Down to Earth

Geosocialities and Geopolitics

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Abstract "Nature" and "social life" tended to be separated by Enlightenment thinkers, setting the stage for a long-standing tension between geology and social-cultural theory. Such a division suppressed the liveliness that humans have often attributed to material things. Several scholars and artists, many of whom would advocate new materialisms, have attempted to recapture this liveliness. Drawing upon these developments, we use the notion of "geosocialities" (the commingling of the geologic and the social and the sensibilities involved) to facilitate appreciation of the mineral and the alignment between geology and social-cultural theory. While geosocialities overlap with nature-cultures and "biosocialities," they are "harder" in the sense of drawing attention to geology and its relation to social life. Such a move seems timely, keeping in mind the popular claim that in the Anthropocene, humans have become a geologic force. At the same time, it opens up a down-to-earth form of geopolitics that exceeds classic notions of the term, attending to different geologic scales; to living bodies, human and nonhuman; to solid rock; and to the planet. We develop our argument through engagement with two sites. One concerns the inscription of human activities in volcanic rock, the second the embodiment of isotopes in living beings. These examples raise questions about the multiple scales of geosociality, which intertwine biography and Earth "itself."

Keywords geosociality, geopolitics, salmon, biomineralization, volcanoes, lava, nature-culture

The Other Volcano" is an intriguing series of "semi-domesticated" scaled-down volcanoes crafted by London-based French artist Nelly Ben Hayoun. Modeled after Mount St. Helens (United States) and Ol Doinyo Lengai (Tanzania), the mountains erupt with pyroclastic flows produced by "a combination of potassium nitrate and sugar that has been baked together into toffee-like pieces and inserted into copper tubes" (see fig. 1).[1] Small detonators trigger chemical reactions at irregular intervals. Ben Hayoun placed

1. Hayoun, "Other Volcano."

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Figure 1. *The Other Volcano*, by Nelly Ben Hayoun (September 2010). Austin Houldsworth, explosive designer; Nick Ballon, photography; Carina Fearnley, Aberthswyth University, volcanologist

the volcanoes with volunteers, who housed them for a couple of weeks. The volcanoes were made to be less than ideal guests. As Ben Hayoun describes on her website:

> These designed supra-natural objects are large, reaching almost to the ceiling, imposing, and extremely inconvenient, erupting dust and gloop into the living rooms of volunteers seemingly at random. . . . *The Other Volcano* imagines a love-hate relationship, a 'sleeping giant' in the corner of your domestic environment, with the power to provoke excitement with its rumblings, and also perhaps fear (if not for one's life in this case, then at least for the soft furnishings of one's clean and neat "living" room).

In Ben Hayoun's visual thought experiment, domesticating volcanoes is not an effort to "tame" them. Rather, it disrupts the so-called domestic by the introduction of a lively and unpredictable geologic being.

Like Ben Hayoun's experimental art, this article seeks to explore the volcanoes in our living rooms—the geologies that are part and parcel of our daily lives. The article's goal is to draw attention to "geosocialities," or the entangled relations of the earth and biologic beings. The notion of geosocialities is not a novel one.[2] Here, however, we advance a particular version of geosocialities as comminglings of the geologic and the biologic and the sensibilities involved. Such a notion, we suggest, helps to assemble and amplify several recent theoretical concepts and developments, including those of new materialism,[3] vibrant matter,[4] geological intimacy,[5] geologic life,[6] and paleontology of the present.[7] The notion of geosociality, we argue, expands and torques the conceptions of agency, intimacy, and politics that have emerged from biosociality and the biosocial.[8] The geosocial, then, at once facilitates appreciation of the mineral and draws attention to points of contact between geology and social-cultural theory. At the same time, it opens up a down-to-earth form of geopolitics (the managing, and mismanaging, of geosocial realities) that exceeds classic notions of the term by attending to different geologic scales—to living bodies, human and nonhuman; to solid rock; and to the planet "itself."

We develop our argument about geosocialities through ethnographic and historical engagement with two sites. The first concerns the inscription of human activities in volcanic rock. Here we discuss the case of the cooling of lava during the 1973 eruption in the Westman Islands, Iceland, a rather successful attempt to inscribe the human in rock in the process of protecting a community. Second, taking up geosociality at a different scale, we discuss the embodiment of isotopes in living beings. Through the example of salmon, which accumulate bonelike material in their ears, we explore how isotopes can tell stories of movements through different mineral worlds and relations among mineral-containing bodies. These examples raise questions about the multiple scales of geosociality, which intertwine biography and the earth, as well as about the complexities of geopolitics.

Why Geosociality, and Why Now?

For more than a decade, the "social" has been shifting, perhaps more than ever before. In the humanities and social sciences, the term long served as an unquestioned shorthand for human-to-human relations. Today, while the social continues to be equated with the human in most contexts, many scholars are pushing for versions of "more-than-human sociality" in which nonhumans are also seen as fully social, as beings engaged in webs of world-making relations.[9] Much more-than-human scholarship,

2. A recent conference session in London, for instance, convened by Clark, Yusoff, and Saldanha, was titled "Geo-social Formations: Capitalism and the Earth."

3. Lemke, "New Materialisms."

4. Bennett, *Vibrant Matter*; Raffles, "Twenty-Five Years."

5. Halperin, "Autobiographical Trace Fossils"; Hamilton, *Volcano*; Farrier, "'Like a Stone.'"

6. Yusoff, "Anthropogenesis."

7. Mitchell, *What Do Pictures Want?*

8. Ingold and Palsson, *Biosocial Becomings*; Lock and Palsson, *Can Science Resolve the Nature/Nurture Debate?*; Meloni, Williams, and Martin, *Biosocial Matters*.

9. Tsing, "More-than-Human Sociality"; see also Haraway, *When Species Meet*; Latour, *Reassembling the Social*; and Palsson, *Nature, Culture, and Society*.

however, has struggled with the geologic, which—composed of seemingly inert minerals—has proved more difficult to see as lively. It is easy to see how entangled histories shape the lives of nonhuman beings, such as how human cultivation practices have changed the genetics of plants. It has also become increasingly easy for social scientists and humanities scholars to see how nonhuman beings, such as microbes, change the lives of people. But rocks have seemed harder for social and cultural theorists, pun intended. For many, geologic forms do not seem to participate in social life, by common standards:[10] they do not seem to have interiorities, they do not strive, they do not metabolize, they do not reproduce or seem to respond.

Such assumptions about the asocial nature of stone run deep in the humanities and social sciences. Dominant strands of European social thought developed in France, England, and Germany—during periods when those areas experienced relative geologic quiescence.[11] When the earth really did move, it indeed shook up what would later be called social theory, such as in 1755, when a catastrophic earthquake struck Lisbon. Discussed extensively by philosopher Immanuel Kant and several contemporary intellectuals, the quake had seismic implications for Portuguese politics and for European culture and society more broadly, as it temporarily destabilized metaphors of "grounding."[12] Published after the Lisbon disaster, in 1788, James Hutton's pioneering work *Theory of the Earth*, sometimes called the foundation of modern geology, recognized subterranean heat as a key geologic force; but overall, his perspective was that of a British farmer and most often focused on the slow processes of sedimentation and erosion.[13]

While smaller quakes, landslides, and sinkholes occasionally garnered attention, major geologic fault lines and volcanoes were rare enough that European intellectuals could forget about them "at home." Dynamic earth movements indeed caught Europeans' attention when they traveled abroad. Alexander von Humboldt, for example, was passionately interested in earthquakes and volcanoes when he visited Latin America between 1799 and 1804. While he developed the thesis that eruptions were not isolated occurrences but represented broad subterranean networks (see fig. 2), if not "a single volcanic furnace,"[14] the wild earth continued to be located "over there" rather than in one's living room.

The notion of the Anthropocene, however, has at last begun to shake Euro-American scholars in the humanities and social sciences from their assumptions that their worlds

10. See Dupré, *Processes of Life*, 208.
11. Oreskes, *Plate Tectonics*; Rudwick, *Bursting the Limits of Time*.
12. Neiman, *Evil in Modern Thought*.
13. Hutton, *Theory of the Earth*.
14. Wulf, *Invention of Nature*, 197.

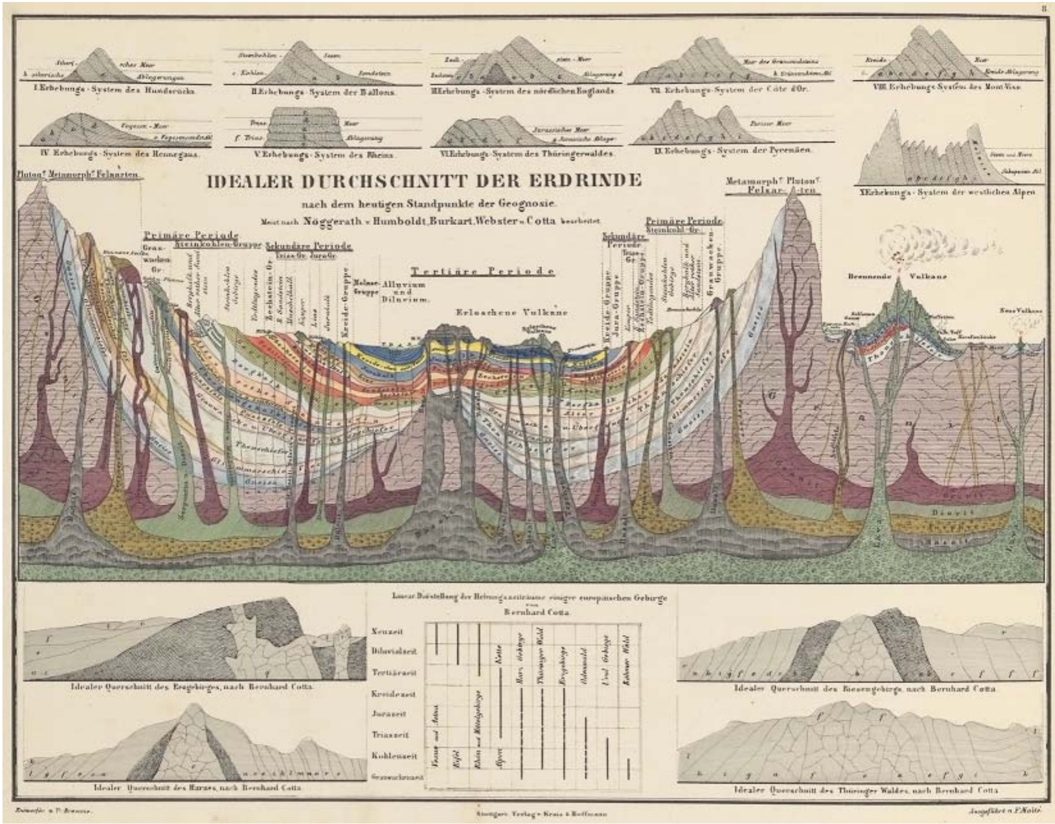

Figure 2. Alexander von Humboldt's "Idealer Durchschnitt der Erdrinde," 1851

are geologically dormant.[15] Climate change has taken up the position of the volcano in the living room. It points to how dangerous geologic intimacies have long been in the houses and factories of Europeans—in the glowing red coal fires entangled with industrial capitalism and "modern" life. But while everyone noticed how coal changed human worlds, few anticipated that it would change geologic ones as well. The "revolutions" associated with fossil fuels were long seen as reconfigurations in human relations, not in terms of geologic shifts. The industrial revolution was seen as "ground breaking" primarily in its metaphoric sense. Mines and pollution might be unavoidable, local side effects, but they did not matter to the earth, which was seen as stable and inexhaustible.

As scientists assemble data on sea level rise and global temperature increases, the planet no longer seems impervious to human actions. Consider recent research on Icelandic glaciation. A headline in the *Guardian* summarizes emerging findings as follows: "Climate Change Is Lifting Iceland—and It Could Mean More Volcanic Eruptions."[16]

15. See, for example, Adeney Thomas, "History and Biology in the Anthropocene"; Gren and Huijbens, *Tourism and the Anthropocene*; and Swanson, Bubandt, and Tsing, "Less than One but More than Many."

16. "Climate Change Is Lifting Iceland."

A second example is groundwater extraction in California. With the expansion of large-scale agriculture, the state's farmers have increasingly turned to wells to irrigate their crops. But the depletion of aquifers is reducing both the volume and the weight of water inside the region's crustal layers. The first is causing some parts of the San Joaquin Valley to collapse downward by nearly two inches per month.[17] The second is causing the state's mountains to rise at an unusual rate, triggering small earthquakes as they move upward. These are not slow, *longue durée* processes. Some human activities operate even faster: notably, fracking and the drilling and tapping of geothermal energy, both of which set off almost immediate and significant seismic activities.[18]

Such events, coupled with the Anthropocene concept, have triggered philosophical and theoretical reflection among natural scientists, social scientists, and humanities scholars alike. The Anthropocene marks the "Age of Man."[19] As Kathryn Yusoff remarks: "What kind of historicity does the human possess if it is a being that can both read and write its own future in the rocks?"[20] Yet while the Anthropocene concept has brought human relations with the "geos" to the fore, it has also unduly circumscribed them by framing the geos at a specific scale. Within Anthropocene debates, the geologic has too often been rendered synonymous with the planetary in its efforts to focus attention on changes in earth systems.[21] This planetary scale has a history that, as Joseph Masco points out, stretches back to the beginning of the Cold War. Masco argues that the Cold War arms race and its technoscientific apparatuses "enabled a new vision of the planet as an integrated biosphere," making it "possible for citizens to imagine a truly planetary crisis" for the first time.[22] These Cold War concerns also significantly shaped the scalar logics of the geosciences, whose practitioners were enlisted, via government funding, to study such things as the movement of radioactive particles around the world.[23] Because the Anthropocene has developed within geoscientific paradigms and practices that are inseparable from Cold War histories, the Anthropocene conversations have tended to take on similar scalar assumptions that have tied both the definition of the era and imaginaries for political action within it to a conjured "global" scale.[24]

Many humanities and social science scholars have rightly objected to Anthropocene planetary framings and the universalisms they imply. Marisol de la Cadena, for example, suggests the notion of "Anthropo-not-seen" to throw light on the erasure of

17. "NASA: California Drought."

18. Ellsworth, "Injection-Induced Earthquakes."

19. Crist, "On the Poverty of Our Nomenclature"; Palsson et al., "Reconceptualizing the 'Anthropos' in the Anthropocene."

20. Yusoff, "Anthropogenesis," 15; see also Chakrabarty, "Postcolonial Studies and the Challenge of Climate Change"; and Latour, "Facing Gaia."

21. Rockström et al., "A Safe Operating Space for Humanity."

22. Masco, "Bad Weather," 9.

23. Ibid., 17.

24. Tsing, "Global Situation."

difference that discussions of the Anthropocene tend to produce.[25] As Dipesh Chakrabarty also reminds us, global thinking often obscures difference: in the making of a singular universal planet, we often end up with a singular universal humankind living upon it.[26] We follow Chakrabarty in insisting that we need to hold on to the ability to think planetarily, but we also insist that a planetary that creates a sense of homogenization and oneness is not viable. One of the greatest challenges of Anthropocene debates, then, is how to think scale: how to craft a planetary that itself brings difference to the fore.[27] While the Anthropocene offers an invitation to engage the geologic (including the climatological), we hope that we might use the geosocial to imagine more multiscalar framings of the geos that may help us move beyond the unproductive juxtaposition of "global" earth systems and "local" human differences.

We are not alone in our efforts to develop multiscalar approaches to a lively earth. An increasing number of interdisciplinary scholars are offering up new terms with which to think. Some speak of geologic intimacy,[28] drawing attention to the ways in which lava and gallstones, the results of identical or similar geologic processes, fuse bodies and rocks. Others argue that a focus on the "paleontology of the present"[29] and the liveliness of stones is long overdue.[30] Scholars, including Hugh Raffles, have insisted that we ask, "What can a stone do?" The answer, his work shows, is quite a lot: "A stone can endure, it can change, it can harm, it can heal. . . . It can open and close the gates of philosophy. It can change the course of nature. It can change its own nature. It can empty the world of time."[31]

In the openings provided by such work, we aim to articulate our concepts of geosocialities and geopolitics. The plurals matter here. In our view, any "geologic turn"[32] needs to be thoroughly situated. There is no grand theory of geosociality; rather, it constitutes an approach for attending to how geologic relations *matter differently* to particular entities in particular locales. Geosocialities are always down to earth, grounded in particular encounters, and they also draw attention to questions of scale. They attend to the intertwinings of bodies and biographies with earth systems and deep time histories.

Because we insist that geosocialities are "embodied" and "down to earth," we approach them ethnographically. We offer two different entry points, based on the geosocial entanglements of the authors. One of the cases begins with the seeming "bigness" of volcanoes but eventually draws us into biographies. The house where one of us

25. Marisol de la Cadena, personal communication, October 2015.
26. Chakrabarty, "Postcolonial Studies and the Challenge of Climate Change."
27. Tsing et al., *Arts of Living on a Damaged Planet*.
28. Halperin, "Physical Geology"; Halperin, "Autobiographical Trace Fossils."
29. Mitchell, *What Do Pictures Want?*, 325.
30. Cadena, *Earth Beings*.
31. Raffles, "Twenty-Five Years Is a Long Time," 527; see also Povinelli, "Do Rocks Listen?"
32. Ellsworth and Kruse, "Evidence."

(Palsson) was born and raised was crushed by advancing lava, erasing an entire neighborhood with its community, playgrounds, and geosocial memories. The second begins with tiny particles inside bodies yet explores how they make those bodies part and parcel of "larger" geologic processes. In this case, one of the authors (Swanson) grew up in a salmon fishing town, intimately connected with fish bodies, and was later drawn into the geologic within them through field and lab work. Each story exemplifies the entanglements of an author with particular places, relations, and geologies.

Freezing Lava

"No physicist," claimed nineteenth-century American environmentalist George Perkins Marsh, "has supposed that man can avert the eruption of a volcano or diminish the quantity of melted rock which it pours out of the bowels of the earth."[33] Although he listed examples of efforts focusing on diverting lava flows, some dating back to the seventeenth century, these were limited in scope. His work represented the equilibrium model of his time, assuming stasis in society as well as environment, the permanence of the "forms" in Nature.[34] Here we take up geosociality at a broad scale, discussing a successful attempt to inscribe the human in rock during an eruption in the Westman Islands, Iceland, in 1973. More than any other event, this case challenges Marsh's notion of the impotence of humans when confronted with lava flows.

The town at Heimaey, the main island in the cluster of the Westman Islands south of the mainland, had about five thousand inhabitants at the beginning of 1973. The local economy centered on fishing. The natural harbor provided safe moorings for one of the biggest fishing industries in the country, close to the rich fishing grounds along the southern coast of Iceland. On January 23, the volcano Helgafell, on the outskirts of town (about two kilometers from Palsson's former home), took everyone by surprise. In the middle of the night, the ground suddenly opened with a roaring sound as the volcano sent glowing lava into the sky and down toward the harbor. Although eruptions have been regular on the Icelandic mainland since the time of settlement in the ninth century, Westman Islanders first experienced serious volcanic threats only a decade earlier, in 1963, when the island of Surtsey ("Devil's Island") was born, with lava bursting through the sea floor close to the main island of Heimaey. During the following years, the condition of "Surtsey neurosis" was diagnosed, characterized by sleeplessness and desperate anxiety.[35] This should be seen as a geosocial condition.

For a couple of days before the eruption of 1973, two men on the mainland attentively followed the seismographs with which they had recently been entrusted, for monitoring geologic activity. Both were struck by very unusual patterns indicating the unleashing of major forces not far away along the North Atlantic rift. They managed to

33. Marsh, *Man and Nature*, 459.
34. Dove, "Perception of Volcanic Eruption," 330.
35. McPhee, "Cooling the Lava," 167.

estimate the distance to the source of the quakes, but they were unable to establish the exact location through triangulation, as the third machine available in the country happened to be out of order.[36] Convinced that something big was going to happen, they did not sleep much. They alerted the relevant experts and authorities in the capital, Reykjavik, to what they were recording, checking from time to time to see if they could detect some signs of eruptions on the horizon.

While the Westman Islanders were taken by surprise when the eruption began at close to 1:45 in the morning, they acted swiftly when they were woken up. In a few hours, most of the people on the island were safely transported over rough seas to the nearest mainland harbor. The next immediate concern was to prevent houses from collapsing under the ash that fell like heavy rain and, above all, to try to redirect the lava flow to avoid destruction of the harbor. A somewhat eccentric physics professor, Þorbjörn Sigurgeirsson, came up with the idea of cooling the lava. He suggested trying to pump water on the advancing lava front in order to slow it down or halt it, beginning with the local fire brigade's truck. Most Icelanders thought that this was an absurd proposal. Forces of Mother Nature, it was argued, could not be tamed by "having a pee" on the edge of the glowing lava.[37]

During the ensuing weeks, a complicated story unfolded, sometimes called the "battle with lava." In brief, it seemed that the initial cooling had some impact; but on the other hand, Sigurgeirsson and many others reasoned that it would not make much difference, given available pumps.[38] Following a series of explosions in the crater, the massive lava flow headed north toward the harbor and west toward the town, with many houses burning or collapsing. Sigurgeirsson managed to convince the authorities to arrange more effective water pumping onto the lava—on an unprecedented scale, multiplying the volume of water. This was a battle with time. Through an agreement with US authorities, about forty massive pumps were quickly shipped to the Westman Islands.

A professor of mechanical engineering, Valdimar K. Jónsson, was hired to organize the pumping while Sigurgeirsson would decide on the strategy on a daily basis, depending on the movements of the lava. The water clearly had the effect of freezing the lava on the edges, but the pressure of the flow repeatedly threatened to break down the walls that had just been created by cooling (see fig. 3). Later on, pumping crews would take the pipes onto the lava, approaching the crater itself in advancing steps, directing the pipes and the water flow onto the advancing lava with the aid of a bulldozer and a crane. This was risky for the crew at the front, as their boots might burn, and they might not be able to return. The process of design, coordination, and employment of the pipes (first steel and aluminum and, later, plastic) was a major engineering feat,

36. Palsson, "Magma and Me."
37. McPhee, "Cooling the Lava," 96.
38. Sigurgeirsson diaries.

Figure 3. Cooling of lava, Westman Islands, 1973. Photo by Kristján Stefánsson

mainly the responsibility of Jónsson. After weeks of intensive pumping and the movement of pipes and people back and forth, the lava flowed eastward, away from the harbor and into the ocean. According to the United States Geological Survey, this was "the greatest effort ever attempted to control lava flows during the course of an eruption."[39] Eventually, the volcano cooled down. On July 2, Sigurgeirsson descended into the crater and declared the eruption "over," sending the local team into jubilation. It was time for Westman Islanders to move back and resettle.

Human agency, then, channeled through the pumping of enormous quantities of sea water at targeted points of flowing lava, significantly slowed down and solidified the fleeting mass, avoiding the destruction of an important fishing harbor and a number of houses. The pumping of water was the equivalent, in John McPhee's words, "of turning Niagara Falls onto the island for half an hour"[40]—an equivalent of the flow of Dettifoss, one of the biggest Icelandic waterfalls, for three hours. The result was peculiar water-hardened stone: "Among the natural patterns of lava flows, it was utterly anomalous. In a very certain sense, it was man-made. . . . After the human contribution passed a higher level than trifling, the evolution of the new landscape could in no pure sense be natural."[41] While humans mix their labor with solid rock in the course of many other

39. Quoted in McPhee, "Cooling the Lava," 144.
40. Ibid., 107.
41. Ibid., 142–43.

activities—especially mining and tunnel operations—there is a significant difference: in the cooling of lava, humans were inscribed in rock during the process of its formation, drafting a new chapter in the history of geosociality.[42]

Now, Westman Islanders commemorate the eruption at Helgafell in 1973 in many ways, partly to deal with the ruptures and the trauma of the recent past. A collective celebration of the "closing" of the eruption (*goslok*) takes place every July. Recently, a museum, Eldheimar (Worlds of Fire), was established to publicly present available imagery in photos and films from the time of the eruption. The building and the museum, sometimes referred to as "Pompeii of the North," was erected around a house that was half destroyed by ash, demonstrating how the family who lived there had left in a hurry, without warning, leaving everything behind as normal.

Volcanoes have immense power and agency, usually unassisted by humans or other living beings. While a volcano is obviously a central agent in the story about the cooling of lava in the Westman Islands, transferring glowing magma from the depths of the earth to its surface and pushing it in all directions, there were other agents as well. The hydraulics of the pumps and the pipes in the harbor and on the boiling and moving lava—an ingenious, mostly metal assembly fueled by diesel and petrol (again, earthly, geologic stuff)—played a central role. Much like the "fluid" bush pumps of Zimbabwe discussed by Marianne de Laet and Annemarie Mol,[43] the components of the Westman Islands hydraulic assembly traveled (at a volcano's convenience) long-distance to an unpredictable place where they would be connected and installed for an unexpected job by an unusual team that had envisioned entirely different agendas. In the process of cooling lava, saving a harbor, and rescuing a community, it did many other things as well, on a scale vastly beyond that of the bush pumps of Zimbabwe: organizing collaboration and crafting geosocial narratives, often with a good deal of irony and humor, of human engagement with volcanic activity.

It may be tempting to see the cooling of the lava on Heimaey as an isolated and innocent battle of "man against Nature" energized through the application of scientific expertise and a powerful pumping system. In fact, it was intimately connected to larger developments, notably the Cold War. For one thing, physicist Sigurgeirsson, the architect of the cooling operation, had been trained with Niels Bohr and his colleagues in Copenhagen, in a leading laboratory partly focused on nuclear research. Bohr had joined the Manhattan Project, although he, like Sigurgeirsson, later became an outspoken critic of the abuse of atomic energy.[44] Also, the American pumps had a military record, as

42. A recent eruption on the Cape Verde island of Fogo provides a very different example of the geosociality of lava flow. In mid-December 2014, an eruption began in the mountain Pico do Fogo. The lava from the crater destroyed two villages, forcing the inhabitants to move away. Interestingly, the lava passed through roads constructed by humans; without these roads, the lava would have taken another course. Unknowingly, in other words, the inhabitants had invited the volcano right into their living rooms. AFP, "Volcanic Eruption in Cape Verde."

43. de Laet and Mol, "Zimbabwe Bush Pump."

44. Feshbach, Matsui, and Oleson, *Niels Bohr*.

they had previously been used in some of the operations of the Cold War, landing fuel on enemy soil. Thus the "battle with lava" was partly informed by Cold War concerns with planetary scale, earthquakes, and unusual weather,[45] precursors to Anthropocenic concerns with damaging and irreversible climate change.

Embodied Geologies: Isotopes Within

Even in the so-called Anthropocene, the inscription of the human in the geologic is only one of many geosocial relations. The geologic itself also becomes inscribed in bodies, making its way inside living beings, both human and nonhuman. As he worked to develop the concept of a "biosphere," Russian geochemist Vladimir I. Vernadsky (1863–1945) was "struck" by how "the material of Earth's crust has been packaged into myriad moving beings whose reproduction and growth build and break down matter on a global scale. . . . *We are walking, talking minerals*."[46]

Pacific salmon may not be "walking, talking minerals," but they are certainly swimming ones. In exploring their relations with the geologic, this section draws from a larger project on Pacific salmon socialities.[47] While the example presented here makes a more generally applicable point about the fundamental entanglement of the so-called biotic and abiotic, it represents an intentional choice to make this argument through attention to nonhuman bodies rather than human ones. In line with other efforts to expand the social beyond the human, we aim to present a case of geosociality in which the term cannot be simply read as geos = rocks and social = people—a case that shows why the very notions of geology and sociality must be thought differently.

On a late fall day, two fisheries biologists in heavy-duty PVC-coated rain gear collect decomposing salmon bodies along a creek in southwest Washington State in the United States. Oddly enough, they are searching for stones. They haul the carcasses of the salmon to a wooden worktable set up beneath the corrugated metal roof of a two-sided shed. With a sharp bread knife, one of the biologists saws vertically into the head of one of the salmon, about an inch behind its eyes. The fish's body is spotted with fungus, and it smells unmistakably of rotting flesh. The salmon is one of many that have returned to the creek to spawn, dying shortly after laying their eggs or releasing their sperm. The biologist cracks the head of the salmon over the edge of the table, peering into the brain cavity exposed by his cut. Swapping the knife for a pair of tweezers, he gently reaches into the lower part of the brain cavity, removing two soft sacs. Inside each is one of the white stones he seeks: an otolith, or fish ear bone.[48] After wiping

45. Masco, "Bad Weather," 14.

46. Quoted in Margulis and Sagan, *What Is Life?*, 49. Emphasis added.

47. Swanson, "Methods for Multispecies Anthropology."

48. Pacific salmon each have three pairs of otoliths. The largest, the sagittae (about 5 mm in diameter), are usually used for analysis. The other two sets of otoliths, the lapilli and the asteriscii, are only about 1 mm in diameter and are harder both to retrieve and to analyze.

them on a paper towel, he places them into small, carefully labeled vials of alcohol to be shipped to a university lab.

Otoliths are an example of what scientists call “biominerals,” or minerals that form within organisms. Biomineralization “links soft organic tissues, which are compositionally akin to atmosphere and oceans, with the hard materials of the solid Earth. It provides organisms with skeletons and shells while they are alive, and when they die these are deposited as sediment in environments from river plains to the deep ocean floor.”[49] Biominerals are not only located within organisms; they are also themselves amalgamations of the bios and geos, “comprised of both mineral and organic components.”[50] Salmon, like many organisms, are filled with multiple biominerals, including their bones, teeth, and scales. Yet their otoliths are perhaps their most intriguing ones. Composed of calcium carbonate and trace minerals deposited into a protein matrix, otoliths are sense organs—ears of sorts—that allow fish to perceive vibrations and pressure changes; they help them to track accelerations and decelerations and to tell up from down. Although fish do not have eardrums, their otoliths work in a similar way to those in humans, turning sounds and spatial orientations into neural impulses as the otoliths bump up against small hair cells inside their cochlea. In contrast to those in humans, salmon otoliths continue to biomineralize throughout the life of a fish. If one looks at a slice from a salmon otolith under a microscope, after it has been cut and polished like a precious gem, it looks similar to a cross-section of a tree, with a series of circular rings (see fig. 4). But in contrast to trees, which typically accrue one ring per year, salmon usually develop a new otolith band every day.

Otolith bands vary in width and mineral composition depending on where a salmon was and what it was doing on the day it formed a particular ring. Biomineralization is at once a metabolic and geologic process; it depends on both the minerals available and the condition of the fish. As with trees, wide bands signal more rapid periods of growth, while narrow bands indicate more difficulties. For a fish, an abundance of food, moderate temperatures, and a lack of competition from more aggressive fish generally mark a good day. But while visually surveying otoliths can immediately provide information about fish growth, microchemical analysis can offer more hints about biominerals. As archaeologists well know, bones and teeth are filled with isotopes and trace minerals that can tell stories about how the relations of a living being shift as it moves through space-times. The same holds for salmon otoliths, but on a daily scale. Depending on what a salmon eats, the salinity of the water, and the minerals of nearby rock formations, salmon build different minerals into their ever-growing ear bones. Their ear bones are in some ways akin to a diary of mineralogic encounters. For example, otolith composition changes depending on what a fish ate on a given day, be it freshwater macroinvertebrates or marine fish. Similarly, the isotopic traces in otoliths

49. Leadbeater and Riding, quoted in Weiner and Dove, “Overview of Biomineralization Processes,” 2.
50. Weiner and Dove, “Overview of Biomineralization Processes,” 2.

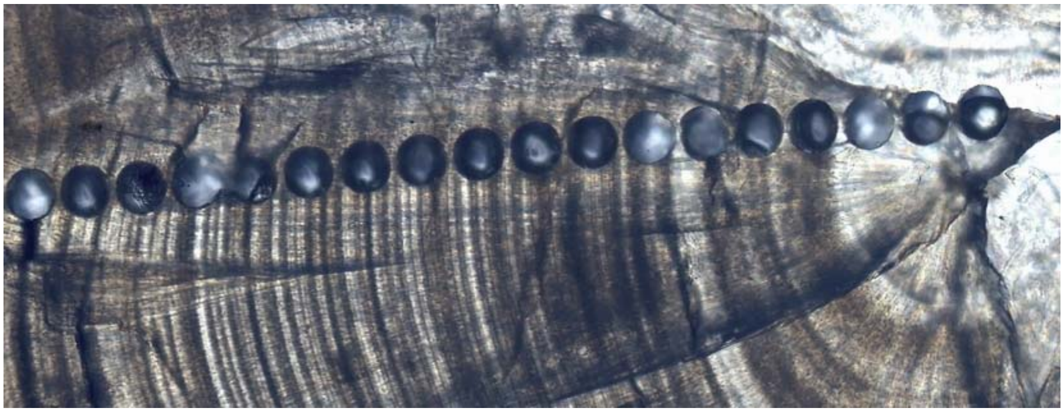

Figure 4. An otolith cross-section that has been placed under magnification. The holes mark where samples for isotope analysis have been extracted with a laser ablation multi-collector inductively coupled plasma mass spectrometer. Courtesy of Rachel Johnson, NOAA Fisheries

vary depending on the water through which a fish swam. Not only does saltwater have different trace minerals from freshwater, but different streams, and even different parts of the same stream, have different mineral contents depending on the types of rocks over which they flow.[51]

Attention to biominerals shows how research on geosocialities cannot simply swap the geos for the bios. Rather, it shows how we must dive into how the bios and the geos are woven together within social relations. In their iterative making, bodies become repositories of geologic encounters and lively geologic materials. This has long been the case—and not only for fish. As Steve Weiner and Patricia M. Dove explain, "first prokaryotes and then eukaryotes developed the ability to form minerals."[52] By the end of the Precambrian, organisms in many different phyla had evolved the ability to form multiple mineral forms. Today, biominerals take forms ranging from the silica cellular coatings of some algae[53] and the shells of mollusks to the iron oxide crystals that allow migratory birds to orient and the bones of vertebrates. These are at once biologic and geologic, social and historical. The exact composition of the shell of a particular nautilus, for example, is the product of layers of interactions of genetics and mineral forms that can never be fully teased apart or sorted out.

Importantly, "agency" in biomineralization does not lie solely with the biotic organism. As Jane Bennett reminds us, the geologic is not just inert matter "under the direction of something nonmaterial, that is an active soul or mind": mineralization itself is a form of "creative agency."[54] Indeed, some biominerals may also shape

51. Barnett-Johnson et al., "Tracking Natal Origins of Salmon."
52. Weiner and Dove, "Overview of Biomineralization Processes," 2.
53. Ibid., 16.
54. Bennett, *Vibrant Matter*, 10–11.

how organisms experience their worlds. While biominerals often become protective structures such as bones or shells, they also commonly become sense organs, like otoliths or magnetic particles that serve as internal compasses.[55] Recently, microbiological research has shown that gut bacteria change the way organisms behave and perceive;[56] perhaps it is not out of the question to assume that something similar might hold for certain mineralizations. It seems possible that for salmon, tiny differences in the structure and mineral content of their otoliths might change how they perceive and interact with their worlds in some way.

We know for certain that for salmon, their entire physiology is bound up with the geologic via dissolved minerals. Salmon, which migrate between freshwater streams and the open ocean, must work with the properties of water and salts in order to exist at all. When in freshwater, salmon must pump salts into their bodies using special cells in their gills so as to maintain the concentrations that their tissues need. Yet after they migrate to the sea, salmon must reverse their osmoregulatory systems so that they remove salt from their bodies, both via their gill pump cells and through the production of highly concentrated urine. In essence, salmon must morph—significantly altering their own physiology—in order to live with the dissolved mineral salts around them. Becoming salmon is thus becoming with minerals.[57]

Geopolitics Rethought

The concept of geosocialities pushes us to think through the multiscalar space-times that link planetary processes, volcanic activities, living bodies, species histories, and tiny dissolved mineral compounds, including toxic stuff. It also demands that we think "life" and its complexities in relation to so-called nonlife. Furthermore, nonlife, as we see through the cases of Icelandic volcanoes and salmon otoliths, is itself quite lively.

Lively matter, Bennett suggests, calls out for new conceptions of politics. Her work aims "to articulate a vibrant materiality that runs alongside and inside humans to see how analyses of political events might change if we gave the force of things more due."[58] We too find that geosocialities push us to consider politics differently—to ask how we might craft forms of geopolitics that start with the assumption that all beings are always already geosocial ones. Traditionally, the term *geopolitics* has been used to refer to politics that take place across a dead earth, a geos that may matter—due to differences in, say, oil or other mineral resources—but that provides only raw materials for politics rather than acting as a political force itself.[59] In contrast, we seek a new form of

55. Gould, "Animal Navigation," 483.

56. Cryan and Dinan, "Mind-Altering Microorganisms"; Wang and Kasper, "Role of the Microbiome in Central Nervous System Disorders"; Diaz Heijtz et al., "Normal Gut Microbiota Modulates Brain Development and Behavior."

57. Lien, *Becoming Salmon*.

58. Bennett, *Vibrant Matter*, vii.

59. See Dalby, "Anthropocene Geopolitics."

geopolitics that begins from a notion of sociality in which the geologic, too, is social.[60] We are not alone in such calls. When other scholars have imagined geopolitics that take the geos seriously, however, they have typically still thought their new geopolitics within the scalar logics of its more traditional forms—namely on an allegedly "big" or "planetary" scale.[61] Yet one of the very insights we take from our ethnographic attention to geosocialities is precisely the intertwining of biographies and planetary systems in ways that challenge our sense of what is "big" and "small." In contrast to efforts to rethink geopolitics by focusing on climate change on a "transnational" scale, we—as the title of our article states—take a "down to earth" approach, asking how scales are braided together in material forms.

Recently, a theoretical project of "biosocial momentum" has emerged out of efforts to deconstruct nature/nurture, nature/culture, and human/environment binaries that have imagined a human sociality separated from living bodies and material worlds.[62] Just as our notion of geosocialities is inspired by scholarship on the biosocial, we turn to biopolitics to help us reimagine the geopolitical. Michel Foucault argued that the eighteenth century gave birth to biopolitics, the rationalization of "the problems presented to governmental practice by the phenomena characteristic of a group of living human beings constituted as a population: health, sanitation, birthrate, longevity, race."[63] But what matters most about Foucault's biopolitics for our arguments here is the way it theorizes connections across scales and sites—from the state to the clinic to the prison to the body and back again. Foucauldian biopolitics attends to the politics of governments but not in isolation. Rather, Foucault shows us how power is immanent and how bodies are made within layers of power-laden relations. Across the humanities and social sciences, biopolitics has been part of broader efforts to situate politics—to insist that politics are not solely the stuff of governments and nation-state interactions but are also part and parcel of everyday life from the supermarket to the doctor's office to one's home.[64]

When Foucault's "population" becomes a geosocial entanglement that links bodies with the earth itself, how might we hold on to such biopolitical insights? Questions of the geologic are not among those Foucault considered, but it might still be useful to imagine what a biopolitics torqued into geopolitics might be. The "phenomena characteristic of a group of living human beings constituted as a population," to use his words, would need to include both the Anthropocenic impact of humans and their geosocial constitution. Nutritional and environmental epigenetics may provide an important avenue for framing the latter. Epigenetics conceptualizes food as an inscription

60. Clark, "Geo-politics and the Disaster of the Anthropocene."
61. Dalby, "Rethinking Geopolitics."
62. Lock and Palsson, *Can Science Resolve the Nature/Nurture Debate?*
63. Foucault, "Birth of Biopolitics," 73.
64. Harding, *Sciences from Below*; Haraway, "Situated Knowledges."

factor regulating gene expression, which in turn is linked to medical conditions including cancer, metabolic syndrome, obesity, and diabetes. Eating is itself a geosocial relation: "Social things (food, in particular) enter the body, are digested, and in shaping metabolism, become part of the body-in-time, not by building bones and tissues, but by leaving an imprint on a dynamic bodily process."[65] Eating also links bodies to the soils in which crops are grown—to histories of fertilizer, property ownership, and deep time processes of soil formation. Attending to such processes may help to better understand the embodiment of inequality and—to update Foucault—the caring for geosocial selves that do not end at the skin but instead reach out to landscapes.[66] Indeed, as Maria Puig de la Bellacasa has suggested in relation to soil, such practices of geosocial care can open up new political spaces precisely because they reconfigure social bodies.[67]

These types of entanglements have been explored in the humanities and the social sciences. Bodies, places, or forces can never be parsed into the categories of the "local" and the "global" but are always both (or perhaps neither) at the same time, because scales themselves are also made in multiscalar encounters.[68] We need ethnography to describe the complexity of all relations—and we need it more than ever to attend to the braids of geosocialities. This points to one of the challenges of geopolitics reconsidered: if geopolitics remains monoscalar even as it begins to open to the liveliness of the mineral, we will have lost some of its potential. As ethnographic attention to geosocialities shows, any geopolitics emerging from them needs much more complex politics of scale—of intertwined space-times.

Consider some of the geopolitics that emerge from volcanoes and salmon, the beings of our ethnographic vignettes. The geopolitics of volcanoes involves a range of important issues and pressing concerns: avoiding escalating volcanic activity (by scaling down global warming and the melting of glaciers), monitoring seismic events and their impact on life (human and nonhuman), addressing the health risks of lava, gases, and ash, seeking ways of directing lava flows (if necessary), managing air travel through volcanic clouds and particles, documenting local notions of earthquakes and eruptions, dealing with traumatic aftermaths, and assessing conflicting perceptions and interests depending on place and context, to mention a few. All of this involves attending to articulations of biographies and processes in the *longue durée*, through ethnographies and thick description of geosocialities. The scale of volcanic disruptions and other "natural" disasters, as Neil Smith emphasizes, "is to a greater and lesser extent a social calculus," with differential prevention policies and social implications.[69]

65. Landecker, "Food as Exposure," 177.

66. Puig de la Bellacasa, "Making Time for Soil"; Lock and Palsson, *Can Science Resolve the Nature/Nurture Debate?*

67. Puig de la Bellacasa, "Making Time for Soil," 701.

68. Tsing, "Global Situation."

69. Smith, "There's No Such Thing as a Natural Disaster," 1; see also Holmberg, "Beyond the Catastrophe."

The minerals in salmon bodies lead to a somewhat different set of geopolitics: When salmon return to the freshwater streams where they spawn and die, they do not only bring back the minerals in their otoliths. Many of their tissues are filled with marine-derived nitrogen, carbon, phosphorous, and sulfur from their years dining at sea. When they die, their carcasses release those elements into stream ecosystems where either they are directly taken up by other organisms while still in their organic form or they return to an inorganic state before being remineralized by primary producers such as phytoplankton.[70] Isotopic analysis indicates that marine-derived minerals from salmon fertilize whole watersheds, making their way into the bodies of trees, insects, birds, and mammals. However, in some places, habitat degradation, dam construction, and a transition to hatchery production has decreased the number of stream-spawning salmon, depriving watersheds of needed nutrients. In a few locales, carcasses from hatchery fish are now placed into streams so that they can rot there and release their nutrients into the watershed, but such efforts remain spotty and on the edges of fisheries management plans that have not seriously considered mineral movements.

The scalar entanglements here—of bodies and communities, eruptions and mineral cycling—call out for something more than politics as usual. They need geopolitics that are not stuck at an already known scale. One way, possibly the only feasible one, to engage with geopolitics in this most radical sense is—perhaps counterintuitively—to draw upon classic political theory of solidarity. Etymologically, the notion of solidarity derives from the concept *in solidum* in Roman law that referred to a joint contract between two or more creditors or debtors. Incidentally, the concept *solid* (as in "solid rock") has the same roots, stemming from *solidus*, meaning firm and undivided. The theoretical discourse of solidarity (and *fraternité*), which has always had a stronger foothold in continental Europe than in Anglo-Saxon countries, has a long and complex history. Jürgen Habermas famously called solidarity the "reverse side of justice" to suggest that "while the operationalization of justice in contemporary theory and practice is focused on the wellbeing of individuals, solidarity is capable of protecting the intersubjective fabric of society, which, in turn, also contributes to individual wellbeing."[71]

Yet geosocial solidarities cannot find their ground in the standard categories of European political thought.[72] They demand that we do solidarity otherwise, in ways that recognize not only the agency of solids but also the differences of diverse geosocial worlds. Attending to "other" voices and ways of being may be the first part of the essential yet difficult work of "going on together well in difference" in the Anthropocene.[73] Some notions of geosocialities have probably existed for ages, but following the Enlightenment they were suppressed in Euro-American discourses, which separated the

70. Kline et al., "Assessment of Marine-Derived Nutrients"; Cederholm et al., "Pacific Salmon Carcasses."

71. Quoted in Prainsack and Buyx, *Solidarity in Biomedicine and Beyond*, chap. 2.

72. For one effort to consider "more-than-human solidarities," see Rock and Degeling, "Public Health Ethics and More-than-Human Solidarity."

73. Verran, "Engagements between Disparate Knowledge Traditions"; Purdy, *After Nature*.

tectonic and geologic from the “social” and “historical.” Attending to geosocialities, including “Other” sensibilities, now seems especially timely given the recognition that humans represent a major geologic force—in both the *longue durée* of climate change and the short term of generating seismic and geologic events—and are constituted at the same time, much like other beings, by geologic material.

Conclusions

The Anthropocene, we think, matters: it is not just a proposed geologic epoch but also a mode of scholarship—one that has the potential to redefine the very nature of the geologic by marking it as a domain that includes intentionality and meaning. The Anthropocene helps draw us into thinking about geosocialities, but it does not delimit our work. Indeed, it has its own conceptual risks. The Anthropocene is a lure to think “big.” This is not a bad thing in itself. But despite all the generativity and creativity it fosters, the Anthropocene concept still leads to too much work that thinks big in relatively simplistic ways. We need bold thinking rather than merely big thinking through planetary frames. This requires careful thinking about scales.

It also, we conclude, requires a continuation of the modes of ethnographic attention to scales and the “glocal” that help us think through the scalar complexities of globalization. Geosocialities, of course, demand interdisciplinary collaborations across the arts and sciences. Under banners such as “environmental humanities,” “geohumanities,” and “geocultures,” exchanges between geology and social-cultural theory seem poised to grow. Such interdisciplinary conversations can only be strengthened through attention to scalar complexities via case studies. Arguably, geos is too hard for environmental theory. After all, planetary activities are not restricted to the crust and solid rock. Atmospheric events and ocean currents in particular affect both landscapes and human lives. Geos, on the other hand, seems pertinent in light of current concerns with Anthropocenic impact, with humans having become a major geologic force. The notion of earth “itself,” moreover, we argue, should be seen as inclusive, pertaining to everything planetary—somewhat along the lines of Humboldt’s early ideas of Gäa and Kosmos, precursors to the modern notions of Gaia and the Anthropocene.[74] The two cases we have discussed in some detail, the subjects of larger ongoing projects, illuminate different aspects of the geosocial: the inscription of human activities in geologic matter and the inscription of the geologic in living beings. They point to how forming adequate geosocial theories and geopolitical actions across braids of biographies and earth systems is one of the key tasks for the Anthropocene.

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74. Wulf, *Invention of Nature*.

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