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# Was the Anthropocene anticipated?

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**Abstract**

Various authors have identified 'precursors' of the new concept of the Anthropocene, with most frequent reference made to Antonio Stoppani, Vladimir Vernadsky and Pierre Teilhard de Chardin. The effect, intended or otherwise, of finding forerunners is to deflate the significance of the proposed new geological epoch. We argue there were no precursors to the notion of the Anthropocene, and that there could not have been because the concept (put forward in the year 2000) is an outgrowth of the recent interdisciplinary understanding of the Earth as an evolving planet inaugurated in the 1980s by the International Geosphere-Biosphere Programme and Earth system science. Earlier scientists who commented on 'the age of man' did so in terms of human impact on the environment or 'the face of the Earth', not *the Earth system*. Moreover, earlier Western conceptions relied on a progressive and linear evolutionary understanding of the spread of humankind's geographical and ecological influence, whereas the Anthropocene represents a radical rupture with all evolutionary ideas in human and Earth history, including the breakdown of any idea of advance to a higher stage (such as Teilhard's 'noösphere').

**Keywords**

Anthropocene, Earth system science, global change, noösphere

> Not all the winds, and storms, and earthquakes, and seas, and seasons of the world, have done so much to revolutionize the world as he [man], the power of an endless life, has done since the day he came forth upon it, and received, as he is most truly declared to have done, dominion over it. (H Bushnell, Sermon on *The Power of an Endless Life*, 1860)

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## The deflationary move

Can we find in the scientific or related literature historical precedents for the current scientific concept of the Anthropocene, or is the advent of the new geological epoch so recent that earlier scientists could not have foreseen it? In their brief seminal article, atmospheric chemist Paul Crutzen and geobiologist Eugene Stoermer (2000) refer to illustrious forerunners, namely Antonio Stoppani, GP Marsh, Vladimir Vernadsky, Pierre Teilhard de Chardin and Edouard Le Roy as among the first to recognize the growing role of humankind as a 'significant geological, morphological force'. In his influential one-page paper, 'Geology of mankind', published in *Nature*, Crutzen (2002) claimed that 'as long ago as 1873' the Italian geologist Antonio Stoppani referred to the 'anthropozoic era'. He added that in 1926 Vernadsky acknowledged 'the increasing impact of mankind' and, like Teilhard de Chardin, used the term 'noösphere'. Both concepts, he said, were precursors of the awareness of mankind's growing influence on Earth history.

In their 2011 review paper 'The Anthropocene: Conceptual and historical perspectives', Steffen et al. (2011) refer to these and some others (Bergson, 1907; Osborn, 1948; Schuchert, 1918; Sherlock, 1922) as antecedents of the current idea of modern humankind as a new geological agent on a global scale, although they caution against drawing an equivalence with earlier concepts. In the 2012 collective book *A Geological Time Scale*, Zalasiewicz et al. (2012) describe the idea that humans 'precipitated a new geological age' as a century old.

The existence of precursors – earlier concepts that capture the essential idea of the Anthropocene or form an important step in its emergence – is now well entrenched. In the March 2012 issue of *Global Change, IGBP* an article titled 'Anthropocene: An epoch of our making' contains a box headed 'The emergence of a paradigm'. It opens with the claim that: 'The concept of the Anthropocene has manifest itself in the scientific literature for over a century under various guises' (Syvitski, 2012). On the website of the Stratigraphy and Geochronology Commission of the International Union for Quaternary Research we can read:

> Although the term 'Anthropocene' is a recent invention, it has precursors. The first was proposed by the Italian geologist Antonio Stoppani who recognised the effects that humans were increasingly having on Earth's systems. He proposed the term *Anthropozoic era* for the recent period. However, this was ignored. Other possible tentative terms include the *Psychozoic*, proposed by the American Joseph LeConte in 1879, and the *Noösphere* coined for this period in 1926 by Vladimir Vernadsky and Pierre Teilhard de Chardin. (INQUA, 2014)

The accepted wisdom that the Anthropocene was foreseen by scientists in the 19th and early 20th centuries can be read in many other places (e.g. Balter, 2013; Baskin, 2014; Bonneuil and Fressoz, 2015). Although the present authors initially accepted this view, after critical reflection and rereading the historical sources we now disagree with this intellectual phylogeny.

The quest for historical precedents is often worthy and interesting, but in understanding the making of scientific knowledge, searching for precursors can be perilous and misleading, especially if we neglect historical semantics, Bergson's notion of 'logic of retrospection', and the post-Kuhn 'scientific revolutions'. We argue that neither Vernadsky's ideas nor Teilhard's ideas, which themselves were markedly different (Levit, 2000), nor those of any other historical thinker, were a 'precursor of the notion of the Anthropocene' (Guillaume, 2014; see also Davis, 2011) because of the novelty of the understanding of the Earth on which it is based. A fortiori, the predecessors of Vernadsky and Teilhard cannot be precursors of the Anthropocene. Before examining the views of these purported precursors we note the core of our argument: that scientists in the 19th and first half of the 20th centuries did not possess the modern scientific concept of *the Earth system* of which the

Anthropocene is an outcome (Ehlers and Krafft, 2006; Graedel and Crutzen, 1993: 403; Steffen and Tyson, 2001; Steffen et al., 2004). We suggest that in referring to precursors, perhaps to bolster the credibility of the new concept by locating it within a respected tradition ('on the shoulders of giants'), the original proponents of the Anthropocene unwittingly undermined the radical novelty of the concept and the actuality of the proposed new geological epoch.

## The rise of Earth system science

Of course, the theme of man as master of nature has a very long history. It is, according to some, embedded in Christianity (Noble, 1998; White, 1967), and was an essential part of 'the rise of Western power' (Daly, 2014) after the so-called scientific and industrial revolutions. In Russia, especially under the Soviet regime (Josephson, 2002), the theme of the new 'era of man' (the 'Anthropogene') in Earth history was well known. But all of these ideas belong to the geological period of the Quaternary, not to the proposed Holocene–Anthropocene discontinuity (Wolfe et al., 2013).

Contrary to Crutzen and the early promoters of the Anthropocene, the earlier natural scientists were not occupied by global phenomena akin to catastrophic nuclear winters or a stratospheric ozone layer altered by synthetic compounds. The giants of natural history, when thinking about civilized man as a geological force, lived in a world unaware of a disturbed global nitrogen cycle, a mass extinction event, and global climatic change due to the atmosphere's changing chemical composition. The discovery of the Antarctic ozone hole was wholly unanticipated; before the mid-1980s it was no more than a controversial theoretical hypothesis (Crutzen, 1995: 105–111; Graedel and Crutzen, 1993: 1–3). For Crutzen and his fellow atmospheric chemists working in the environmental consequences of nuclear war and emerging Earth system science, the ozone crisis was a 'big shock' (Crutzen and Müller, 1989: 28), a sudden global emergency much more surprising than the anthropogenic 'greenhouse effect' and global warming (Schneider, 1989).

The foundations for the development of Earth system science were laid in the 1950s, during the Cold War (Edwards, 2010; Hamblin, 2013). Oceanographic and atmospheric sciences were transformed and globalized. Systems ecology was developed in the 1960s, notably within the Radiation Ecology Section of Oak Ridge National Laboratory (ORNL), an outgrowth of the Manhattan Project (Bocking, 1997; Coleman, 2010). The ORNL became an important centre for understanding the $CO_2$–energy–climate problem. The Carbon Dioxide Information Analysis Center (CDIAC) was founded in 1982, within the Environmental Sciences Division of ORNL. Biophysical modelling of the biosphere (Vernadsky's legacy) was developed from the 1980s by Russian scientists in collaboration with Western colleagues at the International Institute for Applied Systems Analysis and later at the Potsdam Institute for Climate (Jørgensen, 2010).

The computer-based methodology of system dynamics was developed by Jay W Forrester at MIT in the 1950s, and applied to social systems, with its application to the functioning of Earth as a complex 'world ecosystem' prompted by an invitation from the Club of Rome in 1970, leading to the publication of *World Dynamics* in 1971 (Forrester, 1971). Its furiously controversial sequel *The Limits to Growth* was published by the Club of Rome a year later (Meadows et al., 1972; see also Georgescu-Roegen, 1975). The groundwork had been laid with the International Geophysical Year in 1957–1958 (Grinevald, 1990), including the launch of the first artificial satellites to monitor global change, the start of Charles David Keeling's measurements of atmospheric carbon dioxide variations at the Mauna Loa Observatory in Hawaii (Keeling, 1970), and the revelations of ice core drilling in Antarctica which began in the early 1980s (Jouzel et al., 2013).

Biogeochemical studies were not completely new (Hutchinson et al., 1970), but worldwide programmes on biogeochemical cycles were initiated only in the 1970s after the International

Council of Scientific Unions (ICSU) created the Scientific Committee on Problems of the Environment (SCOPE) in 1969, before the 1972 Stockholm Conference (the first UN mega-conference on the 'human environment'). The SCOPE reports on the global carbon and other biogeochemical cycles, the greenhouse effect and climatic change (Bolin et al., 1986) played a leading role before the first reports of the Intergovernmental Panel on Climate Change (IPCC) published from 1990. The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988.

The first World Climate Conference of experts 'on climate and mankind' was held in February 1979 at the WMO in Geneva. Together with ICSU and UNEP, the WMO launched the World Climate Research Programme to succeed the Global Atmospheric Research Programme. Initiated by the United States' geophysical and space community, the new paradigm of Earth system science emerged in the 1980s and took institutional form in the 'International Geosphere-Biosphere Program: A Study of Global Change' (ICSU, 1986; NRC, 1983). It was not until 1986 – two years before the IPCC's creation – that the ICSU's General Assembly launched officially the International Geosphere-Biosphere Programme (IGBP), the institutional heart of global ecology and Earth system thinking (Grinevald, 1990; ICSU, 1986; Steffen and Tyson, 2001), after the first initiatives of NASA (Conway, 2008).

So new was this kind of thinking that when in the 1970s James Lovelock and Lynn Margulis (1974) introduced the 'Gaia hypothesis' of the coevolution of Earth, climate and life, the scientific establishment (with rare exceptions) rejected it (Lovelock, 1988: xiv–xv). Later, Lovelock discovered Vernadsky and praised him and Hutton as his most illustrious predecessors, precursors of the idea of Earth's 'geophysiology' (Grinevald, 1988; Lovelock, 1988: 9–11).[1]

In the history of science and history of ideas, the search for precursors, in its extreme form known as *precursitis*, is well known and often denounced, notably by A Koyré (1961: 79) and G Canguilhem (1968: 20). It is frequently a semantic and historiographical mistake; it is also, as we argue in this case, an inadvertent conflation of two incompatible ways of understanding the world (and so an epistemological fallacy). Apart from these errors, the effect of finding historical precedents is, inadvertently or otherwise, to *deflate* the Anthropocene concept, reading the Earth's future into its past and diminishing its significance and novelty as just another manifestation of a long line of thinking; whereas in fact the Anthropocene represents, according to those who initially put it forward, a dangerous shift, and a radical rupture in Earth history. This rupture means that the Holocene can be no guide to the Anthropocene geologically or intellectually. The 'early Anthropocene' hypothesis (Ruddiman, 2003) and the 'good Anthropocene' reframing (Ellis, 2011) may also be counted as deflationary moves, one because it renders the new era largely co-extensive with the Holocene and the other (building on the first) because it frames the new epoch as an extension of human activity stretching back thousands of years. Both rob the new geological epoch of its power. The elision of weather modification (which began in the 19th century) and modern geoengineering proposals such as sulphate aerosol spraying (e.g. Fleming, 2010) is another manifestation of the continuist thesis.

## The Anthropozoic era

Although now largely forgotten, Abbot Antonio Stoppani (1824–1891) was not ignored in his time (Zanoni, 2014). An Italian patriot and a cofounder of the Italian society of geology, his *Corso di Geologia*, published in three volumes in 1871–1873, was very popular (although it rapidly became outdated because of its anti-Darwinian ideas). In the volume on stratigraphy, Stoppani introduced his peculiar idea of the 'anthropozoic era', writing that with 'the creation of Man' as an absolutely

new and divine element in Earth history, 'civilized Man' (as opposed to pagan Ancients) has become 'a new telluric force that, for its strength and universality, does not pale in the face of the greatest forces of the globe' (Stoppani, 1873: 732).[2] Stoppani's new humanized geology was sufficiently striking to attract the attention of George Perkins Marsh (Lincoln's minister plenipotentiary to the new Kingdom of Italy) whose 1874 book *The Earth as Modified by Human Action* (a new edition of his 1864 book *Man and Nature*) has had an enduring influence. Of Stoppani he wrote:

> In a former chapter I spoke of the influence of human action on the surface of the globe as immensely superior in degree to that exerted by brute animals, if not essentially different from it in kind. The eminent Italian geologist, Stoppani, goes further than I had ventured to do, and treats the action of man as a new physical element altogether *sui generis*. According to him, the existence of man constitutes a geological period which he designates as the ANTHROPOZOIC ERA. 'The creation of man', says he, 'was the introduction of a new element into nature, of a force wholly unknown to earlier periods'. (Marsh, 1874: 609)

Stoppani's idea of 'civilized Man' is in fact a traditional religious and ethnocentric notion consistent with the times and his faith. He published later a 'scientific' creationist book entitled *Cosmogonia Mosaica* (Stoppani, 1887). His religious and stratigraphical perspectives were at one. Like the Jesuit geologist and palaeontologist Teilhard later, Stoppani was an ardent supporter of concordism between Science and the Christian view of Man and Nature. Following the Western medieval interpretation of the Bible (White, 1967), this 'new telluric force' created, according to God's will, a new period in Earth history. A century earlier, in his great book *Les Epoques de la Nature*, Comte de Buffon (1788) interpreted and secularized the six days of Creation as six long episodes of the natural history of the Earth, with the 'seventh and last epoch' being the age of man 'when the power of man assisted the works of nature'. But Buffon (like James Hutton and James Watt) belonged to the Industrial Enlightenment (Mokyr, 2002: Chapter 2), not the later thermo-industrial revolution of the imperial West (Grinevald, 1990).

In the same year that Stoppani announced the anthropozoic era, 1873, a Swiss geologist, Eugène Renevier (1873), introduced in his work of nomenclature the 'Période Anthropique'.[3] At the time, the modern notions of 'biosphere', 'ecosphere', 'ecological crisis', 'environmental revolution', 'global warming', 'global change' and, above all, the Earth as an evolving complex system were unknown (Kump et al., 1999). This was so despite the early critiques of the environmental harms of machinery and industrialism, heavily polluted industrial cities, deforestation and local degradation of landscapes (Bonneuil and Fressoz, 2015; Locher and Fressoz, 2012). Climatic changes were a matter of acid pollution or local deforestation, and not a scientific concern for 'global habitability' (Goody, 1982). Nobody was thinking about a dangerous shift in the Earth as a system (Falkowsky et al., 2000). The Earth's biosphere understood as a holistic concept was still waiting for Vernadsky (Grinevald, 1998; Polunin and Grinevald, 1988; Vernadsky, 1998) and, eventually, Lovelock (Bruce, 1990). In Stoppani's time, and even in that of Vernadsky and Teilhard, no scientific group was studying the anthropogenic disturbance of biogeochemical cycles (or great biospheric cycles) or their interactions with the global dynamics of atmosphere and climate change.

Resistance to the Gaia hypothesis in the 1970s and 1980s arose from the same classical understanding of the surface of the Earth and compartmentalization of scientific disciplines that led to rejection of Alfred Wegener's theory of continental drift from the 1920s to the 1950s. In Stoppani's time, the Earth was believed to change within a smoothly cyclic steady state (akin to Hutton's Theory of the Earth and Lyell's uniformitarian geology). Vernadsky too was a Huttonian in his geological thinking. Teilhard, like his colleagues (notably Pierre Termier), considered Wegener to be a dreamer. The stability of the Earth was the common paradigm of scientists before the late

'Wegenerian revolution'. Since Charles Lyell (1830–1833) and Louis Agassiz (1840), climatic change, except at a local level, was a characteristic of the past (notably the Pleistocene), not for the near future. Before the Greenland and Antarctic ice core drilling in the 1980s and the extraordinary discovery of the correlation between carbon dioxide concentrations and temperature oscillations (Barnola et al., 1987), coupled with the Keeling Curve, which only came to wide attention in the scientific community in the 1970s,[4] there was *no evidence* of any worldwide metabolism (Volk, 2003). The idea of an Earth geophysiology was still a scientific nonsense. In fact, Earth system science's emphasis on the importance of the structure, functioning and evolution of the Earth's biosphere as a whole remained a novelty in the international scientific community until the end of the 1980s (Huggett, 1999; Jørgensen, 2010; Polunin and Grinevald, 1988). In short, since the last decades of the 19th century natural science's understanding of the global environment has undergone a profound transformation, a scientific revolution not yet fully recognized.

Although human impact on Earth was a well-known theme within naturalistic and geological thinking from the time of the Western industrial revolution (Glacken, 1956), there was no foreshadowing of the Anthropocene in its contemporary sense. Stoppani's 'anthropozoic era' and a number of variations – Renevier's 'Période Anthropique' (1873), Joseph LeConte's (1877) and Charles Schuchert's (1918) 'psychozoic era', James Dwight Dana's 'Era of Mind – Age of Man' (quoted by Vernadsky, 1945), Teilhard's noösphere – described the impact of human action on 'the face of the Earth' rather than on the planet Earth as an evolving complex system. The concept of the Earth system – including the anthropogenic alteration of the great biospheric or biogeochemical cycles – was another century in the making (Grinevald, 1987, 1990; Jacobson et al., 2000; Mackenzie and Mackenzie, 1998).

Instead, for Stoppani and those who followed him, the new era of the natural history of Earth was defined by the way humans had transformed the landscapes and, in some cases, the local climates (Locher and Fressoz, 2012), leaving an impact that the geologists of the future could uncover but which in itself was not evidence of a new geological epoch. For Stoppani the first trace of modern Man marks the beginning of the anthropozoic era (unfolding in a Promethean future), but the similarity of names should not lead us to confuse it with the Anthropocene. A term is not a concept, and the concepts are changing. This is especially true if the onset of the Anthropocene is deemed to be later than initially proposed; that is, not with the onset of the European industrial revolution (symbolized by Watt's steam engine) in the late 18th century and early 19th century but after the Second World War. Jan Zalasiewicz and 23 co-authors (including JG) have recently argued that the new epoch can most reasonably be said to have begun with the world's first nuclear bomb explosion, on 16 July 1945 at Alamogordo, New Mexico, USA (Zalasiewicz et al., 2014; see also Waters et al., submitted). It was the beginning of the 'nuclear age', effectively coincident with the 'Great Acceleration' and all its consequences, but it was still too soon for anyone to understand it as a new geological epoch. The evidence was not available.

## The noösphere

The great Russian naturalist Vladimir Vernadsky (1863–1945), a pedologist and mineralogist, was the founder of the new science of biogeochemistry as a subdiscipline of geochemistry. Writing in the 1920s, he had a remarkably prescient understanding of the planet's biosphere as the product of the biogeochemical activity of 'living matter'. He described a zone extending from the highest point in the atmosphere that sustains life to that part of the upper lithosphere (mainly the soils), including the hydrosphere (mainly the oceans), that supports all life. His ideas (partly censored or unpublished) evolved in the 1930s. Pre-empting the modern science of ecosystems ecology and

inspired by Bergson's *L'Evolution créatrice* (Bergson, 1907) and his own early biogeochemical studies, Vernadsky conceived of the human impact on the planet Earth as 'mankind's geochemical work', altering the flow of elements in the whole biosphere (Vernadsky, 1924). However, although his 'Biosphere in the cosmos' (Vernadsky, 1929, 1998) was physically and conceptually thicker and more dynamic than most others (Grinevald, 1988, 1998; Polunin and Grinevald, 1988), it was in the end a biogeological layer, the most active geological force on 'the face of the Earth', rather than a coevolutionary component of the Earth system itself. We should note that Vernadsky's biogeochemical science of the Earth's evolving biosphere is still not well known and has been the subject of scholarly debate only recently,[5] often within the slanted context of the Gaia controversy and the coming ecological crisis (Grinevald, 1987, 1988; Huggett, 1999; Samson and Pitt, 1999; Vernadsky, 1998).

Vernadsky put forward the idea of 'the geochemical activity of Mankind' in the early 1920s (Vernadsky, 1923), notably in his 1924 book *La Géochimie*, published in Paris after his invited Sorbonne lectures in 1922–1923 (*The Biosphere* was written in 1925, and published in Russian in 1926). Impressed by what he saw as the 'influence of consciousness and collective human reason' on the biosphere, Vernadsky took a step beyond biogeochemistry to conceive of 'our geological epoch – [a] psychozoic era, era of Reason' (Vernadsky, 1924: 342). Nevertheless, he always kept his idea of the collective consciousness tethered to the biogeochemical processes that were his life's work, so that the 'influence of consciousness and collective human reason' (including mainly technological progress and scientific research) was always exercised by a creature that belonged to the evolving biosphere. For him, the dawn of the noösphere was the 'last of many stages in the evolution of the biosphere' and was signalled by the human transformation of its chemistry, including the transmutation of its elements, a task soaked in utopian promise (Vernadsky, 1945, 2005).

The word 'noösphere' was first used in print by professor of philosophy Edouard Le Roy (1870–1954), but was probably coined by his younger friend, the Jesuit priest, geologist and palaeontologist Pierre Teilhard de Chardin after his enthusiastic reading of *La Face de la Terre* by Eduard Suess (the final volume [1909], recalling his notion of 'biosphere', was published in French in 1918). Le Roy, a mathematician turned philosopher and Bergson's disciple, drew explicitly on personal discussions with Teilhard and Vernadsky (Le Roy, 1927, 1928).[6] He quoted or paraphrased an unpublished essay of Teilhard's on 'L'Hominisation' dated 6 May 1925 (Teilhard de Chardin, 1967). The notion had emerged, after Vernadsky's Sorbonne lectures, published in *La Géochimie* (Vernadsky, 1924).[7] But it was only after the publication of Le Roy's 1927 book on the Teilhardian notions of biosphere and noösphere that Vernadsky adopted the term noösphere (Vernadsky, 1997, 2005) although, as we argue below, with a very different meaning. Vernadsky published his *Biosfera* in Leningrad in 1926 (Vernadsky, 1998), after his encounter with Teilhard and Le Roy. Teilhard (later exiled in China) and Le Roy ignored the French book entitled *La Biosphère* (Vernadsky, 1929; see Grinevald, 1987, 1988), and of course the 1926 Russian edition. This chronology was the source of further misunderstandings.

Teilhard de Chardin mixed an Enlightenment faith in the power of Mind with a new Christian story of cosmogenesis–biogenesis and, finally, anthropogenesis. For him evolution represented the rise of complexity-consciousness. The noösphere (from *nous*, Greek for Mind, and pronounced no-osphere) is the third and last great stage of Big History – after the mineral (geosphere) and the organic (biosphere) stages – and had in the previous century or two attained such an advanced state of development that it separated itself from embodied humans to float on a plane above. For the Jesuit Teilhard, the noösphere, the thinking layer of the Earth 'outside and above the biosphere' (Teilhard de Chardin, 1964: 163) had, like his zoocentric biosphere, an irreversible tendency to

progress, an evolutionary drive aimed at a destination, the Omega Point, 'the final maturing and ecstasy of Mankind' (Teilhard de Chardin, 1964).

Vernadsky and Teilhard used the terms 'biosphere' and 'noösphere' in radically distinctive ways. After all, one was the Russian Soviet founder of biogeochemistry and the interdisciplinary science of the biosphere (in its global ecological and planetological sense), and the other was a Jesuit priest, continental geologist, palaeoanthropologist, evolutionist visionary and cosmic mystic. Their meanings of noösphere arose from their conceptualizations of what the Earth is as a planet and how it moves. Even their concepts of biosphere are not at all similar. The confusion between Vernadsky and Teilhard is mostly a recent reconstruction, and followed their passing in 1945 and 1955, respectively, as well as the belated publication of their works in translation. The elision is especially apparent in works by Teilhard's ardent supporters such as Ludovico Galleni (1995) and the late Father Thomas Berry (1988) (and in the eastern reading of Ken Wilber (2000)) who promoted a new concordism between ecology and theology, that is, in the association of evolutionism and the coming of the Cosmic Christ.

Whether of the transmundane or the worldly variety, the noösphere emerged after the Great War of 1914–1918 from evolutionary thinking. It is Lamarckian (more than Darwinian) in the sense that the noösphere develops progressively as a higher stage of the directed evolving biosphere; but it also in Teilhard's hands makes a Hegelian shift to a collective force known as Mind or Spirit beyond any process of natural selection and which is invested with its own dynamic.

Both Vernadsky and Teilhard understood evolution as a process directed towards ever-higher levels of cephalization (the development of the central nervous system culminating in the continuing growth of the human brain) and consciousness. They saw the development of intelligent life, including technology and scientific research, as a law inscribed in a cosmogenesis (Teilhard) or in the evolution of the planet Earth's biosphere (Vernadsky). While both extrapolated from biological evolution and technological progress of the human species, Teilhard took a metaphysical leap from the Earth-bound processes of biological selection and complexity to a conception of the collective evolution of consciousness, one that has both immanent and transcendental sides, an inner human dimension and an outer cosmic one. Such an idea was anathema to Vernadsky for whom the noösphere always remained within the limits of the Earth, as an element of its biogeochemical evolution. If the noösphere remained within the biosphere, it was 'the biosphere reworked by scientific thought' (Levit, 2000). It is a higher evolutionary stage with no transcendental or earthly end-point, only the further spread across the planet of human influence, an influence he took as a force for good, as our Promethean destiny (Guillaume, 2014).

But whether in Teilhard's mystic conception or Vernadsky's more materialist one, both versions of the noösphere were products of Western evolutionary thinking in which civilized Man emerges as a geological force *incrementally* over deep time. This fact differentiates all noösphere notions sharply from the sudden arrival of the Anthropocene.

## The Anthropocene's uniqueness

We are not arguing that the discovery of 'precursors' is deflationary because the credit is given to previous thinkers, but that the reference to authors in the 19th and early 20th century locates the origin and nature of the Anthropocene in a pre-Earth system world, thereby drawing the understanding of the Anthropocene into the processes of human alteration of the landscape and changes in the functioning of ecosystems. In so doing it 'gradualizes' the new epoch so that it is no longer a rupture due principally to the burning of fossil fuels but a creeping phenomenon due to the incremental spread of human influence over the landscape. This misconstrues the suddenness, severity,

duration and irreversibility of the Anthropocene leading to a serious underestimation and mischaracterization of the kind of human response necessary to slow its onset and ameliorate its impacts.

The Earth as a total complex 'ecosystem', including the global climate system, is a very recent interdisciplinary and paradigmatic concept developed in the 1980s and 1990s, and not officially adopted by the IGBP and other world programmes of international scientific cooperation until the Global Change Open Conference in Amsterdam in July 2001 (Grinevald, 2007: 247–248; Steffen et al., 2004). Human disturbance of the whole Earth system was not detectable in the 19th century. Although the anthropogenic alteration of the greenhouse effect was conceived in the 1890s by Arrhenius, it was a theory about 'carbonic acid and glacial epochs' rather than a precocious form of Earth system science (Crawford, 1997). Arrhenius himself (1896) traced the story of the greenhouse effect back to Tyndall, Pouillet and Fourier. Their work pointing to the possibility of a warming globe is not the same as arguing that elevated $CO_2$ could disturb the Earth system as a whole.

In the history of science, we can often rediscover a 'prehistory' of a problem solved much later with another approach. Big new ideas or new questions are rare but do occur and the notions of the Earth system and the Anthropocene are instances. Even at the time of the 'environmental revolution' in the early 1970s neither was evident. The integrated and holistic concept of Earth as a total ecosystem or ecosphere (Huggett, 1999), the idea of our evolving 'living' planet, was not available for human awareness before NASA's Apollo missions and the Lovelock–Margulis Gaia hypothesis (Grinevald, 1987, 1988; Lovelock, 1979, 1988). This historical turning point of our 'whole Earth' awareness is now well documented, notably by Denis Cosgrove (2001) and Robert Poole (2008).

When we compare the pioneering visions of a humanized Earth with the arrival of the Anthropocene several differences jump out. Compared with the noösphere (in Teilhard's sense), the Anthropocene is both *more*, because it is built on disturbance of the Earth system rather than the biosphere or landscape, and *less*, because it remains always grounded within the Earth system and does not posit a 'sphere' above or beyond it.

Crucially, while the anthropozoic of Stoppani and the noösphere of Vernadsky or Teilhard represent evolutionary *extrapolations* – that is, founded on the assumption of the inevitable advance of progress – the Anthropocene is a very unwelcome rupture, not so much a regression but a radical breakdown of any idea of advance to a higher stage. It therefore represents an implicit rebuke to all those who indulge in extrapolation, whether it be rooted in evolution, stages of consciousness or limitless economic growth. The Anthropocene is a new anthropogenic rift in the natural history of planet Earth rather than the further development of an anthropocentric biosphere. For all of the sophistication of his biogeochemical and cosmological notion of the biosphere, Vernadsky could not have anticipated the emergence of Earth system science as a mode of understanding. He could not have foreseen the gulf that separates Earth system science from classical ecology, one that requires a leap from 'ecological thinking – the science of the relationship between organisms and their local environments – to Earth system thinking, the science of the whole Earth as a complex system beyond the sum of its parts' (Hamilton, 2014), a 'gestalt shift' that evades many ecologists today.

For the scientists who announced the arrival of the Anthropocene, the larger force that has brought it about is not Mind, Reason, Consciousness or Spirit, or any force that rises above the mere collective in order to command a capital letter; instead the culprit is humankind understood as *homo faber*, the technological man of modern Western civilization rendered as a new geological force by means of the power to disturb the great cycles that govern the planet's trajectory. It is superficially akin to Stoppani's 'new telluric force' except that it is not so much within the earth (telluric) that modern humans have intervened so decisively but in the atmosphere and oceans (coupled fluid geospheres) as components of the global carbon cycle and the climate system.

If for Teilhard the noösphere represented the power of the whole of humankind's consciousness raised above and purified of its earthly connections, the Anthropocene in the approach of Earth system scientists – for whom explosive human population and its total industrial metabolism have become an accelerating force of nature – has dragged consciousness back into the Earth. The condition for the possibility of the noösphere, a human history liberated from the natural history of the Earth, has been wiped away, because, as post-colonial historian Dipesh Chakrabarty (2009) has told us, the two histories have now converged, giving us a kind of hybrid Earth, of nature injected with human will, however responsibly or irresponsibly that will may have been exercised.

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## Notes

1. A full English translation of Vernadsky's *The Biosphere* (first published in 1926) was finally published in early 1998. It was cited by Crutzen and Stoermer (2000) and Crutzen (2002).
2. The Italian pages on the 'éra antropozoica' are now translated into English by Valeria Federighi, and are available online.
3. Renevier (1873) and Stoppani (1873) were both active in the Second International Geological Congress of 1881 in Bologna, Italy, where stratigraphical nomenclature was discussed for the first time on the comparative international level (Freymond, 2012). As the designation of the modern, post-Pleistocene era, the 'Holocene' (a term coined in 1860s by Paul Gervais) was adopted by the International Geological Congress of 1885 in Berlin.
4. See https://scripps.ucsd.edu/programs/keelingcurve/2013/04/03/the-history-of-the-keeling-curve/.
5. Unfortunately, Vernadsky's new science of the biosphere as a whole (later called global ecology) remained for decades ignored or misunderstood, partly censored and unpublished (see the foreword by Lynn Margulis and colleagues in Vernadsky, 1998). Vernadsky's French books *La Géochimie* (1924) and *La Biosphère* (1929) were unavailable after the Second World War. His original book in Russian, entitled *Biosfera*, published in Leningrad in 1926 soon after his longest residence in France (1922–1925), was only published in full in English in 1998 (Grinevald, 1998).
6. Both of Le Roy's books were placed on the Catholic Church's *Index Librorum Prohibitorum* in 1931.
7. Recalled later by both Teilhard de Chardin (1956) and Vernadsky (1945).

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