The Temporal Politics of Anthropogenic Earthquakes: Acceleration, Anticipation, and Energy Extraction in Iceland

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Abstract

This paper is an ethnographic exploration of the volcanic landscapes of Iceland, where the extraction of geothermal energy for the production of aluminum is triggering anthropogenic earthquakes. As the aluminum industry seeks to decarbonize their industrial infrastructure, they are increasingly looking to renewable energy havens, such as Iceland, to supply their expansive energy needs. While this paper is partly about understanding the forms of politics at stake in decarbonizing modernity's infrastructures, it is more specifically concerned with the temporal politics of anthropogenic earthquakes in the Hengill volcanic zone in the south west of the country. The paper takes up the perspective of geologists tasked with analysing the emergence of these new earthquake forms, as well as locals from a small town in the vicinity who are learning to live with them. While focusing on the conflict that has ensued in the wake of earthquake production, the article pays particular attention to the importance of acceleration—both economic and geologic—in their making. This leads to an analysis of how alternate temporal renderings of anthropogenic earthquakes invoke competing claims about the future. Anticipating the future, the paper argues, is a form of temporal politics through which the various actors either legitimise, or protest against, these volcanic interventions.

Keywords: Energy, Iceland, Anthropogenic Earthquakes, Acceleration, Anticipation, Temporal Politics

1. Introduction

The environmental consequences of extractive processes have become an increasingly important part of the emerging story of the anthropocene – as it is commonly, yet contentiously, called (Chakrabarty, 2014; Tsing, 2015; Haraway et al., 2015). Particular variants of this narrative have untangled the complex history of relations between capital, power, and empire over the last 500 years to show, in part, how various landscapes across the globe have been radically transformed in the service of the energy requirements of modernity. In particular, the appropriation of steam and coal landscapes became central to the power-hungry story of the industrial revolution. (Moore, 2015). Today, that power-hungry story continues apace as energy intensive industries, such as chemicals, metals, or even newer arrivals such as data centers, continue to use vast quantities of energy to sustain their round-the-clock need for electricity. Such industries develop mega-projects (Flyvbjerg et al., 2003) that appropriate and transform vast and varying landscapes—whether it be bauxite mines, razed forests, dammed river systems, or volcanic zones—in

order to keep their commodities in circulation. However, with a global shift in environmental and energy politics these industries are being increasingly pressured to decarbonize their energy infrastructures, and as a consequence are constantly on the hunt for greener, more renewable landscapes to fulfil their power requirements. So, while steam and coal landscapes were central to the story of the industrial revolution, renewable energy landscapes are now becoming central to the story of decarbonized futures.

This paper takes us to Iceland, a place where questions of energy transitions and environmental politics are intensively connected. This small sub-arctic state is currently the world's largest per capita producer of electricity (by a factor of two), the majority of which is directly tied to the production of one of modernity's most sought after metals, aluminum. Although aluminum companies have been using hydro-electric power in Iceland since the 1960's, the Icelandic state has recently embarked upon a new renewable energy adventure with the industry, transforming some of the country's most powerful volcanic landscapes into sites of geothermal energy extraction. Proponents argue that coupling one of the world's primary metals with one of the world's cleanest energy forms is a sign of progress, industrial as well as planetary. This paper ethnographically explores the volcanic landscapes of Iceland where the extraction of geothermal energy from the country's most active earthquake zone is triggering anthropogenic earthquakes. While this story is partly about understanding the forms of politics at stake in decarbonizing modernity's infrastructures, it is more specifically concerned with the temporal politics of anthropogenic earthquakes in the Hengill volcanic zone in the south west of the country. Based on one year's fieldwork in this area between 2014 and 2015, the paper takes up the perspective of geologists from Reykjavík Energy tasked with analysing the emergence of these new earthquake forms, as well as locals from Hveragerði, a small town within the volcanic zone, who are learning to live with them. While focusing on the conflict that has ensued in the wake of earthquake production, the article pays particular attention to the importance of acceleration—both economic and geologic—in their making. This leads to an analysis of how alternate temporal renderings of anthropogenic earthquakes invoke competing claims about the future. Anticipating the future, the paper argues, is a form of temporal politics through which the various actors either legitimise, or protest against, these volcanic interventions.

2. Temporal Politics and the Environment

As an object of anthropological attention earthquakes have mostly fallen under the analytical rubric of Disaster Studies, which, in broad strokes, addresses issues of human vulnerability and resilience in earthquake scenarios (Oliver-Smith, 1999; Adams et al., 2009b). 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 (Oliver-Smith, 1999). However, anthropogenic earthquakes have a much shorter history and are increasingly connected to energy production. Take fracking; a process of blasting large amounts of water, sand and chemicals into underground formations, inducing seismic effects (earthquakes) that release the gas bounty lying within. Anthropogenic earthquakes are central to the production strategy of this 'unconventional' energy form. 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 energy companies,' the emphasis remains squarely on the politics of opposition and resistance (Buttny and Feldpausch-Parker, 2015; de Rijke, 2013; Ernstoff and Ellis, 2013; Matz and Renfrew, 2014; Szeman, 2013; Willow, 2014; Cartwright, 2013). 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 (Wylie, 2018). But this only partially resonates with the production of anthropogenic earthquakes in Iceland, the details of which I will come to a little later in the paper. What is important to note here, however, is that the political response to these earthquakes has taken a temporally inflected form. While anthropogenic earthquakes are performed as an acceleration of 'natural' seismic forces by geologists from the energy company, locals living in the area dispute this rendition, leading to the production of competing claims about the future of the volcanic area. In what follows, I use the dual analytics of acceleration and anticipation to think through this form of temporal politics.

The temporalities of acceleration have been taken up by various scholars, more classically as a way of thinking about the changing temporal forms and registers of postmodernity. The German political scientist and sociologist Harmut Rosa (2013), 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. Judy Wajcman (2014) notes that talk of acceleration only makes sense against an implied background of either a slower human past or a stable 'natural' present. 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). 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 Doreen Massey have suggested that these 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.[1] 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)[2]. This is the first intervention that this paper seeks to make; reading 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), what form they take, and what politics they entail. It is an effort to tell partial, rather than epic, tales about the 'continuous weaving' involved in the arts of narrating the rhythms of the world we are becoming with (Duclos et al., 2017: 3). While this story is partially about how technological interventions are speeding up and slowing down parts of the volcanic landscape, its temporal politics are far removed from the recent accelerationalist political vision of scholars such as Alex Williams and Nick Srnicek (2013).

The paper's second intervention is to move away from thinking accelerations in exclusively 'social' or 'natural' terms in an effort to complicate the idea that such accelerations reside within discrete human or non-human collectives. Rather, in analysing how the structure of earthquakes are being remade under accelerating conditions, the article offers a conceptualisation of these new phenomena as crumpled; 'convergences of different temporalities within one rhythmic configuration,' (Bergson cited in Nielsen, 2011: 399). As relations between 'humans' and 'nature,' as well as between the 'past,' 'present' and 'future' begin to crumple, they become too mixed, the paper argues, to be contained within extant categories.

One dominant register for thinking about accelerations comes through Earth System Science. Here explicit connections are drawn between the Great Accelerations of humans (Rockström et al., 2009) and accelerating planetary boundary transformations. Accelerating population growth, urbanisation, energy and water use, modern agriculture, consumption habits, to name a few, are cumulatively impacting upon nitrogen and carbon levels, ocean acidification, biodiversity rates, as well as land, tropical and marine ecosystems. While the planet's boundaries have been unusually stable for the past 10,000 years, this stability, scholars suggest, is now under threat as new planetary thresholds emerge (2009: 472) (Barnosky, Hadly et al. 2012: 54). In particular, ongoing research into how the acceleration of the nitrogen cycle testifies to the dramatic range of cascading effects that such accelerations are having on our ecosystems (OECD: 2018).

However, in this rendering 'nature' ceases to be the presumed backdrop against which societies accelerate. Drawing on Bill McKibben'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 dominant within social theorists of acceleration—are no longer tenable. If one were to hold onto those categories today, it would be 'natural' processes that are accelerating, while society's response to such accelerations appear to be slowing down (our 'slow' transition to renewable energy, for example). Helpfully, Bastian situates temporal processes in moments of 'coordination' amongst human and non-human collectives in ways that take account of the unevenness of their temporal dynamics. The act of telling the time, Bastian suggests, is more than an act of measurement, it is an act of relational performativity, or coordination. We tell the time 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). Bastian argues that we seem to be failing to coordinate our actions with a whole host of non-human actors today, 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. The ethnographic work at the heart of the paper suggests that the triggering of anthropogenic earthquakes has changed how the volcanic area can be coordinated with, and in particular how the future can be anticipated as a consequence.

As part of the 'temporal turn' in anthropology (Bear, 2016b), ethnographers have begun thinking in a more sustained way about the future. Morten Nielsen, in particular, draws attention to the range of interesting future oriented work now being undertaken (2011). While scholars have produced nuanced descriptions of how people orient themselves in relation to unknown futures (Guyer, 2007; Miyazaki, 2006; 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).[3] This paper contributes to these discussions by analysing how seismic accelerations effect the ways in which the future is anticipated. In essence, it puts forward an argument that connects anticipatory practices with politics, as the various actors in the volcanic area either legitimise, or protest against, seismic interventions through particular anticipations of the future. 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 (2009a). Asking critical questions about the forms that anticipation takes in varying settings, as both affective and material, is one way of interrogating the temporality of politics in times of alarming environmental uncertainty.

The overall theoretical thrust of the paper, therefore, is to approach the temporalities of geological processes through the twin analytics of acceleration and anticipation. It argues that speeding up stress release patterns in the subterranean strata through human extractive interventions (acceleration), opens up a temporally inflected political space in which the articulation and contestation (anticipation) of the future becomes a serious matter of concern. As temporalities begin to fold—both in the rock strata and in human experience—the effort to 'co-ordinate' with newly emergent anthropogenic earthquakes requires a geo-political form of engagement that all actors in the area are trying to come to terms with.

3. The Energy-Aluminum Nexus

Iceland is a place with a long history of socio-environmental catastrophe. Its annals are full of stories of unbearable icy winters, famine, and plague, in addition to violent volcanic eruptions and earthquakes (Hastrup, 2012). Stories of these events are no less familiar to inhabitants than those of mysterious rock and hidden people who inhabit the country's rich, yet volatile landscapes. Such turbulent terrains have inscribed themselves within the canonical texts of geologists and poets alike, as well as the bodies and memories of those who live within them. However, the legacies of instability that have plagued Iceland over the course of its history have come at a heavy price. 'Modernist' development has been slow (Magnússon, 2012) and aspirations towards 'progress' have been as palpable as their attainment fleeting. To move beyond these vicissitudes, the

Icelandic state has turned towards the landscape in an effort to convert the volatility of some of the country's powerful volcanic zones into the promise of economically productive sites of geothermal energy. This shift has been facilitated by the aluminum industry.

In *Aluminium Dreams*, Mimi Sheller (2014) gives a detailed account of the global role and effects of the aluminium industry. This metal has come to play a crucial part in the transportation, electrical, construction, aeronautics, and ship building industries. At the same time, it is important in domestic design, architecture, technical equipment, and a host of everyday consumer goods such as baking products, cosmetics, kitchen utensils—the list goes on. Once you begin to look for aluminium, Sheller notes, you start to find it everywhere (ibid: 1-2). As a substance it is light and flexible, non-combustible, durable, and it conducts heat and electricity better than other metals. These primary physical qualities afford a host of possibilities, principal of which is the relationship between lightness and speed. Sheller encourages us to think of airplane flight, space travel, and data transmission: 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 (ibid: 1). As one of the most widely used and valued metals, aluminum is closely tied to the investment and development of large energy infrastructures around the world. It, in effect, 'freezes energy in metallic form' (ibid: 141). As such, controlling electricity production is one of the major forms of transnational power exercised by this industry as vast and varying landscapes are transformed to meet its insatiable electricity needs.[4]

While the relationship between Iceland and aluminum goes back to the 60's, it was only in 2012 that the Hengill volcanic zone in the southwest—the country's most continuously active earthquake zone—became the host site of electricity production for a large multinational, Century Aluminum. The logic ran something like this: Iceland is renowned for its renewable thermal energy from shallow geothermal reservoirs (hot water). 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 cater for a range of other domestic and industrial needs—it has been stable and uncontroversial. Such successful utilisation of volcanically heated water has been lauded by geologists the world over as an exemplar of sustainable production, as well as extolled by tourists as they lounge in the silky silica rich warm waters of places like the Blue Lagoon.[5] Accelerating operations—by switching from the production of hot water for heating to steam for electricity—was considered a strategically smart way of stabilising an economy that had been dragged through the mill of some of the worst excesses of finance capitalism in living memory. Infrastructuring Iceland's volcanic landscapes as part of the circulation of aluminum was seen as a way of unleashing the landscape's potential, converting volcanic instability into economic stability.

One way of thinking about geothermal extraction is as a type of volcanic terraforming. The geothermal power plant is located in the Hengill volcanic zone in the south west of the country, where over fifty wells have been drilled 3 kilometres deep into the subterranean stretching over vast quadrants of landscape. While geothermal fluids exist in an intensely pressurized form deep within underground rock fractures, getting them up to the surface involves calibrating relations between the underground and

overground—in particular heat and pressure relations—to maximum acceleration effect. Moving through underground chambers, fluids accelerate as they heat up, explode upwards through the extraction technologies, and phase transition, almost magically, into steam. So, producing electricity for aluminum is a process of accelerating the landscape to phase shift water into steam. While producing these accelerations deep within the subterranean of a continuous volcanic zone might appear, on the face of it, risky, the probability of inducing seismic activity was deemed close to zero by geologists at Reykjavík Energy. As they pointed out to me on many occasions while on fieldwork; "the history of geothermal hot water is almost 100 years old, this is stable, sustainable: this is not fracking." What these geologists had not accounted for were the forms of economic acceleration at the heart of the how aluminum conducts its business. Century Aluminum's smelters operate 24/7, consuming the over 300 mega-watts of energy that the geothermal power plant produces as smelter pots gobble up continuous round-the-clock current to keep from freezing. Given its control over large parts of the electricity market, the aluminum industry has become very adept at extracting cheap energy prices - particularly from small, inexperienced states - in order to keep aluminum prices competitive. Being "cut to the bone from a price perspective," as a senior geologist at the company put it to me, had serious consequences for the ways in which the volcanic landscape was configured to extract steam. In addition, the time-based financial discounting models used on the project also incentivised extracting steam as fast as possible. Such models are premised on the idea that steam extracted today is more valuable than steam tomorrow.[6] The combination of low prices and discount models fuelled 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) operations.

What I learned from the geologists at Reykjavík Energy was that the tried and tested geologic practice of giving geothermal wells the requisite amount of time to adjust to the unpredictable effects of deep subterranean drilling[7] was overridden by the need to satisfy the huge energy demands of aluminum: in a way that made sense to capital. The effects of making the subterranean a workable proposition for capital were significant. Such economic accelerations led to pressure drops in the geothermal reservoir—decelerating the driving force that explodes steam out of the ground—and hence a loss of energy. So, while economic accelerations dominate landscape terraforming, they can actually work against the geological accelerations that are necessary to produce sufficient quantities of steam for electricity.[8] Doing things slowly, for geologists, is ultimately a way of ensuring accelerations that can be lived with. Economic accelerations, on the other hand, decelerate the landscape and, paradoxically, lead to less economic value. As I will go on to explore in the next section, they also lead to other, more consequential forms of acceleration.

Figure 1: Aerial photo of Hengill Volcanic Zone indicating key locations (geothermal power plant, reinjection site, and Hveragerði). Image courtesy of Einar Gunnlaugsson of Reykjavik Energy.

4. Acceleration and Anticipation

While attending a conference Reykjavík Energy were hosting for a group of international seismologists, I listened to a geophysicist from the energy company explain the complex phenomena of anthropogenic earthquakes:

> *The concern with falling pressure led us to design a new process called re-injection. This is where we re-inject spent geothermal fluids back into the subterranean fractures. The aim of this is to re-pressurize the geothermal reservoir and improve our energy output. But things have been more difficult than we expected. The hot fluids need to be cooled down in order not to clog the reinjection chutes that the water flows down. This colder water has begun to create thermal shock, contracting and crumpling the rock face* (using a tightly closed fist as a way to demonstrate the effect).

One of the seismologists in the audience quizzes the geophysicist: "But is it just about the temperature change, the area would have to be under serious stress already, wouldn't it?" The geophysicist goes on to explain that the site of reinjection lies on the western most boundary of one of Iceland's major fault plains, the South Iceland Seismic Zone (SISZ). This is a zone that is known for releasing seismic stress in approximately 100-year cycles, producing 'natural' earthquakes that Icelanders refer to as *Suðurlandsskjálfti* (the southern earthquakes). He continues on to tell the assembled group that the company's assessment is that the thermal shock from reinjection is inducing a seismic response; it is triggering the release of already built up rock stress:

> *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 triggering the Suðurlandsskjálfti earthquakes that would happen anyway*.

The effect of reinjection, in this rendering, is to release what would otherwise occur 'naturally.' The geophysicist, I realise after several follow up conversations, is careful to avoid the language of generation. Triggering, is about speeding up, it is not a process of causation, but one of acceleration.

It is not that earthquakes are something new to Hveragerði, the small town in the vicinity of the geothermal power plant; quite the contrary in fact. While the last full sequence of *Suðurlandsskjálfti* stress 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. Having lived with, and through, these earthquakes, what the town's residents are particularly concerned about is how these newer anthropogenic earthquakes[9] will impact the next *Suðurlandsskjálfti* that everyone expects at some point in the not too distant future. Consider this recollection of the 2008 earthquake from Arnthor, a town resident:

> *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 back door when the quake hit. And I thought, 'okay I will just keep on walking and walk through the back door to get to her.' But I never made it; I ended up lying flat out on the floor. I couldn't stand up. I couldn't 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 new "man-made" 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 'ah, we won't have another big one for some time,' but then I think, 'who knows now?' But still you always react, you always think, 'Uh, is this another one, is the next big one on its way.' We can't be playing around with these forces; it's beyond imaginable what might happen. Once we begin to play with them, what will happen, how will they affect Suðurlandsskjálfti?*

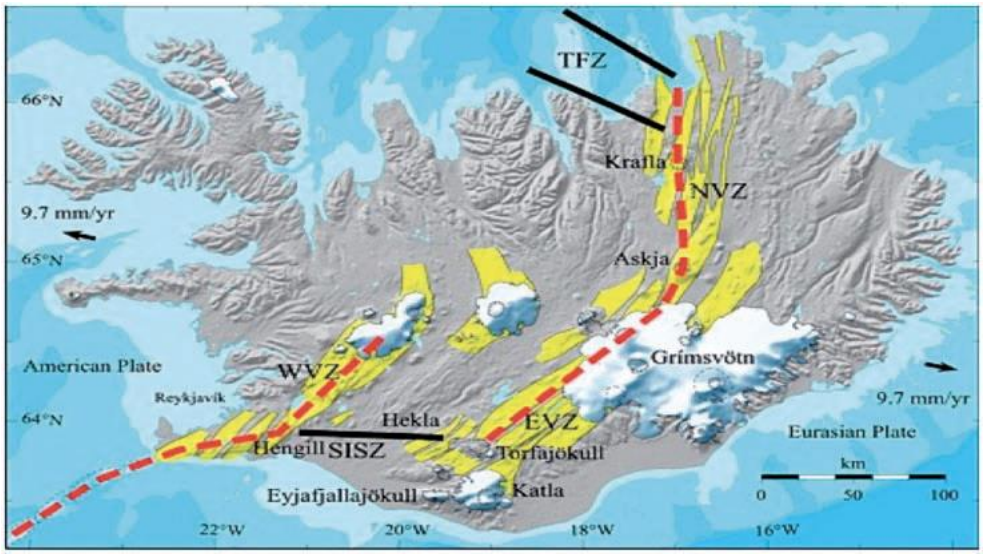

Figure 2: The South Iceland Seismic Zone (SISZ) is a micro plate (thick black line) between the Western Volcanic Zone (WVZ) and the Eastern Volcanic Zone (EVZ). It releases built up lateral stress cyclically, known by the name Suðurlandsskjálfti (southern earthquake cycle). The geothermal power plant's reinjection site lies on the western tip of the SISZ.

For this resident, like others, playing with such forces can make unimaginable things happen as the anticipation of a future in which anthropogenic earthquakes mix with *Suðurlandsskjálfti* continues to provoke anxiety. "The next big one" is the discursive form that such anticipation takes. Anticipating earthquake futures is nothing new for people in Hveragerði, in fact one could argue that anticipatory actions are inscribed within town life 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.[10] 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 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.

The socio-material existence of the town is bound to the seismic release patterns of the Hengill volcanic zone. As such the town has become what one might call a large 'anticipatory infrastructure' (Nielsen, 2008; Thrift, 2005), 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 materially and affectively, and which while ungovernable, remains, nonetheless, anticipated.[11] The uncertainty that *Suðurlandsskjálfti* 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 patterns is affecting what people thought the future would hold. As Arnthor put it a little earlier, "earthquakes produce a genuine sense of the next moments being completely open," and the ongoing production of anthropogenic earthquakes that are being felt in Hveragerði are generating a profound sense of this openness.

As we learned above, geologists from Reykjavik Energy describe these newer earthquakes through the language of acceleration. Geothermal activity, they claim, is accelerating the earth's 'natural' seismic rhythms, speeding up the production of earthquakes that would 'occur anyhow.' Here is how an expert panel of geologists, commissioned to investigate anthropogenic earthquakes, describe the process using a visual aid.

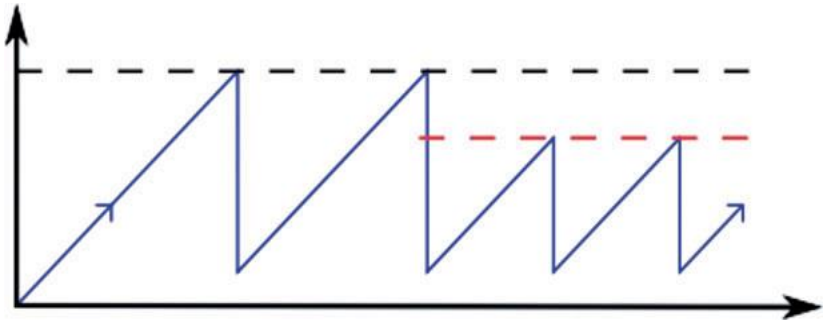

Figure 3: Accelerated earthquakes. The blue line shows how shear tension in the strata increases with time and falls with each earthquake. The black spaced line shows the strata threshold without reinjection, while the red spaced line shows the strata strata threshold with reinjection. If reinjection lowers the threshold it suffices to say that the earthquakes will be more frequent in occurrence but less powerful in magnitude. (Olafur G. Flovenz and Kristjan Agustsson, 2011 (adapted) cited in Bessason, Olafsson et al., 2012: 64).

These experts argue that this production of smaller, albeit accelerated, earthquakes will reduce the magnitude of *Suðurlandsskjálfti*. As they explain it, while accelerating volcanic processes make earthquakes happen more quickly, they also come with the potential of transforming the future into a more benign place. Legitimizing volcanic interventions in these terms strikes townsfolk as an almost perverse form of geo-logic. Consider another resident—Einar's—way of rebuking the panel's accounting of events:

> *At a town meeting, Reykjavík Energy said that by making lots of smaller 'man-made' earthquakes, they are releasing the tension in the western part of the volcanic zone - which would probably have led to an even bigger earthquake in a few years' time anyway. 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.'*

The expert panel, and by extension Reykjavík Energy, perform a version of the future that is somewhat more benign than it otherwise could 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 1). 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 Reykjavík Energy are performing, one in which *Suðurlandsskjálfti* will be 'smaller' (the red spaced line in figure 1). 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 anthropogenic earthquakes and the predictions of the next round of stress release of *Suðurlandsskjálfti* have become blurry and mixed as they fold into one another.[12] 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.[13] In an intriguing conversation with Bruno Latour, Michel Serres creates an image of time as 'crumpling and folding through thunderous accelerations.' Further into the same conversation he uses an analogy of a folding handkerchief:

> 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 (Serres and Latour, 1995: 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 as folded or crumpled. But what, if anything, can this allow me to say about what is occurring in the Hengill volcanic zone? While a handkerchief is apposite material 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 one of time (as measurement). While the former is immediately foldable, folding the latter takes a lot longer. So, while cloth, as foldable, serves to analogise time as non-linear, rock's commonly ascribed characteristic as solid 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. But under accelerating conditions strange things are happening in the Hengill volcanic zone. Geologists own reading of the situation is that their practices are speeding up 'natural' processes. As thermal shock contracts subterranean rock formations, the stress release patterns of *Suðurlandsskjálfti* are being 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*? Drawing upon Serres as inspiration for thinking through a more materialist analytics of time (Bear, 2016a), I want to suggest that what were once the distal stress release patterns of *Suðurlandsskjálfti* have been crumpled, becoming proximal through 'thunderous accelerations' (Serres and Latour, 1995: 57-58). Anthropogenic earthquakes, I am arguing, are 'convergences of different temporalities within one rhythmic configuration;' *something of the now*, a geological phenomenon with disturbing effects, *something of the past*, as the history, and memory, of the volcanic area responds to extractive interventions, as well as *something of the future*, as *Suðurlandsskjálfti* earthquakes crumple and accelerate.

What can be seen from Arnthor and Einar's citations above is that the folding of rock and the folding of human experience occur concomitantly. As rhythmic convergences of different temporalities, anthropogenic earthquakes not only fold the subterranean in ways that crumple the 'past,' 'present' and 'future, they, at the same time, also fold local memories and experiences of earthquake events. In a recent piece, Bronislaw Szerszynski (2019) attempts to think across the sclerotized boundary between the living and the non-living by extending the concept of memory into non-human spaces. Rather than thinking of memory as an isolated human experience, Szerszynski argues that we could conceive of human memory as but one specific example of a wider phenomenon, one that can have different modalities across the geo and bio spheres. He notes, for example, how geologists talk of a 'lithospheric memory' and suggests that rock, in particular, has a type of 'conformational memory' (ibid: 6). In essence, he intriguingly postulates that rock can 'remember' and 'forget' across varying timescales. Memory here is to be understood as the process by which, for example, an elastically deformed rock springs back into its original shape after an earthquake—thus 'remembering' that former shape—or how the same type of rock cannot 'remember' prior deformations as each new earthquake continually resets the cycle. What the ethnography from Iceland adds to this is the suggestion of a form of *connection* across human and geological collectives as the folding of temporalities moves between crumpling rock and human experiences of these events.

As temporalities converge they become too mixed and enfolded for the town to place any faith in Reykjavík Energy's version of what lies ahead; a *pure* earthquake category ('natural') with a more benign impact (less in magnitude).The anticipatory idiom of townsfolk—the "next big one"—suggests that what's to come is no longer what it once was. Similar to Reykjavík Energy'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, they do not 'naturalise' this possible future in the way that the Reykjavik Energy appear to do; what's to come is, in some sense, not 'natural,' but mixed, not uncertain, but indeterminate.

5. Conclusion

In *Aluminum Dreams*, Mimi Sheller notes how nations continue to dream of the benefits that a light modernity can provide. Such lightness puts 'cultures into motion' and propagates the modernist hope of 'accelerated futures' (2014: 27); a dream that has plagued successive Icelandic governments as they have tried to find a way through instability; topographic, climactic, and more recently financial. But the accelerations occurring in the Hengill volcanic zone, however, are not the accelerations of modernity's dreamers, but ones that arise from efforts at making the subterranean at Hengill a workable proposition for capital. While working 'slowly' for geologists produces accelerations that can be lived with (steam), working 'too quickly', as we have seen, decelerates the landscape, and produces alter accelerations that townsfolk in Hveragerði are finding hard to live with.

However these accelerations do not produce 'instantaneous time' (Urry, 2000), 'time-space compressions (Harvey, 1990), or even 'timeless time' (Castells, 2011). Instead, what we have seen is that accelerating 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 the world. When changes in speed (economic accelerations) produce changes in kind (anthropogenic earthquakes), the world is reconfigured, having effects far beyond that which was ever intended. What the comments from residents of Hveragerði running throughout this paper show is that residual anxieties and memories from the earthquake of 2008 mix with the smaller current shakings of anthropogenic earthquakes, and the looming prospect of what is to come. Residents treat the pure 'natural' version of the future—a *Suðurlandsskjálfti* 'light'—with deep suspicion. Einar's death analogy indexes this; just as an untimely death cannot be considered 'natural,' neither can an untimely future.

In one sense the version of the future performed by Reykjavík Energy is both a compelling narrative and a method of displacement, outlining the possibility of a more benign future in the hope of legitimising current extractive processes. While the effort to legitimise the acceleration of smaller earthquakes as a method of preventing larger ones might seem contradictory in an era that is keenly focused on the *slowing down* of earth processes, there are historical precedents. Take prescribed fire burning as one contested example of disaster alleviation (Clark: 2018). Or more recent research that advocates volcanic pressure relief as a method of reducing the risk of more explosive, and dangerous, volcanic eruptions[14]. But in another sense such displacement narratives also work as 'anticipatory actions.' Anticipating the future, in this regard, becomes a form of temporal geopolitics for Reykjavík Energy, an attempt to legitimise ongoing interventions into the volcanic landscape. As different temporalities converge within one rhythmic configuration (anthropocentric 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 Reykjavík Energy, 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 et al., 2009a: 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, one in which the townsfolk have to try and live within a radically extended moment of openness. It is in this context that residents are having a much more difficult time anticipating what comes next; living with the indeterminacy of openness in some senses evades the powers of anticipation.

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Notes

[1]1 Massey (1993: 62) goes on to talk about the inequalities of opportunity that are a feature of the uneven geographies of time-space compression narratives, which for her, are a mostly metropolitan phenomena.
[2] Harmut Rosa also suggests a similar *slowing down* that is concomitant with processes of acceleration (2003: 5).
3 Another formulation from Adams et al is ‘anticipation is the palpable effect of the speculative future on the present’ (2009a: 247).
4 As a primary player in electricity markets, the aluminum industry consumes up to 3% of global electricity output (Sheller 2014).
5 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/.
6 The basic logics of financial discounting models 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).

7 This is known as stepwise development, a process that begins with the drilling of a well, followed by the gathering of geochemical and geophysical data over the course of up to a year, possibly two. This is followed by drilling another well in close proximity to the first to see how they react to one another. Then a third well is drilled, and so on, until geologists have a greater understanding of how each well affects those in its vicinity. Operating at a tempo that allows subterranean relations to stabilise after drilling is considered crucial for sustainable production.

8 Geologists estimated 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 drill additional "make up wells" were approved by the board of Reykjavík Energy during my fieldwork and are estimated to have cost ISK8 billion kroná.

9 These newer earthquakes began occurring in 2012. Over a period of 6 months, 4,600 earthquakes were recorded by seismographs in the vicinity of the reinjection site. A lot of them were very small and hard to feel, but dozens of them were over 4 in magnitude, and several of them were over 5. Some people left the town, while others sought medical treatment for anxiety. But personal impact depended very much on the geography of earthquake distribution, with western parts of the town (closer to the reinjection site) being impacted more acutely.

10 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.

11 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.

12 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).

13 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).

14 See http://www.bbc.com/future/story/20170817-nasas-ambitious-plan-to-save-earth-from-a-supervolcano

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