

FOREWORD TO *EARLY MODERN GEOLOGICAL AGENCY*¹

TINA ASMUSSEN¹ and PIETRO DANIEL OMODEO²

1. *German Mining Museum, Bochum*
tina.asmussen@bergbaumuseum.de

2. *Ca' Foscari, University of Venice*
pietrodaniel.omodeo@unive.it

This thematic issue responds to the growing demand for ‘more history’ on the part of the earth sciences and environmental politics. The impending climate crisis—the iconic images of which range from the melting poles to the drowning water-city of Venice and the burning of Brazilian and Australian forests—creates a broad, heavily debated and politically explosive field of *science in action*. Current studies at the crossroads of the natural sciences, the social sciences and the humanities, which run under the label of ‘Anthropocene’, reflect on the origins of the human induced environmental disaster we live in. The term is a neologism coined by Paul Crutzen and Eugene Stoermer; it stems from geology and originally referred to a possible new geological epoch, after the Holocene, in which humankind has become a major geological force that is transforming the planet in visible and fundamental ways.²

Within the last two decades, the Anthropocene debate has become widely employed and heavily discussed far beyond academia. Its impact cannot be restricted to any disciplinary boundary, as is witnessed by its mounting scientific, cultural and political significance. Different disciplinary cultures have brought forward diverse theses about the genesis of the Anthropocene. While many argue for the second half of the twentieth century (Steffen *et al.* 2015), some point instead to the Industrial Revolution in the eighteenth century (Crutzen and Stoermer 2000, pp. 17–18; Malm 2016), the colonial ventures in early modernity (Lewis and Maslin 2015; Brooke and Otter 2016), or to the beginning of human civilization, as a consequence of settling down and agriculture (Ruddiman 2003, 2013; Ellis *et al.* 2013). The exact determination of the relevant turning point is still debated as much as the main causes, although there is a growing consensus among geologists that it ought to be located in the mid-twentieth century, at the inception of the so-called “Great Acceleration” (Steffen 2015). Critics of the Anthropocene concept point to the teleological narrative on which this geo-history builds, in which history is presented as a static and deterministic sequence of earth ages, ending with an era dominated and controlled by an undifferentiated human species. This teleological success story is powered by groundbreaking technological inventions (the steam engine, atomic bomb, etc.) and the discoveries of outstanding scientists.³

The essays that are here collected address this timely topic from an early modern point of view and build on recent work that aims to historicize the Anthropocene (Bonneuil and Fressoz 2016; Davies 2016). They also benefit from perspectives that unravel the multi-layered socio-technical and political-economic dynamics as well as the complex belief systems, which together shape and propel the rather abstract unit of an ‘earth system’. Historicizing the Anthropocene is meant to shed light on the many different institutions, social groups, technologies and belief-systems that power the broad concept of Anthropocene.

In spite of some ambivalence, this concept offers an attractive heuristic tool because it brings humans, matter, time, and history to the center of the natural discourse. The problem of the incommensurable commensurability of historical time and geological time—or the problem of

¹ doi: 10.17704/1944-6187-39.2.363

² The reference paper is Crutzen and Stoermer (2000). As with all neologisms, the Anthropocene concept has a history that goes far beyond Crutzen and Stoermer (see Davis 2016).

³ For a more detailed critique on the narratives of the Anthropocene, see Bonneuil (2015); Bonneuil and Fressoz (2016, pp. 47–99); LeCain (2015); and Davies (2016, pp. 53–56).

reinterpreting the records of human past against the background of ‘deep time’—has come to the fore after the two *temporalities* reached a synchronic moment of convergence at our entrance into an epoch, the ‘rhythms’ of which (to use a Bourdieusian expression)⁴ are both social and geological.⁵ From these geological and historical temporalities further scientific and methodological questions arise. Most importantly, how can we make the collaboration between the natural sciences and cultural studies fruitful, if the respective epistemological premises are so different? The prototypical natural scientist and cultural scholar address the same object of inquiry (say, the environment) with very different disciplinary lenses (or ‘epistemic values’);⁶ an epistemology of objectivity and quantitative measurement, in the former case, and one of subjectivity and historicity, in the latter. The question of how the perspectives of those who look at the earth and the environment as natural phenomena, and those who look at them as cultural products, can be harmonized and unified is far from settled.⁷ In order to find alternative ways to address and perhaps solve these problems, we here look back at times and scientific cultures, such as the European Renaissance, in which our modern divide between nature and culture operated differently and was seen as a continuum rather than as a division.⁸

The geo-anthropology of tomorrow—a science that is apt to deal with the outlined challenges—will have to overcome the epistemological and disciplinary divides of the *two cultures* (classically, the separation of *Naturwissenschaften* and *Geisteswissenschaften*), and be able to operationalize concepts and results that have so-far been linked to distinct (if not openly antagonistic) viewpoints.⁹ We consider the problem of ‘agency’ as a crucial instance in this debate. In fact, this concept relates to the human sphere of intersubjective exchange and collective praxis while pointing to the objective causes of natural change.¹⁰ Both subjective and objective elements are involved in the concept of agency from the viewpoint of the Anthropocene, just as they were connected in the early-modern vistas which we explore in this thematic issue. The human capacity to know, dominate, and transform the world was at the center of the scientific and philosophical culture of that time, when early-modern Europe became the stage of a process of societal transformation both in extension, through colonial globalization, as well as in intensity, through the implementation of Capitalist modes of organization of society and exploitation of human labor and natural resources.¹¹ However, all interventions into the natural world led to numerous consequences or side effects: the more humans transformed landscapes and produced, manufactured, exchanged or consumed resources, the more they also became increasingly

⁴ According to Bourdieu, time is not an empty and neutral container of social and historical events but rather a rhythm. Societies are marked by plural rhythms and temporalities which, at times, get synchronized, particularly in moments of change. Bourdieu used this concept to explain the political and cultural movement of the ‘68 but its use can be extended to other cases including, as we suggest, the problem of the Anthropocene’s temporalities. Bourdieu (1979, pp. 27–28): “The social order is first of all a rhythm, a tempo”. We are thankful for this reference to Gerardo Ienna, who shared with us his conference talk, “Bourdieu: how to write historical epistemology from below” delivered at the 9th conference of the *European Society for the History of Science*, Bologna/online, 31 August–1 September 2020.

⁵ On the new alliance of history and geology, see D. Chakrabarty (2009). For a critique of the scientist and alienating risks of substituting human history for deep history, see P. Chakrabarti (2020/in press). On the problem of multiple temporalities, see Morfino and Thomas (2018).

⁶ We take this expression, originally stemming from feminist epistemology, in a broader sense, here following the reworking in Daston and Galison (2007). One could alternatively refer to the epistemological dichotomy in (neo-) Kantian terms as a problem of changing *a priori* (Friedman 2001) or, more colloquially, as ‘paradigms’ (Kuhn 1962) or ‘styles of thought’ (Fleck [1935]; cf. Hacking (1992)).

⁷ The so-called ‘Science Wars’ of the 1990s witness the mutual suspicion between internalist and sociological interpretations of science (cf. Segerstråle (2000)).

⁸ For Renaissance climate theories and the aspect of nature-culture divide, see Miglietti (2020).

⁹ For a recent positioning on the two-cultures divide as was canonized by Charles Percy Snow, see Bod (2013).

¹⁰ Schematically, we could say that we need to reassess Habermasian insights on communicative action with Gramscian ideals of cultural collective praxis in a materialist perspective that unites the subjectivity of the knower with claims of ‘stronger objectivity’—according to Sandra Harding’s standpoint (Harding 1986, 1993). For an attempt in this direction, see Omodeo (2019, p. 138).

¹¹ For important insights on early-modern political and economic globalization one can still refer to Braudel (1973). See also Renn (2012). On the historical roots of the Baconian theme of knowledge as world domination, see Omodeo (2020).

entangled with and dependent on nature through their bodily and mechanical work and maintenance.¹² Humans and nature stood in a dynamic relationship with their environment through specific forms of practice and politics.

We here use the expression ‘geological agency’ to address a cross-disciplinary problem, one that trespasses the boundaries between the natural sciences and humanities and rearticulates them within ongoing geo-anthropological debates. The Anthropocene merging of perspectives stemming from geo-history and human history forces us to reassess human agency beyond the cultural (political, social, economic) and even the biological realms.¹³ The geological dimension of human action cannot be neglected anymore as, according to the new predicament, the earth system is not a neutral background for human history. Rather, it constitutes the entanglement of human-natural coevolution (Renn 2020). In consideration of the enlarged scope of collective activity mediated by technology and science, scholars in science studies have gone so far as to challenge the idea that agency should be restricted to human practice and proposed a broader concept understood as embodied, materially mediated arrays of human activity. This activity involves knowledge, imagination, and passions. Pamela H. Smith has very much contributed to opening up this perspective. She has convincingly argued for an embedded understanding of human action and material imaginaries within a widespread culture of making. Her studies show that material knowledge does not arise in a disembodied world of ideas. Rather, its producers, and also the production processes, are situated within very concrete social, spatial, material, religious, political, and economic contexts (Smith 2004, 2014). For us this line of thought is crucial in order to conceptualize the multi-layered connections between the human body and the geophysical environment.

Some scholars have called for a ‘redistribution of agency’, a consequence of which is to bestow quasi-anthropomorphic attributes on natural beings and the earth.¹⁴ We especially refer to Bruno Latour’s attempt to revive the ancestral subjectivity of Gaia, the earth goddess. This attempt reintroduced ‘subjectivity’ into the discussion about our planet but alienates it from humankind in order to allot it to an anthropomorphized nature. The main inconvenience of such a perspective is that it obliterates the prescriptive ethico-political dimension of the Anthropocene debate while fostering passivity and fatalism *vis-à-vis* the unfolding of natural-societal developments.¹⁵ By contrast, in view of the socio-political relevance of the geo-environmental problem, we deem an exploration of early modernity to be beneficial, as it offers us instances of different scientific cultures that are not too far from contemporary outlooks. By making us aware of the historicity of our knowledge, our reconstructions invite us to embrace a responsible epistemological attitude that, by looking at the genesis of our knowledge society, reflects on the consequences of science and technology.¹⁶

In spite of the ostensible novelty of these debates, the idea of geological agency has historical roots that are worth investigation in the light of the concerns of the present. Large transformative projects of the natural environment were launched and accomplished from antiquity to the early-modern period: just think of the high (or rather, *deep*) environmental impact of such pervasive human activities as the management and redistribution of water resources, landscape engineering,

¹² On the aspect of human-thing entanglement see Hodder (2012).

¹³ In historical epistemology, problems of biological normativity and technology were addressed by Canguilhem long before the emergence of the Foucaultian and post-Foucaultian debates on bio-politics. See Canguilhem (1937) and Esposito (2008). Thanks to Giulia Gandolfi for the Canguilhem reference. For a recent criticism of Esposito’s ‘Italian’ theory, see Portinaro (2018).

¹⁴ From Latour (2014, p. 13): “Through a complete reversal of Western philosophy’s most cherished trope, human societies have resigned themselves to playing the role of the dumb object, while nature has unexpectedly taken on that of the active subject!”

¹⁵ For a political criticism of Latour’s ‘anthropology’ of science, especially see Mirowski (2017) and Henning (2020). For some ideas on the apocalyptic tones of some strands of the Anthropocene debate, see Omodeo (2017).

¹⁶ John Bernal pioneered this sort of consideration; see, among others, Bernal (1946). One could trace the related debates to reflect on an emancipatory culture of science back to Marcuse, on whose legacy in the current debates in Science and Technology Studies (STS), see Feenberg (2017).

and mining.¹⁷ Moreover, geological explanations based on an anthropomorphic understanding of terrestrial processes were widespread in pre-modern and early-modern scientific paradigms, most notably in Renaissance vitalism.¹⁸ This thematic issue explores early-modern geological agency in both references: to humans as geological agents and to anthropomorphic visions of geological processes.

A particularly important lesson to be drawn from early modernity, we believe, is that the comprehension of the earth and geo-environmental policy has never been a purely technical issue. It is not a matter of abstract problem-solving, since our knowledge and means of intervention are always rooted in concrete social and cultural settings that constitute the insurmountable horizon of real possibilities. As cultural historians of science we do not look at the past of the earth sciences in terms of a history of ideas that can be insulated from the societal contexts from which it emerges, relates to, and transforms. In other words, the material settings of geological knowledge and action are of paramount importance to us. Among the realms of the early-modern geological culture we here investigate, religion and theology still played important roles as they were integral parts of the epistemic values of emerging theoretical practices while theology inspired basic concepts of the natural discourse that ranged from the most abstract problem of defining space, time and force, to problems of cosmological order and geology.¹⁹ In her essay, **Sara Miglietti** deals with the case of the eighteenth century Swiss naturalist Johann Jakob Scheuchzer and shows how his anthropology, theology, and natural philosophy were tightly entangled. He presented nature not as an ‘incorruptible’ whole designed by God, but as complex and interconnected entity. In his lavishly illustrated book *Physica Sacra* (1731–1735), Scheuchzer used the Bible to develop an ecological theology that was sensitive to the challenges of human agency in creation. With her close reading of Scheuchzer’s work Miglietti offers a nuanced view on the wide range of perceptions of nature and human agency by eighteenth century naturalists.

Whether the Gaia-discourse can be seen as a renewed form of religious thinking in present-day Anthropocene debates is one of the topics that we specifically address in this issue. **Jonathan Regier** stresses the longevity and power of analogies such as James Lovelock’s affinity for the metaphor of the earth as a revenging animal, rather than a goddess as the pagan name of Gaia evokes (Lovelock 2006, p. 21). He specifically looks at early modern views on terrestrial agency in a cosmological framework, especially according to neo-Platonic and Ficinian insights by Giordano Bruno and Johannes Kepler. In their conceptions, terrestrial agency solved fundamental problems, both physical and metaphysical. As this was an embedded component of their conceptual architectures, Regier asks, would a program like Latour’s resuscitation of Gaia work, if terrestrial agency did not figure in what Kuhnians call ‘normal science’, if it could not be made to solve problems in the sciences of ecology and climate? The idea of Gaia looks rather like an assertion of divine will and a projection of current fears for Her *revenge* as a reaction to our techno-scientific action.

Apart from the ‘spiritual’ drivers of the Anthropocene, we investigate the socio-economic reasons for human transformations of the world, for instance in connection with mining. In her analysis of the sixteenth century German mining industry, **Tina Asmussen** shows that it is important to approach the subject of economy and human transformative powers not just as an objective effect of rational and mechanistic factors, but as the interaction of choices, worldviews and passions. Her article critically reviews the utilitarian and anthropocentric view of mineral resources dominated by economic and technological reasoning and argues for a dynamic and more holistic approach to resources as socio-natural entities consisting of material, symbolic, epistemic,

¹⁷ Maffioli (1994), Ciriaco (2006), Mukerji (2009), Maffioli (2010), Luzzini (2016), Miglietti and Morgan (2017), Ash (2017).

¹⁸ Merchant (1980), Bredekamp (1981), Daston (1995). We speak of vitalism in the sense of a conception of nature as a living whole of which humans are an integral part, that is, more loosely than according to the later codification of vitalism in connection to the life sciences after the emergence of mechanism, cf. Wolfe (2019).

¹⁹ Hessen was a pioneer in his discussion of the religious motives in Newton’s scholia on space and time. See Hessen ([1931] 2009). The classical reference work on religious ethics and science is Merton (1938). Copernican astronomy is prototypical of religious-scientific controversies and the secondary literature is immense. We here limit ourselves to two recent publications: Westman (2011) and Omodeo (2014).

political, and discursive dimensions. Without reviving *passé* forms of economic mono-causal explanations of societal and scientific developments, she deems it useful to reconsider economy as a cultural phenomenon that is crucial for the comprehension of the geo-anthropoc interaction. It concerns interests and Capitalist modes of exploitation as well as the actors' perceptions of these interests, natural resources and environmental change as well as their emotions and cognitive dimensions.

In connection with this outlook, we reconsider the *ideological* role of theories and philosophies in justifying, fostering and redirecting the emerging reality of a modern techno-scientific world. Carolyn Merchant's seminal work, *Death of Nature* (1980), argued that Nature was degraded during the Scientific Revolution from a living and fertile organism into a passive resource, that can be explained, mastered and exploited. However, a closer look at the perception of nature in the eighteenth- and nineteenth centuries shows that the vision of a living planet was in fact never completely abandoned (Fressoz 2015, p. 76). **Francesco Luzzini's** article shows that theories of metallic generation which were expressed by organic metaphors such as 'seeds', 'matrices', and 'nourishment', remained central and recurrent issues for natural philosophers, technicians, alchemists and practitioners throughout early modern Europe until far into the nineteenth century. Stressing the continuities of organic and vitalistic models rather than paradigm shifts from organic to mechanistic perceptions of nature, sheds new and much needed light on how our perception of natural exploitability, renewability, and exhaustibility changed through the centuries up to its current form.

Far from the simplistic/deterministic accounts of the past, we do not think that historical evidence shows a univocal connection between the emergence of mechanic natural philosophy and androcentric Capitalist exploitation of humans and resources. Rather, the sources that are at the basis of our historical reconstruction, show that Renaissance vitalistic conceptions could be mobilized towards dominance, alienation, and devastation, similar to later hegemonic philosophies. Hence, the question of the link between science-philosophy and political-economic interests needs to be reformulated in terms of a historicized *Ideologiekritik* that considers the varying functions that ideas (sometimes the very same ideas) assume. A much more complex pattern of intellectual history will thence emerge, in which mechanism did not always coincide with exploitation and alienation, while vitalism did not always coincide with harmony visions and ecological attitudes.

This remark also opens up our contributions to the 'Capitalocene' debate, the question of whether we should call the new epoch differently, in order to bring to the center of the discussion on technology, climate and the earth the most important factor behind the dynamics of today's humanity.²⁰ The Anthropocene is not only the consequence of industrial modes of Capitalist production. Alternative socio-economical models have emerged in the past, such as the societal formations of early modernity or, more recently, the competing geopolitical models of the "short twentieth century" (Hobsbawm 1994), which also contributed to the alteration of our globe in an irresponsible manner. Similarly, one cannot predict that the solution of the most urgent problems that are raised by our present form of civilization will coincide with the end of Capitalism. In line with Dipesh Chakrabarty, we argue that the human capacity to transform the world was not always a capitalistic endeavor nor is its future necessarily linked with a specific socio-economical form (Chakrabarty 2009, p. 212). Thus, we think that it is historically and conceptually useful to keep the two concepts of Capitalism and Anthropocene apart, in order to productively reflect on the interconnections of economic structures and geo-environmental problems, thereby avoiding diagnoses that are too simplistic.

One more insight we gain from our early-modern predecessors is the imperative to connect the various levels of knowledge, that of our earth with that of its surrounding cosmos. The attitude of treating problems of geology, hydrology, the environment and society in close connection with cosmic cycles is typical of the Renaissance but can still stand out as a form of actively

²⁰ For Jason Moore, one of the most prolific authors advocating for the Capitalocene instead of the Anthropocene, the new geological age started with the rise of capitalist civilization around 1450 that increasingly turned nature into a resource (cheap nature) which formed the preconditions for the current crisis (Moore 2013, 2016; see also Haraway 2015; Malm 2016, p. 391).

encompassing abstract knowledge. The hydrogeological controversies on the maintenance of the lagoon of Venice in the Renaissance are a case in point. **Pietro Daniel Omodeo, Sebastiano Trevisani** and **Senthil Babu** engage in an interdisciplinary inquiry into a scientific controversy between the Galilean mathematician Benedetto Castelli in opposition to local Venetian experts of water management in the seventeenth century. The opposing parties offered different assessments of the state of the lagoon and the measures that were needed to preserve it. They also disagreed on what forms of knowledge were the most apt for this task and pitted different models of scientific thought against each other, one resting on physico-mathematical abstraction against one oriented towards cosmos-bounded geo-environmental complexity. The underlying cosmological thought did not rest in the identification of general laws, such as those of physics, but implied a reflection on the contingent reality *as it is* and the nature of the concrete whole. We can call it a form of ‘concrete universal thinking’, an attitude that is still much needed in theory and practice, both for scientific system thinking as well as to achieve the very demanding eco-political goal of connecting local action with global problems.

ACKNOWLEDGEMENTS

Pietro Daniel Omodeo would like to acknowledge the European Research Council and the Italian Ministry of Education, University and Research for funding his research in the framework of the consolidator grant *EarlyModernCosmology* (ERC Horizon 2020, GA 725883) and the FARE grant *EarlyGeoPraxis* (R184WNSTWH). Tina Asmussen thanks the Swiss National Science Foundation (SNSF) for funding her research with an *Ambizione* grant as well as Michael Hagner and his team at the Chair for Science Studies at ETH Zurich for the inspiring research atmosphere and the support during the last years. We are thankful to the Anthropocene working group that Jürgen Renn leads at the Max Planck Institute for the History of Science (Berlin) for intellectual exchange, insightful suggestions and support throughout the years.

REFERENCES

- Ash, Eric. 2017. *The Draining of the Fens. Projectors, Popular Politics, and State Building in Early Modern England*. Baltimore: Johns Hopkins University Press.
- Bernal, John Desmond. 1946. *The Social Function of Science*. London: George Routledge & Sons.
- Bod, Rens. 2013. *A New History of the Humanities: The Search for Principles and Patterns from Antiquity to Present*. Oxford: Oxford University Press.
- Bonneuil, Christophe, and Fressoz, Jean-Baptiste. 2016. *The Shock of the Anthropocene: The Earth, History and Us*. London: Verso.
- Bonneuil, Christophe. 2015. The geological turn: Narratives of the Anthropocene. In: *The Anthropocene and the Global Environmental Crisis. Rethinking Modernity in a New Epoch*, edited by Christophe Bonneuil, Clive Hamilton, and François Gemenne, 17–31. London: Routledge.
- Braudel, Fernand. 1973. *Capitalism and Material Life: 1400 – 1800*. New York: Harper and Row.
- Bredenkamp, Horst. 1981. Die Erde als Lebewesen. *Kritische Berichte*, 9(4–5): 5–37.
- Brooke, John L., and Otter, Christopher. 2016. Concluding remarks: The organic Anthropocene. *Eighteenth Century Studies* 49(2): 281–302.
- Canguilhem, Georges. 1937. Descartes et la technique. *Travaux du IXe Congrès International de Philosophie* 2: 77–85.
- Chakrabarty, Dipesh. 2009. The climate of history. *Critical Inquiry* 35(2): 197–222.
- Chakrabarti, Pratik. 2020/in press. *Inscriptions of Nature: Geology and the Naturalization of Antiquity*. Baltimore: Johns Hopkins University Press.
- Ciccotti, G., Cini, M., and De Maria, M. 1976. The production of science in advanced capitalist society. In: *Ideology of/ in the Natural Sciences. Vol. 1*, edited by Hilary Rose and Steven Peter Russell Rose, 32–58. London: Macmillan.
- Ciriacono, Salvatore. 2006. *Building on Water: Venice, Holland and the Construction of the European Landscape in Early Modern Times*. New York-Oxford: Berghahn Books.
- Crutzen, Paul J., and Stoermer, Eugene F. 2000. The “Anthropocene”. *Global Change Newsletter* 41: 17–18.
- Daston, Lorraine. 1995. How nature became the other: Anthropomorphism and anthropocentrism in early modern natural philosophy. In: *Biology as Society, Society as Biology: Metaphors*, edited by Sabine Maasen, Everett Mendelsohn, and Peter Weingart. Special issue of *Sociology of the Sciences* 18: 37–56.

- Daston, Lorraine, and Galison, Peter. 2007. *Objectivity*. New York: Zone Books.
- Davies, Jeremy. 2016. *The Birth of the Anthropocene*. Oakland: University of California Press.
- Ellis, E. C., Kaplan, J. O., Fuller, D. Q., Vavrus, S., Klein Goldewijk, K., and Verburg, P. 2013. Used planet: A global history. *Proceedings of the National Academy of Sciences of the United States of America* 110(20): 7978–7985.
- Esposito, Roberto. 2008. *Bios: Biopolitics and Philosophy*. Minneapolis: University of Minnesota Press.
- Feenberg, Andrew. 2017. Critical theory of technology and STS. *Thesis Eleven* 138(1): 3–12.
- Fleck, Ludwik. [1935] 2012. *Entstehung und Entwicklung einer wissenschaftlichen Tatsache: Einführung in die Lehre vom Denkstil und Denkkollektiv*. Frankfurt/Main: Suhrkamp.
- Fressoz, Jean-Baptiste. 2015. Loosing the Earth knowingly. Six environmental grammars around 1800. In: *The Anthropocene and the Global Environmental Crisis. Rethinking Modernity in a New Epoch*, edited by Christophe Bonneuil, Clive Hamilton, and François Gemenne, 70–83. London: Routledge.
- Friedman, Michael. 2001. *Dynamics of Reason: The 1999 Kant Lectures at Stanford University*. Stanford: CSLI Publ.
- Gaukroger, Stephen. 2006–2020. *Civilization and the Culture of Science. Science and the Shaping of Modernity*, 4 vols. Oxford: Oxford University Press.
- Hacking, Ian. 1992. ‘Style’ for historians and philosophers. *Studies in History and Philosophy of Science* 23(1): 1–20.
- Haff, Peter K. 2013. Technology as a geological phenomenon: Implications for human well-being. In: *A Stratigraphical Basis for the Anthropocene*, edited by C. N. Walters et al. Geological Society Special Publications 395: 301–309.
- Haraway, Donna. 2015. Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making kin. *Environmental Humanities* 6: 159–165.
- Harding, Sandra. 1986. *The Science Question in Feminism*. Pittsburgh: Cornell University Press.
- Harding, Sandra. 1993. Rethinking standpoint epistemology: What is ‘strong objectivity’? In: *Feminist Epistemologies*, edited by Linda Alcoff and Elizabeth Potter, 49–82. New York: Routledge.
- Henning, Christoph. 2020. The politics of nature, left and right: Comparing the ontologies of Georg Lukács and Bruno Latour. In: *Georg Lukács and the Possibility of Critical Social Ontology*, edited by Michael J. Thompson, 289–317. Leiden: Brill.
- Hessen, Boris. [1931] 2009. The social and economic roots of Newton’s *Principia*. In: *The Social and Economic Roots of the Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann*, edited by Gideon Freudenthal and Peter McLaughlin, 41–102. Dordrecht: Springer.
- Hobsbawm, Eric J. 1994. Age of extremes: The short twentieth century (1914–1991). London: Joseph.
- Hodder, Ian. 2012. *Entangled: An Archaeology of the Relationships Between Humans and Things*. Malden: Wiley-Blackwell.
- Kuhn, Thomas S. 1962. *The Structure of Scientific Revolutions*. Chicago: The University of Chicago Press.
- Latour, Bruno. 2014. Agency at the time of the Anthropocene. *New Literary History* 45(1): 1–18.
- LeCain, Timothy. 2015. Against the Anthropocene: A neo-materialist perspective. *International Journal for History, Culture and Modernity* 3(1): 1–28.
- Lewis, Simon L., and Maslin, Mark A. 2015. Defining the Anthropocene. *Nature* 519: 171–180.
- Lovelock, James. 2006. *The Revenge of Gaia: Why the Earth is Fighting Back – and How We Can Still Save Humanity*. London and New York: Penguin.
- Luzzini, Francesco. L’Itale Terre a vagheggiare inteso. La regolazione dell’Adige nel XVIII secolo. In: *Il fiume, le terre, l’immaginario: L’Adige come fenomeno storiografico complesso*, edited by Vito Rovigo, 287–312. Rovereto: Osiride.
- Maffioli, Cesare Sergio. 1994. *Out of Galileo: The Science of Waters (1628–1718)*. Rotterdam: Erasmus Publishing.
- Maffioli, Cesare Sergio. 2010. *La via delle acque (1500–1700): Appropriazione delle arti e trasformazione delle matematiche*. Florence, Olschki.
- Malm, Andreas. 2016. *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming*. London: Verso.
- Merchant, Carolyne. 1980. *The Death of Nature: Women, Ecology and the Scientific Revolution*. San Francisco: Harper & Row.
- Merton, Robert K. 1938. Science, technology and society in seventeenth century England. *Osiris* 4: 360–632.
- Miglietti, Sara. 2020. Between nature and culture: The integrated ecology of Renaissance climate theories. In: *Early Modern Écologies: Beyond English Ecocriticism*, edited by Pauline Goul and Phillip John Usher, 137–158. Amsterdam: Amsterdam University Press.
- Miglietti, Sara, and Morgan, John (eds.). 2017. *Governing the Environment in the Early Modern World: Theory and Practice*. New York: Routledge.

FOREWORD TO *EARLY MODERN GEOLOGICAL AGENCY*

- Mirowski, Philip. 2017. What is science critique? Lessing, Latour. In: *The Routledge Handbook of the Political Economy of Science*, edited by David Tyfield *et al.*, 429–450. Abington, Oxon and New York: Routledge.
- Moore, Jason W. 2013. Anthropocene, Capitalocene and the Myth of Industrialization, Part II: From Geology to Geohistory in the Capitalist World-Ecology, online: www.jasonmoore.wordpress.com
- Moore, Jason W. (ed.). 2016. *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism*. Oakland, CA: PM Press.
- Morfino, Vittorio, and Thomas, Peter D. (eds.). 2018. *The Government of Time: Theories of Plural Temporality in the Marxist Tradition*. Leiden-Boston: Brill.
- Mukerji, Chandra. 2009. *Impossible Engineering: Technology and Territoriality on the Canal du Midi*. Princeton: Princeton University Press.
- Omodeo, Pietro Daniel. 2014. *Copernicus in the Cultural Debates of the Renaissance: Reception, Legacy, Transformation*. Leiden: Brill.
- Omodeo, Pietro Daniel. 2017. The politics of apocalypse: The immanent transcendence of Anthropocene. *Stvar - Časopis za teorijske prakse* 9: 433–449.
- Omodeo, Pietro Daniel. 2019. *Political Epistemology: The Problem of Ideology in Science Studies*. Cham: Springer.
- Omodeo, Pietro Daniel. 2020. Scientific Revolution, Ideologies of the. In: *Encyclopedia of Early Modern Philosophy and the Sciences*, edited by Dana Jalobeanu and Charles T. Wolfe, 1–10. Springer Online.
- Portinaro, Pier Paolo. *Le mani su Machiavelli: una critica dell' "Italian Theory"*. Rome: Donzelli.
- Renn, Jürgen. 2012. *The Globalization of Knowledge in History*. Berlin: Edition Open Access.
- Renn, Jürgen. 2020. *The Evolution of Knowledge: Rethinking Science for the Anthropocene*. Princeton: Princeton University Press.
- Ruddiman, William F. 2003. The Anthropogenic greenhouse era began thousands of years ago. *Climate Change* 61(3): 261–293.
- Scheuchzer, Johann Jakob. 1731. *Physica sacra... iconibus aeneis illustrata*, volume 1. Augsburg and Ulm: Johannes Andreas Pfeffel.
- Scheuchzer, Johann Jakob. 1732 *Physica sacra... iconibus aeneis illustrata*, volume 2. Augsburg and Ulm: Johannes Andreas Pfeffel.
- Scheuchzer, Johann Jakob. 1733 *Physica sacra... iconibus aeneis illustrata*, volume 3. Augsburg and Ulm: Johannes Andreas Pfeffel.
- Scheuchzer, Johann Jakob. 1735. *Physica sacra... iconibus aeneis illustrata*, volume 4. Augsburg and Ulm: Johannes Andreas Pfeffel.
- Segerstråle, Ullica (ed.). 2000. *Beyond the Science Wars: The Missing Discourse About Science and Society*. Albany: State University of New York.
- Smith, Pamela H. 2014. The matter of ideas in the working of metals in early modern Europe. In: *The Matter of Art: Materials, Practices, Cultural Logics, c. 1250–1750*, edited by Christy Anderson, Anne Dunlop, and Pamela H. Smith, 42–67. Manchester: Manchester University Press.
- Smith, Pamela H. 2004. *The Body of the Artisan: Art and Experience in the Scientific Revolution*. Chicago: University of Chicago Press.
- Steffen, Will *et al.* 2015. The trajectory of the Anthropocene: The great acceleration. *The Anthropocene Review* 2(1): 1–18.
- Trischler, Helmuth. 2016. The Anthropocene: A challenge for the history of science, technology, and the environment. *NTM* 24(3): 309–335.
- Westman, Robert S. 2011. *The Copernican Question: Prognostication, Skepticism, and Celestial Order*. Berkeley: University of California Press.
- Wolfe, Charles. 2019. *La philosophie de la biologie avant la biologie: Une histoire du vitalisme*. Paris: Classiques Garnier.