zeitgeist as the contemporary sounding multifaceted label for the ongoing global reality of the Anthropocene Event from geological history into human history in an Earth-Human Ecosystem context. As well, its potential to be a tipping point in the collective human psyche is enriched by learning from Indigenous cultural traditions of synergy with the natural world.

10. Epilogue

Clearly a here-to-stay term, the Anthropocene has joined the cognate vocabulary of anthropological, anthropogenic and anthropomorphic but as a GTS term its journey has been unparalleled. Rejection of a rigid epoch-level definition by the voting hierarchy of stratigraphy minded IUGS bodies was a watershed science-and-society development. Oblique to the meaning and needs of the global polycrisis, it also averted a controversial application of GTS conventions. More significant was that by encompassing the deep and complex impacts of humans on the Earth System, the Anthropocene Event definition manifests the pure to applied transformation of the geoscience profession with its increasingly integrated past-

[35] https://www.vocabulary.com/dictionary/Zeitgeist (accessed 15 July 2022).

and-present stance with ethical commitments. Thinking forward, the future for the application of the Anthropocene term lies in an inclusive approach to a momentous need. The urgent lesson is less about when each of humanity's complex impacts began and more about how transdisciplinary insights can be leveraged toward stabilizing and potentially reducing anthropogenic impacts on the world's climates, environments and ecosystems.

The Anthropocene Event is the timely premise for an Earth-Human Ecosystem mindset, a societal zeitgeist, and governance of the global polycrisis with new transdisciplinary partnerships. Perhaps most critically, these ideals should inform the UN which is in urgent need of a successful new *Transforming our World* approach and NASA which soon returns to the Moon with a bully pulpit opportunity for a pragmatic successor to its exuberant *giant leap for mankind* 1969 communication. The indirect outcome should ideally be a growing realization that Western societies would do well to emulate the symbiotic nature-and-culture approaches exemplified by Indigenous Peoples.

As scholarly and popular literature surrounding the Anthropocene unstoppably expands and diversifies, a frontier of nuanced perceptions, including the ethical responsibilities of scientists, is valuably emerging. Here are nine illustrations from beyond the traditional perimeter of geoscience — anthropology, sociology, ecology, philosophy, geopolitics, warfare, broadcasting, think tanks, and editorials — since the AWG began to deliberate:

- "Together, the myriad of cultures makes up an intellectual and spiritual web of life that envelops the planet and is every bit as important to the well-being of the planet as is the biological web of life that we know as the biosphere" [Davis, 2009].
- "Humans are part of ecosystems, exerting influence on them and affecting fundamental ecological processes, which in turn feedback on humans as individuals and members of societies" [Courchamp and Bradshaw, 2017].
- "It is time, then, to consider a new kind of declaration. A declaration of responsibility, acknowledging what we have done and recognizing we were mistaken: a simple expression of collective responsibility for what is wrong" [Roberts, 2020].
- "Scientists cannot turn back to an idyllic scientific Garden of Eden where research is pure and unencumbered with consequences for life and death decisions. They need to take part in the public arena" [Ferguson, 2023].
- "We find ourselves living now, at a time of extraordinary change. A time marked by thousands of nuclear warheads standing ready to fire. A time when we are rapidly burning fossil fuels, producing pollution that might last hundreds of thousands of years. A time when we can see catastrophes on the horizon —

from engineered viruses to A.I.-enabled totalitarianism — and can act to prevent them. To be alive at such a time is both an exceptional opportunity and a profound responsibility: we can be pivotal in steering the future onto a better trajectory" [MacAskill, 2022].

- "It is my hope that Christopher Nolan's stunning new film on *Oppenheimer*'s complicated legacy will initiate a national conversation not only about our existential relationship to weapons of mass destruction, but also the need in our society for scientists as public intellectuals" [Bird, 2023].
- "Scientists cannot turn back to an idyllic scientific Garden of Eden where research is pure and unencumbered with consequences for life and death decisions. They need to take part in the public arena" [Ferguson, 2023].
- "Facing a crossroads in human history, we need novel approaches to global governance in support of unprecedented policy, private sector, and citizen-led actions, to shift course this decade and avert the worst of the emergency. Human interference in the life-supporting functions of our planet has already caused intense suffering and heightened inequality. Employing new and existing governance levers in more creative and technically robust ways — that harness the combined talents and commitments of governments and non-state actors — is necessary to meet our shared, colossal challenges [Robinson et al., 2023].
- "We suggest treating the Anthropocene not as an abstract idea in the geological and natural sciences, which is difficult for common people to understand, but as a phenomenon that brings political and economic consequences in the real social world" [Żuk and Żuk, 2024].

The concluding sentiments in this geoethical reflection about the far-reaching significance of the Anthropocene are from the visionary astronomers Fred Hoyle (1915-2001) and Carl Sagan (1934-1996). In a rare book transcribing his BBC Radio lectures, the first entitled The Earth and Nearby Space, Hoyle [1950] stated: "Once a photograph of the Earth, taken from outside, is available, we shall, in an emotional sense, acquire an additional dimension… let the sheer isolation of the Earth become plain for every man whatever his nationality or creed, and a new idea as powerful as any in history will be let loose. And I think th[a]t this not so-distant development may well be for good, as it must increasingly have the effect of exposing the futility of nationalistic strife". And Carl Sagan (1934-1996) mused[36]: "When *Voyager 1* was about four billion miles away as the spacecraft was departing our planetary neighborhood for the fringes of the Solar System, it turned it around for one last look at its home planet… Look again at that dot. That's here. That's home. That's

[36] https://www.planetary.org/worlds/pale-blue-dot (accessed 1 December 2023).

us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives".

In this article we have advocated for the necessity of thinking and acting in the holistic context of a cultural zeitgeist in an Earth-Human Ecosystem to innovatively confront the environmental crises that we have created. The concept of the Anthropocene, specifically as an overarching post Ice Age event, must continue to open scholarly and societal eyes to the imperative of grasping crucial issues concerning the imperiled state of the planet with its threatened diversity of eight billion humans and two plus million other species.

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