Special issue: Perspectives on the technosphere

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In the machine room of the Anthropocene

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The conspicuous term 'Anthropocene' has given a bold heading to the profound impact of humanity on the Earth System. It pointedly captures the fact that industrial society has made it into the ranks of deep time, bringing about a geological epoch that has no analogue in Earth's history. Naming a system-wide and largely irreversible transition of the entire planet, the concept of the Anthropocene dispenses once and for all with romantic ideas of a quasi-stable state of nature to which we should or might eventually return. Humanity does not act on the backdrop of an unchangeable nature but is deeply woven into its very fabric, shaping both its imminent and distant future.

Yet for all its provocative force, the Anthropocene is first of all a descriptive concept, taking stock of the many indicators that speak for or against such a transition. It tells us where we are: sitting in a mobile home with few windows, rapidly curveballing down an unknown path at the end of which stands a new state of the Earth (and a finally definitive entry on the chronostratigraphic chart). But it does not tell us how we got on board this wildly moving vehicle, nor what powers and propels it. As a geological terminus technicus, the Anthropocene lacks explanatory power; it does not tell us what the driving forces behind the current, 'real-time' exodus from the Holocene are nor how these forces operate and function.

Is it the *anthropos* – man – that has brought us here, as the name suggests? Obviously, it is not the direct and immediate metabolic exchange between *Homo sapiens sapiens* and the global environment that is responsible for the shifting baselines in the great circulation of matter and energy. But what about humankind as a whole? There is indeed a fierce debate about who or what might be implicated in this term Anthropocene: many scholars have argued that the term problematically assumes an undifferentiated human species that acts on a planetary scale, diverting attention from the historically specific actors and structural processes that have created our current predicament (Haraway, 2015; Malm, 2015; Moore, 2015). The geosciences have not been insulated from these debates, insofar as the question of when and how the Anthropocene began intersects directly with these political questions (Hamilton, 2015, 2016; Lewis and Maslin, 2015; Oldfield, 2016; Zalasiewicz et al., 2015).

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Contrary to what the name might imply, it seems apparent that the current rupture in the Earth System is brought about neither by humankind as a whole nor by the human as a biological species. Instead, the processes of global change named by the Anthropocene prompt us to understand the *anthropos* as a technological subject. Without doubt, the human entrance into the global metabolism is mediated and driven by the resourceful employment of technologies. Given the apparently systemic role of planetary-wide technologies in modifying the face of the Earth, some have, in fact, begun to speak of an entirely new system from which the drivers of the Anthropocene emerge. The geoscientist Peter K Haff (2014a: 301) has recently brought the term 'technosphere' into the discussion to describe a technological macro-system that 'is of global extent, exhibits large-scale appropriation of mass and energy resources, shows a tendency to co-opt for its own use information produced by the environment, and is autonomous'. In contrast to earlier geohistoric events that have been caused by a disruptive exchange between the biosphere and the geospheres – think, for example, of the Great Oxygenation Event – Haff's thesis suggests that it is the intervention of planetary-scale technology that is giving rise to a new and distinct epoch.

In contrast with the debate over which segments of global humanity might be held responsible for our current predicament (and how), the technosphere thesis radically decenters the human. It posits in its place a new geological agent encompassing a wide variety of socio-technical phenomena that consume, mobilize and, notably, also waste materials, energy and information. This technological macro-system includes the built environment and its infrastructures; energy, resource, and industrial operations; transportation, communication, and financial networks; agriculture; modern states and bureaucracies; and social institutions in general. It traverses a multitude of scales and materialities, from synthetic compounds to vast mining operations, from digital networks and algorithms transforming the world via symbolic logic to food additives transforming human bodies (or those of their highly cultivated livestock). Conceptually, the technosphere is presented as an artificial but highly amorphous meshwork of hard-, soft- and wetware, which acts as much as a geological force as do the biosphere or any of the geospheres, with which it multifariously connects and intersects. It appears to have its own internal dynamic and to create its own path dependencies affecting the long-term future of the Earth. The technosphere emerges as a new player in the game of life (and non-life) that makes Earth such a special place in the Universe. And as Bronislaw Szerszynski (2016: 16) has put it, it also names a 'candidate concept for whatever the Earth does next'. As such, the technosphere thesis raises the question of technological agency in the Anthropocene, and how technologies act to shape our world in ways that are not direct elaborations of human intention.

On closer examination, Haff's idea of a technosphere is a revival of older concepts. The philosopher of technology Friedrich Rapp (1981: 123, 154) used this notion in the 1970s to describe the aggregate of technical artifacts and environments 'functioning according to inorganic and mechanical principles', which he argued 'has today become a force in its own right, increasingly determining the conditions of the biosphere'. The term was also employed by the eminent landscape ecologist Zev Naveh (1982: 207), who, about the same time, sought a holistic 'biocybernetic systems' view in describing the totality of the 'ecosphere':

> For millions of years, primeval man was an integral part of natural bio-ecosystems, until his cultural evolution added unique psycho-sociological and techno-economical dimensions to his biophysical nature. This led in very general terms to the creation of both an abstract system, the noosphere … and a concrete spatial and physical system, the technosphere, in addition to the existing biosphere and geosphere.

The noösphere concept to which Naveh refers stems from a conceptual proposal made in the 1920s by Vladimir Vernadsky, Pierre Teilhard de Chardin and Edouard le Roy. For these thinkers,

the noösphere denoted the shaping of the globe through conscious humankind and marked the final stage in the evolution of the spheres.[1] The introduction of the 'physical' technosphere and its distinction from the 'abstract' noösphere as defined by Naveh shows how, after a few decades of a surging Great Acceleration and further technological diversification, a general bifurcation in the relationship between man and technology came into view, with the latter increasingly being perceived as functionally independent from human intentionality.

It thus comes as no surprise that the latest reintroduction of the term stands more or less in contrast to the noösphere idea. Haff's concept tends to conceal the role of human consciousness, intentions and interests behind a logic of things, systems and networks. He has characterized the properties of the technosphere in terms of six rules that govern the interactions of humans with technology (Haff, 2014b). Together, these rules state that large components of the technosphere and humans cannot directly grasp nor interact with each other because of the different 'strata' they occupy, or the different scales of their respective 'worlds'. Haff's fifth and sixth rules describe the mutual interdependence of humans and the technosphere, insofar as humans must support those technological systems that sustain their lives while the technosphere as a whole depends on humans for the provision of energy. As Haff (2014b: 127) describes, 'the property of technological autonomy relocates the basis for thinking about problems such as environmental degradation from a human-centric to a system-centric perspective'.

In this perspective, human societies are conceptualized in terms of aggregations of individuals, each human constrained to his or her limited scale and incapable of acting on a structural level. Haff justifies this depiction of the technosphere by an operation borrowed from the physical sciences, called 'coarse-graining', which refers to '[t]he adoption of a particular level of resolution or scale in describing the components of a system' in order to capture a system's behavior at a scale larger than that of its individual components (Haff, 2014b: 129). This approach takes a hierarchical understanding of scale, limiting the analysis to those components that are visible at a given level. With this view, Haff sees humans as mere components of a planetary-wide technological system that they did not intentionally design, do not control and from which they cannot escape. Humans need the technosphere for their survival, while the technosphere is indifferent to the fate of individual humans, as long as humanity as a whole helps to sustain it.

For social scientists and humanities scholars with a commitment to critical inquiry, this depiction of the technosphere would appear to evacuate collective agency and deny the possibility of any anti-systemic politics. And Earth scientists may be no less skeptical of the claim that technological systems display an internal 'logic' whose characteristics might be subject to the same scientific rigor brought to bear on other Earth systems. But in light of the profound and accelerating integration of massive technological systems into the planetary metabolism within the past half-century or so, the question of technological agency is not easily dismissed. Indeed, the expected critical reactions may themselves attest to the ways in which the new realities of the Anthropocene violate the parameters of our existing disciplines and challenge our most cherished premises.

This issue aims to engage with the technosphere thesis as a provocation rather than an empirical reality. That is, without taking for granted that the new geosphere described by Haff has indeed been established, we can ask: does the question of technological agency help us to take the Anthropocene seriously, in the sense of confronting the profound challenges the latter poses to our understanding of the role of humankind in Earth processes? To our minds the answer is yes. For us, the technosphere thesis helps to bring the study of the Anthropocene down to Earth, inviting a grounded investigation into the processes through which humankind has inscribed itself into the geological strata. And with this focus on the concrete triggers of global change and their effects, the 'human' nature of that *anthropos* is brought under scrutiny from a novel perspective. By

describing the interdependent and co-evolutionary relation of the technical and the geological, the social and the biological, the 'human age' loses its Promethean character, and is recognized as part of a 'meta-ecology' of interlinking spheres and circulations. The technosphere thesis suggests a historical model of an evolutionary process that transcends human nature or the logic of capitalism. From this perspective industrial societies and the Earth System, the molecular and the global, the laboratory and the field together become a trans-scalar site of analysis.

We might therefore say that engaging with the technosphere leads one into the dirty work inside the 'machine room' of the Anthropocene, amidst the non-linear mechanics of global change, where things are nested and wired more haphazardly than one might believe. This issue is the product of an initial encounter within that machine room. It is not intended to provide an overarching picture or singular definition of the technosphere, but to do precisely the opposite, to disassemble the concept in order to examine its constituent components, its unacknowledged assumptions, and its implications for scholarship. In the process, some key features of the phenomena named by the technosphere come to the fore: we seem to be confronted with a looming *autonomy* of technological processes that tend to achieve a *globally integrated* character, and which therefore begin to display a degree of *systemic* coherence on a planetary scale. As the papers in this issue show, however, there is no consensus as to the precise nature and significance of these new realities, and no one discipline is in a privileged position to diagnose them. For instance, Bronislaw Szerszynski pushes our intellectual parameters by linking evolutionary history to speculative planetology to imagine technospheres beyond the paradigms of metazoan life. The essays in this volume suggest that our ability to come to terms with technological agency depends on a diversity of intellectual resources, including speculative fiction and the arts. Perhaps Marx had the right vision when he wrote in his 1844 economic-philosophical manuscripts: 'Natural science will later become just as well the science of the human, as the science of the human will subsume natural science; both will be *one* science'.

A primary challenge, in this regard, is recognizing how our ability to comprehend the technosphere is both capacitated and constrained by the framework of systems science within which it has been defined. The papers in the issue illustrate both the need to think technological agency as a systemic phenomenon and the limitations of this paradigm. For instance, Zalasiewicz et al. differentiate between the 'active' and 'residual' components of the technosphere, the latter forming an ever-growing 'waste layer' that stands in stark contrast to the 'almost perfect recycling shown by the non-human biosphere'. And yet, the authors acknowledge, some of this accumulated waste plays host to new forms of life, for instance in the form of reclaimed land or artificial reefs. Thus even these seemingly obvious distinctions – between active and residual, waste and recycled material – break down when we accept the technosphere's invitation to think beyond the human. Can we really say that the technosphere does not recycle, or does it simply serve forms of life that are hostile to us, for instance algal blooms, viruses, and invasive species? For whom or what might the materials that are 'residual' from the perspective of human economies remain active? In other words, is the technosphere evolving mutually sustaining relations with forms of existence other than or even hostile to us, such that it might survive our own extinction?

These questions force us to revisit the normative assumptions implicit in notions of biodiversity and recycling, and to ask how they have come to inflect our understanding of the technosphere as it has been shaped by systems thinking and the Gaia imaginary. For instance, can we really claim that other spheres lack a 'waste layer'? After all, tremendous amounts of the biomass do not recycle but fossilize: trapped within geological formations, they fall out of the biospheric cycle for millions of years. And while Edwards envisions the possibility of a technosphere that recycles its own 'data exhaust' in order to relentlessly regulate its own

efficiency, Gärdebo et al. call attention to the geopolitical tensions and technological detritus that shape the possibilities and limitations of our knowledge infrastructures. Evidently, 'recycling' may be only one specific example of the kinds of material interactions taking place among various spheres, others of which may offer less harmonious visions.

The technosphere therefore prompts us to think the *inhuman* dynamics of technological agency. In doing so, it opens our eyes to the surprising forms of diversity that are proliferating in the Anthropocene. Whereas the loss of biodiversity and the homogenization of ecosystems and landscapes wrought by monocultures, habitat destruction, the spread of invasive species, climate change, and ocean acidification are colossal, other kinds of diversity are emerging, including the new forms of chemical existence illustrated by Diamond. Likewise, Zalasiewicz et al. and Gärdebo et al. show us a new world of technological existence with its own taxonomies and logics. These new diversities are not necessarily to be celebrated, and they may very well be hostile to the forms of life we would want to preserve; but understanding the forms of existence they enable and destroy pushes the limits of established scientific practice, and forces us to consider the possible persistence of the technosphere in a world without us.

Attending to these new, toxic diversities prompts us to question the quasi-organic understanding of the technosphere implicit in the analog with the biosphere, which suggests a singular system with a unifying logic oriented toward its own reproduction and expansion. As Diamond shows, the new toxicities unleashed by the technosphere may be undermining its capacity to sustain itself. We can therefore ask: should we attribute to the technosphere the holistic unity of a global ecosystem, or is its coherence a more tenuous and conflicted one, riddled with potential (and actual) crises? Or, to use other metaphors, is the autonomy of technology like the autonomy of an organism – an autopoietic structure reproducing its own organization – or is it more akin to Marx's description of capital, a system whose internal logic is one of antagonism, divided against itself and propelled by the refusal of its components to function simply as cogs in the reproduction of the system?

Clearly, the types of metaphors we use to describe the technosphere inform our understanding of its implications for human agency and politics. While it may be tempting to advance a vision of harmonious global coordination – a new 'data enlightened' vision of stewardship that echoes the imaginary of global management in the 1960s – the papers by Edwards and Gärdebo et al. also prompt us to ask after the political economy and power relations that define the knowledge infrastructures of the technosphere. As evinced by ongoing controversies over what kind of knowledge is 'useful' or necessary for the Anthropocene within academic, intergovernmental, and activist circles, the seemingly technical question of what knowledge infrastructures can do (and for whom) remains a deeply political issue.

The paper by Donges et al. introduces, on this background, a new generation of Earth Systems modeling that includes social parameters, raising the question of how one might operationalize an understanding of structural agency and complex social processes within the field of modeling. In an important sense, however, the technosphere also dramatically undermines longstanding notions of structure and agency. As Thomson and Engelmann show, understanding the technosphere requires that we consider the more-than-human entanglements through which the 'agency' of a given thing (including a human) becomes consequential. Against Haff's static and hierarchical approach to scale (in which the human is simply too small to influence large technologies), they show that such entanglements take place across scales – from the subatomic to the cosmological – such that a neutrino may change the whole way we understand and use energy, and thus make possible a radically different technosphere. In this light, scale cannot be taken for granted as an a

priori division of the world, and the laws governing our ability to collectively intervene in technospheric evolution may not be so clear-cut.

Together, these papers highlight processes that may disobey the proposed rules of the technosphere, and suggest alternative analyses of technological agency in the contemporary moment. After all, the technosphere seems – in contrast to the biosphere, the resiliency of which has been established over the course of at least 3.5 billion years of evolution – a highly unstable entity. Does such a technological house of cards qualify for a 'sphere', an endless and self-perpetuating system of circulation of matter and energy across this planet? However complex and interwoven, does it really constitute a long-lasting intervention into Earth's metabolism, one that is on par with the biosphere? Is there another, more integrated version that takes long-term co-evolutionary forces into consideration? For instance, rather than presuming the hegemony of the technosphere, might we speak of an 'ergosphere' – a sphere of human 'work' – that has not yet been completely transmuted into an autonomous technosphere and in which human agency is embedded in a non-linear coupling of social, technological, and epistemic systems that cannot be stratified into a hierarchy of interactions? Such an ergosphere would have always included a transformative power beyond human intentions.

Might such a sphere remain open in its evolutionary logic to different ways of shaping the relations between humans and the planet?

We as editors ourselves had long discussions about the actual existence of the technosphere and its perceived autonomy. For us and for the contributors to this issue, the concept has been a potent stimulus for fascinating debate. It has raised some of the most fundamental questions: What is human? Is there an inner logic to technology once it becomes systemic? What are the modes and implications of planetary anthropogenic intervention? What characterizes the *inter* between (or within) human and technology?

Addressing these questions, we argue, demands a 'gay science' that is not only unconstrained by disciplinary boundaries but also ruthless in the interrogation of its own premises. This issue originates from an exceptional experiment in such transdisciplinary exchange: the *Anthropocene Curriculum* project, initiated by the Haus der Kulturen der Welt and the Max Planck Institute for the History of Science (see www.anthropocene-curriculum.org). This project has already realized two large *Anthropocene Campuses*, held in Berlin in November 2014 and April 2016, with the latter placing a specific focus on the technosphere. These events informed a remarkable experience in sharing and co-producing knowledge among scientists, humanities scholars, and artists, inventing new practices and new modes of engagement with central issues of the Anthropocene. With the exception of some authors of the paper by Jan Zalasiewicz et al., all of the contributors to this issue consist of instructors and participants in the two campuses. The contributors were also gathered in an editorial meeting in Berlin in September 2015, which provided an opportunity for collective debate and discussion on the initial texts.

As a product of these encounters, the conversation initiated by this special issue is necessarily provisional and incomplete. Nevertheless, we hope that the provocations raised by these papers point beyond this issue, to spark new debates and provoke new conversations among an expanding community of scholars. Our overarching ambition with this special issue is to advance a new mode of scholarship, one capable of confronting the challenges of the Anthropocene.

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Note

1. All three thinkers, however, had quite different conceptions of the noösphere. The naturalist Vernadsky tied the influence of collective human reason on the planet to his foundational work on biogeochemical processes, denoting a direct transition from the biosphere to the noösphere, whereas Teilhard, a geologist, Jesuit priest and cosmic mystic, represented a more transcendental conception in which the rise of Mind as a geological force was part of a general cosmogenesis. See the discussion in Hamilton and Grinevald (2015). Edouard Le Roy, the philosopher and close friend of Teilhard, was the first one to put the term noösphere into print.

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