Chapter 4
Geology and Knowledge Culture

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The result, therefore, of our present enquiry is, that we find no vestige of a beginning—no prospect of an end.
James Hutton

Abstract Since its creation in the late nineteenth century the research university has treated geology as a regional ontology—as one more body of knowledge alongside the other disciplines. The imperatives of the twenty-first century suggest that this needs to change. The purposes of knowledge production reflect the goals of a culture; as those goals change so should the nature of knowledge production. As sustainability becomes the overarching goal of all our efforts our knowledge culture needs to reflect this fact. This implies that geology should become the framework for all knowledge production, facilitating the birth of a new society of maturity and limit.

Keywords Interdisciplinarity · Deep time · Critical university studies · Philosophy of geology · Sustainability

4.1 Introduction

The modern research university treats geology as a science. Geology forms one more element within the horizontal taxonomy of the disciplines, neither higher nor lower nor more central than any other field. Geology obeys the ontology of the academy, where subjects occupy discrete domains within either the natural sciences, the social sciences, or the arts and humanities.

This view is mistaken about both geology and the nature of knowledge. Of course, geology is a science. But it is also an inter- and transdisciplinary field that overturns the theoretical assumptions of the university. Geology is the domain of deep time, the integrative element of the sciences, and the foundation of a sustainable worldview.

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At its furthest extent, geology provides us with the framework of a general theory of limit and a roadmap for restructuring our social norms.

Today we appreciate the permeability of disciplinary boundaries. We understand that disciplines leak into one other. But geology goes further: it exposes the limits of a disciplinary approach to knowledge. As Earth systems science, geology encompasses the other sciences. It frames our lives within new and critically important historical perspectives. Its insights raise pressing social, ethical, and metaphysical issues. Geology has long functioned as helpmate to industrial society, supplying minerals and energy to sustain the status quo. In the twenty-first century its main role should shift to facilitating the birth of a new society of maturity and limit.

4.2 Current Efforts

In recent years a group of geologists have sought to draw out the larger implications of geology. They have done so via the concept of geoethics (e.g., Peppoloni & Di Capua, 2015). These thinkers are motivated by the fact that the relation between humans and the planet they inhabit has fundamentally altered. This realization also lies behind other attempts to describe the challenge before us, for instance, in discussions concerning the naming of a new geologic era called the Anthropocene.

The challenge facing these efforts is to generate a conceptual response adequate to the imperatives of a new period in human history. This is no small task. I view this challenge in terms of breaking our addiction to growth and ushering in an age organized around the concept of maturity. The changes this implies would be profound: shrinking the world's population, halting the endless expansion of the economy, tempering our Faustian scientific impulses, setting aside some of our toys, and recognizing the necessity and beauty in limit.

This view presents two challenges to geoethics. First, while Peppoloni and Di Capua emphasize the conceptual breadth of geoethics, the term threatens to limit the influence that geological thinking should have on society. This reflects a bias within culture at large where ethics is the sole philosophic category worth attending to. Just as the science of geology is understood to encompass all of Earth system science (the lithosphere, hydrosphere, biosphere, etc.), a wider notion of geoethics should involve all areas of philosophy (esthetics, metaphysics, political philosophy, etc.), the arts and humanities generally, as well as the policy dimensions of its insights.

Second, the task before us is both larger and more fundamental than simply drawing out the cultural dimensions of the Earth sciences. Geology reveals the theoretical and institutional limitations of the modern knowledge enterprise as it is embodied in our universities. Properly understood, geology offers a pervasive critique of the epistemic status quo. It challenges the way we have defined the knowledge enterprise over the last 150 years. It critiques the aims and structure of the modern research university and the society that it serves.

At its furthest extent, geology should join hands with the more general project of rethinking the nature of modern culture (Frodeman, 2014, 2019).

4.3 The Huttonian Revolution

Geology dates from the time of Werner and Hutton at the end of the eighteenth century. Philosophy traces its origins back some 2500 years to the persons of Heraclitus and Parmenides, Socrates, Plato, and Aristotle. If we ask whether there is anything substantive that connects the two subjects the first issue that comes up is the concept of time.

Geology (as opposed to mineralogy) was born out of a novel understanding of time. Werner realized that rock units could be defined in terms of time rather than composition, and Hutton intuited the incredible lengths of time represented in the rock record (Laudan, 1987). Then with the discovery of radioactivity early in the twentieth century we were able to put firm numbers on the immensity of Earth history.

The late eighteenth century also saw philosophy being reshaped by temporal perspectives. In 1797 Schlegel coined the term historicism, and soon thereafter Hegel described different philosophical systems not as a series of rejections but as the progressive development of human consciousness across time. In the early twentieth century Heidegger argued that our assumptions about time fundamentally shape our sense of reality. With little or no attention being paid to geologic time, 20th and now 21st-century cultural studies have been deeply historicist in orientation.

Deep time is not the only geological concept that spans the science-humanities divide. Geology contains a rich set of terms that escape disciplinary control—sedimentation, lithification, and metamorphism, uniformitarianism and catastrophism, erosion and angle of repose. But like space (compare the Copernican Revolution), time defines a basic parameter of existence. While taking no notice of geology, Heidegger's masterwork *Being and Time* (1927) placed time at the center of our understanding of reality. As he states in his preface, time is "the possible horizon for any understanding whatsoever of Being." For instance, the Christian idea of an immortal soul presupposes that reality consists of two parts, one of which exists outside the flow of time.

There has been speculation on the cultural implications of geologic time, most commonly by geologists. The conclusion most often drawn is that placing the last few thousand years of human experience against the immensity of geologic time reduces humanity to insignificance. One can just as easily arrive at the opposite conclusion, that the human enterprise is ennobled by being placed within the framework of this stupendous history. In truth, neither narrative takes us very far. Both offer only rudimentary accounts of the impact of geologic time on our self-understanding. They both reduce a multitude of possible insights to a single narrative.

For instance, geologic time is scalar, and so the lessons that we draw will be different at different time scales. From the point of view of the Pleistocene, human culture has developed in the middle of a thaw. But from the perspective of deeper time, we are still in the middle of an Ice Age: there has been permanent ice on the surface for only 7% of the history of the Earth. The implications of geologic time vary depending on the topic, as the geologic record reveals strange creatures, diverse

landscapes, and wide-ranging climates and conditions. For instance, what counts as an exotic species varies by time scale: from the perspective of the last Ice Age 18,000 years ago every species in Yellowstone is an exotic (Pleistocene Yellowstone was buried under an icecap). The rock record also becomes more fragmentary the further back we go even as the planet it reveals becomes weirder.

The points revealed by deep time raise issues that are as much ones of psychology, politics, and culture as of science. Paul Shepard argued that human consciousness needs to be understood against the background of deep time. Not only our body but also our consciousness evolves over time; the modern world of huge cities, artificial light, and constant electronic stimulation has left us permanently off kilter (Shepard, 1982). The awareness of deep time should influence every domain of human and natural history. The crises we face, most notably climate change, demand that we simultaneously think of time in its human and geologic dimensions. This means learning to stretch our awareness across the lags between geologic time and the time scales of everyday existence.

Whether we focus on electronic, human, or geologic scales, time not only entails change; it also implies limit. When Heidegger speaks of human life in terms of being-toward-death (*Sein-zum-Tode*) he is emphasizing that it is through recognizing our finitude that a life of integrity becomes possible. Limits force choices, where we stake a claim and commit to a way forward—or not. Death is the ultimate limit, but life presents us with many other points where something has ended. Ignoring these limits, or pretending that they are not real, is to succumb to a bad infinity—as is our culture's constant demand for new toys.

As Hutton notes, geologic time can seem nearly limitless, stretching back 4.5 billion years and into an indefinite future. But by placing our actions in a larger context geologic time highlights our own particular finitude. The Ogallala aquifer may seem inexhaustible, but we are mining Pleistocene water for the needs of a few decades. A century and a half of burning fossil fuels seems inconsequential until we understand that we are creating an atmosphere last seen in the Miocene. The limits geology points to—of how much carbon and methane we can put into the atmosphere before disaster results, or the point at which continued clearing of the Amazon will turn it from forest to savanna—portend the end of the culture of infinite desire. Geologic knowledge and perspectives imply the need for a new culture of maturity.

4.4 Making Deep Time Intuitive

Humans are short-sighted creatures; long-range planning is a rare accomplishment. Even then, what counts as long-range is measured on human scales. Events involving geologic spans of time—the rate at which lost soils are replaced or a degraded ecosystem reconstitutes itself—are essentially discounted to zero.

Making deep time intuitive will require an innovation in human attentiveness. In *The Genealogy of Morals* (1887) Nietzsche asked how a hairless ape managed to

become human. He argues that the process required more than intelligence and an opposable thumb; human society also depended on the ability to commit to future outcomes. Humans had to develop the capacity to make and keep promises.

Nietzsche argued that a promise became a commitment through the lessons of pain: suffering the consequences of breaking a promise burned future pledges deep into our soul. This gloomy analysis remains relevant today. Acknowledging the existence of environmental limits depends on the capacity of intuitively grasping long stretches of time, where "now" extends beyond the moment to include decades and centuries into the future. Our halting response to the dangers of climate change marks our disregard of the fact that geologic time is also our time.

Our tepid response to the dangers of climate change suggests that Nietzsche is correct: only widespread suffering will motivate culture-wide transformation. Our lack of action will have consequences on the far side of things as well. Few realize that once the climate has changed the new conditions will be irrevocable on human time scales. Absent breakthrough technologies like carbon capture and sequestration the modified climate will be with us for centuries to come: CO_2 remains in the atmosphere on a time scale of centuries.

Nietzsche may be correct about human nature. Nonetheless, it is worth searching for less traumatic ways for extending our temporal horizon. Seeing current events through the lens of deep time should become part of our education from the first years of schooling. I do not mean lessons that focus on representations of geologic time like those that are standard within geology courses (e.g., comparing 4.5 billion years to a calendar year). Rather, we should make geologic time more real through intuitive accounts of one's local surroundings.

I can cite an example from my own work. In 2002, as part of a National Science Foundation-funded project in curriculum development, museum-quality signage was mounted on the outside wall of an elementary school in Boulder, Colorado. The school—Flatirons Elementary—sits at the border of two geologic provinces. The Laramide orogeny rises immediately to the west of the school: the mountains have burst through the sediments of the Cretaceous mid-continental seaway which run for hundreds of miles to the east.

The image below depicts what the area looked like 90 million years ago. Boulder sits at 1650 m/5400 feet of elevation; in the Cretaceous the location was under 760 m/2500 feet of water. The image is attached to a wall facing the school playground, meaning that students are exposed to it daily across their grade school years (Johnson et al., 2005) (Fig. 4.1).

The image comes from a project known as *Ancient Denvers*, a collaborative effort involving geologists and landscape artists funded by the National Science Foundation. The project sought to depict the paleoenvironments of the various strata of the Denver, Colorado area. Scientists collaborated with artists to show landscapes across geologic time, working from the latest science to create accurate and evocative images of the past. The resulting works formed the basis of a 2003 exhibition held at the Denver Museum of Nature and Science.

It is often claimed that geologic spans of time are incomprehensible to a species that lives for less than a century. This sells our imaginative capacities short. Sustained

Fig. 4.1 65 × 52 cm image attached to the outside wall of Flatirons Elementary, with the label: "Boulder, Colorado 90 million years ago." *Ancient Denvers*, 2005

exposure to deep time eventually reshapes one's sense of reality. Evidence of this can be found in the experience of geologists who have spent a lifetime in the field. John McPhee, who coined the phrase "deep time," demonstrates the point across a series of books. *In Suspect Terrain* recounts the comments of a geologist concerning the proposed protection of the Boundary Waters Area in Minnesota. While favoring protection, she likens those lakes to the puddles left after a rainstorm. The lakes are the last remnants of the melting ice sheets: "Another five thousand years and there won't be much to fight about," Anita said, with a shrug and a smile. "Most of those Minnesota lakes will probably be as dry as these in Indiana" (McPhee, 1983).

The point is not to dismiss the protection of the area, any more than we would disregard a broken arm because the person will be dead 100 years from now. Geologic time helps us reframe our challenges so that we can be more strategic in our decision-making.

4.5 Epistemic Assumptions

There is more to be said on the cultural implications of deep time. In fact, the topic deserves its own policy-oriented research program. But set this to one side, for the point of this essay is to survey the overall significance of geology.

Reflection on geologic time should be complemented by attention to the integrative aspects of geology. Geology (or as it is also termed, Earth system science) unites the other sciences. Geoethics, or perhaps better said geophilosophy, should highlight the preeminent goal of all future social policy—tending to the health of the planet that all life depends upon. Doing so will not only raise questions of ethics, value, and policy. It should also underscore how geology challenges the assumptions of

the research university and of contemporary knowledge culture. In contrast to the structure of the contemporary university, knowledge has become hierarchical again. A preeminent value—sustainability—should unite all our epistemic efforts.

Thomas Kuhn argued that most academic work consists of puzzle solving, as researchers strive to make small advances within a disciplinary or sub-disciplinary field. Within these areas there occasionally arise thinkers who challenge the assumptions underlying these research programs. These theorists—the Einsteins or Crick and Watsons of the world—are engaged in radical critique, shifting the paradigm of their field. But Kuhn did not consider the possibility of another level of critique. His paradigm-breakers leave the overall structure and goals of the institution they are housed within intact. Today it is knowledge culture itself that needs a Copernican Revolution.

The modern research university is built on two linked assumptions. First, knowledge is flat: no discipline is viewed as more fundamental than or superior to another. Second, the production of knowledge is an infinite project. There is no end to knowledge production because there is no end to our desires. These two assumptions are so deeply embedded within academic culture and society at large that they are not even subject to debate.

Begin with the first point. Despite increasing attention paid to interdisciplinary approaches, disciplines still dominate the academy. Each operates as a largely separate domain. Clark Kerr, president of the University of California system across the 1950 and 1960s, described the modern university as a "multiversity" serving a vast number of constituencies and interests. The university has no overarching purpose other than the endless pursuit of knowledge. The knowledge it produces has no specific end: it provides a buffet that individuals (or corporations) select from as they see fit.

Compare this with the European medieval university and the American colonial college. Both believed that knowledge had an overall purpose. Knowledge was inherently hierarchical in nature. Individual projects were pursued, and subordinate goals achieved, but there was general agreement about the overall rationale for the institution: education served a religious end.

This was reflected in the structure of these institutions. In the medieval university the division of professors into higher and lower faculties expressed the fact that some types of knowledge were subordinate to others. Within the three higher faculties of medicine, law, and theology formed an ascending order: medicine was concerned with the health of the body, law with the health of the polity, and theology with the health and destiny of our immortal souls. One sign of the non-disciplinary nature of the university was the fact that professors would often move through the different faculties across their career (Clark, 2009).

Similar beliefs characterized the early American college. The senior capstone course in moral philosophy was usually taught by the college president. His role was to pull together the threads of a college education toward overall goals that were both personal and social in nature—one's own salvation and the development of a sense of noblesse oblige, where the fortunate act with generosity toward those less privileged.

The ultimate objective of these institutions was eschatological in nature, the saving of one's own and other's immortal soul. Of course, such a goal today is impossible, at least within public institutions. The question of what constitutes the good life is a private matter, and values are seen as inescapably pluralist in nature. Following social contract theory, politics has been reconstructed to make minimal demands on its citizens, and society now has a libertarian cast.

The restructuring of our knowledge institutions was crucial to the Enlightenment project (and also to the goals of capitalism, which sought profit through innovation). Christian beliefs concerning the *summum bonum* were thrown off as people became free to do as they wish in their lives, subject to minimal conditions. These conditions were codified by John Stuart Mill: people should be free to act however they wish unless their actions caused harm to others.

Few noticed that Mill's argument contained a geological premise. It presupposes the existence of a vast storehouse of resources large enough that their use by one person or group did not affect the prosperity of others. But under conditions of scarcity, one's actions cannot be isolated. The pluralism of contemporary culture, where we treat the existence of irreconcilable differences in life goals as both an inescapable fact and as a virtuous invitation to develop one's individuality, presumes abundance.

The COVID-19 pandemic highlighted the breakdown of Millsian logic: claims that one may choose to not be vaccinated or to wear a mask ignored the fact that these actions inevitably affect others. For scarcity comes in many forms: COVID-19 underlined the scarcity of social space just as the climate crisis demonstrates the lack of sufficient amounts of atmosphere to harmlessly absorb all the carbon dioxide and methane we have been emitting.

Like society, the modern university has been built on a libertarian logic. The smorgasbord approach to knowledge, where its products are treated as a means to whatever ends an individual wants to pursue, assumes a world where we need not consider how inventions or discoveries behave when released within society. The operating assumption, again tacit, is that we can count on all these combinations being benign in their social effects.

Modernity is defined by the development of a libertarian culture whose ever-widening choices are provided by new discoveries in science and technology. Over the last few decades some have predicted the rise of a new, post-modern era. One view sees post-modernity as marking the end of all meta-narratives, those overarching accounts of life that provide a structure for people's beliefs and give meaning to their experience (Lyotard, 1979). The problem with this claim is that humans always reply on some type of meta-narrative, even if it consists of nothing more than the claim that metaphysics is dead and all we have left is physics and our endless desires.

The meta-narrative of modernity has consisted in its belief in progress—the continual satisfaction of our desires through constant innovations in science and technology. Today we are at the cusp of a new meta-narrative where we recognized a common end to society, based not in Christianity or technoscience but in geophilosophy.

4.6 Infinite Knowledge

Turn now to the second premise of the modern research university: the production of knowledge as an infinite task. While never stated, much less debated, this is the norm within every discipline. Except for a few holdouts in the humanities who believe in the idea of a *philosophia perennis*, this view is accepted by everyone across the academy.

Few within the academy realize that this assumption is of recent vintage. In the past people were suspicious of *libido sciendi*, the lust to know. This attitude is still visible in the stories we learn as children, of Icarus, Pandora, Faust, and Frankenstein. As Roger Shattuck (Shattuck, 1997) details, the view was prevalent for millennia, only shifting with the advent of modernity. Immanuel Kant summarized the spirit of modernity when he cited Horace's phrase *sapere aude!*—dare to know. In recent years this view has also become prevalent across the humanities, in the rejection of the idea of a canon of works of perennial value.

Given present circumstances, it is worth asking what premises concerning knowledge production best serve the future of humanity. The answer turns on understanding the place of geologic knowledge—or if you prefer, ecological knowledge with the added perspective of deep time—in the theoretical architecture of the university and in society at large. Earth scientific knowledge is not simply another body of knowledge alongside others. This knowledge, and the societal consequences we draw from it, offers us the outline of a new meta-narrative. Society will still pursue myriad ends. But all of these will need to be checked in terms of their sustainability. This fact should affect the nature of knowledge production and lead to the restructuring of the university as well as the society that it serves.

The assumption of infinite knowledge is connected to the flat and regional nature of the disciplines. Restricting every subject to its own region of being—including philosophy and the humanities, which traditionally had sought to offer a view of the whole—has meant that there has been no organized discussion of the overall purpose of our epistemic efforts. Instead, knowledge production, structured as a group of regional ontologies, has treated knowledge as a means—a rational means to private and often irrational ends. The lack of an end in the sense of limiting knowledge production is a consequence of the lack of end in the sense of there being no overall purpose to knowledge.

At the founding of the research university at the end of the nineteenth century this approach was commendable. We had much to learn in terms of basic health and welfare. A radical pushing of all boundaries made sense to, as Bacon put it, "relieve man's estate." An increasingly detailed focus within each of the sciences served us well. The discoveries made lessened many of the burdens that had long tortured humanity. And our technologies were not so advanced as to raise question of their threatening our well-being.

But the function of knowledge changes over time. The projects and attitudes of one period need to be rethought in another. Within society the pursuit of infinite knowledge has been known as progress. That term has largely been defined in terms

of material and technological development. About 150 years after the founding of the research university this mission remains the same. No distinction is drawn between the pressing needs that have been addressed (e.g., sanitation, striking advances in medicine, and adequate food production) versus the satisfaction of peripheral desires (larger homes, a new app). Nor do we distinguish between satisfying the urges of those in developed countries, whose basic needs have been largely met, versus the situation in those parts of the world still lacking basic services.

Every culture, past and present, makes epistemic efforts. But only one culture has created a system for the continuous production of knowledge to provide an unending stream of (so-called) improvements in our lives. The rational for these efforts seems self-explanatory. For we all want to continue to grow the economy, conquer disease, and address environmental problems.

To state such goals in a piecemeal fashion, as both researchers and the public do, is to make a point that seems irrefutable. Of course, we wanted vaccines to end the pandemic, cleaner sources of energy, and more efficient transportation. The list is as endless as are our desires. But this is to commit the fallacy of composition, the assumption that when the members of a collection all share a property the collection as a whole possesses that property as well. Our individual desires may make sense (some do not, or are trivial, but let that pass). But what happens when they are aggregated? Academics, housed within disciplines, all pursue knowledge of one type or another. But where does this piecemeal process take us when considered as a whole?

Transhumanism provides an answer to this question. Transhumanists approach the knowledge enterprise as a whole, asking about the overall direction of science and technology. Their conclusion is that science and technology are moving us toward a condition of infinite human power. Transhumanists differ on the particularities of how this process will be achieved—perhaps though the physical and cognitive augmentation of our simian bodies, perhaps through a silicon future as artificial intelligence comes to either serve, blend with, or absorb us. But by whichever means, they view the end result as clear: deification.

Transhumanism is typically dismissed as the obsession of a few oddballs. More accurately, transhumanists have revealed the tacit goal of modern culture. Whether judged in terms of capitalism, or the belief in continual scientific and technological progress, or simply in terms of the nature of human desire, our culture's love of infinity is tacitly transhumanist in orientation. Transhumanists make explicit the logical endpoint of the Enlightenment project (Frodeman, 2019).

Once attuned to this the transhumanist impulse can be seen everywhere. The US National Science Foundation places no limit on its program of scientific and technological advance, just as the US National Institutes of Health hope to overcome every infirmity. The same is true for every other nation's path of research. The only difference between the transhumanists and the rest of us is in the degree of self-awareness of where things are trending. Our epistemic trajectory points toward infinite power; transhumanists have simply made the point explicit.

Transhumanists deserve praise for achieving a global view of our situation. But this clarity raises a new set of questions, the most basic of which is whether the goal

of infinite power is a desirable one, or whether like the Sorcerer's Apprentice the process is likely to spin out of control. It is unclear that we are taking the dangers of the continued laissez faire knowledge production seriously enough. The endless pursuit of technoscientific knowledge will lead to any number of improvements. But as our knowledge increases so does our power, which can be used in both beneficial and destructive ways.

Whenever limits have appeared scientific and technological advance has made it possible to transcend these limits. This is why economist Julian Simon called human creativity the ultimate resource. For decades predictions were made concerning peak oil, the point at which petroleum reserves would reach their high point and start their inevitable decline. Then technological advance (directional drilling, hydraulic fracturing aka fracking) resets the entire question.

Technology may or may not come to the rescue to solve today's problems. But even if Simon is correct about our creative abilities, we still face a dilemma. Innovation may leap over every limit, but this raises new dangers rooted in our technological prowess. Technological advance threatens us in three ways: by causing political instability, as society is unable to successfully adapt to new technologies; through the rise of totalitarianism, as advances place the means for surveilling, manipulating, and controlling the population in the hands of governments; and by causing social or environmental disruption, via either a catastrophic accident or the intentional actions of rogue actors (Frodeman, 2019).

Transhumanism highlights the fact that the overall results of knowledge production take us in a direction quite different from the piecemeal outcomes of these efforts. Those who dismiss transhumanism do so by focusing on the piecemeal aspects of our culture of knowledge. Heidegger called this the forgetfulness of Being—the loss of a sense of our overall trajectory as we focus on smaller matters. Across the modern era regional ontology has trumped fundamental ontology as small questions have stood in the place of large ones. Amusements pile up even as civic virtues fade. With all our riches we have created a trivial culture.

4.7 Sustainability and the University

Great questions assert themselves in the environmental crises we face. As I have noted, many of these crises are rooted in scarcity—pollution (including CO_2) being a matter of not enough land or water or air to disperse contaminants, and extinction resulting from not enough space to support wild species. As the science of limit, helping us to understand where planetary boundaries lie, geology should be the sovereign of our epistemic empire.

The account offered here has connected geologic knowledge and perspectives to a fundamental rethinking of the premises underlying our culture of knowledge. The points made are speculative in nature. The scenario described—where a more philosophical and policy-oriented field of geology becomes the culmination of our educational efforts, as well as the governor of our research efforts—is not yet plausible. But one of the roles of philosophy and of intellectual work generally is to

sketch out possible futures, knowing that most of these futures will not come to pass. Such efforts can still be worthwhile. The function of a thought experiment is sometimes to help forestall a future by sketching out its undesirable dimensions. And these efforts may not be entirely utopian: the recent effort in Chile to rewrite the country's constitution from an ecological standpoint—giving nature rights and considering the needs of future generations—is a sign that change is possible (New York Times, 2021).

In a previous work (Frodeman, 2019) I argued that the most likely driver of the shift in intellectual culture called for here would be a medium-sized societal catastrophe. An event where perhaps 5% of the world's population died through a disaster rooted in either environmental crisis or technoscience run amok might prompt the rethinking of our epistemic assumptions. No one desires such a scenario. But Nietzsche may be correct that people acquire new mental habits only through an event painful enough to etch it in their memory. In the meantime, intellectuals make arguments and artists create works in the hope that they may launch a movement or persuade people in positions of power.

As it happened, those speculations have been mirrored by subsequent events. The last two years (this is being written in early 2022) has seen both significant environmental disruption via weather events and the rise of a pandemic that may have resulted from gain of function research that escaped the laboratory. We do not know if the recent bizarre weather is merely the start of massive changes in the climate. Nor do we know if COVID-19 originated in the Wuhan Institute of Virology or have a clear grasp of the societal changes that will occur in the wake of COVID-19. But the early signs are that society seems to have become more dysfunctional rather than using these crises to re-evaluate its behavior.

Even if the suggestion of a new geology-based epistemology sounds far-fetched, it is clear that we are facing epistemic disruption of one kind or another. The function of the modern research university, where it creates, certifies, and disseminates knowledge, is under siege. For 150 years the university has been the uniquely authoritative source for knowledge. Today, however, the university's central role in knowledge culture has been undercut by the rise of the Internet. Web 2.0 and social media have created alternative epistemic spaces that have undermined the role of expertise. This has contributed to a wide range of results, including vaccine skepticism and the rise of rightwing authoritarian political movements in a number of countries.

By way of conclusion, let us note some of the possible consequences of the perspectives offered here. In terms of the university, the current grab-bag, horizontal structure could give way to a hierarchical focus structured in terms of sustainability. Environmental change courses could become part of our intellectual grammar and frame the overall goals of intellectual work. The brightest high school students would take advanced placement courses in geology rather than in physics and calculus. Such courses (for there would need to be more than one) would be complemented by geoethics courses that would be inter- and transdisciplinary in nature, moving from science to risk assessment to restorative justice and back again. The main point of all these efforts would be to recognize that we now have a common end that should transcend all our other values: the protection of our planet.

Concerning our research portfolio, this argument implies moving beyond the libertarian epistemology that has underlain the academy for the last 150 years. Those epistemic pursuits that support a sustainable way of life would be pursued. Those epistemic efforts that will exacerbate our current unsustainable trajectory would be restricted, banned, or go unfunded.

This does not imply an epistemic authoritarianism. Reorienting university life and society generally toward the goal of sustainability should be a matter of persuasion and nudges more than regulation, prompting the slow process of changing the *Zeitgeist* of a culture. People will disagree about the nature of a given project and will argue whether the attached harms are trivial or are offset by positive results. There will be debates and compromises; people will disagree on interpretations. All of this is appropriate within democratic societies. The point is one of framing: there would be a general recognition that protecting the environment and observing its limits is the paramount public good of all our activities.

These points have been put in terms of geology partly in recognition of the fact that we live in a scientific era. But ultimately the change in worldview being called for here is psychological, philosophical, and spiritual in nature. The long history of humanity has been shaped by want. Chronic lack has molded our psyches to always want more. This has reached such absurd heights that men with hundreds of billions of dollars still seek to augment their wealth. It is time to leave the adolescence of humanity behind and create a culture of maturity.[1]

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[1] Other versions of some of the points made here have appeared in earlier publications (e.g., Frodeman, 2019).