Disturbed Earth: Conceptions of the deep underground in shale extraction deliberations in the US and UK

Tristan Partridge[a, c], Merryn Thomas[b], Nick Pidgeon[b], Barbara Herr Harthorn[a]*
*corresponding author
[a] Department of Anthropology; Center for Nanotechnology in Society, University of California, Santa Barbara, CA 93106-3210, USA.
[b] School of Psychology, Cardiff University, 51a Park Place, Cardiff, CF10 3AT, UK.
[c] María de Maeztu Unit of Excellence, Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona, 08193 Bellaterra (Cerdanyola del Vallès), Barcelona, Spain

Hydraulic fracturing ('fracking') has enabled the recovery of previously inaccessible resources and rendered new areas of the underground 'productive.' While a number of studies in the US and UK have examined public attitudes toward fracking and its various impacts, how people conceptualise the deep underground itself has received less attention. We argue that views on resources, risk, and the deep underground raise important questions about how people perceive the desirability and viability of subterranean interventions. We conducted day-long deliberation workshops (two in each country), facilitating discussions among diverse groups of people on prospective shale extraction in the US and UK. Themes that emerged in these conversations include seeing the Earth as a foundation; natural limits (a greater burden than the subsurface can withstand versus simply overuse of natural resources); and ideas about the fragility, instability and opacity of the deep underground. We find that concerns in both countries were not limited to specific, localised impacts but also addressed ecosystem links between surface and subsurface environments and broader questions about the use, identification and value of natural resources.

Keywords:
Underground; environmental values; fracking; public deliberation; extraction

1. Introduction

Oil and gas extraction from shale has increased fossil fuel reserves globally and transformed energy sectors nationally, particularly in the US since 2000 (Broderick et al. 2011). Deep

horizontal drilling and hydraulic fracturing ('fracking') have enabled the recovery of previously inaccessible resources, rendering new areas of the underground 'productive' (Hughes 2013). Numerous, predominantly US-based studies have examined attitudes toward shale extraction and its impacts (Thomas et al. 2017b). These impacts include groundwater depletion and contamination (Anderson and Theodori 2009), social disruption (Stedman et al. 2012), health risks (Perry 2013), landscape damage (Willow and Wylie 2014), and contested links to jobs (Clarke et al. 2015), energy independence (Brown et al. 2013), and climate change (Partridge et al. 2017). However, a further dimension of emergent views on fracking has received less attention – how people view and value the underground itself. Fracking is one of a number of controversial techniques that extend the subsurface reach of extractive processes, and underground spaces are central to other resource-related conflicts including those regarding water extraction, the disposal of toxic and radioactive waste, and carbon sequestration (Kearnes and Rickards 2017). As these socio-political conflicts intensify, a critical task for scholarly inquiry is to trace and interpret changing ideas about the underground and the Earth's ability to withstand novel forms of subsurface intervention. Drawing on key themes that emerged in shale extraction deliberations in the US and UK, here we investigate how conceptions of the underground are articulated and their relation to environmental values and ideas about environmental change.

Shale gas and oil are *unconventional* fossil fuels that are more technically challenging to recover than those found in conventional resource reservoirs (CCST 2015). Fracking involves injecting water, chemicals and sand into shale at high pressure sufficient to fracture the rock, a process not economically viable for decades after initial experiments (Trembath et al. 2012). In certain locales, conventional oil and gas wells are as deep as those drilled into shale (which are often 1.5 miles deep). Shale wells, however, are also drilled laterally at those depths for distances of up to two miles and multiple wells are developed from a single surface site (Broderick et al. 2011, Maugeri 2013). New extraction sites have been created in places located above large shale formations – sometimes in areas without much history of onshore extraction, as with proposed sites in the UK (Hawkins 2015) – and extraction has been revived in other areas where conventional oil and gas reserves were depleted, together creating a shale 'boom' across the US (Jacquet and Kay 2014).

Studies in the US have critically engaged with previous boomtown research to examine contemporary experiences of numerous quality-of-life impacts close to extraction sites (e.g., Stedman et al. 2012). However, the relative abundance around the world of unconventional fossil fuels, including shale oil and gas in the US and UK, means they are a matter of concern beyond immediately affected communities due to potential impacts across multiple scales (Hughes 2013). Such global abundance is reflected in current estimates that suggest shale gas, for example, could increase global gas reserves by more than the amount of all currently known conventional gas reserves (Kuuskraa et al. 2013, Cooper et al. 2016).

Witnessed and anticipated impacts of shale extraction figure prominently in energy debates in both the US and UK. The US now produces nearly all the natural gas it uses, and oil wells drilled since 2014 have provided almost half of total oil production – all due to growth in shale extraction (EIA 2016, 2017). UK political leaders have described prospective shale development as a 'fantastic opportunity' (DECC and Leadsom 2016). In both countries, supporters praise the potential to meet growing energy demand, for example, while opponents highlight damaging effects on local environments and global climate change (Evensen 2015, Partridge et al. 2018). For this study, we selected research sites that represented two major population centers (Los Angeles; London) and two smaller coastal cities (Santa Barbara; Cardiff) all in "pre-impact" locations – where potential for deep shale extraction has been identified but not yet operationalised at commercial scale (Partridge et al. 2017). In the UK, shale extraction is still at an exploratory stage (Bradshaw 2017). In California, while a form of fracking is being used, due to geology impacted by a history of seismic activity, thus far this happens only in shallower, vertical wells, and in other kinds of rock, not shale (CCST 2015). However, oil industry operators continue to explore the potential for deep shale oil extraction across the state (Hughes 2013). For all four of our workshops, we thus facilitated discussions with a focus on what the projected impacts (positive and negative) would be, if such potential expansion of fracking were to be developed.

2. Background

i. Resource frontiers and the underground

By extending human-engineered systems that identify and utilise natural resources, shale extraction represents the global expansion of *resource frontiers* (Tsing 2003). Such physical

and figurative frontiers are important loci for studying environmental values and the potential impacts of human activity on the natural world (Macnaghten and Urry 1998, Barney 2009, Corner et al. 2013). In contrast to frontier 'mythologies' of wilderness literature – picturing white men as dominant within a panoramic image of the Western US (Nixon 2011) – the critical concept of resource frontier scrutinises impacts of colonization and the expansion of extractive operations. Drawing on Tsing, Lydon describes a resource frontier as both a "transactional space" linking people and resources and as a focal point for analyzing how activities in that space may generate wealth and revitalization as well as destruction, exploitation, and injustice (Lydon 2015). When presented as a mode of 'discovery' (d'Avignon 2018) or when coupled with the commodification of previously shared or untitled land, production along resource frontiers has been characterised by conflict, disruption, and disregard for regulatory authorities (Nugent 2003). The "emerging frontiers" of shale extraction are similarly described as being "unsettled" and linked to "tumultuous transformations" in social and ecological landscapes (Willow and Wylie 2014). Both within and beyond those localities, the expansion of resource frontiers through fracking highlights contrasting ways in which natural resources from the deep underground are conceived and valued as compared to more conventional resource sites and practices.

Analytical interest in the ethical and socio-technical dimensions of different forms of underground development contributes to a growing field of social science research and work in science, technology and society (STS) which addresses how the underground is studied, engaged with, known, and evaluated (Birkenholtz 2018, Kinchy et al. 2018). This work draws on Williams (2008) to reconsider the physical world encountered below the Earth's surface, studying for example how "the underground" becomes a metaphor for highly technological environments (Kinchy et al. 2018) or operates as a site where human activities typify projects of modernity (Disco 2010). Such projects involve the transformation of nature into resources, the colonization of territories, and the ideological rendering of the natural world as manipulable matter to meet politico-economic imperatives (Merchant 1990, Bauman 1993). Kearnes and Rickards trace historically how the subsurface has been imagined variously as sublime, fearsome, a source of mineral riches, and a "stratigraphic record" of human-driven environmental change (Kearnes and Rickards 2017). Associated with such a wide range of ideas and values, *the underground* is best understood as a multiple, varied concept, and our perceptions of it mediated. As Pereira argues, *the underground* is a

"fabrication" and conceptions of it "cannot be disconnected from both the mechanisms we use and the ambitions we develop while using them" (Pereira 2015, p. 5). Building on such insights, we focus specifically on the *deep* underground.

ii. Environmental values, non-interference, and opacity

Studying conceptions of the deep underground engages diverse streams of environmental values research on issues including economistic valuation; individual evaluation and opinions about worth; values as universal, moral principles; differences between axiomatic (normative) and relativistic (subjective) approaches; and the contrast between intrinsic and instrumental or utilitarian values (Dietz et al. 2005, Kalof and Satterfield 2005, Satterfield et al. 2013). The latter distinction – where the environment has inherent (intrinsic) worth rather than merely existing as material for human purposes in the form of natural resources (Palmer et al. 2014) – is of particular relevance to shale extraction, commodification of the underground, and expanding resource frontiers. For example, both in general and with specific reference to shale development, environmental justice scholarship has underlined local impacts and stark inequalities between those who benefit from the economic value of subsurface resources and those whose environmental values (and well-being) are disrupted by resource extraction (Pellow 2000, Perry 2013). The consequences of such forms of underground development also cut across local, national, and global scales due to the range of risks associated with extracting and burning unconventional fossil fuels and associated, potentially harmful, environmental futures (Neville et al. 2017).

Other interventions also both respond to and shape conceptions of the underground. One example is the deep burial of hazardous waste, and a core issue its opponents raise is the importance of *non-interference* in the earth's fundamental processes (Mabon and Shackley 2015). Optimistic plans for subterranean urban development, as another example, have had to address the underground's widespread negative associations across cultural contexts with darkness, death, and loss of "connection" with more familiar elements of nature (Carmody and Sterling 1993). Identifying differences between geologists and non-experts in views on subsurface hydrology and geological instability, risk communication research in the UK has identified a wide range of perceptions and understandings of the underground (Gibson et al. 2016). Further tensions emerge in views of the underground between dangers of coal mining (Mumford 2010) and positive images of coal as "buried sunshine" (Dukes 2003); between

aesthetic considerations in conserving cherished landscapes and respecting the (uncontrollable, dynamic) geological processes that both formed and might threaten them (Lee 1995); and between responses to the invisible, unfamiliar, and unknowable aspects of the underground. Responses to these latter qualities – to the opacity of the deep underground – variously conclude it is either a place of darkness and danger, alternatively of wonder, or all these simultaneously (Eckersley 1994, Wolfe 2001).

Such tensions are not limited to questions of how *the underground* is valued – they extend to the environment as a whole. Restating the basis of non-anthropogenic value in nature (independent of human valuing), Attfield (2005) asks "What gives nature its importance or significance, or allows us to understand it not as indifferent but as wonderful?" While his responses encompass all environmental realms, they echo many of the impressions of the underground mentioned above, citing non-humanistic expressions of nature's otherness and desire for experiences with nature that is "untamed," uncontrollable, or at once "fearful, attractive and enticing" (Attfield 2005, p. 517). In sum, while specific contexts and the *type* of human activity or subsurface disturbance are important in shaping views, other critical themes for considering the underground are opacity, non-interference, environmental values conflicts, and otherness.

iii. Energy initiatives and "tampering with the underground"

A number of studies of energy interventions have documented conceptions of the underground – though without a focus on the deep underground adopted in the current research – identifying for example a fear that buried objects might display unusual characteristics (Poumadère and Mays 2003), or exploring views on carbon capture and storage (CCS: the disposal of CO_2 in deep geological formations) (Sharp et al. 2009). In contrast to mental models research on non-expert perceptions that found strong disassociation between subsurface and surface environments (Gibson et al. 2016), two influential sets of values have been identified in views on CCS: (i) the notion of an ecosystem network linking seemingly disparate environmental entities, where disturbance in one part has effects elsewhere (Gough et al. 2002) and, relatedly, (ii) the idea of "interference with nature" (L'Orange Seigo et al. 2014). US studies of CCS have highlighted concerns that 'interference' might cause earthquakes or water contamination (Palmgren et al. 2004). Participants in qualitative studies in Japan saw the intended permanence of CCS projects as

interfering with "nature's laws" (Tokushige et al. 2007); in Switzerland, as "playing God" (Wallquist et al. 2009). In the Netherlands, the depth of CCS operations was linked to concern about CO_2 leakage, but with no direct relation between depth and risk perception (Brunsting et al. 2012). In a comparative review, underground carbon sequestration was seen as an "unknown" hazard (a risk new to science) with potential consequences hard to detect or mitigate (Singleton et al. 2009).

Drawing together many of these ideas, the notion of "tampering with nature" addresses humans' interference in the natural world combined with the arrogance or immorality that such acts may reflect (Sjöberg 2000). A further CCS study in Switzerland found that *tampering with the subsurface* was a particularly influential value construct, suggesting a "moral concept" of nature (and the subsurface in particular) ranging from "naturally untouched" to "unnaturally disturbed" (Wallquist et al. 2012). Such a framework aligns with the established finding that views on emergent technologies are influenced by perceived (un)naturalness (Slovic 2000, Corner et al. 2013). Risk communication research on geothermal energy and elevated seismicity has identified concerns about 'tampering with nature' (Trutnevyte and Ejderyan 2017) and similar studies link such concerns with "primordial fears" about waking a "sleeping terror" that lurks in the deep (Giardini 2009). As such, geothermal power has been linked to risks and uncertainties associated with nonrenewable energy sources, including unconventional fossil fuels (Gross 2013).

Extracting unconventional fossil fuels requires additional technologies to access new underground resources. Oil/tar sands may be found close to the surface but require steam-assisted extraction techniques, while the extraction of methane from coalbed formations or oil/gas from deepwater locations requires modified drilling applications (Neville et al. 2017). Another case is underground coal gasification (UGC) which involves the partial combustion of unmined coal to produce natural gas. It is associated with groundwater contamination, surface subsidence and – a particular concern for participants in a public perceptions study in the UK – risk of underground fires (Shackley et al. 2006). While histories of mutually constitutive relationships between human societies, minerals, and mining span thousands of years (Libassi and Peluso 2016), common to fracking and the interventions cited here are elements of what Erikson calls "new species of trouble:" critical links between technical risk and social processes, unprecedented scale of operations, conflicts of value, as well as new

uncertainties and forms of human-induced toxicity (Erikson 1994), issues that this research investigates. We argue that views on resources, risk, and the deep underground raise important questions about how people perceive the value and viability of subterranean interventions – perceptions we explore here through deliberative discussions on prospective shale extraction.

3. Methods

Deliberative research both facilitates participant engagement with new information and diverse perspectives, and provides effective techniques for cross-national comparison of public discourses on emergent technologies (Pidgeon et al. 2009, Harthorn et al. 2012). We designed and facilitated a series of day-long deliberation workshops to engage diverse publics on the future meanings and consequences of shale extraction, including a presentation on the technical processes involved in hydraulic fracturing in shale and informational materials designed in consultation with a panel of topical experts in both countries (Partridge et al. 2017). Building on existing deliberative approaches used in comparative research into views on other emerging technologies, we recruited groups that were gender balanced, drawn from different areas of the cities, and 'quasi-representative' of local demographics with regard to age, income, education, occupation, and race/ethnicity (Pidgeon et al. 2009, Partridge et al. 2017, Thomas et al. 2017a). A total of 55 people participated in our workshops in October 2014 held in Los Angeles [LA] and Santa Barbara [SB] in the US, and in London [LN] and Cardiff [CF] in the UK.

This research project draws on prior studies of the societal implications of emergent technologies, including nanotechnologies and geoengineering (Pidgeon et al. 2009, Harthorn et al. 2012, Corner et al. 2013). Our workshops involved a series of tasks, facilitated discussions, information sharing and open-ended conversations designed to address key issues associated with shale development, and to enable participants and groups to discuss these issues in their own terms (Partridge et al. 2017). Each workshop followed the same overall protocol to facilitate comparisons across sites, with minor adjustments made to provide locally relevant contextual information (e.g. on regulation and planning processes) (Macnaghten 2017, Thomas et al. 2017a).

Full audio and video recordings of the workshops were made with participants' consent. We hired professional transcription services to generate anonymised texts of all discussions that were then coded and analysed thematically: research team members systematically reviewed reflections and points of comparison in collaborative conversations between research sites. Subsequent rounds of reading and coding enabled us to explore key themes that emerged in the data, including a wide range of concerns and ideas linked to risk and benefit perception, energy and society, inequality and governance (Thomas et al. 2017a). Here, we focus on three core themes: (i) the Earth as a foundation; (ii) the Earth as fragile; (iii) "the world as a resource."

4. Findings

i. The Earth as foundation

A number of participants wondered how the "*stability*" of the underground might be affected by shale extraction, asking for example about the fracking process: "*The drilling [and] the water … is it going to cause an instability and movement? … you're taking out quite a lot of ground… does that cause problems?*" (Ellie, CF). In Santa Barbara, Diane wondered if the concentration of wells in one place would "*weaken*" the subsurface or what Joyce called "*the structure, internal structure*," a question also asked in LA: "*while we're doing this fracturing, what happens to the layers that we're crumbling? …It's like our foundation is being crumbled a mile below us*" (Michelle, LA). Echoing these concerns, Ray saw subsurface drilling as threatening the solidity of the Earth: "*you're pulling a substance out and now there's less substance there. What are the risk factors as far as the ground collapsing[?]*" (Ray, SB).

The idea that extraction was "*invasive*" emerged more than once, as did the sense that fracking was disruptive to a usual order since it involves "*digging [out] what's naturally there*" (Samantha, CF); "*it's something so direct that we're doing, so invasive that we're doing… It seems really idiotic*" (Kim, SB); "*the world has always taken care of itself. It's just us humans have interfered with the way that the world [cycle] goes*" (Tammy, CF). For some, disturbance caused by fracking represented a form of violence: "*I feel a lot of conflict around it… it's quite [an] aggressive way to take something from the earth*" (Ellen, LN). For others, invasiveness meant interfering with or "*disturbing*" what would otherwise be non-threatening subterranean processes, thus creating hazards. Discussing the presence of

radiation in fracking waste material, Ron expected this, as a result of subsurface interference: "*[In some areas] radon is a big concern… That's a natural occurrence, so there's a possibility if you start disturbing the ground, you're going to increase that radon or radioactive gas*" (Ron, SB).

ii. Fragility: natural limits and the animated Earth

Concerns about disturbing the Earth also introduced questions of scale, and how much of any intervention can be withstood by an otherwise stable environment (without creating negative consequences). Running throughout these concerns was the sense of natural limits, which required limiting extractive operations: "*we've pulled out a lot from the core of the planet, like the coal, the oil… [we] have to stop at this point*" (Ellen, LN); "*we may have these resources, it doesn't mean we have to abuse them… so we don't ruin the Earth*" (Bea, LN). Many participants across the workshops felt that shale development exceeded those limits, e.g.: "*Using something is one thing, but abusing it [is] what most often occurs [in] fracking*" (Michelle, LA).

We encountered numerous questions about remediation efforts following shale extraction, often emphasizing the issue of *depth*, e.g.: "*[If] wastewater is left in the well and is capped, how far down do they put [the] cement? …below the water table?*" (Peter, LA). As stated in our workshop materials, shale often contains higher levels of radium than other rock and radiation levels can build up in fracking waste – prompting different responses. On one hand, doubts were expressed over the severity of effects of this waste material and a small number of people thought increased depth of underground storage might actually be more secure: "*I personally am not concerned about the radium… it's in the waste materials which they are mostly capping underground*" (Victoria, LA); "*since it's so deep, really the chance for seepage is nil*" (Eric, LA). On the other hand, and with more widespread agreement among participants, greater depths were imagined to correlate with increased radioactivity and hazard, e.g.:

> "*A lot of other sources you get radioactivity from*" (Aaron, LA)
>
> "*But this is higher levels of it… I feel like the further you go down, the higher it's going to get*" (Michelle, LA).

Many participants were concerned that impacts from shale development might be hidden from sight and hence impossible to personally monitor, e.g.: *"you can't see a mile and a half underground. You're not going to know there's a problem until it's too late"* (Isabel, SB). Moreover, as Isabel also noted, rendering the underground visible involves mediated technological processes that only certain agents have access to (scientists, industry operators): *"with seismic imaging… it's trained scientists that are monitoring it. But the common people aren't going to be able to [see] any signs that something is not going right*" (Isabel, SB). Such technological mediation raised significant issues of trust. In Cardiff, Laurel wondered if it would be possible to "*verify*" company claims and ensure that what "*they're doing underground is actually to the scale that they say*," since "*if it's all underground [it's] very hard to monitor… You have to just trust what they're telling you*" (Jess, CF), and the assurance of extraction companies would be insufficient to assuage these concerns: "*Don't they have independent engineers [to check what] company engineers are reporting*?" (Karen, CF).

The sense of 'natural limits' also emerged in discussions on documented links between subsurface fracking wastewater injection and increased seismic activity – most visibly in Oklahoma in the US but also, on a minor scale, in northern England. Concern about earthquakes was not limited to seismically active areas – in Cardiff, Heather asked: "*Because of the smaller earthquakes being caused, will it lead [to] weakness in the rocks causing bigger earthquakes in the future*?" Other Cardiff participants felt that this risk was so unlikely locally that the prospect was amusing, yet still thought that it warranted precaution. Some participants in both countries even interpreted earthquakes as a form of deliberate response from an animated, personified Earth or Nature: "*the Earth is trying to tell us something*" (Tammy, CF); "*Mother Nature is mad that it's being injected with wastewater*" (Sally, LA).

Others suggested that earthquake risks rendered fracking too dangerous, particularly in California: "*I don't think it's safe in Santa Barbara to use water to try to take oil… from miles under the ground*" (Miriam, SB). Previous experience with onshore extractive operations in California apparently influenced concerns about the industrialization of valued landscapes in Santa Barbara and risks to human health in populated areas of Los Angeles (Partridge et al. 2017). In both these workshops participants also referenced previous direct

experiences of earthquakes, with people in Los Angeles further describing a more acute sense of vulnerability to these and other adverse impacts of shale extraction (Thomas et al. 2017a). That California has gone a number of years without a major seismic event led some to suggest human activity might precipitate one – might "*poke the bear*" (Victoria, LA) or "*wake the sleeping giant*" (Peter, LA) – with potentially catastrophic results: "*[we're] on a major fault line… what's the propensity for causing an earthquake, a chain reaction? … They find the sweet spot for the San Andreas and then Arizona's got beachfront property*" (Eric, LA).

Many participants across sites rejected any idea of the underground as static or predictable, raising doubts about the suitability of underground spaces for storage of waste materials: "*If you pump the water down, in order [to] fracture of the rock… where does that water go?*" (Paul, LN); "*It says [frac-fluid can] can migrate through cracks in the rock and stuff like that, which is a little scary*" (Isabel, SB); "*What happens when the ground starts shaking [with] all this contaminated water?*" (Ray, SB). Underground instability was thus linked to issues of the im/possibility of exerting control over subsurface processes: "*[especially] in California with all the seismic activity*" (Frank, LA). Other studies have identified fear and anxiety in responses to phenomena seen as unpredictable, in which earthquakes are seen as part of "uncontrollable" nature (Joffe 2012). However, participants related uncontrollability not only to earthquakes but also to the idea that toxic materials buried deep underground are unlikely to remain unchanged in perpetuity: "*[treated wastewater from fracking] can't just sit there forever with these chemicals and be fine*" (Sally, LA).

iii. "The World as a resource"

In London, concerns cited above about increasingly deep, excessive or 'abusive' forms of extraction were notably distinct from views on the shallower subsurface, where a history of development meant that relations with the underground were more familiar: "*[London's] a bit like Swiss cheese [with] all the holes that are underneath*" (Ellen, LN); "*We have underground rivers, we have the Underground [transport network], we have an underground aquifer*" (Lois, LN). The idea of excess also emerged in Santa Barbara, for example in this initial response to fracking: "*I put down 'overuse of natural resources'… as opposed to limiting our use to what is easily available… [and] finding ways [to] just keep digging*" (Isabel, SB). For some participants, ongoing investment in and extraction from the

underground reflected the profit motive: "*If there's money there people will do it I'm sure*" (Tony, LN). For Laurel, in Cardiff, the issue was a particular way of seeing the natural world – what we might refer to as a *resource perspective* – in which fracking represents *"[a] way of looking at the world as a resource [that] can be constantly consumed… no matter what the cost is; because we can get a short [gain] from it, let's go ahead [and] deal with the problems later*" (Laurel, CF).

At the same time, most participants acknowledged the economic value of subsurface hydrocarbons: "*you [can] estimate how many megawatts [of] calorific value you're digging out of the ground*" (Joe, CF); "*we need more resources to get more oil and more jobs*" (Natalie, LA). Timescales involved in the formation of subterranean resources – which "*took millions of years to occur*" (Miriam, SB) – further increased their importance, and leaving them in the ground was "*like a savings*" (Pam, SB). Similarly, some participants were suspicious of arguments of "energy independence" that appeal to "home grown gas": "*[natural gas hasn't] been made by us. We haven't had any part of it being there. We're just choosing to exploit it*" (Jess, CF). For others, fossil fuel dependency meant that extraction was a necessary bad: "*we're making holes in the earth… It's bad, [but] are we just going to let it sit there and buy it somewhere else?*" (Saul, SB).

Others rejected such a 'resource perspective' and suggested that the Earth not only is animate but also has value or purpose perhaps not immediately perceptible, affecting how the consequences of deep underground interventions are viewed and disrupting established notions of ownership. In Cardiff, Tammy questioned the UK Government's effective ownership of all subsurface mineral rights, prompting discussion of apparent disregard for Nature's well-being:

Tammy: *"whatever's underneath is owned by who? …By the Government? No – it belongs to the Earth. It belongs to Mother Nature*

Ken: *…but unfortunately, Mother Nature doesn't charge tax on it…*

Dennis: *Mother Nature doesn't have a vote.*

Ken: *Yes.*

Karen: *No, she doesn't have a voice.*

Tammy: *She does have a voice but [we] choose not to hear it.*

For Ruben in LA, the 'world as resource' perspective views shale oil as if "*the only thing you can do with it… [is] get it and put it in your car to drive around*" and yet "*it has its purpose in the rock*" (Ruben, LA). Others echoed this critique of views that imagine a passive, inert natural world: "*It's like saying a rock does nothing, but… there is something that's in there for a reason*" (Sally, LA); "*[whatever] they're taking out… it's [down] there for a reason"* (Tammy, CF). Joel in Santa Barbara introduced a similar perspective that he linked to Native American author John Trudell who described seeing oil as "*like the Earth's blood*" and thus drilling for oil as "*invasive, violent*" (Joel, SB). In London, Ellen drew attention to the interconnectedness of actions and impacts: "*we're a whole… it's all going to impact on all of us*."

5. Discussion and Conclusions

Our findings highlight a number of ways in which people describe the underground as a foundational, supportive, animated realm that is vitally linked to life on the surface. These conceptions of the underground and related environmental values emerged across our workshops. While in some locations (California), the Earth was seen and described as being more animated or reactive (due to earthquakes) than in others, concerns about how underground resources are differentially valued and used were not limited to specific, localised impacts. Instead, we encountered misgivings about a pervasive, everyday dependency on fossil fuels (Beck 1992) and about fracking as one of a number of increasingly intensive extraction techniques. Seen as an expansion of human interventions into new areas of the underground, shale extraction thus constitutes a multifaceted resource frontier, linking people and resources across locations (Lydon 2015) and reflecting shifting paradigms in the "geographical boundedness" of environmental values (Davidsen and Kiff 2013).

Resources and 'otherness'

The idea of a resource frontier highlights tensions between economic values (identifying resources as wealth) and environmental values (expressing concern about destruction, pollution and related inequalities) (Lydon 2015). By questioning the 'resource perspective,' our workshop participants articulated concern about extending this multi-sited, subsurface resource frontier through increased extraction from, and commodification of, the underground. Rejecting the prioritization of instrumental evaluations of nature as resources

for human purposes, geographically unbounded environmental values take seriously the idea of nature and the underground as having intrinsic value that is not to be disturbed in any location (Palmer et al. 2014). This division reflects how modernist and conservationist views have been characterised: the former sustaining a dualistic split between nature and society, identifying anything that can contribute to "urban-industrial systems" as a consumable component of the environment (Escobar 1995); the latter locating humanity within broader ecological systems, often motivated by an apparently contradictory appreciation of the "sacred otherness" of nature (Milton 1999, Hailwood 2000, Davison 2008). Indeed, Attfield's account of environmental value cited above emphasised the importance of nature's "otherness" in appreciation of a natural world "beyond the control of humanity" (Attfield 2005, p. 517).

However, the views we encountered do not map completely onto either side of the modernist/conservationist divide. In our discussions, the "otherness" of the underground generated less a sense of sacredness and more a sense of unease due to uncertainty about the impacts of disturbing the Earth. The opacity of the underground and the invisibility of some of those impacts heightened concerns about uncontrollability and instability. Such attitudes and the desire to prevent or reduce human interventions underground are thus drawing on different values to those associated with the 'conservationist' view above. That said, participants did express a range of nonutilitarian ideas about why the underground matters (Satterfield 2001, Chan et al. 2012), for example the idea that resources 'belong to Mother Nature.' Such views counter both kinds of instrumentalism identified by Lee surrounding landscape conservation: (i) resourcism (what above has been called the 'resource perspective'), in which only humans have intrinsic value and thus nature, as resources, has only instrumental value (for use by humans); (ii) aestheticism, in which nature again has no intrinsic value and instead holds instrumental value in how it provides humans with satisfying aesthetic experiences (Lee 1995).

Natural limits and fragility

Despite countering modernist ideas, however, the views we encountered do not completely correlate with conservationist notions of value. Fracking was seen as posing a *threat to* the value of the underground, but that value and importance were described primarily as representing something that should not be disturbed due to fear about possible consequences,

rather than to preserve a cherished subterranean landscape. Non-interference in subsurface spaces and processes was important. Excessive disturbance of the Earth was seen as likely to result in potential threats to human well-being: the dynamic deep underground was seen to contain intrinsic threat. This challenges straightforward ideas about the fragility of nature. Discussing views that inform understandings in the US of environmental change and which offer utilitarian arguments for environmental protection, Macnaghten and Urry (1998) discuss three cultural models of nature identified by Kempton et al. (1995): nature as fragile; nature as being in balance but at risk of being destabilised by human activities; and nature as endangered by the effects of consumerism and industrialization. The idea of threats from the deep underground as a result of fracking involve all three models but point in particular to the second and highlight the "fragility of nature's balance" as has been developed in relation to the New Ecological Paradigm (Kalof and Satterfield 2005). The risk of provoking threat from the deep underground thus points to the fragility of humans within the balance of nature (Hailwood 2000) and would urge against placing excessive demands on natural systems (Lee 1994).

Indeed, in discussions on topics including natural limits and *overuse* of natural resources, the underground was positioned somewhere between the two environmental 'types' above – one to be exploited, the other to be protected. For many participants, the world-as-resource perspective promoted contemporary extraction practices that were thought to be in *excess* of what ecological systems can withstand or recover from. One response might counter that this represents 'emergent value' – value as the product of interactions between human and non-human parts of a system (Rolston 1982, Kronlid and Öhman 2013) – in this case, expressions of value emerging when the underground is discussed as being under threat. However, participant views on natural limits and the perceived dangers of exceeding them also reflected a sense of the fragility of the deep underground. The fracking process was described as being *aggressive* and *invasive*, and the consequences of disturbing the Earth were most clearly reflected in concerns about human-induced seismicity, even in areas with little direct experience with it.

These views on fracking also draw attention to the underground as an *active* site, not only of extraction, but also of transformation. Documented links between subsurface fracking wastewater disposal (in Oklahoma and elsewhere) and human-induced seismicity illustrate

the creation of new kinds of unforeseen risks. As with CCS, objections to fracking were raised not only because it is potentially directly dangerous to humans, but also because it threatens to disturb vital underground processes that sustain the Earth. Tampering with the subsurface in such a way – rendering the underground "unnaturally disturbed" (Wallquist et al. 2012) – and the expanding *scale* of fracking operations thus contribute to new hazards and uncertainties created by humans (Erikson 1994). Such a critique of fracking considers contemporary, dominant values surrounding resource extraction to be misguided, in a world where "the values have gone wrong, and outrage is being committed" (Law 2004, p. 3).

Participant notions of underground instability were at odds with the sense of permanence associated elsewhere with the underground burial of hazardous waste. So-called "spent" nuclear material is often buried (Erikson 1994), and the intellectual and economic case for creating such large-scale underground repositories is supported by techno-scientific perspectives that re-imagine the subsurface as manageable and empty (Kearnes and Rickards 2017). A key feature of such repositories, and a requirement of the laws that govern them, is the capacity to cope with material that remains hazardous "quasi-indefinitely" (Reyners 2014). In our discussions, many participants described an 'animated' Earth which made the underground an unreliable and uncertain site for waste storage, particularly because contamination or other negative impacts would be hidden from view or difficult to detect.

'Knowing' the underground

Such concerns illustrate how knowledge about the deep underground – for most people a realm removed from immediate sensorial experience – is typically mediated and has historically been limited. In part, this explains why the subterranean world is unlikely to be valued, particularly in aesthetic terms, in the same way as a cherished landscape, as discussed above. Reflecting on the invisibility of the underground, however, participants went further and raised additional concerns about knowledge. As with the deep ocean, inaccessibility has at times generated suspicion, and the mediated nature of knowledge about the underground means that cultural conceptions of this space are inextricably bound up with technologies of observation and representation (Haraway 1997, Rozwadowski 2010). For the deep ocean, this has led to regulatory neglect and calls for a move away from a "frontier mentality of exploitation" (Mengerink et al. 2014). In our fracking conversations, participants made

similar calls to respect 'natural limits' and to refrain from developing extraction techniques seen as testing the already challenged resiliency of the Earth.

As such, people's concerns were not limited to specific risks or impacts; participants also questioned how we might know about those negative impacts *and* whether those charged with preventing them or protecting people from them are thought likely to fulfill their duties. In other risk scenarios, gaps between levels of desired and currently available information affect both risk amplification and trust (Slovic 2000, Satterfield et al. 2009), particularly with regard to what regulatory agencies are expected to do and how effective environmental protection measures are thought to be (NAS 2009). In both countries, this reflects a societal reliance on specialised sociotechnological systems and vulnerability to "recreancy" (Freudenburg 1993) or failure of those systems and institutions that are responsible for risk management (Brasier et al. 2013). In line with this, and reflecting concerns that the geological environment cannot readily be seen or apprehended by average citizens (Pidgeon et al. 2017), we encountered views on issues of mediation, mapping, and representation. However, participants also raised questions about *control* over the types and degrees of future exploration and exploitation of the underground. The call for 'independent' ways to 'verify' company claims suggests widespread mistrust in governments and, in particular, in corporations to pursue anything other than financial gain. Participant views on *disturbing the Earth* thus reveal concerns both about the consequences of human intervention in the underground and about the 'arrogance and immorality' (Sjöberg 2000) that such actions reflect.

Concluding remarks

We have documented a range of attitudes toward and conceptions of the underground as articulated by diverse groups in a series of public deliberation workshops in the US and UK. We have argued that people's ideas about and concerns for the underground – environmental values related to the subsurface world – figured prominently in how they assessed projected impacts of fracking, and that such ideas and values have previously been little studied.

In contrast with the idea of the natural world being constituted by "discrete components" and potential resources (Pereira 2015), participants identified ecosystem links and described the underground (and the environmental consequences of shale extraction that originate or occur

there) as directly connected to life on the surface and thus related to human and other animal health and well-being. These ideas are of interest to future studies of intensifying subsurface resource extraction and numerous other actual and imminent resource-related conflicts occurring underground, including those linked to the utilisation of underground space for waste storage purposes (Evans et al. 2009). Given the growth in such conflicts globally and the ongoing intensification of extraction processes, the "human transformation of the subterranean world" will likely be an ongoing focus of environmental and political concern (Kearnes and Rickards 2017). Analyses of the kind presented above augment understandings of environmental values and the "geologic imagination" (Sonic Acts 2015). Such analyses also offer another approach to incorporating diverse views and values within environmental scholarship and action in an era of unprecedented human intervention in the subsurface world.

Acknowledgments

We thank Terre Satterfield for comments and suggestions during the development of this article. Funding for this research was provided by the US National Science Foundation under Cooperative Agreement #SES 0938099 and Grant #SES 1535193. Supplemental funding came from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 640715. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the EU. Author TP acknowledges financial support during the writing of this article from the Spanish Ministry of Economy and Competitiveness, through the "María de Maeztu" program for Units of Excellence (MDM-2015-0552). The authors would like to thank the anonymous participants in this research for their attentive and thoughtful participation in the deliberation workshops. We also thank Ariel Hasell, Louise Stevenson, Robert Sposato and Erin Roberts for research assistance.

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