

**Thinking permeable matter through feminist geophilosophy: environmental knowledge  
controversy and the materiality of hydrogeologic processes**

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Kai Bosworth

University of Minnesota, Department of Geography, Environment, and Society

Boswo009@umn.edu

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## **Thinking permeable matter through feminist geophilosophy: environmental knowledge controversy and the materiality of hydrogeologic processes**

### **Abstract**

In this paper, I argue that encounters with hydrogeologic processes encourage feminists to rethink the permeable surfaces between human bodies, ecological systems, and political events.

Contemporary geographical accounts of environmental knowledge controversies are insufficiently attentive to how geologic processes exceed and undermine instrumental deliberative political solutions to environmental problems. Through a mobilization of feminist geophilosophy, I argue instead that the limits of instrumental knowledge are not merely produced by uncertainty or lack of evidence, but by the inhuman forces that condition feminist thinking itself. An investigation of a controversy surrounding the permeability of underground materials near a proposed in-situ recovery (ISR) uranium mine in South Dakota demonstrates that subterranean spaces have the ability to heighten a sense of the openness of our bodies to geological forces. Public and expert testimony of the hydrogeology of the region creatively extended scientific accounts to draw conclusions about the meaning and force of geology for the politics of uranium extraction. This essay contributes a unique account of environmental controversies in which materiality does not become instrumental or experiential knowledge, but instead produces a creative understanding of permeable geologic materials which provokes feminist thought.

### **Keywords:**

feminist theory, geophilosophy, knowledge controversy, materialism

## Introduction

While constructivist actor-network theory has been popular in social and cultural geography for years, a set of recent works has pushed its political theories well beyond those initially offered by Bruno Latour (2004). Rather than merely show that politics involves or is constituted through socio-technical relations or networks, recent works by Isabelle Stengers (2005), Jane Bennett (2010), and Noortje Marres (2012) have argued that ‘material publics’ are gathered through constitutive relations with objects or materials that collectively constitute the capacities of a public’s members. These constructivist accounts of environmental knowledge controversies have changed the ways in which geographers and political theorists understand the sites and spaces of political action (Braun and Whatmore, 2010). However, in these works, a focus on differing knowledge effects and controversies produced by materials obscures the ways in which inhuman materials exceed and undermine knowledge claims. I argue that these problems arise, in part, from an overt focus on constitutive connections amongst bounded, human-sized objects and timescales and a political preference for the local and everyday. Feminist geophilosophy, by contrast, has begun to attend to the excess and untimeliness of the inhuman forces constitutive of thought. These works provide a framework for understanding non-local connections – geohistorical and material – that influence the capacities for political action. This paper provides a unique contribution to feminist geophilosophy by offering an account of how the *permeability* of geologic materials might provoke feminist thought and politics to reconsider the shared, inhuman geological matrix that forms the substratum of political subjectivities. This is accomplished through an account of controversy over a proposed uranium mine in western South Dakota, which presented scientists, politicians, activists, and publics with the difficult project of thinking through underground relations between hydrogeology and political life. I argue that the disagreement about the character of fractured and permeable geologic

materials reflects not just different knowledge systems, but different ways of generating thought through encounters with earthly matter.

### **Knowledge controversy and feminist geophilosophy**

Early approaches in actor-network theory focused on whether objects could possibly be endowed with agency, and if so, what implications this would have for political decision making. However, due in part to the implication that agency itself implied decision making, debates often turned to focus on what it meant to be an actor. Recent approaches in ‘constructivist’ actor-network theory have now shifted to focus on the specific role of certain non-human objects to provoke political controversy. For example, Sarah Whatmore has expanded upon the political implications of examining the interfaces of human bodies and material worlds through a creative and collaborative project on making public flood risk science and knowledge (Whatmore, 2013; Whatmore and Landström, 2011). The effects of rising sea levels have shown potential to increase the frequency and/or severity of floods in rural England, resulting in the formation of ‘material publics’ concerned with the manner by which they come to be affected by such sociotechnical events. Others have explored how materials such as synthetic pipeline coatings and metals (Barry, 2013), the human and ecological effects of genetically modified organisms (Stengers, 2005), or mining and toxins (Alaimo, 2010) all gather overlapping, heterogeneous publics whose contestation is formed in and through their concern with material forces. The normative political rub of this approach is that the creative constitution of heterogeneous collectives in a political situation could be further empowered to slow down reasoning, to force thought to take into account the different matters of concern (to use a Latourian concept), and to therefore open up networks of knowledge production, scientific expertise, and political decision-making to a wider range of interested actors – human and non-

human. Objects, materials, and environments are thus generative of ‘problems’ through which social and political formations are created.

While this approach might seem well-suited for examining knowledge controversies centered around a well-bounded material object, it can run into two difficulties in evaluating how and why such situations occur. First, the causal relation between the material object and its knowledge effects can appear reductive and instrumental. As Noortje Marres has argued, materials and objects are politically problematic not just *for* publics – who could then be given the instruments to solve them – but also *in themselves* (Marres, 2012, page 46). The problems posed by materials are not just posed in order to be solved, which would lead too directly back to instrumental rationality as an easy solution. While a goal to “more effectively redistribute expertise between scientists (natural and social) and affected publics” (Whatmore, 2009, page 592) is certainly worthy, it also skirts around the more fundamental (or as Marres argues, ontological) problems that materials pose. These cannot be solved by changing the speed or distribution of knowledge acquisition, expertise, and decision making, for they “resist established routines of problem-solving” themselves (Marres, 2012, page 45).

Second, the material publics approach often fails to account for why *certain* material situations provoke thought and politics. The singular qualities of materials both within and in excess of an emergent historical-political situation might become eminently important, but if they do, then this is often not *only* because of disagreements surrounding the materials themselves. For example: the description and analysis of a material might contribute a new concept to a political movement, or create a shared language or common opponent amongst a collective. This is to say that although particular qualities or aspects of materials are thought-provoking amidst historical situations, the full breadth of their capacities is never fully captured or exhausted by such a situation. The search for

instrumental or deliberative solutions seems to belie the uncertainty and non-knowledge that emerges in between human thought and inhuman forces.

Feminist thought – and especially what we might provisionally call ‘feminist geophilosophy’ – raises some of these key problems for constructivist-materialist approaches to understanding environmental knowledge controversies, despite a shared inheritance<sup>1</sup> of concepts from feminist theory, feminist science studies, and geophilosophy.<sup>2</sup> There are three aspects of feminist geophilosophy that I would like to highlight: geologic forces as substrata of human existence, sexual difference as an inhuman matrix, and the non-local and the insensible as constitutive of thought. First, feminist geophilosophy is focused on understanding human corporeality and subjectivity through excessive and differential geologic and nonorganic forces. Thus, feminist geophilosophy positions itself in both a critical and creative relation to the geo-history that we inherit – that is, the plural, yet singularly intertwined histories of capitalism and the earth. As Kathryn Yusoff puts it, the inheritance of this aporetic geohistory is a matter of understanding “the geopolitical and evolutionary debt that ‘we’<sup>3</sup> owe fossil fuels” (Yusoff, 2013a, page 781), as well as all other materials extracted from the Earth. Feminist geophilosophy is critical of the differential rendering of this indebtedness across gendered, racialized, and working populations. But it also recognizes that our relationship with fossil fuels and the geologic more broadly is one that inspires and challenges our

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<sup>1</sup> An inheritance, as described by Jacques Derrida, is never a unity or gathering together, but a “radical and necessary heterogeneity... difference without opposition” that still necessitates a selection – a choice and a decision to “filter, sift, criticize [and] sort out several different possibles that inhabit the same injunction” (Derrida, 2012, page 18).

<sup>2</sup> Deleuze and Guattari define geophilosophy not as a subset of philosophical thought that would concern itself with Nature or the Earth, but instead as the manner in which all “thinking takes place in the relationship of territory and the earth” (Deleuze and Guattari, 1994, page 85). All thought emerges in between territorializations (fuzzy demarcations of milieux, states, nations, peoples) and deterritorializations, or those relations and movements through which territories “open onto an elsewhere” (Deleuze and Guattari, 1994, page 86). Feminist geophilosophy would not be a genre of geophilosophy (in the same way that feminist philosophy is not a genre of philosophy), but an investigation into those territorializations and non-local elsewheres that are generative of feminist thought and political action.

<sup>3</sup> The ‘we’ here remains a structurally incomplete rendering of differential unity tied together into a loose collective through the geologic materials that condition sociality. “No one is not compromised or enriched by fossil fuels extraction, and in this sense it is a unity from below, but one that is highly differentiated and shot through with relations of power (Yusoff, 2016, page 9).

bio-centric aesthetic and political sensibilities (LeMenager, 2014). Thus the specific attention to the geologic in feminist geophilosophy queries the spatially and temporally inhuman forces that partially generate human corporeality, subjectivity, and thought.<sup>5</sup>

Second, the ‘feminism’ of feminist geophilosophy derives from a post-Irigarian and expansive conception of corporeality and sexual difference. Grosz defines sexual difference in a way that makes it pre-ontological<sup>6</sup> and thus *inhuman* and not simply derived from human bodies, morphology, or sexuality:

“Sexual difference entails not the concept of a continuum, a wholeness, a predivisional world as plenum, but the simultaneous recognition and effacement of the spacings, the intervals, the irreducible if unspecifiable positioning, the fissures and ruptures, that bind each ‘thing’ to every other and to the whole of existence without, however, linking them into an organic or metaphysical wholeness or unity” (Grosz, 1994, page 209).

Indeed, feminist geophilosophy might be defined by its particular attention to, on the one hand, intervals, fissures, and ruptures, and on the other, fluids and flows (Irigaray, 1985; Longhurst, 2001).<sup>7</sup> Sexual difference would thus not be the relationship between two already-constituted sexes, but instead a pre-ontological continuum that constitutes n-sexes (Grosz, 1993). This formative inhuman matrix is also attested to by a focus on bodily fluids, which “attest to the permeability of the body, its necessary dependence on the outside, its liability to collapse into this outside...to the

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<sup>5</sup> While it is important to note that geologic forces are not the only way of generating such attention (think, for example, of feminist work on genetics and evolution), attention to geologic forces compels us to face inhuman and nonorganic problems head on.

<sup>6</sup> Grosz argues that sexual difference “a difference that is originary and constitutive is not, strictly speaking, ontological; if anything it occupies a preontological – certainly a preepistemological – terrain insofar as it makes possible what things or entities, what beings, exist (the ontological question) and insofar as it must preexist and condition what we can know (the epistemological question)” (Grosz, 1994, page 209). Some amount of confusion is possible with respect to this idiosyncratic understanding of ontology. For Grosz, ontological questions remain investigations into Being, while sexual difference is the horizon that conditions Being.

<sup>7</sup> As Grosz writes, her questions concern “*not* the body, which of course is now the most valorized and magical of conceptual terms within the social sciences and the humanities, but messy biology, matter, materiality, which have had to be organized and contained (as body) and dematerialized (through language).” (Grosz, 2005, page 171)

perilous divisions between the body's inside and its outside" (Grosz, 1994, page 193; see also Kristeva, 1982). Permeability (rather than closure) and transcorporeality (instead of individuality or meta-individuality) render collective bodies affectable, such that they become sites "in which social power and material/geographic agencies intra-act" (Alaimo, 2010, page 63). Feminist geophilosophy thus normatively investigates-advocates "moving across the actual container in the direction of the other through porosity" (Irigaray, 1993, page 51). While we must be wary of assuming an essentialist connection between normatively-construed femininity (or women's bodies more generally) and permeability, both have been marginalized in thought in ways that their enunciation together can be particularly clarifying for understanding the political stakes of such thought.

Third, feminist geophilosophy begins not from an uncertainty constituted by a *lack* of knowledge, but a constitutive difference between knowledge (and its functions) and thought (and its concepts). While feminists have critiqued scientific inquiry and rational instrumentality for the underplaying of uncertainty and inattention to the messy materiality of everyday life, we should be wary of re-centering encounters with the earth back on to (only) subjective experiences. Imperceptibility or invisibility are not just reliant on the essential capacities of our bodies to produce sensible experience, but instead on geo-historical encounters among bodies (human, nonhuman) that allow the transfer of some qualities and not others. Instead of an uncertainty constituted by a lack or provisionality of knowledge, feminist geophilosophy finds an "inhuman and nonhuman excess in identity formation" (Yusoff, 2015, page 388). This includes an account of 'non-local' forces (Yusoff, 2015) – that is, those forces that may condition the emergence of life and thought, but are distributed in space-times abyssally separated from the contemporary. This *includes* the geo-history of capitalism as a condition of today's feminist thought, which seeks to wrest itself from the conditions of the present and towards different futures.<sup>8</sup>

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<sup>8</sup> As Colebrook puts it, "feminism might not be one 'ism' amongst others but *the* thought of the future. Feminism

Thinking is differentiated from knowledge insofar as it produces problematic concepts speaking to the excess of forces of the world, while knowledge seeks to contain this excessive contingency and understand how forces generally function. While perceptible forces can be captured by scientific knowledge, the imperceptible emerges through thinking or aesthetics. What is at stake in differentiating thought and knowledge for feminist geophilosophy, which would seem to risk abstracting the sciences from the historical conditions of their regimes of visibility? It is in order to recognize and honor the necessity and yet divergence between these different modes of understanding the forces of the earth. As Stengers explains, it is through honoring this divergence that we could understand how the sciences and philosophy could become complimentary practices. For while knowledge controversies give us insight into how scientific functions come to exist, it is only through the “witch’s flight” of the concept that philosophers can come “to resist the present” (Stengers, 2005, page 164). As Anja Kanngieser puts it “Opening up and listening very carefully to the imperceptible, to the prospect of things beyond human cognitive and sensorial reach, and accepting their value and validity, is to leap into the unknown” (Kanngieser, 2015, page 82). Following this unknown witch’s flight, as Stengers often puts it, requires different skills and produces different effects than those of science. In short, it requires thinking.

Feminist geophilosophy must be distinguished from constructivism in part because the two positions share much, yet also seem to advocate vastly different modes of understanding what it means to practice or produce a *political* materialism. Both approaches appear resolutely immanentist and focus on the coming-together and falling-apart of assemblages of humans and nonhumans, rather than transcendent divisions between Nature and Culture. Yet the above account shows that at least three major differences exist between the approaches. First, while constructivism has largely focused on the micropolitics of human-sized actors and objects, feminist geophilosophy recognizes

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would be something like an openness, vulnerability or becoming as such” (Colebrook, 2013, page 26)

the geologic as a material substrata of political existence and subjectivity that well exceeds our human spatial and temporal cognition or experience. Second, feminist geophilosophy recognizes that an inhuman matrix of sexual difference forms the substrata of corporeality. This explicitly feminist account of the genesis of permeable and transcorporeal bodies challenges the discreteness of the ‘objects’ and ‘bodies’ that often appear in constructivist accounts. Both of these two aspects of feminist geophilosophy challenge the constructivist focus on micropolitics, which can occlude accounts of the planetary (Clark, 2011; Labban, 2014; Yusoff, 2013b), microbial (Hird, 2010), oceanic (Lehman, 2013; Steinberg, 2013), underground (this paper), and other strange-scale forces through which everyday embodied encounters are conditioned.<sup>9</sup> The rhythms and spaces of life and the radical non-life of the geologic are not necessarily easily synchronized into the everyday or mundane. Consequently, the politics of feminist geophilosophy shift, stutter, accumulate, and erode in a manner without any normative focus on slowing things down. Third and finally, while constructivism draws a clean line between material problems and knowledge, feminist geophilosophy instead focuses on the capacity of geologic materials to provoke not just knowledge, but also creative aesthetic and political responses. It is in this way that the ‘problem’ posed by encounters with materials is never eradicated but “insists and persists in these solutions” (Deleuze, 1994, page 163). Thus, feminist geophilosophy asks ‘What kind of Earth invites feminist *thought*? What encounters with matter summon one to think as a feminist, and compose one’s ability to do so?’ These questions seek to reach beyond knowledge controversies, phenomenal experience, and ‘the known,’ towards the constitutive unknown forces of the earth.<sup>10</sup>

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<sup>9</sup> Forces that constructivists describe as ‘abstract’ in opposition to the concrete reality of their accounts of local situations, micropractices, and human-sized objects.

<sup>10</sup> These questions are an extension of several asked by Yusoff: “So, we might ask, why are earth forces such a challenge to thinking? Why do they find such mean accommodation in social and political thought? And how might these earth forces be realised in a way that does not invoke a common ground (ie, in a way that maintains the productive engine of difference)?” (Yusoff et al., 2012, pages 981–982).

This paper contributes to feminist geophilosophy by giving an account of the ways in which the differential permeability of earthly materials (including human bodies) becomes both a problem for thought (and consequently politics) as well as their condition. This account proves to go well beyond traditional geographical accounts of knowledge controversy, risk, and hazards by extending the temporal and spatial scales of analysis and offering a political account of the genesis of thought. While feminist geophilosophy has often been primarily a theoretical and speculative, I add to this approach a focus on hydrogeology and uranium mining in order to better substantiate one of the material processes that currently conditions thought and politics in western South Dakota.

### **Encountering permeable matter**

Walking in the 95 degree heat near Edgemont, South Dakota, I was struck by the variety of holes I encountered. I had been looking for abandoned boreholes and the remnants of larger open-pit uranium mines from the 1960s and 70s. According to activists and scientists, there are over 4,000 abandoned uranium mines (AUMs) and exploratory boreholes in the arid plains and near-desert of southwestern South Dakota. Among these boreholes – which should be plugged to prevent vertical communication of water and contaminants – a 1970s Tennessee Valley Authority survey found 140 open, uncased drill holes, 16 previously cased, re-drilled open holes, four instances of artesian water, 13 holes plugged with wooden fence posts, six holes plugged with broken steel, 12 records of faults within or beside drilled holes, one drawing of two faults and a sink hole within a drilled transect, seven notations of ‘do not record this value on drill hole maps,’ and 63 redacted borehole logs (Atomic Safety and Licensing Board, 2014d) Driving across the landscape of western South Dakota and eastern Wyoming, one often encounters oil derricks and natural gas flares, open-pit coal mines, and trains carrying coal to more populous areas. It is no wonder that the region has long been understood as a ‘national sacrifice zone,’ an area rendered uninhabitable for the benefit of energy-

starved corporations (LaDuke and Churchill, 1985). What was most astonishing to me was the contrast between, on the one hand, the sheer variety of human intrusions into the surface of the Earth, and on the other, a proposed mining project that rested on the assumption that fluids do not and will not significantly migrate through this seemingly permeable landscape. It is this difference in accounts of hydrogeological permeability which became a central controversy in western South Dakota, and which I seek to add to other accounts of radioactivity, toxicity, and environmental justice.

I had come to the southwestern Black Hills area to listen to public testimony at an Atomic Safety and Licensing Board (ASLB) hearing in Hot Springs, SD concerning the Dewey-Burdock ISR mine and to meet with some of the activists – largely women – working to stop the mine from gaining approval. In-situ recovery is a relatively new method to profitably extract low-grade uranium ore from areas where open pit recovery is economically infeasible. At ISR sites, a sodium carbonate solution is injected into ore deposits several hundred feet beneath the surface of the earth. Uranium lodged in the porous material dissolves in the solution and the ‘pregnant’ solution is pumped back to the surface. The uranium is extracted from the solution and then processed off site, while waste water is re-injected into the orebody. According to the World Nuclear Association, ISR accounted for 47% of world uranium production in 2013, up from 16% in 2000 (World Nuclear Association, 2014). Most of this extraction occurs in Kazakhstan, by far the world’s largest uranium producer. Twelve ISR sites exist in the United States, mostly in Wyoming. The Dewey-Burdock site is located in western South Dakota just across the Wyoming border.

Two major sources provided most of the uranium for weapons and nuclear power in the US through the 1960s and 70s: the Colorado Plateau, extending through the southwestern US, and another deposit in the upper Midwest, stretching from the western Dakotas through Wyoming and Montana. While most academic and popular literatures on uranium extraction have focused on the

Colorado Plateau, thousands of uranium mines were dug in the latter region as well, ranging from small test mines dug by prospectors to fully operational open pit mines and refining mills. In southwestern South Dakota alone, at least 169 abandoned uranium mines have been documented, along with thousands of test and exploration holes, and a major uranium mill in Edgemont. Each of these mining events has had cumulative effects on the wider ecology of chemical flows in western South Dakota. However, tailings at the mill near Edgemont have likely been the most concentrated source of toxic elements circulating through water sources in the region. Active from 1956 to 1972, the mill stretched for over 213 acres and produced 2.5 million tons of tailings, resulting in significant impacts on soil, air, and water quality (Jarding, 2011). In one 1962 event, over 200 tons of tailings were washed into the Cheyenne River, which runs through the Pine Ridge and Cheyenne River reservations. Yet when the bottom dropped out on uranium prices in the mid-1980s, most of the uranium exploration in the Dakotas was already waning. The Edgemont mill was closed by 1972 and decommissioned in the mid-1980s. The disposal site is considered by the Department of Energy to be in “excellent condition” (2011, 25) and the responsibilities of the State of South Dakota and US federal government fulfilled.

It is widely documented that residual contamination from uranium mining is common on Native American reservations across the US and Canada, including the Navajo Nation and numerous other Native American communities in the southwest US (Brugge et al., 2007; Eichstaedt, 1994; Endres, 2009a; Smith and Frehner, 2010; Voyles, 2015) and in several Dene reserves in northern Canada (Stanley, 2013; Van Wyck, 2012). Indeed, it has been argued that up to “one half of North American uranium resources underlie [Native American] reservations” (LaDuke and Churchill, 1985). Public and environmental health scholars have also agreed that the impacts from uranium mining have primarily fallen upon Native people (Brugge and Buchner, 2011, page 232). Consequently, the proposition of a new uranium mine in western South Dakota, the Dewey-

Burdock project in 2009, was met with skepticism and opposition from both Lakota and non-Native activists. Over the next few years, a growing number of individuals and groups in the region began to organize against the proposed mine, concerned with the possible effect of ISR on groundwater quality and drinking water.

The risks of a possible effect – even minor – on groundwater quality were highlighted by the grievances brought by the Oglala Sioux Tribe and several native and non-native activist groups. The Oglala Sioux Tribe formally launched several complaints against Powertech, for both failing to properly consult with the tribe and failing to conduct proper historical and cultural resources surveys of the area. But a wider public campaign has focused on linking the effects of historic uranium mining on Lakota people with contemporary attempts to mine uranium. Madonna Thunder Hawk described the discovery of the impacts of uranium mining in the 1980s by the group Women of All Red Nations (WARN) as such:

“[I] had noticed that people were not really feeling well. It seemed like everyone was always sick with various ailments... Our report showed that in one month in 1979, 38 percent of pregnancies reported to the Public Health Service Hospital in Pine Ridge resulted in spontaneous abortions and excessive bleeding. Of the children born, 60 to 70 percent suffered breathing complications as a result of underdeveloped lungs and/or jaundice. Children were born with cleft palates, club feet - diseases uncommon to the Lakota and Dakota people” (Thunder Hawk, 2007, pages 103–104).

Although the direct causes of these ailments cannot be traced back to any single toxic ‘event’ (such as the tailings pile collapse), both drinking water and surface water in several locations on the downgradient (downstream) Pine Ridge reservation continues to contain toxic amounts of radionuclides, arsenic, and other heavy metals. It is well documented that average lifespan on the major reservations in western South Dakota is among the lowest in the country, and cancer rates are

much higher among Native Americans in the state than others – although again, these cannot be directly tied to toxicity due to uranium mining.<sup>14</sup> Nonetheless, for many Native and non-Native activists I spoke with, the health risks of an ISR facility were already clearly untenable. In order to legally raise such concerns within the NRC, ASLB, and federal environmental impact statement process, however, these activists would have to prove both that the groundwater and/or aquifers faced significant contamination risks, even far downstream and that the Oglala Lakota – defined as a minority population – faced an undue toxic burden. While obviously both are significant concerns, they were separated into two in order to be submitted into the legal controversy: on the one hand, the issue of groundwater contamination would be an issue of *knowledge*, while on the other hand, the specific impact on the Lakota would be addressed as proper protection of historical and cultural resources and proper consultation of tribes, both taken as *procedural* concerns.<sup>15</sup> The latter will be addressed briefly later in this paper, but the former will take up the bulk of my analysis.

Together with the Oglala Sioux Tribe, several contentions were raised by the Consolidated Intervenor (a group of individuals and advocacy organizations) about the environmental review and impacts of the proposed ISR mine. These included concerns over establishing baseline groundwater conditions, groundwater consumption, and mitigation measures. While fears of the toxic effects of radioactive materials might have been the motivating factor for many people, the central controversy stemmed from the contention that “the FSEIS fails to include adequate hydrogeological information to demonstrate the ability to contain fluid migration and assess potential impacts to groundwater” (Atomic Safety and Licensing Board, 2014a, page 55). ISR mining rests on the assumptions that fluids (mostly water) do not migrate far or fast in underground settings and most fluids are hydrogeologically isolated or separated from adjacent materials and aquifers by confining layers or

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<sup>14</sup> For a comprehensive summary of the impact of past uranium activity on Lakota health and land, see (Jarding, 2011)

<sup>15</sup> This is not to suggest procedural concerns are somehow outside of knowledge controversy; they are instead disagreements over the proper adherence to and knowledge of the law.

aquitards. In this case, the alluvial aquifer is confined by layers of shale. Although the possibility of excursions or leaks is explicitly acknowledged by the plethora of monitoring wells surrounding the mine, the ISR site is presented in the FSEIS as a relatively bounded three dimensional volume. By contrast, the intervenors contend that the confining layers are more leaky than acknowledged due to the presence of both natural and artificial faults, fractures, and holes that connect and communicate between aquifers.

One might wonder whether the controversy surrounded geologic materials and flows, or if this is a more conventional disagreement over the invisible and long-term effects of radiation on human health. Because most of us associate uranium with radiation, we might tend to think of the risk being debated here as comparable to controversies over nuclear waste storage in geologic repositories at Yucca Mountain, Nevada and the Waste Isolation Pilot Project, New Mexico. In these debates, similar questions over the temporalities of radioactivity and the inevitability of leakage through permeable materials were prominent. Additionally, each of these “nuclear colonialisms” faced criticism from Native American tribes for their impact on indigenous lands and peoples (Endres, 2009b; Kuletz, 1998). However, ISR mining differs in a number of ways. Although radionuclides producing gamma radiation can be produced as a byproduct of in-situ uranium mining, heavy metals and dissolved solids are also waste products that would be re-injected into the earth. The migration of any of these materials into drinking water would be harmful. But unlike other geologic repositories or toxic waste leaks from landfills, the leak does not rely on the crossing of a manmade boundary. There is no manmade layer of concrete or geosynthetic clay liner which would serve as a ‘first line of defense.’ Confinement of the waste products is solely based on a principal of geologic impermeability. The question of risk and uncertainty in this ISR project focused not merely on whether these toxic materials could be confined by human technological solutions, but the rate at which materials pass through subsurface layers themselves. The migration

of treated waste water through permeable materials thus became a specifically geologic question. Consequently, re-examining nuclear waste disposal from the perspective of geologic permeability would add much to other accounts of controversial attempts to confine radioactive materials.

Fluid migration or communication between aquifers can occur in several different ways. On the one hand, the confining shale layer could be more permeable than anticipated. This is suggested and highlighted by a 1982 paper one activist gave to me, in which the following sentence was underlined: “most naturally occurring earth materials have finite permeability; there are no totally impermeable materials” (Bredehoeft et al., 1982, page 297). The hard copy of this report passed down to me contains a diagram of the major aquifers in the region, with extra arrows hand drawn by activists to indicate fluid migration and question marks in between aquifers. A Tennessee Valley Authority survey from 1980 also provided evidence that the confining shale is leaky due to “the primary pore space” (Atomic Safety and Licensing Board, 2014a, page 58).<sup>16</sup> Opposition to the ISR project used this account of the subterranean as a refrain, often arguing that all geological materials in the region are permeable to some degree.

However, most of the evidence of fluid migration was due not to the permeability of confining shale, but rather to larger natural and artificial holes that render confinement incomplete: joints, faults, fractures, sinkholes, collapsed breccia pipes, artesian wells, and boreholes. Joints, fractures, and faults are caused by slight vertical shifts in strata. Sinkholes can form at the surface when water seeps through a subsurface fault, dissolves surrounding material and forms a cave, which subsequently collapses. Breccia pipes are somewhat more complex column formations that result from the dissolution of rock by underlying water. Surrounding material collapses and resediments, forming a vertical column with different permeability than the surrounding materials. The presence

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<sup>16</sup> This sentence from the TVA abstract was quoted frequently, by the public and as official evidence: “The test results indicate that the two aquifers are hydrologically connected via (1) general leakage through the Fuson shale, and (2) direct pathways, probably in the form of numerous old (pre-TVA) unplugged exploration boreholes” (Boggs and Jenkins, 1980, page 1).

of breccia pipes in the region would facilitate the excursion of groundwater between aquifers. Proving the presence of these features in the project area is difficult; despite both expert and non-expert testimony that many of these features are located in the southwestern Black Hills area, it was ruled that breccia pipes, faults, and sinkholes are not located in the project area and that the presence of artesian wells and minor faults would not communicate between aquifers. In short, natural fluid migration was denied by both Powertech-Azarga and NRC, and the project area affirmed as a confined aquifer.

On the other hand, the existence of unplugged test boreholes in the region could not easily be denied, and the boreholes are acknowledged to be the likely cause of fluid migration between aquifers in the project area. In addition to the aforementioned review of TVA driller's notes of 4,000 boreholes in the region, Powertech-Azarga attributed all signs of leakage to improperly cased boreholes. These boreholes are generally about 600 feet deep and six inches wide, although I had also been told by activists that some are big enough to fall into. Initially, the company refused to release its own electronic records of borehole tests before being ordered by the ASLB to release the data to the defendants (this data was not made public). However, rather than understanding the landscape as ridden by (either human-caused or natural) fractures and communication between aquifers as signs that the project might pose fluid migration problems, the NRC simply required that Powertech-Azarga clearly state how they would find and plug existing boreholes. By placing the capacity for leakage squarely on the presence of boreholes, the defense maintained that hydrogeological leakage is not a natural geological state in the project area.

In addition to the expert testimony and legal argumentation above, activists and public testimony further emphasized the permeability of groundwater materials, rejecting the claim that boreholes are the only cause of leakage. One polemic that drew raucous applause serves as an example for sentiments from many I spoke with:

“The TVA concluded the Fall River and Dakota aquifers leak, and they don’t just leak from abandoned bore holes. They leak because the geology itself is fractured in the whole region. Similarly, we also heard this morning about breccia pipes and other fractures allowing the water movement between deeper aquifers in the area, including the Minnelusa and the Madison. Yet, Powertech comes along and reaches the opposite conclusion: ‘the geology isn’t fractured. The aquifers don’t leak. Trust us. We’re the experts. We have a computer model’” (Atomic Safety and Licensing Board, 2014b, page 18).

As this and other testimony attests, the heterogeneous public gathered largely in opposition to the Dewey-Burdock project had knowledge about many of the geologic features of the region and thus contested the expertise of Powertech-Azarga and the ASLB. Several individuals attested to the presence of artesian springs and breccia pipes on their property (outside the project area). As many continued to testify to this end, this lent Powertech-Azarga’s claims that the project area was confined an almost mythic quality. How could this one three-dimensional volume be perfectly sealed, when the rest of the region appears to be ridden with holes?

Together, these testimonies would seem to indicate a classic environmental knowledge controversy, which Whatmore convincingly argues occurs when “an environmental disturbance of some kind forces people to notice the unexamined stuff on which they rely as the material fabric of their everyday lives, and attend to its powers and effects” (Whatmore, 2013, page 45). It is often shown that in such political situations, knowledge and expertise is challenged, and publics form counter-knowledge networks in reaction to such disturbances (Holifield, 2009). Constructivist accounts have shown that the assembly of networks or collectives involves creating trans-local alliances with both humans and nonhumans in an effort to convince all the relative actors that a project is feasible or worthwhile (Latour, 1996). We can see this in the opposition to the Dewey-Burdock project, which clearly involves alliances between activists, scientists, boreholes, concerned

landowners, driller's notes, tribal governments, aquifers, and so on. Yet what would be lacking in such an account is not only a normative political stance on such alliances (for which constructivism has been critiqued *ad nauseum*). Instead, the particular strange-scale features – in this case, permeable geologic materials – provoked activists to think or conceptualize (not merely know) about the role of these bodies in the political situation. Outside the conventions of constructivist accounts of environmental knowledge controversy, encounters with geologic materials have provoked feminist geophilosophy towards speculative theoretical frameworks, as the strange temporalities and scales of geologic life and materials preclude easy formulation as 'actors.' This thought would be at once constitutive of embodied knowledge, yet also constantly escaping its full grasp. Permeability is one possible adequate name for this condition. The Dewey-Burdock controversy demonstrates both that geologic materials evidence such permeability, and that geologic permeability 'undermines' knowledge controversy. In the accounts of many of the non-expert actors who gave testimony in the Dewey-Burdock case, the permeability of underground spaces was both *known* and *exceeded the capacity to be fully known*. It was, in short, a condition for thinking the shared capacities of the human and radically inhuman.

Public comments in the environmental review process attest to the excessive force of the geologic, for the public gathered by the proposed Dewey-Burdock project did not have access to underground spaces or beneath-the-surface activities. It is somewhat surprising then that this heterogeneous public so vociferously claims that seemingly "out of sight, out of mind" (Atomic Safety and Licensing Board, 2014c, page 3) geologic materials are in fact permeable, such that their qualities might be beyond Powertech-Azarga's rendering of scientific knowledge.

"[Powertech-Azarga] claim[s] there is no connectivity between the aquifers, and their project is completely contained. Just recently, spelunkers thought they'd reached the end of the third largest cave in the world, Jewel Cave, which is just north of the project there...The

spelunkers were thrilled when they squeezed through that tight space and found yet more huge caverns. We are not confident with Powertech-Azarga's claims of knowing what lies beneath" (Atomic Safety and Licensing Board, 2014c, page 3).

This quote speaks to both the possibility of human knowledge of underground space (through the experience of spelunkers in the Jewel Cave<sup>17</sup>) and to the limits of this knowledge. By showing that our current knowledge could be undermined by the presence of cave passages, this speaker attempted to not just discredit the expertise of Powertech-Azarga's knowledge, but show that 'knowing what lies beneath' is an only-tenuous possibility. In many ways then, the experiences here testify to the use of human experience of one scale (human bodies in caverns) to testify to another scale (hydrogeologic movement). The visibility of caves is one way in which the *invisibility* of most geologic processes can be recognized.

While this claim rests on human experience of relatively human-sized passages, others testified to stranger, unknown scales. One person cited the experiences of another ISR mine in eastern Wyoming, west of the Dewey-Burdock project area about 100 miles.

"The company doing the mining there reported to the NRC that they have a break in the line that disposes of the deepwater, the toxic water that goes into the deep well, the deepwater well. But, since it is so corrosive, it is a relatively-young mine also, they are losing something like 26 percent of all of the toxic sludge that they are trying to push down into the deepest water they can possibly find. And they don't even know where the break is. Call it high-tech. Call it whatever you want, but they are not even sure where this water is leaking. It could be going into clean water. It could be going into dirty water. It could be going into just groundwater, just any other ground. We just don't even know where it is going, but 26

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<sup>17</sup> 175 miles of Jewel Cave have been mapped by spelunkers, while the nearby Wind Cave is also nearly 150 miles long. The entrances to both caves are within 40 miles of the Dewey-Burdock area.

percent of all of the wastewater is just being pushed out into unexpected places” (Atomic Safety and Licensing Board, 2014b, pages 86–87).

The non-knowledge of what is happening underground turns into an almost-frantic litany of uncertain possibilities. But the uncertainty of *where* the water is migrating is also couched in a certainty that it *is* migrating. Whether or not the firm or NRC accepted this relationship between uncertainty and knowledge, it is clear that in this statement, leakage is a constitutive aspect of the permeability of the geology itself. Consequently, uncertainty is not being promoted for the sake of simply exposing that Powertech-Azarga and other mining firms are presenting tenuous claims about invisible risks. The public also replaced this uncertainty with its own testimony of the permeability of the geology of the region.

Unfortunately, such testimony finds little traction in the institutional structures of environmental review. No doubt, this is a function of the historic and settler-colonial power relations that are condensed in environmental review processes. The entire structure of public environmental review is predicated on federal agencies proactively gathering public testimony for the institutional record without substantially responding to the root causes of the grievances being raised. Thus, the institutional structure of public forums invites knowledge controversy while seeming to preclude thought. Indeed, it is telling that although the ASLB would later require Powertech/Azarga to locate and plug boreholes, the Dewey-Burdock project was further delayed not by the testimony about the migration of toxic materials, but instead by the procedural argument for proper consultation with tribal governments. While this is a victory for the activists attempting to delay and contest the project, perhaps another lasting effect might be the mobilization of permeability as a condition for feminist thought. In the last section, I consider how the account of permeability under contention might spur feminists to consider geologic relations anew.

**“We are a catacomb of tunnels”**

The activities of geologic materials beneath the proposed Dewey-Burdock mine form an only partially knowable matrix which provokes thought to creatively conceptualize the gaps, fissures, and absences in knowledge. Beginning to account for this groundless ground as geologic, feminist geophilosophy has begun to rethink the long history of the Anthropocene and the challenges that fossils, cave art, and fire pose to our conventional understandings of bodies, aesthetics, and politics. Human bioturbation - the large-scale modification of the geologic structure of the earth via boreholes and mines – is part of the inheritance of our political moment, and a challenge for contemporary feminist thought. As the earth scientists Zalasiewicz et. al. note, one of the principal problems in studying human bioturbation is that “the extent and geological significance of subsurface crustal modifications are commonly neglected: out of sight, out of mind. It is a realm that ranges from difficult to impossible to gain access to or to experience directly” (Zalasiewicz et al., 2014, page 3). But were we to end with simply the partial unknowability and non-experience of permeable matter, little would be provided to or for feminism by way of a different manner of thinking, for feminism has long argued that the supposed universal reach of reason meets limits in its ability to account for matter and corporeality. How do geologic materials provoke feminism to think *differently*? How is feminism disturbed in this encounter with the Earth?

“We are a catacomb of tunnels,” one public commenter put it (Atomic Safety and Licensing Board, 2014b, page 15). Perhaps a poetic statement in the context of the ASLB hearing, but also one that speaks to the difference that attention to the geologic momentarily produced among the activists and publics assembled in response to the Dewey-Burdock project. The ‘we’ being invoked here *includes* both the human and drastically inhuman. It includes the communities of people on the surface of the Earth *and* the Earth itself, riven with fractures. The long history of human interaction with earthly materials challenges accounts of bodies as discrete or nested objects, containers, or

entities. It challenges us to view this material history and contemporary geography as entangled together in a way that can't easily be separated from the abyssal gaps in our knowledge of the past and present / presence of materiality. Finally, it provokes feminist thought to reconsider the constitutive relationships between sexual difference and the inhuman conditions of thinking. In each of these ways, we must begin to think anew the relationship between our politics and “what is *inhuman* in all its rich resonances” (Grosz, 2011, page 86).

Perhaps apparent, the permeable or leaky nature of materials cannot be acknowledged by the traditionally patriarchal institutions of capital and corporate science. To acknowledge timescales (or timescapes) wider than the immediate and short term is antithetical to the short-term interests of economic businesses (Adam, 1998). Future generations (or even current ones) are not constituents who vote or buy products. And of course, the fluid, messy bodies of women are the targets of patriarchal control, governance and anxiety (Longhurst, 2001). These problems are not limited to the geologic; just think of the analogous problems in the effects of toxicity more generally (especially in situations of environmental injustice), the possible permeability of oil pipelines, the radical timescales of nuclear waste and decay, and the collapse of permeable materials through hydrofracking. Each of these demonstrates that bodies and materials are constitutively open to their outsides. One must wonder then whether the focus of constructivism on the interactions of relatively-enclosed human-sized objects cannot adequately begin to understand. One begins to wonder whether these situations can be understood as controversies over knowledge *per se*, or if, indeed, there are significant differences in the meaning, significance, and reality of living in a world where ‘we are a catacomb of tunnels.’

The shared permeability of geologic and biologic materials specifically invites feminism to reflect on its own engagement and understanding with human and nonhuman forces, beyond our more intimate companion species and local networks of interaction. While it has become common

for any understanding of ‘the human’ to arrive with a de facto caveat that we are composed of all sorts of nonhuman and inhuman relations, if one were to simply add inorganic, inhuman, or geologic relations to this statement, little would be added to this generalized posthumanism. Instead, what porous materials provoke for feminism is an exploration of *that which is shared or held in common* between human bodies and earth forces. If we begin to understand ourselves as “beings who have something in common with the geologic forces that are mobilised and incorporated” (Yusoff, 2013a, page 781), geologic materials can appear as secret collaborators in developing our differential capacities for political language and organization. Glimpses of such moments appear in Dewey-Burdock opposition amongst the most tireless activists, most of whom perhaps unsurprisingly are women. For many women I spoke with, their understanding of subsurface activity was tied to an understanding of a permeability shared among geologic and nonhuman bodies. For instance, one conversation that began with a discussion of abandoned uranium mines quickly turned to the bodily risks one registered engaging in a decades-long anti-uranium struggle – registered as skin discolorations on gnarled hands and a sense that these individuals were sacrificing their own health in their political activism. Whether or not these wounds could be directly tied to exposure to radioactive elements, they were seen as markers of the permeability of our bodies and the open vulnerability one engaged with as a political actor. The passage of toxic elements through geophysical materials, ecological systems and human bodies signifies an understanding of material activities that begins from permeability, rather than understanding it as derived from a primary surface that is secure, solid, or impermeable. But this was not understood by these activists merely as a vulnerability or *incapacity*; rather, it is a part of the significance of their struggle for clean water and environmental justice. Permeability is an active force of composition that gathers a ‘we’ into being.

The permeability of human and nonhuman bodies renders corporeal feminism open to the interposition of various scales of matter beyond ‘the local.’ One cannot easily point to a proper scale

or temporality at which any particular object or body can be properly understood to be bounded. The future and past timescales and landscapes of the Black Hills uranium mining, for example, interpenetrate with not just the values of political movements, but also the bodies of political activists, past and future. On every scale, bodies or materials are riven with a radical openness to other times, scales, and materials. While the effects of radioactive materials demonstrate this, it is through geological materials that permeability as a shared corporeal capacity is understood. Consequently, it is difficult to understand environmental knowledge controversies as arising from disagreements among local vernacular knowledges and a universal scientific or theoretical knowledges, as commonly portrayed in some feminist geographies.<sup>18</sup> These controversies are as much about fundamentally different views of where both knowledge and thought come from, and thus their politics are not divided by a proper or more discrete bounded scale.

If we are a catacomb of tunnels, what becomes of the political project of assembling a ‘we’? For feminism, the constitutive non-knowledge of porous materials encourages a reflection on the “differential renderings of corporeal vulnerability and obduracy” (Dixon, 2014, page 139) well beyond discrete human and nonhuman bodies towards a recognition of strange scales and with unknown effects. Our question then becomes “what forms of geologic life subtend subjectivity; and how this geologic life holds the potential for a more expansive inhuman thought” (Yusoff, 2013a, page 780). Feminism is invited to think the material *geopolitical* relations that underlie and privilege certain forms of thought, life, and politics and challenge us to produce new modes of interacting with others. We are only beginning to scratch the surface, so to speak, of the implications of the vast subterranean materials and movements that subtend human life.

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<sup>18</sup> Although not explored in this essay, this has further implications for stereotypical representations of indigenous knowledge and politics as ‘local’ as well. Lakota and other indigenous activists involved in the Dewey-Burdock controversy are neither anti-science nor merely involved in local struggles, but constantly network with other Native and non-Native individuals and groups.

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