Icelandic Geopower:
Accelerating and Infrastructuring Energy Landscapes

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by

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Contents

List of Figures

Abstract English

Mounting evidence of increasing carbon and nitrogen levels, warming and acidification of the oceans, as well as ongoing biodiversity loss, has led scholars within the natural sciences, particularly Earth Systems science and geology, to reconceive humans as geophysical force-makers with planetary effects. Such claims have prompted scholars within anthropology and science and technology studies (STS) to reconsider the varying specificities of the relationships within and between humans and the earth under conditions of environmental urgency.

This dissertation makes an intervention into these discussions through an ethnographic and practice based approach to the study of renewable energy. It does so by examining the production of geothermal energy in the Hengill volcanic zone in the southwest of Iceland. The analysis that is produced is based upon an engagement with the practices, ideas and concerns of some of the central actors connected to the volcanic zone as it is transformed into a controversial site of energy production for aluminium smelting. I draw upon varying analytical resources from within both anthropology and science and technology studies.

Conducting ethnographic fieldwork with those who make geothermal energy (geologists) as well as those who protest against its production (residents living in the vicinity of the volcanic zone) allows me to understand how geothermal energy is produced and resisted through particular sets of practices and technologies. At the same time it also allows for a detailed analysis of how the forces of the subterranean are converted into energy resources that are so valuable to the Icelandic nation. Successfully making these conversions, from forces to resources, requires not just complex technical work, but also a range of political initiatives. Carrying out ethnographic fieldwork with key actors allows me to examine how this complex techno-political work is carried out and to what effects.

However, drilling deep in the subterranean of a highly active seismic area is dangerous and risky. In producing geothermal energy, other consequences are produced along the way, the most prominent of which is “man-made” earthquakes. The derivative production of earthquakes in the volcanic zone leads me to analyse the

geological, financial, and political conditions through which this volcanic landscape is being appropriated and transformed for energy production.

More specifically, this dissertation examines how the mixing of geological forces and the forces of capital are accelerating parts of the landscape, and generating new phase shifting thresholds. Examining events unfolding in Hengill through the analytics of acceleration and phase shifting thresholds makes a contribution to debates within anthropology and STS about how to conceptualise processes of rapid change. Accelerating, I argue, is not only a process of doing things more quickly and therefore a quantitative endeavour; it is, in fact, also a qualitative process, which can alter the very nature and composition of our world. Changes in speed can also lead to changes in kind.

The dissertation makes an intervention into these debates as technological and digital practices relentlessly quicken the pace of life, and at a time when collective human actions are seen to be accelerating 'nature' as the planet overheats. A focus on acceleration, therefore, allows me to analyse the urgent issues of energy supply and rapid environmental change both from a temporal and political perspective. Conceptualising the varying temporalities that emerge through such processes of acceleration, as well as the political responses to them is an important part of the work of this dissertation.

Abstract Danish

Et stigende antal beviser, på at global opvarmning finder sted, har ledt geologer til at betragte menneskeheden som medskaber af planetens tilstand her og nu. Denne tilstand, kaldet den antropocæne tidsalder, har medført, at forskere indenfor samfundsvidenskaberne nu genovervejer forholdet mellem mennesket og dets omgivelser.

Denne afhandling placerer sig midt i debatten om menneskets forhold til dets omgivelser set i lyset af den verserende globale miljøkrise. Gennem etnografiske studier udforskes de mange forskellige typer af praksisser, der er forbundet med udvinding og anvendelse af vedvarende energi på Island. Mere specifikt undersøges det, hvordan produktionen af geotermisk energi i det vulkanske område Hengill i det sydvestlige Island knytter an til spørgsmål om aluminiumsproduktion i andre dele af landet og til økonomisk vækst generelt.

Teoretiske og analytiske redskaber fra antropologien og videnskabs- og teknologistudier (*science and technology studies* eller STS) udgør rammen for undersøgelsen. Det empiriske materiale er skabt på baggrund af 1 års feltarbejde blandt såvel geologer, der arbejder med energiudvinding, som blandt beboerne i Hengill-området, hvis liv påvirkes af denne udvinding. Afhandlingen viser, hvordan en intensiveret udvinding af geotermisk energi er et resultat af bestemte praksisformer og teknologier, og peger også på, at selv protesterne mod intensiveringen af udvindingen har sin egen infrastruktur.

Afhandlingen viser desuden, at når kræfter i den islandske undergrund omdannes til værdifuld energi, kræver det mere end blot teknisk viden og arbejde. Geotermisk energiudvinding er også afhængig af politiske nøgleaktørers tekno-politiske arbejde. Afhandlingen beskriver og analyserer dette arbejde og dets effekter.

Et væsentligt bidrag til debatten om mennesket i den antropocæne tidsalder er analysen af menneskeskabte jordskælv, som er en afledt effekt af arbejdet med at bore brønde i områder med vulkansk aktivitet. Analysen af sådanne menneskeskabte jordskælv (inklusive fortællingerne om dem) rejser nye spørgsmål om, hvordan samspil mellem geologi, økonomi og politik former bestemte landskaber og betingelser for liv – på Island såvel som andre steder. På baggrund heraf diskuteres

det, hvordan specifikke forbindelser mellem geologi og økonomi fremskynder tilblivelsen af bestemte former for viden, standarder, modeller og beregninger ('tærskler'), der igen påvirker måden, hvorpå landskabet bearbejdes. Afhandlingen bidrager til begrebsudvikling indenfor debatten om hastig forandring (*rapid change*) gennem begreber som acceleration og tærskel (*phase shifting threshold*). Acceleration ses her som en kvalitativ proces, der beskriver forandringer af ontologisk art; forandringer i hastighed ses således ikke blot som 'mere af det samme', men som forandringer i måder ting gøres på.

Overordnet set bidrager afhandlingen til en dybere forståelse af viden, praksisser og kontroverser forbundet med produktionen af geotermisk energi på Island. Denne viden skabes gennem specifikke karakteristikker af mennesker og steder, der lokaliserer ubegribelige størrelser som tid og energi, og således tilbyder afhandlingen en at se den antropocæne tidsalder fra et lokalt og situeret perspektiv.

Acknowledgements

One incurs many debts in the writing a Ph.D. dissertation. While it is common to acknowledge the various ways in which we stand on the shoulders of academic giants during the process, there are many other ‘giants’ whose shoulders go unrecognised.

I would like to start by extending my sincere gratitude to Orkuveita Reykjavíkur (Reykjavík Energy) for allowing me to participate in the work of their geoscience department. The commitment, integrity and depth of knowledge that this small group of geologists displayed in their everyday practices was truly inspiring.

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The world of Icelandic energy is a bustling one, and many energy actors, including developers, agencies, politicians, environmentalists, and academics contributed to the project through interviews or conversations. I would like to say a collective thank you to that long list of people, but in particular give a special mention to Guðni Axelsson and Sigurjon Vilhjalmsson from ISOR, as well as Sveinbjörn Björnsson and Örn D Jónsson.

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A big thank you to my family and friends for their support, particularly to Louise and John for their never ending encouragement through the latter phase. Finally, to my wonderful wife Laura, who not only shouldered many of the burdens that come with seeing a partner through the all encompassing event that is a Ph.D. dissertation, but who generously advised and guided me, and who most of all, made her love constantly felt.

Prologue

Heading home after a long and difficult day on a small fishing boat in the West Fjords of Iceland in 2011, the powerful forces of the sea begin to wane as the crew settles down for the journey back to the harbour. I'm wet and cold, and covered in fish entrails but can fortunately feel the worst of the seasickness leaving my body. Pallí, the boat's captain, points towards the long slender slopes of the neighbouring harbour's fjord:

> See there, right in that valley, they wanted to build an aluminium plant over there, imagine that. They say we can get energy from the ground but nobody really believes there'd be enough, and anyway, why waste it on aluminium?

I had paid almost no attention to Pallí's comments –he always had an oddly chatty disposition on the return leg of long fishing trips– until a couple of years later when I was back in Copenhagen. As I sat contemplating the future project on energy that would become this dissertation, it had not occurred to me that there could be other connections between fishing and geothermal energy beyond their common categorization as 'natural' resources. But as I recalled Pallí's comment, I realised that both fish and geothermal energy are more than something to be extracted, harvested, and resourced.

What modulates their rhythms, to a strong degree, are movement and water. In both cases, water is the medium through which the resource is extracted (fish and heat), and in both cases motion is what generates the powerful forces that trigger a multitude of effects, making the harvesting of both a risky enterprise. They are both generated through varying relations, be it of the sea or of the earth, and in their making they bring places, people, and politics alive. The making of such lively relations is what drew– and continues to draw–me to Iceland as a place to do research.

As part of the broader Alien Energy research project, which takes a comparative ethnographic approach to the study of renewable energy across three sites in the North Atlantic (Denmark, the Orkney Islands, and Iceland), I travelled to

Iceland in 2013 and 2014 to conduct ethnographic fieldwork in renewable energy. In particular, I was very much interested in the connections that Pallí, above, pointed out, the link between reputedly renewable energy and the aluminium industry.

Chapter 1.
Introduction

1.1: Ethnographic Encounters

Let me start with an ethnographic encounter that occurred in Reykjavík in September 2013:

> *Sveinbjörn talks slowly and deliberately. In his mid 70's he is broad and grey and speaks with the confidence and clarity of a man who likes to take his time. He is former rector of the University of Iceland, geophysict and chairmen of the last two rounds of the energy planning commission. We are not 20 minutes into our discussion when his phone rings, "I'm afraid I have to leave James," he says upon hanging up. "There's been a warning issued from the Met office of a possible 5.2 earthquake in the Hengill volcanic zone, in and around the Hellisheiði Geothermal Power Plant. The civil protection agency has called a meeting in Hveragerði, a small town close by. The residents are quite nervous about the possibility of more man-made earthquakes. We've gotta go and talk to them."*

Sitting across the Mid-Atlantic ridge, the rift zone along the constructive boundary between the American and Eurasian tectonic plates, as well as atop a mantle plume, Iceland is a an eruptive, faulting and fracturing island. It is a place where tectonic activity overflows and envelops the landscape, giving rise to an inspiring volcanic topography.[1] Spewing geysers, mossy green lava flows and expansive glaciers are not uncommon sights, forming part of a panoply of forces that give rise to the possibility of various forms of energy production.

[1] Iceland is characterised by two intersecting geological phenomena, the Mid Atlantic Ridge and a Mantle Plume (also known as a Hot Spot). The former, a 16,000 km tectonic plate boundary running through the Atlantic Ocean, was raised upwards towards its northern end approximately 25 million years ago by the latter, resulting in the landmass Iceland. Geologists imagine this mantle plume to be a large funnel shaped upwelling of magma generated deep inside the earth's mantle.

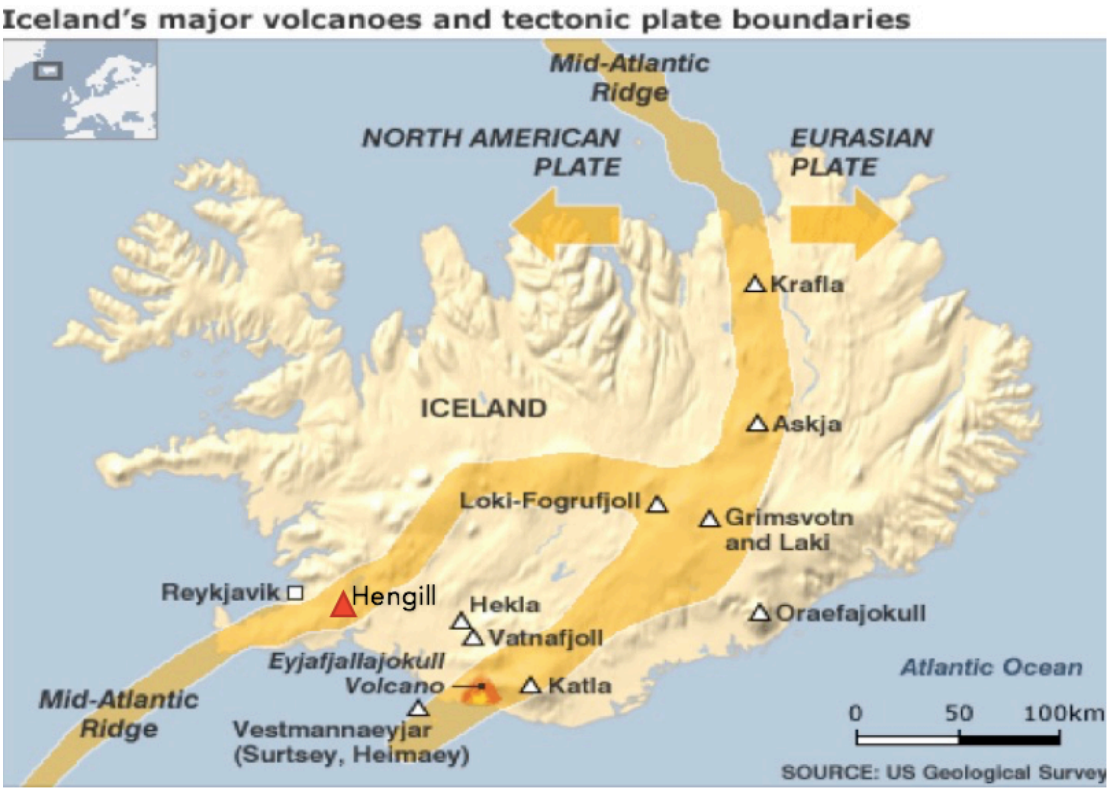

Figure 1: Iceland's Tectonic Plate Boundaries and Main Volcanoes, with the Hengill volcano highlighted in red.

Prior to this moment with Sveinbjörn, I had been roaming around Reykjavík for several weeks moving from one conversation about energy to another. In particular, I was finding it difficult to get some purchase on how, and where, to locate myself within the array of interesting energy discussions taking place in Iceland at that time.

As I would come to learn, Iceland is a country where energy takes up a lot of discursive, political and infrastructural attention. Despite such a small population, circa 332,000 inhabitants,[2] the country has the highest per capita production of electricity in the world, and almost all of it from reputedly renewable sources.[3] As I will discuss in detail in Chapter Two, the vast majority of this electricity is produced for various aluminium companies operating around the country.

As such, energy companies, contractors, agencies, and institutions are many and varied, and quite visible in the public domain. While getting to speak with

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[2] http://www.worldometers.info/world-population/iceland-population.

[3] In fact it produces double the amount of electricity per capita as Norway, the next highest-ranking nation.

energy actors did not present a problem for this newly minted anthropologist, finding an ethnographic inroad, a perspective from which to ethnographically engage with energy, did.[4]

Interviewing Sveinbjörn on that cold afternoon in September 2013 was an ethnographic moment, a serendipitous encounter through which a particular scale of enquiry emerged. In a couple of intriguingly packed sentences, Sveinbjörn managed to draw my attention to a place, and a set of issues, that were to become the heart of my project.

Geothermal energy production is a set of processes and practices that extracts, on average, 300 degree Celsius fluid (steam and water) from wells drilled up to three kilometres deep into the volcanic landscape.[5] The Hellisheiði Geothermal Power Plant, owned and operated by Orkuveita Reykjavíkur (Reykjavík Energy), is located in the Hengill volcanic zone about thirty kilometres southeast of Reykjavik. This power plant supplies electricity to Century Aluminium, a large aluminium company also located in the southwest of Iceland (figure 2). According to Sveinbjörn, geothermal operations have been triggering "man-made" earthquakes[6] that are being felt in the small town of Hveragerði at the outskirts of the Hengill volcanic zone.[7] The 5.2 earthquake warning that interrupted our discussion took him by surprise, not in terms of the magnitude - in a country with a history of eruptions and earthquakes he has lived through bigger – but in terms of its timing. As he would later tell me, he had thought that "man-made" earthquakes were beginning to settle

[4] Over the course of the first 2 months I spoke with representatives from the National Energy Authority (NEA), the National Power Company (Landsvirkjun), Iceland Geosurvey (ISOR), Orkuveita Reykjavíkur (Reykjavík Energy) the National Transmission System Operator (Landsnet), the Icelandic Meteorological Institute (IMI), HS Orka and Reykjavík Geothermal (two privately owned energy companies), several geology and earthquake scholars at the University of Iceland, several members of the two leading environmental agencies (Landvernd and the Icelandic Nature Conservation Association), the South Iceland Conservation Society, as well as several energy consultant companies.

[5] Because the fluid is under pressure in the subterranean it can reach temperatures far in excess of normal atmospheric boiling point, i.e., 100 degrees Celsius. Fluids emerge at the geothermal wellhead as a mixture of steam and hot water within a temperature range of 250 to 350 degrees Celsius.

[6] While the designation "man-made" earthquakes is clearly problematic in terms of gender politics, it is an emic term very commonly used to describe these newer forms of earthquakes occurring close to the Hellisheiði Geothermal Power Plant in the Hengill volcanic zone. As such I will continue to use it within double quotation marks.

[7] For the rest of the dissertation I will refer to Orkuveita Reykjavíkur (Reykjavík Energy), simply as Orkuveita. When I want to specifically talk about the geothermal power plant I will use the term Hellisheiði. In referring to the broader volcanic landscape within which Hellisheiði is situated I will use the term Hengill.

down.

Scaling my attention to the production of geothermal energy and its collateral production of earthquakes connected the Hellisheiði Geothermal Power Plant and the small town of Hveragerði together, through the Hengill volcanic zone. Situating my research within such an interconnected volcanic area became my way of approaching this study of Icelandic energy, one that attempts to draw together and think through a series of partial connections (Strathern 2004) between and within the turbulent and eruptive forces of the volcanic landscape as they affect various actors in the vicinity.

Figure 2: Southwest Iceland. The Hengill volcanic zone is a 110 square kilometre area that extends from Þingvellir southwards to the landscapes of Hveragerði. The Hellisheiði Geothermal Power Plant lies within Hengill, ten kilometres north west of Hveragerði. Century Aluminium's smelters are located north of Reykjavík. Image from Google Earth.

From a practical perspective, being able to conduct fieldwork at the Hellisheiði Geothermal Power Plant and within the greater volcanic area meant negotiating access with Orkuveita, the power plant's owner-operator. Orkuveita are a municipal utilities company 94% owned by the city of Reykjavík who provide a range of important services to the residents of the city, including cold water, sewerage, and energy (hot water and electricity). Having had my attention drawn to their operations in Hengill by Sveinbjörn, I was prompted to ask a series of questions.

Firstly, how are a municipal company making “man-made” earthquakes in a volcanic zone? What are the practices by which they do so? Asked in another way: what are the socio-technical, political and economic practices through which Orkuveita convert the forces of the volcanic landscape into energy resources for aluminium smelting? What else (relations, concepts, values) gets converted along the way?

Secondly, what type of political responses are these interventions into the volcanic landscape provoking, both at a local and national level? These questions also prompt me to consider how best to understand the production of reputedly renewable energy for a ‘heavy industry’ such as aluminium, particularly as such renewable energy forms are increasingly being heralded as planetary saviours; ‘almost salvational objects’ in Cymene Howe and Dominic Boyer’s characterisation (2015).

While thematically this dissertation is about geothermal energy, it is also about more than that. As I will discuss in detail throughout this chapter, the dissertation is an ethnographic attempt to come to terms with how humans are becoming geophysical force-makers in a particular landscape, and the effects that this is having, both politically and temporally.

As the production of energy in a volcanic landscape comes with various unintended consequences, “man-made” earthquakes being the one I have mentioned thus far, investigating energy spills over into other areas of investigation. This includes thinking about the role of capital in Iceland, and specifically its effects in this volcanic landscape as Hengill is converted into an energy node in the global circulation of aluminium. At the same time, I have also needed to analyse the types of geology practices that are a crucial part of how these landscapes are being transformed, the municipal politics that arise alongside such transformations, and the local forms of resistance that have emerged during my fieldwork. In addition, I have been challenged to think about how longstanding conceptual categories are being disrupted as the earth is being disturbed. Allowing questions of energy production to spill over into other areas of investigation is a way of taking the performativity of our methods seriously (Law, Ruppert et al. 2011), remaining open to the recursive interplay between our area of investigation and the inventive methods needed to apprehend them; as our objects of enquiry shift, so must we.

This is particularly the case with geothermal energy as it is made and circulates through the volcanic landscape, emerging out of the subterranean and into the overground. As highly pressurised fluids capture heat through subterranean rock fractures, phase shifting explosions occur that drive the fluids upwards as they convert into steam. Although stabilized through infrastructures, these stabilizations generate their own instabilities. In the same way as turbulent energy flows transition and transform, so too does my mode of enquiry, adapting to these transformations. However, before continuing on, let me firstly talk a little about my approach to energy.

1.2: The Problems and Potentials of Energy

In a special issue of Theory, Culture and Society titled *Energy and Society*, John Urry contemplates 'the problem of energy' (2014). The problem, as he refers to it, is not just the lagging pace of carbon transitions, but that energy has been and continues to be a problem for social theory itself. In particular Urry suggests that the ways in which societies are energized are crucial for how they work, as the varied forms of energy structure the social, temporal and spatial organization of society and 'life' itself. Social theory has paid limited attention to energy systems, including the practices and habits they are generative of. As such, energy thinking makes scant appearance in social theory's armature, Urry argues (ibid : 4-5).[8]

Another reason why social theory should be bothered by energy is the ways in which relations of power are connected to dominant energy forms. Recent work in anthropology takes up this more overtly political angle. In a special issue on *Energopolitics*, Dominic Boyer characterises anthropology's sporadic engagement with energy as a generational impulse (2014). From the universal theory of Leslie

[8] Urry uses Zygmunt Bauman's idea of 'liquid modernity' (Bauman 2000) as an example. As one of the 20th-century's most influential concepts, social theory never noticed how such liquid relations depended upon 'black gold' (Urry 2015: 6).

White in the 1950s, to the less thermodynamically inclined more indigenously sensitive accounts of the 1970s, to the recent flurry of publications on the anthropology of energy (Nader 2010, Behrends and Reyna 2011, McNeish and Logan 2012, Strauss, Rupp et al. 2013, Cross 2014, Howe and Boyer 2015, Winther and Wilhite 2015), the sporadic impulse to study energy is spurred by vulnerable or transitional moments in the dominant political regimes of energy.

In these accounts energy is a problem for social theory, just as its study is a response to given political configurations. But the study of energy also contains analytical and political potential. Inspired, in part, by Timothy Mitchell's work (2011),[9] Boyer notes the need to re-think political power through energy, by searching out signals of the 'energo-material transferences and transformations incorporated in all socio-political phenomena' (2014: 325).

Penny Harvey and her co-editors also point towards the ways in which energetic materials and forces are implicated in broader issues of sociality and politics. While not positing any determinist link, these authors imply a connective tissue between such forces, the technologies that play a role in mobilizing them, and the politics and socialities that emerge along with them. As they neatly put it; 'the differential powers of water or sun, (for example), inflect not only the temporalities and spatialities of energy, but also the subjects we may be able to become'(Harvey, Jensen et al. 2017: 158).

What Harvey et al's observation suggests to me is that to engage in the anthropology of energy today means being attentive to issues of force, flow, and matter as they intersect with, or are generative of, politics. This is one challenge that this dissertation will take up by being attentive to the ways in which volcanic landscape forces become political matters as they are made into geothermal energy.

1.2.1: Energetic Materials

Let me turn to Andrew Barry, who also points toward some challenges in how energy is treated both analytically and politically. Barry asks the question of why the

[9] Analysing how an abundance of carbon energy became a crucial factor in the emergence of new political forms, Mitchell makes insightful connections between the material properties of coal and oil and the types of politics and political systems that developed through them (2011).

concept of energy is not more prominent in studies of both energy and materiality. If energy is a part of matter, then it seems strange, he argues, that neither literature takes seriously what scientists say about energy and its political import (2015: 110-111). His argument, briefly put, is not to suggest that energy should provide a new basis for rethinking the concept of materiality, but to open up the question of how scientists understand energy as an aspect of matter, and in particular, its political import as energy is converted between different forms (ibid 2015: 111). While Barry turns to the concept of energy through Isabelle Stengers' thinking on thermodynamics as a way to examine the connections between energy, materiality, and politics, this dissertation takes up a more ethnographic, practice-based approach. As I will explain in more detail later in the chapter, one of my primary focuses is working with geologists, and their concepts of energy, as they convert explosive subterranean forces into steam for electricity.

Working and thinking with geologists in the volcanic landscape is not only a way of seeing how geothermal energy is constituted through a particular set of practices. It also allows for an ethnographic perspective on subterranean forces as they are made into resources that the nation cherishes. This conversion, from force to resource, is both highly technical and highly political and being present in the volcanic landscape with geologists is one way to understand the varied conversions that are occurring. As forces (magmatically heated rock, water, and pressure) are converted to resources (electricity), they trigger other, unintended, conversions along the way ("man-made" earthquakes). These 'others' become political matters, the materiality and temporality of which are central to how these matters are dealt with. These are materials that are political (Knox and Huse 2015), or a politics that are ontological (Mol 1999).

This type of approach puts me in dialogue with a cross section of work coming out of anthropology and Science and Technology Studies (STS) that is thinking about the relations between the material and the political, such as Mol, and Knox and Huse cited above. It is also connected to what is varyingly referred to as 'the ontological turn' (Holbraad 2009, Pedersen 2011, Viveiros de Castro 2015), 'the ontological opening' (De la Cadena 2015), 'ontics' (Verran 2014a), and 'practical ontologies' (Jensen, Gad et al. 2014).[10]

However, the phase shifting explosions that are necessary to transform geothermal fluids into steam for electricity at Hengill make me ask questions about what anthropologists and STS researchers consider as materials in their analyses. Geographers Ben Anderson and John Wylie suggest that there is a need to address the full range of forms (earth, fire, water), phases and states (gaseous, solid, liquid) in which materials exist (2009). This is the position staked out by Andrew Barry as he asks theoretical questions about how best to register the properties, capacities and agencies of such material phases and states. A lot of work from within STS, particularly earlier variants, Barry argues, has had a tendency to overly equate materiality with the existence of distinct physical objects, and as such has predominantly focused on what are recognizably bounded physical or biological artefacts (2015: 112).[11]

John Law has addressed this critique head on, arguing that in earlier versions of Actor Network Theory (ANT) it was sometimes assumed that relations were ordered in part through the circulation and flow of 'immutable mobiles;' things that move while holding their shape (machines, ships, charts, money, texts, or information) (Moser and Law 2006: 58). In later versions of ANT, Law argues, the focus has changed. Objects still circulate but they also change their shape as they move. In short, they are better understood as 'mutable mobiles.' The 'after ANT' intuition is clear for Law (ibid);[12] the turn to multiplicity has developed better tools for dealing with more complex orderings, including flows and fluids.

While I will go on to develop this point more fully in Chapter Three through a particular focus on the turbulent fluids of Hengill, for now I want to suggest that while Barry's critique is still relevant, some of the moves of post-ANT have already tackled some of his broader concerns. Nonetheless, the material-semiotic (Haraway 1988, Law 2007) sensitivity towards how objects emerge in varying, oftentimes

[10] I do not mean to suggest an equivalence between these terms given the differences they contain, but merely to indicate an analytical affinity with my work. For an excellent discussion on some of the differences between practical ontology and the ontological turn see Jensen et al (2014), *Practical Ontology: Worlds in STS and Anthropology.* Also, for another excellent discussion on the generative interfaces between anthropology and STS, see De la Cadena et al (2015).
[11] He gives examples such as John Law's aircraft study (2002) as well as Mol and De Laet's bush pump (2000).
[12] This has also come to be known as post-ANT (Jensen and Gad: 2010).

multiple, configurations through specific sets of practices, still has a weak spot when it comes to energy-matter relations, and this is what Barry hones in on.

Other contemporary work that has been theorizing materiality comes out of New Materialism; an intellectual lineage predicated on Deleuzian inspired ideas of the internal differentiation of objects, their powers and intensities. Such scholars argue that objects, far from being inert, are infused with liveliness and agency, focusing in particular on the 'lively materialities' that make up the world and out of which political relations are composed (Massumi 2002, Bennett 2004, Bennett 2009, Coole and Frost 2010, Connolly 2011). While such work is an interesting way to think about materiality, the focus on the liveliness of objects, as objects, retains a strong sense of the object-in-itself, begging the question of how such liveliness (agencies, properties, and capacities) can be determined in the first place.[13]

Adopting Stengers' thermodynamicist view of the relationality of matter, Barry suggests that matter is neither inert nor lively, but is always already a part of ongoing energetic relations.[14] If energy is taken to be an aspect of matter in general, then energy-matter, or energetic material, is always undergoing change. Apprehending the ways in which that change occurs is one way for social science to think about the power materials have to differ through space and time (2015: 112). While Barry comes to this by focusing on scientific processes of energy conversion and measurement,[15] I want to think about conversions a little differently. A relational approach to conversions requires me to think of energy materially -

[13] The in-itself focus ends up giving too much uncritical sway to scientific accounts, as the lively object is considered without the sets of relations of which it is a part. Take for example Abrahamsson & Mol's critique of Bennett's discussion of omega 3 (2014), the tendency is to, in fact, undo some of the main learning points of STS, i.e., the material semiotics relations through which objects come about and are sustained.

[14] Barry gives an example; 'If the potential energy of an object is not given as an inherent property of the object itself but by the distance of its mass from the ground onto which it might fall, then the energy of an object is, therefore, an effect of its relations with a shifting set of forces and objects, rather than an inherent property. As such matter is inherently variable and subject to change in ways not necessarily predictable or governable' (Barry 2015: 112).

[15] Barry is interested in Stengers' Cosmopolitics, particularly the relationship between scientific practices and politics. Barry claims that while Stengers work is not overly political, her intent is to reorient the hierarchy of the sciences so as to undo the dominance of physics in understandings of matter. He uses energy conversion and measurement as a way to address ongoing questions of materiality and energy in STS. In particular, how physical scientists' transform reality in order to render energy into a calculable and comparable form.

through its practices and infrastructures - and to think of material energetically, as fluids accelerate and phase shift into different forms (water/steam).

As subterranean forces are converted to resources other forces are derivatively produced. Paying ethnographic attention to the practices through which these conversions happen is not just a question of thinking about the power of materials to differ over time, as Barry puts it, but is an invitation to also think about the way producing power in a volcanic landscape can alter politics and time. Both of these issues, temporality and politics, will be central in the chapters to come.

While the last several pages have been an attempt to set out my relational approach to energy, this approach has led me to questions that might normally be considered outside of energy's purview. Let me now turn back to address the various issues that emerged through my discussion with Sveinbjörn, whom I introduced at the start of the chapter.

Earthquake production in Hengill opened up my concerns to encompass thinking about geological practices, but not in isolation. The conditions (political, economic, as well as geological) through which this volcanic landscape is being appropriated and transformed for energy production are important. Undergoing sweeping neo-liberal reforms over the last two decades, Iceland has been characterised as 'the canary in the coalmine,' of the global financial crash of 2008 (Durrenberger and Pálsson 2015). Garnering a reputation as the financial Mecca of the North Atlantic, capital has played a powerful role in the transformation of Icelandic society in general, and the transformation of this volcanic site in particular. As I will come to explain in far more detail, the intersection of capital and the earth at this particular juncture in Iceland's history is altering longstanding landscape rhythms. The effects of such alterations include the structural remaking of earthquakes, the cooling down of volcanic mountains and the generation of hazardous pollution. While these disturbances speak to the specificity of the relations unfolding in this landscape, they also talk to more general discussions of capital, power and time in the anthropocene.

1.3: Anthropocene

Thinking about the production of “man-made” earthquakes at Hengill focused my attention on the idea of humans as ‘geophysical force-makers.’ In the emerging literatures discussing the role and extent of humans in altering the planet, predominantly called the anthropocene, this is not an uncommon way of characterising humans: as force-makers on a planetary scale. But there is something qualitatively different about what is going on at Hengill, as activities reverberate around a specific location and group of actors, far removed from planetary talk.

Over the next two sections I am going to set out some of the arguments made about the anthropocene, as well as an alternate way of thinking about these issues, referred to as the capitalocene, as they intersect with my concerns around the Hengill volcanic area. While not a literature review in any strict sense, I feel it important to discuss some of theses issues in detail in order to help me adopt and modify two central terms that arise in these discussions, namely acceleration and landscape transformation. Reviewing the literature around these terms allows me to go on to propose an ethnographic way of studying humans as so-called ‘geophysical force-makers.’

With that in mind, let me now turn to the anthropocene, a term connected to a debate that has grown significantly over the course of the last decade. The atmospheric chemist Paul Crutzen, borrowing from biologist Eugene Stroermer, first deployed the term in 2000 as a way of talking about the impact of humans on many of the earth’s vital systems. Mounting evidence of increasing carbon and nitrogen levels, warming and acidification of the oceans, as well as ongoing biodiversity loss, mobilized a group of scientists in an effort to rethink climate change as one part of humanity’s more extensive effects on the biosphere.

A series of papers emerged over the course of the proceeding decade proclaiming the arrival of the anthropocene (Crutzen 2002, Steffen, Crutzen et al. 2007, Zalasiewicz, Williams et al. 2011). Reconceiving Man[16] as a ‘geophysical force-

[16] These debates are filled with the terms human(s) and man in reference to a species having effects on a planetary scale. Many of the authors do not problematize the politics of either term. While I will continue to use the terms human(s)/humanity, I will adopt the capitalised Man to signify that I am writing up against the western, modernist, progressivist master narratives that the term carries.

maker' with planetary effects, these papers postulated that an epoch-scale boundary had been crossed within the last two centuries.

In essence, the argument is a stratigraphic one, claiming that humanity's activities are becoming increasingly legible in the rock strata. The earth, it is argued, is undergoing such significant anthropogenic changes that a global stratigraphic signature, distinct from our current geological epoch, the Holocene, is emerging. While these changes are only in their initial phases, they are distinct enough to suggest a Holocene-Anthropocene boundary shift in the recent past (Zalasiewicz, Williams et al. 2011). As such a new geological epoch is warranted, proponents argue.

A proposal to formalise the term 'Anthropocene,' developed by the Anthropocene Working Group for consideration by the International Commission on Stratigraphy, was established in 2012. In mid-2016 the group recommended the adoption of the term. They have now been tasked with ascertaining a signal, referred to as a golden spike, that future geologists would feel is robust enough to mark out the change in signature from one epoch to another. Candidates for this golden spike range from radionuclides (nuclear radiation), to concrete, to the fossilized remains of domesticated animals.

The term anthropocene, while catching on rapidly in the natural sciences as well as the social sciences and the humanities, remains highly problematic. As Donna Haraway reminds us, while scientists such as Stroermer and Crutzen, who introduced the term, were worried about the bleaching of the coral reefs from ocean warming and acidification, they were also fighting to mobilise support around the idea of anthropogenic effects on the planet; rocks, oceans and atmosphere (Haraway and Wolfe 2016). In many ways the term anthropocene, while erasing much, produces a clear and graspable narrative that locates responsibility for serious environmental problems at the door of the anthropos.[17]

But the new designation brings with it serious political and historical erasures. A lot of criticism focuses on how the term collapses distinctions across

[17] Haraway makes us aware of the contested etymology and ambiguity of the word anthropos, suggesting that it predominantly comes to take on the meaning of 'man,' or 'he who has the face or shape of a man…..as opposed to woman, a god, or a boy.' She also points out that what the term never figures is the rich generative home of a multispecies earth (Haraway 2016: 183).

region, ethnicity, age, gender, and class (Malm and Hornborg 2014, Moore 2015, Haraway 2016), as the anthropos re-emerges at a planetary scale to claim responsibility for a series of global effects that vast swathes that the term designates had no involvement in. As a meta-theory of humans as collective agents, the generic Man as species erases the particular acts of certain Men throughout history.

Additionally, the term is, for many, just too anthropocentric to be fitting for the almost intractable problems the planet is now facing. Right at a moment when humans are becoming so conspicuously aware of the existential importance of the biotic and abiotic processes of the earth (corals, rainforest, ice sheets, amongst others), naming the epoch as the *era of Man* has the potential to misrecognise the *problems of Man* that have given rise to so much of our current predicament.

Eileen Crist in a provocative article, *On the Poverty of Our Nomenclature*, (2016) argues that the anthropocene discourse downplays the destruction that is being wrought on the planet by translating it through a more bucolic neutralised terminology of planetary change and transformation. More potently, she argues that the discourse tacitly implies an inability to change historical course. The humanization of the earth, although still contestable, has fast become an accepted reality. The consequence of such an acceptance, she suggests, is to close down the possibility of more politically creative forms of intervention as the twin logics of despair and inaction work alongside talk of a ‘good anthropocene’ (Hamilton 2015); human exceptionalist saviour narratives in the guise of planetary techno-engineering projects.

Crist also points out that names do more than simply designate a given state of affairs. Borrowing from Ian Hacking, she suggests that naming has the conceptual power to frame and gather our thinking about a given topic in ways that foster particular forms of action while delimiting others (Crist 2016: 24). By affirming the centrality of Man, the anthropocene discourse unwittingly risks crystallising human progressivist narratives that shrink the discursive space for challenging the domination of the biosphere by Man for Man.

The designation of a name provides an opportunity to think about the earth not by that which caused our ongoing problems, but by that through which our problems might be resolved, or more realistically, just lived with. Naming for the future, Crist implies, can be a first step towards learning to think about how to co-exist differently, possibly through more-than-human flourishing. Letting go of the 'time of Man' as a way to frame our actions is one possible step in a world that urgently needs to recuperate from the actions of Man. While some continue to use the term anthropocene for collaborative and interdisciplinary reasons despite its clear political problems,[18] others have grown to love it (Morton 2014). As academics struggle to get to grips with how to think, act and research in times of ecological urgency new methodologies and terminologies are beginning to proliferate; Anthrobscene, econocene, misanthropocene, manthropocene and necrocene (Moore 2016a: 6), Eurocene and Technocene (Sloterdijk 2015: 328) to name a few.

1.4: Capitalocene

While many riff on possible ways to name and refigure the term anthropocene, I want to begin to take the first steps towards suggesting an ethnographic approach to engaging with such broad and varied issues. First, I want to continue to lay out some of the positions at stake in the argument. Then I want to follow up by suggesting how I can ethnographically engage with some of the argument's key concerns, although reconfiguring them specifically in relation to the Hengill landscape.

As I mentioned a little earlier, working in 'post financial crisis' Iceland I was faced with the stark ethnographic realities of a nation that had very recently experienced the zenith of unfettered access to capital, as well as the nadir that followed closely on its heels. While I talk about this in a lot more detail in Chapter Two, the pervasiveness of capital in the discourse of those I got to know was unrelenting, whether through discussions about housing debt, municipal bankruptcies, excessive consumer spending, failing companies, or the capital controls on international financial transactions that all Icelanders have had to live with in the years after the crisis.

What I want to bring into focus in this dissertation is the ways in which the volcanic landscapes of Hengill have become the object of appropriation of capital

[18] This was a comment from Anna Tsing at a UCL conference titled Anthropology and Sustainability in January 2015.

forces.[19] As this landscape is arranged to generate vast quantities of steam in the provision of electricity for aluminium smelters, capital and the earth intersect with troubling geophysical effects. Trying to think through these geophysical effects as enfolded within the relationship between capital and the volcanic landscape takes me to a particular current of thinking that has also found its own nomenclature, the capitalocene (Malm and Hornborg 2014, Haraway 2015, Moore 2015, Haraway 2016, Moore 2016a).[20]

While the last couple of pages pointed to some of the political problems with the anthropocene as a discourse, meta-theory, and a conceptual lens, Marxist sociologist Jason Moore critiques the anthropocene as a troublesome analytic that does multiple types of work at the same time. In particular, he is concerned with an over emphasis on geophysical processes and their drivers, and what this implies for the ways in which environmental history gets told (Moore 2016b: 82). The tendency, according to Moore, starts with the biospheric consequences of human activity. Then, by using a stratigraphic signal as a basis for historical periodization, proponents generate an overly simplified version of environmental history to account for such biospheric effects (population growth and technological development being predominant in the literature). For Moore this strategy is too limited to account for the historical relations of power, capital and empire that have been so central to the story of how such planetary disturbances have emerged. Crucially, the dominant anthropocene argument, he claims, poses a question that it itself fails to answer; *how have humans become a geological force* (2016b: 83)? This 'how' leads Moore to suggest the capitalocene as an alternative analytic to tell the story of global environmental relations.

While the Anthropocene Working Group have still not decided upon the golden spike that will inaugurate the Age of Man, two interconnected moments have become central. The Great Acceleration, circa 1945 (Steffen, Broadgate et al. 2015, Zalasiewicz, Waters et al. 2015), and the industrial model of modernity that is

[19] In using the term 'capital forces,' I do not want to dehumanise capital. As I will discuss in Chapter Two, I think of capital as a performative set of practices covering swathes of spatially and temporally distributed processes, operations and activities. Such practices are both generated and generative.
[20] Moore claims to have first heard the term from Andreas Lund at a conference in Sweden in 2009, adopting it shortly afterwards and continuing on to develop it. Haraway suggests that she began using in in early 2012.

connected to such accelerations (Zalasiewicz, Williams et al. 2010), more particularly the advent of steam and coal power (Crutzen 2002).

Moore argues that this approach, while acknowledging industrial capitalism's role, obscures the remarkable remaking of land and labour beginning in the long sixteenth century, circa 1450. For him the industrial revolution was a 'revolution in environment-making' (Moore 2015) and the analysis of the sets of relations constituting such environments is a more productive approach to environmental history. From 1450 forward vast transformations swept across the Atlantic area, wheat in the Dutch lowlands, minerals in the Baltic regions, timber in Norway, and sugar in Brazil; the list goes on (Moore 2015), as colonialist and mercantilist relations appropriated these landscapes as a precondition for the development of the industrial revolution.

Coal and steam power, through this analytic, are not origin points for the story of the Age of Man, but endpoints in a longer history of relations between capital, power and empire. Donna Haraway drives this point home:

> One must surely tell the story of networks of sugar, precious metals, plantations, indigenous genocide and slavery with their labour innovations and relocations and recombinations of critters and things sweeping up both human and non-human workers of all kinds. The infectious industrial revolution of England mattered hugely, but it is only one player in planet transforming, historically situated, new enough, worlding relations. The relocation of people, plants and animals: the levelling of vast forests; and the violent mining of metals preceded the steam engine (2016: 48).

Like Moore, other scholars also focus on periodization. Malm and Hornborg discuss how uneven distribution is the very condition for the development of the fossil fuel economy underpinning the industrial revolution. They suggest that the rationale for investment in steam power was geared towards opportunities provided by the constellation of a largely depopulated New World, Afro-American slavery, the exploitation of British labour in factories and mines, and the global demand for inexpensive cloth (Malm and Hornborg 2014: 3). Similarly, Lewis and Maslin suggest a start date for the anthropocene around 1610, drawing on Alfred Crosby's term the Columbian exchange.[21] This is the period of mass movement of plants, animals and pathogens among continents that began with the wave of exploration and exploitation that followed Columbus' initial voyage (Crosby 2003). Contact between the so-called Old and New worlds, Lewis and Maslin argue, contributed to a 'swift, ongoing, radical reorganization of life on earth without geologic precedent' (2015: 174). New food crops, such as maize and potatoes were brought to Europe, while wheat, domesticated animals and a number of diseases were transferred to the Americas. The results of such human induced species movements have left stratigraphic signatures that meet geological standards: one can detect the appearance of maize pollen in lake and marine sediment across Europe, as well as a dip in global CO2 levels (recorded in glacial ice cores) as a result of the mass death of people in the Americas (Lewis and Maslin cited in Swanson 2016: 160).

In a review of Lewis and Maslin's work, Heather Swanson brings an interesting counter critique to social scientific critiques of the anthropocene as depoliticizing (Swanson 2016). Drawing on Lewis and Maslin, she highlights the ways in which political considerations, particularly colonialism and capitalism, are starting to explicitly embed themselves into the dating techniques of the anthropocene. Sounding an optimistic note, Swanson, as I read her, implies that geoscientists are learning to think the earth, not just as humanized, but as differentially politicised, forging new alliances with social science in the process.

There are other, more direct, critiques of such periodizations. Clive Hamilton in particular takes Lewis and Maslin to task for what he argues is a fundamental misunderstanding of how the anthropocene marks a paradigm shift away from environmental science towards Earth System science (Hamilton 2015, Hamilton 2016). The capitalocene-like argument put forward by the authors, Hamilton argues, while being accurate in suggesting that landscape transformations have been changing the earth over many centuries, misses a fundamental point. That which defines the anthropocene is not changes to the earth, but perturbations in planetary

[21] Lewis and Maslin set out arguments for several start dates (the Columbian exchange, the industrial revolution and the Great Acceleration) but end up favouring the first.

boundaries significant enough to alter the 'safe operating space' that humans exist within (Rockström, Steffen et al. 2009). 'Let me spell it out,' Hamilton scolds,

> [t]he Anthropocene concerns human impacts on the Earth System, not on the environment, and one cannot understand the emergence of the concept of the Anthropocene without an understanding of the radically new conception of the Earth System that emerged with Earth System science in the 1980s and 1990s (Hamilton 2015: 2).

Dipesh Chakrabatty offers a more nuanced critique (2009, 2012, 2014). While acknowledging that capitalocene arguments redress the colonial and imperial shortcomings of anthropocene positions, he ponders why the narrative of capitalism is not sufficient for interrogating the history of climate change and understanding its consequences. The anthropocene has, for Chakrabatty,

> brought into view certain other conditions for the existence of life in the human form that have no intrinsic connection to the logics of capital, nationalist, or socialist identities. They are connected rather to the history of life on this planet, the way different life forms connect to one another, and the way the mass extinction of one species could spell danger for another. Without such a history of life, the crisis of climate change has no human 'meaning.' For, as I have said before, it is not a crisis for the inorganic planet in any meaningful sense (ibid : 217).

For Chakrabatty this is partially a temporal argument. While capital may have been a primary driver of our current state of affairs, the temporal logics opened up by climate change entangle 'the geologic now of the anthropocene with the now of human history' (ibid : 212) as carbon and nitrogen million-year cycles become a part of how we now think our history and our future. These are temporal scales that cannot be contained within capital's analytic (2014).[22]

What is important in all of these approaches, whether using the analytic of the anthropocene or capitalocene, is the attempt to ask the question of when. When did the anthropocene-capitalocene begin? A clear focus on periodization stands out as a way of locating human activity in geological time, and as such as a method to create some form of origin point for the story of our contemporary environmental predicament. Periodization is clearly important, after all it affects who or what gets to be part of the story. The when of the anthropocene-capitalocene tends to elicit the how and the who. Take anthropocene accounts that set the starting point at the industrial revolution. Through this periodization the story of capitalism runs the risk of being told through an innovation and progress narrative, erasing the historically significant, and disturbing, sets of relationships that the industrial revolution is the outcome of. Opening the story up to include the knotty history of colonialism, mercantilism and the transformation of landscapes that underwrote it, creates a passageway for other stories that include rather than erase. These stories provide the potential to think about our current state of affairs more critically and reflexively and even retain the possibility for the emergence of alternate ways to move forward in tremendously difficult circumstances. But as Haraway cautions us, telling the capitalocene story though a more fundamentally Marxist idiom, with its trappings of Modernity, Progress, and History, also subjects this term to fierce criticism (2016: 50).

While not all scholars engaging in these debates focus on periodization (Tsing 2015, Haraway 2016),[23] there is a heightened concern with it in many anthropocene-

[22] Karen Yusoff suggests something similar; thinking of humans as embedded in geologic temporalities, rather than just as authors of them, opens up our sense of history beyond biological materialism into thinking through geologic materialisms (2013: 785).

[23] In her new book Donna Haraway suggests more than one big new name is warranted, hence Anthropocene, Plantationocene and Capitalocene (2016: 100). At the same time she also advocates for the need to find a new name for the dynamic ongoing symchthonic forces of the earth, one where unlike the dominant dramas of the Anthropocene and Capitalocene discourse, human beings are not the only important actors. 'I am calling this the Chthulucene – past, present, and to come: a term which includes rich multispecies flourishing along with people. My Chthulucene, even burdened with its problematic Greek-ish rootlets, entangles myriad temporalities and spatialities and myriad intra-acting entities-in-assemblage – including the more-than-human, other-than-human, inhuman and human-as-humus' (ibid: 101). Clearly Haraway is here breaking with the idea of periodization and human-centric accounts in an attempt to weave together earth like figures to think new times and spaces.

capitalocene discussions. What I would like to do is build upon these approaches. Developing an ethnographically grounded method is one that–while relying less upon grand historical narratives–does not side line history. It means locating the story in and through particular processes and practices as they relate to a specific set of contemporary phenomena in Iceland. What we saw with Chakrabatty was a shift from questions of temporal periodization to ones of temporal generation as the anthropocene and capitalocene debates open us up to the multiple temporal issues being generated through rapidly accelerating planetary processes. *Rather than locating the anthropocene-capitalocene in time, I want to pick up one of its central notions as a wedge to open up questions of time(s) as enmeshed with capital, the earth and power in Iceland.* With that in mind I turn now to talk about this central notion: acceleration.

1.4.1: Grounding Great Accelerations

'Human conditions are pushing biospheric stability to breaking point' (Steffen, Broadgate et al. 2015). 'The conditions of life on planet earth are changing rapidly and fundamentally as multiple planetary boundaries are now being crossed, or soon will be' (Rockström, Steffen et al. 2009). 'We are now living through a transition in planetary life with the potential to transform life rapidly and irreversibly into a state unknown in human experience' (Barnosky, Hadly et al. 2012).

All of these comments, while alarming, point to a common idea: the earth is radically altering under processes of rapid and accelerating change. We are now on the threshold of what scientists call a planetary state shift (ibid). In 2004 a group of scientists at the International Geosphere-Biosphere Programme (IGBP) brought together a decade of research in an effort to better understand the structure and functioning of the Earth System as a whole. In particular they sought to capture the effects of ever-increasing human activity on the earth.

Recording the trajectory of the 'human enterprise' through twelve indicators, the team visualised the growing impact of humans on the earth from the start of the industrial revolution forward. Unexpectedly, they saw a dramatic change in the magnitude and rate of impact from about 1950 onwards, prompting them to claim that 'the second half of the twentieth century is unique in the history of human existence on earth, as human activities accelerated sharply giving rise to the most rapid transformation of our relationship with the natural world' (Steffen, Broadgate et al. 2015: 82).

Borrowing the term The Great Acceleration from Polanyi's The Great Transformation, the group aimed to 'capture the holistic, comprehensive and interlinked nature of the post-1950s changes simultaneously sweeping across the socio-economic and biophysical spheres of the Earth System' (ibid : 82).

In visualizations that have now become almost iconic symbols of the anthropocene, the group juxtapose 12 socio-economic trends[24] that capture what they claim to be the major features of contemporary society alongside 12 earth system indicators.[25] The graphs show a slow steady rise in human activity from 1750 to 1950, but the period from 1950 forward shows a clear spike in all indicators. As such, this date is heralded as the point at which humanity's effect on the planet sharply accelerated.

Accelerating population growth, urbanisation, energy and water use, modern agriculture, consumption habits, to name a few, are all seen to be impacting upon carbon levels, ocean acidification, biodiversity rates, as well as land, tropical and marine ecosystems. The authors are careful to say that there is no cause and effect relationship between the two sets of indicators. Instead these processes are considered to be complex non-linear relationships that operate through multiple feedback loops, which are, nonetheless, bound together.[26]

Rockstrom et al conceptualise these Earth System indicators a little differently. These scholars have defined nine Earth System processes that are rendered as the planet's life support system. Each process (for example climate change or ocean acidification) operates within a given boundary, or a safe operating space for humanity with respect to the Earth System. Although the earth has

[24] World population, urban population, GDP, FDI, Primary Energy use, large dams, water use, paper production, fertilizer, transportation, telecommunications, and tourism.

[25] Caron dioxide, methane, nitrous oxide, surface temperature, stratospheric ozone, ocean acidification, coastal nitrogen, marine ecosystems (fish and shrimp capture), land systems, tropical rainforests, and terrestrial biosphere degradation.

[26] The new 'planetary dashboard' highlights how the trajectories of Earth and Human are now lightly bound, see http://www.igbp.net/news/pressreleases/pressreleases/planetarydashboardshowsgreataccelerationinhumanactivitysince1950.5.950c2fa1495db7081eb42.html

undergone many periods of significant change, the planet's boundaries have been unusually stable for the past 10,000 years, the authors claim.

But this stability is now being threatened by accelerating human activity; as a series of state shifting thresholds emerge, the earth is moving into a new state with potentially disastrous consequences for humans (2009: 472). Once such 'critical transitions' occur, it is argued, it is extremely difficult, if not impossible, to return to the previous state.[27] While the earth has seen several state shifts in the past, the rate of change occurring today is having planetary effects that are much greater than those that characterized the last global-scale state shift (Barnosky, Hadly et al. 2012: 54).

The discussions emerging from the anthropocene discourse are big Earth System stories, ones in which acceleration, or more particularly the acceleration-threshold relationship, emerges as central. These stories tell of the ways accelerating collective human actions are having planetary effects. Such effects are bringing about state shifting thresholds that are radically altering the conditions of life on the planet.

At the same time, the discussions emerging from more capitalocene inclined discourses are also grand earth stories in their own way, but the focus is instead on the accelerated transformation of landscapes. Sweeping narratives of capital, power and empire tell of landscape transformation as a precursor to the industrial revolution and the acceleration effects that follow on. Jason Moore's work on the capitalocene, in particular, is a set of interconnected historical abstractions that, while acting as a powerful counter narrative to anthropocene tellings, also operates at a scale that could benefit from further specification. While I think this work is fascinating, *I would like this dissertation to be a more modest, ethnographically situated, contribution to such grand stories about the earth. Not humans on a planetary scale, nor landscapes, capital and empire on a global scale, but an ethnographic intervention that is situated in a particular volcanic landscape as it is*

[27] Rockstrom et al (2009) claim that three Earth System processes have already transgressed their boundary. While each system is described in terms of individual quantities and separate processes, they are tightly coupled. The relationships between each Earth System process is non linear and a boundary transgression by one can trigger feedback effects on others. Although each boundary transgression puts the others at serious risk the mechanisms by which this might occur are still unclear.

transformed at a moment of intense capital flows that connect Iceland to the global economy.

The production of geothermal energy in the Hengill volcanic landscape is having disturbing geophysical effects ("man-made" earthquakes and the cooling of volcanic mountains). By focusing on such geophysical matters, I want to try and unfold the relationship between capital and the earth that they are implicated in. *By examining their partial connections, I hope to bring some of the anthropocene-capitalocene discussions 'down to earth' (Pálsson and Swanson 2016), grounding them not in geological theory, but through the practices and issues of those living with the turbulence and bounties that this volcanic zone affords.*

In doing so I do not want to critique anthropocene-capitalocene ideas outright, but critically reflect upon them through ethnographic material. As I have suggested above, the idea of acceleration is central to many of these discussions. In particular, I want to develop the acceleration-threshold relationship as an *ethnographic analytic* through which I can open up questions about the practices of capital and the practices of geology as they work through each other at Hengill.

This approach, I believe, opens up for a way of thinking about the relationship between humans and the earth not through the lens of great accelerations, but through the lens of volcanically specific accelerations in which capital plays a pivotal role. Let me now try to specify this acceleration-threshold relationship.

1.4.2: Accelerating Landscapes

In order to develop this I need to give a small sample of the work going on at Hengill. To do so I am going to provide three brief descriptions, each of which contain accelerations that I want to think about in terms of phase shifting thresholds

But first a little about Hengill (see figure 2, page 4), a volcanic system with an area of 110km^2 that lies within Iceland's western volcanic zone, 25 kilometres east of

Reykjavík (Franzson, Gunnlaugsson et al. 2010).[28] Hengill displays the highest level of continuous earthquake activity in a country predisposed to significantly high levels of seismic events (Foulger and Toomey 1989). As such it is a site of intense liveliness: a bubbling, hissing, forming, and deforming, volcanic landscape. Earthquakes are a common, daily, feature of life on these lava plains and sub surface eruptions are not unusual.

Stretching south from the well-known Þingvellir lake and national park, and continuing southwards to the rolling hills surrounding Hveragerði, Hengill is also a place of activity for many walkers, hikers, and the occasional skier. It is a heterogeneous landscape filled with lava flows from multiple eruptions over vast stretches of time, verdant green moss, sheep, spewing geysers and fumaroles, as well as hot-spring rivers with lush colours from micro organic activity.

In 2012, the final units of capacity were installed at the Hellisheiði Geothermal Power Plant, which sits on the plateau to the south of the plains (see figure 3). While these landscapes have formerly been used to produce hot water for heating (thermal energy),[29] the recent focus on the production of steam to make electricity (electrical energy) is a new development. Such a development speaks to an altered way of thinking about and acting in volcanic landscapes in a time of intense capital influx in Iceland.

Today the power plant produces vast quantities of steam supplying 303 mega watts of electrical energy to Century Aluminium, a large aluminium multinational located north of Reykjavík.[30] It also supplies 130 mega watts of thermal energy (hot water) to the residents of Reykjavík.

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[28] Geologists characterize Hengill as a complex triple point junction. It is an area where two rifting sections of the mid Atlantic ridge, pulling in opposite directions, intersect with a lateral transform fault. The three plates meeting at this junction are the North American plate, the Eurasian plate, and the Hreppar micro plate located between the overlapping Western and Eastern riff zones in south Iceland (Sigmundsson et al 1997).

[29] Another plant, Nesjavellir, lies to the north east of Hellisheiði. Its primary purpose is the production of hot water for the city of Reykjavík. Constructed in the early 80's the plant has developed slowly over 30 years to get to its full production capacity of 120 mega watts of thermal energy.

[30] Norðural is the name of the Icelandic subsidiary that is 100% owned by Century Aluminium. I will refer to the company as Century Aluminium throughout the dissertation.

Figure 3: Hellisheiði Geothermal Power Plant, Hengill in late September.

The transformation of such a volcanic landscape to generate steam for electricity in the service of aluminium smelters requires risky tectonic interventions that drill several kilometres into the subterranean. One of the primary jobs of geologists is to ensure an on going supply of steam to enable Orkuveita to meet the terms of their energy contracts with Century Aluminium.

Firstly, this requires infrastructuring subterranean earth processes (Maguire and Winthereik 2017). However, this is not the earth as a singular entity, but as a series of turbulent forces that are calibrated to produce acceleration effects. It is such accelerations that generate steam. Subterranean fluids are magmatically heated under intense pressure to a critical point of acceleration whereby a phase shifting threshold emerges, as water becomes steam, exploding out of the subterranean fractures and up and into geothermal wellheads, through pipes, and into turbines for electricity production.

Secondly, after the energy contents have been extracted from geothermal fluids and processed for electricity and hot water, these spent fluids are reinjected back into the subterranean.[31] According to geological testing, the speed at which this water is being reinjected is now beginning to cool down the area around the central

[31] I will discuss this reinjection process in greater detail in the forthcoming chapters.

volcano. As fluids accelerate through the subterranean fractures they begin to alter their flow form. At critical points of acceleration phase shifting thresholds emerge through which state changes occur. At slower speeds fluids flow in a linear (laminar) state, but as they accelerate they phase shift to a wavy (convective) state. As they continue to accelerate they phase shift again into a more turbulent state. The quicker the water travels the more turbulent it becomes, and as a consequence, the faster heat is extracted from the rock. Volcanic cooling is now occurring more rapidly than any modelling suggested.

Thirdly, pumping colder reinjection water back into a highly seismic area already under serious stress is "triggering" earthquakes, locally referred to as "man-made." A geology report, written by an expert group of geologists and seismologists about these occurrences, describes the process in terms of acceleration. By lowering the earthquake threshold, geological practices are accelerating the release of already in situ rock stress before it otherwise would have been released. As such earthquakes are occurring "before their time."

All three descriptions above contain accelerations that I want to think about in terms of phase shifts. In the first, critical points of acceleration generate phase shifting thresholds as water becomes a new entity: steam. While this change of state is the desired outcome of the entire landscape transformation, it has two geophysical effects. Under conditions of continued acceleration, fluids change their flow state from laminar to wavy to turbulent, activating volcanic cooling. Additionally, the structure of earthquakes is being remade through the acceleration of long standing seismic rhythms at Hengill.

Phase shifting thresholds, in all three descriptions, help me to think about the relationship between acceleration and the production of new states. These thresholds are not the planetary-scale phase shifts that anthropocene discussions refer to, but a particular set of phase shifts that are occurring in this volcanic landscape as it is being transformed for the production of geothermal energy.

Phase shifts are also a way of suggesting that accelerating processes do not just entail changes of a quantitative nature, but are also sometimes of a qualitative one; *changes in speed can also lead to changes in kind*. Speeding up the rate at which things happen, or at which change occurs, is important and has serious consequences. This resonates with something Donna Haraway has said in her recent book *Staying with the Trouble:*

> I think the issues about naming relevant to the Anthropocene, Plantationocene, or Capitalocene have to do with scale, rate/speed, synchronicity, and complexity. The constant questions when considering systemic phenomena have to be, when do changes in degree become changes in kind? What are the effects of bioculturally, biotechnically, biopolitically historically situated people (not Man) relative to, and combined with, the effects of other species assemblages, and other biotic/abiotic forces (2016: 99).

Thinking about the historically situated relationship between the abiotic forces of the earth in Iceland and capital is central to this dissertation. As I will talk much more about in Chapter Two, the rate of socio-economic change that Iceland has recently undergone is extensive. Hengill is one part of this story, although a part through which we get a chance to see how accelerating relationships are generating phase shifting thresholds, thresholds that are both productive and disruptive for those who live in the vicinity of the volcano.

While geologists at Hengill are taking the well-known phase shift concept from physics and putting it into practice through a volcanic landscape, I am borrowing the concept from them and putting it into ethnographic practice through the same landscape. This type of move has been called lateral analytics, initially developed in the thinking of anthropologists such as Stefan Helmreich (2011), Bill Maurer (2005) and more recently by scholars such as Gad and Jensen (2016), Jensen and Winthereik (2013) , and Ratner (2012). I will develop these ideas more fully in Chapters Three and Six.

Adopting the analytic of acceleration to think phase shifts ethnographically allows me to think a little differently about the geophysical changes occurring at Hengill than geologists do. At the same time it allows me to deploy the terms a little differently than scholars engaged in anthropocene-capitalocene discussions do.

While these scholars engage these concepts as a way to speculate abstractly about the relationships between planetary conditions and the accelerating activities of humans, I want to mobilise them as a way of thinking concretely about specific sets of relationships between capital and the earth at Hengill.

Thus, accelerations generative of phase shifting thresholds are a way to help me think about and engage with landscape transformations that are underway as Hengill becomes a site of steam, and hence electricity, production for aluminium. As subterranean fluids phase shift from water to steam, other state changes are also triggered, as new earthquake entities emerge and volcanic landscapes cool down. At the same time they suggest that the qualitative changes brought about by accelerations can also be of a temporal kind, as earthquakes occur "before their time."

As Moore pointed out, one of the questions that the anthropocene asks but fails to answer, is, how do humans become geophysical force-makers? *This dissertation offers an ethnographically situated answer to that question, telling an alternate story of humans as geophysical force-makers.*

By ethnographically grounding a central coupling of anthropocene-capitalocene narratives, acceleration and landscape transformation, I want to tell, not an Earth or Planetary story but a geostory. My hope is to develop what Haraway, borrowing from James Clifford, calls 'big-enough stories,' ones that while not able to account for everything, can account for some things through 'sites of contact, struggle and dialogue' (Clifford in Haraway 2016: 185).

1.5: Accelerating Times

The idea of acceleration is not new to social theory. Scholars have long been theorising the 'high speed' or 'acceleration society' (Wajcman 2014: 1); a world where the relationship between capital and technology have been apparently quickening the pace of life. The German political scientist and sociologist Harmut Rosa, for example, examines what it means to say that Western societies are accelerating by imposing three distinct frames. Technological acceleration, for Rosa, is the speeding up of transport, communication and production technologies, while the accelerating pace of life is rendered in cultural terms as people feel ever more harried in their home and work lives, paradoxically so in a world with more and more time saving devices. In Rosa's view, the acceleration of social change refers to the manner in which society, conceived of institutionally, is rapidly changing as family and work life become increasingly less stable than they were once perceived to be (2013). Here we have the speeding up, and splitting up, of technology, culture and society.

Judy Wajcman alerts us to further links between ideas of speed and narratives of progress and modernity in the nineteenth century. Railways, cars, the telegraph, to name but a few, became iconic technologies of the imagination that bound together machines, money and progress, through speed. Speed, as such, became a prime mark of social progress, valorised through the association between the pace of mechanical production and the delivery of material improvements (Wajcman 2014: 44). Overcoming the physical realities of space and distance as obstacles to the fulfilment of human needs and desires fed into these broader cultural narratives of human progress. Wajcman also points out how theorists of acceleration frame the contemporary era as one of historically unprecedented change, although, as she suggests, a cursory glance at previous eras reveals similar claim making; the futurist manifesto from 1906 being one example (ibid : 47).[32] Talk of acceleration only makes sense, of course, against an implied background of either a slower human past or a stable 'natural' present.

Acceleration, it seems, is a recurring theme, a way to think about a host of ideas around change, progress, capital, and technology in relation to some stabilised past or entity. In particular, discussions about speed and acceleration invariably bring out questions of how these ideas are linked to time. Several theorists of modernity have developed, in one form or another, temporal concepts linked to acceleration. 'Time-space compression' (Harvey 1990), 'dromological time' (Virilio 1986), 'instantaneous time' (Urry 2000), or even 'timeless time' (Castells 2011) are a few examples.

[32] Futurism was an artistic, cultural and social movement that passionately embraced the future, exalting speed, power, technology, youth and violence (Wajcman 2014: 47).

British geographer David Harvey's term 'timespace compression' has become a well-known metaphor through which to think modernity. In particular, Harvey links this idea to the dynamics of capital: 'I use the term "compression" because….the history of capitalism has been characterized by a speed-up in the pace of life, while…space appears to shrink to a "global village"' (Harvey 1990). In essence, life speeds up and distance is shattered through the processes of contemporary capitalism.

Harvey's entry point is drawn from Marx who is one of the first to make the connection between accumulation and acceleration; the faster the conversion of capital to goods and services, and goods and services back to capital, the greater the power of capital to accumulate. Through this optic an inverse relation develops between time and money, less time gives more money; faster means better and as such speed becomes an unquestionable 'good' of the modern age (Adam 2003).

While the many critiques of these positions need not delay me here, I do want to point to one; these are all embracing linear narratives of speeding up that suggest accelerations are happening across all societies at the same time. However, significant analytical work has been carried out to undercut this notion by paying more attention to specific instruments and devices beyond the dominant transport and telecommunications technologies that such accounts privilege (May and Thrift 2003). Writers such as Massey have suggested that such narratives reflect specific 'power geometries" (1993) associated with the pull of capital to big cities, rendering a quite specific, if not elitist, version of how speed and time operate.[33]

Paul Virilio also combats this notion of all encompassing accelerations by pointing towards the varying declerations that occur in tandem with accelerating features of life; waiting in traffic jams in high powered cars, or time spent waiting at airports for international flights are but two forms of slowing down concomitant with different forms of speeding up (Virilio 1986). I read this type of critique as a call to look towards specific accelerations in specific places, posing questions about where and how people encounter accelerations (as well as declerations) and what

[33] Massey (1993) goes on to talk about the inequalities of opportunity that are a feature of the uneven geographies of time-space compression narratives, which she characterises as 'a mostly metropolitan phenomena.'

effect they have for their lives. The events occurring at Hengill are a rich site for such encounters.

There are two points of intervention I would like to make into these discussions. The first is that scholars, critics included, who consider acceleration as an object of social theory are interested in *accelerating societies*. As such the dominant temporal concepts that emerge tend to, in some sense, compress time. In contrast, what we see in anthropocene-capitalocene discussions are ideas of *accelerating nature,* or more precisely, an explicit connection between the Great Accelerations of humans, as put forth by scholars such as Steffen and Rockstrom, and accelerating planetary boundary transformations.

However, the domain of 'nature' and the human are still, analytically, treated as separate, with an emphasis on the impact of humans on the biosphere (Moore 2016a). Given a clear acknowledgement of the human-as-strata in these arguments, the anthropomorphising of the earth seems to be the dominant take away point.

As such, there are few accounts of the *mixing of naturecultures*. This is one advantage I see of the ethnographic method, its attention to grounded practices generates a scale where it is possible to examine the detail of the enfolding of humans with the earth. In this particular ethnographic instance, sets of geo-capital practices are beginning to accelerate parts of Hengill. Such accelerations are generating new volcanic and seismic rhythms productive of new natureculture entities ("man-made" earthquakes). The accelerations that I am interested in, therefore, are natureculture accelerations.

This brings me to my second point. Anthropocene-capitalocene discussions bring questions of temporality to the fore. The struggle over periodization, which I drew attention to earlier, is primarily about how to inscribe humans into a linear geological temporal framing; an attempt to define a new temporality for the human as a being situated in geologic time (Yusoff 2013: 781). But rather than locating the anthropocene-capitalocene in time, I want to use acceleration as a way to open up questions of time(s) as enmeshed with capital, the earth and power in Iceland.

As Bruno Latour suggests in *Telling Friends from Foes in the Anthropocene*: 'What I want to do is to probe with you in what sort of time and in what sort of space we find ourselves when we accept the idea of living in the Anthropocene'

(2013). This dissertation is one way of trying to probe what sort of times and spaces are emerging at Hengill as natureculture accelerations begin to occur.

One scholar that provides an interesting way into discussions of temporality in times of environmental urgency is Michelle Bastian. In opening up a discussion of clock time (time as measurement), Bastian skilfully avoids a common trap that uses the clock as a foil with which to critique the ever pervasive seeping of abstract time into economic and scientific practices. Instead, the clock becomes a device to generate questions about the ways in which we can tell the time under conditions of environmental urgency. The act of telling the time, Bastian suggests, is an act of social coordination. We are familiar with many instances in which we use time telling to coordinate our actions, from coordinating with our own bodily rhythms of hunger and tiredness, to the disciplines of the industrial working day, to the conventional familial and social rituals of holidays and festivities, to our everyday organizing of meetings and events. In this rendering, time becomes a tool for asking, and producing, who, or what, we want to coordinate our lives with. Keeping the time, therefore, is not just an act of measurement; it is also an act of relational performativity (Bastian 2012).

Drawing on Bill McKibbon's suggestion that we are now in the grip of a 'fatal confusion about the nature of time' (McKibbon cited in Bastian 2012: 23), Bastian suggests that more typical arguments about society's acceleration vis-à-vis 'nature's' stability (a position we saw within social theorists of acceleration) no longer hold. Paradoxically, today it is the processes of 'nature' that are accelerating, while society's response to such accelerations appear to be slowing down (our 'slow' transition to renewable energy, for example).

Following Bastian in considering the question of who, or what, is speeding up and slowing down, we might also observe that the very success of clock time as a method of coordinating ourselves has obscured the question of what others we should consider coordinating with. As a result our conventions for coordinating – keeping the time - in a rapidly changing environment are not up to the task; our lack of coordination with, for example, icebergs, corals, and carbon cycles shows that we simply cannot tell the time anymore. Bastian clearly shows how clock time is itself neither context nor coordination free. It is in fact a mediated output from a series of coordinations; atomic time rendered through caesium atoms is coordinated with the earth's rotation to give us a form of coordinated universal time; 'thus even the seemingly objective clock requires on-going decisions about what is of significance to us, and consequently which elements of our world we want to keep time with' (Bastian 2012: 31).

Far from providing an objective measure of the world, clocks rather 'orient us towards particular relational worlds, and in doing so, afford certain modes of relationality, while hindering or obscuring others' (ibid : 37). What Bastian seems to be suggesting is that rather than coordinating our lives with and through a stable and predictable atom, augmented by movements of a planet around a star, perhaps we need to begin thinking about how to coordinate our lives with something less predictable, but maybe more relevant for the times we live in.

As volcanic and seismic rhythms begin to accelerate at Hengill, neither the evacuation of time as 'time-space compressions,' nor 'deep time' concepts seem sufficient to address the temporal conflicts that are emerging. In Chapter Three, building on Bastian's provocation, I will discuss in more detail how geologists are attempting to coordinate with the rhythms of capital and the rhythms of the volcanic zone as they mix to strange effect.

1.6: Geopower

"Iceland is the most famous location in the world for rootless volcanic cones, did you know that James? We have the highest concentration of them," says Gretar, volcanologist at Orkuveita, as we drive through Hengill on a journey that will take us to the northern end of the volcanic zone and lead us into the famous site of Þingvellir. On this trip Gretar regales me with anecdotes and insights that mix and blend all manner of stories about geology, politics, and tourism:

> Some of these cones here were formed in sub glacial eruptions, others when lava flowed all the way through Reykjavík 5,500 years ago. But have you noticed how everybody gets a crazed look in their eyes, a crazed look of lava when they hear of eruptions, and they get into their cars with their families

> and they drive……..towards the eruptions. And the police almost always have to try to stop some of them. I remember once when I was down by the coast measuring volcanic gasses, the guys from that car show Top Gear were up there, driving on the lava, people love that show. Anyway this lava here (pointing out the car window), the lava flow that went into Reykjavík, this is what we call the Christianity lava, it flowed in the year 1000 passing through Þingvellir, north of Hengill, when the early Vikings settlers were debating whether to adopt Christianity or to continue the old pagan traditions.
>
> They were arguing and this rider came in saying that there had been an eruption in Hellisheiði and that the lava was flowing towards one of the Christian chiefs. 'The gods are angry,' they said, you know, the usual shit. So one of the wise guys, one of the pagan chiefs, he stood up, 'at whom are the Gods angry when these lavas flowed, which we are now standing on?'
>
> So they were aware that basalt was volcanic, this was argued about until the 19th century in Europe, there was Plutonists and Neptunists, and the Neptunists considered all basaltic lava to be sedimentary, lifted up from the sea, while the Plutonists believed it to be of igneous eruptive origin.
>
> Anyway the most respected pagan chief was asked to think about this and make a decision for the whole parliament so he went to his tent and lay there for three nights and three days and he then came and said 'we're gonna adopt Christianity, but all chiefs and free farmers will be allowed to practice the pagan religion in privacy.'
>
> So this was a political decision, basically, because all of the countries around us were Christian, so to make sure that trade functioned we couldn't be of another religion, so we adopted Catholicism, and then turned Lutheran in 1551 when we chopped the heads of the Catholic bishop and his sons, good riddance to em.

In this section, I want to give a sense of the geological legacy of the volcanic landscapes of Hengill, a legacy that is saturated in power. While today the power that emerges from the earth makes electricity, at one point in the past these landscapes were making the foundations of Icelandic democracy. While the Hengill volcanic landscape connects the geothermal power at Hellisheiði to political power at Þingvellir, it is also more than that this. I want to talk about this place, both then and now, as a site of *geopower,* one where politics and geology are inseparable.

1.6.1: Geopower and Iceland

There is no better guide to exploring geopower than Gretar. A volcanologist now in his late 50's, he carried out his PhD field research in these landscapes and has been working in them on and off ever since. His own connection to this place runs deep, and he unfolds his story in layers, as dexterously as lava, blending concerns of the old with concerns of the new, as sports car TV shows (Top Gear) and tourists testify to the ongoing lure and power of this volcanic world.[34]

The geology of Iceland is rendered through a broad canvas of geological time as Gretar makes reference to both sub-glacial and postglacial formations. But these ideas become quickly bound up with ideas of politics, and particularly settlement politics, back in the 10th century. Tectonically, the site known as Þingvellir sits in the Þingvellir graben, or rift valley; part of the Hengill volcanic system. In Gretar's story this area is transformed into a place where men of power congregate and decide important issues of state and religion, demonstrating, at the same time, their understanding of lava and geological processes.[35]

Þingvellir,[36] variably translated as 'Parliamentary Plains' (Hálfdanarson 2000) or 'the ground for things' (Pálsson 2005), is a historical and political site of huge significance for Icelanders, particularly as it emerged as an object of reverence for nationalists during the campaign towards independence in the 1800s. It was home to what today would be called the settler's first parliament, the Alþing, or general assembly, established in 930, not long after the first settlement of Iceland in 874. At that time Iceland was a society of farmsteads and the Alþing functioned as a

[34] There are many stories of how tourists respond to eruptions in oftentimes-bizarre ways. While my geologist friends were prone to lightly mocking their naivety, at the same time, there was also an undertone of wonder in their critique. The ways in which the earth continues to inspire impulsive, if at times a little irrational, responses registered as not too dissimilar to the curiosity that drives their discipline.

[35] The pagan chief demonstrates an understanding of the origins of basalt by uttering that he was 'standing on' lava flows. This links into an Icelandic claim that men of the 10th century sensed what it took the classic geological texts hundreds of years to conclude.

[36] Pronounced Thing-ved-lir.

sovereign legislature of a loosely federated farming society (Þorsteinsson citied in Loftsdóttir and Lund 2016: 123). The country's main chieftains gathered here for two weeks every summer during the Commonwealth period, spanning from settlement up to 1262. Law making, as well as dispute settlement, was, from the outset, very much bound to this fractured volcanic landscape.

Figure 4: Aerial view of Mid Atlantic Ridge running through Þingvellir. Photograph courtesy of Gretar Ivarsson (Orkuveita Reykjavíkur).

The central place of gathering was the law rock, or Lögberg, where the Law Speaker assembled the chieftains to proclaim the laws of the Commonwealth out loud. This rock was situated in the Almannagjá gorge, a distinctively visible fault that is described as having an amphitheatre type of effect, amplifying the speaker's voice as he delivered the law. At the Alþing, the Law Speaker was the most powerful person in the country, but in-between, he was officially powerless. At Lögberg anyone could step forward; speeches were given about important matters, and news was reported of significant events. Inauguration and dissolution of the assembly also took place here, where rulings by the Law Council were announced, the calendar was confirmed, legal actions were brought and other announcements made which concerned the entire country.[37]

I want to turn to the work of Kenneth Olwig to help me think a little about this relationship between landscape and law. Olwig focuses on changing forms of governance in northern Europe, discussing the transition from many small semi-autonomous polities in medieval times, to regions or provinces under the rule of a centralized state in more modern times. He argues that the notion of Landschaft,[38] or township, changed during this transition from designating a polity and its lands which could be physically disconnected from one another, to designating a regional territory and the things within it (2013: 254). Olwig sees the discipline of geography as playing an important role in this development as the geographical notion of Landschaft emerged alongside as a demarcated physical and cultural region. Landscape, in this latter reading, became an aggregate of physical things within an area, and legal issues of interest revolved around making laws that concerned those things (2013: 253). Unlike this rendering, the historical idea of landscape as a polity and its lands was not considered an aggregate of physical things (objects) but an assemblage of land and laws crafted through the thing (those that gathered). Law derived not from a state, but through the working out of disputes of those gathered as the landscape and the law became bound. The landscape, in this analysis, is the assembly of its polity and laws, and is, in that sense, deeply political.

This takes me back to the Icelandic Alþing as such an assembly. Proclamations of the law could only be read out by the Law Speaker while standing upon the law rock within the amphitheatre gorge. This special geological setting was just that, a setting, but it was also more than that. The law rock was the object that gave the law its force and power. It was that thing (special object) around which the thing (assembly) gathered and through which proclamations, and thereby the polity, gained their legitimacy. It was a site of geopower.[39]

[37] The role of Lögberg disappeared early on in the history of the Alþing when Icelanders took allegiance to the Norwegian king in 1262. Because of this, the precise location of the Lögberg has been a matter of some debate. See http://www.thingvellir.is/history/the-law-rock.aspx

[38] German, Landschaft; Swedish landskap, Dutch lantscap, English landskip.

[39] I will explain this characterisation of object as assembly in the pages to follow.

Þingvellir remained the site of Iceland's parliament until 1798, and continues to be a place of gathering for the nation in times of political remembrance and celebration, as it performs the imagined community through the power of its geology.[40] It is described by varying politicians as a sacred site, 'the heart of Icelanders' that embodies both history and nature, two main sources of national pride in the country (Hálfdánarsson citied in Loftsdóttir and Lund 2016: 127).[41]

Gretar reminds me that as one of the few places in the country where the Mid Atlantic ridge is so clearly visible to the naked eye (figure 4), Þingvellir has also become a scared site for the generation of tourist dollars as many thousands flock to pay homage to this geologically inspiring place.[42] As we can see, Iceland is a place where the geological and the human are intimately connected, inseparable even. It is a place where the earth-politics nexus has a long historical legacy, even while such connections are different at different points in time. Having discussed the special significance of Þingvellir; let me turn to another example of what I am referring to as geopower.

In 1783, the Laki volcano erupted in the south of Iceland to devastating effect. It is estimated that 25% of the population lost their lives through either disease or starvation, while 70% of livestock died and fisheries were closed off for at least 2 years (Thordarson 2003, Thordarson, Larsen et al. 2003). One response to the famine that ensued in the wake of the eruption was the abolition of the Danish trade monopoly that had strangled Iceland over the previous centuries.

This in turn considerably strengthened the rise of the independence movement (Oslund 2011). At that time, this nationalist movement were developing a potent political argument for sovereignty that drew upon the settlement period from 930 to 1262 as a source of purity (Hálfdanarson 2000). In particular, they were

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[40] Such occasions were the celebration of the millennium of the Althing in 1930, the foundation of the Republic in 1974, and the commemoration of the fiftieth anniversary of the Republic in 1994.

[41] Loftsdóttir and Lund (2016) refer to the speeches of two former prime ministers and a president who use the terms 'heart of Iceland', 'place of the heart', and 'the nation's heart beats at Þingvellir.'

[42] Tourism has now overtaken fishing and aluminium production as the country's largest export. However, the quantity of visitors per year is causing alarm, particularly at geologically sensitive sites such as Þingvellir. Numbers have trebled since 2000, with a huge increase since the financial crisis and the devaluation of the currency. From 480,000 in 2010, to 800,000 in 2013 when I was on fieldwork, to 1.3 million in 2015, and estimates up as far as 1.7 million for 2016, see http://www.ferdamalastofa.is/static/files/ferdamalastofa/Frettamyndir/2016/juni/tourism_-in_iceland_in_figures_may2016.pdf

constructing an idealised relationship that they saw as existing between the settlers and the earth. It is important to note, budding nationalists claimed, that in the settlement period, the climate was better, there were fewer eruptions, and there were more trees and better crops. Such political rhetoric suggested that the settlement period did not just signal the arrival of a new people on a supposedly uninhabited island; it also suggested that these newcomers were able to make a 'settlement' of sorts with the earth itself, one which would enable these newcomers to live together with existing powers. Such provocative thinking implied that this human-earth settlement was soured during the Danish colonial period, as evidenced by the coming of the little ice age and the series of huge super volcanic eruptions that occurred during this timeframe. The Laki eruption at the end of the 1700s was the culmination event in a span of 500 years in which colonial rule coincided with volcanic eruptions, famine and huge loss of life; colonial rule was, it was interpreted, unsettling the earth. The continued political oppression of a free spirited northerly people was provoking violent volcanic responses.

The abolition of the Danish trade monopoly in the aftermath of Laki was read in political terms. The colonial attempt to politically domesticate the inhabitants of the island resulted in the converse effect on its volcanic landscape; as the undomesticatable earth responded in ways that the self ascribed non-violent constitutionalists could not. In this way the relationship between the people and the earth undergoes a metamorphic transformation as the powerful earth unleashes a force that its people are impotent to perform. But it is the people who suffer in this unleashing, as a bond is made between the geological and the political in a sacrificial rite of usurpation.

Through the two examples above - Þingvellir and the Laki eruptions - I have shown the ways in which Iceland can and should be considered a place of geopower, an island where the geological and the political are inseparable. Since both examples are historical, I now want to come to the term a little more analytically by engaging with an emerging literature that is thinking of the geo- in terms of the political.

1.6.2: From Material Politics to the Geological Turn

In *How to Make Things Public* Bruno Latour makes a switch from one German term *Realpolitik*, to another, *Dingpolitik.* His purpose is to signal a move from the no nonsense, matter-of-fact, interest-only politics of the former, to a call for a politics of things, as gatherings or assemblies (matters of concern), of the latter (Latour 2005).

Latour's text is part of a trajectory of thinking that has spawned a rich lineage of work dealing with the materiality of politics.[43] One recent collection from Hannah Knox and Tone Huse brings together an ensemble of scholars posing questions about the analytical challenges and conceptual possibilities at stake through large scale environmental processes (2015: 1). Knox and Huse herald a call to ask not what type of politics are necessary to address problems emerging in the anthropocene-capitalocene, but what type of political reconfigurations these issues are generating; in essence asking what it would mean to bring environmental processes into our attempt to describe contemporary politics. Environmental processes not just as the stuff of politics but as that which can rearrange the subjects, and objects of politics (ibid : 4).

This work helps me to develop analytically what Iceland has been showing me ethnographically. That is, by seeing the geological not as a substrate to political matters, but as political matter that can relocate the grounds of politics. Although given the earthquakes occurring in Hengill, the ground metaphor might not be the most appropriate. Chapter Six will pick up on how to rethink this metaphor.

Following on from this work, and in a similar spirit to Latour, I would like to make a shift from *Geopolitics* to *geopolitics.* The former, an international politics of nation states and transnational corporations is not dissimilar to Realpolitik by virtue of its interest and money based approach to dealing with power relations. The latter, while having many things in common with the material turn to politics, or the politics of things as Latour calls it, focuses specifically on the earth as the shaky ground for thinking about political reconfigurations.

[43] Another connected strand of this thinking is Timothy Mitchell's Carbon Democracy. In this book Mitchell makes connections between the material properties of coal and oil and the types of politics and political systems that developed around them. This is one way of paying attention to the political affordances of material properties (2009).

Latour, drawing upon Icelandic anthropologist Gísli Pálsson's brief discussion of the Alþing (2005), hints towards what he calls a political geology:

> Of all the eroded meanings left by the slow crawling of political geology, none is stranger to consider than the Icelandic Althing, since the ancient 'thingmen' – what we would call 'congressmen' or 'MPs' – had the amazing idea of meeting in a desolate and sublime site that happens to sit smack in the middle of the fault line that marks the meeting place of the Atlantic and European tectonic plates. Not only do Icelanders manage to remind us of the old sense of Ding, but they also dramatize to the utmost how much these political questions have also become questions of nature (Latour 2005: 23).

What I have being outlining above is a type of historical political geology. To help me push these ideas forward, I want to turn now to engage with other scholars that are thinking through, and with, the geological.

'Something is happening to the ways that people are now taking up "the geologic"' proclaim the editors of a collection *Making the Geologic Now* (Ellsworth and Kruse 2013), a book bringing together a host of artists, architects, scientists and philosophers around geological thinking and practice. Geographer Kathryn Yusoff also makes a similar pitch for a 'geological turn that takes seriously not just our biological (or biopolitical) life, but also our geological (or geopolitical) life' (2013). Other scholars such as Pálsson and Swanson engage the prefix *geo-* in other modalities, talking of 'geosocialities' and 'geopolitics' (2016).

One place to turn for help in understanding this prefix geo- is Elizabeth Grosz, who raises the question of geopower in the context of the structure of life at its very eruption and subsequent elaboration. For Grosz, geopower is the relations between the earth and its life forms. It runs underneath and through power relations, immanent in them as their conditions of existence (Grosz, Yusoff et al. 2012: 975).[44] It is the human ability to make the geopower of previous fossilizations our own by capitalising geologic forces (burning fossil fuels), which allows us to generate what

[44] But this is not to be thought of as one level subtending another, i.e., non-life subtending life, but as a cycle where the earth's forces produce life, and life produces the earth.

we more classically call politics - regulations, actions and movements of individuals and collectives relative to other individuals and collectives (ibid).[45] In this reading, political questions are shot through with geological forces.

While Grosz's work is useful as a way to conceptualise the relations between geopower and more classic understandings of politics, I want to turn to anthropologist Elizabeth Povinelli, a scholar who brings together some of the above ideas in a more situated ethnographic context. In her latest book, *Geontologies: A Requiem to Late Liberalism*, Povinelli examines a formation of power she calls 'geontopower' from the perspective of Indigenous Australians as they manoeuvre between the 'settler state' and a large mining company (2016). Although biopolitics, as 'a set of mechanisms through which the basic biological features of the human species became the object of a political strategy, of a general strategy of power' (Foucault cited in Povinelli 2016: 1) has become the predominant mode of thinking the political, Povinelli wonders if such a fascination may have obscured other formations of power in late liberalism. The liberal state, for Povinelli, gains its legitimacy by demonstrating that it anticipates, protects and enhances the biological and psychological needs, wants and desires of its citizens; a biopolitical mode of governance through life itself (Povinelli 2016: 3-4). Biopolitics, she argues, is predicated upon an unmarked ontological assumption that there is a distinction between life and non-life, a distinction that makes a difference.[46] This distinction is fundamental to, and reproduced by, late liberal strategies for governing difference (people) and markets (capital).[47] However, what we are experiencing in the contemporary moment as anthropocene-capitalocene discourses emerge is the break down of those very distinctions of life and non-life that have underpinned late liberalisms operations, and our fascination with biopolitics. The emergence of these

[45] Grosz is careful to note that the differences between life and non-life are not to be thought of as a difference in kind but only as a difference of degree (2012: 975).
[46] In fact she goes on to argue that Western metaphysics is a 'covert biontology,' not because there are no concepts of non-life, but because as a system of thinking it measures all forms of existence by one form of existence; bios (2016: 5). That is, concepts of non-life only take form in relation to specific characteristics and qualities of life.
[47] The life/non-life distinction becomes an important difference in the governance of indigenous peoples in particular. Those who do not follow Western sets of distinctions between life/non-life as the basis of modern reason are governed otherwise, as pre-modern subjects. The importance of the life/non-life distinction in the governance of markets shines through in the various ways that 'nature' is considered an inert entity, free for the exploitation of energy, minerals, and commodities etc.

new discourses, affects and tactics, used in late liberalism to maintain or shape the coming relationship between life and non-life, is what Povinelli terms geontopower/geontopolitics (ibid: 8).

These concepts are meant to both indicate the current phase of thought and practice of late liberalism, a phase that is simultaneously reconsolidating the life/ non-life distinction while contributing to its unravelling (ibid: 5). Povinelli is clear in her argument that geontopower is not a new mode of power emerging to replace biopower, on the contrary biopower has long depended on subtending geontopower (the difference between the lively and the inert). The later is beginning to emerge more visibly as the former begins to crack.[48] What I find attractive in this work is the way in which Povinelli rethinks the geo- along with the practices of late liberalism. As capital continues to appropriate 'nature' (non-life) as a resource to be exploited, we, through the powerful forces of the earth, have become part of the biosphere; and are pushed, in turn, to rethink our distinction between life and non-life. This is an interesting way to think geontopower as an emerging formation of power in late liberalism; not just as *power over the geos*, but as the *power of the geos* as its forces mix with us, exceeding and altering us at the same time. In Hengill, the production of reputedly renewable energy for aluminium smelters contains all of the hallmarks of the logics of capital in late liberalism. As capital seeks to recompose itself through reputedly renewable energy production, it works through the geo- of Hengill. As I will unpack in Chapters Two and Three, the blending of geo-capital practices has begun to accelerate parts of the volcanic landscape. Such accelerations are productive of new forces and concepts, generative not of a politics of territories, but one of thresholds, as the political geology of accelerated volcanic and seismic rhythms comes to the fore.

While I want to adopt the analytical spirit of Povinelli's work, the terms geontopower/geontopolitics are too located in a particular type of indigenous

[48] 'Thus the point of the concepts of geontology and geontopower is not to found a new ontology of objects, nor to establish a new metaphysics of power, nor to adjudicate the possibility or impossibility of the human ability to know the truth of the world of things. Rather they are concepts meant to make visible the figural tactics of late liberalism as the long-standing biontological orientation and distribution of power crumbles, losing its efficacy as a self-evident backdrop to reason' (Povinelli 2016: 7-8).

politics in Australia to be productively transposed to Iceland. Following the history of political geology in Iceland, I want to adopt the terms geopower/geopolitics to indicate the inseparability of geology and politics, the power over and of the earth. Adopting the term geopower in relation to the geo-capital practices at Hengill brings with it several imbricating layers. As power (steam for electricity) is generated through the earth, powerful forces (accelerated earthquakes and volcanic cooling) emerge in response. This, in turn, is both conceptually and politically generative, prompting new categories of thought and a range of geopolitical responses.

1.7: Doing Ethnography in Volcanic Landscapes

1.7.1: Mutual Methods with Geologists

The questions generated through my early research meeting with Sveinbjörn led me to a two-phase research strategy. The first phase ran from September 2013 to February 2014 and saw me occupying a desk in the geoscience department of Orkuveita Reykjavíkur, the energy company operating the Hellisheiði Geothermal Power Plant at Hengill.[49]

Through another turn of events I met Bjarni, a geologist at Orkuveita, at dinner one evening. Bjarni, who was to go on to become a good friend and one of my main fieldwork companions while in Iceland, is married to an anthropologist and was immediately, if not cautiously, sympathetic to my plight of ethnographic access. He also seemed a little drawn to the idea of an anthropologist conducting fieldwork with geologists as they conducted fieldwork in a volcanic site.

Bjarni negotiated my access to the company and arranged for me to have a desk next to his in the geoscience department. This department is a small unit within the structure of Orkuveita, consisting of six staff members, Bjarni (geologist), Gunnar (geophysicist), Ingvi (geochemist), Gretar (volcanologist) and two other geologists. I sat amongst them and listened to their discussions, was invited into some of their

[49] In compliance with EU energy deregulation laws, the company underwent a restructuring during the time of my fieldwork. It was split into four different companies, all still operating from the same location; Orkuveita Reykjavíkur, Orkuveita Náttúrunnar, Veitur, and Gagnaveita Reykjavíkur. I will continue to refer to the company as Orkuveita throughout the dissertation.

meetings, joined them for morning coffee and lunch, and invited them for more structured chats as often as their busy schedules allowed. During down times, I read their academic conference papers and the reports they produced for the company. One report in particular became important in my efforts to understand and analyse "man-made" earthquakes. Parts of Chapters Five and Six are primarily based around data generated from this document.

Mostly I hung around awaiting an opportunity to travel with the geologists to the Hengill volcanic zone. As a small group, Bjarni and his colleagues are part of multiple project teams, and while they work alongside engineers and other members of the company, they are primarily relied upon as earth experts; that group to which others turn for an understanding of how the earth might respond in any given number of production scenarios. In particular, these production scenarios mostly revolve around how to generate sufficient quantities of steam to satisfy the burdensome electricity contracts with Century Aluminium.

As I will go on to talk about in detail in Chapter Three, one of the major issues the group faced while I was present was a concern with falling pressure, and hence falling steam output. Tasked with finding a creative solution to the problem in times of limited resources, Bjarni and his team had begun what they called an experimental *tracer test*. While I will discuss the details of this in Chapter Four, in short, the tracer test is an effort to figure out where reinjected water flows after it has been pumped back down into the subterranean. Figuring this out is one piece in solving the larger puzzle of falling steam output.

This necessitated the formation of a sampling team to collect fluid samples from the over 35 active geothermal wells throughout parts of Hengill. As an extra pair of hands, I became a part of the team and travelled out to the lava plains on many occasions in all forms of inclement weather.

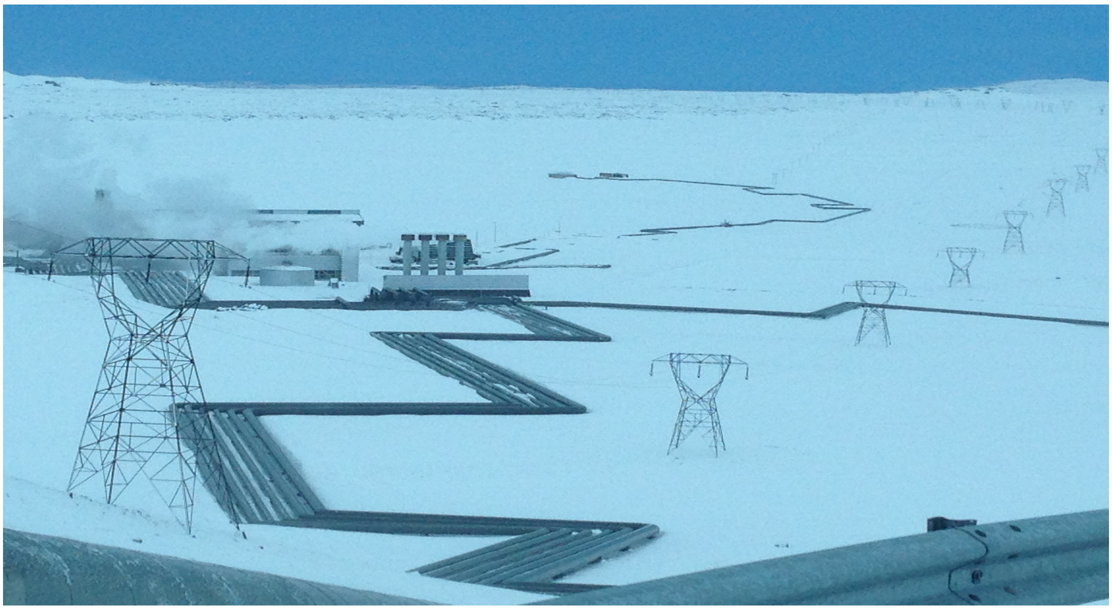

Figure 5: Hellisheiði Geothermal Power Plant, Hengill mid December.

While sampling with the geologists in the Hengill postglacial lava plains that envelop the power plant, Bjarni and his team strenuously urged me to tread carefully and learn as best I could the skills of navigating through such an unstable landscape. In simple terms this implied donning a comical looking orange fluorescent jumpsuit to guard against the darkness and, at times, extreme temperatures, sometimes as low as minus 25 degrees Celsius. It also meant wearing a gas detection sensor in case of prolonged exposure to either carbon dioxide or hydrogen sulfide. Approaching the wells to collect water also necessitated moving carefully as geothermal wellheads rumbled and screeched as fluids (water and steam) emanated from the subterranean and exploded up through the piping infrastructure for energy production.

The turbulent liveliness of this place was very palpable as we drove through the mountains, travelling from well to well. Although, at times, the difficult terrain or snow filled pathways demanded journeying on foot. Trekking overground wells in an effort to trace the underground flow of geothermal fluids was an important method for the geologists, but proved critically important for me at the same time.

This was primarily for two reasons. The first was that in assisting on the long and difficult sampling days, several of which were accompanied by flat tyres, breakdowns, and, or long spells of waiting for the weather to clear up, a type of fieldwork kinship developed between us. My impression is that, over time, Bjarni noted the different ways in which I went the extra mile. Whether it was simply battling the elements, or digging out the snowed-in wheels of the jeep when they became stuck, or less simply, my desire to learn and understand the detailed processes of the sampling method. My ongoing presence in the field evidenced my commitment to one of the things we both held as important: fieldwork as a method of knowledge generation.

While the centrality of fieldwork was the source of several interesting comparisons between our disciplines - more of which will appear in Chapter Four - it also opened up for reflection on the mutuality of our methods. Gunnar, geophysicist at Orkuveita, joked a couple of times about how, in helping geologists with their fieldwork, I was, in fact, helping them to help me. Importantly though, this methodological bond opened up for a generosity and frankness of discussion about what it means to be a geologist involved in energy extraction at such a critical juncture in the planet's history.[50] Alerted to my desire for reflexive conversation most of the team seemed to enjoy talking about geology and Icelandic landscapes, as well as the recent financial crisis and the role of capital - at Orkuveita and elsewhere.

Whether it was travelling through Hengill together, waiting for the weather to break, writing up notes, documenting processes, taking photographs, or back at the head office looking at geological maps, discussing the energy efficiencies of the various wells, I sensed a comradery that was different to other ethnographic work I have conducted.

While the direct reciprocation of this feeling only ever manifested itself in the odd caustic remark from my friends, my sense is that, as fieldworkers, this bond was part of an opening up that was analytically generative. The openness with which

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[50] There is a heightened awareness of climate change issues amongst the geological community in Iceland. In particular, melting glaciers are having tectonic effects as reduced pressure on the landscape leads to processes of uplifting. While geologists at Orkuveita are not directly involved in studying these processes they do speculate as to the effects they are having on geothermal areas. This coupled with Iceland's role as a world leader in renewable energy (per capita) led to many discussions about climate change issues and the role of renewable energy in mitigation. Being a geologist working in renewable energy at this particular historical juncture was a source of pride for these geologists, while at the same time these feelings were complicated by the presence of aluminium as the company's biggest customer. I will discuss the aluminium industry in a lot more detail in the next chapter.

Bjarni and his colleagues spoke about the company's operations, and its problems, while at the same time very passionately about the municipally mandated role of Orkuveita in the lives of Reykjavik's residents was very productive for the dissertation as a whole.[51]

The second reason why specific geological methods were methodologically important for me was that Bjarni and his colleagues, by taking fieldwork so seriously, brought home to me some of the debates in anthropology about the idea of *taking seriously*, albeit performatively and not discursively. Taking fieldwork seriously for them translated into a practical way of sensorially engaging with the landscape. While sensing the terrain was predominantly about risk and safety,[52] listening to the sounds of the fluids as they thunderously emerged from the subterranean and into the wells, I would learn, was crucial. As Chapter Four will discuss in detail, the roaring, sonic sounds emerging from the underground were used as an acoustic method to help geologists generate the right type of data.

Learning to listen, it seems, is not only an important part of the methodological apparatus of anthropologists, but also of geologists working with geothermal. As I learned to listen in this volcanic landscape in a double sense, they learned to open up to my listening. It was these days and experiences that generated many of my ethnographic descriptions and insights. Working on the lava plains in difficult, risky conditions taught me an appreciation for the forces of the earth and the processes of geothermal, but not just as background information for contextualizing further stories.

As I explore further in Chapters Four, Five and Six, taking geologists and earth processes equally seriously is an ethnographic commitment to specifying the relations within and between the earth and people as they generate energy, knowledge and collateral others in volcanic settings. However, the earth in Iceland is not just a site of energy production and geological knowledge making. As I will go on to show, and as I have already suggested in the anthropocene-capitalocene discussions above, these landscapes are deeply political.

[51] Although it does not feel possible to quantify this in any strict sense.
[52] This included learning how and where to walk, what signs of potential danger to look for in the landscape, as well as sets of instructions on how to approach wells and take fluid samples.

1.7.2: Hiking and Riding as Method

My second phase of fieldwork also involved being in the surrounding landscape of the Hengill volcano, albeit differently so. I spent 5 months from June to October 2014 in the small town of Hveragerði (population 2,300), which lies approximately ten kilometres south east of Hellisheiði within the Hengill volcanic system.

The name Hveragerði translates invariably as hot spring town, or hot spring garden. Some residents like to think of it as the hot springs within the mountain's garden. Being there helps with this image. The town is nestled within the curvatures of Hengill's high, long rolling valleys. As one drives along route one from Reykjavík, the town becomes visible at a 500-meter overpass (figure 6). Looking down, the name hot spring garden immediately resonates, as the town hugs the edges of the mountain's contours. But while this name has the tendency to produce a mildly bucolic image, this is no ordinary garden.

These hot springs reside within a northeast- southwest fissure swarm, which at several points over the last 10,000 years have erupted with teeming hot lava. The craggy mountain structures of these solidified lava flows are all around the town, and are indexed in many of the street names. Large gaping surface deformations are not only visible to the eye, but characterize the town's more recently self-ascribed identity as the 'earthquake town of the south west.' Steam emanates from hot springs and mud pools, and rises hundreds of meters into the air almost as a visible calling card for the many tourists who visit during the summer months.

Figure 6: Hveragerði from Overpass on Route 1.

Renting a house in the town's centre, I discussed town life, the earth, energy, earthquakes, pollution and the financial crisis with many residents. In particular, I conducted interviews with political and business leaders, as well as those who had an interest in, or opinion about, the production of earthquakes. As a town with a history of 'natural' earthquakes, the prevalence of "man-made" earthquakes was both physically, and conceptually, disturbing for many.

However, a lot of my time was spent with Björn, a former teacher in Hveragerði. Björn has much to say about the sanctity of the volcanic area and actively worked to protect it. The focus of his energies has been mobilising against deep drilling geothermal, or high temperature geothermal, as it is referred to in the industry.[53] He talks of this landscape as being an inheritance to all Icelanders, including unborn future generations; inter-generational justice is near to his heart, as is preservation and protection. Although he is 73 years old he is incredibly spritely and active, and took me on many day-length hikes through the volcanic zone. On these hiking trips Björn enjoyed pointing out the richness of life in the area bringing

[53] High temperature geothermal is accessed through fluids circulating at depths of up to three kilometres. These fluids contain far more energy per kilo than low temperature, making them highly sought after in the production of steam for electricity. Low temperature fluids are found in many places around the country, but particularly large volumes are extracted from around the Reykjavík area where they are primarily used for spatial heating.

my attention to the myriad of geological features on display.[54] Whether walking together or bathing in a geothermal river, as we did on a couple of occasions, he never tired of talking about these volcanic landscapes and their place in the hearts of many.

These trips were part joy, part politics for Björn, as he documented the impact of the power plant on the surrounding landscape in great detail. As I will discuss at length in Chapter Seven, he did this by mobilising features of the landscape, in in particular its lava flows, as an infrastructure of protest to lobby against current, and potentially future energy interventions into the area.

In addition, Björn also encourgaed me to take horse riding trips with Stefan, a guide at the local horse riding company Eldhestar (Volcano Horses).[55] Not only did both men take the time to instruct me on the geology of the landscape, its lava flows and multi species inhabitants, but they also bound this together with a strong sense of its political and social history. Both Björn and Stefan were keen for me to experience the landscape as people would have in former times by travelling through some of the old gateway routes between south and southwest Iceland. In particular, they emphasised the route from Hengill to Þingvellir, where 'heroes rode through the region'[56] to the Icelandic parliamnet that convened there for many centuries.

Connecting lava, horses, politics and history Björn and Stefan used these occassions to bring me to places that were almost impossible to reach by foot, making visible areas where some of the more obvious impacts of hydrogen sulfide pollution (H2S), a big concern amongst residents in Hveragerdi, could be seen. In some ways, riding through the landcape was a transformative experience, connecting me via the lava rich landscpe to past times and hidden places. While Chapter Seven will be specifically devoted to my experiences with Björn and Stefan, my time in the landscape with them informed a lot of my thinking, and provoked

[54] Including the various subterranean features that were emerging overground; the bubbling, thudding and spewing of the hot spring water, mud and clay, the hissing of the mud pots, but also the thermophiles; lithotrophic organisms that produce the vast array of colours on display.

[55] Björn and Stefan are members of the South Iceland Conservation Society and are active participants in ongoing public debates about the benefits and problems of geothermal production in volcanic landscapes.

[56] This is a quote from a well known patriotic nineteenth century Icelandic poem that Björn and Stefan were fond of.

many questions that helped me engage with other residents of the town as well as reflect upon my experiences with the geologists from Orkuveita. Hiking and riding with these men, not dissimilar to trips with Bjarni and his colleagues, was a way of learning to listen and see in this volcanic landscape.

Both sets of fieldwork companions were concerned with tracing. While Bjarni and his colleagues were tracing the flow of reinjected water through the fractured subterranean arteries of geothermal, Björn and Stefan were tracing the damage wrought on the landscape by geothermal production. Both were, in effect, tracing energy's inscriptions into this volcanic landscape. As an ethnographer trying to understand the practices of both sets of fieldwork companions, I did my best to think about, and learn from, their landscape tracing practices so I could begin my own textual tracing of energy's, and hence capital's, inscriptions at Hengill.

Whether bathing in geothermal springs, walking through the hills, riding on volcanic horses, or collecting water samples from thunderous wells, sensitizing my body to volcanic relations became part of my methods assemblage (Law 2004). Listening for sounds, coping with horse riding, reading the lava, and sampling water all involved attuning myself, with and through others, to ways of tracing the landscape as a descriptive method. Specific landscapes and their inhabitants (humans and non humans) are part of one another, and learning to use tracing as a descriptive apparatus for writing this landscape meant learning through the tracing practices of my fieldwork companions. I will unfold the specific performances of these methods in more detail within each of the upcoming chapters.

In order to begin our exploration of the importance of the intertwining of geological practices and practices of capital in the transformation of the Hengill volcanic landscape, I will now move on to Chapter Two. Maintaining my focus on practices, I move to characterise two moments of capital in recent Icelandic history, and their role in mediating energy-aluminium relations.

Chapter 2. Making the Earth a Valuable Proposition for Capital

2.1: Performing Geothermal Energy

Coming off the snow laden lava plains of the Hengill volcanic zone in my orange fluorescent suit, I am tired and cold. The day's sampling has been cut short due to numerous misadventures from heavy snowfall. A near crash in our large four by four jeep necessitates a snowplough rescue close to geothermal well HE29. Bjarni, geologist at Orkuveita and my main fieldwork companion at the company, calls it quits for the day and we head back to the power plant at Hellisheiði.

As we sit and eat lunch in the staff canteen, the conversation turns to sampling difficulties in snowy conditions. Geothermal well accessibility is becoming a problem and the rate of sampling has slowed, a lot. Bjarni tries to impress upon me the importance of sampling and its relation to the ongoing loss of steam. "By tracing the flow pathways, we can figure out where the fluids are going, and why we're losing power." But there is a lot for me to take in during these conversations. While being here in the volcanic landscape is new and exciting, the scale of things is hard to comprehend; everything is just so vast (figure 7).

With thirty-five operational wellheads spread over many kilometres within Hengill's volcanic terrain, moving through this landscape with the geology team by jeep, and then on foot, is not easy going. Our purpose for roaming around these historically and geopolitically layered lava plains could not be more specific: to collect small vials of water. Despite the narrowness of our task, one cannot escape the vastness. In popular discourse, Iceland is renowned for evoking a sense of the sublime, as the limitedness of the human takes palpable form amongst the grandeur of these landscapes. Yet here I am, in this place, with Bjarni, a volcanic steam maker.

Figure 7: Aerial photography of a section of the Hengill Volcanic Landscape, indicating the Hellisheiði Geothermal Power Plant and an approximation of the location of the small town of Hveragerði (top left of image). Photograph courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

I am keen to learn more: big picture stuff. How does it all connect together, I ask Bjarni, naively. Almost always ready to offer a patient and detailed explanation, Bjarni sits quietly over his half eaten food as if he hasn't heard the question. I have not yet learned to read this particular mood. He is stressed, and I'm not helping. "I've got some things to do before we head back to Reykjavík," he says, "why don't you go and take a look at the Visitors Centre for a while, that might be interesting." Bjarni points the way towards a sleek silver monochrome building that stands in stark contrast to, and adjacent from, the functional steam condensers of the power plant. "It's that place over there, the one for the tourists," he says, "it tells them all they need to know about geothermal energy."

Wondering what it is that people "need to know" about geothermal, I head over to the Hellisheiði Visitors Centre just some one hundred meters away. Upon entering, I remember how the President of Iceland described this place in a speech he gave at an Icelandic Energy Summit held in Reykjavik several weeks prior. The president, not known for his modesty on behalf of the nation,[57] talked of Iceland's emerging role as an Arctic powerhouse, and particularly of the ongoing scaling up of geothermal energy for industrial purposes. As a green form of energy, the president proclaims, geothermal is both good for the nation and good for 'nature.'[58]

Discourse surrounding green energy has taken an almost salvational turn in 'post 2008 financial crisis Iceland,' as politicians and business leaders look for other - non-financial service sector - ways to stabilise the nation in times of difficulty. In light of the recent controversies surrounding hydropower (something I will touch upon shortly), geothermal energy is just the ticket. As an energy form that people have had an intimate relationship with for many years - providing the warmth necessary to heat cold homes in sub-arctic temperatures, bathe cold bodies in public pools, as well as take care of a range of other domestic needs - it has been relatively uncontroversial.

The country's successful utilisation of volcanically heated water has been lauded by geologists the world over as an exemplar of sustainable production, as well as loved by tourists as they lounge in the silky silica rich warm waters of the Blue Lagoon.[59] The Hellisheiði Visitor Centre is Orkuveita's paean to geothermal energy, which, according to the president, is an "exhibition" built to showcase its virtues; clean, green and renewable as it provides not just hot water for Reykjavik, but electricity for heavy industry. The exhibition comes with a guide (a former worker at the power station) and I take a tour to kill the time before heading back to Orkuveita's head office in Reykjavík with Bjarni. In thickly, yet endearingly, accented English, the guide shows me around and explains the process of geothermal energy; or at least all those parts that tourists "need to know."

The focus is squarely on fluid circulation, as an interactive screen assists the guide through his circulation story (figure 8). The display is lit up with multiple flow

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[57] The president's speeches from the 2000s are filled with an optimism that analysts, in particular historians, see as typifying the rhetoric of the boom time era. Bombastic and self-aggrandising claims about the unique nature of Viking entrepreneurs are commonplace. I will talk more about this a little later in the chapter. See (Magnússon 2012: 259-261) for an analysis of president's speeches before the financial crash.

[58] http://bicc.is/en/news_o_events/id/197/succesful_energy_summit_

[59] The Blue Lagoon is one of Iceland's best-known tourist spots. The company has capitalised upon the warm geothermal run off waters from the power plant next door, Svartsengi, see http://www.bluelagoon.com/about-us/.

channels in varying colours, each representing different forms of fluid as they flow up through the wellhead, into the piping infrastructure, and off to their final destination points.

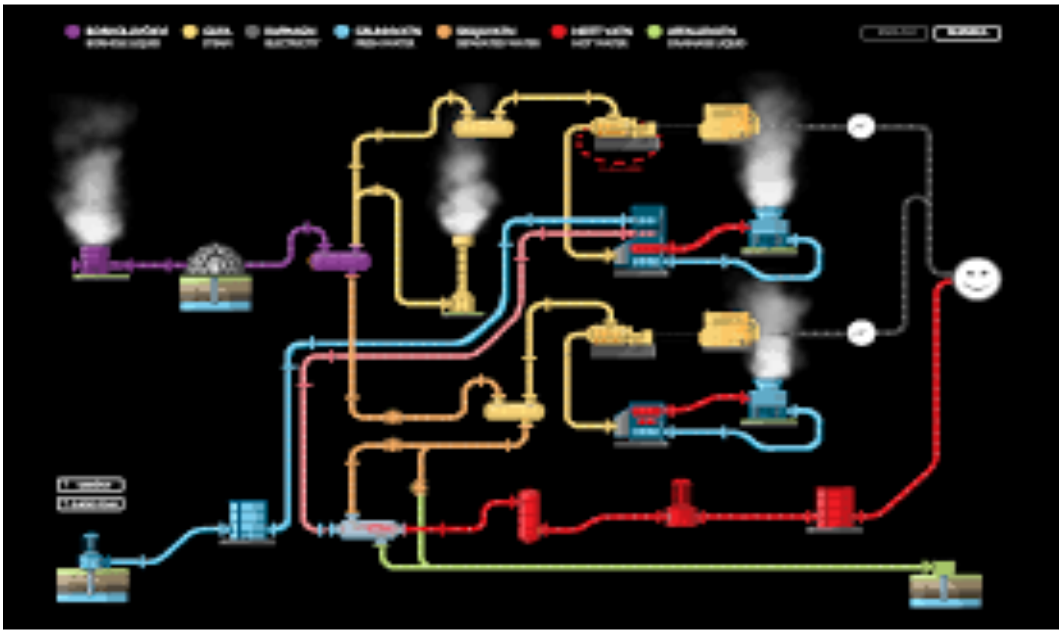

Figure 8: An interactive rendering of the Fluid Cycle at Hellisheiði

The first flow channel, a deep purple colour, emerges from the subterranean through an image of a wellhead: this is geothermal brine, a mixture of steam and water between 200 and 300 degrees Celsius. This brine is separated into water and steam, represented by the emergence of two offshoot colours (a yellow and an orange) from the purple flow. The yellow is a rendering of the separated steam that then flows into the turbines driving the generator to make electricity. Connected to the turbine-generator is an image of a cable that itself connects to a large smiley face at the latter end of the display, indexing the happy customers of the electricity – Century Aluminium.

The orange is a rendering of the separated water that flows downwards (in the image), and ends up in a heat exchange unit towards the bottom of the display. From here previously cold groundwater (blue) which has been heated up by the excess steam from the turbines (light red) goes through a heat exchange process through which heat is transferred from the geothermal water (orange) to the heated groundwater (light red) resulting in 82 degree heated water (deep red).

This deep red channel flows towards, once again, the large smiley face at the latter end of the display indexing, this time, the happy recipients living in the eastern part of Reykjavík. Finally, the geothermal water (orange) that has transferred its heat transforms to green; spent geothermal water that flows towards a well (at the bottom right hand of the display) where it is reinjected back into the subterranean rock matrix.[60]

While the guide is happy to entertain questions about the performance of the process as almost carbon free (green) and pollution free (clean), he is a little more reluctant to be taken in by my questioning its renewability.[61] “Of course it’s renewable,” he replies, pointing back towards the fluid cycle. “Look, the water goes back into the earth, and this creates a balance. Whatever we take out, we put back in, that’s how it works. That’s what reinjection is about.”

The guide brings me upstairs to the exhibition’s second floor to explain further. The story of geothermal is laid out in clear chronological segments from the foundation of Reykjavík forward, sculpted into the wall in a type of moulded plaster. Adjacent to it is another large wall installation sculpted in a similar fashion and capturing a similar message as the lower floor but on a grander scale. *The Renewable Energy Cycle* stands in bold clear font as the headline banner above the installation. This rendering involves the precipitation cycle, highlighting how rainfall enters the underground, is heated by rocks through magma intrusions, and is extracted by the power company. The remnant steam is seen leaving the cooling towers as several curved arrows drifting towards the sky.

The connection between the two floors now becomes a little clearer to me; while the upper floor performs *geothermal extraction* as a neatly fitting component of fluid circulation *at a hydrospherical scale*, the lower floor performs *geothermal reinjection* as the balancing work necessary to the extractive interventions of

[60] There are many small problems with the way this interactive setup renders the process, suggesting that the complexity of the operation is very difficult to represent in a linear logic that can be mapped visually. Interestingly, one key element that is missing from the display unit is the condensed steam (the excess steam from the turbines that is turned back into cold water), which, under normal operating processes, joins up with the spent geothermal water (green flow channel) to be reinjected.
[61] The guide uses the language of renewable and green interchangeably from time to time. Green energy (Græna Orku) is not a term that Icelanders have used in the past to describe geothermal, but has emerged as part of an internationalised vocabulary that connects energy supply to the aluminium industry.

humans *at a subterranean scale*. Humans and 'nature' working together at multiple scales in one large balanced circulation of fluids.

This is not the only time I have heard this particular account. Several geologists at both Orkuveita and ISOR (the Icelandic Geosurvey Institute) describe the process in similar terms. Extraction, utilisation, and reinjection enable geothermal energy companies to work with the landscape through large cycles of fluid circulation and heat transference. Different forms of fluid emerge and flow between the subterranean and the technological apparatus of extraction. Water and steam are separated, heat is transferred, usable hot water and electricity are made, and spent fluids, oftentimes referred to as waste water, are reinjected back from whence they came. That which is taken from the landscape is given back to it. A type of equilibrium is achieved, in principle.

This is what the world gets to see of geothermal. This is the version that is performed daily, to tourists, to energy companies, to visiting foreign government delegations. It is this version that exists in all of the industry's fulsome literature, through its websites, at company, municipal and government levels, even in presidential speeches; one large story of renewable fluid circulation.

2.2: Perpetual Motion Machine

One day sitting with Einar over coffee, a resident of the small town of Hveragerði, and a self-ascribed environmentalist, we get talking about the development of the Hellisheiði power plant, its constant production of steam and the powerful by-product smell of hydrogen sulphide that is immediately recognizable as one enters the town. Talk turns to planning, or what Einar bemoans as the lack of it.

"In oil and gas operations there is always some sort plan, even if it's not very good, there is usually some money to try and do something about the landscape after all those wells and pipes. Here there's nothing." When I ask him why that's the case, he replies "well it's because they say all this is renewable, that we can just keep on getting steam and water, but what I don't understand is how they think they are building ever-lasting things." This expression, "ever lasting things," has stayed with me as I have tried to come to terms with how to think about the various actors and operations in the volcanic landscape at Hengill.

There are many voices, from within both academia and the environmental movement, which are critical of the above performance, challenging the idea of geothermal as renewable. Stefan Arnarson, geochemist and respected public intellectual, tells me that there is some confusion about the ways in which people use the language surrounding renewability, and that this is connected to the dual composition of geothermal, that is, as thermal energy subsisting in water.

Given that there is constant heat emanating from the earth's mantle and through the crust, geothermal's heat source, according to Stefan, can clearly be thought of as renewable. But it still requires a medium of extraction: water. Stefan characterises high temperature geothermal - drilling deep into the volcanic landscape for the extraction of steam - as a type of heat mining, and they way this heat is mined can set a large question mark over the resource as renewable. The distinction for him is between the source of the heat and the resource of energy.[62]

Renewable geothermal energy advocates draw their arguments from a well-known hot water extraction area within Reykjavík, known as Laugarnes. Artesian wells - wells from which water is pumped from just below the surface - have been in operation in Laugarnes since the 1930s. Deeper wells, fifty to one hundred meters down, again using pumps, have been in operation there since the 1960s drawing ten times more water volume than the artesian wells. These wells have had little to no loss in either water pressure or temperature over the years. But as Stefan tells me, this is low temperature extraction (hot water), not the sort of high temperature extraction (mostly steam) going on at Hellisheiði. These are interesting and necessary critiques. But I want to take a different route and suggest that the ways in which geothermal landscapes are performed is not based on a type of confusion about energy, but that such performances are what help to attract capital.

In *Friction*, Anna Tsing argues that what calls capital to the forests of Indonesia is a type of conjuring act (2005: 62-65). Conjuring is a way of attracting financing through performing the company - in this case by venture capitalists - as a

[62] This is based upon interview material, but see also (Arnorsson 2000: 1254).

strong and stable economic actor. The magic of the act resides in acting 'as if' the company is that which it claims to be. The dramatic effect of such a performance is to secure financing that then provides the opportunity to become that which was initially performed. Such dramatic performances, argues Tsing, precede economic performances as the difficult work of actually producing something can only get underway after the even more complex work of securing capital has been completed. In Tsing's case, venture capitalists need to perform themselves in a particularly dramatic way in order to become an entity worthy of capital. In Hengill, the volcanic landscape has to be performed as a viable entity for capital, and the idea of "ever-lasting things" that Einar mentioned above is an important part of how this is achieved.

In the performance at the visitor centre, the tectonic landscape becomes a type of 'perpetual motion machine' (Brown and Capdevila 1999), which, once set in motion continuously produces energy in a cycle of renewability. The idea of a perpetual motion machine, or *perpetuum mobile,* dates from the eighteenth century when a fascination for automata gripped society, mostly inspired by Newton's imagery of a clockwork universe and timekeeping machines as symbols of linear order and precision (ibid : 28). The ambition was to discover the principle behind the construction of a machine that once set in motion would continue for all eternity. The *perpetuum mobile* is an expression of such a principle, a pure going-on, a demonstration of how an entirely self-closed mechanism may persist in being without any dependence on the world around it (ibid).

Once set in motion the machine is a 'cause-in-itself,' continuing on by virtue of its own self-contained, unlimited reservoir of energy. With the dawn of the new physics of the nineteenth century however, in particular thermodynamics and the laws of energy conservation, the *perpetuum mobile* exited the stage as a credible scientific idea (ibid : 31-32).[63]

[63] Although it did not entirely disappear; it was reconfigured by Hermann von Helmholtz to become not a machine made by man, but the storehouse of 'nature,' the universe as a whole.

Geothermal energy is what the energy industry refers to as base load energy.[64] It operates all day every day, without rest.[65] Century Aluminium in the west of Iceland also operate 24/7, consuming the large quantities of electricity that Hellisheiði produces as smelter pots gobble up continuous round-the-clock current to keep from freezing. As such, investors and energy developers have long seen geothermal as the perfect match for the power-intensive industries:[66] renewable 24/7 volcanic energy feeding the 24/7 needs of global aluminium. By plugging into and becoming an extended part of these powerful landscapes, Century Aluminium continues its ceaseless provision of one of modern consumerism's primary metals. It is partly this imagery of "never ending things" that draws capital to the landscapes of Iceland.

In this chapter, I want to think about the relationship between energy and aluminium through *two moments of capital* that have arisen in recent Icelandic history. As capital becomes more freely available, the imaginative horizon of what constitutes the value of Icelandic landscapes opens up. But this takes a lot of work. Energy deals are protracted affairs and extensive effort goes into reconfiguring the landscape so that it becomes a valuable proposition for capital. One way is through performances like the one we have just seen, where the landscape is rendered as perpetually renewable, something all investors like. But it also take the city of Reykjavik to make these deals work, as they too have to act as renewable, but in a different sense.

As we shall see, this first moment occurs in the 1960s when aluminium arrives in Iceland, an industry that is globally on the hunt for propositions that fit a particular capital profile. The ensuing energy deals provoke a shift in thinking about glacial forces; from uncontrollable free flowing melt water to controllable water conceived as convertible to electrons.

[64] Base load energy is what supplies the electricity grid with its basic fixed needs. Other energy sources that have storage capacity, which in the Icelandic case is hydropower, can be switched on and off to meet fluctuating demand.
[65] Wells are however taken offline, as geologists call it, on a rotating basis for maintenance.
[66] The term 'power-intensive industries' is a category widely used within business, statistics and economic circles to describe industries that use vast quantities of electricity. These include aluminium, as well as ferrosilicon, and data centres, a recent arrival to the island.

The second moment occurs in the 2000s. As global asset values accelerated during this decade, vast quantities of capital found a temporary resting place upon Iceland's shores. Heralded as the financial Mecca of Northern Europe, this moment in the country's history is one where access to capital, formerly distributed through political affiliations, now became available to all Icelanders, as the lives of residents, companies, and municipalities were transformed in unprecedented ways. Orkuveita took advantage of theses capital flows to do an energy deal that transformed the volcanic landscape from a place for the production of hot water for heating Reykjavík, to a place for the production of steam for electrifying aluminium smelters.

2.3: Farming, Fish and Foreigners

Before I move directly into these two moments of capital, let me first try to create a little context through a quick look at the industrial difficulties that Iceland has faced over many years, difficulties that the aluminium industry has been heralded as an antidote to. As a peripheral northerly nation, the Janus-faced ambiguity of both belonging and not belonging to the Western world (Oslund 2011) has always plagued the land of fire and ice.[67] While economic historians may argue over whether Iceland has ever gone through an industrial revolution (Jonsson 2004), it is clear that its industrial trajectory has not been similar to more standard northern European models.

Iceland has experienced considerable socio-environmental catastrophe over the course of history. In a 2012 article, Kirsten Hastrup provides a useful summary of the difficulties. From the extensive Icelandic annals, it is believed that at least one fourth of the years between 1400 and 1800 were locally known as lean years, marked by extensive famine and death (Hastrup 2012). From 1402 to 1404, the Black Death ravaged the island killing off between a third and a half of the population, decimating it to 45,000 from a settler colony of about 80,000. Pack ice off coastal waters during the so-called Little Ice Age as well strong winds prevented ships from docking with essential supplies (ibid : 120). As we learned in the introduction, the effects of the Laki eruption in 1783 wiped out a quarter of the population through

[67] The land of Fire and Ice is a commonly used predicate in the fulsome production of tourist literature that one finds in Iceland.

famine, and this was far from the only volcanic outbreak. The combination of difficult weather conditions associated with such a northerly latitude and such extreme events meant crop cultivation was limited, the surplus of which is a common factor in many forms of industrial development. The Danish Trade monopoly also contributed to the ongoing misery of the population as locals were prohibited from selling to international markets.

By the mid 1800s, Iceland was by far the poorest country in Europe, with only half the GDP of the other bottom ranking nations. Farming dominated economic and social life with over 4,000 farmsteads spread throughout the country. Mainly a tenant farming system, the vast majority of farms were owned by the church and state. Livestock was crucial (mostly sheep with some cattle) as was the production of fodder for winter-feed. Farms were small and relatively unproductive, and labour was intensive with little to no mechanization. Fishing also became an essential part of surviving through the difficult year as farmers moved to the coast at varying times to follow the northward migrating cod stocks (Magnússon 2012: 22-30).

The full lifting of the Danish trade monopoly in 1854 was a particularly significant moment, one that led to both the export of salted fish to a growing European population, along with the sale of livestock to England, heralding the emergence of a new merchant class earning foreign currency for the first time (ibid : 32).[68] Historian Sigurdur Magnússon suggests the significance of this first foreign currency surplus was to help lead the way to the mechanization of the fishing fleet at the start of the twentieth century (ibid), a major moment in any semblance of what can be called ‘industrial development’ in Iceland. As a small island nation with few economic options, the fish stocks have formed the backbone of the economy over the last 100 years. As such most regional economies became dependent on the vagaries of each year’s catch, peaking and ebbing in rhythm with, for the most part, cod stocks. When catches were up, life was bearable: when catches were down, the

[68] Until 1787 trade with Iceland had been the monopoly of the Danish Crown, with the king selling licenses to his Danish subjects. In 1787 the right to trade with Iceland was extended to all subjects of the Danish Crown, including Icelanders. Even so, business still had to be conducted through Copenhagen, and the few Icelanders who tried to set up in Iceland met with little success. Trade with Iceland continued to be in the hands of Danish merchants, who had better access to finance, and as a result almost all profits returned to Denmark with little to no reinvestment in Iceland. This situation did not seriously change until 1854 (Magnússon 2012: 31-32).

currency was devalued (in order not to cut wages directly), inflation increased, and life became less bearable.

The area around Reykjavík also enjoyed a post World War Two boom from the development of an American military base at Keflavik, just south of the capital. Marshall Plan aid in the years shortly after the war brought dollars, new consumer demand, technologies and ancillary jobs (Sigurdsson 2000, Sigurdsson 2005). This was Iceland's first taste of capital in an economy that had formerly been based on local community initiatives from cottage industries. From this point the economy slowly began to be monetized (Jónsson and Sæmundsson 2015: 27).

But both of these primary forces, maritime, as well as neo-colonial, were highly uncertain: both the Americans and fish, it was argued, could leave on a whim.[69] The desire, therefore, to develop a solid industrial base, one that could provide what Iceland had always lacked – a sense of stability over a broader temporal scale - has remained the clarion call of successive Icelandic governments. The aluminium industry offered the opportunity to diversify away from fish and foreign powers, and towards the stability of industrial production.

2.4: Energy, Capital and Aluminium – A First Moment

As political theorist Timothy Mitchell has noted, post World War Two global capital flows have had a tendency to follow energy flows as the entire global financial infrastructure became organised around flows of oil (2009: 399). For Mitchell, tracing the intersection of energy and capital provides a perspective from which to think about politics and economics as the abundance of carbon energy became a crucial factor for the emergence of both new political forms (organised labour) and new objects of calculation (a new science of 'prices and flows of money') (Mitchell 2011: 131). At the same time, tracing this intersection unearths a host of other connections through which these relations are maintained.

[69] In fact both did, over time, disappear. The collapse of the cod stocks in the 1980's was shortly followed by the introduction of a quota system, which, despite the adoption of stringent management techniques, continued to see stocks fall - from 500,000 tons in the early 80's to 160,000 in 2011 (the year I conducted fisheries research in Iceland). The withdrawal of the Americans in 2006 also dealt a blow to the local economy.

Aluminium is one such connection point between energy and capital, a form of *metals capitalism* as inventor, architect and philanthropist Buckminster Fuller put it (Fuller cited in Sheller 2014: 82). As a primary player in electricity markets, the aluminium industry consumes up to 3% of global electricity output to meet the needs of its insatiable smelters. In *Aluminium Dreams*, Mimi Sheller (2014) gives a detailed account of the global role and effects of the aluminium industry. Over the course of around fifty years, from 1910 to 1960, aluminium came to play a crucial part in the transportation, electrical, construction, aeronautics, and ship building industries. At the same time it was important in domestic design, architecture, technical equipment and all kinds of ordinary aspects of everyday life such as baking products, cosmetics, kitchen utensils - the list goes on. Once you begin to look for aluminium, Sheller notes, you find it everywhere (ibid : 1-2).

As a substance it is light and flexible, it is non-combustible, it does not corrode easily (making it durable) and it conducts heat and electricity far better than other metals. These primary physical qualities afford a host of possibilities, principal among them the relationship between lightness and speed. Sheller encourages us to think of skyscraper buildings, aeroplane flight, space travel, and shiny new Apple electronic devices that travel the world over: all embrace the physical powers that aluminium affords. But its powers are also more than physical, argues Sheller, as the quest for lightness and speed has become one of the defining preoccupations of modernity. Aluminium puts 'cultures into motion' as it generates mobility for people, objects, electricity, and data, as industrialists and nations alike dream of the benefits of light modernity, prosperity and leisure filled utopias (ibid : 1).

But Sheller also brings aluminium's darker side to our attention, focusing on how bauxite mining and the operations of transnational corporations affect developing countries, as well as postsocialist nations and indigenous groups, bringing environmental pollution and political turmoil around the world (ibid : 5).[70] Particularly worth noting is aluminium's long-time connection to what General

[70] Bauxite extraction leads to deforestation, toxic red mud lakes seep into groundwater supplies, and considerable pollution and respiratory damage arises in connection with alumina dust. Alumina processing contributes to large carbon and PCP emissions (up to 10,000 times more heat inducing than carbon). There is also a whole host of issues around the many human rights violations of indigenous groups located close to bauxite mines.

Dwight Eisenhower called the military-industrial-complex. While much warfare may have been conducted over energy, it has been conducted through aluminium. Alcoa, an aluminium industry leader and possibly the world's first multinational (Padel and Das 2010: 271), expanded dramatically during World War Two as the US government purchased several hundred thousand planes, equivalent to a 600% rise in aluminium production (Sheller 2014: 53). But it was not only planes: the provision of electrical supplies, small parts, as well as explosives and bombs made aluminium a strategic wartime material. As the aluminium industry helped to modernize warfare, warfare reciprocally helped to modernize aluminium. As Sheller puts it, 'it's fair to say that the entire history of innovation and technical development in the uses of aluminium was in many respects driven by war' (ibid : 62).

At the same time the US military's need for aluminium was closely tied to government investment in energy infrastructures. Huge hydroelectric power stations were built to ready the nation for the electricity demands of wartime's primary metal. Here we see the emergence of two factors in aluminium production that directly connect to Iceland. The first is the development of hydropower as a tightly coupled electricity generator for aluminium. In fact, this relationship continued to such an extent that almost all of the economical hydro river sites in the US have been developed by the aluminium industry. Second is the subsidization of energy prices. Although the average cost of electricity to American homeowners was 3.5 cents per kilowatt-hour post World War Two, the cost to the aluminium industry was only .35 cents. This practice of cheap energy through state subsidization has become a lynchpin in the global strategy of large aluminium companies as they cross the globe sourcing energy. As I will shortly come to, this issue of subsidized cheap prices is hugely important in Iceland.

General Dwight Eisenhower's military-industrial-complex could also be called the military-industrial-aluminium-complex, and its development continues apace today. Whether it is contemporary supersonic jets flying over six times the speed of sound, aerospace technology, or modern weaponry (from hand grenades to nuclear weapons), protection of, and investment in, the technologies of lightness and speed continues (ibid: 67). Tracing the 'silvery thread of aluminium across time and space draws together some of the remotest places on earth alongside some of the centres of global power' (ibid : 5).

2.4.1: From Melt Water to Electrons

Aluminium has been dubbed 'packaged or solidified electricity' because smelting requires so much power; up to 17,000 kilo watt-hours per ton (Sheller 2014: 52). As such energy comprises between 20% of and 30% of aluminium's overall cost structure. As we learned a little earlier, the industry has a history of getting state subsidised energy and these subsidies have become an embedded part of doing business (Padel and Das 2010: 298).

As discussed above, with the exception of Marshall Plan aid after the Second World War, foreign capital had played a limited role in Iceland. The original proposals for aluminium smelters in the 1960s provoked a strong debate about the role of foreign investment and foreign ownership in the country (Skúlason and Hayter 1998: 36). Such projects are grand infrastructural undertakings that require large capital flows, not just for the construction of the smelting plant, but also the power plant and the upgrading of the energy infrastructure that comes with it. In Iceland's case, power supply was entirely government controlled at that point.

Proponents of the first aluminium deal in Iceland with the Swiss company Alusuisse in 1966, argued through the classic, and positive, logics of capital: importing electricity intensive aluminium companies into the country would increase investment, leading to more jobs, better infrastructure, and the opportunity to transform and diversify the economy away from the vicissitudes of fish and towards the stability of industrial production. The idea that the melt water from Iceland's numerous glaciers, which had hitherto 'flowed freely into the sea' (Jonsson cited in Skúlason and Hayter: 36), could be transformed into electrons for aluminium production was an unprecedented way to think and act within the historically harsh landscape. The very volatilities of the island itself, formerly rendered as forces of inherent danger, were, in relation to capital, now conceived of as forces of potential abundance as topographic instability (melting glaciers, and in time volcanic landscapes) became convertible to economic stability (energy resources). The path to a stable future lay not in the agricultural practices of cultivation, nor the harvesting of fish stocks, but through the stabilization of formerly uncontrollable forces. A shift, one could say, from the virtualization of force as risk, to the actualisation of force as power.

Alusuisse were at that point as similarly dominant in Europe as Alcoa were in the US, and like Alcoa, they used their global leverage to aggressively negotiate with energy providers. With bauxite sites in Africa and Australia, they examined nuclear power options in Germany and Sweden, opened up a smelter in Norway while at the same time siting locations in Africa, all the while negotiating with the Icelandic state over a five-year period. Indeed, the Icelandic government's concern that nuclear power was likely to be the energy source of the future, further reinforced its commitment to making a deal with Alusuisse 'before it was too late' (ibid: 37).

The power of this large multinational relative to a small island of, at that time, 175,000 people, became increasingly clear as time went on. While aluminium companies adopt an aggressive global strategy to keep electricity prices as low as possible, they also insist upon the acceptance of capital as 'an appropriate vehicle for development' (ibid : 29). Parts of the public record on the negotiation process between the parties show a long shopping list of reforms that the Alusuisse required before investment could proceed.

The list ranged from a power supply deal with pricing and taxation formulas, to a series of infrastructure requirements (ports, tunnels, cables etc.) political assurances, and environmental exemptions. In addition, suggested legislative reforms ranged from changes to labour law (attempting to outlaw strikes), to pension reforms, to educational and language guarantees, as well as local and regional taxation exemptions (ibid : 39-42).

In this sense, capital is not just a flow of investment but is a whole suite of extended practices, which, prior to converting the forces of Icelandic landscapes into valuable energy resources, perform a series of other conversions. In order to transform freely flowing water into electron production, Iceland had to be *made into a valuable proposition* for capital. The generative force of capital that flowed into the country as a result of the energy deal did not only transform large swathes of the landscape as tracts of important glacial rivers were dammed for hydropower. At the same time, parts of the country's financial, political, and juridical apparatus were altered. Capital not only exacts a financial cost, it also exacts a structural one as places and the complex ecology of practices that configure them are reconfigured.

The reason for lingering on this first deal with aluminium is twofold. Firstly, I want to give a sense of the technics of capital, the practices by which it operates and the impacts it can have. I will flesh this out in greater theoretical depth in the next section. Secondly, over the subsequent decades general ideas of societal progress and development became almost synonymous with energy development in Iceland. As local and regional politicians looked for "magic bullet" solutions to rural de-population trends, aluminium smelting became the rhetorical panacea, and the deal with Alusuisse at Straumsvík in Reykjanes (the Greater Reykjavík area) became the template from which new possibilities took their point of departure, as many other locations around the country began their own vetting processes for future projects.

The 33,000-ton aluminium deal eventually signed in 1969 with Alusuisse was enlarged to 185,000 tons over the next two decades, and paved the way for the entrance of Columbia Ventures in 1998 and Alcoa in 2008, as total aluminium production reached over 800,000 tons. As I mentioned in Chapter One, Iceland is currently the world's largest per capita producer of aluminium, and the world's largest per capita producer of electricity, by a factor of two, with over 80% of its output going to aluminium. It is hard to overstate the effect that metals capital has had on the country. As such energy production has become the primary source of environmental conflict, if not one of the primary sources of societal conflict more broadly, in Iceland. Ever-increasing antagonism between pro- and anti- energy camps has led to escalating levels of polarisation.

2.4.2: Energy and Price

While a full history of conflict over hydropower is too detailed to discuss here, Alcoa's deal with Landsvirkjun, the state owned National Power Company, at the start of the 2000s is highly significant and marked the high point of environmental tension in the country. The protests against the project were surprisingly intense and broad based for a country with little to no history of direct protest action, and included a coalition of local and international environmental activists that leveraged considerable media attention.

The proposed landscape alterations were enormous. Two large glacial rivers from Vatnajökull, Europe's largest glacier, would be rerouted through seventy-three kilometres of tunnels and nine dams creating several reservoirs delivering 690 mega watts of power.[71] The environmental concerns were equally large; the alteration of entire river ecosystems, including the untold effects on important river fish stocks, and the habitat destruction of many important migrating bird species, the flooding of historic geological sites, elevated soil erosion in an already soil sensitive area, and carbon and sulphur dioxide emissions.

While the National Planning Agency issued a negative judgement for the project in its environmental impact assessment on the grounds of 'substantial, and irreversible negative environmental damage,' the then Minister of the Environment dismissed the judgement and issued the planning license nonetheless. This prompted a series of lawsuits and ignited heated debates around the country about the uses and abuses of political power.[72]

Though most of the focus in the early stages was on the environmental and social problems associated with the project, economic concerns came to the fore as the project developed.[73] In more recent times, the broader argument has pivoted around the energy industry's claim that long-term energy contracts with aluminium secure investment and jobs, while providing a world-class energy infrastructure. Environmentalists, to the contrary, argue that such agreements are narrowly conceived economic devices. Not only are they hugely destructive in terms of landscape transformations, they do not take account of a range of other costs, what they refer to as "cost externalities," that come with the damming of rivers. For many

[71] The main dam is the highest rockfill dam in Europe, 190 metres high, 800 metres long and 600 metres wide at its base. It has created a huge reservoir, Hálslón, which flooded a wilderness area of 57 sq. km. 70 km of tunnels will carry water to an underground powerhouse, which will have a 690 megawatts capacity, see http://www.savingiceland.org/2004/08/karahnjukar-by-robert-jackson/.

[72] See,https://www.theguardian.com/environment/2003/nov/29/weekendmagazine.conservationandendangeredspecies

[73] While the project was sold as a regional development initiative, particularly as regards the benefits it would have for the small fishing village of Reyðarfjörður in the east of Iceland, most of the workers were migrants from Eastern Europe and China. The Icelandic press is filled with stories of the scandalous maltreatment of these workers by the Italian contracting company Impregilo.

Icelanders these rivers are *priceless,* and the untold damage being wrought upon them for limited economic benefit cannot be justified.

What is at the heart of these economic claims is the price of energy. The recently appointed CEO of the state owned National Power Company, Landsvirkjun, has stated several times that the pricing structure of the deal with Alcoa is far too low.[74] In the original aluminium deal with Alusuisse, price was a crucial factor as an inexperienced government negotiated with a giant multinational. In fact according to several reports the price was far below estimates that would allow the state to break even (Kirchner 1988: 72).[75] After the deal was renegotiated ten years later, the government of the day agreed to a pricing formula that linked part of the electricity price to aluminium market prices. The effect of such an agreement was to relocate the risk in the international metals market away from the large multinational and into the lap of a very small state. This became standard practice in all future aluminium deals, and one that the CEO of Landsvirkjun laments. Linking part of the energy price to the market price of aluminium on the London Metals Exchange means that the price fluctuates, sometime wildly.[76] In the several years following the opening of the Alcoa smelters aluminium prices were at a historic low, and Landsvirkjun struggled to break even.[77]

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[74] See http://www.savingiceland.org/2011/12/time-has-told-the-karahnjukar-dams-disastrous-economical-and-environmental-impacts/

[75] Padel and Das argue that it is not possible for aluminium smelting to make a profit without large subsidies, which come by way of cheap energy deals. The story of aluminium is littered with cases of energy deals with governments from Canada, to Africa, to South America, and India. The lack of support for such subsidies is one reason why the smelting industry has all but vanished from Europe (with the clear exceptions of Iceland and Norway)(Padel and Das 2010: 298-300).

[76] The price of aluminium is notorious for its fluctuations. Given its connection to the defence industry, it is particularly sensitive to military interventions. Demand from China also disproportionately affects the market. There is also a lot of evidence of price manipulation through cartel practices. Padel and Das list a history of such practices from the start of the twentieth century forward. Joseph Stieglitz, Nobel laureate in economics, is on record as saying that Alcoa CEO Paul O'Neill (who was later to become Treasury Secretary under George W Bush) was central to the formation of a cartel structure in the 1990s. O'Neill is not the only Alcoa CEO to go on to become Treasury Secretary. Andrew Mellon held the position from 1921 until he resigned under impeachment in 1932. Part of the list of charges included an accusation that he continued to control the interests of Alcoa while Treasury Secretary (Padel and Das 2010: 308-315).

[77] According to a report commissioned by the Ministry of Finance, total profitability on power supply to aluminium has been on average 5% since 1990. This is far below average industry profitability, and much lower than the profitability of similar industries in Iceland's neighbouring countries. See http://www.savingiceland.org/2011/12/time-has-told-the-karahnjukar-dams-disastrous-economical-and-environmental-impacts/

While a lot of industry literature renders Iceland as having a 'natural advantage' for power-intensive industries, price, it seems, is not part of such 'naturalness.'[78] In fact, the price of electricity has become such a sensitive issue in energy deals with the aluminum industry that they are not publicly disclosed. The contracting parties find cover in the explanation of "commercial sensitivity." While contractually confidential, price has become somewhat of an open secret, as industry analysts continue to make confident statements about pricing structures.[79]

Converting the "power of nature," as many of my friends put it, into power for aluminium is a contentious issue in Iceland, but doing it on the cheap is even more so. But this is not new. The commodification of 'nature' has been extensively catalogued. But I will return to this issue in more detail in Chapter Three. If price emerges as a central feature of Icelandic energy deals then it is a concern that traverses and links multiple issues together, in particular capital, landscapes and politics. But this is not just the case for hydropower–as we shall see price is also central to geothermal.

2.5: Energy, Capital and Aluminium – A Second Moment

As a concept, capital covers swathes of spatially and temporally distributed processes, operations and activities. Getting a grip on it is difficult and requires a particular form of ethnographic purchase. Oftentimes projected as a singular logic, structure, or trajectory, capital can appear–or is articulated as being–a totalizing and coherent force. So the standard argument from mainstream neo-classical economics goes, along with its broad church of followers.

[78] In a list of such 'natural' advantages price does not appear. The list includes, 'a modern society with well developed infrastructure, political and economic stability ('Scandinavian'), strategic market location between North America and Europe, EEA membership giving tariff-free access to the European market, supportive government policy, efficient environmental regulatory system, low corporate income tax (18%) and an absence of corruption in business and politics (OECD)' (Hilmarsson, 2003: 3).

[79] The power companies disclose average electricity prices only. Energy analysts use return on investment numbers from the power companies to gauge an approximate price. The 2014 price of electricity to aluminium is estimated to be between \$25 to \$28 dollars per mega watt-hour. Equivalent prices for aluminium smelters in Africa were 30% higher and 45% higher in the US and Europe. See https://askjaenergy.com/page/2/?s=landsvirkjun.

Critiques of capital on the other hand have a tendency to focus on deconstruction. By suggesting an analysis of capital as a form of misrepresentation, a revelatory moment is uncovered, one that, while interesting, is nonetheless limited in telling us about the ways in which capital does not work as its proponents suggest. In focusing on a structural critique these authors (Harvey 1990, Jameson 1991, Harvey 2014, Moore 2015) risk 'conflating the interests and the actions of capital' (Bear, Ho et al. 2015).

I would like to follow what could be thought of as a more performative route, one advocated in a recent manifesto by Laura Bear, Karen Ho and Anna Tsing (ibid: 2015).[80] In this manifesto, the authors, while acknowledging the powerful effects and inequalities produced by capital, also emphasise its generativity, that is, as a force that is both generative and generated.

Tracing the ways in which capital is made, and that which is made from it, the authors argue, demonstrates both the heterogeneity of the processes that are ascribed to capital while at the same time recognizing the powerful performative effects that it has as something that appears to be totalizing and coherent. As clearly argued by Hannah Appel, 'rather than only a (mis)representation to be deconstructed, capital is a constant construction project to be traced through research' (2015).

It is in this spirit that I have begun to trace capital and its effects in and through Icelandic landscapes by suggesting a *first moment of capital* during the 1960s. What we saw here was how energy deals transformed parts of the political and judicial apparatus in order to make the glacial landscapes into a valuable proposition for capital, a proposition to which aluminium, in particular, was drawn.

At the same time, capital began to transform the glacial landscape through damming for power production, creating a series of political problems around the apparent benefits of aluminium. Energy price, and its secrecy, is the particular political issue that has since sparked people's attention. These relationships between

[80] The manifesto is titled, 'Gens: A Feminist Manifesto for the Study of Capitalism' published in Generating Capitalism, part of Cultural anthropology's new writing forum, Theorizing the Contemporary.

energy, capital, aluminium and politics are very much present in the turn to geothermal, and price, again, plays a central role.

2.5.1: Viking Ventures with Capital

Iceland's change in economic circumstances was rapid, moving from one of Europe's poorest countries to one of its richest in a matter of a few decades (Jónsson and Sæmundsson 2015: 26). While early metals capital constitutes what I am calling the first moment of capital in Iceland, eighteen years of consecutive conservative rule secured the next.[81] Iceland underwent a series of aggressive neoliberal reforms during the 1980s and 1990s that structurally transformed the economy. The rhetoric of the liberating powers of capital was central to policy changes such as deregulation and private ownership, which became the calling card of successive governments (Durrenberger and Pálsson 2015).

The hydropower energy deal with Alcoa in the early 2000s came with a $US1.25 billion dollar investment in aluminium smelters, and a $US3 billion dollar investment by Landsvirkjun in the Kárahnjúkar hydroelectric power plant. Such capital infusions increased already high interest rates and strengthened the already overvalued krona. But these developments were preceded by important changes in the fishing and banking sectors.

The introduction of a fisheries quota system in the 1980s after the collapse of the cod stock, while initially signalling an ecological response to disappearing fish, soon had the effect of privatising the fish stocks in the hands of a small group of large fishing companies. While quota numbers continued to fall, quota values continued to rise as the selling, renting and mortgaging of quota became common practice, ensuring the inexorable rise of virtual fish (Maguire 2015). Capitalising the fishing quota as a means of extracting value out of the sea and transferring it into the general economy was considered an act of liberal genius by some, an act of seafaring treachery by many others.

[81] Such a separation is of course arbitrary and while it would be possible to argue for a continuum over a separation, I want to hold onto the idea of moments of capital to qualitatively distinguish between a pre and post neoliberal era that my Icelandic friends constantly talked about.

In a paper written just several months before the financial crisis in 2008, Ragnar Arnason, a prominent and influential fisheries economist, argued that the ability to use the fishing quota to raise financial capital created up to $US5 billion dollars in wealth 'where none existed before' (Arnason 2008: 37). Moreover, he made a direct correlation between the creation of this wealth, or 'living capital' as he referred to it (ibid : 36), and the growth of the Icelandic economy during the economic boom years.[82]

Changes in the banking sector were also crucial to the availability of capital. The banks had been under the control of the two dominant political parties for many years and were widely seen as a patronage system through which capital was distributed to political allies, within either the fishing or the farming sectors. The economy had been developed into a comprehensive, yet more or less closed, system driven largely by political governance in which market forces had a marginal role (Jónsson and Sæmundsson 2015: 28).

The privatisation of the banks between 1998 and 2003 followed on from Iceland's entry to the EEA and the adoption of GATT.[83] These newly emergent banks rapidly internationalised the economy as vast amounts of capital flowed through the country, primarily through debt financing strategies that leveraged bank debt to a ratio of almost ten times Gross Domestic Product (Boyes 2009, Jónsson 2009).

Tales of the *Útrásarvíkingar*, variably translated as Venture or Business Vikings, emerged alongside capitally infused endeavours; a trope that lauded the risk taking practices of investment bankers as bold and courageous. Valorised as wild, yet serious figures of a newly emerging era of globalised capital, these (for the most part) young men were rendered as national icons reminiscent of saga heroes from the pre-colonial era of Nordic glory.[84]

[82] While he does acknowledge the contribution of capital inflows from aluminium, he gives it a secondary role to fishing quota. Using the indebtedness of the fishing industry, which doubled from 1997 to 2007, as a metric for how much funds flowed from fishing to other industry sectors, his clear inference is that the quota significantly contributed to the take-off of the economy as a whole.
[83] The European Economic Area and the General Agreement on Tariffs and Trade.
[84] The rector of Reykjavík University suggested that the historic 'battle with the forces of nature, weather, storms, volcanic eruptions, and isolation had fashioned individuals determined to survive whatever occurred'; this was reflected, she argued 'in the life of Icelanders through difficult times as well as now in the outvading turn of Icelandic companies' (Durrenberger and Pálsson 2015: xxii).

As a small cohort continued to buy up companies around the globe, Iceland was engulfed in the activities of the financial markets. Capital had next to magical effects on the everyday as banks arranged for Icelanders to circumvent inordinately high national interest rates by brokering low interest foreign currency loans.[85] As banks aggressively marketed such loans,[86] consumer spending exploded as large SUV's and shopping trips to Europe became de rigueur. Property prices, as well as pension funds, soared, as Iceland became a momentary resting place for vast quantities of globally circulating capital.

From 2001 to 2007 the value of the Icelandic Stock Exchange rose, on average, by a stunning 44% per year (Durrenberger and Pálsson 2015: xvii). However, in the wake of the global liquidity crisis sparked by the collapse of Lehmann Brothers, the Icelandic krona crashed and the three main banks declared bankruptcy in October 2008.[87] Only a loan from the International Monetary Fund was enough to stave off national bankruptcy.

As an import based economy, the devaluation of the currency–43% against the dollar–hit hard as many products soared in price. In addition, many Icelanders were left trying to service foreign currency loans in a next to worthless krona. Recession hit, unemployment drastically increased, as did migration. An all too common pattern of austerity marked all sections of society, disproportionately affecting the weaker members (Rice 2015). The pace of change, from zenith to nadir was stunning as parliamentary enquiries were set up and some of the bankers jailed (Árnason 2015).

The economic miracle, as it was called at the time, was predicated upon capital entering into the lives of Icelanders at an unprecedented scale and speed. The sheer exuberance for the 'Manic Millennium years' (Wolfgang 2015: 33) was not

[85] A long economic history lies behind these high national interest rates. But as mentioned a little earlier, one part of this story is the vicissitudes of the fishing economy that led to frequent currency devaluations to compensate for low catch years. The effects of which was a circular relationship between higher inflation and higher interest rates to counter inflationary effects. A rapidly growing economy did nothing to alleviate these high rates, at times up to 18%. Borrowing in a foreign currency offered a way out of this loop.

[86] Friends tell stories of being repeatedly called by the banks pushing various financial products. One friend from the Westfjords told me of a death in the family that left him with a small inheritance. He recounts how he received a call from the bank asking him to convert the money to an account in Swiss francs not two days after he had received the inheritance.

[87] The banks were Landsbanki, Kaupthing and Glitnir.

to be enough to mark a permanent turning point in Icelandic history. This second moment of capital is laced with stories of aggressive growth and expansion. The prefix *útrás* of *Útrásarvíkingar* means just that, *outward expansion*. But continual expansion required ever-greater sums of capital, as activities at both home and abroad were capitally intensified. Lauded, above all, was the value of speed; being the best meant being the fastest, as acting quickly in volatile and information intense markets became almost virtuous. A marketing video for Kaupthing, one of the three main banks, hones in on this speed in one of their pre-crash promotional videos '*What is Kaupthinking*' (Wolfgang 2015: 39).

While determining how widely shared these ideas were is hard to pin down, the sheer breath of infiltration of *Kaupthinking* - Kaup is the infinitive of the verb to buy - across the country is quite evident. Not just in consumer spending and property speculation, as mentioned above, but through municipalities across the country, as they too borrowed on the international markets in the realization of long standing infrastructural dreams, as community swimming pools, school buildings, and libraries sprung up one after another in remote locations around the country. Orkuveita Reykjavíkur, Reykjavík's primary municipal services company, was no exception to these borrowing trends.

2.5.2: Orkuveita, Debt and Volcanic Landscapes

The view from the sixth floor of Orkuveita Reykjavíkur's geologically inspired head office is impressive, as snow stretches towards the horizon, stencilling out the boundaries between the tectonic landscape and the city. To the east lies the Hellisheiði geothermal power plant in the Hengill volcanic zone, its operations made visible through the wafting emissions of condensate steam rising high into the atmosphere. To the west and north lies Reykjavík; a cityscape littered with small sleek silver hut-like objects, architecturally recognizable as low temperature geothermal wells.

Erikur, the CEO, points towards these many small wells that pump hot water to the city's residents and talks about the history and importance of geothermal energy to Reykjavík in particular, and to Iceland more generally. He recalls the company's early mission at the start of the twentieth century; to provide clean drinking water to the rat infested homes of the tiny town of Reykjavík.

Much has changed since these times, but particularly since the start of the 2000s. As Orkuveita eagerly joined the capital fray it morphed from a basic utilities company (hot and cold water, residential electricity and sewerage) into a multi-purpose company with a broad portfolio of activities, of which provisioning aluminium was one. A leading exposé article in the Reykjavik Grapevine puts it like this:

> Overrun by Viking ambition, Orkuveita Reykjavíkur built luxurious headquarters, expanded ambitiously, dabbled in tiger prawn farming and flax seed production, went into the fibre optics business, invested in a new geothermal plant, speculated in places like Djibouti, and finally managed to run itself so completely into the ground that foreign investors will no longer offer the company loans.[88]
>
> With thousands of lifetime subscribers and a means of producing energy at very little cost, the company had all the makings of a cash cow. So what happened to Orkuveita Reykjavíkur, an entity that less than a decade ago was a perfectly viable, municipally owned company providing the city with basic utilities: cold water, hot water and electricity?[89]

In the space of ten years, the debt of the company rose to $US2 billion, nearly four times the city's annual budget, with $US1.7 billion denominated in foreign currency loans. This leveraged the debt profile of the company to almost one thousand percent of its 1990s level.

The city of Reykjavík was called upon to rescue its multi-utility service company from bankruptcy in 2010. Not only did it stop receiving its annual dividend

[88] Orkuveita is 94% owned by the city of Reykjavik, and as such its board is comprised of several city councillors, including the mayor. During the 2000s the majority of executive power was ceded to the senior management team who set up a subsidiary company to run its African operations. After it was publically revealed that the management team had shares in the subsidiary, despite it being a wholly owned subsidiary of a municipal company, an investigation ensued that led to the toppling of the city council on two separate occasions.

[89] See http://grapevine.is/mag/mag-featured/2011/07/15/reykjavik-energy-in-deep-water/

payment from the company, an essential supply of revenue for the city over the past decades, it also had to front up a rescue package. A 12 billion ISK ($US105 million) loan, which is nearly its entire reserve fund set aside for the company, was made in 2012, with the same amount provided again in 2014. While this is only a small part of the company's massive foreign debt, it was a huge commitment from a crisis struck city.

Erikur, a geologist, was appointed CEO in 2010 after the near collapse of the company. His main responsibility, he tells me, was to cut the debt and guide the company back towards a more basic utilities operation. The list of changes that have been initiated since he started is long: de-leveraging through the selling of all non-core assets, restructuring both the company's debt and the organisational form, and a massive cost cutting program, including many staff layoffs.

After talking about the crisis and the ensuing changes at the company, Erikur refocuses my attention back towards the speckled geothermal huts that litter the Reykjavík cityscape and particularly towards what he considers to be one of Iceland's greatest achievements - the supply of cheap and replenishable hot water to residents and businesses throughout the greater Reykjavík area.[90]

As Erikur tells me this story, the Hengill volcanic zone emerges, surprisingly for me, as a central actor in the provision of hot water from shallow wells in and around Reykjavík. The heat that emanates from the ground throughout the Reykjavík area is remnant heat of an older volcanic system, heat that has cooled down to present temperatures over huge timespans.

Around 2.5 million years ago, Erikur explains, the volcano now submerged in the bay at Reykjavík was situated at the Hengill volcanic zone, the present location of Hellisheiði, some 25 kilometres southeast. Rifting tectonic plates in this area have pushed apart at an average rate of 1cm per year, and as such the land has moved like a conveyor belt in both northwesterly and southeasterly directions.

As the plates spread, the land, volcanoes included, has been slowly transported to its current position, although disconnected from its originary volcanic heat source deep in the mantle. What once was an eruptive volcano at Hengill, has

[90] The greater Reykjavík area is home to75% of the country's residents.

now become a cooled down matrix of rock, and it is the remnant heat emanating from this cooling rock that gave licence to the city's legendary first denizen, Ingólfur Arnarson, to name it smoky bay (Reykjavík). Today, the temperatures are still warm enough to provide hot water, or low temperature geothermal heating, to the city's current residents.

The 1920s brought the first successful attempts to supply geothermal hot water to the residents of Reykjavík, a tectonic intervention that enabled the development of a thriving metropolis on the outer rim of the subarctic. While preliminarily used for domestic purposes, in particular washing and cooking, it was in the 1930s that it began to be developed as an alternate heating system to coal.

During the 1960s geothermal water became the central component of Reykjavík's heating system, spreading across the country in the 1970s as the global oil crisis catalysed the government of the day to fully develop this potentially rich indigenous energy source. Today, geothermal sub-stations draw and pump water from many shallow sub-surface springs, up to 80 degrees hot.

As I mentioned a little earlier, this story of hot water for heating has become a much valorised one at geothermal conferences and conventions the world over as Iceland is held up as a leading example of the sustainable use of indigenous energy resources.[91] Today, 93% of all Icelandic heating needs are satisfied by geothermal hot water as it provides energy across the country for residential and business heating, fish farming and processing, greenhouse production, swimming pools, winter pavement de-icing, and a host of other ancillary uses.

One way of putting this is to say that the tectonic landscape is being used in a particular way in order to produce replenishable, and cheap, hot water. In more analytical language, one could say that the liveliness of Hengill has been arranged in a specific way so that one configuration of tectonic relations (hot water for heating) has emerged and stabilised over the course of the last several decades. Arrangements of tectonic liveliness have been mobilised in the service of particular arrangements of living, as humans, volcanic rock, heat, and water form lively, thriving coalitions at subarctic latitudes.

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[91] This is based on reading geothermal conference papers from multiple conferences over the last 20 years.

2.5.3: Intensive Capital for Power-Intensive Industries

But what I want to emphasise is the specific role that capital has played in these arrangements. To do so, let me now turn to my discussions with Grimur, managing director of reservoir engineering at Orkuveita during the development of Hellisheiði. In a long conversation one winter afternoon in 2014, Grimur talks to me about the importance of geothermal hot water in Iceland. In some ways I feel as if I have had this conversation several times before, although Grimur's words are now putting a specific type of linguistic flesh on the bones of my numerous embodied encounters with hot water in Iceland.

Being around and within this earthy water requires a sensory adjustment, that's for sure, as the pungent sulphuric smell and the burning heat of this silica rich, silky-to-the-touch water washed my body, cleaned my dishes, and warmed my Reykjavík apartment when I lived there for five months.

Almost daily trips to my local swimming pool in central Reykjavík, where residents of the area bathe and chat in the 40 plus-degree outdoor hot tubs, tunes me in to the sheer joy and pleasure of being soaked in a blissful heat, albeit it a little scalding at times. At first I find the long bouts of silence between chatting a little discomfiting as I search for stories and topics of interest. They come, but slowly, especially when people in the hot tubs sense my foreignness, but again I get stories similar to those I have heard before; tectonic displacements, smoky bay, rat infestations. But then they talk about heat coming to Reykjavík. Not the heat from burning peat or coal, intermittent, unstable and dirty, but the consistent reliable, easy heat from geothermal hot water.

But now it's quite ordinary, and that's a good thing they tell me. This ordinary heat allows for such post-work evening gatherings, as heads bob momentarily under the water to counter the ice forming on our hair, while sounds of contentedness emanate from people around me. I begin to enjoy the spaces of silence more over time, learning to partake in this 'silent contract' as hot water bathing counters the long dark cold winter months. In a place such as this, hot water is ordinary in extraordinary ways.

Grimur points towards the possible reasons why geothermal hot water has stabilised and been such a success story in Iceland. And it has a lot to do with how capital is arranged in relation to geology and politics.

> Heating is based on a municipal model. No matter what the temperature, whether 2 degrees or minus 20 degrees, we have a setup whereby the towns always have a plentiful supply of heating at a cheap cost. In this way heating stabilises unstable towns. So this is its politics, the town pays off the debt and the people, as the owner of the resource, get the profits. Well, they are distributed to the citizens by way of cheap energy bills (2 cents per kilowatt-hour). This is what made geothermal hot water spread so rapidly throughout Iceland. But today it's all about power [electricity production], and the same approach just doesn't work.[92]

Grimur brings many interesting points to the fore in this small but powerfully concise statement about geothermal hot water. Firstly, he highlights the question of liveability. Many people I spoke to in Iceland liked to repeat this point in one sense or another, underlining in no uncertain terms that it has not been easy to stabilise liveable relations in a place far north at the interface of multiple climactic and geological phenomena. Hot water is articulated as central to this.

Grimur makes connections between how capital is arranged in relation to the town, that is, how municipal politics and capital make liveability through a particular way of extracting shallow subterranean water. At this extraction rate, replenishment occurs over the course of a town's lifetime. As such residents can take advantage of cheap energy over multiple generations. The history of bio-chemical tectonic processes that have slowly transplanted older parts of Hengill to Reykjavík, enable rock, heat, and water to transform and change as they are enfolded within particular arrangements of capital and politics. Liveable spaces emerge that enable small townships to stabilise and, at times, thrive.

[92] The energy industry refers to electricity as power production.

This is the sense I have of what Grimur is telling me when he talks of freezing temperatures, energy prices and municipal politics, and what I read from my own experiences of being sensorially attuned to geothermal water: the ways in which hot water makes a difference. Not a minor difference, but the difference between townships being able to survive, or stabilise as Grimur puts it, or not. This is how liveability emerges, not as mythic stories of men and women battling the subarctic world though hardy constitutions, but through modes of arranging relations through rock, water, heat, capital and politics; arrangements that operate and stabilise at specific thresholds.

Secondly, Grimur suggests that arranging geothermal to configure hot water is just not the same as arranging it to configure steam. As we learned in the introduction, steam production requires deep drilling practices that are designed to accelerate the landscape. This acceleration is also a process of accumulation, of both steam and capital. Given that electricity sells for fives times more than hot water, the switch to power is very much about extracting as much value from the landscape as possible; as capital is converted to steam, the value of steam is converted back to capital.

But as Grimur puts it, hot water and steam just don't work the same way. While hot water production requires capital, it is capital of a different order. Low temperature geothermal can get by with what might be called low intensity capital, capital that small municipalities have borrowed from state funded Icelandic banks in local currency. This is an arrangement whereby the accumulated benefits of extraction are distributed back to residents over generations; more or less stable configurations of capital, geology and politics result. But electricity supplied to the power-intensive industries requires highly intensive capital. Yet this type of capital comes with a series of instabilities that actors do their best to minimise. Let me develop this point a little.

The EU deregulation of electricity markets, and hence the removal of Landsvirkjun's monopoly on the supply of electricity to the power-intensive industry, created an opening that geothermal advocates had been long awaiting.[93] Given that

[93] Although not a member of the EU, Iceland is a member of the European Economic Area (EEA) and is bound to follow EU industry directives (with the exception of fisheries).

Icelandic hydropower was still recovering from the "mess" of Kárahnjúkar as many in the energy industry referred to it, the timing for Orkuveita to enter the power-intensive market was opportune. Orkuveita signed a power purchase agreement with Century Aluminium to supply their second aluminium smelting pot line, producing 110,000 tons of aluminium in Grundartangi in the west of Iceland.[94]
Adopting the same strategy as Alcoa, Century Aluminium pushed to link a part of the energy price to the price of aluminium on the London Metals Exchange. I took this issue up with Ragnar, the company's Icelandic CEO in a long interview in 2014. Ragnar was the chief financial officer for ten years before becoming CEO in 2007. As one would expect he is smart, reasonable and accomplished at giving interviews. Ragnar tells me that building aluminium smelters is very capital-intensive, and as such investors are very much focused on how to minimise risk, especially in the opening years of any new project.[95] Stability is their watchword.

Given the volatility in aluminium price markets, investors had begun to insist upon price linking agreements with power companies, in fact, Ragnar says that without them the likelihood of a deal is very low. One way to guarantee price stability, and hence minimise the risk of falling profit margins, is by offloading the pricing risk in the market to the power supplier.

If energy prices track aluminium prices, then energy becomes a variable cost for the aluminium company, stabilising their profit margins as a percentage of their highest cost component. Whether aluminium prices go up or down, the percentage paid in energy costs remains constant. It is this price stability that the investors require to commit such intensive amounts of money.

In years of low aluminium prices Orkuveita earn a lot less, that is, they take market metal price instability upon themselves. Ragnar explained that aluminium

[94] Columbia Ventures developed the first pot line smelters at Grundartangi in 1998 with an opening capacity of 60,000 tons of aluminium, followed by another 90,000 tons. The plant was sold to Century Aluminium in 2004; just after the power agreement had been signed for the second pot line smelters. Orkuveita supply 52% of the energy needs, with Landsvirkjun supplying 33% and HS Orka 15%.

[95] When I asked Ragnar what being capital-intensive means, he answered by saying that both aluminium smelters, as well as power providers, need not only very large quantities of capital, they also need the vast majority of it up front in order to get all the production facilities up and running. Under this type of setup there is no way to make any revenues until almost all of the capital has been invested. This creates a higher risk profile as any setup problems can jeopardise the entire investment. Investors want to minimise this risk in whatever way they can.

prices tend to drop when the global economy is performing badly, but interest rates tend to drop at the same time. He suggested that this correlation is a natural hedge for Orkuveita. Given that they are also so capital-intensive, Orkuveita are sensitive to any change in interest rates, with even small movements being potentially significant for them, significant enough to make up for the drop in revenue associated with falling aluminium price, Ragnar suggests.[96]

Capital intensity, it seems, has some interesting globally interconnected feedbacks. As the aluminium industry seeks to stabilise their fluctuating prices, and the Icelandic state seek to stabilise their economy through aluminium, the power company ends up taking on the instabilities arising from intensive capital. But pushing these price instabilities into the volcanic landscape has serious geological consequences.

Let me return to Grimur again, managing director of reservoir engineering at Orkuveita during the development of Hellisheiði. While the move from producing hot water for heating to producing steam for electricity was talked about as a technical point, he reminded me that in fact making steam in volcanic landscapes is a whole different story:

> To get steam to make power is different to getting water. With water you don't have to do too much work to get it, but steam, that's a whole different story. I always say that in aiming for steam we are trying to get the landscape to serve power, rather than how it should be, getting power to serve the landscape.

That different story, as Grimur points out, is in large part one of landscapes. Switching to high temperature production requires moving back towards the intense heat sources of Hengill and drilling dozens of 3-kilometre wells into the seismic landscape in an effort to get access to super hot fluids that circulate at such

[96] When I suggested that such a feedback benefit is also available to the aluminium company, Ragnar replied by saying that while this is true, it compensates them for the years in which aluminium prices rise. He suggested that they 'pay more to the power companies' during these periods. While this may be true in an absolute dollar sense, that is, as aluminium prices increase, electricity prices increase proportionally, it does not mean that the aluminium company make considerably less money. Their profit margin remains stable as a percentage of energy costs.

depths.[97] It means arranging the relationships between the landscape, power, and capital in a more intensive fashion.

The contrast can therefore be drawn in this way: arranging landscapes to configure water, as has been done for many decades, renders these landscapes more valuable than what they can produce. But arranging them to configure steam inverts this value relationship, making landscapes subsidiary to power production.

2.5.4: The Politics of Price

My discussion with Grimur on this day is long and fruitful. He continues on:

> But just like in oil and gas, coal you name it, geothermal is mining, a type of heat mining. But remember with power, the commodity (energy) price is always the decision maker. Those big aluminium smelters, they only locate wherever the energy is cheapest, so we had to compete with the cheapest coal and natural gas, and the only way to do that was through cheap prices. We end up only getting about 3 to 4 cents (per kilowatt hour).
>
> But everything about power here in this country is political; power is a political story. The business model of high temperature geothermal is run on 100% debt, but it's the debt of Reykjavík. The financing was guaranteed by the city, and that gives a much lower capex (cost of capital). In that way we could borrow much cheaper from the European investment bank and other Nordic banks. In a normal power company, you would have to sell for 8 cents (per kilowatt hour), but we could cut it right down and that's what got aluminium here. We end up only getting about 3 to 4 cents (per kilowatt hour). Selling power at the lowest possible price through politics.

What Grimur brings out here is the centrality of energy pricing. I drew attention to this earlier in my discussion of Century Aluminium's pricing arrangements with

[97] I say moving back towards the intense heat of Hengill area as a way to contrast with the idea that the shallow low temperature heat emanating from Reykjavík today was at one point a part of Hengill. While rock has moved through its cycles, emerging from the mantle at huge depths and then slowly shifting with the rifting plates towards the west of Iceland, humans are now following that trajectory in the reverse direction. They are now moving back towards the east in order to make steam, where intense heat is located at great depths in Hengill.

Orkuveita. Here, I would like to flesh it out in more detail. For Grimur, price is crucial. It is what can lure aluminium companies to Iceland, being the bottom line component in any energy deal. At a given price model of 3 to 4 cents per kilowatt-hour, there is very little room for manoeuvre. Price, he suggests, is the decision maker. While I examine the geological consequences of price in the next chapter, for the remaining part of this chapter I want to focus on the politics of price.

What we learned earlier from Ragnar of Century Aluminium, Grimur affirms from Orkuveita's perspective. The aluminium industry consolidates its position in the power market by aggressively focusing on price. In competing with other energy sources, price is everything. Grimur argues that 3-4 cents per kilowatt-hour is a political price, it is, as he puts it "selling power through politics." In saying that the price is political, Grimur is not only referring to the processes by which the board of Orkuveita, as a municipal entity, made "political" decisions about how best to do a deal with Century Aluminium. He is also indicating that this price is composed politically; it has a political layer. But what does this imply?

As we learned a little earlier, Orkuveita went on a buying spree raised through debt capital. These acquisitions consisted of buying up many other heating companies throughout the country, as they extended their services into more than twenty other municipalities. At the same time, they invested in a long list of companies not connected to their core services (flax seed, tiger prawns and so forth). But according to Orkuveita's former Chief Financial Officer (CFO) the bulk of Orkuveita's debt is related to the development of the power plant at Hellisheiði.[98]

A large portion of that Hellisheiði debt was foreign currency capital raised through the European investment bank and other Nordic investment banks. Applying a model similar to that of municipal heating (hot water), Orkuveita leveraged cheap debt by virtue of its ownership structure, that is, as a municipal entity owned by the citizens of Reykjavík. As such, these financial institutions were willing to lend capital a lot cheaper as it was guaranteed, not by an enterprise, but by a city. So a cheaper cost of capital, another way of saying cheaper interest rates, eventually finds its way

[98] For example, each geothermal well costs circa $US3 million dollars to dig (57 wells have been drilled to date), while each turbine cost over $US40 million dollars (of which there are 8).

into the energy prices between Orkuveita and Century Aluminium.[99] Less debt on their loans to financial institutions is translated not into a benefit for the city of Reykjavik (as owner of Orkuveita), i.e., more municipal services such as schools and hospitals, but is passed onto the aluminium company via cheaper energy prices. At the same time the instabilities embedded within foreign currency prices were retained by Orkuveita, and as we have seen this currency risk was actualized to very serious effects. With 85% of its debt in foreign currency, the huge devaluation that followed the crash in 2008 almost doubled the company's loans overnight.

So while the benefits of the debt structure were passed onto the aluminium company, the city of Reykjavík retained the risks.[100] Not only were the instabilities in the global metals market prices taken on by Orkuveita; they also shouldered the pricing instabilities in currency markets. Another way of saying this is that dealing with power-intensive industries requires intensive capital, and that while these intensities bring with them their own sets of instabilities, such instabilities are not distributed evenly. In this particular municipal instance, the city of Reykjavík became the mediator between the financial markets and the aluminium company.

This price, though politically composed, is contractually confidential, a practice that has become common in Iceland. I raised this apparent 'secrecy' issue in interviews with both the CEOs of Century Aluminium and Orkuveita. Both men clearly said that the need for "confidentiality" as they put it, was a requirement of the other party. So while the city of Reykjavík is an important component in leveraging a cheaper price, it is not privy to its value given the commercially sensitivity of the contracts. What we see here is an erasure of politics out of the price as the basis upon which sensitive commercial transactions can occur.

Jane Guyer (2004, 2009) argues that anthropological theories of price have always run counter to standard neo-classical definitions, which suggest that price is a singular value that arises at the intersection of supply and demand. For her,

[99] In my discussions with Jakob, he further explained to me that the link between energy and aluminium market prices only constitutes part of the pricing structure of electricity (although he would not tell me what percentage). Another portion of the price is based upon what they call a cost plus model (the production cost of electricity plus a very small mark up). This implies that cheaper capex costs contribute to a cheaper cost structure, which in turn is passed onto the aluminium company.

[100] Perhaps this is another version of the all too common post crisis logic we saw applied to states on the brink of collapse; while profits are privatised, losses are socialised. Countries such as Ireland, Greece and Portugal spring to mind.

anthropological work has focused implicitly on price as a composite, mostly as a means of recognizing the various sociocultural components that price consists of; it is not just *a worth*, it is a layering of *composite worths*. The ‘concealment of composition’ as Guyer puts it, has been the main function of price ideologies that have helped to circumvent moral and political analysis of worth for many years. As such, she advocates ‘paying attention to elements of price that are hidden in plain sight’ (2009 :205). In this ethnographic instance, price is a composite, composed of both formal (contractual) and informal (city of Reykjavík) layers. The ‘concealment of composition,’ in Guyer’s terms, is effected, as the worth of the city becomes one element of price that is ‘hidden in plain sight.’

2.6: Conclusion

In Chapter One, I suggested that there are certain geo-capital practices in operation at Hengill that are beginning to accelerate parts of the volcanic landscape. While difficult to segregate these practices from one another in any strict manner, this chapter has been an effort to give a sense of the capital component of the hyphenated couplet.

I identified two *moments of capital* as being of particular significance in recent Icelandic history. As energy deals were made at these moments, landscapes were reconfigured as valuable propositions for capital. One way of generating value is through performances like the one we saw at the start of the chapter, through which the volcanic landscape is rendered as perpetually renewable; something all investors are attracted to. But as we have seen it also takes the city of Reykjavík, as the owners and funders of Orkuveita, to act in a certain way for these deals to work. As such the city is also performed as renewable, but in a different sense.

While the landscape perpetually generates power through the circulation of fluids, the city perpetually regenerates capital through the circulation of bodies (birth and death). Such *relational renewability*, that is, the performance of the relationship between the landscape and the city of Reykjavík as renewable, makes the earth at Hengill a valuable proposition for capital, a lure that investors, both Century Aluminium and the providers of debt capital, find hard to resist. As we saw, the city was called upon to fulfil its renewable role as it bailed out Orkuveita on the brink of bankruptcy.

But this performance only works though a series of elisions, which I have been working to bring back into the picture. While Century Aluminium is a critical presence in these landscapes, it does not appear at all in the performance of geothermal energy at the Visitors Centre in Hellisheiði.[101] At the same time, while the city of Reykjavík regenerates capital, its political presence is excised from the price as it is effectively 'hidden in plain sight'(2009 :205). But these excisions are far from totalising. Hengill is, as I will go on to demonstrate, too turbulent a place for a single story: both the city and the earth want their say.

What we also learned from these *two moments of capital* was that in an effort to move beyond the vicissitudes of both fish and foreign powers, the Icelandic state turned towards the landscape in the hope of converting topographic instability (melting glacial waters and volcanic landscapes) into sources of economic stability. This was facilitated by the aluminium industry. Paradoxically however, supplying electricity to power-intensive industry requires a type of intensive capital that comes with its own set of instabilities.

As the Icelandic state seeks to diversify and stabilise the economy and the aluminium industry seeks to stabilise their fluctuating prices, Orkuveita ends up taking on the instabilities arising from intensive capital. These instabilities were twofold, both the price risk in the metals market as well as the price risk in the currency market. But, as I will go on to show, these instabilities are converted into specific geological practices with particular effects. I now turn to these geological practices in much greater detail, as we begin to see how the effects of intensive capital mix with volcanic intensities at Hengill.

[101] While figure 8 (page 57) does indicate the presence of an electricity consumer it is only through a large smiley face at the end of the fluid circulation process.

Chapter3.
Accelerating the Rhythms of Hengill's Landscapes

3.1: Geological Dilemmas

Bjarni sounds disconsolate as we sit and drink coffee in Orkuveita's canteen one snowy December morning. He begins talking openly about the financial excesses of the years leading up to, and during, the construction of Hellisheiði.

> Well James, it would probably hurt too much to tell the whole story. The energy story in Iceland is analogous to the financial collapse; all of this buying of big cars, going on shopping trips abroad, all that stuff, we (Orkuveita) were also part of it. What people don't really understand is that it takes so much to make geothermal (for electricity); it takes scientists, engineers, drillers, plumbers, but also money, lots of investment to make things work.
>
> Extracting geothermal energy, well, it's like opening a very large coca cola bottle. We put big holes in the ground and the pressure differential will drive the fluid (water and steam) out. But geothermal is also like a living organism, it's an entity that's changing all the time, when you drill a well in one place, you affect the field elsewhere, but you don't know how, it's a constantly changing process.
>
> There are sets of relationships going on, everything is responding to something, one well can dry up and another can open up. But we have to do it slowly, and carefully, we have to give the landscape enough time to respond to us. But the excel tribe on the floor above us, they just kept talking about speeding things up, if we just speeded up production we could pay our debts down quicker, and maybe make a profit some day…. of course, people (the board) listened to that.

Bjarni is expressing multiple sentiments at the same time here. Frustration, yes, pain even, both borne of a certain reflective angst at the entanglement of capital and life in Iceland in the boom era. But he moves quickly back to his own field of expertise: geology, of the geothermal persuasion. A descriptive soul, Bjarni speaks of geothermal in relational terms. It is a complex endeavour, blending regimes of expertise, finance and sets of subterranean processes. But as geologists see it, the landscape needs time - time to respond to extractive interventions. But there is also a need for speed, which Bjarni figures through what he calls the "excel tribe." This bind that Bjarni articulates, both the need to give the earth time and the need for speed is central to how the geoscience group at Orkuveita think about and operate in the volcanic landscape at Hengill.

In this chapter, I want to use Bjarni's bind as a way to unfold the effects of capital in geological terms. While the last chapter gave a general sense of how the Icelandic economy was saturated in capital during the time Hellisheiði was under development, it also gave a more detailed account of the ways in which the instabilities of intensive capital were shifted onto Orkuveita through pricing arrangements.

This chapter will examine how these instabilities have been converted into the volcanic landscape, and the effects this has had on the rhythms in operation at Hengill. To make this argument, the focus will be on the terraforming activities of Orkuveita as they drill the landscape in search of *power spots* (zones where heat enthalpy is estimated to be the highest).[102] In particular, I will examine the geological practices that have been transforming Hengill from a powerful landscape to a landscape of power, as the volcanic zone becomes a nodal point in the global production of aluminium.

These extraction practices centre on the production of steam to meet the electricity needs of Century Aluminium. It is here Bjarni's bind is most acutely felt. Although geologists need to produce a geological form of acceleration in order to make steam, there are also other accelerations that arise from the demands of capital that impact upon how they carry out their work.

[102] Enthalpy, as used by geologists at Orkuveita, is the heat content per kilo of fluid.

Such impacts have generated a new geological practice: reinjection. But this practice triggers other forms of accelerations with disturbing knock on geophysical effects, namely volcanic cooling and "man-made" earthquakes. This chapter will focus on the former, conceptualising volcanic cooling in terms of volcanic rhythms. It will be the job of Chapter Five to examine the issue of "man-made" earthquakes in terms of seismic rhythms. To begin, let me give an ethnographic sense of the way steam producing accelerations are being generated at Hellisheiði.

3.2: Volcanic Accelerations - An Awakening

Well HE28 sits like a quivering bucket of rust atop the snow-laden lava encrusted earth (figure 9). Its pipes are thick and eroded, and they pulsate and screech as Bjarni and the geology team attempt to coax up 300-degree fluid. Compressed air at 60 bars is delivered down into the well in an attempt to pressurize the fluids and boil them up through the wellhead, or "awaken" the well as Bjarni puts it.

I try to speak but Bjarni instructs me to pull my ear mufflers down as the screeching noise intensifies. The entire arrangement of well, igloo and pipes shakes and roars, intermittently yet violently, as dense, thick steam billows out from the earth.

Being up here on the Hengill lava plains (figure 10) is visually striking; staggering even, as the volcanic landscape's power becomes increasingly palpable. The fiery tumultuous earth is right here, right beneath our feet as a three kilometre deep well mediates the relationship between the underground and the overground, encouraging the flow of super hot fluids (steam and water). I awkwardly shield my face as the well thunders and roars, knowing of course that this would be of little use to me in the event that something went wrong.

Bjarni disabuses me of any notion I may have had of an earth, a *singular entity, turning my attention instead to a whole series of differentiating forces at work as heat and pressure boil water and steam out of the subterranean rock matrix.*

He describes theses processes to me as one of fluids moving though subterranean fractures, pulsating and throbbing at varying temperatures under different pressures, as they find their way into the well and explode up to the surface, *through the wellhead and into the piping infrastructure for distribution to the electricity generating turbines.*[103]

Figure 9: Geologist at awakening of geothermal well HE28, Hellisheiði, Hengill.

As I learn on this day, it takes some effort to “awaken” a well as geologists attempt to trigger the first in a series of explosive events that can lead to a productive geothermal well.

The volcanic interventions taking place at Hellisheiði are an amalgam of the practices of geology, engineering and water management as they intersect with a highly active volcanic terrain. But Bjarni and his colleagues are primarily steam makers; one of their main jobs is to figure out how to get as much steam from the landscape as possible, and this requires arranging the volcanic zone to maximal acceleration effect. Let me try to develop these landscape practices a little over the coming sections.

As discussed in the introductory chapter, the entire process at Hellisheiði is driven by the supply of electricity to Century Aluminium through the operation of six

[103] A different version of this vignette also appeared in (Maguire and Winthereik 2017: 161).

turbines producing 303 megawatts of power (electricity) and 120 megawatts of hot water. Such a production system operates 24/7 and as a result needs to be constantly fed by the more than 35 wells in operation.[104]

In order to achieve this, the landscape is arranged in a way so as to produce vast quantities of steam by exploding fluids out of the subterranean and into the piping infrastructure for processing.[105] What we saw in the vignette above is the post drilling process of well activation. Accelerating and driving fluids upwards is the primary objective, and the success of the entire operation hinges on such accelerations.

Figure 10: Landscapes of Power, Hengill.

This explosive power, or "driving force," as geologists refer to it, is achieved by managing pressure differentials between subterranean water pressure and the pressure maintained in the piping infrastructure. Keeping up the pressure in the geothermal field is crucial.[106]

[104] While thirty five wells are in operation at any one time, over fifty seven have been drilled.

[105] The piping infrastructure is maintained at 7 bars of pressure and the differential between this and subterranean water pressure is this "driving force."

[106] The term 'geothermal reservoir' is commonly used in geothermal literature. However, it tends to generate an image of the subterranean as a large open expanse of water in which rocks are situated. I prefer to use the geoscience team's more common term ' geothermal field,' which stimulates an image

Bjarni, above, uses the wonderfully simple analogy of a coca cola bottle to describe these pressure relations: "put big holes in the ground and the pressure differential (driving force) will drive the fluid (water and steam) out." Such pressure relations contribute to this "driving force" but only as they relate to heat.

Magma intrusions into the crust are considered to be the most likely heat source in the volcanic area. While acknowledging the dynamic nature of the area (eruptions, earthquakes), the geothermal field is still modelled as a system with specific boundary conditions, of which the heat source is one of the most important. A lot of uncertainty remains as to the specific location and quantity of these intrusions given the uniqueness of each geothermal area, so learning from the field over time is considered crucial.[107]

It was at this point in the process that I needed Bjarni, on more than one occasion, to explain the basic physics principles that they operate with and put into practice in the landscape. He explained that as fluids circulate through the subterranean fractures they pick up magmatic heat from the rocks. According to standard physics models, all molecules contain some amount of kinetic energy, that is to say, they have some intrinsic motion. The hotter these subterranean fluids become, the faster the motion of their molecules. As the heat from the rock is transferred to the fluids their molecules accelerate: vibrating and rotating in a *turbulent* fashion.

But the high-pressure state of the subterranean fractures keeps these fluids in a mixed form; geologists call it geothermal brine, a mixture of both water and steam at the same time. Seeking out and drilling into power spots in the landscape alters these subterranean relations as pressure differentials are created between the overground and the underground. As high-pressure fluids find low-pressure passageways through the well, the acceleration effects of both heat and pressure work together driving the fluids upwards in explosive bursts.

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of the subterranean as a matrix of porous and permeable fractured rock within and through which water circulates.

[107] As the team at Orkuveita is so small, Gunnar, the resident geophysicist, is solely responsible for modelling. However, he works very closely with the other members of the team, as live data from the field is input to the model to make it as site specific as possible.

Geothermal brine enters these wells from different fractures at various depths, rapidly ascending and depressurizing as they explode upwards. Such acceleration alters the architecture of the fluids as they change form at particular points of acceleration. At a certain temperature, at a given pressure, a phase shifting threshold emerges as fluids change from what the geologists call a laminar state, to a convective state, finally phase shifting into a turbulent state.

A range of philosophers have written about these phase shifts that so concern my geologist companions. Manuel DeLanda, in his book *Intensive Science and Virtual Philosophy,* characterises these phase shifting moments as singularities - *turbulent moments* when something special or remarkable happens - where not just quantitative, but qualitative change occurs (2004). As fluids phase shift into a turbulent state, a new, almost magical ontological configuration is generated that has the power to drive the turbines creating electricity to feed aluminium smelters: steam.

In his book *Genesis*, Michel Serres (1995) gives some intriguing descriptions of heating water molecules that I want to draw upon here. Mobilising Henri Bergson, Serres suggests that our metaphysics are primarily the metaphorics of the solid, which, for Serres, has led to a binary classification system of solids and fluids, or ordered states on the one hand, and disordered states on the other. Serres suggests that all the effort consists in the traffic going between the ordered and the disordered state. But, he writes, 'disorder is the worst word imaginable, I prefer to call these two states unitary and multiple. The one is a gathering, and the other a distribution (ibid:108). Serres deploys *turbulence* as a form of intermediary, a mixture that is a state both difficult to conceive and difficult to study scientifically, but which is nonetheless widespread. Turbulence contains both order and disorder; it is where chaos is found; 'chaos can appear spontaneously in the order, while order can appear in the midst of disorder' (ibid:109).

Thinking with turbulence directs us to how processes of gathering and distributing produce mixtures poised between order and disorder, or that *are* order and disorder at the same time. By focusing on the accelerating and disorderly motion of heat molecules, Serres depicts a world of agitation and disruption: turbulent states that can be both productive and disruptive at the same time.

As we have seen above, Hengill is being arranged to accelerate the motion of heat molecules to a point of turbulence, as water phase transitions to steam. But as Serres points out, turbulent states are both orderly and disorderly, and it is to some of the effects of this disorder that I now want to turn.

3.3: Unearthing the Geology of Capital

The ongoing production of vast quantities of steam is necessary to supply Century Aluminium with the majority of their electricity requirements, in accordance with the power purchase agreement they have with Orkuveita. Failure to live up to the terms of the agreement obliges Orkuveita to purchase the shortfall of mega watts from the market, a prohibitively expensive option. But falling steam output has become an increasing problem at Hellisheiði and has put the municipal service company under tremendous pressure. As this issue became more acute during the course of my fieldwork, it prompted many discussions about the development of Hellisheiði, and particularly the dilemma that Bjarni earlier articulated as both the “need for speed” and the “need for time.”

To begin to discuss this, let me return to Grimur, managing director of reservoir engineering at Orkuveita during the development of Hellisheiði. Grimur reminded us that making steam for power is a whole different story than making hot water. In aiming for steam, he suggests, Orkuveita are trying to get the landscape to serve power, rather than getting power to serve the landscape. During our long discussion on that same day, he continued:

> But I always said we needed to be careful about the price because if it is too low then you will have lots of potential problems. Basing everything on 3 to 4 cents, we are cut to the bone. We had to be aggressive, develop fast, sometimes using 5 drilling rigs simultaneously. If you were to double it (the price) you would get a totally new picture, in terms of how many wells you can drill, make up wells and so on. So everything is possible in geothermal, but only if the price is good. When the price is low you have to neglect many things, especially the environmental part, and this has happened here a lot.

In the previous chapter, I discussed the politics of price, drawing particular attention to the way the city of Reykjavík has become embedded within energy pricing arrangements as an unacknowledged form of value. Here, I would like to flesh out the geological implications of such pricing. For Grimur, price is many things. It is an attractor, luring aluminium companies to Iceland; it is what makes energy deals or breaks them. When energy prices are low, the environment gets left out, or devalued as something not central enough to warrant significant consideration. Although Grimur suggests that this leads to problems, he does not identify them.

A cheaper price means lower profits per kilo of energy produced, and hence lower profits per well drilled, increasing the number of wells needed over the life of the project. In general the entire process is, according to Grimur, aggressive and fast. Here price and pace become connected, as reduced prices fuel more aggressive development, and hence the need to scale up (the number of wells) and speed up (the drilling of those wells and the extraction rate per well) the rhythm of operations. Let me try to explain this in more detail.

3.3.1: Seeking Power Spots in the Landscape

Arranging the Hengill volcanic zone to configure steam for power requires a host of tectonic interventions. In the previous section, I gave an ethnographic example of one such intervention, the activation of a well.[108] However, during the construction phase of Hellisheiði drilling was the key activity. In particular, the focus was on targeting porous and permeable sections of subterranean rock fractures, ones that were estimated to contain enthalpy rich geothermal fluids;[109] *power spots* my friends called them.

The rich history of geological surveying and mapping of Hengill is the starting point from which the primary fracture sites can be located. Hengill consists of a large

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[108] This well was drilled a couple of years prior to its activation in 2014. Geologists refer to it as a "make-up" well, that is, an extra well needed in an effort to make up for the loss of steam that the power plant had been experiencing. Three such wells were activated between 2013 and 2014 while I was on fieldwork at Orkuveita.

[109] As I mentioned in the last chapter, geologists at Orkuveita use the term 'enthalpy' to refer to the quantity of energy per kilogram of fluid.

set of fissure swarms covering an area approximately 3-5 kilometres wide and 40 kilometres long. These fissures are characterized by geologists as eruptive rifts in the earth through which multiple lava flows have emerged from the subsurface over the period since the last glaciation (Einarsson 2008, Franzson, Gunnlaugsson et al. 2010).

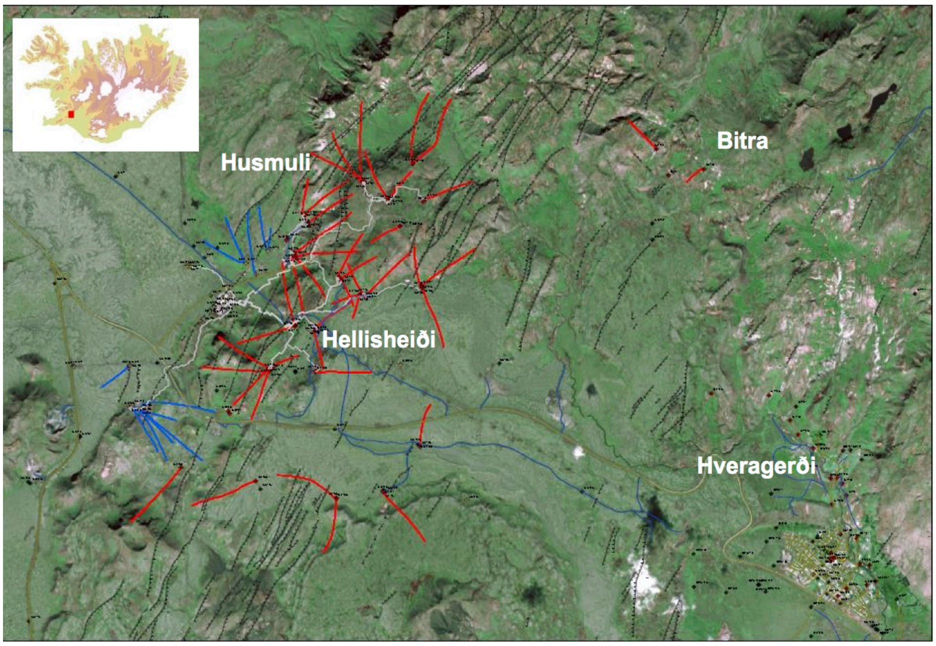

Figure 11: Drilling map of the geothermal wells throughout Hengill. The red lines show the subterranean direction of the production wells, while the blue lines are for reinjection wells. The jagged black lines running north northeast are the many fissure swarms that characterise the Hengill area. Image courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

These swarms form a type of depression in the landscape, known as a graben structure,[110] and it is through here that the primary faults run in a north-north-east south-south-west direction. While the area is rich in indicative surface phenomena such as vents and fumaroles, further geochemical and geophysical tests are needed to assess fluid chemistry and resistivity respectively.[111]

[110] Graben faults are a common type of faulting structure in Iceland. The rifting mid-Atlantic ridge plate boundary creates tensional faults that pull the earth in opposing directions. A graben forms when the earth between two parallel faults sinks.

[111] It is the work of the geochemists to map all the geothermal manifestations on the surface, including sampling and analysing the gas composition as a method of making drilling temperature maps. It is geophysicists that conduct resistivity tests. In essence, this is a way of assessing the degree of alteration in the subterranean. The idea is that the higher the amount of alteration that can be detected in the rock, the more likely it is that geothermal process are in operation. As water flows through the rock, some minerals are dissolved while others are deposited. The latter forming minerals have different resistivity levels; that is, they do not conduct electricity very well. By measuring this resistivity, geophysicists can surmise how much alteration is in the subterranean, and hence make an

While surface signals, and chemical and physical analysis are well known tools for the assessment of geothermal heat sources and volumes, as well as fracture locations, they are still akin to swinging a large axe where a scalpel is required. Precision in these endeavours is, for the most part, elusive, and the arts of geo-analysis are supplemented by another practice, itself far from the hallmark of precisional methodology: deep drilling practices.[112]

My geology companions talk about drilling as the part of the process when things get really interesting. Examining the rock and mineral fragments that emerge in the wake of large drilling rigs gives them a clearer insight into the findings from the original sets of geo-analysis. But drilling into the subterranean is also a huge operational undertaking that reveals many points of difficulty. Like Bjarni, the other geoscientists talked of conflicts between geology and capital, and they invariably did so through stories about drilling. Let me introduce some of Bjarni's colleagues to help with this.

> In Hellisheiði we had to drill with three drill rigs at the same time, and we had to locate the next drill hole before we got the results from the previous one, so there was far more failure in the siting of wells. So we ended up drilling more wells than we should and a lot of them were not very productive, all because we didn't have time to learn. We had to keep drilling when it was cheapest (Einar, Orkuveita).

> Normally [in geothermal] you try to drill as few wells as you can, that is usually the goal, because they are so expensive, a couple of million dollars each I think they cost. But that was not the case in Hellisheiði, they would just drill, drill, drill. A well needs to time to respond and you need to get some basic geological information, but there was no time for that, they just

initial estimate of potential heat. There are certain difficulties with this method and so it is only used to site drilling locations in combination with an assessment of surface geology, gas chemistry and temperature profiling.

[112] Locating subterranean heat sources is on-going point of contention within geothermal modelling. While older models simulate one large heat source, more recent modelling suggests multiple heat source locations that may come from magma chambers or a series of smaller dyke intrusions (Gunnarsson 2014). Locating putative heat sources has implications for determining the boundaries of the system, and therefore the spatial distribution of well drilling sites.

kept drilling new wells and the data was overflowing, there was data everywhere and nobody was looking at it. Look at Skarðsmýrarfjall, the mountain of the central volcano. We had big expectations and got really poor results because we were just drilling without taking time, without letting the mountain respond. But I guess it comes down to the economics of the system, but is it better to drill fast? (Ingvi, Orkuveita).

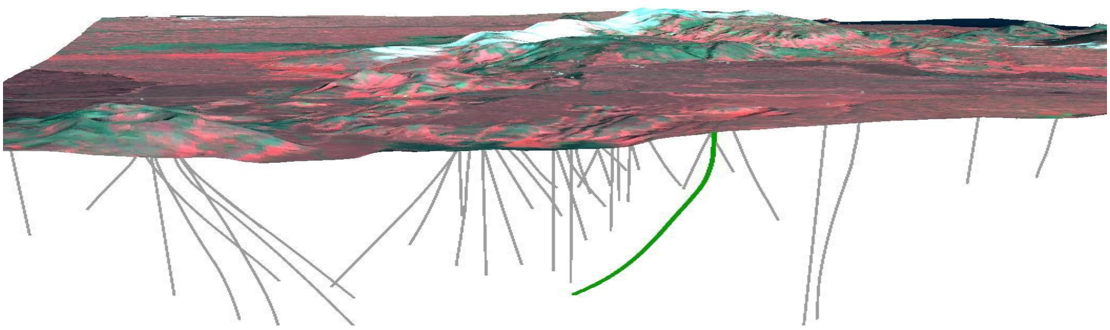

Figure 12: Computer generated image of deep drilling at Hengill. Image courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

Drilling wells in a volcanic landscape is a difficult enough task under the best of circumstances.[113] The rigs, systems and equipment used in geothermal drilling are legacy technologies from oil and gas. This comes with a host of problems, not least of which is the tendency of the high tech electronics that are used to guide the drills as they descend into the subterranean to melt as they meet fluid temperatures far in excess of those encountered in oil and gas drilling. The perils of drilling are well known within the industry and many companies adopt their own in situ technical fixes that are oftentimes not commercially available (Gross and Mautz 2014).

But between 2003 and 2008, the Icelandic economy was awash with capital and the construction sector was booming on the island. Drilling rigs were in short supply and more expensive as a result; cheaper nighttime drilling was not uncommon. Stories of both excesses and mistakes were rife. Here's one from Bjarni:

[113] Each drilling platform contains four wellheads. While the igloo shape of the wellhead protrudes out of the ground, the rest of well structure extends downwards through the earth to a distance of between two to three kilometres, depending upon the site. Recent improvements in drilling technology allow for what is called directional drilling. The first eight hundred meters of the subterranean drill hole is vertical. Over the next two kilometres the well begins to move in a more horizontal direction targeting specific faults and fractures.

> The drilling company were siting a well at 2am one night and as project leader, I was responsible for confirming declension parameters.[114] I was on call at home, but I was so tired and stressed that I fell asleep and missed a declension check. Needless to say the drilling went off course and missed the target fractures.

Self depreciatingly, Bjarni chalked it up as the most expensive snooze in Icelandic drilling history. But for him this story is far from humorous and attests to the odd drilling practices that were not uncommon around this time. Under such conditions, errors will occur. But it is more than bleary nighttime errors that were at stake.

In the introduction to this chapter, I quoted Bjarni as referring to geothermal as being like a "living organism." As wells are drilled subterranean relationships change; the drilling of one well markedly disturbs the relations between the rock fracture matrix, hydrostatic water pressure and circulating fluids. As such, newly drilled wells need to be sampled and monitored to see how these relations work themselves out over time. Usual practice is one year, but in some cases it can be longer.

When the sampling data stabilises, the team move on to siting the next well, and sufficient monitoring time is given to ensure that both wells can work together, and so forth. The process, known as stepwise development, is how the team describe an optimal drilling strategy. Geothermal drilling does not work, therefore, off a fixed drilling blueprint; the siting of wells is an on-going process of responsiveness, as wells form relationships with subterranean forces and the drilling of each and every subsequent well alters these prior sets of relations.

As such, the relationship between the quantity of energy to be delivered to the aluminium company and the arrangement of the landscape to service those contracts cannot be known in advance. This is where the work of the geoscience department becomes important, as they experiment with varying landscape configurations that can produce the most steam.

[114] When a well is being drilled, longitudinal and latitudinal readings have to be taken at specific declensions to ensure that the drilling is proceeding on course (to intersect with a fracture array).

Above, Ingvi mentions Skarðsmýrarfjall (figure 13), a mountain located beside the central volcano in Hengill. Preliminary geochemical testing had indicated that this site would be the volcanic zone's primary *power spot*. As the pressure to realise the steam from this spot was so pivotal to the overall project plan, three wells were drilled at the same time.[115]

Figure 13: Aerial photography of a part of Hengill indicating the location of Skarðsmýrarfjall. Image courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

As Ingvi recounts above, the prevailing attitude of drilling without first giving the mountain "time to respond," led to data overflow and limited analysis. While the first well began producing as expected, the next two wells changed their output pattern and all three have since continued to perform far below expectations.

Grimur's earlier remarks shed a little more light on the comments above from Einar and Ingvi. Doubling the price, for example, would have given a "whole new picture" in terms of how the landscape was drilled. Being "cut to the bone," as Grimur puts it, implied using multiple rigs simultaneously to benefit from economies of scale, in addition to getting cheaper nighttime drilling rates. Smaller profit margins

[115] Orkuveita specifically purchased two turbines (at over $USD40 million each) for the steam that they estimated would be produced from these three wells.

meant using rigs more quickly, so less time was spent analysing data, in turn affecting the quality of well siting techniques.

The pressures of capital in these instances led to faster drilling practices, the consequences of which were drilling failures though accidents and poor well siting techniques. What I learned from my geology friends is that thinking about energy prices unearths a range of connections between capital and geology that play out in terms of landscape transformations.

3.3.2: Temporal Conversions

Curious and provoked by Bjarni's reference to the "excel tribe," I sought out, and found, this 'tribe' just one floor above the geoscience department at Orkuveita's head office in Reykjavík. This led me to Jakob, Finance and Planning Director at Orkuveita. During several interesting discussions, Jakob openly engaged with the points of critique raised by his geoscientist colleagues. Discussing the relation between the "need for speed" and the "need for time," as the geologists put it, Jakob brought up the Nesjavellir geothermal plant.

As I noted in Chapter One, the Nesjavellir Geothermal Plant lies to the north east of Hellisheiði. While its primary purpose is the production of hot water, it does, subsidiarily, produce electricity. Adopting a cautious drilling regime allowed wells to be drilled, assessed, and put into production, before the siting of the next well took place. Such a stepwise approach, as it was referred to a little earlier, brought the plant up to full production capacity over a 30-year period.

When I ask Jakob why the same approach was not adopted for Hellisheiði, he responded that the "capital requirements wouldn't allow it." To shed light on this, Jakob explained some of the mechanisms at the heart of the project's capitalization model, known as Net Present Value (NPV).[116]

As the project is financially assessed over the course of 25 years, profit streams arising from many years in the future are 'discounted' at a particular time

[116] NPV is a financial appraisal method that has become extraordinarily popular for assessing the financial viability of projects that require capital investment.

based rate in order to translate them back into the equivalent of today's money.[117] However, the further into the future a given profit stream arises, the bigger the discount rate that is applied. This is based on the way in which the model renders the relationship between uncertainty and the progress of time; the more time that passes, the more uncertain events become, the higher the risk. A premium is added to the discount rate as a method of valuing such risk.

The effect of such time based discounting is that money made now is more valuable than money made in the future.[118] These models operate not only with a linear notion of time that adopts a uniform set of discount rates, they also come with an embedded set of inter-temporal value conversions, converting the value of the future into the present in a standardised fashion. A type of temporal discrimination emerges, as future money, and hence action, is constructed as less valuable. Thus, speed is valorised through the model's particular way of converting future value into present value.

In these models, no attention is paid to Hengill as a particular type of place, its varying rhythms or specificities.[119] The model standardises time, value, and geology to such a degree that it makes little difference if the object of capital's

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[117] The net present value has to be positive for a project to be considered worthwhile. However most companies have a particular performance criteria used to assess exactly how positive the value needs to be before development begins. This can be factored into the discount rate. A common method is to use an Internal Rate of Return (IRR), which is effectively a return on capital that the project wants to achieve. Discount rates can be calculated for various IRRs over time, by cross-referencing a given IRR with discount logarithmic charts.

[118] The basic logics of discounting are laced with assumptions arising from behavioural economics that are typically, western, white, male and consumerist. A common example goes like this. Faced with a choice of taking $US 1,000 now or $US 1,000 in ten years, most people would opt for the former. As prices are assumed to rise, the money, if taken today, could be invested making it 'grow' to an amount that would exceed the alternative. Another, more psychosocial, assumption is that humans have a proclivity to prefer enjoyment or reward today, and push pain or hardship away to the future (Price: 1993).

[119] That is supposed to be the job of the geophysical models of Hengill. Interestingly there is minimal connection between the specific geological models and the investment models apart from an estimation of output (steam and water) over the number of years of operation. The geology of Hengill becomes a revenue line in the NPV model.

attention (the “capital requirements” as Jakob put it above) is electricity production from a coalfield in the US or from an Icelandic volcanic zone.[120]

Although many economists have expressed unease about the results and philosophical foundations of these models over the years, the institutional power and convenience of using just one appraisal technique as the standard model has proven too difficult to overcome (Price 1993: 324). But one of the powers of such models is their performative effects; rendering *earlier action* as better and more valuable than *later action* in the model enacts that very form of temporal proclivity in the landscape.

While low energy prices drive the need for more wells and the faster development of those wells, the connection between these prices and the type of temporal conversions that the model performs makes speed more financially attractive; extracting now is more valuable than extracting later. The “excel tribe’s” “need for speed” translates into a type of *capital acceleration* whereby the pressure to extract as much fluid as possible, as quickly as possible, is an embedded feature of the capitalization model. Capital and the rhythm of the landscape become inextricably linked.

3.3.3: Conversions in Resource Landscapes

In the literature within the anthropology of finance and debt, capitalization models are conceived as one way of valuing. Fabian Muniesa, in a small think piece in Cultural Anthropology’s *Theorizing the Contemporary*, underlines that while the development of markets is one of the crucial characteristics of the spread of capitalism, the focus on marketization and commodification as the central components of capitalistic value is lamentable (2012).

For Muniesa, such a focus overlooks the importance of capitalization’s role in valuing. I would like to add some empirical detail to this by suggesting that the temporal conversions in this valuing process work as a form of acceleration, pushing

[120] Paradoxically, that which many people seem to value most, the future (being alive, having children), is valued least in these models. Part of this seems to stem from the method of inter-temporal conversion. These models make an assessment of the future from the standpoint of the present, monetise it, and then return it to a value in the present. The myriad of assumptions that go into such conversions can make many an incomprehensible action seem rational (Adam 1998: 75).

the “excel tribe” to demand a type of speed that unsettles both the landscape and the geologists working in it.[121]

Anna Tsing’s work discusses the creation of new resource frontiers around the world, enabled by both the cold war militarism of Africa and the growth of transnational corporations (2005). The landscapes of Indonesia, Tsing tells us, are not naturally discovered frontiers, wild spaces awaiting exploitation, but require material and imaginative work to become so (ibid:32).[122] Part of this work happens through processes of conversion. Tsing picks up this issue of conversions as part of a recent collective piece with Laura Bear and others, who suggest approaching formal models (contracts, money, financial models, yield curves) as subsets of broader *conversion processes* between diverse life projects (Bear, Ho et al. 2015: 5).

Tsing, in particular, uses the term ‘salvage accumulation’ to characterise the ways in which ‘stuff with other histories of social relations (human and non human) are converted into capitalist wealth’ (Tsing 2015, 2015a). What Tsing is essentially trying to bring across is the ways in which non-capitalist forms of value are constantly being converted into capitalist value. She suggests that most analysts of capitalism, following the lead of nineteenth and twentieth century thinkers, have ignored the formation of ‘raw’ materials, taking them for granted as capitalist resources. Yet, Tsing argues, these materials have their own genealogies of production outside the capitalist purview. Given the severe environmental problems we now face, ignoring these genealogies is something we can no longer afford to do (Tsing 2015a).

Tsing uses energy as an example. Take oil and coal, which as formerly living entities are not made by capital, but are made into an extractable value through capital. Capital, in this regard, both unmakes (the genealogy of resources) so it can

[121] These processes are undoubtedly connected to the logics in operation throughout the broader economy and financial markets, referred to by one of the main banks as Kaupthinking. Speed of thinking, speed of decision making, and speed of action are all rendered as virtues through the ways in which capital values the relationship between the future and the present.

[122] In an insightful analysis, Tsing suggests that the work of frontier making is oftentimes that of erasure; landscapes have to be unmade from the worlds that they belong to, so as to be re-made into wild barren spaces disconnected from any pre-existing relationships. As areas of made wilderness, or wildness, they become part of a ‘natural’ sphere that invites the logic of extraction. Through processes of detaching (from existing relationships) and attaching (to constructed naturalized zones), such lived landscapes are made into frontier commodity spaces (Tsing 2005).

make (extractable value). What capital does particularly well is make certain parts of the world legible as valuable for purpose beyond their own genealogies of production. Tsing's work is partly an effort to bring these edgy sites of capitalism into play in order to show how such value conversion processes work. What I brought to attention above are the temporal conversions embedded in the capitalization model at Hengill, conversions that have performative, accelerating effects; capital accelerations I called them. The fact that the capitalization model being used in Hengill is not unique to Iceland emphasises the power of these models to 'erase particularity and sever objects, people, and resources from their contexts of production' (ibid).

Historians of America's Great West write similarly of such processes at work during mid-nineteenth century America. William Cronon, in his epic work *Nature's Metropolis*, describes similar effects as he notes how the land of the vast, flat prairies came to resemble the maps that were drawn of it by government surveyors in the distant east. Once within the capitalist system, places lost their particularity as geography came to matter less and less, except as a problem to be managed (1991: 259). Capital is the great agent of change in *Nature's Metropolis*, and the object upon which it acts and to which it reacts is the landscape, as the prairies are inexorably commoditised.

Jason Moore, a Marxist sociologist and prominent voice in capitalocene discussions, looks specifically to the role of price in landscape transformations. Moore argues that capital accumulation only works by rendering 'nature' – both non-human and human – as cheap; and this in a double sense. Cheapening or degrading 'nature' allows for it to emerge as inferior in an ethico-political sense, which in turn helps us to appropriate it at a cheap price. This twin strategy, Moore argues, has been entwined in every major capitalist transformation over the past five centuries (2016b: 2-3).

One way of tracing the transformations occurring in resource landscapes, then, is to think of these transformations, along with Bear et al, as part of broader conversion processes. At Hengill these processes involve thinking about both temporal and price conversions; as the former converts the value of the future into the present, the latter converts the pressures of capital into subterranean pressures.

What I have been trying to do through this tracing is to unpack the various components of the "excel tribe's" "need for speed." The connections between temporal and price conversions have generated a form of capital acceleration, as speeding up extraction becomes more valuable. What I want to do now is show how these capital accelerations have triggered other forms of acceleration in the landscape.

3.4: Natureculture Accelerations

The capital accelerations described above have, in a paradoxical sense, been very costly at Hengill, both geologically and financially.[123] The continual push to extract as much fluid as possible as quickly as possible has had a serious impact on hydrostatic water pressure in the field. At present extraction rates, the fluids that are extracted cannot be replenished fast enough by what is called 'natural' recharge, and so water pressure continues to fall.[124] As I explained a little earlier, keeping up subterranean water pressure is the main mechanism for generating the accelerations needed to make steam.

Falling pressure is a real problem for the power plant, and for the volcanic area in general. When the "driving force" of extraction processes is altered, other consequences follow. Formerly productive wells become less so, and, as we saw earlier, "make up wells" need to be activated. The effect of falling pressure has amplified effects on steam production.[125] The solution to this problem was deemed to be the reinjection of spent geothermal fluids back into the subterranean. As geologists tell me, the primary purpose of this practice is to "recharge" subterranean water and re-pressurize the field.

While Orkuveita do not reinject all of their spent fluids, they get close, up to 80%. Reinjection is a tricky issue, a "double-edged sword," as Gunnar, geophysicist

[123] Extraction at Hellisheiði had been operating at a rate of 1,300 kilos of fluid per second prior to a fall in output.
[124] Current thinking suggests that these fluids are replaced by a 'natural' recharge mechanism that pulls fluids from 'outside' the geothermal field due to pressure differentials. The faster the rate of extraction the less likely it is that such 'natural' recharge can replace the extracted fluids, and so pressure continues to drop.
[125] Bjarni estimates that the drop in pressure has resulted in up to a 10% loss of steam output, or 60 kilos of fluid per second. The plans to activate additional "make up wells" were approved by the board of Orkuveita during my fieldwork, and are estimated to have a cost of ISK4 billion kroná.

at Orkuveita, put it to me one day. While it re-pressurizes the subterranean field, it also comes with its own set of accelerations, ones that are having powerful geophysical cooling effects. Let me try to explain this a little.

Another cold December day at Orkuveita, this time sitting in the meeting room with Bjarni, drinking coffee, chatting about drilling, the financial crisis, and the freezing snowy weather (as we always do), we get to talking about how all Bjarni's time is taken up with the overriding concern of falling pressure. The need to regain the pressure loss is a financial imperative in terms of the energy contracts with Century Aluminium, and the geoscience department is working overtime to try and figure something out. More "make up wells" are always an option but money is really tight since the near bankruptcy of Orkuveita in 2010. The team needs to be creative. I am on a steep learning curve with everything regarding geothermal, and am having difficulty understanding how reinjection and recharge water could possibly be cooling down a volcanic site. My simple reading is that this colder water is flowing in such large quantities that it is somehow cooling the subterranean fluids. Bjarni, showing rare signs of impatience with my 'slowness,' picks up the marker to draw on the whiteboard.

> Ok, so pressure differentials drive fluids out of the ground. As pressure drops in the field, water from higher-pressure zones outside the field flow in.[126] We call this recharge water; but its not enough to make up for the pressure drop. So we need reinjection water to supplement the recharge. Given the rates of extraction and reinjection both types of water are moving fast. It is the speed that is important.

Bjarni continues by asking me to imagine the fluid cycle; the way a fluid flows depends upon its speed. As fluids accelerate through the subterranean fractures they begin to alter their flow form. At critical points of acceleration phase shifting

[126] Fluids are modelled as flowing laterally 'into' the field, as well as vertically, from greater depths. The distinction between 'inside' and 'outside' the field is not always so rigid in our discussions. While models simulate boundary conditions that locate 'inside' and 'outside' in clear geometric terms, the dynamic nature of the subterranean occupies a more central place in the geologist's conversations and descriptions. As such, the terms 'inside' and 'outside' are used quite liberally.

thresholds emerge through which state changes occur. At slower speeds fluids flow in a linear (laminar) state, but as they accelerate they phase shift to a wavy (convective) state. If they continue to accelerate they phase shift again into a more turbulent state. The higher the speed the more turbulent the fluid, the faster heat is extracted from the rock. As an insulator, rock conducts heat very slowly and so the heat that is sucked out of the rock matrix by turbulent reinjection fluids takes considerable time to replenish. Bjarni and his team suspect that this is having volcanic cooling effects, but this needs to be investigated.[127]

What we are seeing occur throughout Hengill are varying forms of acceleration and deceleration. As I described earlier in the chapter, steam production is a process of acceleration. However, ongoing falling water pressure reduces theses acceleration effects, and so one way of thinking about falling energy output is as a type of deceleration. At the same time this is creating the need for reinjection practices that bring with them new acceleration effects. As the pressures of capital are being converted into subterranean pressures, some accelerations begin to decelerate while at the same time new accelerations emerge.

In Chapter One, I referenced the work of Paul Virilio, who points out the ways in which varying declerations occur in tandem with accelerating features of life. Waiting in traffic jams in high powered cars, or waiting for flights at airports are but two forms of slowing down that occur in relation to different forms of speeding up. While Virilio was very much concerned with the speed of change in technological societies, the principle here is not entirely different. However, what I would like to focus on is the emerging inseparability of the geological and capital in this volcanic landscape. It is impossible to isolate accelerations, or declerations, that are either 'natural' or human, the mixing is just too extensive. These are *natureculture accelerations* that I want to think of in terms of phase shifting thresholds.

3.4.1: Moving Laterally

A little earlier, I began to use the term *rhythm* in relation to the volcanic landscape, particularly as a way to articulate a set of connections between geology and price.

[127] The method of investigation is the tracer test, which I will discuss in Chapter Four.

Specifically, I suggested that the pressure upon geologists to extract fluids from, and therefore reinject fluids back into, the subterranean at an accelerated pace is affecting the rhythms of the landscape. In this section I would like to flesh out my adoption of the term rhythm a little more.

Etymologically, the word rhythm comes via Latin from the Greek term rhuthmos, meaning *to flow*.[128] So thinking about the ways in which fluids flow throughout Hengill, as rhythms, has an etymological basis. But adopting the term rhythm as flow, analytically, comes with some limitations. The terms flow and flows have been extensively treated in academic literature, most often in a metaphorical sense to analogise, in particular, processes of capital and globalization. As Anna Tsing has noted, thinking globalization and global connections as smooth flows paints a picture of global interactions through the imagery of a well-oiled machine, and misses the awkwardness, or stickiness, of such 'encounters.' Tsing opts instead for the metaphor of 'friction' as a way to think both the connectivities and the disruptions that come with global encounters (2005).

John Law and Ingunn Moser also make an alternative move by connecting flows back to one of the material sources that has given rise to the metaphor: fluids. They suggest, for example, that information flows are best thought of as fluids that change in shape and form as they circulate inside and outside of organisations (2006: 58). In his more recent work, Stefan Helmreich proposes a lateral move. Thinking about seawater as something that is both a force of the world that affects us in a variety of ways, as well as something that is good to think with, he suggests thinking 'athwart theory' (2011). As a fluid, water is both empirical and analytical at the same time, and using this example Helmreich challenges us to think through the relationships between the empirical and the analytical that are generated through fieldwork.

Such a 'lateral move,' as it is called (Jensen and Winthereik 2013, Gad and Jensen 2016), has been advocated by others. Bill Maurer has talked explicitly of 'lateral reason' in his work on Islamic banking, suggesting that we think about the people we meet through fieldwork as 'fellow travellers along the routes of social

[128] See https://en.oxforddictionaries.com/definition/rhythm

abstraction and analysis' (2005: xv). He also encourages us to think of concept production as a meeting place between indigenous concepts, our descriptions, and the analytical tools of anthropology. Annelise Riles gives a wonderful example of making a lateral move as she turns practices of Fijian mat making into a conceptual and comparative device for the interpretation of policy documents (2001).[129]

In a concise and informative article, Gad and Jensen suggest that thinking laterally is a response to the complex relations that arise through ethnography, as the knowledges and practices (theories, concepts, assumptions) of the researcher interact with those of the researched in more explicit and experimental ways. Anthropology and STS, they argue, are not simply concerned with applying theories as explanations to ethnographic settings, but are trying, in some sense, to allow such theories to be shaped by those settings (2016: 4). This is not dissimilar to what Martin Holbraad calls 'conceptual affordances' - the attempt to allow the empirical materials of fieldwork to generate, or inspire, analytical insights (2011).

This is, as I read it, the essence of thinking laterally; a more sensitised approach to the ways in which we develop the relationships between the empirical and the analytical. It is not a new thought in anthropology, but has of late become more explicit, particularly as a way of thinking about concept production as a more decolonial and experimental sensitivity sets in within both anthropology and STS (De La Cadena, Lien et al. 2015). Openly experimenting with the descriptions, concepts and practices we encounter in the field, as they rub up against our own, has become even more necessary in times of environmental urgency.

Taking inspiration from these moves, I want to think laterally with volcanic fluid flows as they move into and out of the subterranean rock matrix. But these fluids become *turbulent* as they accelerate. As I discussed earlier, fluid acceleration generates phase shifts. Learning from geologists about how they operationalize a physics concept in practice in the landscape helps me to think about how I can do so ethnographically.

Speeding up the rate at which fluids are being extracted, and reinjected, generates phase shifting thresholds that make fluids *turbulent*, and this turbulence

[129] For more interesting examples see (Gad and Jensen: 2016).

has serious consequences. *At the same time it helps me to think about the relationship between phase shifts and the production of new states, both productive and disruptive. W*hile extraction practices generate steam, reinjection practices generate volcanic cooling (and, as we shall see in Chapter Five, "man-made" earthquakes). Phase shifts are a way of suggesting that accelerating processes do not just entail changes of a quantitative nature, but are also sometimes of a qualitative one: *changes in speed are leading to changes in kind at Hengill*.

For the remainder of this chapter, I focus on thinking through these relationships as a way to trace the effects of capital as it is being unfolded in geological terms. As capital is being inscribed into geology these *turbulent fluids* are beginning to remake the rhythms of the landscape. I want to draw upon some extra resources to help me think about the ways in which rhythms can make, and remake, landscapes.

3.4.2: Locating Rhythm

Henri Lefebvre, in his discussion of rhythmanalysis (1996), conceptualises the mutuality of rhythms and place. Rhythms, for Lefebvre, are always linked to a place, whether it is the beating of the heart, the fluttering of the eyelids, the movement of the street, or the tempo of the waltz. As rhythms make places, places make rhythms. One has to pay attention to rhythms as they fold time and space, much as Lefebvre listens for the rhythms of the city.

For Deleuze and Guattari, too, rhythm is a crucial operator that allows for a linkage of time, space, and ordering, as Brown and Capdevila make clear (1999). Deleuze and Guattari develop the notion of the refrain as one of 'repetitions that make a difference' (1988: 311-12). That which is repeated, they write, becomes a basic element, a discernable rhythm. As rhythms mark out time through a type of ordering, they become located, and as such a rudimentary sense of place emerges. Rhythm is, for Deleuze and Guattari, what territorialises, but in specific ways. Drawing on an example of a child who sings a song over and over as a way to banish its fear in the dark, the authors suggest that the song, as a rhythmic series, creates by its very repetition, a sense of the familiar, a sense of place (Deleuze and Guattari 1988: 311-312).

These approaches argue that repeated movements, whether it is the oscillation of cells, the fluttering of eyelids, or a child's song, are all types of rhythms. One way to say this is that such rhythms are timed order; they mark time through ordering and thereby become *located.* Another way to say this is that rhythms *enfold space and time.* Rhythms are an important part of making places. Building on this, I want to think of the fluids that flow through the subterranean at Hengill as volcanic rhythms. They *locate capital* in the volcanic landscape, *as Hengill becomes, or is made into,* another type of place, a landscape of industrial renewable energy.

Chapter Five will go into detail about the second form of acceleration that the dissertation takes up- the acceleration of Hengill's seismic rhythms ("man-made" earthquakes). But to do that I need to lay some more groundwork by specifying the relationship between rhythm, temporality and landscapes a little more clearly in the remaining part of this chapter.

3.5: Landscapes and Temporal Rhythms

There is a long history in anthropology of thinking about the relationship between rhythm and temporality. Marcel Mauss discussed the role of rhythms in the social imaginaries and practices of Inuits, as he studied the rhythms of dispersal and concentration of individual and collective life (Iparraguirre 2015: 12). Franz Boas made a strong connection between rhythm and aesthetic practices (Mauss 2007), while Emile Durkheim was one of the first to explicitly talk about how rhythm is embedded within temporality as a regulator of social activities (1995: 9).

Evans-Pritchard also used rhythm as a way to think temporality, referring to the three layers of rhythm in Nuer life (physical, ecological and social) which help to illuminate how Nuer think about time (1995: 9).[130] While the list goes on, I want to

[130] While the Nuer observe the movements of celestial bodies, they do not regulate their activities in relation to them, nor use them as points of reference for an account of the seasons. It is cattle needs and variations on food supply that mainly translate ecological rhythms into the social rhythms of the year, and the contrast between the ways of life at the height of the rainy season, and the dry season is that which provides the conceptual poles for the temporal account (Durkheim 1959: 114-115).

draw some insights from contemporary thinkers who bring environmental and temporal processes into relation through the idea of rhythm.

In Timescapes of Modernity, sociologist Barbara Adam urges us to reassess environment issues including environmental hazards, waste, and pollution as temporal problems. For her, the radical transformation of the environment, including landscapes, is a problem of 'out of synch temporalities' (1998: 14) as the tempos set by industrial processes and those of the environment come into ever increasing conflict.

She begins by critiquing the Newtonian version of time as measurement. Concerned with applying Euclidian geometry to mechanics and the movement of bodies, Newtonian mechanics reduces temporal relations to spatial form insofar as temporal relations between events are represented by the relations between points on a straight line. Time takes the form, in this rendering, of succession. It is this linear perspective that affords the idea of time as measurement: as objects move they cover distance and time elapses. According to Adam this is one of the crucial turning points in the development towards the modern techno-scientific way of conceiving the world (1998: 37).

This leads Adam to point to various ways in which this version of time (as measurement) is embedded in dominant modes of organizing both scientific and economic practice. Charting, mapping, categorizing, and knowing are practices that–along with the cost benefit analysis and discounting techniques we have already seen–have transformed time. Time, not unlike money, labour and machinery, becomes an abstract universal variable that can be used similarly in all places, at all times, with wildly different effects (ibid: 70) . In this mode, time is disembodied from events, and in particular from the varyingly rich rhythmicities of the world. It is this basic problem of temporality that Adam sees running through multiple environmental issues, from nuclear power (and radiation) to genetically modified organisms. It is a problem of not taking alternative temporal rhythms seriously.

Problematically however, Adam has the tendency to reify distinct temporalities, whether talking about 'the' temporality of capital, or 'the' temporality of 'nature' (as in the quote below). And even though this militates against what has become common academic currency in recent times, that is, an analytical awareness that there is neither one synchronous time, nor dichotomous times (human and non-human), but only a multiplicity of times that proliferate,[131] she is, it seems to me, ultimately urging a method that aims to take the varying rhythms of the world seriously as productive of alternative times nonetheless.

For her this is a question of making a temporal analysis of socio-environmental processes. 'To explicate the temporality of nature, therefore, we need to reconnect the externalised phenomena to their generative processes, the countryside to its re/production, the forests to their formation' (ibid: 33). It is such a focus on generative processes that I think is crucial in thinking with Hengill and its temporal rhythms.

Tim Ingold's *Temporality of the Landscape* has become a touchstone article on issues of landscapes and temporal rhythms. Ingold draws attention away from representations of the landscape and towards the many and varied practices that constitute its temporality, or 'taskscape' as he refers to it (1993: 162). In particular, Ingold's analysis of Breugel's painting 'The Harvesters' gives us a description of 'the interwoven temporalities of the hills and valleys, of paths and tracks, of trees, the church and people' (ibid : 165). While we get a sense of how these temporalities are smoothly interwoven, what we lack is a sense of how they are different from each other. As Barbara Bender argues, 'by overdetermining coherence at the expense of friction and rupture, a type of harmony of resonances emerges which omits a discussion of power and politics' (2002).

In their respective ways, both Ingold and Adam focus on the varying generative rhythms of the world as important ethnographic insights into understanding landscapes and environmental issues as temporal processes. But as I wanted to bring out above, the rhythms at Hengill are more turbulent than the coherent flows of Ingold's landscape, and more mixed than the temporal dichotomies of Adam. Such rhythms are putting geologists, as we learned, into a difficult bind, and I would like to conclude this chapter by returning to this bind.

[131] I will address this more specifically in Chapter Five.

3.5.1: Temporal Coordinations

Michele Bastian, a scholar working at the interface between philosophy and environmental humanities, brings issues of the environment and temporality together in interesting ways. The act of telling the time, Bastian suggests, is more than an act of measurement, it is an act of relational performativity, or social coordination, as she also puts it. We tell the time, according to Bastian, to coordinate many of the actions in our lives, and in doing so we bring forth the actors (human and non human) that we want to form and continue to maintain relationships with (2012).

We seem to be failing to coordinate our actions with a whole host of non-human actors today, however, for example, icebergs, corals, and so forth, and to potentially devastating effect. The very success of clock time as a method of coordinating ourselves, she suggests, has obscured the question of what others we should consider coordinating with. We have simply forgotten how to tell the time in times of environmental urgency.

One way of reading geologists at Orkuveita is to suggest, following Bastian, that the geoscience team are learning how to tell the time in a volcanic landscape under conditions of rapid acceleration. The idea of coordination is helpful here, as geologists attempt to figure out who, or what, is most important to coordinate with in managing and responding to the various accelerations and decelerations occurring in the landscape. The answer to this question is not always the same, as accelerations, and priorities, change.

A little earlier, I brought up a discussion I had with Bjarni in one of Orkuveita's meeting rooms. Towards the end of this conversation, Bjarni added that if they could only learn to slow things down, if operations could pay more attention to "the pace of the system," (the heat relations between flowing fluids and rock) then things could be different. Less aggressive extraction rates, and therefore reinjection rates, would slow down the speed of the fluids as they travel through the fracture matrix, and as such take heat out of the rock face less aggressively. Given the fluid-rock heat relations in operation, the heat that is 'slowly' extracted could be 'slowly' replenished as it is pulled into the rock through other connections.[132] In fact, *coordinating* the practices of capital and geology more closely could generate rhythms that would make reinjection more productive, encouraging more heat to flow in and potentially increase energy output, not reduce it.

Geologists can neither ignore nor fully accept the emergence of these new rhythms at Hengill. This is the essence of Bjarni's bind as I see it. It is not a call to stop accelerating the landscape altogether, that would be impossible; Orkuveita and Reykjavik are too embedded in the production of geothermal energy in this landscape to think about stopping. But it is a call to pay more attention to how they, and through them the company, can better coordinate the practices of capital and geological practices in the landscape.

Allowing capital practices to dominate the landscape has led to many problems, not just geological (pressure drops, cooling), but also financial (costs of lower output, extra wells etc.). In fact, as we saw, geological problems swiftly become financial problems. Converting the pressures of capital into subterranean pressures, paradoxically, leads to less capital and other geophysical problems beyond capital's purview. Taking time for Bjarni and his team, therefore, is a way to suggest that the relationship between the landscape and capital has to work differently, for the sake of the landscape, the sake of capital, and, given Orkuveita's importance to the city, for the sake of Reykjavík.

In a talk at Halifax, Canada, a few years ago, Isabelle Stengers (2012) struck a note not too dissimilar. In her talk she argued for a way of moving beyond the conservation-utilization dichotomy, suggesting that in the new world, identified by the trope of Gaia, we are past the time where it is possible to think that the earth is either in need of our protection or ripe for our sole use.

Instead we have to learn how to compose our world together with an indifferent, potentially devastating power.[133] In a country that has had difficult, at times deadly,

[132] 'Slow' in this context is not an absolute metric, but a relational effect of fluid-rock heat relations. One way to make a distinction between 'slow' and 'fast' is in terms of fluid phases, with turbulent flows considered aggressive and 'too fast.' I will discuss this more in the next chapter.

[133] The full quotation was; 'Gaia is the figure of the many figured earth, not in need of our love or protection, but the kind of attention to be paid to a powerful being. Our time as being the only actors in history is over, as is our freely discussing if the earth is available for our use or in need of our protection, we have to learn to compose, even with a devastating power.' The talk is available here

relations with the forces and powers around them, learning how to coordinate in the volcanic landscape is important. The relevance of this will become clearer in the subsequent chapters, but for now I want to turn to how the geology team investigate their suspicion that the volcanic area is undergoing processes of cooling, by moving into a discussion of a set of practices that helps them explore these suspicions - the tracer test.

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http://www.situsci.ca/event/isabelle-stengers-cosmopolitics-learning-think-sciences-peoples-and-natures

Chapter 4. Ontological Signals: Making the Subterranean through Sounds and Pulses

4.1: Geological Legacies

In Memory Practices (2005), Geoff Bowker introduces us to the thinking of Charles Lyell, one of geology's founding fathers, who reconfigured the discipline as it flourished in the mid 1800's. Conceptualising the earth as eternal, Lyell explains that while the earth may have had an origin at one point, trying to establish what that origin might have been is not possible. Operating through complementary destructive and creative forces, the earth's history, according to Lyell, is only ever traceable through its last iteration of creative destruction. As the earth is eroded and ground down through destructive forces (flowing water, wind and so on), its sediments are re-distributed through other more creative forces (volcanism and so forth) with no trace being left of its state prior to each particular cycle. Each and every part of the earth, writes Lyell, only bears traces up to its last dissolution (2005: 53). For Lyell, the myriad features of the earth were also a way for the earth to keep records of itself. Breaking with previous geological traditions, he suggested that the earth formed its own archive, although its archival process was somewhat inefficient. As a bad archivist, the earth needs a mediator to supplement for its deficiencies. This mediator came in the guise of the geologist; the Man of science who pulled together the information from the traces left by the earth.

Lyell's intervention into geological thinking, Bowker suggests, embeds archival thinking into thinking about the earth. Central to this type of understanding is that all things on earth can be seen as at once objects and archives. As objects, things function in the world, and as archives they maintain traces of their own past. Thus a rock could be rendered as an object that is part of the lithosphere, and equally as a document that contains its own history written into it. For example, striations on the surface indicate past glaciations, strata index complex stories of deposition over time, and so on (2005: 36).Tracing and thinking about traces, it would seem, have been central to the history of thinking about the earth. The leaving and documenting of traces are a part of the way in which theories of the earth have developed over time, but also a part of the practical suite of methods of geologists, as archivist mediators.

Let me return to Bjarni and his colleagues at Orkuveita. As I mentioned in Chapter One, the geoscience team at the municipal utilities company consists of a small group of six that work alongside engineers and other groups on various projects. As self-proclaimed industrial scientists, they think of themselves as practitioners first while continuing to self-identify with the legacy of the discipline of geology. However it is the way in which Iceland intersects with this legacy, particularly as an important figure in the development of geological theory, which they speak about more often.[134]

Talk of doing science within the structures of an organisation, albeit a municipal one is never too far from my discussions about method and standards with Bjarni and some of his colleagues. As Steven Shapin has discussed in his work on industrial scientists at the turn of twentieth-century America, while no science can be considered pure in any naive realist sense, there nevertheless remains more than a hint of a suspicion that industrial settings in some way distort the scientific process (Shapin 2009). The boundary between scientists working out of academic settings and those working out of industrial settings became somewhat blurry during this period, particularly as corporations began to increasingly attract top graduates straight out of university, Shapin informs us. In his analysis, rather than being corruptive of ‘pure’ science, industry-led research centres became cutting edge spaces for scientists to operate, with some even racking up a series of noble prizes to their credit (ibid).

Geology, in particular, has a history of operating within more hybrid knowledge production spaces and has been very specifically bound up with energy extraction since the Second World War. Post World War Two, the major oil companies began to explore the ocean floors in the hunt for new energy, and

[134] In the eighteenth century Iceland was central to debates over the rock cycle, and continues to play an important role in thinking about plate divergence and mantle plumes (hot spots)(Oslund 2011).

brought with them the necessary capital and technologies to achieve their ambitions. Ocean geology emerged as a critical part of these endeavours and it was this intersection of capital and knowledge production that led to several innovations that ultimately transformed the study of earth history (Westbroek 1991:73). Some of geology's most fundamental knowledge claims have emerged alongside and within an energy exploration context.

One such development, the seismic profiling of ocean floors, resulted in the first extensive imaging of ocean floor cartography, an innovation that was crucial in the furtherance of the then nascent theory of plate tectonics. Other developments, such as core sampling from deep sea drilling, helped in vastly extending our understanding of deep geological history, and resulted in the refinement of fossil dating techniques that have been of considerable value in multiple scientific domains ever since (Westbroek 1991:77-81).

So not only is this particular form of exploration capitalism not corruptive of geological science, it could in fact be seen as one of its conditions of possibility. The relationship between energy capital and geology is both historically extensive and, as the world turns more towards both unconventional energy (fracking) and renewable energy, instructive for present times. As producers of geothermal energy, Bjarni and the geoscience team at Orkuveita find themselves caught up in this awkward relationship with energy capital; reliant upon it to develop their suite of methods and knowledge about earth processes, while at the same time uncomfortably constrained by it.

In the last chapter, I discussed the bind that geologists at Orkuveita find themselves in as they continue to arrange the volcanic landscape in the pursuit of steam. We learned that falling pressure has led to a significant drop in energy output at the Hellisheiði power plant, which is a commercially untenable position for Orkuveita. While activating "make-up" wells is one short-term way of trying to address the problem, it is too costly in a company recovering from bankruptcy, and as it turns out, not in itself sufficient; despite reinjection efforts energy output continues to decline. As such in 2013 the geoscience team was tasked with developing more creative approaches.

Their chosen method is what they call a tracer test: an experimental attempt to trace and describe the fracture pathways and flow patterns of the subterranean arteries of the geothermal field. The purpose is to understand what is happening to reinjection water after it is has been pumped back into the earth, asking where the water is flowing and what effects it is having. Geologists are interested in assessing the impact of such water flow on current production but also what, if any, cooling effects this water is having on the volcanic area.

The chapter will be split into two parts. The first is an ethnographic exploration of some of the practices of the geoscience team as they conduct the tracer test. In essence, it is an engagement with my fieldwork with geologists as they conducted fieldwork in Hengill. In this sense it is also a reflection on methods. Sampling water from geothermal wells is a risky task in a volcanic setting. Carried out in all forms of inclement weather, the straightforward purpose of collecting small vials of water from various wellheads creates many difficulties. Geothermal wells emit roaring, vibrant sounds throughout the landscape. In this part of the chapter, I examine the practices of Bjarni and his colleagues through the lens of articulate listening; they ways in which they use sound as a lively acoustic signal to generate the *right sort of data*.

The second part of the chapter has two components. The first analyses how geologists use this data to trace the fracture connections and flow pathways of geothermal's subterranean arteries. It discusses the ways that tracing helps them to *make the subterranean* through response pulses, the temporal rhythms of flowing fluids. As they generate a version of the subterranean that is good enough for them to work with, geologists imagine other sets of relations in an effort to produce analogies about the future. In this sense, tracing is also a descriptive technique. This realisation opens up for, in the end of the chapter, a reflection on the descriptive apparatuses of both geologists and anthropologists and the role that tracing has in the production of analogies.

4.1.1: Tracer Tests and Reinjection

While there was an attempt to carry out a much smaller scale tracer test in Krafla, north Iceland, a few years prior to the one conducted by Orkuveita, it was unsuccessful. "Failure," the expression used by Bjarni to describe the test in Krafla, means that the test did not produce results that were usable by the power station operators. Bjarni seemed convinced that the results were contaminated by a less than rigorous scientific methodology, something he was stringently focused on addressing.

As we learned in the last chapter, reinjection works by putting spent geothermal fluids back into the earth,[135] replenishing the extracted fluid in an effort to re-balance hydrostatic pressure (water pressure). While in the last chapter I introduced reinjection as a direct response to falling pressure, it is, at the same time, part of an upgraded suite of thinking about the environmental impacts of geothermal energy. Such thinking is intended to take account of, and minimise, the negative environmental impacts of the power plant on the surrounding area; namely groundwater contamination and landscape erosion through acidification.

In geothermal operations where hot water production is the main focus, such as Nesjavellir, north east of Hellisheiði, spent geothermal fluids are released back into the open landscape.[136] However, given the industrial scale of Hellisheiði's operations there is a fear that releasing such vast quantities of spent fluids into the lava plains could result in some of the water seeping into and contaminating ground water supplies.[137] In addition, the water becomes highly acidic upon interaction with oxygen and runs the risk of mass erosion of moss and lava formations.

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[135] These are fluids whose heat has been extracted for processing into hot water and electricity production. Such fluids are sometimes referred to as wastewater.

[136] The release of these fluids into the landscape at Nesjavellir over many years has also become an issue of environmental concern.

[137] There are two distinct forms of geothermal energy. Enhanced Geothermal Systems (EGS), also known as hot dry rock geothermal, and hydrothermal geothermal. This latter form is predominant in Iceland and consists of the circulation of hot, minerally intense, fluids within subterranean fractures. Hydrothermal systems form a self-sealing layer of cap rock that enclose and segregate this system from the ground water system that lies above it. The risk of drinking water contamination is, therefore, negligible, and is not a concern for locals or environmentalists. However, allowing vast quantities of reinjection water to run into the landscape with the potential of 'seeping' into ground water supplies is considered too high a risk. Reinjection is one solution to this problem, which, by drilling through the groundwater system and further down through the cap rock, pushes these spent fluids back into the hydrothermal fracture system.

As such the reinjection has become a part of securing the power plant's environmental license, granted as part of its environmental impact assessment (EIA). It is also, as we saw in the last chapter, considered to be a remedy to the problem of dwindling pressure in the geothermal field, and as such has been taken up by Orkuveita as a practice that is both good for production and good for the environment; a rare moment of alignment between environmentalists and the energy industry in Iceland. However, potentially cooling down parts of the volcanic area is an unintended consequence of reinjection that was not envisaged.

As we also learned in the last chapter, it is not the *temperature* of the colder reinjected water that is the problem in this instance, but the *speed* at which this water is flowing through the rock matrix. While some forms of acceleration generate thresholds productive of steam, others generate thresholds that may be cooling down very old rock formations. The tracer test is the geological response to part of the bind that Bjarni and the team find themselves in (both the "need for speed" and the "need to give the earth time").

This test consisted of injecting 100 kilos of a thermally resistant compound called naphthalene sulfonate into six different reinjection wells in Hellisheiði, with each well receiving one of six versions of the compound dissolved in 400 kilos of water. While this initial step lasted a little over two days, sampling the tracer throughout the Hengill volcanic zone's production sites, and the subsequent and on-going analysis of the sampling results, would take the best part of eighteen months.

A cluster-sampling regime was established in which each production well adjacent to any one of the six-reinjection wells was sampled first. If tracer was detected, the sampling moved on to the next set of adjacent wells, and so on. Over the course of the next year and a half, the entire production area of the Hengill zone was sampled (over 1,500 samples in total). My ethnographic engagement with Bjarni and his team began just a few months after tracer sampling commenced, in the summer of 2013.

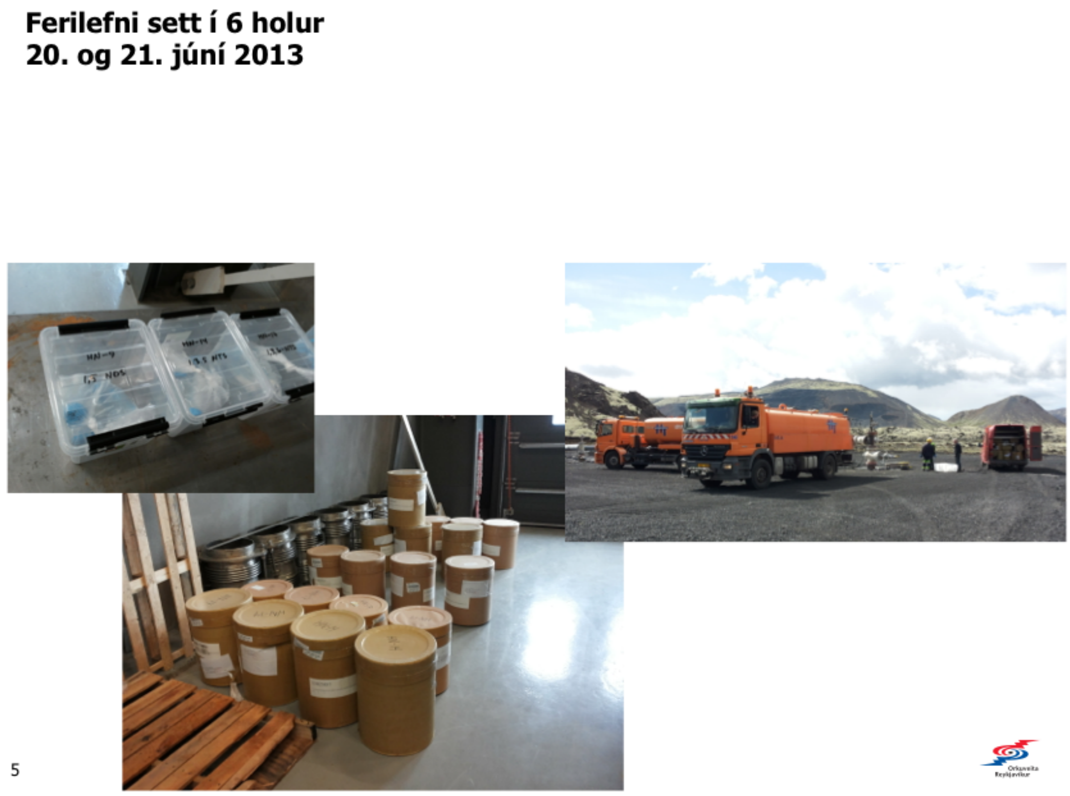

Figure 14: The caption reads: Tracer put into 6 wells on the 20th and 21st June 2013.

Consisting of a rotating team of six persons, sampling activities occurred in all forms of weather, from bright sunshine filled summer evenings, to bitterly cold snowy winter days. Being physically present at the geothermal wells to collect a small sample of fluid in a vial, while sounding relatively straightforward, involved a whole host of difficulties, not least of which was the temperamental, inclement Icelandic weather. Bjarni, aware of my desire to participate as fully as possible, incorporated me into the team as an extra pair of hands, and as a result, I began to learn to relate to the intensive forces of the earth at Hengill.

4.2: Volcanic Acoustics as Method

The landscape begins to alter as Bjarni drives me to the Hellisheiði Geothermal Power Plant from Orkuveita's head office in Reykjavík. The power plant is located a little over thirty kilometres south east of the city, and about halfway there we enter the purview of the Hengill volcanic system, the tectonic host of Hellisheiði.

Dark basaltic lava-encrusted rocks are strewn all about us, and these diminutive craggy structures crawl and blend over and through one another, so much so that it is hard to distinguish where one rock ends and another begins. Stopping to examine them, the amount of detail modulates with scale - the closer one looks, the more one sees. What appears to be one rock gives way to another universe of rocks, and again to another. Nearby, the soot-like colour becomes encased in the most wondrous green, giving way to a flowing, undulating mossy canvas. Walking on this surface the following day revealed it to be soft and bouncy, cushioning the foot that walks upon it; a canvas of light atop a deep dark smouldering inner earth, a surprisingly lively combination that changes hue in a soft subtle fashion as the sun rolls back and forth between the clouds of a standard misfit day in Iceland.

The stories Bjarni and his colleagues tell on these trips to and from the volcanic zone are very similar to the story I recounted from Gretar in the introductory chapter. Days are filled with tales of how geology, politics, and economics intersect with harsh, and at times magical, moments in Icelandic history. The inseparability of the fiery earth with life in Iceland–whether it be volcanic eruptions decimating populations or stories of rock people and elf folk who populate these craggy and mysterious places–have pride of place. The earth in Iceland is unruly, its agency is palpable and it is deeply embedded in ways of living and modes of telling stories.

Figure 15: Aerial photo of Hellisheiði Power Plant, Hengill. Photograph courtesy of Gretar Ivarsson (Orkuveita Reykjavíkur).

We drive past the main entrance to Hellisheiði and proceed up the mountainous pathway leading to the geothermal wells. Fifty-seven wellheads, clustered in groups of four on smaller platforms, are scattered throughout this part of the Hengill volcanic zone. Standing at the highest altitude of six hundred meters, a sprawling energy infrastructure lies beneath us. In today's sunlight the pipes carrying the separated water and steam glisten as they snake there way though the mountain's curvatures. "We've got to put our ears to the ground and try to reconnect the different strings of the area," says Bjarni, "the wells could be acting up, could be misbehaving. Are you ready to sample 30 of them today James?"

The weather is constantly changing up here and at a pace that is difficult to register. At one moment the sun is beaming down creating broad silhouettes over the mountainous landscape, but within minutes the clouds roll in at breakneck speed, the wind gusts up around us, and snowfall beats against our faces. The steam and remnant gasses from some of the wellheads mix with the clouds, showing at higher altitude what is more abstract at lower: the atmosphere is a blending of mixtures that shift and change in form and proportion. One can easily imagine that the people living in the local town of Hveragerði could most certainly come into some sort of health difficulty with both the gasses and the effluent of such minerally intense fluids.

Being up here on the lava plains is visually striking, but for Bjarni being attentive to the cacophony of screeches and rumblings that pierce our ears also matters. He is constantly commenting on the types of sounds that the wells make– "did you hear that, it's screeching, where did that screech come from,"– always trying to locate the sounds, and frequently describing what he hears in battle metaphors.

He describes the fluids in the subterranean fractures that feed the well as "battling or fighting with one another to gain access." The geothermal brine moving though these fractures, under varying temperatures and pressures, finds its way into the well chute, phase shifting and exploding up to the surface through the wellhead, and on into the piping infrastructure for distribution. Screeching is positive, albeit frightening; screeching is what happens when high temperature fluids make their way up the three kilometre directionally drilled wells. Sometimes the sounds come at regular predictable intervals, but then abruptly change to irregular ones, pulsating, then roaring, and Bjarni pays attention to all of them. *This is the sound of phase shifting fluids as they interact with the extraction technologies*

The pipes of the well shake intermittently, yet violently, spasming and wobbling as dense, thick steam billows out. I can feel my own descriptive categories beginning to mimic Bjarni's as I imagine these fractures as subterranean creatures wrenching in pain as their world is disturbed, altered, sucked up and spat out by the drill tentacles. Pressures change, the high seeks out the low as a connection is made between the inner of the earth and its gaping exterior. Then the noise stops for a moment, pulsates and screeches again, but a little differently. The wellhead sits like a small silver igloo atop the blackened lava encrusted earth (figure 16), the pipes connected to it are rusted and thick and they pulsate and screech as fluids flow through them.

Moving through the sampling pattern, cluster by cluster, the sense of power, risk and fragility become bound together, as I awkwardly shield my face every time I pass by one of the thundering wells or large steam emitting pipes, knowing of course that in the case of disaster the gesture would be futile. The power and the attempts to arrange it are extraordinarily palpable here. The fiery earth is right there, right beneath our feet and how it rumbles as we stand here above it, trying to trace some of its inner workings. But as recounted in the last chapter, the earth is not just a thing, an earth, a singular entity; it is a whole series of differentiating forces that play out as heat and pressure boil and explode water and steam out of the subterranean fractures and into and up through the wellhead.

The turbulent capacities of the earth respond to geothermal process, and Bjarni and his colleagues heed these responses. What I want to relay in this segment is that listening to, or taking account of, sound is one way of doing that. Sound emerges as the differential capacities of heat and pressure respond to the well and piping infrastructure, as excessively hot fluids "fight" their way out of the fractures and up through the wellhead. For wells that go offline and are temporarily disconnected from the system, a silencer is needed, as screeching, roaring fluids go sonic, breaching the sound barrier to emerge over ground.[138] "Putting our ears to the ground to reconnect the different strings of the area," as Bjarni puts it, is, I argue, a lively acoustic method of generating data in the volcanic landscape.

4.2.1: Generating Data

I sample well HE16. Unlike on previous occasions I am now allowed to go to the well alone. I attach the separator to its connection point, protruding out from the rattling and rumbling blackened and rusted pipes, and turn it on.[139] It is not as easy as it looks, HE16 screeches, emitting copious amounts of steam, but no water.

[138] As we learned in Chapter Two, geothermal wells, once drilled and activated, cannot be turned off in any strict sense. All wells are connected to the piping infrastructure, operating at 7 bars of pressure. When a well needs to be cleaned or undergo maintenance it goes offline, that is, it is temporarily disconnected from the system but continues to produce fluids. These fluids are routed to what is called a Silencer, a large container like object that dampens the sonic sounds. Even with the Silencer in operation, the sounds are incredibly loud and penetrating. On several occasions, I literally felt as I my body could not handle the force of the sound as I began to vibrate along with it.

[139] In order to take a sample of fluid from the wellhead, a separator needs to be connected to the larger piping infrastructure. It is a small one-meter implement that fits onto the foremost section of pipe. As a mobile add-on it allows geologists to sample fluids at the wellhead without disturbing the flow of fluids through the pipes on their way to the plant.

Figure 16: Geologist at geothermal wellhead, Hellisheiði, Hengill. The wellhead is the igloo like structure to the left of the picture. Following the thick pipe rightwards, there is an additional segment wedged between two pipe sections. The separator is attached here to access fluids. In the background to the right is the silencer.

Figure 17: Geologist at geothermal wellhead, Hellisheiði, Hengill.

I become frustrated at not being able to do it right. I open the valve some more, I get more steam, again a little more, but more steam and more bellowing, and at this point the pulsations are frightening. I turn the valve off again, it calms down, I compose myself, and once again turn it on, slightly; it pulsates and screeches as if something really ugly is on the way up.

The pipes not only vibrate, they leap with each belch of the earth. My ears are pierced, the steam is dense, full, thick, the smell is all encompassing, penetrating all of my pores, my mouth and my nose simultaneously. The wind is blowing the steam directly into my face, but it’s too hot. I have to try and reposition myself as I saw Bjarni do on many occasions, but I can’t, and need to call for assistance. While collecting a small quantity of water in a vial looks like a relatively straightforward procedure it comes with a learned, embodied way of being around these wells in this landscape, and I am just a novice.

On another sampling day a month later, snow is everywhere and ice has formed at the separator apparatus. I try to stretch my arm and contort my body as if playing Twister, head as far away as is elastically possible. Bjarni saunters over. “What’s the problem?” he asks. “There’s no water,” I bellow. He takes a look, reaches over and turns the valve off. “Wait, listen, then after the noise has passed, turn, gently, that way you’ve more chance of getting water.”

Then ever so gently he performs his own instructions, adjusts the valve even as the wind howls and the snow beats against him. Steam pushes out the top half of the separator and trickles of water flow from the bottom end. The noise is now minimum. “There, see, easy, slowly,” he says. “Hmm, like that,” I mumble. Doing this for some time, Bjarni knows how to listen, how to recognize the sounds that come from the wells. He knows the differentiating sensorial forces of the earth, and how to treat pipes to get water, even if they are excessively temperamental.

Geothermal is a process of opening up the access pathways of the subterranean rock fractures, encouraging the flow of excessively hot fluids. It is a process of attempting to arrange turbulent overground-underground relations; an arrangement of liveliness transformed towards particular arrangements of living. The geologists of Orkuveita work at the coalface of geothermal living, mediating these overground-underground relations, listening intently to subterranean responses as they try to arrange with, rather than against, the seismic landscape. According to Bjarni these shaking, sulphur rusted pipes are too complicated and too expensive to replace, so the workers have to take their chances. This is what is required to take tracer samples from the wells, as fragile, rusty and blackened pipes–elements under strain from the rumbling noisy inner earth, wind, snow and ice–are negotiated with minimal protective gear. New relationships are being formed, subterranean, and the uncertainty of the forces of the earth make tracer sampling risky work; screeching fractures don't play to anyone's tune but their own, as the wits of an acoustic method guide us through.

It did take me some time to understand what Bjarni meant however: why the need to listen to the pulsating responses of the fractures, to wait for the intense sounds to pass? Why does this give more water, and why is this significant? Caring, almost obsessing about the method, Bjarni consistently talked about the only other tracer test conducted in Iceland several years prior, and how it became a "bit of a mess." The mess revolved around how they treated, or did not treat, the relationship between water and sound. Again and again, Bjarni had to impress upon his team that not all water is the same. For him, sampling is first and foremost a process of trying to identify a specific version of water: tracer water.

The chemical naphthalene sulfonate was considered the optimal tracer for these tests due to its thermal resistivity; it can survive the excessive temperatures of the subterranean. It can also 'live' in minute amounts of water that can be transported from well to well by the samplers, so they can unwittingly become an alternative vector, a substitute route that needs to be protected against or in some way excised out of the process.

Migrant water from other wells can easily be present on the gloves, clothes, and instruments of the samplers, and as such can contaminate the sampling process. Bjarni, in his own words, had "too much stress and sleepless nights thinking about all the test results being useless because one of the guys was careless about their gear." In each wellhead, Bjarni left a pair of gloves and a separator head, to be used at that well only. All of the other accoutrements of the sampling process were stocked up in the jeep for each trip, including boxes of new IKEA glasses to hold the water in, as well as vials and labels used to transfer the water from the wells to the lab.

So for Bjarni being careful about water is crucial to the entire process, and taking precautions against migrant water is one step he can make. However, even when the risk of migrant water is minimized, there is still a concern that the sample may still not be the *right* version of sampling water. This is where sound emerges as integral to sampling. Steam, being lighter than water, moves through the system more quickly. When the separator valve is turned on, steam is usually the first to emerge through the pipes. Here is Bjarni again:

> It is very possible that the well will convulse and pulsate, sending up a huge quantity of steam. If that happens then most of the fluid that comes out of the separator would be steam that has condensed into water upon touching the colder exit pipe. Naphthalene sulfonate does not show up in steam, only in water, so its possible that a portion of the fluid we get from the separator could be this condensed steam. That would dilute the tracer concentration of our sample, meaning that what shows up in our sample might not represent what is present in the well.[140]

What this means is that the water we collect in our vials may not be the right type of water: tracer water. Not getting the right version of water leads to strange and unusable data, as was the case in the previous tracer test in the north of Iceland. Monitoring the response pulses of the well and taking the sample after, or between pulses, was, despite seeming insignificant, an important part of tracer sampling. Bjarni has set up an acoustic method to cut away other versions of water so he can get at the right type of data (tracer water).

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[140] Bjarni also instigated a periodic control check on the sampling process. Taking a second sample at particular points during the day, the chlorine content of the sample was analysed as a way to check the ratio of water to condensed water (steam). If the sample has, for example, 100 ppm of chlorine and the well has a given chlorine content of 200 ppm then the inference is that the sample, containing half the usual chlorine, is 50% condensed water. As neither chlorine nor the tracer molecule Naphthalene sulfonate show up in condensed water, chlorine can function as a proxy for the tracer. In this instance the tracer recovery rate in the fluid of that sample is adjusted by this quantity, that is, it is doubled. This can then be compared against the tracer content of the original sample and an average variation can be established as a correction mechanism.

4.3: Sound Signals and Articulations

One way of trying to think about these sounds might be to talk of a volcanic soundscape. Tim Ingold critically engages with what he calls the ‘scaping of objects,’ an overly dominant tendency to think objects analogically through landscape. For Ingold, the power of the prototypical concept of landscape lies in the fact that it is not tied to any particular sensory register, whether vision, hearing, touch or smell (2007: 10). Weary of this ‘scaping’ move, Ingold offers several reasons not to think of sound through the metaphor of soundscape. By way of an analogical critique, he comments on how visual culture scholarship comes to the visual through the production of images, and particularly through focusing on the relationships between objects, images and interpretation. But what they lack, for Ingold, is ‘an engagement with the phenomena of light’ (ibid). Ingold pleads for scholars of sound to avoid a similar trap by encouraging them to engage with the phenomena of sound, but not just through sound recordings. This prompts Ingold to suggest that as light is not something we see, but something we ‘see in,’ sound is not something we hear, but something we ‘hear in.’ Sound is not an object, he suggests, but a medium through which we move (ibid: 12). This is one way to think about the sounds of the volcanic landscape.

Elsewhere Ingold makes a similar point, stating that ‘thunder is not an object that makes a sound, but is its explosive sound’ (Ingold 2010: 247). This helps me to think of the volcanic landscape not as an object *making* a sound, but *as* sound. However, this is also where I begin to part company with Ingold. While I want to hold onto his general relational thrust, thinking sound as a set of relational effects, I find it harder to go along with his slightly excessive use of analogies and dichotomies as he brings the reader through a thicket of structured resemblances. Analogising sound with light seems to hold for the purpose of his argument, but he then moves on to think sound with wind, suggesting that sound does not stay put, but flows like wind. ‘To follow sound’, he writes ‘to attentively listen is to wander the same path, the opposite of emplacement” (ibid: 3).The sounds of Hengill are not the ‘opposite of emplacement,’ as Ingold puts it, they are very much emplaced; located through a very particular set of relations. This is neither the ‘natural’ sounds of, for example, birds or wind, nor human sounds of, for example, technical recordings.[141] Rather, the volcanic landscape emerges as sound through sets of differential, phase shifting forces as they work their way out of the subterranean through a technological apparatus of extraction.

Thinking of sound as emerging through set of relationships between and within earth processes, humans and technologies of extraction is partly inspired by a fascinating recent article by Stefan Helmreich. Helmreich's article takes its point of departure from a recent event in which U.S.-based astronomers at the Laser Interferometer Gravitational- Wave Observatory (LIGO) announced that they had detected gravitational waves; vibrations in the substance of space-time (2016).When they made the detection public, the scientists had translated the signal into a sound, a 'chirp,' a sound wave swooping up in frequency, indexing, scientists said, the collision of two black holes 1.3 billion years ago. While gravitational-wave phenomena are not acoustic, translating them into sound can aid in judging a signal's significance. While the data can also be read visually on graphs, listening to them adds another dimension; 'the ears pick up what the eye sometimes misses' (ibid : 479).

The LIGO detector is a massive device distributed across two physical sites and is constantly vibrating owing to seismic, ambient and quantum fluctuations. For signals to be discerned at all (by machines or people) the ambient noise or hums of the detector have to be controlled, or held steady. To make sense of the data scientists need to develop an 'articulate form of listening.'[142] Helmreich cites an informant, Evans:

> We listen to the sound, and when the detector is 'locking' to get the control systems operating, it thumps with a particular pattern – it clicks and bumps, and things like this, going through various transitions. And then at some point you get a nice humming sound from the detector. That's sort of a peaceful moment, when you know you have things operating in a happy state….We use

[141] This is one of several dichotomies that Ingold establishes.
[142] Helmreich asks, who or what is doing the listening in gravitational-wave astronomy? The discipline itself (in opening its ears to the cosmos), the LIGO experimental system (the detection system), a computer algorithm, and the scientists themselves, he suggests.

> our ears to diagnose the performance…..There are things which happen in the spectrum, but without thinking about it, you can listen to it, you hear the clicks and bumps very obviously (ibid : 481-82).

Listening here is critical, it is a learned process and it gives, as Helmreich puts it, 'a sense that something is happening.' Listening for the pattern of the detectors thumps and bumps as it goes through various types of transitions is what allows these scientists to diagnose the performance. 'Once noises are stabilized it becomes possible to detect a signal' (ibid : 482). Articulate listening, for this group of scientists, is an acoustic method which helps them to 'make sense and sensibility from signals' (ibid : 479).

While this group of astrophysicists set their ears, and instruments, towards the cosmos, the geologists at Hengill put their ears, and instruments, "to the ground," as Bjarni put it a little earlier. Both have developed an articulate form of listening that helps them make certain sound distinctions in order to generate better data. For Helmreich's scientists, transitions in the detection equipment are part of what's important. While the focus for Bjarni and his team is the moments between phase transitioning fluids as they accelerate and roar out of the earth and into the wells. This is the signal that activates them to either wait for such a roaring sound to pass, or turn the valve on. This *sound signal* is what enables them to get the right type of water.

Helmreich also argues that gravitational wave detection sounds are not acoustic emanations of the cosmos; rather, they are types of 'articulations.' For Helmreich these articulations are not just speech acts; they are also ways of thinking about how sound is translated and is linked through various entities (astrophysics as a discipline, the LIGO detector, computer algorithms, and the scientists). As a certain type of connection, articulations can make a unity out of these different elements. As such, Helmreich suggests that gravitational-wave sounds emerge from semiotically and technologically specific articulations of humans with machines with nonhuman phenomena (ibid : 467).

Thinking with the idea of articulation is helpful. What I initially thought of as *sounds of the landscape*, describing them as rumbling, guttural, screeching, roaring, pulsating, and sonorous, I can now think of as *articulations of the landscape* through earth processes, humans and technologies of extraction. The sound that emerges through these articulations is neither *the* sound of the subterranean, nor *one* sound of the subterranean, but a version of the subterranean in sonic form; a lively sound signal that allows for a set of distinctions to be made generative of the right type of data (tracer water).

4.3.1: Sensory Methods

Trekking between overground wells taking small fluid samples, listening attentively as they go, is the primary method of the tracer test, as geologists attempt to generate the right type of data in order to trace the underground flow of geothermal fluids. As we have seen, an important part of this is they way they sensorially engage with the volcanic landscape in all of its facets.

In her book, *Doing Sensory Ethnography*, Sarah Pink outlines the history of anthropology's engagement with the senses, from a more classic focus on senses as the object of ethnographic attention, for example mapping out the sensory orders or sensory profiles of indigenous groups, to a more methodological position of engaging with the senses as an embedded part of ethnographic practice (2015: 3-25). Pink makes a pitch for 'emplaced ethnography,' as a way of thinking beyond theories of embodiment that have dominated recent discussions of the senses in anthropology. Arguing that ethnography is a multi-sensorial practice of engagement between bodies, places and materialities, Pink points towards the need to attend to the sensory knowledge making practices of both researched and researcher (ibid : 28).

Thinking about the role of the senses in place-making allows Pink to draw upon ideas of landscape and place from authors such as Doreen Massey and Tim Ingold, as a way of re-thinking ethnographic process as emplaced (ibid : 33-37).[143] However, while drawing on such landscape ideas, Pink has little to say about the practices of those operating within landscapes. Here I am thinking particularly of scientists. While it is well understood that individual scientists bring their own

[143] This is Pink's reading of Ingold, but as I have just outlined he argues that to follow sounds is the 'opposite of emplacement.'

subjectivities to research processes, sensory knowledge production of the environment is a topic that has been addressed in the anthropological cannon, for the most part, through a focus on indigenous peoples' relationship with the environment.

However, more recent work has moved towards engaging with the role of the sensory in scientific knowledge production. Carla Hustak and Natasha Myers, analysing Charles Darwin's study of Orchid reproduction, push back against the image of scientists as detached, objective observers. They note, through the ways in which Darwin 'moved with and was moved by Orchids,' how scientific knowledge can be formed through intimate interactions with the object of study (2012). Again, Natasha Myers shows how sensory interactions, while considered peripheral, can be crucial in cultivating scientific expertise. In her ethnography of a protein-folding class, Meyers suggests that students have to be wiling to let molecular models instruct their bodies so that they can 'embody the fold' (2009: 188). In effect, they have to learn a particular mode of embodiment in order to become experts in their field. Similarly, when Jessica O'Reilly explores the intimate engagements of field scientists with ice in the Antarctic, she highlights how ways of sensing ice are not primitive, elemental or instinctual, but are bound up with scientific expertise (2016: 30). In particular she talks of the difficulties in predicting the future of the West Antarctic Ice Sheet, and how expert advice is elicited through informal methods of ice sensing, beyond traditional quantitative data and scientific observations (ibid : 38-40).

Approaching the wells to collect water necessitates being careful in this landscape, as wellheads rumble and screech from exploding fluids, and noxious carbon and sulphur gasses linger all around us. That we used our wits and our bodies as sensory tools for protection came as no surprise. What was surprising however, was the ways in which the senses became part of a methods assemblage, not just for me, the anthropologist, but also for my geology companions. They taught me how to listen, not just to them, but to listen specifically, and attentively, to landscape sound articulations. Attentive listening was a way of generating usable data for both of us.

Working on the lava plains in difficult, risky conditions taught me an appreciation for the forces of the earth and the processes of geothermal, but not just as background information for contextualizing further stories. Bjarni and his colleagues took the various forces of the earth seriously as signals, not just to protect themselves, but as a sensorial way of generating data. Working on a volcanic site, its array of signals are a part of what it is, and Bjarni, and I took these signals seriously in our analysis.

4.4: Ontological Signals

While Bjarni and his team carried out the difficult job of taking fluid samples at Hengill, the analysis of these samples was conducted at ISOR, the Geosurvey Institute of Iceland. Here, each sample was analysed in terms of the intensity of its tracer content. The results of these analyses were then modelled and collated into a series of graphs displaying which of the six tracers showed up in which wells, and crucially what time interval it took them to get there.

Bjarni and his team referred to this in terms of *response pulses* (figure 18). That is, the time it takes the tracer to pulsate through the system after it has been reinjected back into the fractures. The amount of tracer that shows up at each production well, its recovery rate, is plotted on a graph relative to the time it takes to get there (figure 19).

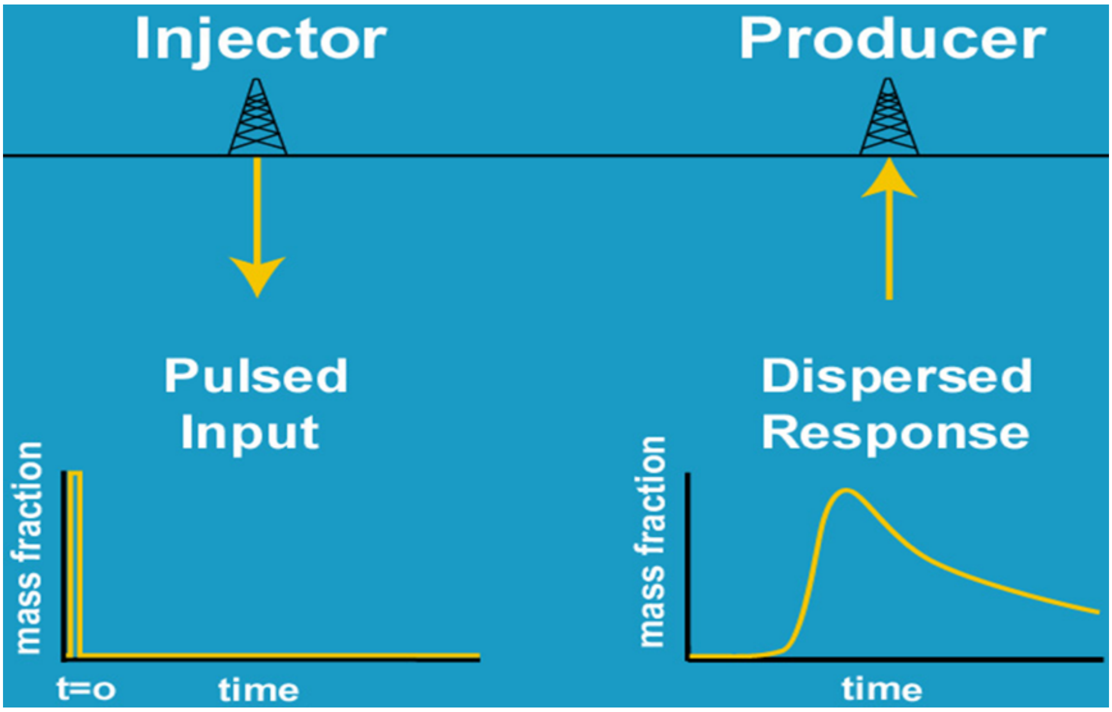

Figure 18: Response Pulses

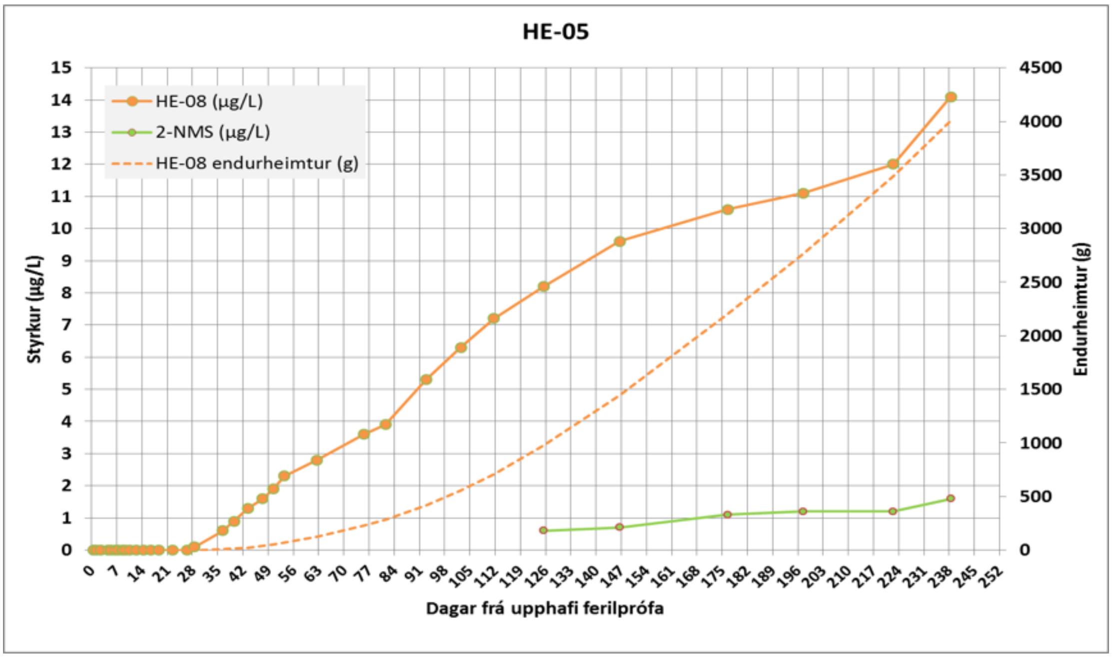

Figure 19: Recovery rate of tracer injected into reinjection well HE-08 showing up at production well HE-05. The X-axis shows number of days while the Y-axis shows concentration of tracer per litre of fluid. The large yellow dots on the thick yellow line indicate samples that register a given concentration of tracer arriving at the well after a given number of days. The right Y-axis shows the cumulative amount of recovered tracer from the well. The dotted line is interpreted as a sharp peak. Each colour on the graph represents a tracer that showed up at production well HE05. Almost the entire recovered tracer comes from reinjection well HEO8 (yellow), with a negligible amount coming from a second tracer (green).

These graphs allow the geologists to develop a temporal profile of each tracer. On the basis of these temporal profiles, the structures that carry the water, that is, the fracture connections and their flow pathways are *simulated.* Guðni, the senior geologist at ISOR, explains it like this:

> The timescale tells us about the properties of the geothermal fractures through which the waters are flowing. And by timescale I mean when you have the peak of the tracer-recovery, how dispersed or broad it is, and how high the concentration is.
>
> Using a simplified model we simulate the structures that carry the water [the fractures and their flow channels]. Simplified because we can only allow for a one, two, or possibly three fracture connections per reinjection well - production well relationship depending on the *signal.* The simulation provides estimates of the volumes of the connections [flow-paths] as well as their surface areas, because we know, approximately, the lengths of the connections. Then based on some common fracture properties, e.g. expected height and width ratio, we estimate the surface areas of these flow paths.
>
> From the flow path volumes and estimated surface areas we can calculate how the reinjection water is heated up by the rocks along the way to the production wells, and thereby how long it will take the wells to start to cool down over time.

This is a very clear, important statement by Guðni. Response pulses are used to generate a temporal profile of the tracer, that is, the rhythms of fluid flow are transformed into a temporal mode (days), and these temporal rhythms are what are used to simulate the fracture connections. Guðni is direct in his assessment of the simulation technique; it is simplified. For example what he calls *strong and clear signal*s (a high sharp peak on the temporal profile of the tracer, figure 19) gives a one or two-fracture connection between the reinjection well and the production well where the tracer has showed up.[144]

In this scenario, the *signals* they are getting allow the connections between areas of the volcanic zone to be simulated in relatively clear terms. On a day when we are having one of our long conversations, I push Bjarni a little on why they use the simulation model that Guðni and ISOR have developed. Particularly given that Guðni characterizes the model as simple. Bjarni explains that Gunnar, Orkuveita's geophysicist, is responsible for the overall simulation model of the entire volcanic area. He is building a program that is extremely detailed and which requires vast quantities of data points, far beyond the limited data that is being generated by the tracer test. While over the life of the project, circa 25 years, Gunnar's model will become the standard bearer, right now, in practically addressing the immediate problems they face, Guðni's model, despite its simplicity, is what they have to work with. Bjarni continues:

> Well, the model is a simplification of reality, I suppose you could call it a more-or-less-reality model. In fact our reality is the reality of the response pulses between the wells. That helps us simulate the fractures, and we imagine some phenomena that could describe this relation, or these relations. That's what we work with.

This phrase, *our reality is the reality of the response pulses between the wells,* is key. Here Bjarni is suggesting that far from trying to represent the subterranean in any holistic sense–an impossible task–they are making a limited version of it that they can work with. Throughout our discussions Bjarni articulates the process as at times fictional, and at other times a simplification of reality, but one that, nonetheless, is real and can be very helpful.

What these geologists and their models teach me is how response pulses simulate the subterranean matrix at specific relational points between reinjection and production wells. Guðni characterises these in terms of signals. In the last

[144] This would be where there is a strong percentage recovery of tracer over a short period of time, that is, a sharp, less dispersed peak.

section we saw how articulated volcanic sounds work as signals to help generate the right type of data (tracer water). Here the role of signals in simulating fracture connections becomes more evident. What I want to suggest is that signals, acoustic (sounds) and rhythmic (pulses) are how these geologists make their reality, how they generate their version of a workable subterranean.

Both Bjarni and Guðni display a nuanced sense of what they are doing, and Bjarni clearly recognises their job as reality-makers of a sort. Their reality is "the reality of the pulses" as he puts it. At the same time they are keenly aware of the limitations of their simplified model, its "more-or-less reality" status. As I mentioned at the start of the chapter, geologists are always working in particularly constrained circumstances given the nature of their work. The features of the earth are, for the most part, traces that help them describe and index a range of other processes (glaciation, rock deposition and so on).

However working in Hengill, Iceland's most continuously active earthquake zone, presents its own set of challenges, particularly as it is being drilled and accelerated in order to provoke particularly explosive reactions. Such challenging and constraining conditions, which these geologists openly acknowledge their complicity in producing, nonetheless make data gathering and hence simulations of the subterranean difficult work. More-or-less reality is a good enough reality in these circumstances.

What I want to suggest is that signals, both acoustic and rhythmic, are how geologists make the subterranean at Hengill; they are subterranean reality-makers. As a rupturing, fracturing, quaking volcanic zone the earth at Hengill is full of lively processes. Walking through this landscape, but particularly in close proximity to geothermal wells, the earth rumbles and roars, as sounds articulate through human, subterranean and technological connections. The earth resonates through these connections, and geologists listen attentively, picking up the earth's sounds and pulses as a way of generating a workable version of that which cannot be directly seen, or directly accessed; there is no 'other' earth outside of that which these signals help geologists to make. While for Helmreich's scientists, articulate listening is a way to 'make sense and sensibility from signals,' (2016: 479) at Hengill geologists need to develop and maintain a sensibility to the various sorts of signals as the earth roars and fluids pulsate throughout the landscape. Maybe one could call these signals ontological, given the type of work that they do, but a 'practical ontology' (Jensen, Gad et al. 2014), attuned to the *ontological signals* that emanate from this place.

4.4.1: Making Analogies

I have shown how geologists are using specific signals to generate a version of the subterranean that they can work with, a version that is good enough for what they need. The primary purpose of the tracer test is to understand what is happening to reinjection water when it is pumped back into the geothermal field.[145] Estimating where the water is flowing to and in what time frame it is showing up allows them to develop production strategies that best optimise reinjection flows. At the same time it also allows them to estimate what, if any, cooling effects pumping vast quantities of water back into the rock matrix is having.

Above, Guðni explains that when they have simulated the fracture connections, they estimate the surface area of their flow paths in order to calculate how reinjection water is heated up by the rocks along the way to the production wells, and thereby how long it will take the wells to start to cool down over time. Bjarni parses this in more analytic terms, saying that simulating the fractures between the wells is a way of imagining fractures as a type of phenomena that can help them describe other sets of relations. Generating a version of the subterranean through tracing is also, then, a descriptive technique that allows geologists to describe other relations between rock, water and heat, relations constitutive of potential volcanic cooling.

Understanding heat relations between flowing fluids and rock is key. In essence, how, over time, reinjection water extracts heat from the rocks as it flows through the subterranean arteries of geothermal. What is crucial is the speed at which reinjection water travels from one area to another. As rock is a poor conductor of heat, it needs ample time to regenerate the heat transferred to the

[145] One of the reasons why reinjection is not re-pressurizing the field in the way that the team had hoped is that a lot of the water is 'disappearing.' There are many possible explanations for this, but ultimately it shows how much uncertainty there is within the entire knowledge making apparatus of geothermal.

water flowing within the rock matrix. The faster water travels, the more heat it picks up from the rocks. In the last chapter, I discussed how Bjarni helped me to understand the way in which accelerating water alters its architecture. As water flow speeds up it moves through phases, from uniform (laminar), to wavy (convective), to turbulent. It is this latter turbulent phase that extracts heat most aggressively from the rock. The inverse is the case for slower moving water.[146]

What is being shown by the most recent analysis from the tracer test is that one of the priority production areas, the mountain Skarðsmýrarfjall (see figure 13 chapter 3, page 105), which lies next to the central volcano, is not recovering from extraction-reinjection practices. In fact, the preliminary results of Bjarni and Guðni's work show cooling that will not only significantly affect production over the course of the next twenty five years (and is already doing so) but will inhibit the mountain from recovering over the next one thousand years.

The tracer acts as a proxy for flowing water because it has, in a sense, different relations with the world. By different relations I mean that as a thermally resistant chemical it does not interact with the rocks in the same way as flowing water, and as such travels more quickly than water through the fracture matrix. In this way its pulse is a form of future agent, simulating not how water acts now, but how water will act several orders of magnitude into the future. Because the chemical signal of the tracer shows up earlier than the thermal signal of the water, analysing the time of the tracer allows geologists to predict the time of the cooling. Bjarni and his team work with a very simplified rule of thumb; if the peak of the temporal pulse profile is, for example, one month, then the cooling will follow approximately 1,000 months later.

[146] Several things affect the speed at which water travels through the rock matrix from one area to another. The quantity and pressure of the water being reinjected back into the fractures (this is dependent on the rate of extraction), the temperature of that water, as well as the quantity and structure of the fractures and their flow pathways between different areas.

The tracer test works analogically then, by creating a specific type of relation with the future, a relation of proportion (1:1000).[147] Telling the time of the tracer today allows geologists to estimate the time of the future; the time of cooling. As I began discussing in the last chapter and have continued here, the geoscience team are very aware of trying to coordinate the practices of capital with the practices of geology. As production rates continue to fall and preliminary results from the tracer test indicate the cooling of the main mountain of the central volcano, the team, in their limited capacity continue to argue to slow things down.

The tracer test is the scientific practice that they are now using to argue for such a slowing down, one that in their estimation of heat relations would give the area more time to recover its heat loss. As the temporal rhythms of the landscape are accelerating, telling the time of the future is one way of creating attention around this issue. In the last chapter I suggested that, as geologists in a bind, the geoscience team are trying to figure out how to coordinate in a landscape with both productive, and disruptive accelerations. Trying to coordinate between accelerations is complex, and the tracer test is one attempt at the 'how' of coordination. It is an experiment in trying to tell the time by tracing the temporal rhythms of the subterranean arteries of geothermal.

4.5: Methods Reflection: Descriptions and Tracing

I would like to finish this chapter by way of a short reflection on methods, more specifically a reflection on the methods of both Bjarni and his team and my own through the idea of tracing. Listening to Bjarni talk about simulations as being "more-or-less reality models" that facilitate imaginative descriptions of relations, struck me as being a quasi-anthropological way to talk.

[147] One way to think of analogies is in terms of proportion, that is, a relation, reference or order of one thing or principle to another. Take the number couplets 2:4 and 8:16. We know that 2 is not 8 or that 4 is not 16, but we do learn something about a relationship or structure that inheres in them which is applicable to other sets of similar number couplets. Another example would be the way a ship produces on the water an effect similar to that which a plough produces on a field. Analogy renders intelligible relations between things, which might otherwise not be obvious. For Aristotle this was to 'perceive the similarities of dissimilars' (Kelly: 1996), which for Wittgenstein was a question of words existing within language games that share a 'family resemblance' (1973).

Geologists have been described as lonely intrepid fieldworkers who work for months on end, away from the comforts of home in harsh and perilous environments. They are also thought to be the type of fieldworker who can find hidden insights in very complex sets of relations (Valdiya 2012: 581-583). Furthermore, what we learn from tracer sampling is that listening is an important part of the method. None of these descriptions are too dissimilar from what would be taken as good anthropological qualities.

While we both (Bjarni and I) work hard to create descriptions that are as 'thick' as possible (Geertz 1973), we are also resigned to a sense of inadequacy in what we do, realizing that the best we can hope to achieve are descriptions that are 'good enough' (Viveiros de Castro 2015). Anna Tsing, commenting on the work of Marylyn Strathern, discusses descriptions in the broader service of generalizing processes. A Strathernian mode of analysis, Tsing argues, is a process of reification for the work of comparison, useful for making cultural analogies, but also serving the purpose of critical reflection. 'Critical descriptions,' Tsing calls them (2014).

Both geologists and anthropologists are involved in the production of descriptions; thick, partial and critical. And both, in varied senses, use tracing as a descriptive apparatus with which to do so. While anthropologists use descriptions to make relations and connections between and within people, places, entities and concepts, geologists, historically, have focused more clearly on descriptions within and between rocky places, their process, and concepts.

In our current era of environmental urgency, both natural and social scientists are beginning to broaden the scope of their research enquiries. In the particular case of geologists and anthropologists, what might formerly have been regarded as the privileged objects of their respective disciplines, namely rocks and people, are now, in an interesting turn, becoming each other's legitimate objects of attention. The role of humans in geological descriptions, and the role of non-humans in anthropological descriptions are becoming more marked.

In the case of anthropology, we trace relations through field-writing experiments, immersing ourselves in both as we move between each (Strathern 1999: 6). We use a host of tools to help us make varying types of comparisons and analogies, cultural and otherwise, which emerge from such tracing. Such tools help us not to invent realities, but to re-invent them as we work our descriptions over and over.[148] I want to pause a little here to think about this idea of tracing as an apparatus of description. In a recent article Valentina Napolitano explores the trace as a methodological tool and theoretical pathway in anthropology (2015). She sets out a genealogy of anthropological thinking about traces and I would like to draw on a small section of her work before moving back to talk more about the tracing occurring at Hengill.

Napolitano suggests that Edward Tylor's evolutionary anthropological work on 'cultural survivals' could be thought of as a study of traces. For Tylor the 'civilized' world is saturated with remainders of the past, physical artefacts that are the remains of a link to the past that dominant history has effaced. In this context cultural survivals are ways of tracing the 'barbaric' in the present; the forms, processes and institutions that remain today, but which sit uncomfortably with dominant narrative forms of history (Napolitano 2015: 49). Here there is a sense of multiple past temporalities co-existing within material objects. Napolitano follows traces through other theorists: for Boas, traces are cultural traits, the bodily forms, gestures and materials that show how cultural forms were distributed and transformed over different geographies at different times (ibid : 50). For Malinowski, traces speak more to cultural lineages and kinship structures and relations, while for Levi Strauss, traces are "a capacity for remembering and imagining after an event has occurred." (ibid : 51). For Michel de Certeau, traces are links to the absences and abjections at play within social formations, grasped through flashes, excesses, impasses; histories of everyday lives. In this context traces are a way of thinking about silences, absences, and alterity, the histories that have never been spoken. They are material reminders of affective circulations (ibid : 52).

In these accounts anthropologists use traces as signs; types of marks, indications, or clues, that index historical forms and institutions, whether they be

[148] One set of tools comes from the literary world, and particularly some of the narrative techniques of both fiction and creative non-fiction. Ursula Le Guin offers an insightful way to think about the art of fiction as the 'bringing of invented characters into an already existing world' (the ordering and patterning of invention). The art of non-fiction for Le Guin is the bringing of 'the recalcitrant world into a story' (the ordering and patterning of descriptions) (Le Guin 2004: 135-138). This is an interesting way to think about anthropology; the ordering and pattering of descriptions through which we bring the recalcitrant world into a story form.

bodily gestures, languages, material artefacts, kinship lineages, or affective reminders of absences. Tracing is a method that affords historically informed descriptions. What is interesting is the temporal orientation, as tracing moves towards the past from an instant of the present.

In tracing the subterranean arteries of geothermal at Hengill analogies also emerge. Acting as a proxy for water, these chemical tracers maintain different relations with the subterranean. As such, tracing creates a specific type of relation with the future, a relation of proportion, as telling the time of chemical tracers today helps geologists to tell the time, analogically, of the future in volcanic landscapes, the time of cooling. Tracing, then, is a type of descriptive capacity, imprinting the future through analogy.

While anthropologists use tracing as a descriptive apparatus through field writing experiments, geologists, in this instance, use tracing as an apparatus of description through field-modelling experiments. Both are concerned with the production of analogies, but to do different types of work with different temporal orientations.

What the small genealogy of tracing in anthropology shows is that while we tend to produce analogies that help us to think about the past through its relationship to the present, geologists at Orkuveita are producing analogies to help them think about what may happen in the future. They too reify, as they produce descriptions that they openly acknowledge to be caricatures of the subterranean, but ones that are useful as *more-or-less reality models that facilitate imaginative descriptions*. These descriptions could be called critical, as geologists, by telling the time of tracer flow, analogically tell the time of the future of the volcanic area.

What Bjarni and his team help to show me ethnographically is how to see time across the human and non-human; time keeping as coordination. As geologists try to coordinate with the practices of capital and geology under the difficult environmental conditions of late liberalism, I try to keep time, or coordinate, with their subterranean practices, as we both attempt to produce descriptions that are 'good enough.'

Chapter 5. Accelerating Seismic Rhythms: “Man-Made” Earthquakes and Temporality

5.1: Introduction

In Chapter Three, I discussed the mechanisms through which capital is being inscribed into the geology of Hengill, and how the rhythms of the landscape have begun to accelerate as a result. Chapter Four ethnographically developed one part of this claim by engaging with the tracer test, as geologists investigate how *volcanic rhythms* are being altered as turbulent fluids have begun to accelerate processes of subterranean volcanic cooling. This chapter will focus on how reinjection practices are accelerating Hengill’s *seismic rhythms*, the tectonic stress built up in the area surrounding Orkuveita’s reinjection site. To do so, I will turn to the relationship between the residents of the town of Hveragerði and Orkuveita as the energy company produce what the town refer to as “man-made” earthquakes.

The chapter has two purposes. The first is to describe the specifics of the practices through which Orkuveita are derivatively producing “man-made” earthquakes. I will do this primarily by examining a report produced by an expert panel (Bessason, Ólafsson et al. 2012) in 2012 investigating the production of earthquakes in the area surrounding Orkuveita’s reinjection site. As we will learn, this report emphasises the temporal aspects of earthquake production, primarily as a process of acceleration. As such, I will use this chapter to develop a way of thinking about, or conceptualizing, “man-made” earthquakes from a temporal perspective.

The second purpose of the chapter is to reflect upon how the residents of the town are responding to these earthquakes. In particular, I will discuss the ways in which the future is being anticipated, both by the residents of Hveragerði and by Orkuveita. As multiple versions of the future come into play, anticipating the future becomes a way to make particular claims about the legitimacy of volcanic interventions. I argue that a form of temporal politics is being practised in which the future has become a site of political contestation. This chapter also, therefore, serves as the starting point for a discussion of geopolitics that will extend into Chapters Six and Seven.

5.2: Seismic Disturbances

In Chapter Two, I discussed the way in which geothermal energy is performed at the Hellisheiði Visitor Centre. As I recounted, the upper floor of the centre performs geothermal *extraction* as a neatly fitting component of fluid circulation *at a hydrospherical scale*, while the lower floor performs geothermal *reinjection* as the balancing work necessary to the extractive interventions of humans *at a subterranean scale*. This is the version of geothermal that the world gets to experience, one large story of circulation and balance.

On another day at the Visitor Centre, Gunnar, Orkuveita's geophysicist, gave a more nuanced version of the processes of geothermal than the one I had experienced with the tour guide some weeks before. In this performance, Gunnar lets us in on another, more turbulent, version of geothermal production.

A large group of European seismologists have gathered at the assembled chairs on the second floor of the Visitor Centre. On a trip to the power station as part of a seismology conference in Reykjavík, Orkuveita have agreed to give the group an information talk about some of the more challenging seismic issues that they have been dealing with over the last couple of years. Gunnar, the team member who has published most on the processes of reinjection at Hellisheiði, has agreed to give the talk. The title that pops up on the PowerPoint as I sit patiently amongst the seismologists is *Temperature Dependant Injectivity and Induced Seismicity*.

Gunnar begins by laying out the history of Hellisheiði, its operational details and capacity, as well as giving a very short overview of the geology of the area. His presentation mirrors, in broad strokes, the story of circulation and balance that all of the audience have become familiar with through the tour of the Visitor Centre they have just taken.

Reinjection works by putting most of the extracted fluids (80%) back into the earth, re-balancing the hydrostatic pressure (water pressure), while protecting the groundwater from contamination as well as the lava landscape from the acidic effects of the water. In general terms this creates a balance between production and reinjection.

“But there have been problems,” Gunnar tells us. Although hot water should flow more easily into the subterranean (as it is more viscous than cold) the 120-degree reinjection water is full of silica, which scales and clogs up the reinjection wells, impeding downward flow. As reinjection is a pre-condition for the power plant’s environmental license, no reinjection equates to a halt in operations. Gunnar tells of the many months of panic and ensuing experimentation that led them to what he calls a “relatively simple solution:” take cold condensed water (formerly steam) and mix it with the hot water to give 60 degree silica free, reinjectable water. While this works, it has a couple of side effects, one of which is ‘induced seismicity.’

The atmosphere in the room shifts, the seismologists visibly excited by the change in language from injectivity to seismicity, a sensation I share.

“So it’s a type of fracking?” asks one Italian seismologist.

“Well, no not really” answers Gunnar, continuing,

> with fracking the pressure at the well head is about 300 bars and that’s what breaks the rock. We’re only operating at 7 bars (applied pressure 25 bars), so there is absolutely no reason to expect seismic activity from the pressure. It’s the temperature change; it’s what we call *thermal shock*. The colder temperatures contract the rock face and cause further permeability. It’s this enhanced permeability that allows the water to flow down with much less difficultly than before. This is also good for further production activities.

In a previous discussion with me, Gunnar put it this way:

> The company never viewed earthquakes as something dangerous or something that we should be careful about. At the start they viewed them as something very positive. For us earthquakes mean that we have permeability and that we have active faults that will open up and will create even more permeability. And permeability, from that perspective, is good, it opens up more fractures and more fluids can flow, it’s a good activity.

What we learn here from Gunnar is that earthquakes have become a prerequisite of reinjection. The production of earthquakes is a necessary part of the reinjection process. Without thermal shock, reinjection cannot work, and without reinjection Orkuveita cannot retain its environmental license. In addition, earthquakes are considered 'a good,' a positive fluid-inducing activity.

Back at the presentation one seismologist quizzes Gunnar, "But is it just the temperature change, the area would have to be under serious stress already, wouldn't it?"

"That 's my second main point," Gunnar replies, and proceeds to tell the group about how the original reinjection zone, planned for Gráuhnúkar in the southwest of Hengill, was switched to Húsmúli in the northwest of the volcanic zone. When routine testing of fluids from the proposed reinjection site at Gráuhnúkar displayed a higher than expected energy content, a strategic decision was made to convert this area into a production zone and reinject fluids in a place called Húsmúli in the northwest instead (figure 20).

Figure 20: Aerial Photo of Hengill indicating key locations (Hellisheiði, Gráuhnúkar, Húsmuli, Skarðsmýrarfjall, Hveragerði. Image courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

As we learned in Chapter Three, the lower than expected yields of the three wells located in the mountain of the central volcano, Skarðsmýrarfjall (figure 20) meant that the entire project was under pressure to live up to the agreed energy output with Century Aluminium. Such pressure was a critical part of the decision to switch reinjection location. Gunnar continues,

> As most of you already know, Húsmúli is the western most boundary of the South Iceland Seismic Zone (SISZ), a fault system running from the Hekla volcano in the east of Iceland towards Hengill (figure 21). Every hundred years or so we have some earthquakes on this fault system, called the southern earthquake cycle (*Suðurlandsskjálfti*). Normally the earthquakes start on the eastern part of this region then shift westwards. There was an earthquake in 2000 and another one in 2008, and it is estimated that over half of the stress has been released to date.

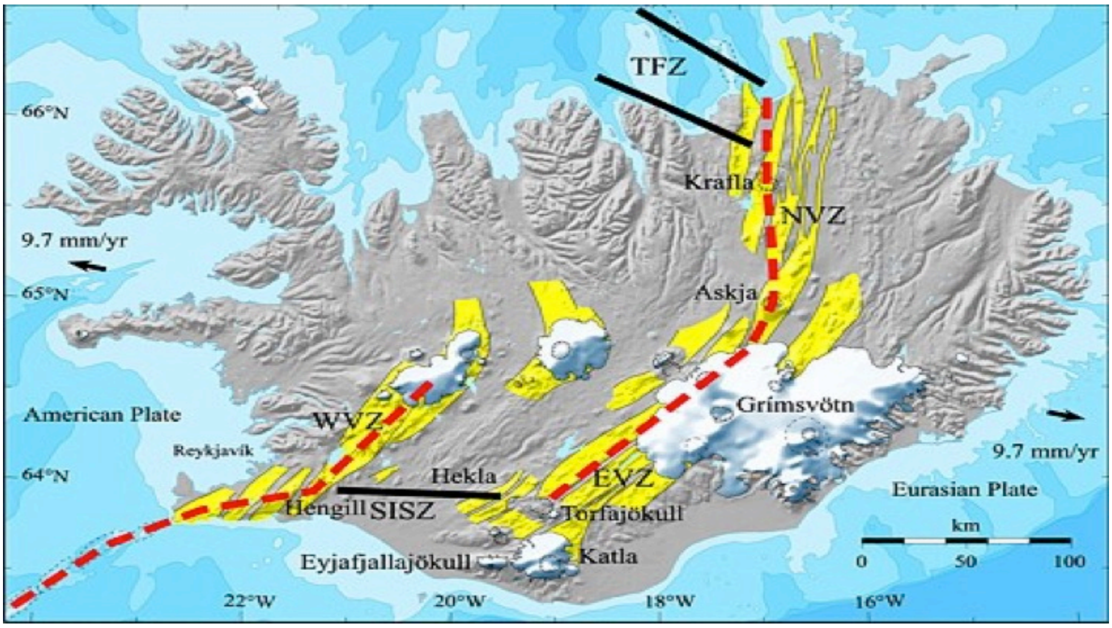

Figure 21: The South Iceland Seismic Zone (SISZ) is a micro plate (thick black line) between the Western Volcanic Zone (WVZ) and the Eastern Volcanic Zone (EVZ). It releases built up lateral stress cyclically, known by the name Suðurlandsskjálfti (southern earthquake cycle). The Húsmuli reinjection site in Hengill lies on the western tip of the SISZ.

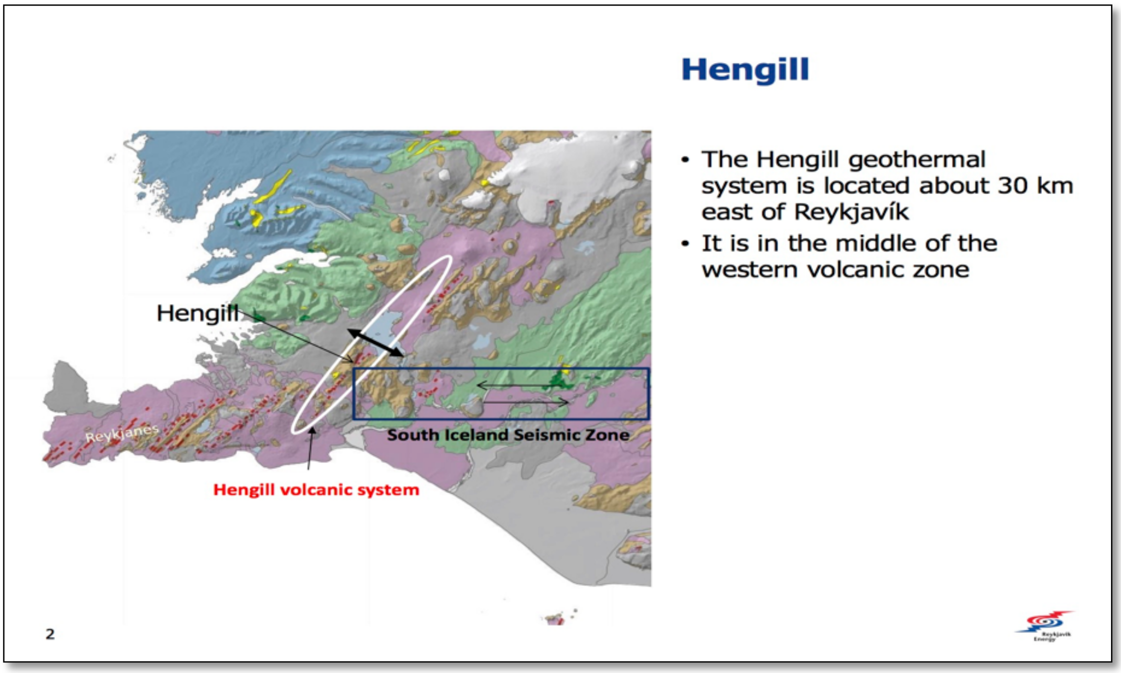

Figure 22: South Iceland Seismic Zone (SISZ). Image courtesy of Einar Gunnlaugsson (Orkuveita Reykjavíkur).

The seismologists begin to talk amongst themselves in a slightly agitated manner. One asks, “Just so I understand properly, are you saying that you are directly targeting the fault zone of a fault plane under critical stress?”

“Yes,” replies Gunnar and proceeds on to talk about the intense period of induced seismic activity that occurred in the period from October 2011 to May 2012. Over 4,000 earthquakes in all, several of which were over 4 in magnitude.

“But when we really started operating the reinjection site at Húsmúli,” continues Gunnar, “we got much more earthquakes than we had ever thought of, and much bigger. These quakes were felt in the village of Hveragerði and people were complaining about this and well in short, this was a complete public relations disaster.”

Gunnar’s characterisation of the matter as a public relations disaster provokes another response, with another seismologist suggesting that maybe it is a little more than just a public relations issue; after all, "earthquakes of over 4 are no small matter."[149]

Gunnar goes on to tell the assembled group that Orkuveita's assessment is that reinjection is inducing a seismic response, which is acting as a trigger mechanism for already in situ naturally occurring processes.[150]

> As I just mentioned, we are not pumping down the water under enormous pressure, so we are not introducing much energy, we are just somewhat speeding up natural processes. *We are not really creating any earthquakes; we are releasing earthquakes that would happen anyway*.

The effect of reinjection, in this rendering, is to release what would otherwise occur 'naturally.' Gunnar is, I realise after several follow up conversations, careful to avoid the language of causation, or generation. Releasing, or as other geologists have put it to me, triggering, is about speeding up, it is a process of acceleration, not causation**.**

Gunnar's continues on, commenting that Orkuveita's actions may, in fact, be beneficial to the residents of Hveragerði: by releasing the built up stress earlier, he suggests, they are most likely reducing the magnitude of the already under way 100-year naturally occurring *Suðurlandsskjálfti* (southern earthquake cycle). For Orkuveita, on whose behalf Gunnar speaks, "this is evidenced by the decrease in induced seismicity over the last year." Upon uttering this last sentence, multiple hands shoot up from the audience. Gunnar selects one. This time a French seismologist comments:

> Well sure, if the system is in a critical state, then extra activity will bring it over the threshold. But just because the quakes have died down for the moment

[149] I do not read this comment by Gunnar as one of indifference or disregard for the plight of the small town of Hveragerði. Instead, I see it more as a compromise statement from a man who is trying to create an ironic distance to the company that he is representing, but whose actions he personally sees as difficult to justify.
[150] Geologists talk of stress level changes in 'in situ' rock.

doesn't mean that all the stress has been released. They could have just triggered a tiny part of what's to come.

5.3: Island of Power

As I mentioned in the introductory chapter, the small town of Hveragerði lies roughly ten kilometres south east of Hellisheiði, located in the southeast corner of the Hengill volcanic system. The town has been formed around the power that emanates from the earth–its geopower–and its history is a story of people trying to live from and with the bounties that this power has to offer. Upon my initial arrival, the town's local historian, Njordur, took me on a walk through the neighbourhood. He points out, using the very visible placards that litter the town's primary tourist spots, how these earthy powers have generated experimental approaches to living and industry.

Both a dairy and wool factory attempted to harness the heat of the water and power of the steam at the start of the twentieth century. While both enterprises failed, they did attract enough of a critical population mass so that more permanent settlement on this "inland island," as Njordur describes it, could take hold. Inland towns are a rarity in twentieth century Iceland as the majority of townships could only ever survive in close proximity to fishing grounds.

A housing crisis in Reykjavík in the 1940s led a group of artists to resettle in Hveragerði, giving it a reputation as a place where free spirits could come to practice their art, all the while heating themselves for free and growing their own food. It is this latter endeavour, horticulture, which remained the town's focal point, as the warmer soil gives the possibility of growing in a country severely lacking in cultivation opportunities.

The National Horticulture Institute, later to become a campus of Iceland's Agricultural University, was located in the town, and since then greenhouses have become its signature enterprise, with cucumbers, peppers and flowers benefitting from the next-to-free heat that emanates from the earth. Wanting to capitalise on the potential of its geopower, the town became an autonomous political entity in the 1940s, separating itself from the broader municipality, Ölfus, whose lands continue to physically encircle Hveragerði.

This move, it now turns out, is a source of consternation for the town. In the early 2000s Orkuveita signed a land lease deal with the municipality of Ölfus to develop the Hellisheiði Geothermal Power Plant. While Hveragerði is by far the closest township to Hellisheiði, the volcanic area is technically under the use rights claim of Ölfus.[151] As we walk Njordur comments, "while Ölfus get all the benefits of the energy deal, we only get the problems;" an island of power without any power.

5.4: Earthquakes and Disasters

I want to use this section to consider how best to situate the seismic disturbances underway in Hengill and Hveragerði in terms of literature that speaks to earthquake issues. The majority of anthropological work dealing with earthquakes comes under the umbrella term Disaster Studies, which has a particularly concentrated focus on human vulnerability and resilience (Oliver-Smith 1999, Adams, Van Hattum et al. 2009).

The literature is clear in suggesting that disasters can no longer be conceptualised as 'natural;' they do not simply happen, suggests Oliver Smith, they are caused (1999). Smith roots causation in the structural imbalances between rich and poor. Breaking away from a former pattern of framing disasters as purely 'natural' events, Disaster Studies literature instead connects these events to socio-economic conditions that structure human-environmental relations (ibid).

What this literature also points towards is the relationship between disasters and politics; disasters become interesting empirical sites for understanding how politics works. In a recently edited collection, Michael Guggenheim summarises the varying ways of thinking politics in relation to disasters (2014). Some approaches, like those above, leave the disaster untouched theoretically, that is, they take it for granted as an event, focusing analytical attention on political responses. Other approaches, in particular those from STS, tend to keep the question of what the disaster is, open.

[151] While the State owns the majority of volcanic landmasses, the closest municipal land area has use rights over the land's development (Ögmundardóttir 2011).

In these latter accounts the ‘naturalness’ of the disaster is bracketed, not just because political processes have a role to play in the production of disasters in the first place, but because science and technology also play an important part in constituting such disasters; there is no way of thinking about of such material disruptions without taking account of science and technology (ibid : 8).

This can be explored through two levels of analysis. First, by examining how science and technology produces disasters as material events through varying types of technologies and ecological interventions, and second by focusing on either risk and preparedness in the face of a disaster, or how risk and prediction practices become a part of the disaster.

While I take inspiration from such STS approaches, “man-made” earthquakes are neither thought of by residents nor categorised by municipal institutions as a disaster, as such. While the southern earthquake cycle (*Suðurlandsskjálfti*) is articulated in such terms, these new disturbances are not. But it is also difficult to think of “man-made” earthquakes in terms of more traditional industrial accidents (Wynne 1988). They are not a specific type of one-off breakdown or failure of, for example, a warning system, but are very much embedded in extraction and reinjection practices at Hengill.

At Hengill, the role of humans is not just in accentuating or mitigating a geophysical event, culminating in a potential disaster, but in the very activation of events termed geophysical. The question is less one of being concerned with a broader focus on what a disaster is, and more a move towards specifically asking what a “man-made” earthquake is.

This has led me to think that literature around fracking might be of more help. There are some interesting similarities between fracking and what is occurring in hydrothermal geothermal at Hellisheiði. As Elizabeth Cartwright explains, fracking is a process of blasting large amounts of water, sand and chemicals into underground formations where natural gas is found with the purpose of inducing seismic effects (earthquakes) in order to release the flow of gas. The primary consequences of which are contamination of underground sources of drinking water along with air pollution (Cartwright 2013: 201-201). Under processes of fracking, contamination of groundwater is a direct outcome of earthquake production, while at Hellisheiði, somewhat inversely, it is the very desire to prevent ground water contamination that leads to earthquake production. The effort to 'manage' the environment through extraction processes seems fraught with consequences that cannot be contained in ways that the energy industry would like. Additionally, what we learned from Gunnar in his presentation a little earlier is that the blast, or pressure of the water, is not what geologists believe to be the problem at Hellisheiði. Rather, it is a contraction of the rock matrix through what they call *thermal shock*.

While the constellation of issues that are generated through fracking raise serious questions around the politics of health and risk, indigenous rights, scientific knowledge production and expertise, as well as more classic political economy questions as to the role of 'big oil companies,' the emphasis remains with the politics of opposition and resistance (Cartwright 2013, de Rijke 2013, Ernstoff and Ellis 2013, Szeman 2013, Matz and Renfrew 2014, Willow 2014, Buttny and Feldpausch-Parker 2015). There seems to be good reason for this, given the ethnographic context. Oil and gas companies continue to mount powerful disinformation campaigns in an effort to convince all parties that the environmental effects of fracking are negligible, even as evidence to the contrary piles up. But this only partially resonates with the situation in Iceland. While relations with Orkuveita are strained, the politics is not outright oppositional. Local response has never been fashioned in terms of a desire to expel the energy company, but to, in some fashion, work with them to shape a better set of outcomes. Aldis, the mayor of Hveragerði, characterizes the situation in such a fashion over coffee one morning:

> For many years there have been earthquakes here, and people are not afraid of that, we know what they are. In many ways Icelanders are proud of not being scared, they always have to face nature and try to live together with it, trying to live in harmony with it, if that's possible.
>
> But these ones from Hellisheiði, they are different, that's not living with nature, that's provoking it. We started noticing very strange earthquakes in late 2011, and in a period of two to three weeks we had around 1,200 of them that we could feel here in Hveragerði and some of them were 4 and 4.5 on the

> scale. And that is quite big. And these ones, they make you feel….well….a little scared.
>
> So the inhabitants were furious because it was obvious that something was happening at the geothermal plant, even if the company tried denying it to begin with. Every single one of those earthquakes originated from the same spot and earthquakes just don't behave like that. Usually they originate on a line, on a crack, or on a fissure, so they happen along a longer or bigger area.
> We are on a highly active volcanic area here, and we are used to earthquakes, but those were different. What made us so angry was that nobody told us this would happen. They had so many big files on all the possible effects that the power plant would have on the surrounding area. But not a single line in it says that reinjecting waster water might cause earthquakes.
>
> So we kind of felt betrayed. The power plant was built as a sort of experiment before knowing what would happen, and we are working along the road after production has started, on trying to live with those things, trying to make them better. We are not fighting the company itself, we would like to utilise the energy that is in the earth in Iceland, of course, we all need that, but it has to be done in consideration with the inhabitants and the nature.

In this long quote, Aldis highlights the history of geothermal energy use as beneficial to the town, one might even say existentially so; the town is *of* geothermal, it is a geotown. Residents have, in some sense, gotten used to earthquakes, but not these new versions; they are provocations of 'nature,' enrolling the town as part of a larger experiment in which they are very uncomfortable participants. Trying to get on with things as best they can, or 'staying with the trouble,' as Donna Haraway puts it (2016), Aldis advocates some form of settlement between the parties with the express desire of taking all of them into consideration, 'nature' included.

5.5: Rhythmic Convergences and Temporality

In continuation of the above conversation, Aldis goes on to tell me that these "man-made" earthquakes are still occurring today, but at a less frequent rate, probably about three or four a month, she guesses. The most active period was between late 2011 and 2012 when the Icelandic Meteorological Institute (IMI) registered 4,600 earthquakes in the Húsmúli area (figure 20). While the majority were under three in magnitude, there were up to 200 between magnitude three and four, several dozen over four, and just a few over magnitude five.[152]

During the start of this "intense period of shaking," as many in the town refer to it, a town meeting was called at Hotel Ork in the town centre where representatives from Orkuveita were invited to explain the worrying, and on-going occurrence of these earthquakes. Gunnar, Orkuveita's geophysicist, was in attendance along with the company's CEO and the public relations director. The outcome of the public meeting was an agreement to set up a special expert panel to investigate the earthquakes. The ensuing report from the committee is itself an interesting ethnographic object, one that highlights not just the story of drilling and reinjection at Hellisheiði, and its connection to Hveragerði, but also the logics and practices of geothermal production within Iceland's most continuously active seismic area.

5.5.1 The Rhythms of Suðurlandsskjálfti

As I explained in the introductory chapter, Iceland sits atop a spreading rift zone and a mantle plume. However, given that the entire global tectonic plate structure is itself in motion, moving in a north-north westerly direction, this mantle plume has changed relative position over the course of the last 65 million years.

At one point the plume was located under what is today's Greenland, but only became active around 25 million years ago under the western section of contemporary Iceland (WVZ on figure 21). The plume has migrated further eastwards since the country's formation, and according to geologists has now

[152] While residents in Hveragerði still talk about earthquake magnitude in terms of the Richter scale, the scale used by geologists and seismologists is the moment magnitude scale.

relocated under the main glacier at Vatnajökull (Guðmundsson, Kjartansson et al. 2007).

This has created a second rift zone in the east (EVZ on figure 21) whose forces pull towards the ones from the west.[153] The area between the two rifting segments is known as the South Iceland Seismic Zone (SISZ)(figure 21), and is characterized by geologists as a micro plate, one that accumulates lateral stress that is prone to 'strike slip faults' over time (Einarsson 2015). *Suðurlandsskjálfti* is the Icelandic name given to the phenomenon of accumulated micro plate stress release, one that operates at a particular *seismic rhythm*.

While the last full sequence of *Suðurlandsskjálfti* release occurred between 1896 and 1912, seismologists are operating under the working assumption that a new release cycle is now under way. It is estimated that almost half of the current accumulated stress in the micro plate has been released through two recent events: a 6.0 earthquake in 2000, with an epicentre 30km east of Hveragerði and a second, a 6.3 in 2008 just 8km east of the town (Khodayar and Bjornsson 2010). Predictions of another release event over the next decade somewhere to the west of Hveragerði are common currency amongst geologists and townsfolk alike.

Problematically, the reinjection area, Húsmuli, also lies just to the west of Hveragerði and is the location where the majority of "man-made" earthquakes are occurring. For the townsfolk, the idea that Orkuveita are producing earthquakes right in the middle of this area has created a strong sense of unease about how the rhythms of *Suðurlandsskjálfti* are being, and will continue to be, affected.

As Aldis gave expression to above, nowhere in all of Hellisheiði's planning documentation, including its environmental impact assessment, was there mention of the possibility of the occurrence of such "man-made" earthquakes. Trust in Orkuveita's expertise, therefore, has-to put it mildly- been damaged.

[153] As the western rift zone spreads, one section pulls towards the west and the other towards the east. At the same time the eastern rift zone spreads in a similar fashion, that is, it also pulls west and east. So the eastern pull of the western rift zone and the western pull of the eastern rift zone creates lateral, or transform, stress as their forces pull towards one another.

5.5.2 Accelerating Seismic Rhythms

The expert panel that was established to produce a report in response to "man-made" earthquakes was comprised of geologists and seismologists, including representatives from Orkuveita, the University of Iceland, the Geosurvey Institute of Iceland (ISOR) and the Icelandic Meteorological Institute (IMI), as well as an observer representative from the town council of Hveragerði. The report itself, *Procedures for Induced Seismicity in Geothermal Systems*, is direct in its style and language and does not shy away from the difficult question of Orkuveita's role in the production of earthquakes at Hengill. The report states that:

> It is considered certain that the increased frequency of surface movements in Hveragerði, due to reinjection earthquakes at Húsmúli, have caused the residents increased aggrivation and inconvienence. Although residents are accustomed to earthquakes and hot spring activity, it is clear that recent large and harmful earthquakes have made people more vulnerable than before (Bessason, Ólafsson et al. 2012: 74).[154]

The relation between reinjection and earthquakes, and the effects that this relation is having on the town, is clearly acknowledged, but the precise mechanism of the relation only becomes clearer through a more detailed discussion on the topic of pressure. The report makes a distinction between different types of pressure. In liquids, pressure is constant in all directions, but in rock strata, pressure varies. Both horizontal and vertical pressures work to create what is called shear tension, and as this tension increases the strata can fracture, creating a fault along the fissure plane. In the language of the report:

> Shear tension increases in seismic areas over time due to tectonic movement, and earthquakes occur when this tension gains the upper hand over the strata's resistance (ibid : 63).

[154] This report was translated from Icelandic by Nadia Asgeirsdóttir.

It is here that reinjection can make a difference. As we learned from Gunnar a little earlier, it is not the extra pressure that reinjection water is adding to the system that makes this difference count. It is the change in temperature of reinjection water that creates *thermal shock*, which, in effect, *contracts the rock matrix* and reduces the resistance of the fracture plane, thereby lowering what is called the *shear tension threshold* (the point at which the rock strata can no longer contain its accumulated stress). Again, in the language of the report:

> Due to this process (lowering the threshold) it is to be expected that built up pressure is released that would have resulted in an earthquake sooner or later, even without reinjection. Such an earthquake is called a triggered earthquake. It can then be deduced that in the long run reinjection will decrease the magnitude of natural earthquakes in relation to what they otherwise would have been, that is, the process accelerates earthquake production (ibid : 63).

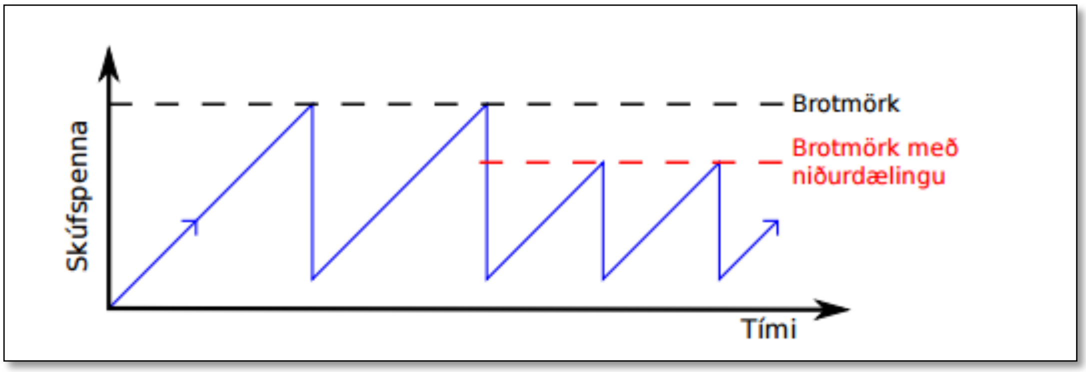

Figure 23 Triggered earthquakes. The blue line shows how shear tension in the strata increases with time and falls with each earthquake. The black spaced line shows the strata threshold without reinjection, while the red spaced line shows the strata threshold with reinjection. If reinjection lowers the threshold it suffices to say that the earthquakes will be more frequent in occurrence but less powerful in magnitude. (Ólafur G. Flóvenz and Kristján Ágústsson, 2011 (adapted) citied in Bessasson, Ólafsson et al. 2012: 64).

Contracting the rock strata lowers the *shear tension threshold* triggering more frequent events, but at reduced magnitudes. What this statement and its accompanying image (figure 23) point out is how longstanding seismic rhythms at Hengill are being *accelerated*. Reinjection is accelerating processes, which according to the report, 'would have happened sooner or later.'

The expert panel are highlighting the temporal dimensions of these accelerating seismic rhythms. Through reinjection practices, Orkuveita are altering the shear tension threshold, accelerating the release of stress that otherwise would have occurred 'naturally' (the black spaced line in figure 23). Accelerating 'natural' seismic rhythms ('natural' earthquakes)(the red spaced line in figure 23*)* suggests that "man-made" earthquakes are a rhythmically converged version of *'natural' earthquakes.*[155] Another way to put this is to say that accelerating the earth's rhythms makes earthquakes happen more quickly, and therefore, "man-made" earthquakes are both *something of the now*, a geological phenomenon with disturbing effects, *and something of the future*, as 'natural' earthquake rhythms are accelerated. Let me try to flesh this out in more detail.

5.5.3: Acceleration, Rhythms and Temporality

As many anthropologists have attested, anthropology, like other disciplines, has never had an easy relationship with time (Gell 1992, Munn 1992, Hodges 2008, Bear 2016). It was Nancy Munn, in particular, who challenged anthropologists to analyse the temporalizing practices from which timespaces emerge (1992). I want to position this chapter in productive conversation with her idea of temporalizing practices.

The anthropological record is replete with discussions of time, and has supplied two prominent geometric forms through which time is apprehended: linear and cyclical. The former brings with it the image of time as an irreversible progression of moments, as well as providing a language and framework for understanding change and sequence. The latter, on the other hand, offers an image of time as anchored in constant alteration between opposed and reciprocal states; day and night, life and death, summer and winter, dry and rainy season, and so on. So while cyclical time talks to ideas of repetition, linear time implies irreversibility.

Carol Greenhouse addresses the clear limitations of geometric metaphors in general, pointing to a whole list of places and peoples whose temporal orientations have been consigned as 'timeless' due to their nonconformity with geometric

[155] While the expert report uses the term "triggered earthquakes," I will continue to hold onto the local term "man-made" for the rest of this chapter. It will be part of the job of Chapter Six to explore in more detail the distinction between these two terms.

imaginaries. An insistence on geometric representations obscures the multiplicity of times that are able to coexist, at the same time (1996: 36-46).

In his reflections on social time in *The Elementary Forms of Religious Life* (1995), Emile Durkheim is one of the first to discuss collective representations of time, focusing on how time is learned at an institutional level, through specific rules, traditions, rituals, and so forth. For Durkheim, time works both at the level of personal experience, and as a category that provides the conceptual background to many forms of action, guiding people as they figure out when to act, how to act and with whom to act (Bastian 2009: 36). Many of the overviews of the anthropology of time take Durkheim's work as their point of departure (Bear 2014, Iparraguirre 2015, Ringel 2016),[156] paving the way for contemporary anthropology's engagement with time's multiple articulations. It is Durkheim's emphasis on institutions as the nexus of temporal production that has lead to a more specific focus on 'modern social time;' economic, political, and bureaucratic representations and techniques of time (Bear 2014).

While Laura Bear draws heavily on Durkheim's legacy, she also draws on Louis Althusser, who developed a complex model of the temporalities of capitalist society. Althusser argued that various institutions have peculiar rhythms, and that we should track the 'intertwining of different times, i.e., the type of dislocation and torsion of the different temporalities produced by the different levels of the structure' (Althusser cited in Bear 2014: 19).

However it is not enough to trace the diverse institutional representations and practices of time, suggests Bear, we have to track 'how these produce social rhythms and follow the relationship of these rhythms to each other' (Bear 2014: 19). This is the tracing I have been conducting thus far in Hengill, the ways in which seismic rhythms are being accelerated by the practices of a municipal entity, Orkuveita.

In order to develop my approach to "man-made" earthquakes as accelerated rhythms, I want to turn to some of the work of Bruno Latour. In *Trains of Thought:*

[156] Continental philosophy is also another source of inspiration, in particular see (Hodges 2008, Nielsen 2008).

Piaget, Formalism, and the Fifth Dimension, Latour, with his usual aplomb, takes philosophical orthodoxy to task in an effort to develop a science studies approach to temporality. Latour regales us with the 'paradox of the twin travellers,' as he calls it (1997: 172). We find the first twin battling through a jungle, axe in hand, slashing away through the thicket. She is part of an engineering expedition to map a territory that will eventually become a route for a bullet train. We find the second twin sitting uneventfully on that very bullet train passing though that jungle.

Latour uses this analogy to address a deficiency he sees in both objective and subjective philosophical accounts of time, namely that that there is a fundamental separation between space and time on the one hand and entities, beings or events on the other. The paradox of the twin travellers is a way for Latour to argue that such a distinction is not in fact fundamental, but that the production of space and time is made through the relation between 'transportation and transformation' (1997: 174).[157] And since this relation differs in each of the travellers' cases, the production of times and spaces are also different.[158]

While Latour's argument is very detailed, I want to take up his point that spaces and times are produced through particular arrangements of movement and transformation. This, it strikes me, is a very rhythmic argument. Deeper than time as 'frame' or 'lived' is a relation between movement and transformation, and the way in which this relation unfolds is what generates times and places.

Part of what I have been trying show is how the seismic rhythms of Hengill are constituted by such relations of movement and transformation. The entire *Suðurlandsskjálfti* cycle is a sequence of movements that transforms the Hengill area in very significant ways. But as these rhythms are accelerated, we are seeing the emergence of a new entity. How, then, to think about this new entity from a temporal perspective?

[157] I tend to think of this as relations of movement and transformation, or movement and change more broadly.

[158] For the first twin of the analogy, there is no separation between space and time and the events and activities of the world. She 'moves' through the jungle, cutting away with an axe, and bleeding as she moves. She sees herself 'transforming' (changing), maybe even dying through her movements. Whereas the second twin sits in contemplative reverie through which he can make a separation between space and time and the events of the world.

For Latour, we never encounter time and space, but rather a multiplicity of interactions with actors that have their own timings, spacings, goals, means and ends. Times and spaces are made as varying times and actants of different qualities and tempos fold together (ibid : 182). It is this line of thinking I want to develop, the making of time through the folding together of qualities and tempos, but to do so I want to switch to a conversation between Latour and Michel Serres. In this conversation, Serres suggests:

> That time does not flow according to a line or a plan, but rather, according to an extraordinarily complex mixture as though it reflected stopping points, ruptures, deep wells, chimneys of *thunderous acceleration* (my emphasis). Time is paradoxical, it folds, it twists, it doesn't flow; it percolates (Serres and Latour 1995: 57-58).

And continuing on:

> The usual theory supposes time to be always and everywhere laminar. With geometrically rigid and measurable distances……No, time flows in a turbulent and chaotic manner, it percolates…this time can be schematized by a kind of crumpling, a multiple, foldable diversity (ibid : 59).

This is an intriguing way to think about time. In the first citation we get time percolating and folding through thunderous accelerations. In the second, Serres suggests that if time does flow then it is a turbulent, chaotic flow, a crumpling, folding diversity.

Serres develops the point:

> If you take a handkerchief and spread it out in order to iron it, you can see in it certain fixed distances and proximities. If you sketch a circle in one area, you can mark out nearby points and measure far-off distances. Then take the same handkerchief and crumple it, putting it into your pocket. Two distant

> points suddenly are close, even superimposed. If, further, you tear it in certain places, two points that were close can become very distant (ibid : 60).

In this topological example of a handkerchief, what is proximal and what is distal is not fixed, and serves as a useful analogy with which to think time; again, folded and crumpled. But what, if anything, can this allow me to say about Hengill and time? While a handkerchief is an apposite material form to analogise the folding of time, I am more prompted to think through the material practices and processes underway in the landscape at Hengill.

We know from geological thinking that rocks, in fact, do bend and fold. The entire rock production cycle is a malleable process of creative destruction as rocks circulate through various cycles of erosion and transformation, changing form along the way. As we saw above, earthquakes are part of such cycles, as rock under shear pressure begins to bend and fold until it can no longer maintain its accumulated stress. It then breaks and releases energy waves.

The difference, then, in thinking about cloth and rock as foldable materials is of course one of time (as measurement). While the former is immediately foldable, folding the latter takes a lot more time. So while cloth, as foldable, serves to analogise time as non-linear, rock's commonly ascribed characteristic as solid, itself partly a result of thinking liner time into the constitution of material things, does not lend itself to thinking about time beyond images of depth.

In fact, as analogical material, rock is the foundational stuff of philosophical thought, 'that mundane object on which a philosopher might perch in order to think, ideation's unthought support. Foundation of the inhabited world and its most durable affordance' (Cohen 2015: 11). Rock is that which is stable and solid: the ground that affords the possibility of thought and action. Yet still not the right type of material for turbulent thinking.

But under accelerating conditions strange things are happening. At Hengill we are witness to practices that are speeding up normal geological processes. As thermal shock contracts the rock face, seismic thresholds are altered and shear stress release is accelerated. Such rock contraction has oftentimes been described to me by my geologist friends through the squeezing of a closed fist, indicating the effect that the water is having on the rock face. Could we not call this *rock crumpling*?

In earlier chapters I developed the idea of thresholds, suggesting that the concept helps me to think about the production of new states, particularly as a process of acceleration. Sometimes changes in speed can effect changes in state, I argued. As we learned in these chapters, at critical points of acceleration phase shifting thresholds emerge and state changes occur. As fluids flow through the subterranean they can phase shift from a laminar flow regime, to convective, to turbulent. Acceleration generates these phase shifts through which fluids change their rhythm, and hence their form. What we are seeing here, however, is not the accelerating rhythms of subterranean fluids, but how rock crumpling is accelerating seismic rhythms. Let me return briefly to the image presented by the expert panel (figure 23). One way of reading this image would be to suggest that processes of acceleration are bringing time forward, relocating it in some sense. However, drawing upon Serres as inspiration for thinking time and extending it to help me think about the material processes occurring at Hengill, I want to suggest that time is being crumpled, or folded. Not unlike the handkerchief analogy in which two formerly distant points become superimposed through crumpling, the distant rhythms of *Suðurlandsskjálfti* are crumpled and accelerated as time folds through one rhythmic configuration. “Man-made” earthquakes, therefore, are both *something of the now*, a geological phenomenon with disturbing effects, *and something of the future*, as rocks, **and** time, crumple through reinjection practices.

This section has argued for a more material approach to time (Bear 2016), one that suggests that time can be made in practice. In paying attention to the practices occurring at Hengill, I have focused on the landscape’s seismic rhythms as they are being altered by reinjection. These events are deeply affecting those in the town of Hveragerði, not just in terms of the shaky disturbances they are feeling, but also in terms of how they think and talk about time and the future. In the next two sections, I will take up this point through the perspectives of the town’s residents, as they also begin to articulate a sense of crumpled time.

5.6: The Next Big One: Crumpling Events and Times

As Aldis, and many others in the town have mentioned, residents have learned to live with not just earthquakes, but the various forms of geological instability that are part and parcel of life in Hveragerði. During my fieldwork the town's physical instability was a discussion point that emerged quite frequently. As a tectonically and seismically active zone, shifting ground is not an uncommon occurrence in Hveragerði; new areas are uncovered, while old ones disappear. Svenni and Bee, a local couple, talked to me about shifting ground:

> The whole town moved 20cms during the 2008 quake, even the hot springs moved, they relocated, up the hill, imagine that, imagine if they relocated under your house. There is no way they would be allowed to build a town here today, it's just too risky; too many things shift around.

Others talk of parts of the town moving and changing a lot over time, stories of people coming down to their basements to find hot steam emanating from the floor are, like Svenni and Bee's, not uncommon, as the surrounding landscape, and the town, continues to move and change. Asgeir, another resident tells me:

> There used to be a 'sprunga' (crack or fracture) running right through my garden, right here (pointing to where his hedge is now growing). In the '70s we had all of theses hot spring tremors going on constantly. One day I was cycling down the street and the entire roadside fence just started moving, it was so weird.

As we have seen above the powerful forces of the earth constantly move and transform; tectonic plates, continents, countries, regions and towns are made, and remade, over time. While such forces are not unique to Iceland, their processes and effects are perceptible at a human scale much unlike other places.

In Hveragerði, these forces are contented with as a matter of daily life. For example, the geothermal park in the centre of the town is a site where stories of shifting grounds and their effects are on full display. As both a tourist attraction and a living exhibition, the park is a ruptured, deformed section of transformed earth that performs the change and instability that people articulate.

Figure 24: Deformed earth in Hveragerði's Geothermal Park.

Figure 25: Deformed earth and hot spring in Hveragerði's Geothermal Park.

Let me take now you into the kitchen of Einar and Gudrun in Hveragerði one rainy Saturday afternoon, where the conversation turns to Hellisheiði and earthquakes. Einar, like many other residents, moves relatively seamlessly back and forth from *Suðurlandsskjálfti* to "man-made" earthquakes:

> I've experienced a lot of quakes. I used to be a documentary filmmaker working on volcanic eruptions in active areas, but the one from 2008, it left a bit of a mark, and I still have some anxiety left in me that I didn't notice before. So every time we have a small earthquake, we always prepare for the next one. We have this feeling, this stress or tension, for some time, maybe constantly, because a big one might come in a minute or an hour…..that's why people here do not like earthquakes that are "man-made" [laughs in an exasperated manner]. We can accept quakes from nature cause we don't rule nature, but we can rule them ["man-made" quakes].

Others from the town also mix events together, making connections between the earthquakes of 2008 (*Suðurlandsskjálfti's* latest incarnation), ongoing "man-made" earthquakes and the anticipation of what lies ahead. Arnthor, a friend in the town, talking of his experiences from 2008 gave the following account:

> My wife was out in our small garage when the earthquake hit and a shelf packed with stuff fell against the door, so she couldn't get out. And she was really terrified. I was walking through the house towards the outdoor when the quake hit. And I thought, 'okay I will just keep on walking and walk through the outdoor to get to her.' But I never made it; I was lying on the floor. I couldn't stand on my feet. I could not make those few meters to the door. I was just down.
>
> An earthquake is kind of a rare moment; there is a genuine sense of the next moments being completely open.
> Then we went through 12 sleepless nights of aftershocks, which was terrifying. And now it is very difficult with these other earthquakes, having

> lived through the big one from 2008, you go through this sort of nerve wrecking period every time you feel one.
>
> I try to talk to myself and say ‘we won’t have another big one for some time,’ but then I think, ‘who knows now?’ But still you always react, always think, ‘Uh, is this another one, is there another big one on its way.’ We cannot be playing around with such forces; it is beyond imaginable what might happen. Once we begin to play with them, what will happen, how will they affect *Suðurlandsskjálfti*?

As articulated above, playing with such forces can make unimaginable things happen as the anticipation of a future in which “man-made” earthquakes mix with *Suðurlandsskjálfti* continues to be an ongoing cause of concern for residents of Hveragerði. “The next big one” is the discursive form that such anticipation over future seismic rhythms takes.

Back in Einar’s kitchen, he goes on to tell me about the meeting between the residents of the town and Orkuveita at Hotel Ork. In trying to come to terms with the logic of Orkuveita’s explanations about “man-made” earthquakes, Einar says:

> At the town meeting at Hotel Ork, they (Orkuveita) were trying to argue that actually what they were doing by making lots of little earthquakes was releasing the tension of the expected quake in the west which is due in the next few years, you know the one that is part of *Suðurlandsskjálfti*. They said, ‘we are just doing something that nature will eventually do,’ and so I raised my hand and said ‘nature will eventually slay me dead but it doesn’t give you the right to do it now,’ and then there was lots of laughter and you should have seen their faces!!

Einar’s comment hones in on the temporal logic being set out by Orkuveita in one concise, yet deadly analogy. The explanation put forth by the municipal company that they are merely doing something that ‘nature’ will eventually do is taken to task. The effect of Einar’s comment, according to many at the meeting, was a kind of subdued laughter. Invoking an untimely death is in many ways stark and obdurate, but yet the analogy's finality seems to have had a strong impact upon those assembled at the meeting.

The explanation that Orkuveita are accelerating 'natural' forces that otherwise would have occurred strikes most people I spoke with as a strange way to legitimate the ongoing side effects of geothermal extraction. "Death comes 'anyway' but we don't speed it up" was the sentiment repeated to me by many when they recounted the events from the town hall meeting, and in particular Einar's comments.

The invocation of an untimely death is one way for residents to interrogate Orkuveita's practices, indexing unease with the effects of accelerating events. But it also points towards the implications of such temporal turbulence, and the sense of uncertainty it is generating. What emerges through these discussions is a particular concern about future seismic activity and how it will affect life in the town, as the future becomes the temporal terrain upon which contestations over geothermal energy is carried out.

A form of consensus had emerged in the town around the University of Iceland's predictions that *Suðurlandsskjálfti's* next sequence of stress releases will most likely occur within the next several years to decade. But, as the idiom of the "next big one" suggests, the folding of "man-made" earthquakes with *Suðurlandsskjálfti* has altered the way in which people think about what the future holds.

5.7: Anticipating the Future

As part of the 'temporal turn' in anthropology (Bear 2016), ethnographers have begun thinking in a more sustained way about the future. Citing Nancy Munn's claim that 'futurity is poorly tended as a specifically temporal phenomenon,' as anthropologists have viewed it in 'shreds and patches' in contrast with the 'close attention given to the past in the present' (1992: 115-116), Morten Nielsen draws attention to the range of interesting future oriented work now being undertaken in anthropology (2011).

While scholars have produced nuanced descriptions of how people orient themselves in relation to unknown futures (Miyazaki 2006, Guyer 2007, Hodges 2008), what Nielsen points to is the importance of how these studies have added to the anthropology of time by shedding new light on what he calls 'anticipatory action' (2011: 398). Through detailed ethnographic accounts these scholars unfold how the future emerges as anticipations inscribed in the present. In essence, the idea suggests that the present becomes a function of an imagined future moment that is extended backwards in time to ground the current act. Kirsten Hastrup puts it somewhat more elegantly, 'we perform worlds into being, acting as much upon anticipation as upon antecedent' (2005: 11).[159]

Others are also working in this direction. As Adele Clarke and collaborators have shown, anticipation in the form of prediction, risk and optimization profoundly structures biomedicine and technoscience (2010). Marilyn Strathern offers the term 'anticipatory audit' (2000) to describe ways that contemporary accountability in the academy and elsewhere is oriented to pre-constituted futures. In addition, Lakoff and Collier illustrate how regimes of security and simulation bring future disasters into the present as part of how we learn to organise ourselves for the inevitable disaster they predict (2008). Whether they come to pass or not, these disasters, the authors argue, impact on people's lives.

Nielsen's intervention is to push this work forward by arguing for a view of anticipatory action that takes seriously the range of possible worlds that inform those actions. To do so, however, he suggests, means acknowledging that 'anticipation is not always oriented towards an unknown future which is fixed to the present through a linear chronology.' His point of divergence from some of the scholars named above is in suggesting that particular moments do not necessarily

[159] Another formulation from Adams et al is 'anticipation is the palpable effect of the speculative future on the present' (2009).

have to be fixed to only one temporal regime that categorizes events according to a past, present, future chronology (2011: 398-399).[160]

To make this argument, he mobilises Bergson's suggestion that time erupts as 'durations, i.e., convergences of different temporalities within one rhythmic configuration' (ibid 2011: 399), a term I used a little earlier. Such eruptions cannot be seen as quantifiable entities which can clearly be distinguished from each other, and so it makes little sense to categorize them through relative scales such as 'before' or 'after' (Ansell Pearson cited in Nielsen 2011: 399).

But let me bring this back to Hveragerði. For residents of the town, the necessity of orienting themselves towards an uncertain future is nothing new. As I set out above, living in an earthquake prone zone means dealing with shifting ground as part of the course of normal existence. At the same time, anticipating what the future might hold is not a speculative affair, but embeds a whole series of anticipatory actions within the town's ongoing life.

Anticipations of the future are inscribed in a multitude of sociomaterial ways. All structures, both public and private are built to minimise earthquake effects, as new building code standards are rigorously imposed through funding schemes for ongoing upgrades. Interior house design takes account of potential motion through a set of guidelines on household objects, their form as well as their weight, height and distance in relation to other objects.[161] In addition local stores supply earthquake-proofing instructions for a range of domestic products while hiking trails, and trail maps of the surrounding landscape, come with instructions on how to act in the event of rock fall during earthquakes.

Earthquake response procedures are practiced across the town, with the school system being a key site as children learn a series of actions and techniques to

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[160] Nielsen's own ethnographic contribution to these matters takes place in Maputo, Mozambique where he examines, in great detail, house constructions on the outskirts of the town. Although many residents start house building projects, few finish them. The very fact of starting these constructions helps to 'cultivate a life' for their children. As a form of virtual home, these unfinished houses actualise a whole series of relationships in the present that otherwise would not have occurred (Nielsen 2011, 2008).

[161] This includes a lot of what locals describe as 'common sense' solutions such as techniques for how to mount objects on walls; maximum weights and so forth, along with instructions on where not to mount objects around the house (close to beds and sofas for example). Minimizing the use of glass in the home (cabinets, vases etc.) is strongly advised and a lot of public institutions have begun to mount filing cabinets, bookshelves and the like, on wheels to enable flexibility during earthquakes.

be adopted in the case of an earthquake event. Instructions on how to avert danger in shaky circumstances are even printed in the back of the phonebook, while the civil protection authorities run emergency response simulations annually.

Hveragerði's socio-material existence is bound to the seismic rhythms of Hengill. One could even say that in an effort to coordinate itself with the rhythms of the earth, the town is trying to learn how to move as the earth moves. As the rhythms of global plate tectonic movements combine with the movements of more localised lateral micro plate tension within the South Iceland Seismic Zone (SISZ)(see figure 21), *Suðurlandsskjálfti* earthquake events are generated.

Earthquakes in 2000 and 2008 have had a huge impact on the town and these ongoing rhythms, while ungovernable, are anticipated.[162] As such the town has become what one might call a large 'anticipatory infrastructure' (Thrift 2005, Nielsen 2008), as the relation between it and *Suðurlandsskjálfti* is materialized in all the ways I have described above. *Suðurlandsskjálfti*, in that regard, is not merely an earthquake prediction that people treat in a manner similar to say weather forecasts, or polling predictions, instead its occurrence as a stress release phenomenon is built into the conditions of daily life, both material and affective.

Today, the town is geared up for a very specific type of future, one that resonates with *Suðurlandsskjálfti's* rhythms of stress release. The uncertainty that this provokes, while significant, is a question of degree, one regarding the specificity of the precise timing, location and magnitude of the next round of stress release.

However, as we have seen, the acceleration of Hengill's seismic rhythms is affecting what people thought the future would hold. As Arnthor put it a little

[162] At 6.3Mw the 2008 earthquake wrought much damage. The earthquake engineering literature describes the event in relatively clear terms. While there were no deaths, 28 people were injured and 25 houses were classified as uninhabitable after the quake. 2,000 buildings were damaged with cracks in foundations, walls, and ceilings. Windows were smashed; equipment, furniture and household items were damaged and displaced. Infrastructure was severely hampered for an extended period of time, including electricity, water, sewage and telecommunications. Landslides and rockfall in the surrounding landscape were significant (Halldórsson et al 2009). People talk about how lucky the town was, the time of day the earthquake struck, 16.30, meant that kids and public employees were off, the weather was bright and sunny, so many were outdoors, and therefore at reduced risk. What might happen under different circumstances, or higher magnitudes is always on people's minds. In this way the earthquake exhibition in the town mall it is also a type of foretelling, a passageway to imagine other, more destructive events.

earlier, "earthquakes produce a genuine sense of the next moments being completely open," and the ongoing production of "man-made" earthquakes that are being felt in Hveragerði are generating a profound sense of this openness.

However, Orkuveita have very quickly begun to articulate a new version of the future that is compatible with the continued production of geothermal energy in this highly unstable seismic area. As a part of what could be called a legitimation strategy, the company talks openly and candidly about the issue of reinjection and the effects that it is having on the town. We came across this a little earlier through some of the citations from the expert panel's report and the manner in which it acknowledges the connections between what is calls "triggered earthquakes" and reinjection practices, citing the increased aggravation and inconvenience that this is bringing to residents of the town.

If we briefly return to Gunnar's presentation to the group of visiting seismologists at the start of the chapter, we will recall his claim that by accelerating the stress release of Suðurlandsskjálfti, reinjection will, in fact, decrease the magnitude of 'natural' earthquakes in relation to what they otherwise would have been. This, according to Gunnar, is evidenced by a drop in the current rate of occurrence of "man-made" earthquakes, which for him indicates the release of most of the rock strata's stress. While there was clear disagreement with his analysis amongst the seismologists in the room, I do not want to belabour that point here. What I do want to focus on is the way in which Orkuveita perform a version of the future that is 'natural' which at the same time is articulated as somewhat more benign than it otherwise would have been. The suggestion is that seismic accelerations, while provoking disturbances now, will, quantitatively speaking, provoke less disturbances vis-à-vis a future that otherwise would have been.

There are two versions of a possible future in operation here. Let us call the first version a *past future*, the future that would have occurred if reinjection practices had not gotten underway, and where *Suðurlandsskjálfti* would have been 'bigger' (the black spaced line in figure 23). But that version of the future is no longer possible due to tectonic interventions, and so a second version emerges, let us call it a *present future*. This is the version of the future that Orkuveita are performing, one in which *Suðurlandsskjálfti* will be 'smaller' (the red spaced line in figure 23).

Interestingly, the earthquakes of this present future are performed as being purely 'natural,' only being lessened in *degree* of magnitude by human intervention; a *Suðurlandsskjálfti* light, if you will.

However, this version, the *present future*, is being met with strong resistance from residents, both in terms of its classification ('natural') and its impact (magnitude). As I recounted earlier, in discussions with residents of the town, the connection points between the earthquakes of 2008 (*Suðurlandsskjálfti's* latest incarnation), ongoing "man-made" earthquakes and the predictions of the next round of stress release of *Suðurlandsskjálfti* have become blurry and mixed as they fold into one another. [163] While formerly there was uncertainty about *Suðurlandsskjálfti* – its precise location, timing, and magnitude – now there is a stronger sense of indeterminacy emerging, a sense of not knowing what *type* of earthquake awaits the town.[164]

In my analysis earlier, I noted that "man-made" earthquakes are both something of the now, a geological phenomenon with disturbing effects, and something of the future–accelerated 'natural' earthquakes. As the time of earthquakes crumples and folds, that is, as a futurity is brought into the present, then so do their makeup, as 'nature' enfolds with human to become indistinguishable. As seismic rhythms are disturbed through reinjection practices, rocks, and time, begin to crumple and fold through the convergence of different temporalities within one rhythmic configuration.

As relations between humans and 'nature,' as well as between the 'past,' 'present' and 'future' begin to percolate, as Serres puts it (1995: 59), they become too mixed and enfolded for the town to place any faith in Orkuveita's version of what lies ahead; a *pure* earthquake category ('natural') with a more benign impact (less in magnitude).[165]

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[163] Adele Clarke and her co-authors describe such a process of tacking back and forward between past, present and future as a composite element of anticipation, one that they refer to as 'abduction;' the work, the labour of living in anticipation, of being out of time (2009: 255).

[164] Here I am thinking of uncertainty as the probability of an event whose nature is largely known, and indeterminacy as an event whose nature is not yet known (Mathews 2016:14).

[165] As Henrik Vigh eloquently puts it, 'the future continually flees our epistemic grip, as crisis can extend into chronic crisis, and where representations of the future can only ever be unconvincing' (2008).

The anticipatory idiom of the “next big one” suggests that what’s to come is no longer what it once was. Similar to Orkuveita’s performance of the future, the town seem to accept that one version has now passed, and another one is possible. Contrary to this performance, however, the townsfolk do not ‘naturalise’ this possible future in the way that Orkuveita appear to do; what’s to come is, in some sense, not ‘natural,’ but mixed, not uncertain, but indeterminate.

5.7.1: Temporal Geopolitics

My focus in this chapter has been on the production of earthquakes and their temporal effects, and less so on questions of how people do or do not know what a “man-made” earthquake is. The extent and degree to which earthquakes can be felt depends upon where in the town one lives, with residents in the western part of town, closer to the geothermal power plant, being more vulnerable than others.

As I noted at the start of the chapter, the town was deeply shaken in 2012 when over 4,000 earthquakes were registered. At this point almost all of the motion felt in the town was attributed to “man-made” earthquakes. People quickly learned how to ‘assess’ what was “man-made” and what was not by using the Icelandic Meteorological Institute’s (IMI) website, which correlates reinjection pumping data with earthquake location.[166]

Ongoing shaking, while far below the levels between 2011 and 2013, is still occurring. As would be expected there have been a wide range of reactions to these earthquakes within the town. While a few have moved away, another small section have been deeply affected, seeking medical and psychological help. The more common reaction, however, is one of resigned acceptance and frustration. But as I have been trying to show in the analysis above, it is very difficult for residents to separate events and times from one another in any clear manner.

What the comments from residents running throughout this chapter show is that residual anxieties and memories from the earthquake of 2008 mix with the smaller shakings of “man-made” earthquakes, and the looming prospect of what

[166] Although far from an exact science, the correlation between what people felt and the data available on this website was consistent enough to be taken as a reliable index.

that might be triggering, either in the immediate moment, or at some undesignated time into the future. Residents treat the pure 'natural' version of the future–a *Suðurlandsskjálfti* 'light'–performed through the expert report and through Orkuveita's public engagements with the town, with deep suspicion. Einar's death analogy indexes this suspicion. Just as an untimely death cannot be considered 'natural,' neither can an untimely future.

In one sense these performances are a method of displacement, outlining a more benign possible future in the hope of legitimising current action. In this regard such performances also become types of 'anticipatory actions,' ones which, in Nielsen's terms, attempt to legitimise present extraction practices through an imagined future that is extended backwards in time to ground these current practices. Anticipating the future, in this regard, becomes a form of temporal geopolitics for Orkuveita, an attempt to legitimise ongoing interventions into the volcanic landscape.

As Adele Clarke and her co-authors make explicit, anticipation has long been a component of political practice; decolonialization, Marxism and feminism, for example, all rely on conjuring the possibility of new futures (2009). Asking critical questions about the forms that anticipation takes in varying settings as both affective and material is one form of doing temporal politics in times when states, corporations and military complexes are increasingly producing regimes of anticipation (fear, anxiety) as a means to govern subjects (Orr cited in Adams, Murphy et al. 2009: 249).

As different temporalities converge within one rhythmic configuration ("man-made" earthquakes), a sense of the radical openness of the future has emerged amongst residents of the town. The anticipated future that the town is infrastructured for no longer seems to be a viable possibility. At the same time, the future on offer from Orkuveita, the details of which I have outlined above, is far from one that residents can place any faith in.

In general terms one way of thinking about anticipation is as a strategy for the avoidance of surprise, while living with uncertainty (Adams, Murphy et al. 2009: 50), and it partially works by mobilising affective states (fear, anxiety) into material infrastructures. Anticipating the future is an ongoing process for residents of

Hveragerði as they work hard to avoid surprises, ones that have the potential to be deadly.

What we have been seeing in the town is a shift from a sense of uncertainty - of not knowing the specificities of *Suðurlandsskjálfti*; its precise location, timing, and magnitude – to a sense of indeterminacy about the future. It is in this context that residents are having a much more difficult time anticipating what comes next; living with indeterminacy in some senses evades the powers of anticipation.

Chapter 6.
Geopolitics:
Settling Shaky Matters

6.1: Introduction

Sitting in the local library, as I did on many a rainy day in Hveragerði, I overhear a teenager talking to one of her friends; "Wow, is it an actual faultline or is it, like, made?" she asks. "You can't make a faultline," her young male friend scolds her, "this is Iceland, they have them here."

A fracture in the rock, a 'sprunga' as locals call it, meanders through the entire building, the Sunnumörk mall (figure 26). In 2003, when the building was being constructed, the builders uncovered an older unmapped fracture below the surface.[167] The building's original three storey plans were shelved and a single story building was constructed instead, just to be on the safe side.

I ask Hlíf, the local librarian, about the 'sprunga' and she tells me that the town council decided to build around it, leaving it visible to shoppers by encasing it in glass and illuminating it through red lighting. The effect is a snake-like one-meter wide panel of glass embedded in the building's floor that runs through several of the shops in the mall (the library, the post office, the tourist office and the general foyer). Standing over the glass peering into the 'sprunga' feels a little like being in a Jules Verne scene, as the inner earth becomes palpably activated.[168]

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[167] While fractures are mostly subsurface phenomena, there are many in Iceland that are visible to the eye, particularly in the Hveragerði area.

[168] As the 'sprunga' had already proven to be such a hit with tourists, the town council decided to develop the fracture as the basis of an 'earthquake exhibition,' as it is now known. This exhibition sits in the foyer of the mall that connects the other shops together. There is an earthquake simulator that people pay for (mostly tourists) to simulate the experience from the 2008 6.3 earthquake. There are multiple 'my earthquake' stories from residents juxtaposed with photos mounted on placards on the wall, there are camera recordings of violent shaking at the local petrol station, bus station and wine store displaying how people, cars and products were thrown around for several seconds. There is also a more technical screen display from the Earthquake Institute visualising the many after shocks from the event. In addition, there is a life size mock up unit of a kitchen, frozen in time, as dishes and other domestic items are thrown to the floor and smashed, as well as a large interactive model of Hengill that positions the town relative to other landmarks, Hellisheiði geothermal power plant included. There is no mention of man-made earthquakes. I passed through this exhibition almost everyday on my way into Bonus, the local supermarket, seeing, for the most part, bus loads of tourists shuffle through. Comments on the 'sprunga' and shrieks from the simulator, for those daring enough to try, were common.

As our conversation develops about the town's history of earthquakes, the subject of "man-made" earthquakes arises and Hlíf remarks, "we are making earthquakes now. Is that not very strange? It really is a shaky matter." Hlíf's characterization of earthquakes as a "shaky matter" has stayed with me as I have been thinking though events in Hveragerði. The term, as I read it, is rich in possibility, striking at both the physical and conceptual disturbances that residents have to deal with as the earth continues to shake, while at the same time hinting that the matter, as a political and ethical state of affairs, continues to remain shaky, that is, unsettled.

Hlíf's characterization is the driving inspiration for this chapter as I explore attempts to 'settle' such "shaky matters." Given the unexpected nature of these earthquakes, all parties, the town council, as well as residents of Hveragerði, along with Orkuveita and Reykjavík city council, are uncertain about the best way to proceed. Life continues on as people and institutions attempt to figure things out as they go. Everybody, it seems, just wants the 'matter' to 'settle' down, but the process of settlement is difficult and variable.

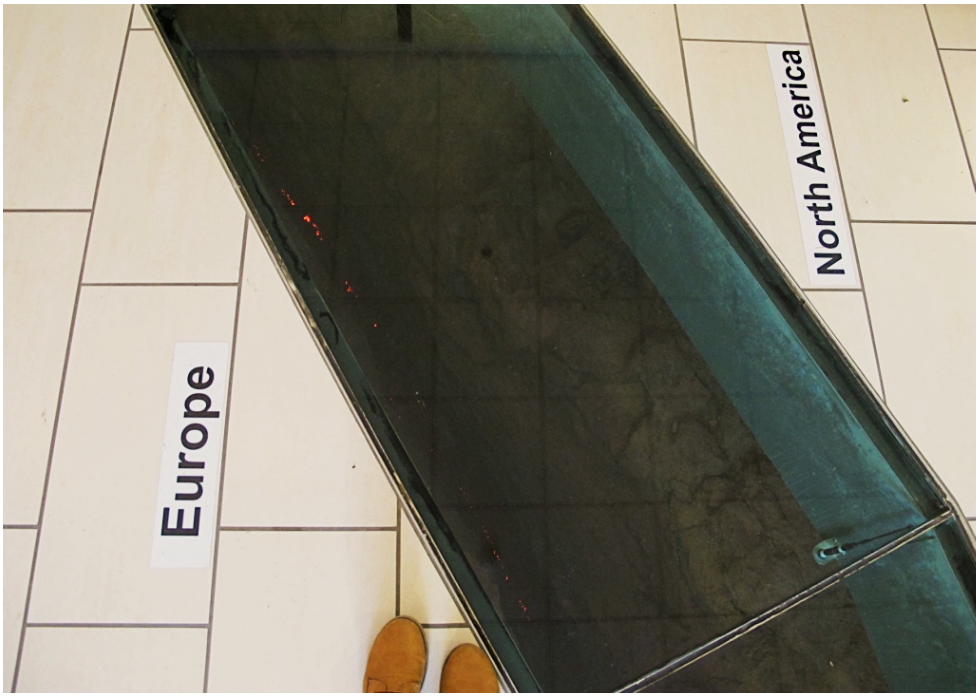

Figure 26: Fracture in Mall, Hveragerði.

In my discussion with Hlíf, as well as with many others around the issue of "man-made" earthquakes, residents of Hveragerði and geologists alike, the question of whether 'nature' or humans are responsible for such earthquakes always hovered in the background.

As a researcher coming to Hengill with roots in anthropology and Science and Technology Studies (STS), one of my fascinations with "man-made" earthquakes was what I perceived to be their blending of 'natural' and 'cultural' forces. On many occasions I tried to draw people to speculate upon this blending, but more often than not I was greeted with a slightly perplexed look, or, if the person was feeling more polite, my provocation would be swatted away with comments such as "hmm, interesting, I hadn't thought about it quite like that before."

What was more common, however, was a quick repositioning of the question in more pragmatic terms. A primary concern for residents was the question of who would settle an insurance claim in the eventuality that a "man-made" earthquake caused damage to their property. Whilst I was trying to prod what I thought of as more philosophical reflections on the question of 'nature' and 'culture,' my friends turned to more specific concerns about how such earthquakes were affecting their lives.[169] The question of who would pay for the damage caused, in effect, articulates questions of responsibility through a register of insurance.

The previous chapter examined the relationship between the residents of Hveragerði and Orkuveita with a specific focus on the production of "man-made" earthquakes and their temporal impacts. In particular, I discussed the ways in which the future is anticipated, both by the residents of Hveragerði and by Orkuveita. As multiple versions of the future come into play, anticipating, as a practice, becomes a way to make particular claims about the legitimacy of volcanic interventions. But such claims are not the only ones in operation.

This chapter, in exploring such claims, will be split into two parts. The first part will discuss how insurance claims and settlements have become one practice

[169] In some ways I think that I over-literalised Bill Maurer's insight that people in the field are not just mere informants, but 'fellow travellers along the routes of social abstraction and analysis' (2005). While I still believe Maurer's insight to be valid, the manner in which we apprehend those insights can be less than straightforward. In some ways this is a basic methodological lesson for me in terms of how to ask questions and how to listen well.

through which an effort is made to assign *responsibility* for “man-made” earthquakes. Furthermore, by taking a more lateral approach I will focus on claims and settlements as performative processes that–while doing insurance work–also do additional category work, as versions of ‘nature,’ and human are performed and legitimised.

In trying to come to terms with, and manage, these new entities, varying actors give competing accounts of how these entities have come about, articulated primarily through the language of “making” and “triggering.” These accounts perform specific ‘cuts’ in an effort to both locate and allocate responsibility. In essence, the various parties are trying to figure out how to *settle* these very shaky matters.

While the conflict over geothermal energy in Hengill is new, the entangled relations between the earth’s forces and energies, and human inhabitants in Iceland have long predated such conflict. As we saw in the introductory chapter, since the earliest arrivals to the island, the inhabitants and the earth have been bound together in politically formative ways. Settlements with the earth have had to be reached. The emergence of shaky matters is provoking the need for a new type of settlement as the various actors struggle to take the agencies of these entities into account. This will be the focus of the second part of the chapter.

6.2: Catastrophe Insurance

Insurance related to earthquakes in Iceland is governed through the Iceland Catastrophe Insurance (ICI). The ICI was established in 1975 by a special act of parliament and covers all catastrophic perils arising from what are considered ‘natural’ disasters, including earthquakes, volcanic eruptions, snow avalanches, landslides and floods (Bjarnason, Einarsson et al. 2016). As a compulsory insurance, ICI is purchased as part of all residential and commercial fire insurance policies.

The ICI was brought into existence after several volcanic eruptions occurred around the cluster of islands known as the Westman Islands, located just south of the mainland. These eruptions caused a renewed sense of concern about the potentially destructive effects of 'natural' disasters on local populations.[170] In 1963 the island of Surtsey (Devil's Island) was born as lava burst through the sea floor close to the main Westman island of Heimaey. In 1973 the Helgafell volcano erupted, just on the outskirts of Heimaey. While all of the residents managed to get off the island safely due to the presence of the weather bound fishing fleet, a long battle ensued in an effort to protect the town from the oncoming lava flow (Pálsson and Swanson 2016).

As a response to such events, catastrophe insurance has become one settlement mechanism for Icelanders in their relationship with 'natural' forces. Such insurance is a practical way of coming to terms with the excessiveness that these relationships produce. Operating through the state, ICI can be thought of as a way to mitigate some of the burdens that come with such excessive relations.

So how to think about insurance beyond its purely financial connotations? While anthropology is full of accounts of how societies deal with unfortunate events (Evans-Pritchard 1940, Evans-Pritchard 1976), it is Mary Douglas who brings the idea of insurance into discussions of non-western gift economies. In *Risk and Blame*, Douglas talks about how gift giving and extensive support networks work to obligate groups in various ways, and in particular how they operate as a means of avoiding neglect and transgression in difficult times. Such circumstances are routinely circumvented through these obligations which work, as she puts it, as a type of 'social insurance' (1994).

In other earlier studies, if and when researchers looked to insurance as a topic strictly beyond finance, they often turned to the issues of morality that it is bound up with (Zelizer 1978, Zelizer 1979). So while the concept of insurance is not new in anthropological discussions, emerging as it does at the intersection of multiple debates around misfortune, economics, gifts and morality, it has in more recent times become a focused object of study in and of itself. In this more contemporary work, there is an attempt to think insurance as a part of the wider discussions in the anthropology of finance, credit and crisis.

[170] See http://www.ccrif.org/partnerships/WFCP/Sessions/Day2/Iceland_ICF_WFCP_Meeting_Oct_2011.pdf, accessed 10/10/16.

In this contemporary literature insurance is seen as a technology of risk management, where risk is the mathematical probability of dealing with uncertainty (Golomski 2013). In simple terms it is a kind of protection against the risk or hazard of a particular event happening. It can never, of course, protect against the event itself, but only against the potential loss arising from that event, manifested in a monetised form.

But insurance is about more than the finances connected to it. It is also a site for the production of futurity, one through which people can imagine and materialise a future that is both planned, and at the same time contains something beyond what is planned and managed. In terms of the language I used in the last chapter, catastrophe insurance is a classic form of 'anticipatory action,' one that Icelanders rely upon in the event that a particular anticipated future is materialised.

Catastrophe insurance has become a mechanism for Icelanders to deal with the uncertainty of the many encounters they have with 'natural' forces.[171] Through a collective effort - the compulsory payment of a nationwide fee through a state agency - some of the risks of living with volcanic forces are dispersed through the distribution of responsibility for their potentially harmful effects.

Insurance is, in many ways, a banal topic in the lives of most ordinary Icelanders, consisting as it does of somewhat tedious engagements with overly bureaucratized modes of interaction, form filling and the like. As such it tends to remain under the radar of topical conversation. However, on occasion, it emerges from the quotidian and reinserts itself into people's everyday lives as a serious concern. When it does, the relations and attachments that are contained within its terms reassert themselves as key nodes of how we categorize and act in the world, and hold out, for the researcher, a moment of analytical potential.

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[171] In Iceland 'natural' forces have a strong presence in people's lives. While I gave some sense of this in Chapter Two, in more recent times there has been some form of 'natural' disaster almost every year for the last decade, (earthquake, eruption, major flood, or avalanche). Volcanic eruptions, in particular, have caught the imagination of both the national and international media. The most well known is Eyjafjallajökul, which erupted in 2010 and spewed vast quantities of ash into the atmosphere, disrupting air traffic over large swathes of trans-Atlantic and European air space in the process. Bárðarbunga, a volcano within the Vatnajökull glacier, erupted while I was conducting fieldwork in 2014. At the time of its eruption I was visiting a well-known geological site in the north of the country and was evacuated under very stressful conditions along with other visitors.

For residents of Hveragerði, the earthquake of 2008 was one such moment. In the aftermath of the earthquake residents with claims to make went through, successfully for the most part, the task of settling with the ICI.[172] While I will not linger on these processes, what I want to follow up on is the ways in which the talk around, and practices involved in, the settling of insurance claims has become a common register for thinking about other questions; in particular questions of responsibility in the face of uncertainty.

Making insurance claims generates particular questions of responsibility. In the above case, the question is one of where responsibility for the earthquake in Hveragerði in 2008 lies? But there is a double sense of responsibility embedded in these claims. The claim asks who, or what, is responsible in the sense of who or what has made things happen or brought things about. If 'nature' is deemed responsible in this first sense, then the state are deemed responsible in a second sense, that is, they are answerable or accountable for what has happened; they have an ethical duty to respond. The claim is then settled under the terms that the insurance contract specifies; responsibility is thereby located (cause/agency) and allocated (held accountable).

So while these insurance claims generate a double sense of responsibility, they also generate further claim making practices. When claims are made for damages in the event of loss and subsequently settled by the state, 'nature' is performed as a legitimate category. While a claim for *damages* is being made, at the same time a claim for the validity of a particular *category* is also being made. Making insurance claims also triggers other modes of claim making; it is a way to perform, and hence embed particular categories over time.

While the classification of the 'natural' and the human as clearly distinguishable entities has a long history in Iceland, in more recent times it has been partially upheld through many years of such claim making practices. The broader settlement, until now, has been one where state responsibility has hinged upon

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[172] Cost estimates amounted to approximately €40 million, see http://www.wfcatprogrammes.com/c/document_library/get_file?folderId=13567&name=DLFE-523.pdf, accessed 10/10/16.

‘natural’ responsibility. However, in the case of “man-made” earthquakes, these questions become somewhat more fuzzy.

6.3: Not Quite Human, Not Quite Natural

When it comes to the issue of “man-made” earthquakes, the situation continues to remain particularly unsettled. This is how Gardar, an English schoolteacher in Hveragerði, puts it:

> Orkuveita says that that are just speeding up stress in the rock, that it would come anyway, that it is just a matter of time, and the insurance people say that the quakes are not natural catastrophes, while we are left in the middle wondering what to do. We don’t know where we stand. When nature does something, the catastrophe insurance pays, but [they will] not [pay] if men are making it happen. There is tension everywhere, the pressure is moving, but when will it break out and how? Nobody is sure.

The ICI has determined that they will not settle claims that may emerge from “man-made” earthquakes, much to the consternation of Orkuveita.[173] For the ICI, these earthquakes do not fit the category of ‘natural catastrophe’ that the revised 1992 Iceland Catastrophe Act (55/1992) specifies.[174] So while the ICI claim that these earthquakes are not ‘natural,’ Orkuveita, as Gardar reminds us, claim they are simply accelerating ‘natural’ forces. Gardar, like many in Hveragerði, feels trapped in the middle, of not knowing where to stand between competing versions of what constitutes the ‘natural.’

All other cases of ‘natural’ catastrophe - eruptions, avalanches, landslides, and floods – are seen as relatively uncontroversial.[175] As such the ICI are used to

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[173] According to some employees at Orkuveita that I spoke with, the company asked the ICI to process any claims that might emerge ‘as if’ they were from ‘natural’ earthquakes, in order to weed out those that were invalid according to normal claims procedures. However, it appears that ICI did not agree to this request although I could not get anyone at Orkuveita to officially confirm this. The ICI would also not comment on the status of any pending claims.

[174] https://www.vidlagatrygging.is/UserFiles/Documents/ACT_ICI.pdf

[175] There are some categories of flood that do not qualify under the ICI scheme, see http://www.islandvulnerability.org/iceland.html#insurance, accessed 12/10/16.

settling claims that fit with a common understanding of what constitutes the 'natural.' In settling such clear-cut claims, claim making produces a somewhat 'pure' version of the 'natural' in the process. For example after the 2008 earthquake, there was little to no discussion about where responsibility for the earthquake lay. 'Natural' forces were clearly considered the locus of action, and discussions around settlements were contained within the bureaucratic net of indexing and itemising loss, and verifying values.

This allocation of responsibility went unquestioned despite some little known geological articles discussing the possibility that geothermal extraction may have had an effect on the stress pattern release of both the 2000 and the 2008 Suðurlandsskjálfti earthquakes. The geological conversation is, however, contained within specific disciplinary circles and has not gained enough momentum to disturb the claims process.[176]

However, the discussions that "man-made" earthquakes have set in train are disrupting normal claim and settlement practices. As we learned in the last chapter, in trying to take account of these new earthquakes, Orkuveita are claiming that they are accelerating 'natural' forces through reinjection. So what is being performed here is an account of events that is not quite human, but at the same time, not quite natural. The version of 'natural' arising here is somewhat different to prior earthquakes; it is not purely 'natural,' but a *more-than-natural* account of action.

The implication of the ICI response to claim making for these new earthquakes is to suggest that the state does not see itself as being responsible (answerable or accountable) because 'nature' is not responsible (the cause), that is, 'nature' cannot be determined as the locus of action, or at least not *purely* the locus of action.

6.3.1: Making and Triggering

In Chapter Five I introduced a report, *Procedures for Induced Seismicity in Geothermal Systems,* produced in 2012 as a response to the intensification of "man-made" earthquakes being felt in Hveragerði. It was produced by a committee of

[176] While geologists working within geothermal are writing about these issues, see (Flovenz et al 2015), seismologists, who dominate the hierarchy of the IMO, seem less than enthusiastic.

expert members (Bessason, Ólafsson et al. 2012), one of whom put the problem of determining the locus of action to me like this:

> There is a known relation between reinjection and earthquake location but in terms of actual causal evidence for which type of quake it is, it doesn't seem possible to distinguish.

Orkuveita can, and do, correlate their reinjection pumping activities with seismographs around the reinjection area (Húsmuli). The correlation between them is the basis for this 'known relation,' that is, earthquake activity in the area rises and falls in line with changes in reinjection activity. This is one of the reasons why the ICI deny claims to settlement. Such earthquakes, in their estimation, do not qualify as 'natural.'

But as the expert report goes on to discuss, while this 'known relation' is able to be demonstrated, what is more complex is assigning agency in the process of earthquake activation. In both interviews that I conducted with the expert panel members, and in the report as a collective work, the committee take the ICI to task on the question of responsibility. They invoke a skiing analogy to outline their position:

> What is occurring can be compared to an avalanche that occurs as a skier skies down a mountainside. Would the ICI deny claims of damage that resulted from such a scenario and put the onus onto the skier who triggered the avalanche? It is not acceptable for the sufferers of damage resulting from triggered earthquakes or the energy company responsible for reinjection, that there is no clear policy of who bears the liability of possible damage (Bessason, Ólafsson et al. 2012: 89).

Here Orkuveita make an interesting move. By delimiting their responsibility to reinjection, they acknowledge the 'known relation' between reinjection practices and incidences of earthquakes. However, they add to this account through the skiing analogy, locating their actions, and hence their responsibility as a secondary causative relation to 'natural' forces that they did not create. While Orkuveita are taking a kind of quasi responsibility for these new earthquakes, the source of their disagreement hinges upon how their verb choice– "triggering"– interferes with more traditional understandings of agency.

As I have remarked several times, while many of the town's residents characterise the company's activities in terms of "making" earthquakes, the expert panel describe reinjection as a process of thermal shock that accelerates the release of rock tension. As the instructive analogy above points towards (as the experts see it), in the same way that a skier can trigger an avalanche from already built up snow, Orkuveita are triggering earthquakes from already built up rock tension. The municipal company's claim is not that they are causing or *making* earthquakes, but *triggering* already *in situ* 'naturally' occurring processes.

But these descriptions produce a sense of analytical disconcertment (Verran 1999) within me. I am confronted with two sets of claims, "triggering" and "making." The former, "triggering," provokes an image of the activation, under certain conditions, of something that is already 'given.' This militates against a type of analytic sensitivity I have developed over time, one which suggests that there is no 'given' world, but only various worlds that are enacted, or performed into being (Mol 2002).

As such, I find myself in an ethnographic dilemma about the nature of the terms being used. Matei Candea (2011), in a similar bind, reflects upon the ways in which schoolteachers in Corsica make a split between the non-political classroom and the political world outside. Being analytically groomed in a post Foucaultian perspective, Candea has trouble reconciling his own understandings of power as being micro and distributed, while his schoolteachers make a separation between domains that are political and others that are non-political. Candea ponders further; even if there is a non-political space, as his teachers claim, such a space has to be produced, and in this sense it is also a type of political act.

Candea raises the question of how to take the categories our interlocutors use seriously, while at the same time remaining sensitive to the knowledge production of ones discipline(s). Borrowing from Latour, one possible answer for Candea is to suggest that we could enlarge our definition of politics to the point where it accepts its own suspension, but that would problematically lead, again, to the conclusion that everything is political, including the non-political (2011: 321).

Could I analogously then claim that "making" be enlarged to include its own suspension, suggesting that everything is made, even the non-made? This would imply, that as accelerations, "triggers" are also made. But this would run counter to the expert panel who explicitly claim that "triggering" is not about "making."

Candea's above intervention is part of a set of debates within the 'ontological turn,' a set of concerns within anthropology that speak to the difficulties of coming to terms with some of the more radical disjunctures between anthropological modes of analysis and ethnographic practices. One concern these debates have coalesced around is the question of how to 'take seriously' the categories and perspectives of the accounts of others (Candea 2011, Viveiros de Castro 2011, Holbraad 2012, Pedersen 2012)

While I do not think it is necessary to regurgitate the rich accounts from the above authors,[177] one central point of reflection seems to be about the ways in which we can hold open moments of analytic potential. The question becomes how to take the accounts of others seriously in ways that do not sweep them aside through a particular ingrained repertoire of concepts and analysis bound up with Western metaphysics.

While 'taking seriously' does not of course suggest taking literally, or taking sides when faced with competing claims, what I am faced with is two competing claims, one of which resonates more loudly with my own sensibilities. With this in mind, one way of moving forward then, as I intimated earlier, is to work a little more laterally. This means taking what otherwise might be thought of as an empirical process, such as insurance claims and settlements, and figuring out what other angles of analytical potential I can develop.

Thinking laterally allows me to focus on claims and settlements as performative processes that do certain types of work within the realm of insurance, but at the same time open up for another mode of analysis; one that allows me to investigate the ways in which versions of the 'natural' and the human are also

[177] For a concise summary of these debates see Antonia Walford Transforming Data: An Ethnography of Scientific Data from the Brazilian Amazon (2013: 17-20 and 218-219).

performed. Claims and their potential settlements have been one way to perform and keep intact the distinction between the 'natural' and the human that is so well established in Iceland.

However, with the production of new earthquakes, comes new claims, and these claims are far from settled. What I would like to do in the next section of the chapter is to laterally explore such claims by the varying parties as they take account of these new earthquakes ("triggered" or "man-made") and the unexpected situation they find themselves in. The chosen route is one that thinks about the differences between "making" and "triggering" as they relate to the idea of agency.

6.4: Cutting Agencies and Responsibility

The concept of agency has loomed large for many years in social science discussions. Marylyn Strathern, for example, suggests thinking of agency as a way to discuss the manner in which social action is conceived. As the term developed conceptual ground in the 80's, Strathern urged anthropologists to be attentive to the variety of ways in which persons might be seen to impinge upon each another, as well as the ways in which people allocate causality and responsibility to one another. She was also quick to point out that this did not have to be in reference to intentions, or indeed anything mental at all (1987).

Despite such prescient warnings, in the hands of the practice theorists (Ortner 2006), agency came to be conceived as the autonomy of persons in relation to and against structural constraints. It is against much of this type of thinking–agents as intentional subjects where the focus seems to lie with the ability of a self-conscious individual to achieve a previously articulated goal–that Bruno Latour sets his writing.

Since his early publications, Latour has paid special attention to the notion of agency. In *Reassembling the Social* (2005) he suggests that action is not done under the full control of consciousness, but should rather be felt as a node, or a knot; a conglomerate of many surprising sets of agencies that have to slowly be disentangled. Drawing from Goffman, Latour asks us to imagine a stage in which the actor, far from acting alone, is surrounded by a host of others that impact upon what is occurring; backstage crew, lightening, script, audience, and so on. The word actor, he suggests, directs our attention to a complete dislocation of action. Action, as the sees it, is ‘borrowed, distributed, suggested, influenced, dominated, betrayed, translated’ (ibid : 46).

In any account of what happens, we can never be certain who, or what, is making things happen. But we give accounts nonetheless, as some form of expected rational response to the world we live in. Accounts are demanded of us. In these accounts the many agencies, or forces, that could be making things happen come to take on particular figurations (ibid: 54); shapes or forms through which the locus of action is accounted for.

In laboratory setups, scientific accounts of the world define agents by setting up trials of action that slowly capture what they do, over time. The naming of a new entity in the world is a name given to the actions that entity performs; that is, performance precedes the designation of a series of competences that each entity will eventually come to be known by. It is only at a later point, according to Latour, that these positions are reversed as competences begin to precede performances (Latour and Woolgar 1986).

In later work, Latour talks of the contradictory morphisms–shapes or agencies–that scientists, engineers and even novelists have to take account of in the anthropocene, as they explore the shape of unknown actants before they stabilise as recognized actors (2014: 12). Before they become these recognizable entities–whether they be characters in a novel, scientific concepts, technical artefacts or natural features – they are all part of what he calls a ‘metamorphic zone’ (ibid 2014:13); a time and space of comingling before agencies are designated as either ‘natural’ or ‘cultural.’

While Latour’s work helps me to think through the emergence of new entities through the idea of comingling agencies, I want to draw Marilyn Strathern back into the discussion to help me think more about how specific accounts are rendered. In *Cutting the Network*, Strathern discusses the emergence of the concept of network, as deployed by actor-network theorists. They have captured a concept, she suggests, ‘with similar properties of auto-limitlessness; that is, a concept which works indigenously as a metaphor for the endless extension and intermeshing of phenomena.' However, the power of such analytical networks, as she puts it, 'is also their problem, theoretically they are without limit' (1996: 522-523). Yet analysis, like interpretation, must have a point she continues: it must be enacted as a stopping place.

Borrowing the term 'cutting' from Derrida, Strathern asks us to think about the ways in which, for example, the force of the law cuts into the limitless expanse of justice, reducing it and rendering it expressible, creating in the legal judgement a manipulable object of use (ibid:522). Another example of making cuts occurs through the notion and performance of property. Strathern talks about the ways in which patents for medical technologies are developed, remarking that any one 'invention' is only made possible by the field of knowledge which defines a scientific community. While the social networks are long, patenting is what truncates them (ibid : 524). Cutting, therefore, is a way of bounding, or truncating what otherwise could be an endless series of agencies, it is a performative practice through which some things come to belong while others are excluded.

In Hengill what we are seeing is the emergence of new earthquake entities whose forces, or agencies (that which is making it happen), are still in the process of being designated as either 'natural' or 'cultural.' Through their respective claims, each of the recognized actors with something at stake in the issue (Orkuveita, the expert panel, ICI, and local residents) are making a particular cut into the ways in which these entities are seen to be arising, as some agencies come to belong to particular accounts and others are excluded. This is one reason why there is still a range of names being used to designate these agencies. While locals refer to them as "man-made" earthquakes, as do geologists in informal conversations, the term 'induced seismicity' is what appears on the title of the expert report.

However, the description of these agencies that appear within the detail of the report adds a layer of ambiguity to committee's own chosen designation. Induced seismicity, as they describe in geological detail in the report, is closely aligned with both fracking and Enhanced Geothermal Systems (EGS) (Bessason, Ólafsson et al. 2012: 62).[178] Within these operations, highly pressurized water introduces large quantities of extra energy into the system. It is this extra energy that can fracture the rock and induce a seismic response.[179]

As we learned in the last chapter, it is not the introduction of extra energy in the system through highly pressurized reinjection water that the expert panel and Orkuveita say is the issue at Hellisheiði, but thermal shock from the water temperature that is crumpling parts of the rock matrix. While not 'inducing' seismicity, reinjection practices are "triggering" already *in situ* stress, that is, they are not adding stress to the rock strata, but releasing what is already there. This is a fine-grained distinction, but an important one nonetheless.

Given that these earthquakes were completely unexpected, their occurrence left the Icelandic geological community scrambling for explanations. The term 'induced seismicity' is commonly used in US geological literature as it relates to Enhanced Geothermal Systems (EGS) and fracking processes, and several of the committee members acknowledged to me that this literature was their point of departure in trying to understand what was happening. The term 'induced seismicity' was an opening gambit that 'stuck,' possibly as a basis of comparison. As the report develops and the specificity of the Icelandic situation emerges more clearly in its pages, "triggering" becomes the more dominant term. Despite such a *redescription* in the report from 'inducing' to 'triggering,' its title still remains *Procedures for Induced Seismicity in Geothermal Systems* (Bessason, Ólafsson et al. 2012).

While all the parties are familiar with many of the complex series of interlinking events through which earthquakes occur, the emergence of a new type

[178] As I explained previously (chapter 4, page 127, note 137), Icelandic geothermal systems are known as hydrothermal. This is where fluids circulate within subterranean fractures and are extracted as hot water and steam. EGS occurs in areas where there is only hot dry rock, that is, there are no fluids circulating through the subterranean. In such operations high-pressure water is injected into rock formations to break up the rock and create micro earthquakes that make the rock strata more permeable. Cold water is then injected down into the permeable hot dry rock to pick up its heat. It is this water that is then extracted for production.

[179] These quakes are usually less than 2 in magnitude, and tend to go unnoticed by humans. However the largest reported earthquakes of this kind have been between magnitudes of 3.0 to 3.7. One exceptional event occurred in the Geyser Geothermal Field in California with a measured magnitude of 4.6 (Bessason et al 2012: 62).

of earthquake is destabilising the familiar ways of ‘*cutting’* into such events that produce accounts that fit with existing categories (human and ‘nature’).

Each of the respective claims makes a *cut* in such a chain of events a little differently. By cutting relations at the ‘known’ (the relationship between reinjection and earthquake location), the ICI look to one particular antecedent of these earthquakes - Orkuveita’s reinjection practices – as that which is making things happen. By making a cut here, the complex relation between action and responsibility is located at reinjection practices (read “man-made”) and as such the claim to the ‘natural’ cannot be settled.

Orkuveita, particularly through the expert committee, suggest that things are a little more complicated. While they acknowledge responsibility for reinjection practices, their responsibility for the new earthquakes is somewhat more diluted. By analogising their agency with that of a skier, Orkuveita and the expert panel are cutting into the chain of events in a way that distributes agency in a manner unfamiliar. While humans are active to a particular degree through reinjection practices, they are “triggering” forces that would have occurred sometime in the future, accelerating them into the present, suggestive of a form of conjoined agency.

In their accounts of how they are “triggering” earthquakes, Orkuveita do not cut relations at the ‘known’ but foster an alternative ‘temporal rhythm for action’ (Latour 2013: 130). While the ICI looks to the antecedent of the earthquakes, that is, to the past, Orkuveita look partly to the future, as these accelerated agencies are allowed in as part of the action.

Anthropologist Carol Greenhouse is one scholar who advocates thinking temporality and agency together; for her, conceptions of time are theories of agency. Most time concepts, at some level, express collective understandings of how change happens and how the power to enact that change is distributed. As she puts it, ‘time’s many forms are propositions about the nature and distribution of agency’ (1996: 82). However, trying to reshape western accounts of agency away from the intentional subject, Greenhouse argues, has proven extremely difficult because such accounts are unknowingly connected to, and thereby restricted by, concepts of time (cited in Bastian 2009: 102). In a Western context, these forms of agency tend to be undergirded by a linear account of time as the dominant way of thinking about the way in which change happens, that is, as a series of irreversible progressions from past to future.

So what we can see is that the ICI, in not settling claims, are making cuts in complex chains of events that distribute agency in a temporally linear form; the past is where agency resides, and as such human responsibility for the events that follow reinjection is established. For Orkuveita relations are cut differently. Their account interferes with common understandings of agency as flowing from the past and opens up for the forces of the future to become part of such an accounting. As rocks and time crumple at Hengill, the temporal rhythm of action changes with them, and accelerated earthquakes become part of the accounting of action.

6.4.1: Unsettled Responsibility

As Strathern has suggested, thinking about the ways in which people allocate causality and responsibility to one another is an important task (1987). Under accelerating conditions of environmental change this task has become increasingly more complex. As I mentioned in the introduction chapter, the very term anthropocene is itself one that assigns responsibility for environmental change to the anthropos (human) on a planetary scale (Chakrabarty 2009, Alberts 2011, Pattberg and Zelli 2016). I noted how criticism of the term focuses on how it collapses distinctions across region, ethnicity, age, gender, and class (Malm and Hornborg 2014, Moore 2015), as the anthropos re-emerges at a planetary scale to claim responsibility for a series of global effects that only a small proportion of the population have contributed to. Here, again, a double sense of responsibility is evident; holding planetary humans accountable on one scale implies the agency of all humans on another.

The neologism anthropocene re-centres humans as responsible – albeit problematically as we have just seen - just at a time when the extent of our future ability to act comes under serious scrutiny. As Earth Systems begin to breach their safe operating spaces due to Man’s actions, the effects of these actions set a serious question mark over our ability to act effectively in the future.[180] While locating responsibility with the anthropos on such a planetary scale might be a satisfactory narrative for scholars looking at ocean acidification or geological strata (Steffen, Crutzen et al. 2007, Zalasiewicz, Williams et al. 2010, Steffen, Grinevald et al. 2011), it is far from enough for social scientists.

This chapter is trying to get at the thorny question of responsibility and how to locate, and allocate, it within complex sets of situated practices. In particular the insurance industry is a primary site that exemplifies the messy realities of the institutional setups we currently have for dealing with such responsibilities. In one sense, responsibility points towards agency, an attempt to give an account of action (what has happened) by locating that which makes the action occur. It is a practice of making a cut into the various possible forces that could potentially be attributable to an action and settling on one, or some, of them. In this sense it is a *practice of locating*. In another sense, responsibility speaks to the need to hold parties to account as they become answerable for the actions that occur. It is also a *practice of allocating*. But these practices are not mutually exclusive, and for the most part work side by side.

In a recent book on ethics and anthropology, James Laidlaw draws on a typology of meanings of responsibility through the work of Bernard Williams; responsibility as cause (what made something happen), intention (was the state of affairs intended or not), state (the question of the state of mind or condition of the actor) and response (who has to do something about it). While there are clear problems with such a typological approach, Laidlaw does suggest that these four categories are not always weighted or related to each other in the same way, and that events in life are, of course, more complex and messy than Williams' typology suggests (Laidlaw 2013: 189). J.L. Austin's examination of excuses is one interesting thread that Laidlaw draws upon, in which Austin talks about the many situations where people try to mitigate, or attenuate, their deeds by claiming that they may

[180] The serious doubt over our ability to act in the future to mitigate or 'fix' the range of problems we have set for ourselves is one of the painful ironies of our current moment. While humans have exercised great agency over the earth in recent centuries, the possibility of pushing the planet through a tipping point and provoking a whole host of feedback loops that we can do little about is now very real.

have done something, but 'only in a way' (Austin in Laidlaw 2013: 190). Interestingly, this 'in a way' is reminiscent of Orkuveita's claim to the *more-than-natural.* Laidlaw also draws out the complex relationship between responsibility and action by pointing to the centrality of ethical evaluations in any assessment of what happens, and why things happen. Ethical judgements about the nature of an action are implicated in locating and allocating responsibility for such an action.[181] Upon allocating responsibility, a response is most often demanded. But what happens in situations where responsibility cannot be allocated?

As we have learned, the claims being made in relation to "man-made" earthquakes at Hengill remain unsettled, in both senses of the term as I have adopted it. At the level of insurance, the ICI have stated that claims to loss in the eventuality of damage will not be settled, while at the same time the legitimacy of the categories that are performed along with these claims also remain unsettled.

In figuring the future in the present, Orkuveita perform a version of 'natural' that interferes with both more traditional definitions of agency (its temporal trajectory) as well as the distinction between humans and 'nature.' Being not quite human, but yet not quite natural, such *more-than-natural* accounts of action are still not acceptable to a traditional institution such as the ICI.[182] In rejecting the claims being made, the ICI do not take a position on Orkuveita's responsibility, they simply say that the state is not accountable because the earthquakes are not 'natural' in their definition of the term. In Laidlaw's terms, an ethical evaluation about the nature of the action is enfolded within the action. When 'natural' forces are deemed to have acted, a history of ethical relations between the people of Iceland and 'nature' are triggered. In these circumstances the state is obliged to accept

[181] Laidlaw remarks, 'so a purported causal account of a grievous misfortune I have endured will not be explanatory at all if it omits the fact that just one of those constituent causes was motivated, for example, by personal hostility to me. That will make all the difference, because my interpretation of not only why but actually what happened, is inseparable from, because partly constituted by, my judgements about its ethical character as an action, and this includes judgements about responsibility for it (2013: 185).

[182] Even though the expert panel articulate a sense of conjoined agency through their own descriptions and in interviews, there still remains some form of claim to the 'natural.' That is, the skier analogy as they describe it retains a strong sense of 'natural' forces that, although triggered, would have otherwise occurred. It is for this reason that I tentatively hold onto the term more-than-natural, both as an ontological mixture, and as a way to signal Orkuveita's attempt to legitimise their actions as still connected to the category 'natural' that continues to be very powerful in Iceland.

responsibility, and hence respond. When *more-than-natural* forces are deemed to have acted, responsibility remains unsettled.

So even though the state does not have to respond (through the ICI), the rest of the actors in the vicinity of Hengill do. While matters remain shaky they have to figure out the best ways of responding to one another in difficult circumstances. To help me think a little more about the complex sets of responses between human and non-human actors, I want to draw briefly on some of the work of Astrid Schrader. Schrader, in analysing an on-going scientific-political controversy over the toxicity of a fish-killing microorganism, explores the relationship between responsibility and nonhuman contributions to agency in experimental practices (2010).

Drawing upon Karen Barad's work on 'agential realism,'[183] Schrader argues that in experimental setups different cuts between 'objects and measurement agencies establish different phenomena.' Responsibility in experimental setups, then, entails accounting for the practices that enact a specific cut such that 'objects-in-phenomena become determined,' that is, a cut through which objects 'materialise' and 'matter' (ibid : 285). Scientific practices, in this sense, are meaning-making practices that require accountability to what comes to exist; responsibility and causation come to condition one another. Part of this relates to the temporalization of the scientific object, that is, the joint possibilities of causality and responsibility vary with the temporalities of the objects enacted (ibid : 277).

As Schrader unfolds in her example of the fish-killing microorganism, how the fish is enacted impacts upon what it comes to be, and temporalization is an important part of such enactments. Various laboratory practices have enacted different kinds of object - the atemporal genetic fish-killer, the fluid object of reproductive processes, and a phantom – exhibiting various degrees of responsibility in enabling or disabling responsiveness (ibid : 298). In enacting the fish-killer as an atemporal object, scientists erase its means of variation under altered experimental and environmental circumstances, and as such foreclose its ability to respond. Effacing response-ability effaces a responsible practice, Schrader argues (ibid : 287).

[183] Barad conceptualises the world as the ongoing flow of agency through which part of it makes itself differentially intelligible to other parts. As a process of ongoing mattering, what is important is where one makes a 'cut' in the world (2007: 820).

Elsewhere Schrader develops the above line of thought; arguing that accounting for such cutting practices requires 'attention to the agencies of the object of study, to maintaining their ability to respond.' Responsibility, in this sense, is not about a particular type of response, but an enabling of responsiveness within experimental settings (ibid : 285). Here, responsibility hinges on response-ability, that is, how agencies are taken into account (ibid : 279). In the case of the killer-fish, responsibility is the ability for the microorganism to respond. While for Laidlaw response is an effect that occurs after responsibility has been allocated, for Schrader the ways in which responses are made and taken into account is what constitutes responsibility.

While it is a little risky to take insights generated within experimental scientific setups and apply them to experiments in the landscape,[184] I do think response-ability is a helpful term as a way of asking how actors are continuing to take account of the varying human and non-human agencies at Hengill, particularly as responsibility, in insurance terms, remains unsettled. As we leaned above while they remain *more-than-natural* affairs, the state is not responding to events at Hengill in any significant way. But other actors must. Each of the groups is learning how best to respond to one another as they try to settle these shaky matters. It is to these efforts that I now turn my attention.

6.5: Geological Settlements

Iceland is a place with an interesting history of settlement making. While the period between 872 and 1272 is designated the 'Settlement Period,' the name refers to more than just the time when the first families came to these lands and settled in the south and south western parts of the country. As I discussed in the introductory chapter, the term settlement also holds within itself a reference to the types of compacts that occurred as families gathered at the almost scared Þingvellir site, settling disputes and making laws through recourse to old rock and stone.

[184] This is the way the mayor of Hveragerði, Aldis, characterised Orkuveita's interventions in the last chapter. It is also the way many in town have talked about "man-made" earthquakes, an experiment within which they are uncomfortable participants.

The 1800's were a period that saw a constitutional settlement with Denmark, a long non-violent process of gaining constitutional recognition. As we also saw in the introduction, volcanic landscapes played a particular role in the development of this brand of nationalism, as the unsettled spirit of geological power was transferred to its people's claim to exist as 'unique' and 'independent.' But today steam production for Century Aluminium is transforming this very same volcanic zone into an industrial-renewable energy landscape. However, settling the shaky matters that have arisen here is no easy task.

Let me briefly return to the town hall meeting in Hveragerði that I mentioned in the previous chapter. The most prominent questions being discussed at this meeting were ones of responsibility, which while remaining unsettled for all the reasons discussed above, gravitated towards the question of how to respond. As I discussed at the end of the last chapter, how to manage the future is a concern that all the parties at Hengill are preoccupied with; making some type of settlement is the pragmatic form that this takes. As Aldis, the town's mayor, put it:

> We are not fighting the company itself, we would like to utilise the energy that is in the earth in Iceland, of course, we all need that, but it has to be done in consideration with the inhabitants and the nature.

The town are not fighting the energy company as such; after all, the energies and forces of the earth are the very *raison d'être* for the town's existence. Its ongoing survival is also considered to be a matter of providing the right range of innovative energy solutions to attract small businesses to the area; something Orkuveita can be very helpful with. What they are looking for is some form of settlement, that, while allowing for the continuation of energy extraction, takes the inhabitants and 'nature' into account if such settlements are to be lasting.

The first step was the establishment of the expert committee, which included a member of Hveragerði's council as a guest observer. The ensuing report from the expert committee, segments of which I have already analysed in detail, paved the way for further discussions about how to make a settlement that the varying parties could live with. Agreeing to the need for a settlement, however, is far easier than actually agreeing to what that settlement might consist of. Although everyone wants things to settle down, for Orkuveita, the residents, and local environmentalists (who I will discuss in detail in the next chapter) such settlements do not occur as one moment of contractual agreement between various groups. Neither are they a question of halting production. The city of Reykjavík is far too invested in the Hellisheiði Geothermal Power Plant, both financially and politically, for this to be even discussed as a possibility.

But it is not only on financial and political grounds that the argument for halting production has not gained any traction. There is also a compelling geological argument for why the plant should remain in operation, despite the problems emerging from it. As my geology friends were at pains to point out, during the first wave of seismic events in late 2011 various remedial measures were taken to try and counter earthquake activity. Temporarily halting production was one effort, as was changing some of the parameters of reinjection, mostly by adjusting the water's pressure and temperature. But these responses only aggravated the situation as seismicity increased up to a level of 4,600 registered events within six months. Once such volcanic interventions get under way and the landscape beings to respond through seismic events, it is extraordinary difficult, or at least too risky, to unwind them.

The geoscience team characterised this in layman's terms for my benefit as "not fiddling with the buttons too much." Learning the lessons from 2011-12, steadiness and consistency have become the strategy of choice. While not making any sudden changes to production parameters can, and has, significantly reduced earthquake intensity over the last two years, "triggered" earthquakes continue nonetheless. This is because there is always a need to interrupt normal operational parameters, whether due to the many and various forms of breakdowns that can occur during such a complex operation, regular maintenance checks, or even just standard cleaning operations that necessitate taking a reinjection well offline for a short period. The extraction-reinjection cycle cannot operate undisturbed. And as disturbances occur, seismic responses ensue.

The geologists always use a kind of bogeyman story when talking about these issues, which comes from an Enhanced Geothermal System (EGS) project in Basel, Switzerland.[185] As previously discussed, EGS projects inject large quantities of water in the hope of breaking up subterranean rock in order to release its heat. So in essence, actively producing thousands of subsurface micro earthquakes is part of the production plan. But in the Basel case, seismographs picked up surface seismic activity not long after the first series of injections in 2006. Injection was halted shortly thereafter. It was only after the shutdown that the biggest and most damaging sequence of earthquakes hit. While starting injecting processes disturbed the area, stopping them elevated these disturbances.

What we are seeing here is that Orkuveita's intervention into the volcanic landscape has initiated a set of responses from the earth that require a further set of responses from geologists; "staying plugged into" the landscape and "not fiddling with the buttons" are modes of geologically responding to the earth, as it responds to humans. This is a mode of responding that holds what geologists believe are worse outcomes at bay, one that *settles* humans into the rock face for the indefinite future.

6.5.1: Settling Instability

As seismic activity continues in Hengill, both 'natural' and "more-than-natural," Bjarni and his team have learned how to take advantage of such instabilities. We saw this in Chapter Three through a volcanic intervention that the geoscientists called an awakening. On the day in question I asked Bjarni why they were trying to "awaken" this particular well. "There have been many earthquakes here over the last while, both 'natural' and from reinjection," he said. "All sorts of things are changing down there, and while we're not really sure how, we think there'll be some sort of response." Geologists at Orkuveita work under the continual shadow of declining water pressure and energy output, and are very aware of trying to avoid the punitive measures that come from not living up to their energy contracts with Century Aluminium. Learning to work with the earth's seismic responses is something they have become very good at. Interestingly, the seismic responses (earthquakes) that

[185] See http://www.nature.com/nature/journal/v462/n7275/full/462848a.html

the geologists are responding to are themselves a partial response to geological work (reinjection).

While "triggered" earthquakes are dangerous and unpredictable for the residents of Hveragerði, they also have the potential to be generative, as vast quantities of water and steam are released through increasingly fractured rock. So as instabilities proliferate, the geology team target their efforts towards these sites of instability, awakening wells and rearranging the unstable forces around them for productive means. Another way of putting this is to say that as geologists continue to arrange the liveliness of volcanic sites for energy production, their work triggers seismic responses, which they respond to by infrastructuring, as these very instabilities become a part of emerging energy infrastructures. In some ways what we are seeing here is a responsive, or recursive, loop that is mediated through infrastructuring.[186]

Infrastructure has long played a role in anthropological thinking as an empirical site for social and political change, although the focus of attention seems to have leaned heavily towards clear infrastructural projects that speak to, amongst other things, issues of state power and spatial organization (Appel 2015). In recent years as certain branches of anthropology have intersected with specific work from within Science and Technology Studies (STS), the concept has gained in analytical traction (Edwards, Bowker et al. 2009, Carse 2012, Harvey and Knox 2012, Jensen and Winthereik 2013, Harvey, Jensen et al. 2017).

Two residual ideas remain in infrastructure thinking, first that infrastructures, or overlapping infrastructures (this pluralisation is in itself an important move), are what distribute, circulate, or move people, objects, ideas, and relations, and second, that they do so in rather stable and durable ways. While Geoffrey Bowker and Susan Leigh Star coined the phrase, 'infrastructure as second nature' (Bowker 1995, Bowker and Star 1999), it is Ashley Carse's work that breaks with the notion of infrastructure as nature plus cultural additives, demonstrating 'nature as

[186] This does not mean that new wells are drilled in areas of "triggered" earthquakes. But it does mean that wells that have been previously drilled but are inactive can be activated. For example there were originally 17 wells designated as reinjection wells. During my fieldwork, Orkuveita 'converted' and then "activated" three of these wells into production wells in an effort to tap into steam and hot water generated through increased permeability from earthquake activity.

infrastructure' in the provision of essential ecological systems services (2012). Yet even Carse's work still leaves a sense of a nature-object that is, to a significant extent, a provisioning demarcated entity. I want to treat Bowker, Star, and Carse's work as an invitation to further extend our thinking about the relationship between infrastructure and 'nature.'

While stabilising the seismic landscape is absolutely necessary, in fact a huge quantity of work goes into doing just that, it is never the full story. Stabilising processes (reinjection) are themselves productive of moments of instability ("triggered" earthquakes) that, in turn, enhance the productive potential of the geothermal field.

While Brian Larkin suggests that infrastructures are 'matter that enable the movement of other matter' or 'objects that create the grounds on which other objects operate' (2013: 2-3), the implication, as I read it, is that such grounds need to be stable enough to allow those other objects to operate. Although the pervasive idea of circulation through stability still lingers within infrastructure thinking, I want to think with the thresholds of the volcanic landscape by arguing that instability has now become a generative part of Orkuveita's infrastructure, as it continually encroaches upon the landscapes of Hengill.

What I want to suggest through this section is that once such volcanic interventions get under way and the landscape begins to respond through seismic events, pulling out is too risky an option. In this way humans are geologically settling into the earth on an indefinite basis. At the same time the ongoing production of instability is also settled, albeit temporarily, through its infrastructuring. But it is important to say that the recursive responses we are seeing at Hengill are not between the earth's capacities and geologists, they are among and within 'arrangements of existence' (Povinelli 2012b) that the concept infrastructure helps to elucidate. Another way of putting this is to suggest that infrastructuring the earth is how responses and counter responses within and between landscapes actors are mediated, that is, infrastructuring is one attempt at making human-earth settlements. While I have focused on the geological component of settlements up to now, I would like to move on to talk about what political settlements are also afoot, and the ways in which they are partly constituted by the geological.

6.6: Political Settlements

After the publication of the expert report, an agreement was reached to set up a warning system to be activated in the event of any increased risk of "man-made" earthquakes. As I explained above, the normal course of operations leads to this being a more common occurrence than any of the parties would like. When scheduled maintenance or cleaning occurs, or indeed unscheduled breakdowns, the risk of seismic activity increases and a warning is issued to the town.

Today, warnings consist of electronic communications between the company and the town council, who then release the information on the town website. Initially, this struck me as a resoundingly mild way to treat what I saw as such a serious issue. However, after several discussions with the mayor, as well as local politicians and businessmen, it became clear that the town, or at least those in positions of authority in the town, are none too keen on such a warning system, despite having agreed to it in principle.

In the introduction of the dissertation, I spoke of an interrupted interview I had with Sveinbjörn, geophysicist and former rector of the University of Iceland, who was called to an emergency meeting in Hveragerði. The reason for the meeting was the issuance of a predictive alert from the recently appointed head of the Icelandic Meteorological Institute (IMI). The alert declared that a 5.2Mw earthquake could possibly occur within the next 24 hours around Húsmúli, the reinjection site at Hellisheiði.

The warning was generated through the use of an experimental seismology program that predicts rock strata stress release based on an analysis of micro-earthquake activity.[187] On that day in September 2013, the IMI publicised the information and mobilised the civic protection agency, the chief of police, the head of Orkuveita, and the town council of Hveragerði, as well as various media outlets.

No earthquake of any significant magnitude occurred over the subsequent days and weeks. Aldis, Hveragerði's mayor, described the town's reaction as being one of panic, while Sveinbjörn emphasised the inexperience of the new IMI chief in publicising the results of such an experimentally predictive technology. More

[187] Micro-earthquakes are defined as events under 1 Mw.

particularly, he was very dissatisfied that she had mobilised the various members of the civic protection agency.

There is much debate in the town regarding the relevance and benefit of earthquake warnings. While most are in agreement that expected changes at the power plant should be communicated in one way or another, the anxiety inducing effects of being given a specific magnitude is difficult for a lot of people to live with. Warnings of “man-made” earthquakes on this scale only feed into the sense of indeterminacy about “the next big one” that I discussed in the last chapter. Living with warnings as a method of settlement can also be very unsettling.

In light of these events, the town and Orkuveita agreed upon the current system that is in place, a simple electronic communication of information. A passive warning system so toned down so as to beg the question of the usefulness of its existence. But what type of political settlement is this? Talking to the Hveragerði representative on the expert committee, Eythor one day, he told me that, in fact, warnings are a residual issue of a larger political discussion going back to the establishment of the power plant itself. As I mentioned in the last chapter, in some sense Hveragerði is an island of power without any power. Given that all of the land leasing agreements in relation to the power plant are conducted between Orkuveita and the municipality of Ölfus, Hveragerði has almost no formal political remedies at its disposal.

While there are some in the town (and I will engage with them in the next chapter) that talk of using the warnings as a platform for pressurizing the company, particularly by trying to gain traction via the media, the town authorities, both formal and informal, have developed a far more cautious approach. Both the mayor, Aldis, and Eythor spoke to me of being in “an awkward situation” and of “needing to dance on a line, by not shouting too loud or attracting too much attention over the issue.” They fear that making too much political noise about the earthquakes could trigger other forces, which while not the same, could be as differentially powerful.

There are several reasons for this, but primary among them is the shadow cast over the town of the 2008 financial crisis. For many years Hveragerði used its geopower to develop a large horticulture industry (flowers, peppers, tomatoes, cucumbers, even bananas and tobacco at one point) and was known for many decades as the "greenhouse capital of Iceland." However, the property bubble that preceded the 2008 crash brought with it the lure of rising land prices and many greenhouse owners (usually more elderly people) succumbed to the lavish prices on offer, selling their land and upping stakes to another town further east.

The main idea was to develop these former greenhouse areas into residential zones in an effort to position Hveragerði as an attractive commuter satellite town for those working in Reykjavik but desiring a different lifestyle. As one local put it, "everybody was dreaming of property at that point." The October 2008 crash put an end to these plans as the banking system froze, unemployment soared, and property prices plummeted, leaving behind a trail of empty lots that were formerly thriving greenhouses. Today the town survives from a few main businesses, two of which are an old folks home and a rehabilitation centre for people with varying types of chronic illnesses. Highlighting seismic warnings with such a 'health based' industry portfolio is highly problematic for the town.

While many parts of Iceland still suffer from the effects of the 2008 crisis, a particular relationship has developed in Hveragerði. In effect, the relation between the seismic landscape and the post crisis political-economic landscape has produced another threshold, but this time of a political nature, and one that the town has to be very careful not to activate.

A line of argument I have been developing throughout the chapters is that phase shifting thresholds are generative, both in a material and a temporal sense. Warnings, as political thresholds, have the potential to generate other forms of instability, which although beyond the seismic are nonetheless bound up with it. In making settlements about how to live with earthquakes, the town has to "dance on a line," as Eythor remarked. Such a line is form of *political threshold*. While warnings seem reasonable, making too much of a fuss about them, politically, could bring about effects equally, if not more, destabilising than the seismic instabilities surrounding them; dwindling investment, property price declines, unemployment and so on.

But what does this political threshold tell us about politics? Noortje Marres, in discussing the role of material objects in democratic politics, draws upon John Dewey and Walter Lippmann (Marres 2005). Unpacking some of their thinking on how the relation between democracy and the expression of human subjectivity breaks down in technological societies, Marres discusses their respective ideas on how publics emerge around particular types of issue. She reads Lippmann as suggesting that it is the failure of existing social groupings and institutions to settle an issue, which sparks a public into being.

Given that the residents of Hveragerði have no formal political remedies at their disposal, warnings are the best settlement that the town can get in such politically ambiguous circumstances. *But yet at the same time these warnings emerge from a tentative mode of geologically settling the earth*. As humans settle into the rock strata on an indefinite basis, earthquake warnings are the effect of the ways in which this settlement still remains shaky. As geological settlements remain shaky, so do the politics they give rise to, as these shaky matters configure the conditions of political possibility.

Such political thresholds put the town in a real bind. The town's authorities are eager to discourage the emergence of a public around their issue. By instituting the placid information warning system they are not exactly supressing the issue but playing it down to the extent of making it almost irrelevant. There is simply too much at stake for the town authorities (council, businesses etc.) to politicise this issue in the way some locals would like.

Contra Marres' notion of issue politics, wherein it is the failure to settle an issue than sparks a public into being, what we find in Hveragerði is how such shaky matters, as unsettled, generate a type of *non-issue politics*, one in which the town explicitly tries not to make a political issue out of these earthquakes.

6.7: Geopolitics

But what does this tell us about politics? While Jacques Rancière suggests that the construction of the domains of the political and the non-political is, in essence, the definition of politics (Rancière, Bowlby et al. 2001) this does not seem sufficient here. Other authors such as Chantal Mouffe and Slavoj Žižek have proclaimed the rise of the post-political; a political formation that forecloses the political, that prevents the politicization of particulars (Žižek 1999, Mouffe 2005). But these ideas, while tempting, are not specific enough to what is happening as the political relationship between Orkuveita and Hveragerði continues to develop. Non-issue politics as unsettled shaky matters contain more than this.

What I want to suggest is that in Hveragerði geology and politics are inseparably bound together. I broached this in the introductory chapter through a discussion of the geological legacy of the volcanic landscapes of Hengill. While today the power that emerges from the earth at Hengill makes electricity, at one point in the past these landscapes were making the foundations of Icelandic democracy. Connecting geothermal power at Hellisheiði to political power at Þingvellir (the former site of Iceland's parliament) through the Hengill volcanic landscape is one way of thinking about the earth-politics nexus, as geopower.

What we are seeing in the relationship between Orkuveita and the town of Hveragerði is one way that the earth-politics connection is playing out in a contemporary setting. Warnings in Hveragerði, I want to suggest, are a type of geopolitics. They emerge from the ways in which humans are geologically settling into the earth. "Triggered" earthquakes and the warnings that ensue from them are the effect of the ways in which this settlement still remains shaky. But this type of geopolitics is not the (capitalized) Geopolitics of international relations and territory as seen from the perspective of some form of globalised terra, but more of a *situated politics* of and with the earth.

The last several chapters, leading up to and including this one, have been an intensive engagement with the earth's dynamic processes. They have been an effort to think the political through the geological: that is, thinking about the ways in which dynamic geological processes (phase shifting thresholds, crumpling and folding rock) are reconfiguring the political. At the same time the settlements that are emerging from these processes fold back upon the geological; both social and political agency are constrained and made possible by the forces and processes of the earth.

Here the geological is not just a substrate to political matters, but is 'political matter that can relocate the grounds of politics,' as Knox and Huse so adeptly put it (2015). Yet the ground metaphor does not feel satisfactory. In taking the subterranean forces of Hengill into account as they work through and with the forces of capital, we see how shaky things have become, the earth included.

This begs an analytical pause. The entire direction of the politics of things (Latour 2005), or material politics (Knox and Huse 2015) is to ask us to think differently about the relationship between the materials of the world and politics. By opening up our understanding of materials beyond sheer 'matters of fact' (Latour 2004) the varying powers and forces of these materials have, it is argued, the potential to reconfigure politics. Rather than a static politics that treats all materials similarly, that is, as objects that enter into a prefigured political realm (one of passions and interests) varying material configurations can potentially reconfigure how politics is done. If I am to take this analytical injunction seriously then using the metaphor *ground* as the basis of rethinking the relationship between the material and the political at Hengill would be a strange move.

In this ethnographic instance the ongoing shaking of the earth provides an opportunity to rethink the relations between the material and political, through the geological. By holding open a focus both on the materiality of energy (its practices, conversions and infrastructures) as well as on materials as energetic (phase shifting, crumpling), what emerges is more a sense of a turbulent, shaky geopolitics. While there is no stable ground from which this politics can operate, the efforts to settle these shaky matters generate their own shaky geopolitics as the relations from which they are composed remain turbulent. Shaking, one might say, is the geological as well as the ethico-political form that turbulence takes.

6.8: Conclusion

This chapter has been an attempt to analyse how the various actors in Hengill take into account the emergence of new sets of agencies that are varyingly referred to as "man-made" earthquake, 'induced seismicity,' or "triggered" earthquakes. One concern for residents in Hveragerði is the question of who will settle a claim in the eventuality that such earthquakes cause damage to their property. The question of who would pay, in effect, articulates questions of responsibility through a register of insurance.

Taking a more lateral approach to insurance was a way to focus on claims and settlements as performative processes that while doing insurance work, also perform versions of the ‘natural’ and the ‘human.’ The method for doing this was to focus on claims as articulated through the contrasting languages of “making” and “triggering.”

What we learned was that while residents of the town and the ICI hold on to an idea of “making” as human agency, the expert report suggests “triggering” as conjoined agency. This latter form, in suggesting an alternative temporal rhythm for action, performs a version of the ‘natural’ that interferes with both more traditional definitions of agency as well as long standing distinctions between humans and ‘nature.’ Such *more-than-natural* accounts do not resonate with the institutions of the state, and the issue of responsibility, like much else, remains unsettled as people continue to deal with the material, conceptual, and ethico-political ramifications of such shaky matters.

This brought us into the second part of the chapter, exploring how claims are being settled. As extraction and reinjection practices continue unabated, a series of recursive responses emerge between the actors in the landscape. Infrastructuring the earth, then, becomes one mode of trying to settle matters geologically. But such geological settlements remain tentative, as ongoing earthquakes continue to unsettle matters. Warnings, as a political threshold, lead to a form of *non-issue politics* that signal the inseparability of the geological and political in Hengill. While the town’s authorities learn to live with the terms of this bind, others, as we shall see in the next chapter, do things a little differently.

Chapter 7. Protesting Infrastructures

7.1: Introduction

Having dinner one evening with Margrét and Geir, a local couple from Hveragerði, the conversation turns to the construction of Hellisheiði:

> We weren't against the building of the power plant, not at first, but nobody said anything about these "man-made" earthquakes or hydrogen sulfide (H2S) pollution. They are driving us crazy. And then they started to talk about drilling more wells at Bitra, so we had to do something about that, we couldn't just continue to trust that things would be ok, like last time. Bitra is too close to us.

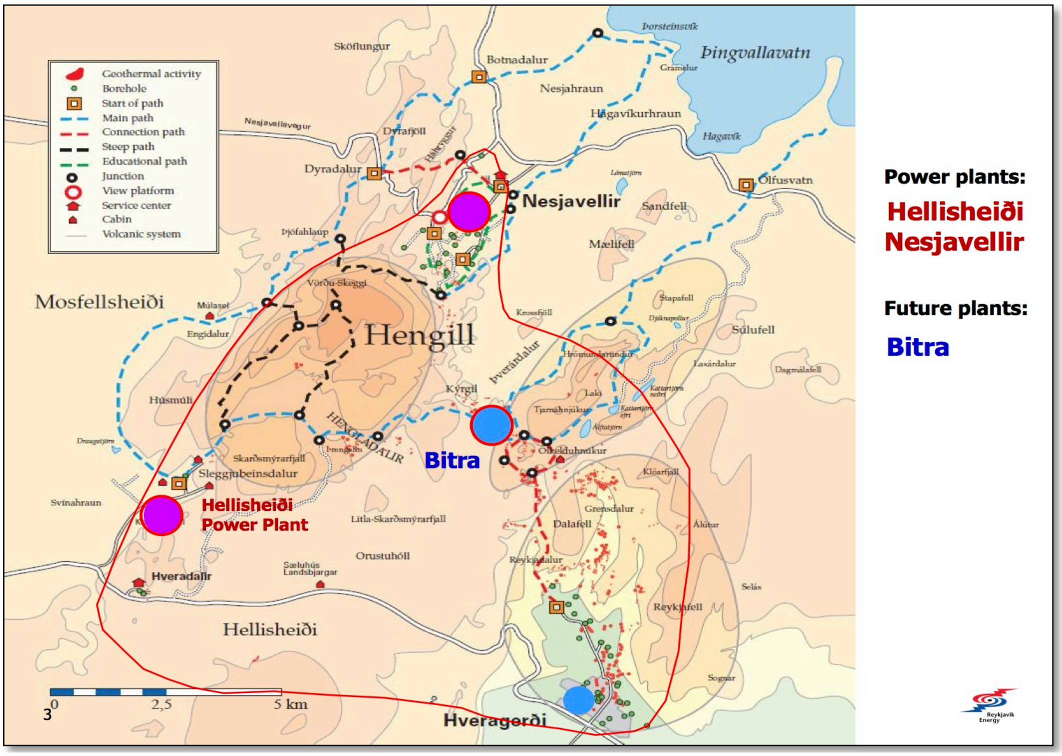

Figure 27: This adjusted map shows the two current geothermal operations in Hengill (Hellisheiði and Nesjavellir) as well as the proposed power plant at Bitra that connects to the hills surrounding Hveragerði. Image courtesy of Einar Gunnlaugsson of Orkuveita Reykjavíkur.

While Hellisheiði lies to the north west of the town, Bitra is situated just to the north adjoining the rolling valleys that encase Hveragerði. The area has been in the sights of Orkuveita since the development of Hellisheiði, and two research wells were built there during the power plant's construction phase. In an effort to convert these research wells to full production wells, Orkuveita lodged an application for planning permission in 2012, just as "man-made" earthquakes started to emerge as an issue for the town.

Margrét echoes what I have heard many times. The lack of protest against the original construction of Hellisheiði being replaced with a sense of disbelief about the effects the plant is having on the town, followed by a determination to do something about further developments. Her husband Geir adds to the discussion: "yeah we were very mobilized. We didn't lock ourselves to any machines or anything, but who knows if we would have." When I ask what form this mobilization took, the couple explain that they walked door to door with a petition, which the vast majority of the town signed. "Actually, it was quite easy," says Margrét:

> Björn had drafted a letter and had a whole pack of information about the damage that would be done to the area around Bitra, and the problems it would cause for the town if the planning permission was approved. Most people signed straight away, nobody wants more earthquakes or pollution, do they?[188]

My ethnographic fieldwork in Hveragerði led me to two men from the town with whom I would come to spend a lot of time, Björn and Stefan. Björn is a retired geography teacher, while Stefan is a tour guide at a local horse riding company. Both men have taken a keen interest in energy developments within the Hengill area over the years. Björn, in particular, is known around these parts as the man who knows this volcanic landscape like no other. Hiking through the landscape is a regular activity for him, as is documenting in detail the various types of damage he sees on

[188] Given its closer proximity to Hveragerði, reinjecting water at Bitra would likely create "man-made" earthquakes of a greater magnitude than those currently being experienced. In addition, residents were very concerned about increasing the levels of H_2S in the area.

his trips. In many ways he is the voice of authority in the town on all maters relating to Orkuveita's incursions into the Hengill volcanic landscape. He is especially vigilant when it comes to the valleys surrounding Hveragerði, including Bitra. It is to him that others in the town turn in order to learn more about Orkuveita's future permit and drilling plans, or to him they provide further details to about something they have seen in the landscape that looks damaged or unusual. In short, he is considered both a gatherer of data and a repository for data on the landscape effects of geothermal energy.

This chapter is an effort to discuss some of the more direct political actions afoot in Hveragerði and the Hengill volcanic landscape. In the last chapter, I talked about the different ways in which the town are trying to settle 'shaky matters.' I did so by developing the relationship between geology and politics through the idea of geopolitics, suggesting that those in authority find themselves in a particular type of bind; making too much political noise about "man-made" earthquakes has the potential to trigger other, equally destabilising, forces.

In this chapter I take up the materiality of political action. I do this through descriptions of Björn and Stefan's protest activities in the landscape as they try to resist Orkuveita's ever-encroaching energy incursions into Hengill. By documenting and recording various features of the volcanic landscape, they make Hengill into a political site, one that makes visible both environmental damage and the health risks posed to the town by further energy developments.

7.2: Toxic Effects

One day over coffee with Stefan and Björn, Stefan railed about the effects of the power plant on the landscapes of Hengill, and on the town. While I am eager to talk more about "man-made" earthquakes, Stefan and Björn want to impress upon me what they see as another very serious issue, the production of hydrogen sulfide (H2S). Along with carbon dioxide, H2S is one of the primary gasses found in volcanic areas; its pungent eggy aroma cannot be mistaken upon entering Hveragerði.

H2S is a heavy, poisonous, corrosive gas that flows down the mountainside from Hellisheiði to Hveragerði, blackening the landscape, as well as destroying moss and lava formations along the way. Living in a house downwind of the geothermal park in Hveragerði, I was keenly aware of its presence, not just through its powerful olfactory manifestation – an eggy, almost sweetly pungent scent – but also how it could be tasted in the mouth and throat, particularly on days when the wind blew strongly from the northwest.[189]

As we chatted over dinner, Margrét and Geir talked worriedly about the effects of the gas. Geir, who works for a drilling company, talks of the time his crew left their vehicles up at the power plant over a weekend: "they were nearly destroyed, the windows, mirrors and lights had to be replaced, the electrics were badly damaged, and this is only after two days, imagine what is happening to us over the course of our lives." Margrét adds, "our roof is in constant need of repair, and we can't even use aluminium in our drains, it corrodes too much, so we have to use plastic. Now isn't that funny when all of this is for aluminium."

While gaseous and invisible to the eye, the effects of H2S are materialised through everyday objects. It is visibly indexed in the town through the corrosion of jewellery, electrical equipment and other forms of higher metals. More important than this though is the increasing worry that these effects are also materialising through the bodies of residents as reports of eye irritations are on the rise, as are rates of asthma amongst children. Others in the town also make connections between H2S and more grave threats, such as breast cancer, as the incidence levels in Hveragerði are greater than the national average. While Orkuveita argue that this is part and parcel of living in a volcanic site, residents respond that the 800 tons of H2S emissions released through volcanic openings in Hveragerði fade in comparison to the 16,000 tons (Már Júlíusson 2013) now coming from the deep drilling activities at Hellisheiði.

Geir puts it this way, "it's real pollution, it's not just damaging scenery and all those things that the environment people talk about, but it's poisonous, fatal sometimes. There were three deaths during the construction of Hellisheiði, all

[189] During my first fieldwork phase with Orkuveita, I also had an unnerving incident while working at one of the geothermal wells with a geoscience team member. While we were setting up a device to monitor the pressure on one of the wells that had recently been 'awakened,' my gas detection sensor began to emit a sound. My companion thought that the sensor was malfunctioning and we continued to work for another hour. The following three days I had a very uncomfortable raspy, irritable voice and irritation in my eyes due to over exposure to H2S.

because of over exposure to H2S." Concern for the welfare of children in the town is particularly heightened. Although health authorities have recently set up H2S monitoring equipment in the town, there is little to no data on the effects of long-term exposure.[190]

Continuing our chat over coffee that morning, Stefan also makes a point of noting that neither he nor Björn object to the production of geothermal energy as such, what they do object to, he goes on to say, is the pace at which Orkuveita continue to develop the landscape. As we learned in the last chapter, in arranging the liveliness of volcanic sites for energy production, Orkuveita's work triggers seismic responses, which they in turn infrastructure for productive purposes, adding to a growing energy infrastructure at Hengill. It is this ongoing *infrastructuring of the earth* that Björn and Stefan regard as a serious encroachment that they need to do something about.

While taking advantage of the seismic events in the area is one strategy deployed by Orkuveita to tap into the potential generativity of their own disturbances, "awakening" and activating wells, as we have seen, is not enough as energy output continues to fall at Hellisheiði. Looking for new energy possibilities within Hengill is one of the only ways left for the company to meet the punitive energy contracts they have with Century Aluminium.

In order to develop new areas within Hengill, Orkuveita need to apply for a whole suite of permits, a time consuming and costly process. However, drilling for the purposes of 'scientific research' is governed through a lighter regulatory regime, and as such applying for research-drilling permits is not nearly as burdensome. As both my companions from Hveragerði see it, this is a workaround for the company, a small but significant loophole that makes it easier to get a foothold into a new area. If research permits are granted, and testing of those research wells is positive, the pathway to full planning permission for more extensive development gets easier.

[190] This is not just an issue in Iceland. One study of the long-term health effects of H2S comes from Rotorua, a town in New Zealand. A comparison of the towns' exposure levels has activated the concerns of many in Hveragerði.

Demonstrating the energy richness of an area is a significant plus in terms of planning approval parameters.[191]

Orkuveita, therefore, are continually encroaching upon more and more of the landscape through such practices. It is here that Björn and Stefan see the possibility of making some form of intervention. While hiking and riding through these landscapes they document the damage wrought by Orkuveita in great detail. One of the main purposes of this type of activity is to generate enough documentary evidence to support their protests against the company, if and when they seek planning permission for extra research wells. Or, as in the case of Bitra, if they seek planning permission to convert existing research wells into full production facilities. It is to this protesting activity that I will now turn my attention.

7.3: Hiking the Landscape

Being retired, Björn spends a not inconsiderable amount of time hiking the landscape over the summer months. Living a few streets away, I was fortunate enough to be able to join him on many of these trips during my time in Hveragerði in the summer and autumn of 2014. On our hikes, Björn has a lot to say about the quantity of tourists coming to the Hengill area. He groans on about their littering habits and bad hiking techniques; the way in which they trample the moss is a particular bone of contention. But he has a lot more to say about the effects of drilling three kilometres into the earth to produce electricity for Century Aluminium.

In Chapter Four, I described the way I assisted Bjarni and his sampling team as we moved from well to well collecting small vials of water. Now, over the other side of the mountain, in summer weather, I move through the landscape very differently with Björn, walking stick in hand, satchel on my back, coffee and sandwiches at the ready.

[191] Not only does it make the application more valid, it also has the strange effect of lessening the environmental arguments against establishing new drilling areas. If an area is already 'disturbed,' then the logic runs that additional wells do not change the nature or character of such areas. Simply put, the quality of being 'undisturbed' is one that gives an area preferential environmental ranking in any environmental impact assessment. Environmentalists see such logic as a clear regulatory sop to the energy industry.

Although 73 years old, Björn is incredibly spritely and active, displaying the capacity to hike for hours on end. On these hikes together, he is keen to impress upon me the richness of the Hengill landscape, a richness he sees as lost not only on energy developers, but also on the planning authorities that approve energy sites and the political regime that regulates the planning apparatus. He wants, he tells me, to "show them what they don't see or understand;" documenting the landscape is one part of how Björn tries to achieve this. On one particular summer's day we hike north through the hills surrounding Hveragerði, moving towards Reykjadalir, a well-known tourist spot where people come to lounge in hot geothermal rivers.

The water is hot, unbearably so at some moments, but Björn, smiling, says I'll get used to it, it's only 40 degrees after all. My muscles are tense and sore as I half sit, half bob, in this stony geothermal river after a long hike through Hengill with my elder companion (figure 28).

The pungent smell of sulphur wafts around us, invading the senses. Avoid the mouth, Björn warns. People, tourists and locals alike, talk and laugh in the water and on its banks, as some set up tents to camp overnight on this positively scorching 13-degree celsius summer day.

"This is one spot in Hengill that the energy industrialists won't dare to touch, geothermal as it should be," Björn says as we lounge in the bubbling hot spring rivers of Reykjadalir. This is far from our first hiking trip together, but it is the first time we have bathed together. I take it as a sign of our growing friendship.

Figure 28: Björn approaching geothermal river at Reykjadalir, Hengill.

Bobbling about in this pungently sulphuric geothermal river seems to reenergize both of us. Björn talks of his long engagements with this landscape and through it with the energy company and the media. Getting the media's attention is harder than it might sound, particularly through the years before and after the construction of the Kárahnjúkar dam in the east of the country. Alcoa, one of the world's largest aluminium companies, and the electricity consumer of the energy produced by the Kárahnjúkar dams, became public enemy number one for a significant part of the Icelandic population.[192] As a result almost all of the protesting energy gravitated towards these activities in the east of the country, while Hellisheiði, "springing up in Kárahnjúkar's shadow," as locals put it, got little to no attention. But this was not without reason. Geothermal, as I outlined in Chapter Two, had had a long period of stable relations with the earth and its inhabitants prior to Hellisheiði.

Reykjadalir, hot spring heaven for many tourists and locals alike, is, according to Björn, "geothermal as it should be," albeit with too many tourists for his taste. He talks of particular ethical arrangements of the volcanic landscape; producing replenishable hot water for heating and for leisure is one way of living *with* the landscape, one that allows for a myriad of others to live alongside. Three-kilometre deep drilling, and the phase-shifting thresholds it generates, does not form part of these liveable arrangements for Björn.[193]

Reykjadalir lies roughly halfway between Hveragerði and Bitra and makes a nice resting point for us before we move onward to Bitra's contested landscapes. It is to Bitra that Björn is eager to take me; it is here that Orkuveita continue to actively pursue planning permission for drilling permits. Björn enjoys pointing out that volcanic zones are not barren places, despite popular representations of desolation. He brings my attention to fissures that were previously subterranean but which have now emerged to become surface features; the bubbling, thudding and spewing of the hot spring water, mud and clay, the hissing of the mud pots, but also the

[192] As I noted in Chapter Two, production of the dam began in the early part of the 2000's, while the Alcoa aluminium smelter came online in 2008. Focus intensified in the years after the opening, as critics were keen to highlight the dam's ongoing negative environmental impacts.
[193] Just to remind the reader, producing hot water only requires shallow subsurface intrusions.

thermophiles; lithotrophic organisms that produce the vast array of colours on display (figure 29).[194]

Figure 29: A lively Hot Spring at Hengill.

Walking through Bitra after our dip in the geothermal river at Reykjadalir, we come across a rich flourishing of rock figures and formations (figure 30), as lava flows twist and bend and fractal forms emerge and overlap at differing scales. As an earthquake prone area, there are many dykes, former subterranean cavities filled with magma, which are pushed overground during seismic activity. Björn gives details of their composition, móberg rock (palagonite tuffs), hyaloclastites, pumices; the list is long.[195] In addition there are stories of weary travellers who did not respect

[194] Lithotrophic organisms are bacteria and archaea that live in geothermal hot springs. They do not depend on the sun for energy but make it from the inorganic matter around them. They seem to survive and work at the interface of abiotic and biotic life, processing hydrogen sulphide and carbon to produce energy, solid sulphur and other forms of biomass. A lot of work is being carried out by molecular bio-physicists to synthesise their DNA for enzyme production, with multiple applications in mind, including biomass production, fertiliser and natural salt substitutes in processed foods.

[195] Móberg, also known as palagonite tuff, are mostly formed as hyaloclastites (loose, glassy material) in subglacial eruptions. This waterlogged tuff pile heats up due to percolating water carrying heat from underlying pillow lava, intrusions, etc., and the volcanic glass, being very unstable and reactive, becomes partly devitrified at 80-150°C to form various minerals that transform the loose pile of tuff into a hard rock called palagonite.

particular routes and paid with their lives. Björn's register does not, for the most part, include trolls or hidden people, and on those rare occasions when he does mention them, there is always a wink to be seen in accompaniment. But he does encourage me to think about landscape power a little differently, suggesting that I read some texts that enliven the hills we are walking through.

Figure 30: Rock Figure at Hengill.

Folklorist Terry Gunnel reminds us of particular *power spots* in the landscape, but this is a very different way of thinking landscape power to the one I described in Chapter Three. Drawing upon ideas of *álagablettir*, enchanted or cursed spots, Gunnel describes how pithy one-line sayings work to act as preservation techniques, or regulatory methods, for protecting *álagablettir* areas connected to farms throughout the country. Such grassy areas, hillocks, bushes, or even stones become preserved sites, to remain undisturbed by humans.[196] Gunnel reads this as reflecting an apparent need to 'see something sacred, mysterious and dangerous about the landscapes that we inhabit' (Gunnel 2014: 11).

[196] At Mannskaðahóll (human danger hillock) there is a spot on the farm mound which must never be harvested; that will cause bad luck to animals or people. Old people say that without exception, animals have died if a scythe has been used on that spot (Gunnel 2014: 2).

For Gunnel these stories and pithy expressions offer 'insights into the borderlines people saw as existing between themselves and the various types of 'other' that inhabited the landscape' (ibid: 312). Today the array of geothermal energy infrastructures (wellheads, roads, pipes, and large electricity pylons), together with disturbing earthquakes and corrosive H2S pollution, are this landscape's 'others' as it is accelerated through phase-shifting thresholds that alter the relationship between the volcanic area and its powers, and what many see as an ethical arrangement of living together. Although pithy one line expressions are far from enough to act as preservation devices today.

Never without notebook or camera, Björn documents the surroundings as we hike; scribbling notes, drawing rough sketches, or photographing. He does all this to capture changing geological features (emerging dykes, new hot springs) but what he is most taken with are the ways in which energy is inscribing itself into the landscape.

When we arrive at Bitra, Björn takes pictures of the pools of spent geothermal fluids that flow in small rivers close by. The once lava rich, moss laden area is now corroded from the effects of H2S, as brown and blackened patches remain visible. He puts his pen, or bag beside the remaining small tufts of moss in order to index their size in the photos he takes. Such research wells (figure 31) are generically problematic for Björn given that they require a host of supporting infrastructure (roads, pipes and so on) that damage the area. But in the specific case of these wells at Bitra, their location is a real problem as they sit above the town of Hveragerði.

Figure 31: Research well in the distance at Bitra.

It is on this trip that Björn tells me about the petition he mobilised in Hveragerði, the one that Margrét and Geir went door-to-door with, collecting signatures to protest Orkuveita's attempt to turn Bitra's research wells into production wells.

> Imagine what geothermal wells this close would do to our town. Look at what H2S is doing to the landscape here. And now that we know what is making these "man-made" earthquakes, they wouldn't be allowed pump the water down (reinjection), but if they let it run into the landscape, well, imagine what it would do to our local rivers, our hills. It would flow down into the town from up here and it might even get into the drinking water. That is not acceptable.

Before Björn was a geography teacher he worked as an archivist in the southwest region. He was responsible for several collections but talked most fondly of local historical records. Archiving, he tells me is important, records are important, so much gets lost, or forgotten, he laments.

> It’s important to keep records James, those people in the planning agency don’t know anything about these landscapes, most have never been here, and they use maps and documents that are out of date. But I don’t. We can’t get enough documentation in fighting these hungry energy types.

I begin to understand why he is so keen on taking so many pictures, and writing notes. He is recording the landscape as an archivist would.

7.4: Horses, Lava and Records

On the same day that Stefan railed over coffee about Orkuveita’s endless encroachments into the landscape, he also mentioned a horse-riding trip he and Björn organised with several parliamentarians, including the former minister of the environment a few years back. During the summer months Stefan works as a guide for Eldhestar (Volcano Horses), the local horse riding company that specialises in horse tours throughout the Hengill area, including trips to Þingvellir; an increasingly thriving business. He suggested that taking politicians on a journey through the volcanic landscape on horseback was one way to get them to see and feel what they had hitherto been able to ignore about energy developments in the area.

> Well James the thing is, nature from horseback is completely different from anything else. The experience, the feeling, is exceptionally strong. I can’t compare it. What we wanted to do (with the politicians) was to *open their eyes on the horses, so that they might see what they hadn’t seen before*.

I was eager to figure out not just what it was that Stefan and Björn wanted these politicians to feel and see so that they might better understand the relationship between energy development (which they all supported) and the landscape. I was also curious about how they tried to achieve this, how was it that they made energy’s inscriptions into the landscape more visible to a group of politicians who might have the power to make a difference? Stefan and Björn decided that the only way to do this would be to take me on a similar trip. We agreed to go horse riding on the next weather-permitting day, where we would ride out of Hveragerði and up through Reykjadalir, take a dip in the geothermal rivers, and continue on to Bitra, our journey's destination. So let me, over the course of this section, take the reader on a similar Volcano Horse journey through the landscapes of Hengill. But before I do, a little background on the Icelandic horse is necessary.

The horse arrived in Iceland along with the settlers circa 830 (Bjornsson and Sveinsson 2007) and has featured prominently in the lives and stories of Icelanders over the ensuing centuries. As an animal that developed in a landscape barren of agriculture and significant road networks, the Icelandic horse has retained its robust and distinctive form; diminutive yet sturdy. Functionally deemed a mode of transport, the horse has long been more than this. Over the years it has developed into a fellow traveller and friend, a status symbol, and importantly for this story, part of a set of geopolitical arrangements. The horse, it is argued, was an indispensable part of the political assemblies that took place at Þingvellir (ibid : 30)

As we learned in the introductory chapter, the country's main chieftains gathered at Þingvellir for two weeks every summer during the Commonwealth period, spanning from settlement up to 1262. The primary reasons for the assembly were Law making, as well as dispute settlement. According to several accounts, one advantage of holding assemblies at Þingvellir was its difficulty of access; the concern of warding off unexpected attacks was a serious issue at that juncture in time. The only way to reach such a parliament of rocks was on horseback, prompting one commentator to refer to Iceland as a 'democracy built on hooves' (ibid: 30-32). It is through these lava filled pathways and tracks that Eldhestar horses today take both Icelanders and tourists on riding trips, and where Stefan and Björn took national politicians to show them that which is difficult to do by other means.

As we ride, my tölting improves.[197] *I'm able to gather the horse as instructed and begin to understand the benefits that such a gait has as we move through the Hengill*

[197] The Icelandic horse has many types of gait but is well known for tölting; a four beat gait in which the horse keeps its back level, its head up, and neck arched, as it lifts both front and rear legs high. At least one foot is on the ground at all times in the tölt.

landscape. Our altitude rises and falls as we follow the contours of the ever-modulating earth. We saunter over smooth lava formations, broad disks of layered lava that have settled in circular form over time, we jerk over craggy rock, and we tölt through soft light mud. In other parts the terrain is rocky and inordinately steep.

A real sense of trust becomes necessary between us as I allow Breccie, my horse, to generally find her way. She takes my guidance well as we cut a path through Reykjadalir towards Bitra, stepping over the rocks and avoiding the bubbling hot springs and hissing mud pots along the way.

The edge of the pathway narrows and steepens as we ascend up the volcanic mountain, now entering territory where only 'horses dare to tread.' As Breccie finds her footing I imagine how a fall would undoubtedly be life threatening to us both. But I have to learn to trust a creature I have just encountered for the first time on this very day.

So I think about the story of this horse and how many times she has made this journey. I imagine her connected to the history of Icelandic horses, as they have travelled back and forth through this terrain for many centuries and I hold, if not grip, onto Stefan's explanations of how Breccie is genetically predisposed for this task, explanations I had previously derided.

Björn, who is not at all fond of horses, points towards a geothermal research well in the distance. "There's one of them, can you see it, the research well. Even though we blocked them from making a smaller power station here in 2012, they are applying for more research permits again just 500 meters away. It's called Ölkelduháls, but it's really Bitra, it's the same place."

Figure 32: Author riding downhill on Breccie towards Reykjadalir, Hengill.

Figure 33: Riding through Hengill. Photograph courtesy of Birgit Guðjónsdóttir.

I comment that the research wells are smaller than the production wells I remember from the other side of the mountain at Hellisheiði. “They are easily scaled up to full size,” Stefan tells me, “if they get the planning permits.” My riding companions photograph the now inactive research well that sits in the landscape like a strange lunar module, the area around it looks bleached and dead, a testament to the corrosive effects of H2S (figure 31). As Björn put it the last time I hiked this area with him, they can “never have too much documentation in fighting these energy types.”

Stefan tells me a very similar story to the one I heard from Björn on our hiking day. H2S corrosion of lava and moss, abandoned wells, roads, pipes. Most prevalent for Stefan is the fear of these research wells being scaled up to production wells, and their effect on the town. If they were to reinject water the risk of “man-made” earthquakes at increased magnitudes is quite high, if they don’t reinject but let the water flow out over the landscape then H2S becomes a real problem, for the landscape but more importantly for people’s health in the town.

While the research wells at Bitra are the culmination point in our round trip, they are but one part of the energy infrastructure that my riding companions are eager to point out on this journey. Hengill on horseback is a trip through a variegated geological landscape. Björn points out the *hraun-lög* (lava records) we are riding over as we make our way back towards lower altitudes; firm, layered, folds of lava, which he suggests are between 2,000 and 7,000 years old (figure 34 & 35).

Björn explains their formation to me; as lava flows, the surface area cools down first and begins to harden, while the underside of the molten material remains warm and continues to flow. This spreads and stretches the underside, as layers begin to form as they harden at a slower rate. The structure that the lava then takes consists of circular (ish) overlapping layers, one on top of the other, almost like records (disks). These overlapping layers allow horses to walk more assuredly.

Figure 34: Lava records can take a more broken shape (this picture) or a relatively smooth shape (figure 35) depending upon which postglacial lava flow they were a result of, and where in the landscape they were formed. In the above photo, taken on a different day to the one I am describing in this section, the records we are standing upon are more broken. Stefan (left), author (middle), and Björn (right).

Figure 35: Smooth lava records with cairns and pylons in the background

But such lava is also an on-going record of the volcanic landscape. As a flow of over ground molten magma, lava is, and records, the geological history of the Hengill area. As I discussed in Chapter Four, Geoff Bowker, drawing on the work of Charles Lyell, brings our attention to the ways in which archival thinking is embedded into thinking about the earth. Central to this type of understanding is that all rocks can be seen as at once objects and archives. As objects, they function in the world, and as archives they maintain traces of their own past (2005: 36).[198]

This is a compelling way to think about lava records, as both route makers and as recorders of the geological history of the area. But such lava records also record other flows of activity and it is Stefan who reminds me of this, emphasising the way in which earth, human and animal have shaped one another over the years.

Hopping off his horse, he puts his face to the ground and with his hand sketches out the pattern of faded horse hooves moulded into the lava records. In the southwest region people on horseback have used these records as pathways and tracks, and over time, the form of these horse hooves have become enfolded into them. It is along these pathways that cairns (mounds of rough stones built as memorials or landmarks) have been constructed over the centuries, signposting the way for long distance traveling parties trying to pass through these oftentimes treacherous south to southwestern passageways. Stefan continues:

> Look to the west and you can see the line of cairns these people would have followed, and the big one in the middle, can you see it, that was used for temporary shelter when the weather was too bad to continue. And see how those damn electricity pylons follow the cairns; now why is that do you think, because it's still the best route, that's why. Look how the pylons have changed things, the amount of visual and noise pollution that they've brought with them, but they are also being rusted now too.

[198] Thus a rock could be rendered as an object that is part of the lithosphere, and equally as a document that contains its own history written into it. For example, striations on the surface indicate past glaciations, strata index complex stories of deposition over time, and so on (Bowker 2005: 36).

Figure 36: Cairns (on the left), lava records (the greyish patches) and electricity pylons (middle and right) follow the same landscape route.

Stefan and Björn use these lava records as route makers as we ride, as others have done in the past. Lava records are in some sense a layered landscape infrastructure, bringing together the overlapping layers of the landscape; a route maker and a *record* of moss, lava, humans, horses and pylons as they enfold through one another. At the same time my riding companions also use the infrastructure of the lava records as a way to trace and record energy and its inscriptions into the landscape. At many points along the route, we see damage to the landscape, uprooted lava formations from the construction work of the pylons, scorched and corroded lava and moss close to research wells, as well as rusting pylons. These pylons are of particular concern to my riding companions, not just because of the physical damage they cause, but because they index the ways in which H2S is eating away at the landscape and possibly at people's health in the town. Like Margrét and Geir, the irony is not lost on my riding companions. "All this for aluminium," says Stefan, as they continue to take pictures of the rusting aluminium rods on the pylons as one of the clearest visible indexes of the corrosive inscriptions of H2S in the landscape (figure 37 & 38).

This is the effect my riding companions want to have on me, making me see what otherwise would be difficult. But more importantly, this is what they wanted to show politicians on a similar journey a couple of years back. Following lava records on horseback offers a perspective on the landscape that is hard to replicate by other means. It makes visible particular types of damage occurring in the landscape as well as indexing what is otherwise invisible (potential health effects). Ironically, this is done through documenting the effects of aluminium production upon aluminium itself. [199]

Figure 37: Björn noting Pylon rusting and lava damage at Hengill.

[199] While Björn and Stefan treat cairns as artefacts that 'belong' in the landscape, they treat pylons as those that 'do not belong.' As in Chapter Six, particular cuts are being made productive of what counts as the right type of landscape arrangement. Despite being a "man-made" presence in the landscape, cairns present no difficulties for my riding companions given that they are rock formations that have aided Icelanders to traverse this landscape when necessary (trade, health). Pylons are very different given their connection to the aluminium industry. "Aluminium companies are stealing Iceland's resources," is a way both Björn and Stefan put it on many occasions. Like in Chapters Two and Three, energy prices come to have an effect on the landscape in various ways, through their inscriptions, but also in the way that impact upon how people make cuts between what belongs and what doesn't.

Figure 38: Pylons rusting at Hengill.

Björn scales moss and lava by laying a bag or phone alongside while taking pictures. He talks about recent seismic activity, writes small descriptions in his notebook of all that we have seen, always comparing and commenting about changes from his last visit. Björn and Stefan document the landscape in detail on these trips; compiling *records* of the many landscape features and their alterations. One could say that they record the landscape in a way that is similar to how lava records do; layering some of the interactions of the geological, human, and animal together.

When we get back to Björn's home he downloads all the day's pictures and organises them by date, area and impact (on moss, lava, or pylons for example). He then shows me all the files he has amassed over the years, both digital and manual; a trove of landscape records, notes, pictures, maps, drawings and reports that have been generated over time. These records are activated at certain times, when Björn thinks the protest moment is right.

Common among these methods of protesting are letters sent to the Icelandic National Planning Agency (*Skipulagsstofnun*) protesting Orkuveita's planning applications.[200] Such letters of protest to the planning authority lay out very specific grounds as to why a particular area should not be granted drilling permits, including descriptions of flora and fauna, the range of geological phenomena that are historically particular to that site, as well as new phenomena that may have emerged over recent times that few are aware of, even geologists who target their mapping efforts in very strategic ways. These letters from Björn are those of a concerned resident, nothing more. But all the parties know him, the town council, his fellow residents, even the employees at the planning agency. He speaks only with the authority of his detail, which is second to none.

Not uncommon in these letters are sets of corrections to names and descriptions that are listed on the planning application documents. "Beating them at their own game," was one way Björn described these letters as he berated planners and administrators for not knowing enough about the local landscape that they were authorised to make judgements about. The sites of potential drilling can be out of the way places, which may not have names, or whose names may be unclear and require a lot of documentary work to validate. Björn sees himself as providing this service.[201]

Always accompanying these letters was 'evidence' of some kind, records of damage that such wells have caused in parts of the landscape not dissimilar to the one under review, furnished by way of Björn's trove. He also draws upon his records for local meetings on any one of a range of issues, and for generating petitions, as was the case with the petition that was lodged against developing Bitra into a production site. All of the hiking, riding and documenting work that I have described

[200] Skipulagsstofnun, the Icelandic National Planning Agency is a state authority, under the Ministry for the Environment and Natural Resources, responsible for the administration and implementation of the Planning Act, the Environmental Impact Assessment Act (EIA) and the Strategic Environmental Assessment Act (SEA), see http://www.skipulag.is/english/ accessed 14/01/17.

[201] Björn gave me full access to this archive. In one of the letters to the planning agency he disputes the name given to the area around a proposed drill site. The letter outlines a history of the area, and a genealogy of its name. Björn concludes the letter by suggesting that the name on the planning document is not the name of the area that the planning agency have indicated on their maps, but a site several kilometres away. In very direct language, Björn comments that such "errors" are unacceptable and highlights that so called "planning experts" do not have the requisite local knowledge and hence authority to make legitimate decisions that will effect the people who live in these areas. Björn enclosed a set of older maps to highlight the error.

ends in what I have come to think about as Björn's archive. Recording the landscape as lava does is a form of activism that is also a form of archivism.

Howard Zinn, writing in the 1970s, argued against seeing archives as neutral objects, setting out instead a position which implicated archives with the interests of the dominant in society (1977). With the shedding of this sense of archives as being passive and neutral, a more active sense emerged. Invoking the idea of archives as active, that is, arguing that they are political and have political effects, triggered a call for new approaches to a range of archival concepts and practices. In the years since Zinn's intervention, archives have become active in a range of ways as various archival practices have become more explicitly political.

While some have taken traditional archives and read them against the interpretative grain of history, others have focused on developing non-official archival repositories as activist projects (Buchanan and Bastian 2015: 8). At the same time a whole range of advocacy and community groups working on issues from property rights to discrimination issues, have developed much more sophisticated techniques when generating, collecting, and disseminating documents. Other examples include Freedom of Information Act legislation to declassify, collect, disseminate and analyse government documents. And, there are groups such as Archivists Without Borders and the Documentation Affinity Group that work globally and collectively to address a variety of archiving and documentation projects and challenges.[202]

I want to suggest thinking of the type of protesting that my riding companions engage in as *archivist-activist*. Protesting against Orkuveita requires both moments of very active engagement in the landscape, as well as documentary patience. Björn and Stefan record the landscape like lava does, translating one archive (the landscape) into another (Björn's trove) through its records, all the while awaiting the right moment to politicise both.

[202] See https://blog.witness.org/2010/09/archives-for-change-activist-archives-archival-activism/ accessed 17/01/17.

7.5: Demonstrations

In *Direct Action*, David Graeber engages with various parts of the global justice movement, or alter-globalisation movement, giving an extensive ethnographic account of their preparations and actions in the run up to the Summit of the Americas in Quebec City in 2001 (2009). Graber describes ‘direct action’ as a form of political resistance that is ‘overt, confrontational and militant, yet stops short of military insurrection’ (ibid : 210). Clearly this is not the form of political action occurring at Hengill.

As a way to clarify the term, Graeber situates it in relation to civil disobedience; a form of political resistance that, unlike direct action, acknowledges the legitimacy of the state and which, in effect, comprises sets of actions that appeal to the powerful to change their behaviours (ibid : 208). Demonstrations, marches, and rallies constitute the majority of such types of actions. However, they have the tendency to be regarded as ‘merely’ symbolic by many activists as their aims are, in many instances, one of communicating a message or producing an image to be acted upon by those in authority.

Less symbolic yet more effective political actions consist of ‘doing politics away from the state’ as well as ‘taking matters in ones own hands’ (Krøijer 2016: 210). The way this separation between symbolic and effective action is rendered, demonstrations come off as ‘mere’ performances. I want to take up this line of thought on demonstrations as performative, but beyond the ‘merely’ symbolic. Political action through the landscapes of Hengill, as we are learning, mixes these categories in varying ways.

My riding companions see their work in the landscape as political work, the type of work they see as lacking from the town council. While not in disagreement with the council as to the town’s precarious position vis-à-vis warning systems for “man-made” earthquakes, their focus is on stopping further encroachments into the landscape, particularly at Bitra. The only way to do this, they feel, is to *demonstrate* that which would otherwise not be noticed.

Although demonstrations as a form of protest are rare in Iceland, the collapse of the banking system in 2008 prompted thousands to demonstrate at

Austurvöllur, a small square outside parliament buildings, demanding, successfully, a change of government. It became known as the "pots and pans revolution," as the banging of domestic objects became a rallying cry symbolising the outrage of the ordinary citizen (Bernburg 2015). The only other public demonstration of note through the country's history was in 1949 when people gathered, again at Austurvöllur, to protest against parliament's decision to join NATO. On that occasion, there was no political effect.

As the above implies, one common way to think of a demonstrator is as a political actor, a protestor against a particular form of injustice or intolerable situation. These demonstrations, generally speaking, occur at sites of power, at parliaments, in front of corporation headquarters, in town squares, amongst other places. But as Andrew Barry reminds us, the idea of demonstration has multiple valences (2001).

Barry alerts us to an older meaning of the term demonstrate. The role of a demonstrator at an anatomy lecture in the middle ages was one who made visible to the audience the object of which the lecturer spoke, pointing towards body parts and so forth. To be in the presence of a demonstration was a matter of witnessing a technical practice.[203]

Barry draws upon work from STS to highlight the similarities between political demonstrations and scientific technical demonstrations. In interrogating the conduct of scientific demonstrations, scholars have sought to understand the complex relationship between the social site of demonstration and the kinds of persons and devices deemed necessary for a demonstration to be performed. Paying attention to political demonstrations also demands attention to the technology and ethics of telling and witnessing, and the ways in which sites of demonstrations are made. In this mode of analysis demonstrations are technical, ethical and spatial practices (ibid : 176).

Demonstrations, whether they are understood in a technical or a political sense, are political matters; there is a politics to the question of who can be or should be allowed and trusted to witness a demonstration. Being a witness is to

[203] Barry notes that a sense of the term still exists in some form today at universities, as demonstrators (usually graduate students) assist undergraduates with their scientific work.

adopt an ethical stance, Barry suggests (ibid : 178). As Steven Shapin has argued, the development of 'science' in the seventeenth century involved an effort to regulate who could or could not be properly called upon to witness 'matters of fact about the natural world' (1994).

To further his argument, Barry uses an empirical case study of protests against the construction of the Newbury bypass, a road in southern England, arguing that these demonstrations lack a specific ideological project as well as a well-defined political constituency on which they are based. He stresses that the effects of the protests were as much technical as they were political; to demonstrate a truth which it had been impossible to show by other means. Allowing thinking from the history of science to enter contemporary political conflicts, he argues that conducting a political demonstration can be a matter of making visible a phenomena to be witnessed by others (Barry 2001: 178).

As political actions, these site-based protests did not take place at centres of power nor were they directed towards icons of the state (parliament, office of the prime minister). They occurred in particular places where they could point others towards, or make visible, the forms of environmental destruction that were occurring as a result of road construction. In this way they are types of technical and ethical practices that do not work by representing the views of a group or a constituency but by making visible to witnesses ongoing damage and destruction.

But such demonstrations are difficult, it requires a lot of work to set up a site that enables the demonstration to have particular effects. In a way not dissimilar to the work it takes to make an object of scientific knowledge in a laboratory, it also takes a lot of work to make an object political and create the type of sites in which political action can take place.

On the day of my horseback trip with Björn and Stefan, I was witness to the ways in which energy has begun to inscribe itself into the volcanic landscape at Hengill; the abandoned research wells, the corrosive effects of H2S on moss and lava, the rusting electricity pylons; indexing not only the damaging of electrical equipment in Hveragerði but also the harmful, and potentially deadly, affects of H2S on residents of the town. At the same time, pointing towards landscape deformations and alterations brings out a powerful sense of the eruptive volcanic and seismic forces of Hengill, particularly *Suðurlandsskjálfti*, (the southern earthquake cycle) referencing the ever-present disturbances of “man-made” earthquakes. In addition, it serves to provide a space where discussions of “the next big one” take on a more palpable, situated sense. Such a demonstration makes visible certain effects in the landscape, while at the same time indexing others that are less visible; it politicises geology, or maybe it is better to say it geopoliticises the landscape. Let me try to flesh this out a little more.

My trip only repeated the journey that Björn and Stefan took with Icelandic parliamentarians (including former government ministers) on horseback through Hengill’s lava plains, up to the abandoned research wells at Bitra, towards the geothermal river at Reykjadalir, over the lava records, and through the cairn and pylon laden route ways of old. It was a political *demonstration* through which parliamentarians could witness the visible effects of energy throughout parts of Hengill.

As we learned in the Chapter One, Hengill is a landscape saturated in power. By taking politicians through the volcanic landscape on horseback, Björn and Stefan are actively connecting the geothermal power at Hellisheiði to political power at Þingvellir. Journeying through the landscape on horseback, politicians are afforded a perspective in and on this place that is otherwise hard to acquire, walking and *tölting* over and through the many layered lava records. Connections are made to politically significant journeys of old, ones in which former Men of power made their way to Þingvellir to decide upon the laws of the land. Journeying through this craggy, mossy, lava recording terrain on horseback enfolds the ‘pure times’ of old (when travel to the parliament of rocks was reliant upon hoofy companions) with the more ‘polluted times' of the present. Such juxtaposition has a powerful resonance with Icelanders.[204]

However, while enacting Hengill as a demonstration site has historical precedents, there are still complex sets of relationships that need to be worked through between the varying locations, as well as the kinds of entities and devices needed for a demonstration to be performed in a convincing way. The ethical effects of witnessing that politicians went through in 2012, as I did in 2014, could only be accomplished through a host of other activities, ones that I described earlier as archivist-activist.

Activating Hengill as a demonstration site is not just about activating one part of the landscape, but many. As we have seen Orkuveita can, and do, shift their planning applications throughout various parts of the volcanic zone. While Bitra has been the focus before, and is now again, it is not only Bitra that Björn and Stefan need to be concerned with. They have to be prepared to activate multiple zones within the landscape at short notice; that is, if and when they find out that Orkuveita have decided to apply for permits at new locations.

It requires ongoing and painstaking work to set up and link up the various areas, processes and entities in a way that is capable of producing Hengill as an effective demonstration site. While Barry calls this the 'technical work of demonstration' (2001: 178), I want to broaden the term to suggest that the archivist-activist work of Björn and Stefan is a form of infrastructuring. As a means of protesting against the ever-encroaching energy infrastructuring of Hengill, Björn and Stefan have begun to develop their own infrastructure of protest, one that is capable of being activated at particular moments in time. Such an infrastructure *enables* the demonstration to take place and have particular effects, which in the case of the

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[204] The trope of purity and antiquity are still very prevalent in Icelandic discourse. As I discussed in Chapter One, the nationalist 18th century was a period of political change as arguments for a new constitutional settlement began to percolate. During this period the Settlement era of the 9th to 13th centuries were reconfigured as being a purer time, one that highlighted the uniqueness of many facets of Icelandic identity, the language, Saga literature, the landscape and so forth. But this trope has leaked into, and continues on in, many walks of contemporary Icelandic life. The Icelandic horse, for example, is considered unique and distinct amongst other European breeds. A particular language of genetic purity was evident during the deCODE genetic database debates in the 2000s (Fortun 2008), as the 'uniqueness' of the risk taking New Vikings of the recent financial collapse was lauded around the country, for a time.

horse tour from 2012 was to make energy's inscription into the landscape visible to a particular group of witnesses.

7.6: Infrastructures of Protest

In Chapter Six I discussed the geological settlements under way at Hengill. Settling, geologically speaking, I argued, is about responding infrastructurally to the emergence of various new agencies in the volcanic zone. I want to reintroduce the idea of infrastructuring here in the context of the ongoing archivist-activist work of Björn and Stefan.

In the last chapter I also discussed how the town council of Hveragerði finds itself in a bind; while warnings of earthquakes are the best settlement they can get under politically ambiguous circumstances, they feel it is too risky to make an 'issue' out of these warnings for fear of generating other forms of socio-economic instability. Shaky matters lead to shaky settlements, I suggested. Learning to live with the physical, conceptual and ethico-political impacts of such shaky matters does not, however, preclude alternate, one could say experimental, forms of political action.

The geopolitics of Björn and Stefan are different to those in authority in the town. While still very much a politics in and of the earth, they take more direct political action in and through a particular articulation of landscape relations. This form of political action does not need to represent a particular constituency, and the variegated interests that lie therein; instead it can, and has, taken the form of a demonstration against the ever-encroaching infrastructuring of Hengill. This demonstration is enabled through the generation of Björn and Stefan's own infrastructure of protest.

Conducting a political demonstration in Hengill requires articulating and making various connections between different sites, entities and devices within the landscape; lava, horses, humans, cairns, wells, pylons and so on. But at the same time Björn's archive is also layered into this infrastructure.

On the day out with the politicians in 2012, local and national media were in attendance. Björn and Stefan had written an article in the newspaper prior to the event, and they distributed the findings of their painstaking work to the politicians in the form of a binder handed over at the end of the tour. These materials are very much a part of the demonstration.

In my descriptions of lava records a little earlier, I suggested that the earth at Hengill has what could be called a layered infrastructure. At the same time I wanted to resist saying that lava is a natural flow upon which other social flows are embedded. While layers is a useful image with which to think lava flows, what is emerging here is more enfolded and enmeshed than layering allows for. It is more the case that lava records are *geo-socio entities,* enfolding cairns, horses, people, and pylons. Björn and Stefan, I am arguing, articulate these entities as part of their infrastructure of protest. They use these records as route makers as travellers have done (horse travel), and as the energy industry continues to do (pylons). At the same time, lava records record places where moss, lava, and pylons show visible signs of environmental damage, helping my companions to trace energy's inscriptions in the landscape.

Tacking back and forth between the landscape and the archive is what generates this infrastructure of protest, as each one informs but does not entirely encompass the other. While the landscape is rendered as archive, the archive is rendered as a form of landscape; both are strewn with records.

In Chapter Six, while I focused on how geologists continue to infrastructure the earth, here we are seeing how my riding companions also focus on infrastructuring. Although in their case, it is a way of bringing together humans, animals, lava and archival data in order to perform geopolitical demonstrations against the energy infrastructures that Orkuveita continue to develop.

Earlier in this dissertation, I commented on the limit of seeing infrastructures as smoothly facilitating the flow of people, objects, data, ideas; allowing for their exchange over time and space. For circulations are not always smooth, indeed, internal gaps and inconsistencies can be an important part of what propel infrastructures forward (Harvey, Jensen et al. 2017: 13). In the case of Hengill, seismic instabilities, while becoming generative parts of energy infrastructures, remain shaky and dangerous.

At the same time we have now opened up for multinatural and multispecies elements to be productive parts of such inconsistent circulations. The work of Atsuro Morita and Casper Bruun Jensen are but two recent interventions that push our thinking beyond the more traditional socio-technical take on infrastructures, as varied 'others' become key actors within them. The former does so by making visible the role of multispecies (rice and farmer) relations (2016), and the latter by demonstrating that natureculture configurations can go through many figure-ground reversals depending upon which entities' perspective one takes (2016a). The emphasis in these authors' work is in underscoring the relational and frictional components of infrastructures, as well as emphasising the important question of who or what it is that can relate. As Dominic Boyer puts it, whatever else it might be, an infrastructure must always serve as the foundation that enables something else to happen; it is enabled to enable (2017: 175). While in Chapter Six, I argued that these foundations do not always have to be stable, what I want to pick up on here is the idea of an infrastructure's capacity for enablement. In enabling a demonstration, the infrastructures of protest I have discussed in this chapter make energy's inscriptions in the landscape visible to a group of witnesses.

However, the question of visibility remains a thorny one in infrastructure thinking. While traditionally infrastructures have been conceived of as operating as invisible backdrops to social action, an analyst could perform an 'infrastructural inversion' (Bowker 1995) revealing the complex socio-technical and political work that goes into their functioning. Brian Larkin brings our attention to the fact that often infrastructures do not go unnoticed at all, and are frequently designed to be very visible and public. Instead he argues that infrastructures inhabit a whole spectrum of visibilities, ranging from the opaque to the spectacle (2013).

What is important to note is that visibility is generated differently in different ethnographic contexts. Bruno Latour and Emile Hermant in *Paris: Invisible City* move from a panoptican infrastructural vision to an oligoptic one. The oligoptican is capable of gaining very fine-grained views, but only of very specific things, while panoptican visibility, the authors suggest, is impossible (2010).[205]

[205] Harvey and her co-editors suggest that while infrastructures may inhabit a whole spectrum of visibilities, such forms of visibility are not necessarily comparable; as, for example, the technical

What this draws attention to is that certain arrangements make particular types of vision possible; what we need to understand, scholars argue, are the 'infrastructural trails' that generate these particular visions (Harvey, Jensen et al. 2017: 15). Thinking lava records as infrastructural trails highlights their role as route makers and recorders, articulating specific parts of the landscape together in the making of an infrastructure of protest.

As energy output continues to decline at Hellisheiði, Orkuveita have little choice but to look for alternative ways of making up the shortfall, and seeking new locations at Hengill is one way forward. Without these locations, the company faces additional and punitive contractual costs in supplying energy to Century Aluminium. Orkuveita, owned by the city of Reykjavík, was rescued by the taxpayers on two separate occasions in 2010 and 2014. The city cannot afford a third bankruptcy, and therefore Orkuveita cannot afford to default on its energy contracts. While the residents of Reykjavík have a financial-political stake in the survival of Orkuveita, residents of Hveragerði have a different type of stake in the Hengill landscapes. Right now there is no easy way to reconcile such conflicting positions.

During the many hikes and several horse riding trips I had with Björn and Stefan throughout my five months in Hveragerði, it became clear that they were deeply concerned about energy's inscriptions into the volcanic landscape; that is, their focus was in demonstrating how high temperature geothermal energy production is damaging the landscape, and the town. Extensive landscape destruction through the building of wells, pipelines and transit roads was one concern, while the corrosive effects of H2S on moss, lava and other landscape formations was another (figure 37 & 38). At the same time as such corrosive effects index concerns about the long-term health profile of the town, eruptive and seismic changes in the landscape also index both "man-made" earthquakes and the anxieties of the "next big one." Arranging the tectonic liveliness of Hengill for the production of steam for Century Aluminium is not, from their perspective, an ethical arrangement of living together in these landscapes.

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standards and categories of a particular infrastructure will still remain invisible to one that is situated next to a publically exhibited infrastructure (2017: 4).

Put simply, all of their infrastructural work focuses on demonstrating the damaging effects of Orkuveita's energy infrastructures in the landscape. While some in the town argue that the parliamentarian-riding trip did not have any effect on the outcome at Bitra, it seems clear that the demonstrations did have two practical effects. The first was the badly needed fast tracking of a H2S monitoring system for the town, as well as the activation of a set of debates around imposing a H2S emissions cap on the power plant at Hellisheiði (a maximum average H2S concentration within a 24-hour period).[206]

The second was that although the politicians could not in any way affect the planning application processes, their riding trip did garner a lot of attention and energised many within the town either to sign the Bitra petition or mobilise on its behalf, like Margrét and Geir who we met at the start of the chapter. The petition, in this instance, was successful in blocking Orkuveita from developing Bitra into a production site. The demonstration, as such, was not contained to these politicians but extended through them to ordinary members of the town, for whom some things had also gone unnoticed. Varying moments of witnessing, one could say, were activated through records, both of the landscape (lava) and through the petition (archive).

In an interview with members of the planning agency, I learned that the petition lodged against Orkuveita's application was constituted as individually signed letters by residents of Hveragerði, accompanied by a folder of pictures, descriptions and maps (furnished by Björn). According to the interviewees, this is the highest number of protest letters that they have ever received against a planning application, inclusive of the Kárahnjúkar dam in the northeast.

7.7: Conclusion

Maybe characterising the object of protest as *Orkuveita's energy infrastructure* is too myopic an analytical perspective. Vast quadrants of Hengill, not just the Hellisheiði

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[206] This limit has been an ongoing battle for the town. While it was further reduced in April 2014 to a maximum average concentration for 24 hours of 50ugm3, Orkuveita were successfully granted a three-year exemption to the law while they develop their experimental "Sulfix" program. Sulfix is an attempt to mineralise H2S gas back into subterranean rock. See (Mar Juliusson et al 2015).

Geothermal Power Plant, are being arranged in the production of steam for Century Aluminium. The energy infrastructure of Orkuveita (wells, pipes, roads, pylons) is just one of a series of infrastructural layers that are enfolded within aluminium's operations. As I mentioned in the introductory chapter, Hengill has become just one nodal point in the global distribution of this highly valued metal.

Maybe in the same way that lava records enfold other landscape entities that are then articulated by Björn and Stefan, Hengill enfolds varying actors and entities that are then articulated by the aluminium industry. Björn and Stefan's protesting is but one small pocket of resistance within aluminium's architecture of global circulation, an infra-structure (e.g. *infra* "below") of protest within one of modernity's key infrastructures.

Mimi Sheller draws attention to the particular relationship between aluminium and energy infrastructures. As I discussed in Chapter Two, the aluminium industry is closely tied to the investment and development of large energy infrastructures to feed the electricity needs of its smelters, while, at the same time, being adept at maximizing state subsidized energy prices. Controlling electricity production is one of the major forms of corporate national and transnational power exercised by the aluminium industry (Sheller 2014: 56). The transformation of vast and varying landscapes around the world (bauxite mines, razed forests, dammed river systems, and volcanic zones) is one way this power is exercised, a transnational politics of environmental appropriation.

But not only this, the technological developments in global energy infrastructures have greatly benefited from aluminium as a particular sort of metal; its supple strength, lightness and conductibility have made it an essential component within modern energy infrastructures. Simply put, while aluminium infrastructures rely on energy, energy infrastructures also rely on aluminium.

Nowhere is this clearer than in Hengill. The entire landscape is being transformed to produce steam to meet Century Aluminium's energy needs; the aluminium industry is infrastructuring Iceland's volcanic landscapes as part of their circulation of one of modernity's primary metals.

But as Björn and Stefan, as well as Margrét and Geir, pointed out there is a strange irony afoot here. While the landscape is transformed to produce energy for aluminium, the toxic effects of that energy production are most visible upon aluminium itself. Although one of the physical characteristics that aluminium is lauded most highly for is its resistance to corrosion, the H2S emerging from deep within Hengill's subterranean is proving to be too much, even for this metal, as rust sets in throughout many parts of Hengill and Hveragerði. Not only must residents purchase plastic drains instead of the preferred aluminium types, the very electricity pylons, made from aluminium, built to transport electricity to make aluminium, cannot hold out; aluminium cannot tolerate the toxic side effects of its own making.

The irony of aluminium not being able to tolerate its own toxic effects is evident for many in the town, but the demonstrations of Björn and Stefan make it clearer to a wider political audience. As they build their own infrastructure of protest, as a pocket of resistance within aluminium's globally circulating infrastructure, they demonstrate one of modernity's paradoxes that residents in Hveragerði have to live with; in relating aluminium to itself as disturbing and toxic, they are demonstrating, possibly, a threshold in the very notion of progress. It is to more of these thoughts that I will turn as I move on to conclude this dissertation.

Chapter 8.
Conclusion: The Geopolitics and Temporalities of Acceleration

8.1: Geostory

In *The Natural Contract* Michel Serres shares some prescient thoughts that prefigure a number of the ongoing anthropocene discussions taking place today:

> For, as of today, the Earth is quaking anew: not because it shifts and moves in its restless, wise orbit, not because it is changing, from its deep plates to its envelope of air, but because it is being transformed by our doing (1995: 86).

Serres continues on to say that ‘nature’ has long acted as a reference point for modern law and science because it had no subject. Objectivity, in the legal sense, as in the scientific sense, emanated from this place without humans, which did not depend on us and upon which we depended. But now, ‘it depends so much on us that it is shaking; we are disturbing the earth and making it quake.’ The earth has, in Serres terms, re-emerged as a subject (ibid).

Picking up on Serres’ thoughts, Bruno Latour suggests the earth gains the name of subject because it is subject to the vagaries, emotions, and bad temper of another agent: us. To be a subject is not to act autonomously in front of an objective background, argues Latour, but to share agency with other subjects that have also lost their autonomy (2014: 5).

In becoming agitated by the highly complex workings of many enmeshed living organisms, the earth has taken back all the characteristics of a fully-fledged actor. It is once again an agent of history, or rather, an agent of our common geostory. Telling our common geostory, Latour suggests, will require all of us to play our part, novelists, engineers, scientists, activists, citizens, even generals (ibid : 12-13), and, I would add, anthropologists. The prefix *geo* in Latour’s geostory does not stand for a return to ‘nature,’ but ‘for the return of object and subject back to the ground – the metamorphic zone[207] – most believed it possible to escape' (ibid : 16). What I have been trying to do in this dissertation is to tell a geostory. But the geo of this dissertation is not planetary, but situated, not grounded, but shaky. The ambition has been to tell a geostory that is 'big enough' (Clifford in Haraway 2016: 185), one that brings some of the grander narratives emerging from the anthropocene-capitalocene down to earth.

To do this, I conducted an ethnographic study of geothermal energy in the southwest of Iceland. Here, I engaged with the practices, ideas and concerns of some of the key actors connected to the Hengill volcanic zone as it is converted into an energy node in the global production of one of modernity's most widely distributed metals, aluminium. To help me think about the various issues at stake, as well as analyse some of them in detail, I drew upon varying theoretical resources from within both anthropology and STS.

In order to address the question of how humans have become geophysical force-makers in a specific volcanic site, I needed to examine the processes through which volcanic forces are converted into energy resources. We learned that these conversions, in turn, activate others, as "man-made" earthquakes, volcanic cooling and H2S pollution are made alongside steam for electricity production. It is these conversions that generate political and temporal matters, and it is to this that I would like to address my concluding remarks

8.2: Aluminium, Acceleration and Change

In *Aluminium Dreams*, Mimi Sheller provides an analytic with which to think about aluminium, one that is hugely apposite for my discussion. Aluminium is, in many ways, a technology of lightness and speed, one that puts 'cultures into motion;' supersonic jets, aerospace technologies, skyscrapers, tech devices and so forth. But its powers are also more than physical, as the quest for lightness and speed has become one of the defining preoccupations of modernity, generating mobility for

[207] I discussed this Latourian idea in Chapter Six. Before entities stabilise as recognized actors - whether they be characters in a novel, scientific concepts, technical artefacts or 'natural' features – they are all part of what Latour calls a 'metamorphic zone, a timespace where agencies comingle before being designated as either 'natural' or 'cultural.'

people, objects, electricity, and data. Nations continue to dream of the benefits that such a light modernity can provide, 'a dream of accelerated futures,' as Sheller puts it (2014: 27).

This modern dream of 'accelerated futures' is something that has plagued successive Icelandic governments as they have tried to find a way through instability; topographic, climactic, and more recently financial. The Icelandic state has chosen the path of selling vast quantities of cheap energy to power-intensive industries. Unlike fossil fuels, renewable energy is difficult to export in any conventional sense, particularly for an island nation. Importing power-intensive industries such as aluminium is the only way of 'exporting' the country's energy, which, for the most part, becomes packaged aluminium.[208] But exporting energy as packaged aluminium has occurred through the conversion of the country's landscapes, firstly glacial rivers for hydropower, and now, as we have seen, the volcanic landscapes of Hengill. These conversions, however, draw other forces into the process, and as such their effects are far from linear; while certain stabilizations do occur, other forms of instability are also collaterally produced.

As we saw in Chapter Two, the instabilities of the capital and metals markets were transferred to Orkuveita as the asymmetries of transnational corporate power geometries played themselves out. In effect, the pressures of capital (the instabilities of accelerated capital and aluminium flows) were converted into subterranean pressures (the instabilities of accelerated volcanic and seismic rhythms). Enfolding currency and metals instabilities within tectonic and seismic processes has produced turbulent, shaky effects.

The accelerations occurring at Hengill, however, are not the accelerations of modernity's dreamers, as Sheller puts it, but ones that are having very specific geological, temporal and political effects. Examining events unfolding in this volcanic landscape through the analytic of acceleration is a way of contributing to debates within anthropology and STS about how to conceptualise processes of rapid change. The dissertation makes an intervention into these debates during a moment when

[208] Although in 2015 the Icelandic and British governments set up a joint taskforce to investigate the possibility of constructing an interconnector cable between Iceland and Scotland with the ambition of supplying 1,000MW of electricity. The IceLink project, as its known, is undergoing feasibility studies that will take approximately 5 years.

not only technological and digital practices are relentlessly quickening the pace of life, but also when collective human actions are seen to be accelerating 'nature' as the planet enters a period of severe distress.

Thomas Hylland Eriksen takes up the analytic of acceleration in a recent book, *Overheating: An Anthropology of Accelerated Change*, as a way to think about the relationship between accelerating global processes and the overheating of the planet. However, in Hylland Eriksen's work the term acceleration is left distinctly under analysed, beyond a generic suggestion that we are living in a treadmill, or runaway, world, one through which the accelerating forces of globalisation are having profoundly negative environmental, financial as well as socio-political consequences (2016).

What I have been trying to do in this dissertation is to specify the acceleration-threshold relationship in order to examine the specific effects that are being produced in one particular landscape. Not just the geological effects however, but importantly, also the ways in which politics and temporality are reconfigured in the process. To say it a different way, focusing on geological practices and practices of capital as they enfold through one another in the landscape is a way to understand the specific processes of, and effects of, acceleration. This allowed me to argue not just that accelerating processes have effects on traditional domains, such as the social or environmental, as Hylland Eriksen does. It also gave me the opportunity to demonstrate how accelerations are both generative (steam) and disruptive (earthquakes, cooling and pollution) and how such disruptions, in turn, generate further political and temporal matters. I will develop this in a few moments.

While I support Hylland Eriksen's generic claim that accelerating forces generate 'a fundamental contradiction between growth and sustainability' (2016: 8), I have tried to be more specific in my claims by seeking to ethnographically demonstrate how particular sets of tensions and dilemmas emerge as the Hengill volcanic landscape continues to accelerate and phase shift. We saw this with geologists in Chapter Four as they attempted to work through both the "need for speed" and the need to "give the earth time" under the difficult constraints of capital and municipal politics. We also learned about the way the small town of

Hveragerði is trying to figure out how to respond to the bind of earthquake warnings that have the potential to generate other, more destabilising forces. Part of my ambition in adopting the acceleration-threshold analytic, therefore, has been to try and specify the types of tensions and contradictions emerging through specific forms of acceleration-threshold relationship.

In his book, Hylland Eriksen does make a fleeting reference to the physics of acceleration, remarking that 'speed, in physics, is closely related to heat. In other words when you say of someone that he or she is suffering from burnout, the metaphor is an apt one. But the metaphor is also appropriate in other areas' (ibid : 31). These other areas are, for example, environmental; where the heat-speed relationship is brought out through metaphors such as 'overheating,' as well as financial, where talk of 'meltdowns' draws upon the same relationship. While Hylland Eriksen talks of runaway accelerating processes, the analysis remains on a metaphorical level, and does not, it seems to me, offer much more than we have learned from the theorists of acceleration that I discussed in the introductory chapter.

What I have tried to do throughout the dissertation is to specify the ways in which accelerating processes generate particular types of change, by drawing acceleration into relation with the idea of phase shifting thresholds. I gave a detailed examination of how this works in Chapters Three and Four. It is this couplet (acceleration-phase shifting thresholds) that allows me to point to the precise mechanisms through which change occurs, and the derivate effects of such change. Accelerating, I argue, is not only a process of doing things more quickly and therefore a quantitative endeavour; it is, in fact, also a qualitative process, which can alter the very nature and composition of our world. When changes in speed produce changes in kind, our world is reconfigured, and this can have effects far beyond that which was ever intended, generating responses that reconfigure politics in the process.

British Geographer Noel Castree, discussing the role of social science in the anthropocene in a recent commentary in the journal *Nature*, suggests that:

> Social science shows that the way people perceive and react to environmental and social change is both varied and contingent. It can elucidate the value judgements in most things that people do, including by experts across all fields. Through research, we can determine why, how and to what degree human activity is changing our planet. But in my view, it is folly to believe that there is an objective way to define a new 'age of humans.' What counts as epochal change is a matter of perspective and emerges from judgements about when quantitative change morphs into qualitative transformation (2017).

As I mentioned at the start of this concluding chapter, this dissertation offers an ethnographically situated answer to the question of how humans become geophysical force-makers. By analysing how volcanic forces are converted to energy resources I have been telling an alternate story of humans as geophysical force-makers. Part of the method I have adopted is to situate my work at a 'site of contact, struggle and dialogue' (Clifford cited in Haraway 2016: 185) in order to analyse when quantitative change morphs into qualitative transformation, as Castree puts it above.

While my geologist field companions take the well-known physics concept of accelerating phase transitions and put it into practice through the volcanic landscape, Earth System scientists use the same concept to develop arguments about planetary tipping point and feedback loops. I have used the concept more laterally in order to make a set of arguments about how accelerating phase transitions produce temporal and political matters. However, in order to do this I had to introduce another concept to help me make the connections between acceleration, temporality and politics more specific: that of rhythm.

8.3: The Rhythms and Temporalities of Acceleration

As I noted in Chapter Three, there is an etymological basis for thinking of fluids as rhythms, but, as I also argued, this can only work if we think of them as turbulent. Drawing upon Serres helped me to do this. As scholars have suggested (Ingold 1993, Adam 1998), focusing on the varying generative rhythms of the world as important ethnographic insights is a way of understanding landscapes and environmental issues as temporal processes. In effect, it is a question of taking rhythms seriously as productive of alternative times.

I try to make an ethnographic contribution to these debates in Chapter Four by way of my work with geologists. As fluids pulsate through the subterranean arteries of the geothermal field, geologists use these rhythms temporally. I conceptualised these *volcanic rhythms* as types of *ontological signals* that help these geologists to generate workable versions of the subterranean, and make analogies about the future. This is not an academic exercise for them, but an urgent one as they try to live up to the punitive energy contracts that Orkuveita have with Century Aluminium. Telling the time of the tracer today allows geologists to estimate the time of the future tomorrow: the time of cooling. Figuring out how to coordinate, or tell the time, under conditions of rapid environmental change is, in part, a dilemma of acceleration.

Analysing the generative rhythms of Hengill in detail is a way of understanding landscapes as temporal processes, and is what allows me to point out how we can be more attentive to the dilemmas of coordination that the entire planet is facing under the conditions of late liberalism. Telling the time, beyond measurement, within the complex conjunctures and disjunctures of environmental and financial distress is becoming increasingly more urgent in today's world. The work of ethnography in addressing these urgencies, as I see it, is to think through and with the perspectives and practices of those working at the coalface of these issues as they attempt to figure out how to deal with their own particular dilemmas. What I have been learning is that the dilemmas that both geologists and residents of Hveragerði are facing do not present any simple solutions and involve multiple entanglements that implicate some of the very ideas that are supposed to be the basis of how to move forward, namely particular notions of progress as they are bound together with renewable energy. While options for changing the worlds we inhabit seem particularly restrictive right now, and I am conscious of concluding this research in the *time of Trump*, pushing the lateral relations of analysts as citizens and field companions as analysts becomes even more important as we take on ever more shaky matters.

I also think rhythms temporally in Chapter Five as the *seismic rhythms* of *Suðurlandsskjálfti* (the southern earthquake cycle) are accelerated. Under accelerating conditions strange things are happening as the structure of earthquakes are being remade. At Hengill, scientists are suggesting that we are witness to practices that are speeding up normal stress release processes. Thermal shock is contracting the rock face as the future seismic rhythms of *Suðurlandsskjálfti* are crumpled and accelerated. "Man-made" earthquakes, I argued, are both *something of the now*, a geological phenomenon with disturbing effects, *and something of the future*, as rocks, and time, crumple through reinjection practices.

Thinking of both rocks and time as crumpled is a way of contributing to an understanding of the materiality of temporality, but not just that. I also want to suggest that various situated practices can be productive of various types of temporality. That is, in Hengill there seems to be a deep connection between the rhythms of the landscape and the people who live there. As reinjection practices accelerate earthquakes through crumpling rock, residents of the town also begin to articulate their sense of time in not too dissimilar a fashion, as they talk about relations between the 'past,' 'present,' and 'future' as crumpling together.

Taking rhythms seriously as generative of alternative times is an analytical move that is inspired by anthropology and STS. Taking up this mode of analysis changed the stakes of the analysis for me as the temporalities of acceleration became more important throughout the dissertation. If I turn again to Hylland Eriksen, as a prominent example of how contemporary anthropology is engaging with ideas of acceleration and change, there seems to be a curious lack of temporal thinking. His engagement with the temporality of acceleration is fleeting, limited to a set of suggestions regarding what he calls 'temporal scale…..the time horizon you imagine, forwards and backwards, when taking decisions and making plans' (2016: 29). That is, time is rendered as linear, and remains unaffected by his engagements with, and analysis of, acceleration.

The temporalities of acceleration have, however, been taken up by various other scholars, more classically as a way of thinking about the changing temporal forms and registers of postmodernity. These ideas theorise an *accelerating society*; a world where technological and digital practices are relentlessly quickening the pace of life. The dominant temporal concepts that emerge tend to, in some sense, compress time; ‘instantaneous time’ (Urry 2000), ‘time-space compression (Harvey 1990), or even ‘timeless time’ (Castells 2011).

Earth System scientists talk about acceleration differently. More precisely, explicit connections are drawn between the Great Accelerations of humans (Rockström, Steffen et al. 2009) and accelerating planetary boundary transformations. These effects are bringing about state shifting thresholds that are radically altering the conditions of life on the planet. In these discussions, time is rendered as vast and deep, not only by earth scientists and environmentalists (Aubry 2009) but also by anthropologists reflecting upon such matters (Irvine 2014).

Paying ethnographic attention to the practices through which volcanic forces are being converted into resources for aluminium production is not just, then, a question of thinking about the power of materials to differ over time, but points towards how such energetic materials can impact upon time. The temporal effects of these volcanic transformations do not suggest that our accelerating world has entered a phase of ‘compressed time’ or a phase of ‘deep time;’ instead, I would argue, such powerful interventions are provoking rapid change in ways that suggest that humans, as geophysical force-makers, might just be able to provoke phase shifts in time itself.

8.4: The Geopolitics of Acceleration

The politics of acceleration has taken a new turn in recent times, even finding its own political program, popularised by Benjamin Noys in his book, *The Persistence of the Negative* (2010). However, the term ‘accelerationism’ arose in connection with the work of Alex Williams and Nick Srnicek who published an accelerationist manifesto in 2013. This work is directed at experimenting with the possibility of speeding up and intensifying capitalist relations and ways of living in an effort to shake up a moribund leftist politics, as the authors perceive, one frozen in the lights of neoliberal hegemony. This includes the failure of the alter-globalization movement (Williams and Srnicek 2013). Accelerating capitalism is supposed to be a way of escaping capital’s gravitational orbit, allowing for a repurposing of the its material infrastructures (Gardiner 2017: 31). The politics of acceleration that I see emerging from Hengill is very different to this.

Throughout this dissertation, I have attempted to hold open a focus both on the materiality of energy (its practices and infrastructures) as well as on materials as energetic (phase shifting, crumpling), in order to analyse the practices and conceptualise the effects of volcanic forces being converted into energy resources. As we learned in the latter chapters of the dissertation, these conversions are reconfiguring the political as varying forms of geopolitics are emerging through such accelerated relations. Settling these "shaky matters" is no easy task. Shaking, I suggested, is the geological, conceptual as well as ethico-political form that turbulent phase shifts take. But residents of Hveragerði continue to have to deal with the range of disturbances (physical, conceptual and temporal) that this shakiness provokes, while attempting to find a way to move forward politically.

It is, of course, important to ask what work the prefix *geo- i*s doing in the compound noun geopolitics. Speaking of geopolitics is a way to mark a shift, but in a double sense. Firstly, it is a way of suggesting that today's politics has to concern itself with matters of the earth. We can see this in the growing call for improved 'planetary stewardship' (Steffen, Persson et al. 2011), 'Earth Systems governmentality' and 'global earth systems governance' (Clark 2014), a movement to greatly strengthen the frameworks needed to meet the political challenges of maintaining earth systems in ways we can continue to live with. This is geopolitics of the planetary kind.

Secondly, there is also a very familiar sort of (capitalized) Geopolitics. This older, but very much alive Geo-, is concerned with earth politics, but in a territorial sense, as nations and transnational corporations work out a power politics of interests and territorial ambitions. The Geo- here relates to the earth as a surface or stage upon which political contests take place. For geographers Stuart Elden and Peter Dalby, reclaiming this Geo- is a matter of practising and thinking geopolitics as beyond a horizontal and synchronous globality; 'it must acquire a volumetric or vertical dimension' they argue (Dalby 2013, Elden 2013).

While this work picks up an interesting axial shift in thinking about territory and power with a move from horizontal (area) to vertical (depth) thinking, Elden, in particular, also notes that just as the world does not just exist as a surface, nor should our theorizations of it. ‘Work examining what happens below the surface needs to be better connected to the discussions of the “above” and the surface’ (Elden 2013: 15). Nigel Clark pushes in a similar direction, suggesting that we are at last awakening to Michel Serres’ call for a ‘geopolitics in the sense of the real Earth’ (2014: 30), an awakening that draws attention to how the inherent instability of the earth is beginning to impact on our understanding of the composition of the political.

This is the space of intervention of my ethnography at Hengill, as varying ways of doing politics emerge from an intensive engagement with the earth’s dynamic processes. A focus on this ‘real Earth,’ means, as I see it, thinking the political through the geological: that is, thinking about the ways in which dynamic geological processes (phase shifting thresholds, crumpling and folding rock, as well as lava records and trails) are reconfiguring the political. At the same time the political settlements that are emerging from these processes fold back upon the geological.

Here, the geological is not just a substrate to political matters, but is ‘political matter that can relocate the grounds of politics’ (Knox and Huse 2015). But as I addressed in Chapter Six, the ground metaphor is not satisfactory. In taking the subterranean forces of Hengill into account as they work through and with the forces of capital, we see how shaky things have become, the earth included.

Shaking, as a manifestation of turbulent relations, provides an opportunity to think about the relationship between the material and political through the geological. While there is no stable ground from which this politics can operate, the efforts to settle these “shaky matters” generate their own shaky geopolitics as the relations from which they are composed remain turbulent. This form of politics of acceleration is not, as accelerationist thinkers would have it, repurposing capital’s infrastructures through its intensification, but merely creating extraordinarily difficult circumstances for actors in Hengill to try to live with.

As I discussed at the end of Chapter Seven, there is a certain paradox of progress on display at Hengill. Although being made from volcanic forces, aluminium cannot tolerate these same forces, despite being known as a highly noncorrosive metal. In effect aluminium cannot tolerate the toxic side effects of its own making. This is evident for many in Hveragerði as residents sit not only at the intersection of the Eurasian and American tectonic plates, but also, in a sense, at the crossroads of accelerations. As the volcanic landscape is accelerated to produce one of modernity's finest technologies of acceleration, something has to give; in Hveragerði it is the ground beneath their feet.

As Mimi Sheller puts it, 'tracing the silvery thread of aluminium across time and space draws together some of the remotest places on earth alongside some of the centres of global power' (2014: 67). In this sense, aluminium is a tale of both the Geopolitics of old, while giving rise to shaky geopolitics. Accompanying my field companions as they traced energy's inscriptions in Hengill - as both Bjarni and his colleagues were doing through the subterranean, and Björn and Stefan were doing through lava records - has also been a way for me to trace capital, and once removed, aluminium's effects on the landscape. This energy-aluminium-capital complex is not new, but adding 'renewable energy' into the mix is seen to be a progressive step for everyone involved.

After all, from Orkuveita's perspective reducing the carbon footprint of a metal that is embedded into the fabric of modern life and that is not going anywhere, is a worthy and valuable service that Icelanders provide the 'earth,' when 'earth' is conceived as planetary. Secretive pricing arrangements aside, the powers that be, municipal as well as national, consider it a reasonable use of Icelandic landscapes. From Century Aluminium's perspective, greening their aluminium processes also makes good common sense, especially if they can do it cheaply. Coupling one of modernity's primary metals with one of the planet's cleanest energy forms is a sign of progress, industrial as well as planetary.

However, thinking of the earth not as planetary but as a situated set of fractured and turbulent processes in a specific type of landscape, we come to see that maybe progress has its own threshold; in this case indexed through the volcanic landscapes of Hengill itself. As the geo's turbulent reactions are excised out of the manner in which both the energy supplier and energy consumer perform the relationship between energy and the earth as planetary, the effects, material, temporal and political are borne by the geo inhabitants of Hengill's landscapes.

Tracing such energy-aluminium-capital configurations in, through and out of the volcanic landscape of Hengill, has been one of the ambitions of this geostory.

8.5: Icelandic Analytics

In *Promising Genomics*, Mike Fortun develops an intriguing analytic through which to show the connections points between genetics and speculative finance as told through the deCODE genetic database controversy in Iceland in the late '90s (2008).[209] Fortun draws on the fissures of Iceland as a resource with which to think. Fissure swarms, he writes, suggest 'a country constituted by eruptions, crustal upheavals, subglacial lifts, lacrustine sedimentations, and other types of flows at varying speeds folding into or grinding against each other, sometimes imperceptibly, sometime violently' (2008: 13).

Fortun asks us to take this geo-logic of the fissure very seriously and very broadly, and to open ourselves up to its operation in the domains of genetics and finance. The fissure marks out both separation and joining at the same time. As spots of volatility, yet promise, fissures generatively unsettle and recombine.[210] Such a concept, argues Fortun, has been marginalised in favour of the comforting ground against which it occurs, provoking the more common categories of stability, identity, presence, and solidity. Like the geological fissures that swarm across parts of Iceland making it a volatile yet promising LavaXLand, Fortun examines the conceptual fissures that mark the social, scientific, and political landscapes of genomics (2008: 11-14).

Moreover, Fortun encourages us to take the landscapes of Iceland seriously as analogical tools with which to think across domains, in his case finance and genomics, and to learn from the relationship between the landscape and its people in order to think other situations. Fortun surmises, a little generically perhaps, that

[209] In 1998 the Icelandic parliament passed a bill setting up a national medical database. deCODE genetics won the license to map the genome of the Icelandic people as part of this larger medical database. The controversy mostly revolved around the way in which the company solicited consent to use DNA samples from Icelanders.

[210] Fortun uses the figure of an X to mark the fissure, the spot of vulnerability and promise he sees throughout debates surrounding genomics and speculative capital. Each chapter is designated with such an X figure. For example, the X in the chapter LavaXLand marks the fissure out of which emerges both flowing lava and solid land. It marks an and, a lava and land, and it marks a not, a not lava, not land. In essence it marks the joining and the separation, a spot of volatility and promise (2008: 13).

‘Icelanders have learned to live with geological volatility, with the fact that their land rides precariously on a viscous sea of lava, and that apparently foundational groundings are not only more fluid than we habitually assume, but they are also open to rattling, rumbling destruction’ (2008: 15).

I wholeheartedly second Fortun’s call to take Icelandic landscapes seriously, as well as his call to learn from Icelanders’ relationship with the landscape in order to help us think analogically. While there is clear merit and interesting conceptual purchase in allowing Icelandic analytics to help us think through other domains, I have tried to slow that process down a little. This dissertation has been an effort to work *with* and *in* Icelandic landscapes with Icelanders as they try to resolve a series of dilemmas they have made through *converting the volatility of the earth into the promise of a stable industrial nation.*

Another way of saying this is that fissure swarms are not only useful conceptual tools for thinking about ideas of volatility and promise as they relate to other domains (in Fortun’s case capital and genomics), they are also material relations that Icelanders have to work *in* and *with* as they try to convert the volatility of their landscapes into the specific promise of a stable industrial nation. At the same time they still use the forces and processes of the earth as analogical tools. We saw this through the work of Bjarni and his geologist colleagues at Orkuveita as they used the signals of the landscape, its sounds and pulses, to think analogically about the future.

8.5.1: Landscape Thresholds

In thinking about the question of how humans become geophysical force-makers, one needs to also think about the question of the conversion processes through which this happens. In converting volcanic forces to energy resources, or in converting volatility into promise, certain thresholds are generated that are of deep consequence. It is from here that I drew upon my own Icelandic analytics. Thinking a suite of concepts together, acceleration, turbulence and thresholds, has allowed me to interrogate the relationship between geology and capital as Hengill is converted into an energy node for aluminium. What I have mostly focused on, however, is the turbulent phase of these phase shifting thresholds.

I introduced the idea of turbulence through the work of Michel Serres and his descriptions of heating water molecules. By focusing on the accelerating and disorderly motion of heat molecules, Serres depicts a world of agitation and disruption. My adoption of this analytic helps me to think about the stabilities and instabilities happening throughout Hengill in terms of acceleration. As fluids accelerate through a turbulent phase shift they bring with them their own set of internal inconsistencies; both order and disorder simultaneously. As forces are converted to resources within the landscape, accelerating phase shifting thresholds are generated, both productive and disruptive.

As I have driving at in the dissertation, these thresholds are ontologically generative, both in the material and temporal sense. But thresholds can also multiply, as one conversion begets another. As concept, maybe that is also their generativity. One way of thinking about this is to suggest that not only have Icelandic landscapes become sites where conversions are taking place - from volcanic forces to energy resources – they have, at the same time, themselves become conversion devices, ones that are being articulated in an effort to convert Iceland into a modern, stable industrial nation. At the same time, this transformation is also part of how the aluminium industry is infrastructuring Iceland’s volcanic landscapes as part of the circulation of one of modernity’s primary metals. As volcanoes are converted to aluminium, the landscape is converted into another type of threshold, and notions of both progress and modernity emerge, like much else around Hengill, as shaky.

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