Grounding Territory: Geoscience and the Territorial Ordering of Greenland During the Early Cold War

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Thesis submitted for the degree of Doctor of Philosophy

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2018

Abstract

Following recent calls for a more 'earthly' geopolitics, this thesis contributes to the ongoing momentum within Political Geography to add depth, volume, and matter to the concept of territory. Merging insights from Science and Technology Studies with geographical studies of territory, this thesis asks how the sciences of the Earth may serve as technologies of territory. How, in other words, might states use science to forge a seemingly stable ordering of space which is extendable through time from a world defined by chaos, instability, and incessant change? To address this question, the thesis mobilises two instances of territory construction in Greenland during the early Cold War, when two differently motivated intruding powers, Denmark and the USA, both used Earth Science as a means of territorialising Greenlandic geographies. Firstly, the high-profile case of Danish uranium prospecting at Ilímaussaq exemplifies Danish attempts at casting Greenland as a space of extraction – as land upon which the nation might capitalise. Secondly, the practices of two interrelated US military scientific expeditionary outfits are used to show how the US sought to cast Greenlandic landscapes as a military terrain serving as an extra-sovereign extension of American state space.

Despite the apparent differences between these two cases, the empirical findings of this thesis complicate simplistic distinctions between land and terrain, the voluminous and the horizontal, and also between bio- and geo-political orderings of state space. Reading across these two instances of territory formation, the thesis draws attention to the temporal and processual characteristics of territory by showing how territory's formation in Greenland was informed by a complicated interplay between stability and flow rather than a rigid 'logic of solids'. Building on Stuart Elden's work on territory and Elizabeth Grosz's philosophies of Earth, this thesis thus argues that territory is, in part, a geo-political technology which allows the state to attune to the rhythmic forcefulness of Earth and draw on and over its latent power.

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AEK:	Atomenergikommissionen [The Atomic Energy Commission]
AERE:	The Atomic Energy Research Establishment
CRREL:	Cold Regions Research and Engineering Laboratory
FFR:	Forsvarets Forskningsråd [The Danish Defence Research Establishment]
GARR:	Geologisk Arbejdsudvalg for Radioaktive Råstoffer [Geological Committee on Radioactive Resources]
GEUS:	Danmarks og Grønlands Geologiske Undersøgelse [The Geological Survey of Denmark and Greenland]
GGU:	Grønlands Geologiske Undersøgelse [The Geological Survey of Greenland]
NAB:	National Archives Boston
NARA:	National Archives and Records Administration
SIPRE:	The Snow, Ice, and Permafrost Research Establishment
STS:	Science and Technology Studies
TRARG:	Transportation Arctic Group
UAF:	University of Alaska, Fairbanks
USAF:	US Air Force

Acknowledgements

Like any piece of work, this thesis is the product of a long line of interactions and exchanges and of the coming-together of people, places, and ideas. My encounters with rock, ice, and documents in places far from Durham were facilitated by the financial support I have received. As such, I am grateful for the Politics of Emergent Geographical Spaces doctoral scholarship from Durham University as well as fieldwork grants from the UArctic and the Royal Geographical Society. First and foremost, however, I wish to express my gratitude to the people who made my research possible.

Throughout my studies, I have had the great fortune to encounter many inspirational academics who have supported, guided, and encouraged me. Most of all, I am grateful to Phil Steinberg for his mentorship and for providing me with opportunities to better myself as an aspiring academic. I would not have been able to complete this thesis without his guidance, patience, and encouragement. Phil first opened my eyes to the fascinating politics of a chaotic and stubbornly material world in flux at a departmental talk in London in 2013. I am grateful for the many discussions we have had on this topic over the years since. I am similarly indebted to Joe Painter for his insightful and constructive commentary on my work and for his continued encouragement and support. Thanks to Ben Anderson for helping me develop my ideas when I first started my doctorate and to Chris Stokes for offering a scientist's perspective on my geological musings. I also owe my thanks to Klaus Dodds for 'awakening my Arctic imagination' and introducing me to the wonders of frozen geographies. In significant ways, the seed which grew into this thesis was planted as I sat next to the inflatable emperor penguin in his Royal Holloway office engaged in discussions of Polar geopolitics. Similarly, I want to extend my thanks to Alasdair Pinkerton and Peter Adey for an inspiring year of master's studies. Finally, I remain grateful to Henrik Gutzon Larsen who encouraged me to pursue my studies further and provided me with mentorship and support beyond the remits of his job description. Henrik inspired me to become a political geographer.

This work would not have been possible without the help of the librarians, archivists, scientists, and researchers who aided me in my data collection. In particular, I want to acknowledge the invaluable help I received from George Clark without whom my dataset would have been significantly poorer. I am also grateful to Henning Knudsen who spent hours of his time helping me dig through dozens of unmarked boxes at the Danish Natural History Museum.

From the very first day of my PhD, I have benefited from being surrounded by an amazing cohort of fellow PhD candidates who provided mutual support, comfort, and friendship and thus helped me retain my sanity. In my first year, 'experienced voices' tirelessly reminded me that the PhD is an organic process and that one must retain a sense of openness towards what might emerge from it. Thank you Ankit, Boris, Brendan, Adam, Simon, Lizzie, and Ruth. *Tusind tak* to Ingrid for years of Arctic bonding, to my amazing office mate Sarah, and for their invaluable friendship and therapeutic Manley Room tea sessions I thank Alice, Pete, Sophie, Mariana, Phil, Hung-Ying, Andrew, Leonie, Ramjee, Julia, Lara, Olivia, Yo-Hsin, Vanessa, and Sam. The list could go on. I am grateful to have had great support from friends and family in Copenhagen who put up with me for extended periods of time when I was burying myself in Danish archives. For decades of friendship and the provision of a safe space of love and understanding, I am grateful to Nanna for always being there for me. Finally, the patience and understanding of my closest family was indispensable. Thank you for bearing with me and giving me space when I needed it.

Last but not least, Jens Kristian. Although I should perhaps steer clear of geological puns, I cannot resist noting how Jens has kept me grounded throughout the at times testing years of doctoral research. Jens provides much needed daily reminders that the world is real and tangible and that some things are perhaps less ephemeral than what some of the literatures I engage in my work might suggest.

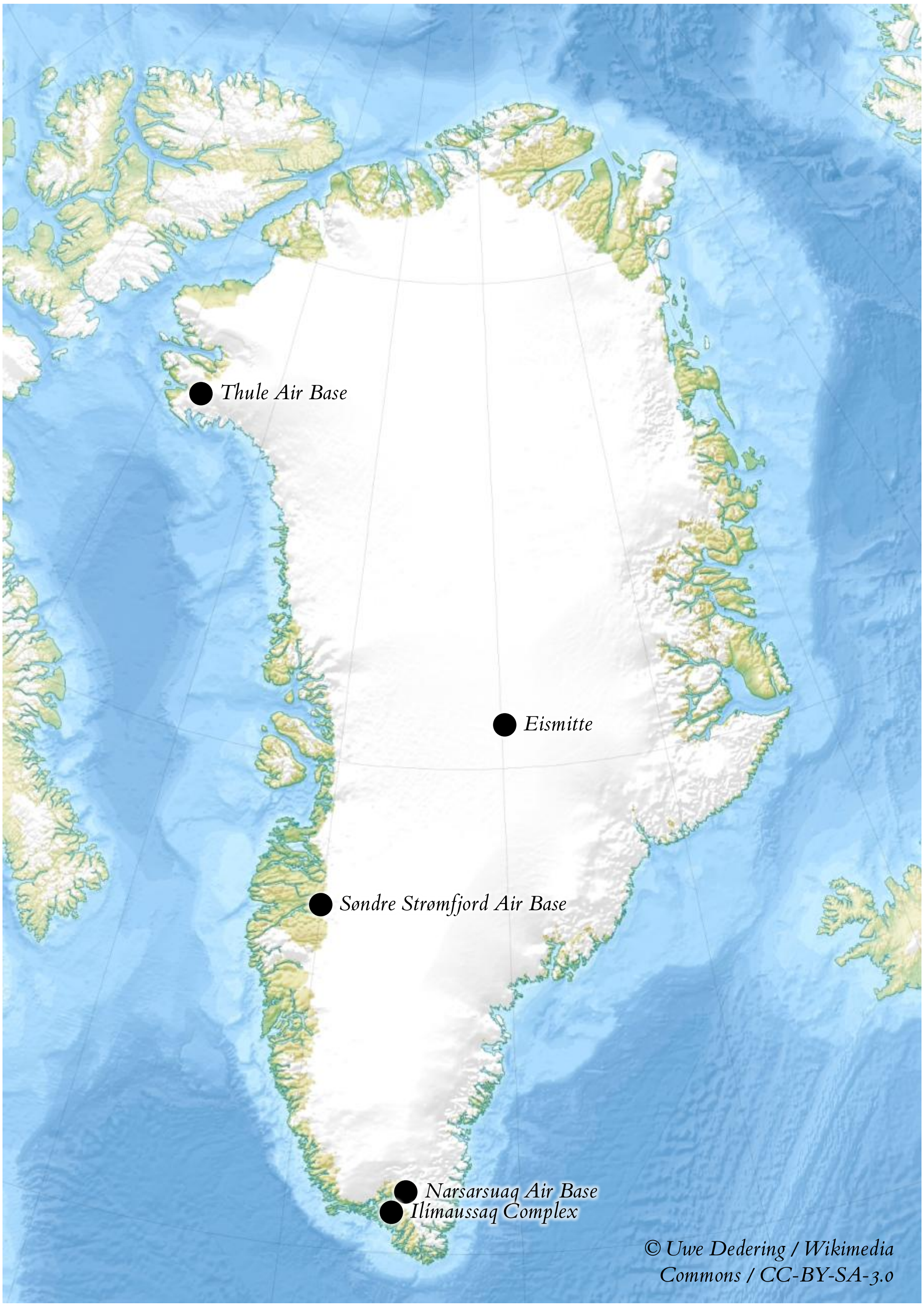

Figure 1: Map of Greenland.

“There is only earth rather than territory
until qualities are let loose in the world.”

Elizabeth Grosz (2008: 102)

1. *Introduction*

Territory as a geo-political question

Territory in glass cabinets

Behind the red brick walls of the Geological Museum in Copenhagen[1], the hidden subterranean geographies which underpin the small Kingdom of Denmark are brought to the surface for all the world, not least Danish citizens, to see. Visitors enter the museum through a hallway decorated from floor to arched ceiling in the abstract image of a colourful geological sketch, immediately subsuming the visitor in a subterranean realm upon which a discernible order has been imprinted. Moving from 'inside' the geological to an equally privileged spectator position, the next room offers a bird's eye view of national geologies where visitors are invited to look both down at and through the Earth. Glass cabinets display carefully scaled models of geological formations alongside vertical sections cutting through rock and sediment to emphasise the rich diversity of the ground that supports the Danish nation, both as material foundation and as economic resource. The exhibits trace 'Danish soil' across geologic epochs, visualising the histories of its formation before it 'settled' into its familiar shape. At no stage is the nationality of rock and sediment shifting through the course of ice ages and as a result of continental drift called into question. Rather, the displays

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[1] The following account is based on the author's most recent visit to the Geological Museum in Copenhagen in July 2016. The museum is currently being remodelled as part of an expansion of the Danish Natural History Museums.

tell the story of an ontologically stable foundation of the Danish state, not timeless, but rooted in deep time.

Amongst the dominant narratives of the Geological Museum is the story of a productive Earth, articulating a desire to bind and capitalise on its forceful systems of energy and matter. Geological formations are arranged in terms of categories which emphasise their potential as national resource. They are, in other words, arranged to communicate a set of valued 'qualities' upon which the nation might capitalise. A critical part of this narrative is dedicated to the scientists and explorers who unearthed (and unearths) the secrets of the Danish mineral kingdom as well as the practices, instruments, and technologies that made their feats possible. From these exhibits, it becomes clear that the qualities of the Earth did not simply emerge, but were rather, as Grosz (2008: 102) would say, actively "let loose in the world". As such, the Geological Museum affirms the scientific underpinnings of the subterranean order it puts on display.

The Geological Museum displays segments of the Earth as part of the known realm of Danish state space and communicates at once the apparent stability of state space and the rhythmic forcefulness of a lively planet. The museum collections also bring together under one roof the constituent parts of a subterranean Danish Kingdom, coherent despite marked differences and geographical dispersion, from the gently undulating sand dunes of mainland Denmark to the dramatic formations of ice and rock that make up the faraway Arctic constituents of the commonwealth, Greenland and the Faroe Islands. As a site deliberately designed to bring citizens 'in touch' with the deep subterranean structures of state space (Braun 2000), the Geological Museum monumentalises the strong political link between state and Earth. What is on display in the cabinets of the Geological Museum in Copenhagen is not simply an arbitrary collection of rocks and minerals, but rather signifiers of the material structures of Danish state space. Providing both epistemological and geographical affirmation of the extent and depth of Danish power/knowledge, the cabinets and their content articulate a geological configuration of Danish *territory*.

Territory with its qualities

As a set of practices which allows the state to draw on and over the qualities and forcefulness of an infinitely complex Earth and attune to its material vibrancy, the sciences of the Earth serve as key technologies of the territorial ordering of space. Territory is more than a passive, bounded space within which political events unfold. Territory is a complex, malleable, and open-ended ordering of space, carved from the chaos of an infinitely complex material world which both comprises and exceeds human beings. Like any spatial assemblage, territory is both form and formation, being and becoming. Considering territory to be a geo-political question, this thesis argues that the production of territory is, in part, a scientifically anchored process. To understand the role of science in constructing territory, this thesis brings together Science and Technology Studies and current geographical theories on territory. Merging these two literatures and exploring empirical examples of the territorialising mechanisms of science in the field, this thesis raises questions about the territorial politics of scientific 'groundings' of the state. By paying attention to the practices through which the qualities of Earth are framed and brought into the realm of politics, it is possible to expand current theories of the mechanisms of territory's production by having such theories take into account how human beings relate to and exist in a complex geophysical world.

The Geological Museum offers an explicit articulation of the relationship between the material Earth and a conception of space as state territory whilst simultaneously paying homage to the processual and manufactured nature of such territorial assemblages. As such, while the Geological Museum and its politics are not the direct focus of this thesis, the museum is an important site where the underlying elements that this thesis explores come to light. At the Geological Museum, depth, volume, and matter is added to the imaginary of what Thongchai Winichakul (1994) calls the 'geobody of the nation'[2]. Similarly, the museum rehearses the temporal and processual characteristics of territory – the complicated intersectionality between stability and flow which, as this thesis will show, is at the heart of territory's formation. The national geobody is the spatial identity of the state which emerges as an effect of geographical technologies such as the map and, as a scientific construct, "appears concrete to the eyes as if its existence does not depend on any act of imagining" (ibid: 17). The national geobody is vested with cultural and emotional significance, but, as

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[2] Throughout this thesis, the term geobody will be used in this slightly expanded sense to include the voluminous qualities of space.

an instrumental part of the state apparatus[3], it simultaneously has to be configured scientifically to provide it with a physical rather than a metaphysical form.

The 'geo' of geopolitics

Throughout the disciplinary history of academic geography, the object of study for geopolitics – and the referent of the prefix 'geo' – has gone through multiple processes of (re)framing (see Livingstone 1992; Ó Tuathail 1996). Classical geopolitical scholars such as Friederich Ratzel, Halford Mackinder, Rudolf Kjellén, and Gudmund Hatt, writing at the beginning of the twentieth century, saw their subject matter as the relationship between state politics and physical geographies. Each of these scholars promoted their own highly problematic theories which effectively reduced human political histories and mechanisms to matters of environmental causation (Larsen 2015; Bassin 1987). Land, soil, and Earth were of both symbolic and practical political importance. For Ratzel, for example, the occupation of land was a measure of political strength, and the body politic was firmly rooted in the body of the Earth (Ó Tuathail 1996). Although the physicality of the Earth was seen as a determining factor of politics, the Earth itself remained radically at rest while the people represented life and movement. The state, for Ratzel, was vibrant and organic, the Earth less so (Bassin 1987). Although Bassin (1987) rightfully cautions against conflating *Geopolitik* and the National Socialist ideologies of Nazi Germany, the dangers of simplistic and deterministic thinking disguised as objective science remain manifold (Megoran 2010). Classical geopolitical writings provided grounds for 'scientific racism' and forms of social Darwinism which may legitimise violence (Ó Tuathail 1996; Elden 2006b). Hence, it is not surprising that the subsequent movements in academic geography seeking to reclaim the term 'geopolitics' were reluctant to engage the physical geo.

Early critical geopolitics as spearheaded by scholars such as Gearóid Ó Tuathail (1996) and Simon Dalby (1991) used a deconstruction of classical geopolitical discourse as their point of departure. This was used to underline the power of geography, not as a physical space, but as a scripted and imagined spatiality. Geopolitics was reinvented as the study of

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[3] Why and how the national geobody is of instrumental value to the state will be explained in subsequent chapters of this thesis, see in particular Chapter 3.

discursive practices of 'earth writing' (or 'geo-graphing') – how places were imagined and framed by political elites and practitioners of statecraft (Ó Tuathail 1996). In their seminal paper entitled *Geopolitics and Discourse*, Ó Tuathail and Agnew (1992) reconceptualised geopolitics as follows:

> Geopolitics, we wish to suggest, should be critically re-conceptualized as a discursive practice by which intellectuals of statecraft 'spatialize' international politics in such ways as to represent it as a 'world' characterized by particular types of places, peoples and dramas. In our understanding, the study of geopolitics is the study of the spatializations of international politics by core powers and hegemonic states. (Ó Tuathail and Agnew 1992: 192)

Put rather crudely, the political geo of critical geopolitics is merged with the concept of space rooted in discursive practices of meaning-making. While the immense political power that lies in discursive framings of space and the mobilisation of geographical imaginaries should not be underestimated (see Gregory 1994; Said 1991), a narrow preoccupation with discourse is not without its faults (Anderson and Harrison 2010). Any real significance of the physical geo is all too easily pushed aside or stubbornly ignored. The Earth is thus reduced to an open repository for discourse; it becomes a stage or a passive foundation upon which geography simply 'takes place' (Clark 2013). Recent geographical scholarship has sought to 'revitalise' the Earth in geographical thought, thus taking on the challenge of negotiating the physicality and materiality of spatial relations without reverting to environmental determinism – and without taking it to the other 'extreme', which is a purely social constructionism. The physical geo, understood in terms of a vibrant and materially complex Earth, must be rendered at least somewhat autonomous without naturalising its agential potential (Clark 2011; Whatmore 2006; Yusoff et al. 2012).

Encouraging geographers to take the physicality of the Earth seriously, Simon Dalby (2013: 39) suggests that a more productive approach to thinking about the subject matter of early geopolitical theories may emerge from approaching earthly agencies in terms of *possibilism* rather than *determinism*. There are, Dalby points out, environmental restraints on a cast of human activities, and simply ignoring this will only limit our understandings of the complex interplay between people and Earth. Similarly, geographers inspired by 'new materialism' or 'material semiotics' have argued that multiplying signs of existence by bringing non-human agents, forces, and entities into the conversation may break down longstanding philosophical dichotomies between nature and culture. This, it is argued, will offer a richer understanding of the world we inhabit (Hinchliffe 2007; Greenhough 2010; Murdoch 1997; Whatmore 1999, 2002).

Following such calls for a more 'earthly' geopolitics (Elden 2013e, 2013f; Clark 2011; Yusoff et al. 2012; Dalby 2013; Steinberg and Peters 2015), this thesis seeks to contribute to an ongoing movement within Political Geography to add depth, volume, and matter to the concept of territory by exploring the intersectionality between scientific practice and the political geo. Following Clark (2011), the political geo will be understood in terms of a material Earth which is both actively politicised and simultaneously caries its own intrinsic forcefulness, its own material agency and politics. Within this framework, territory is not reducible to a passive geography defined by national borders (see Delaney 2005; Sack 1986). Like any spatial assemblage, territory does not simply 'happen', but requires constant work to retain its apparent stability (Brenner and Elden 2009; Painter 2006a, 2010; Strandsbjerg 2010). Following this logic, territory will be approached in this thesis as a geo-political question in quite a literal sense; specifically, one which is related to, and in part constituted by, practices directed at nature's intelligibility.

Territories of scientific knowledge

Following Foucauldian notions of the relations between knowledge, power, and space, territory may be conceptualised as a political strategy aimed at organising space and making it legible for the purpose of intervention and governance (Elden 2007; Hannah 2009; Neocleous 2003). Calculation makes it possible to imagine a coherent and contiguous world, neatly ordered with everything occupying its own discrete space. Governance becomes possible through the partitioning, ordering, and designation of particular purposes to segments of space (Foucault 2002; Hannah 2000). All acts of measure, control, and calculation inevitably both require and produce a knowledge base, which suggests that scientific practices are imbricated in the production of territory. Science is a multifarious concept, but it may be regarded as an institutionalised practice (or set of practices) producing a particular kind of formalised knowledge that is commonly idealised as 'objective' and 'pure'. Modern science ('Western' science in particular) purportedly offers a disembodied 'view from nowhere' which supposedly sets scientific knowledge apart from, for example, religious, cultural, or otherwise situated knowledges (Brown 1993; Haraway 1988; Shapin 1998). This privileged position lends a considerable power potential to scientific knowledge and such power may be mobilised for political purposes. However, scientific practice never happens in a depoliticised context and it is itself both a space-making practice and an application of power (Doel 2003; Livingstone 2006).

The ordering of nature through modern forms of knowledge has a profound effect on how nature is integrated into political rationalities and becomes part of the known realm of territory (Scott 1998). Bruce Braun (2000) has persuasively argued that the emergence of modern geology as a scientific discipline was crucial in making it possible to extend the territorial reach of the state downwards along a vertical axis. Opening up the subterrain as a distinct knowledge space made it possible to reorganise state territory with a distinctly vertical outlook and draw explicit lines of connectivity between Earth and state (ibid; see also Latour 1987).

Knowledge and control require a narrowing of vision which brings into focus select elements of an infinitely complex world (Scott 1998: 11). Needless to say, this process of selection produces a selective reality – a distinct territorial ordering which corresponds (to a greater or lesser degree) to political goals and desires. However, the geological world is not simply made up of a series of loosely assembled objects passively waiting to be mapped and accounted for (Clark 2011). Although the practices of modern geology and other such sciences of the Earth have long been heavily institutionalised (Rudwick 1976, 2014), there is nothing inevitable about the ways in which landscapes like those captured in the Danish Geological Museum are encountered and accounted for. How landscapes are ordered by their division into more or less discrete nominal objects is tied up in a long line of contingencies which govern science in the field. Such contingencies are many and varied, and they include funding, available technologies and expertise, unpredictable 'acts of nature', and not least the objectives guiding the research. Additionally, such orderings may also depend on a long line of overarching questions pertaining to ontologies of what nature is and what functions nature fulfils as well as the dominant paradigm in science (Kuklick and Kohler 1996; Naylor and Ryan 2010).

The Geological Museum provides evidence of how different orderings of the geological may coexist. Models of the same geological bodies occupying adjacent glass cabinets emphasise different sets of underlying qualities of the Earth. While separated, these orderings are not necessarily discrete, but may form part of the same territorial assemblage. Drawn together in the space of the museum, these overlapping geologies may be read as evidence of how multiple knowledges become coextensive of the territorial reach of the state. Arguably, however, the coming-together of qualifiedly different geologies into a coherent territorial ordering cannot necessarily be taken for granted. The multiplicity of the geological models is illustrative of the *potential* for more than one ordering of the same geo to be brought into being. This potential may, in theory, lead to the construction of different kinds of action space, condition different spatial politics, and perhaps even different modalities of territorial power.

Braun (2000: 18) suggests that difference across geological orderings must be understood in terms of mundane historical practices which gave rise to particular modalities of 'seeing' and 'knowing' nature. He encourages attentiveness to spatial practice: "those contingent processes of making 'assemblages' and 'linkages' that draw together people, instruments, theories and practices at a variety of sites, so as to make knowledge possible" (ibid: 18; see also Kuklick and Kohler 1996). While Braun's (2000) focus is what made possible the emergence of a vertical territorial order which extended governmental logics to the underground, his account simultaneously opens up a new set of questions concerning the geologic configuration of territory and its production. Arguably, the geological ordering of territory did not end once the science of geology was consolidated. The project of mapping national geologies and rendering them productive in the service of state and nation (or at least complacent to state projects) is never finished. The scientific enactment of the Earth to construct and extend territory is not just a practice, but an ongoing process of framing – a process of pushing and pulling the political geo into one shape or another.

Territory-as-land/territory-as-terrain

As argued above, there is nothing necessarily pre-given about the territorial assemblage that might emerge from an attempt at incorporating qualities of the political geo into the realm of the state. What kind of territorial order is brought into being – which earthly qualities are 'let loose in the world' – thus appears to be an empirical question governed by factors such as political agendas motivating research efforts alongside the material properties of the Earth from which territorial orderings are carved. Stuart Elden's (2010a, 2013a) work on territory as a political technology provides a useful framework for studying the role of scientific practices in the production of territory whilst also interrogating the potential for the emergence of different modalities of territorial order.

Elden (2010a) conceptualises territory in terms of a political technology which relies on a calculative ontology of space. He suggests that territory comprises two central components, land and terrain[4]. Territory as a political technology comprises techniques for measuring land in order to ascribe value to it and rationalise its productive potential. It also comprises techniques for controlling terrain to enable effective defence of state space. As such, territory is a relation of security as well as prosperity which brings together the economic and the strategic through the technical (Elden 2010a, 2013a; see also Gottmann 1973). Thinking territory in terms of these constituent parts affirms the central position of the political geo and the practices of its enactment. Knowledge of the substrata is central to the production of any resource landscape (Bridge 2013) just like geological and geographical intelligence is instrumental to military operations (Doyle and Bennett 2002).

Elden (2010b, 2013a, 2013c) sets up a framework for doing a spatial history of territory which necessitates that close attention be paid to the ways in which power and knowledge get mobilised onto and through land in its various forms. As will be argued in the chapters to follow, the practices through which territory is rendered intelligible and legible (and by extension governable) are pivotal to its production. This, in turn, makes science (as a space-making practice and an application of power) an essential component of territory.

A simplistic reading of Elden (2010a) might suggest that land and terrain are discrete components of territory[5]. Indeed, one might intuitively expect that territory gets worked out in distinctive ways depending on which of these two constituent parts serves as the leading objective of a territorial project. Casting Earth as land might not achieve the kind of order that is required to cast it as terrain, and the framing of space in accordance with economic or strategic objectives may invite and enable different kinds of interaction with space, thus forging different spatial relations of power. To unpack the underlying mechanisms of the production of territory through science, this thesis examines the relationship between land and terrain empirically by adopting a dual case study. The thesis thus examines two instances of territory construction in Cold War Greenland, where two

[4] A more detailed discussion of territory as a political technology is provided in Chapter 2.

[5] Notably, Elden (2010a) explicitly states that land and terrain are not separable.

differently motivated intruding powers, Denmark and the USA, both used Earth Science as a means of territorialising Greenlandic geographies. Notably, the division between land and terrain in this thesis is purely instrumental. As the empirical analysis presented in Chapters 5, 6, and 7 demonstrates, land and terrain are not opposites, nor are they neatly separable in either theory or practice.

Empirical context: Greenland in the early Cold War period

The Geological Museum in Copenhagen takes particular pride in its collection of Arctic rocks and minerals, most notably its specimens from Greenland, which include the famous four-legged fish fossil found in Northeast Greenland. Since Denmark's colonisation of Greenland and its indigenous population in 1721, the island has been the scene of a long and proud Danish tradition of exploration of a more or less scientific character (Gad 1984; Lynge 1993). Early state sponsored attempts at a systematic mapping of the island and its mineral riches were, however, few and unsuccessful, partly because of the state of technology, low levels of funding, and the notorious climatic challenges of polar travel (Ries 2003). In the first half of the twentieth century, technological innovation led to a surge in expeditions which were considered to be more 'scientific' in nature as opposed to the cumbersome voyages of the past where surviving the extreme environment had been the main objective[6] (Cronin 2015; see also Naylor and Ryan 2010; Driver 2010). However, as will be outlined below, the most significant period in time for the construction of Greenland as a thoroughly geological space was the first decades of the Cold War. More so than ever before, during the Cold War the field and operation of power in Greenland became heavily impacted by the production of knowledge of the material Earth as another invading state, the USA, used science to expand its territorial reach across Greenland (Petersen 2013; Korsmo 2010).

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[6] Notably, the idea that the twentieth century marked an 'end of exploration' has been subject of much critique (Cronin 2015; Naylor and Ryan 2010; Driver 2001, 2010).

The political status of Greenland

As noted, Greenland and its indigenous population had been under Danish colonial rule since 1721, and international contestation made against Denmark's territorial claims had been limited[7]. However, on 9 April 1940 when Denmark was invaded by Nazi Germany, the political status of Greenland became significantly more complicated. When the lines of communication between the incapacitated Danish Government and its administration in Greenland broke down, the two Danish Governors of Greenland, Axel Svane and Eske Brun, issued a proclamation declaring Greenland independent from German-occupied Denmark (Lidegaard 1997; Berry 2012). From a North American vantage point, the situation in Greenland was disconcerting for several key reasons. Firstly, Greenland was then supplying cryolite for Canadian aluminium productions, which were vital to the manufacture of military aircrafts (Berry 2012). Secondly, the 'power vacuum' left behind by Denmark led to fears of German encroachment on the North American continent as Germany had already begun the process of establishing weather stations in Greenland (Archer 1988; Selinger 2001).

In a failed attempt at retaining some political autonomy, the Danish King had remained in Copenhagen rather than setting up a government in exile. The King's apparent capitulation caused a number of Danish overseas officials to denounce their Government, including the Danish Ambassador to the USA, Henrik Kauffmann (Lidegaard 1997). On the first anniversary of the German invasion of Denmark, Kauffmann, acting on his own initiative, signed a bilateral agreement with the USA granting the Americans "exclusive jurisdiction" (Greenland Defense Agreement 1941: Article VI) over "any area deemed by the Government of the United States of America to be needed" to defend Greenland (ibid: Article V). Although the Danish Government in Copenhagen declared the Agreement invalid and charged Kauffmann with high treason, the American Department of State took the position that the Danish Government was acting under duress (Briggs 1941; Lidegaard

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[7] One notable exception was the Norwegian claims to East Greenland put forth in the early twentieth century. The dispute was settled in favour of Denmark at the Permanent Count of International Justice in The Hague in 1933, and the extent of Danish scientific knowledge of the land in question played a key role in the proceedings and their outcome (Ries 2003).

1997). The US Government made it known that Greenland was considered to be covered by the Monroe Doctrine, which prohibits outside powers from entering the 'new world'. While the Doctrine had not been applied to Greenland prior to World War II, it was nonetheless invoked to legitimise a connection between Greenlandic defence and American security interest (Berry 2012).

When World War II ended, the Danish Government saw itself pressured to ratify the 1941 Greenland Agreement. Nonetheless, Danish officials still expected the US to evacuate its wartime occupations in Greenland (Petersen 2013). However, Danish hopes that the US would lessen its grip on Greenland suffered a severe blow when the US offered to purchase the island in 1947. While the offer was promptly refused, the US had made it clear that the Americans were determined to retain their northern stronghold[8] (Doel et al. 2014). In 1951, Denmark and the US signed a renewed agreement regarding the defence of Greenland. This agreement granted the US almost autonomous rights to conduct both scientific and military activities within three 'defence areas', the most extensive being the Thule Air Base in the north and the others being Søndre Strømfjord Air Base and Narsarsuaq Air Base on Greenland's mid- and southwestern coast (see Fig. 1, p. xix) (Petersen 1998).

According to the new Greenland Defense Agreement (1951), all activities outside the designated defence areas required approval by the Danish state[9]. Denmark found itself having to perform a careful balancing act to account for both US security interests and Danish national concerns over the sovereignty of Greenland. While Denmark formally retained control over US activities outside the defence areas, the Danish government

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[8] A formerly classified US Government memo of 7 August 1959 discusses the feasibility of purchasing Greenland from Denmark, suggesting that at least some members of the US Government continued to see this as a desirable strategy (Kerrigan 1959).

[9] The asymmetrical power relation between Denmark and the US left Denmark in an inferior bargaining position, and Denmark thus had little choice but to comply with the majority of the American demands. Nonetheless, the Agreement was seen as advantageous to Denmark since the outsourcing of Greenland's defence was an efficient means of safeguarding Danish formal sovereignty (Dansk Udenrigspolitisk Institut 1997a; Doel et al. 2016; Borring Olesen 2011; Heymann et al. 2010; Petersen 1998).

simultaneously found itself forced to turn a blind eye on activities which may on closer inspection have proved contentious (Petersen 2011, 2013). Permissions were often given on broad and unspecific applications, making it difficult to determine whether activities were covered by the permissions. US activities gradually spread across the entire island and their scope was often difficult to determine as they walked the line between projects with obvious military purposes and what seemed like purely scientific projects (Dansk Udenrigspolitisk Institut 1997a; Heymann et al. 2010; Borring Olesen 2011; Petersen 2013).

Cold War Earth Science

The early Cold War period saw some of the most explicit (and well-researched) articulations of the relationship between science, politics, and the Earth. In an effort to project and consolidate its hegemonic status on the global political arena, the US greatly increased its funding for research that was considered of military value. This expansion of military patronage of scientific programmes had significant impact on the institutions, disciplines, and practices across a broad range of sciences and tightened the bonds between science and foreign policy (Doel 1997; Barnes and Farish 2006; Krige 2006). Earth scientists and their work may have occupied a less prestigious position in what is now often referred to as the military-industrial-academic complex than did the physicists who revolutionised weapons technologies. Yet the Earth Sciences, and the field sciences more broadly, were no less caught up in the military-industrial-academic complex (Doel 1997; Siever 1997). The physical properties of landscape strongly influence military intervention, and as tensions grew between the US and the Soviet Union, the need for geophysical knowledge seemed more acute than ever (Landsberg 1954). Ronald Doel (2003) notes that the first decade of the Cold War marked a significant revival of the Earth Sciences akin to the wave of geological exploration that characterised the late Victorian era (see Braun 2000; Rudwick 2014). Knowledge of the Earth was assimilated into national security and foreign policy planning whilst great symbolic value was ascribed to being able to subdue hostile and extreme environments by rendering them legible and controllable (Doel 2003).

The effects of military patronage on the organisation and content of knowledge produced during the Cold War is well documented, also with specific reference to the sciences of the Earth (Dennis 2003; Siever 1997; Ries 2011). Doel (2003: 636), for example, outlines how military patronage created a new "intellectual map" for the Earth Sciences by staking out a research agenda which met military needs. To meet military needs, new classificatory systems were developed (Harper 2008), new instruments were brought into the field (Oreskes 2003; Barth 2003; Bishop 2011), and academic disciplines were reconfigured (Barnes and Farish 2006).

As tensions between the two Cold War antagonists were on the rise, the frozen expanses of the Arctic, which barely seemed to separate the USA and the Soviet Union, emerged as a critical frontier of exploration. As the Arctic region was reconfigured from a frozen wilderness to a prominent theatre of war, it became apparent that this little-known environment had to be brought within the political reach of the American state for the sake of national security (Grant 2010). Science was an important register through which the Cold War played out in the Arctic, and the strategic value ascribed to Arctic terrain intelligence fostered unprecedented state investment in the physical exploration of its environment in order to open it up to political intervention as a potential site of war (Korsmo 2010). As the only major landmass between the key political and industrial centres of the two superpowers, the then Danish colony of Greenland emerged as a key geostrategic site, making Greenlandic environments a prominent object of scientific exploration (Doel et al. 2016; Heymann et al. 2010).

US research programmes in Greenland

Filling in the blank spaces on maps has historically been linked to entitlement and possession as well as the production of territory (Strandsbjerg 2010; Edney 1997). The blank spaces of the map both precede and legitimise the desire to fill them in (Bloom 1993). Similarly, the quality of Danish maps of northern Greenland was used to legitimise a significant US presence beyond the defence areas defined by the 1951 Greenland Defense Agreement. When the US first took possession of Greenland, the primary source of terrain intelligence was small-scale Danish dogsled expeditions guided by abstract academic objectives and the search of fame and glory rather than practical military pursuits (Ries 2012b). Arctic field science had undergone significant changes in the decades leading up to World War II. The figure of the polar hero, which had dominated early imaginaries of polar exploration, was gradually replaced with that of the modern scientist (Doel et al. 2014; Zeller and Ries 2014). New logistical technologies such as the airplane, ground faring vehicles capable of negotiating icy terrain, and not least navigational technologies vastly reduced dependency on Inuit technologies such as the dogsled and animal skin clothing (Cronin 2015). Less energy was spent on merely surviving, leaving greater capacity to be dedicated to more systematic and in-depth research. Beforehand, there was little to no coordination of scientific efforts in the Arctic and "most Arctic research was conducted on an individual, case-by-case basis, with fragile and impermanent funding" (Doel et al. 2014: 60-61). As a consequence of the lack of systematic research, the state of both cartographic and geologic knowledge of northern Greenland did not meet the expectations and needs of the US military (Ries 2012a). Hence, the task of US military scientists was to effectively bring what they saw as an essentially unmarked wilderness into geographical existence.

Before the introduction of middle-range ballistic missiles in the early 1960s, the US military deterrent against Soviet aggression depended on Greenland as a steppingstone between continents, bringing key strategic points within the Soviet Union within the reach of US nuclear weapons (Archer 1988). The effectiveness of this deterrent depended entirely on establishing the necessary geophysical knowledge to secure a stable foundation for hard infrastructures, such as military bases and landing strips, as well as to ensure efficient passage for men and equipment across the rugged Greenlandic terrain (Benson 2001). As noted in a report published by the Arctic Institute of North America:

> Science will permit our use of Greenland as an Arctic sword and shield – a mighty bastion of deterrent power essential to the NATO concept [...] An absolute prerequisite to our effective use of the high Arctic is harnessing of its environment. The Arctic's true military potential can only be transformed to the dynamic by means of studies specifically oriented to the problem. [...] However, more knowledge is required to permit military man to work with the cold rather than against it, and to do so in a practical and economic manner. The Arctic is friendly only to those who comply with its implacable laws. (Arctic Institute of North America 1958, quoted in Ries 2011: 861)

This quote is illustrative of US ambitions to capitalise on Greenlandic physical geographies for strategic purposes by using science to bring the physical world into alignment with their political project. Terrain intelligence capturing the Greenlandic environment as a coherent and entangled whole would allow the US to work with rather than against the environment, thus drawing strength from it (Martin-Nielsen 2012). Greenland became the scene of unprecedented geophysical investigation carried out by US military institutions keen on building the necessary arsenal of knowledge to expand their increasingly global network of military outposts (Petersen 2011).

The significance of the Earth Sciences in US Cold War military research is reflected in the surge in new academic institutes funded by the US military that both expanded and transformed knowledge of the material Earth (Doel 2003). Two of the most significant institutions in relation to the US military research directed at enlisting Greenlandic geographies as terrain were the US Army Snow, Ice, and Permafrost Research Establishment (SIPRE) and the Transportation Arctic Group (TRARG) of the US Army Corps of Engineers. As a Department of Defense establishment assigned to the Department of the Army and the Chief of Engineers, SIPRE's primary mission was to conduct "research and development in the field of cryological phenomena pertaining to snow, ice and frozen ground on and beneath the earth's surface" (SIPRE 1955). Although SIPRE was set up as a US military institution and its mission statement reveals an explicit military agenda behind its scientific programmes (ibid; Flint 1953), the scientists employed by this institution did not necessarily perceive themselves as 'military scientists' but rather as scientists conducting research with potential military applications. The TRARG, by contrast, was located within the US Army Corps of Engineers and was an expeditionary outfit comprising both scientists and military personnel carrying out a long line of tasks pertaining directly to military questions of landscape trafficability and the impact on the landscape on motorised vehicles.

While patronage unquestionably shapes research, it is too simplistic to argue that military patronage fully determined the ecology of knowledge that dominated the Cold War Earth Sciences in the US as well as the work of SIPRE and TRARG scientists. Both institutions employed civilian scientists, many of whom retained university affiliations. Evidence from the archival records of some of these expeditions suggests that some of these scientists had their own aspirations for their work[10]. Nonetheless, US scientists were to a great extent forced to rationalise their research programmes in accordance with the military's operational needs to secure funding for their work (Siever 1997; Benson 2001).

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[10] See for example the Carl S. Benson Papers, Elmer E. Rasmusson Library and Archives, University of Alaska Fairbanks.

Danish geological research

As noted by Heymann and Martin-Nielsen (2013: 232), US military and scientific interests constituted a deep intrusion into the island of Greenland as well as into Danish politics – an intrusion which was not entirely consensual (Petersen 2013). The US had seen immense techno-scientific progress during World War II and with the Cold War on the rise, vast financial and technological resources were vested in developing its strategic intelligence (Doel 2003; Korsmo 2010). Having been under German occupation for the best part of five years, Denmark, on the other hand, found itself both economically and technologically weakened. As such, funding for geological research was scarce and the community of Danish geologists was small, under-funded, and internally divided (Ries 2003). Regardless of these challenges, Denmark experienced its own revival of the Earth Sciences while the US was gathering Arctic terrain intelligence, albeit a revival guided by different motivations. To the Danish government, Greenland was not merely a terrain to be overcome or a military outpost. Rather, Greenland (and its underground) was an integral part of the Danish national geobody and a part of Danish history and identity.

The US presence in Greenland fostered Danish concerns regarding territorial sovereignty over the island (Borring Olesen 2013). As noted in the Danish newspaper, Grønlandsposten:

> At a time when Greenland is no longer an unnoticed periphery with no interest to politics, but in contrast has emerged as a strategic focal point, one is missing some initiative which would emphasise the Danish state's sovereignty and demonstrate Danish abilities and willingness to bring order to the state of affairs up there so that they meet the demands of our time.[11] (Grønlandsposten 1950: 94)

Establishing a strong scientific presence in Greenland was soon framed as a central means of bolstering Danish territorial sovereignty (Nielsen 2016). Research efforts which had come to a halt during the War were resumed, plans were made for the Danish Geodetic Institute to complete topographical maps of the entire island, and for the first time an independent geological survey was set up for the sole purpose of exploring the Greenlandic substrata (Ellitsgaard-Rasmussen 1996). Established in 1946, the Greenland Geological Survey,

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[11] Author's translation from Danish.

Grønlands Geologiske Undersøgelse (GGU), was founded based on an expressed desire to configure Greenland as one coherent geology that could be understood as a legible and logical whole (see Braun 2000: 22). 1946 thus marked the beginning of the first systematic mapping of Greenland's subterrain and its mineral resources (Ellitsgaard-Rasmussen 1996).

The 1950s saw the end of centuries of formal Danish colonial rule of Greenland as well as the onset of Danish attempts at assimilating Greenland as a constituent part of the Danish commonwealth (Lynge 1993; Beukel et al. 2010). Systematic geological mapping became an integral part of this project of constructing a coherent and contiguous Danish knowledge-space. In this context, geological research was not only significant in terms of the discovery of new resources, but was also articulated as an obligation of the Danish state towards Greenland and its people (see for example Grønlandskommissionen 1950). Having the most sophisticated and deepest knowledge of state space was seen as key to asserting Danish sovereignty, and proponents of an independent Geological Survey made their recommendation with direct reference to how Denmark's neighbouring countries had done the same. The mapping of the subterrain was construed as a crucial part of modernity, and Denmark, it was argued, was lacking behind (Ellitsgaard-Rasmussen 1996).

With the military defence of Greenland largely in the hands of the US, the focus of Danish geological research was to construct a coherent map of the territory at the surface and below whilst mapping its productive potential (Ellitsgaard-Rasmussen 1996). Rendering landscapes productive as a means of asserting territorial sovereignty has a long history as a technology of colonisation (Scott 2008). Similarly, the Danish government ascribed particular significance to economic geology (Ries 2011). Measuring land and its resources would both benefit the Danish nation whose energy resources had been virtually depleted during the war with Germany whilst simultaneously serving as a powerful performance of active occupation (Nielsen and Knudsen 2013).

Research aims and empirical case histories

As suggested earlier in this introduction, what kind of territorial order emerges from any attempt at constructing territory through technologies of land or terrain is an empirical question rooted in the practices of the Earth's enactment. In order to interrogate the possible tensions between territorial orderings, this thesis offers an analysis of two instances of territory-making, one Danish and one American. In each of these instances of territory-making, a state was seeking to capitalise on the political geo, but with markedly different territorial objectives in mind. Since territory both comprises and exceeds Earth/state relations of both land and terrain, reading across these markedly different examples of territory-making will be instrumental in building a broader understanding of the mechanisms of territory as a political technology. This, in turn, may have implications for broader conceptual debates within Political Geography on the mechanisms of territory in a materially complex physical world. As such, this study seeks to make a modest contribution towards addressing the question of how theories of territory may account for how human beings exist in and draw on the complexities of a dynamic and fast-changing geophysical world.

The first case example is one of the most high-profile and controversial Danish geological expeditions of its time, namely the state-prompted search for radioactive minerals in the Southwest Greenlandic mountain ranges of Ilímaussaq (see Fig. 1, p. xix). With its richness in rare earth elements, Ilímaussaq became a central figure in the geologic mapping of Greenland, and today it still occupies a prominent position in the Geological Museum in Copenhagen. The search for radioactive minerals was cast by Danish state officials and scientists alike as a key element in securing Danish energy futures whilst simultaneously providing an opportunity to assert Danish sovereignty through means of active occupation. While no viable ore was found, the prospecting continued for decades. For the sake of limiting the scope of this study, the focus will be the period from when the prospecting began in 1955 until the first drilling programme was commenced in 1958. These years formed the backdrop against which subsequent research took place and offer telling examples of how different scientific practices and technologies were used to construct Greenland as a Danish resource landscape and as Danish national territory.

State-prompted science does not always take place on sovereign state territory. However, as the second case study will illustrate, this does not necessarily mean that such science is any less territorialising. Foregrounding the strategic dimension of territory, the second case study is a multi-year project launched by the US military in 1953. Ries (2011: 861) notes how the early Cold War was marked by "a concept of warfare based on small, mobile combat units equipped with helicopters, aircraft with short take-off and landing capability, and low ground-pressure vehicles" which could move swiftly across vast stretches of land. As a consequence, trafficability was a key strategic issue informing the geophysical investigation of Greenland. Under the auspices of TRARG and SIPRE, the expeditions in question gathered terrain intelligence for the purpose of rendering the Greenland ice sheet and its northernmost marginal zones accessible to heavy military convoys. The expeditions, collectively entitled *Operation Ice Cap*, employed scientists from disciplines such as meteorology, glaciology, geology, and seismology, each with their own objective, but simultaneously aimed at furthering the principal operation. The related research endeavour, which continued the glaciological research programme of Operation Ice Cap will also be part of this analysis. Under the name of *Project Jello*, this effort carried the glaciological research through to the very heart of the Greenland ice sheet. Additionally, this study of the production of terrain in an environment informed by ice will contribute to the geographical literature on ecologies of war from which ice appears to be curiously absent (see Bélanger and Arroyo 2016; Gregory 2016; Stephenson 2003).

For the US, science was an "endless frontier" (Bush 1945) which was of greatest significance to securing the continued progress of a growing US military apparatus and extending the political reach of the American state across the globe in manners which may be described as 'extra-sovereign'. For the Danish Government, by contrast, science was construed as a key mechanism through which Denmark could reassert and communicate its territorial sovereignty over Greenland by showing evidence of active occupation and, importantly, by enrolling the Greenlandic subterrain into circuits of extractive capitalism. Greenland thus seemed to be enrolled in multiple territorial orderings. As these two occupying powers (with differing degrees of legitimacy) sought to bring geological planes and volumes into alignment with their respective political projects, land and terrain seemed like almost separate phenomena. At the surface, the objectives of constructing Greenlandic space as land and constructing it as terrain was associated with separate sponsoring institutions, different infrastructural technologies, and different scientific practices. Similarly, while the Danish prospecting was explicitly directed at the deep, voluminous qualities of space, the US practices of terrain making were, at a glance, more concerned with features of the surface.

Notwithstanding the differences between the Danish and the US scientific programmes, the territorial mechanisms of the scientific practices deployed to enact territory as land or terrain had more in common than what might be expected. While each case study foregrounds its own aspects of the relationship between science, Earth, and territory, the dual case study also reveals a heuristic overlap between scientific articulations of territory's production through technologies of land and terrain. The empirical findings and discussions of this thesis complicate simplistic distinctions between land and terrain, the vertical and the horizontal, and also between bio- and geo-political orderings of state space. This thesis argues that none of these three 'pairings' are neatly separable by illustrating how they were folded into each other and came together in the making of Danish and US territorial orderings of Greenland.

The overarching question which informs this thesis is how, in practice, the sciences of the Earth may serve as technologies of territory. How, in other words, might states use science to forge a seemingly stable ordering of space which is extendable through time from a world defined by chaos, instability, and incessant change? The formative question is thus an empirically anchored one of how, in practice, territory is brought into being and what kind of territorial order might emerge. The aim is to explore the role that geoscientific enactments of the material Earth play in the production of space-as-territory. Through the empirical lens outlined above, the thesis elaborates on how the emergent territorial orderings worked beyond the spaces that human beings can physically inhabit, across scales from the micro- to the macroscopic, and beyond the confines of sovereign state space. A further objective of this research, then, is to build an understanding of how, and to what extent, scientific practices informed by different constituent components of territory (land and terrain, the economic and the strategic) might lead to the production of different modalities of territory. Finally, while the case examples are chosen based on what they might reveal about the underlying mechanisms of territory's production, each case study also aims to make a modest empirical contribution to the existing body of knowledge on the politics of scientific fieldwork in Cold War Greenland. As such, the final question which this thesis addresses is how territorialising mechanisms were expressed in the scientific exploration of Greenland during the Early Cold War.

2. *State, Space, Territory*

Conceptualising the space between the borders

Territory is a key concept of Political Geography as well as related disciplines such as International Relations and Political Science. As such, a sizeable literature exists which engages the concept of territory across these disciplines. Before beginning to unpack the formative relationship between scientific practice and the production of territory (see Chapter 3), this chapter reviews select scholarly engagements with territory and discusses the role that territory plays in modern political organisation. The purpose of this discussion is to establish a sense of what territory *is*, what it achieves as a concept and a political practice, and what makes the concept significant amidst claims that politics is increasingly 'post-territorial'. A review of this literature is a necessary first step towards contextualising the study in hand and positioning its conceptual contribution in relation to wider scholarly debates on territory as a key political component.

This chapter loosely falls into two parts. Beginning from a relatively uncomplicated understanding of territory, the first part briefly outlines the position of territory in the contemporary political world. Examining how a territorial imaginary of political authority both shapes and is shaped by modern political organisation, the significance and the critiques of territory are discussed. Understandings of what territory *does* underpin conceptual debates about what territory *is*. Hence, this first part of the chapter outlines the basic premises upon which conceptual scholarly engagements with territory have generally been formed. The first part thus feeds into the second part, which offers a review of how territory has been theorised and defined, most notably within the field of Political Geography. Drawing on critiques of tendencies in academic writing to take territory for granted, to conflate it with the related concept of territoriality, or to limit it to simplistic notions of 'bounded space', it is argued that territory cannot be reduced to a spatially inert backdrop of politics. Rather, attention needs to be paid to the processes of its becoming as opposed to its being. Based on the well-rehearsed argument that space (and, by extension, the spatial formation of territory) is inherently processual, the chapter draws on ideas from assemblage theory and non-representational theory to open up questions about what kind of work is required for territory to emerge as a seemingly stable political category. Based on insights from the critical cartography literature and a review of Stuart Elden's (2005, 2006a, 2007, 2009, 2010a, 2013a, 2013b) extensive work on territory as a political technology, it is argued that modern territorial formations are underpinned by calculative practices. The chapter is concluded with the suggestion that Elden's insights might be fruitfully extended by considering the role of scientific knowledge production in territory formation.

Territory as state space

A plethora of 'territories' shape social life. As such, territory as a concept has been mobilised to explain markedly diverse configurations of space and power across all thinkable scales. The concept has been applied to describe the relationship between public and private property, to 'micro-territories' such as a desk or a personal office, as well as to the intimate sphere around the human body (Sack 1986; Engelstoft and Larsen 2014; Storey 2001). In this sense, there may be some truth to Delaney's (2010: 10) suggestion that territory could be considered a "human universal" or, as Ardrey (1969) has argued, even something which transcends humanity and characterises all animals. However, as noted by Jessop et al. (2008), there is a risk in over-extending the conceptual span of territory to encompass all socio-spatial relations. Rather than bringing new insights into the mechanisms of territory, such broadening may instead dilute the concept to the point where it loses much of its substance and analytical potency. Adapting a popular trope, if everything is territory, then nothing is territory. Hence, to explore the workings and mechanisms of territory as a key component of modern political organisation, the subsequent discussion in this thesis is limited to what is arguably the most prominent format of territory, namely territory as state space.

The notion of territory in a modern sense is closely associated with the political-spatial institution of the modern state, and state and territory both emerged at the same historical juncture (Elden 2005: 8; Brenner and Elden 2009). As will be explained below, the state has long relied on territorial logics as a foundation of rule. Notably, however, the state operates in ways that are not strictly territorial (Agnew 1999, 2009), and as Sassen (2000, 2013) has argued with reference to transnational financial structures, large-scale political territorial orders may function in manners which are not necessarily linked to the state (see also Elden 2005). States nonetheless remain central actors in the making of territories, and territory is inextricably linked to the spatiality of the state (Paasi 1997; Strandsbjerg 2010). As argued by Brenner and Elden (2009: 363), the concept of territory "is comprehensible only through its relation to the state and processes of statecraft" and territory, state, and space are connected to the extent that "each term reciprocally implies the other, both analytically and historically" (ibid: 364).

The idea of the territorial nation-state has become so prominent in our modern political imagination that it is difficult to picture something radically different in its place (Biggs 1999; Shah 2012). As stated by Revel (1991: 134), "[w]e think in terms of [state] territory; we have learned to weigh our information and distribute it on a map". Deeply embedded in our political psyche is a territorial map which depicts the political world as an intricate jigsaw of distinct polities, neatly ordered with every state occupying its own discrete space. Thus, it is unsurprising that most definitions of the state invoke territory. For Gottmann (1973), for example, territory is the state's "spatial definition", Biggs (1999: 375) describes it as "the natural ground of the state" as the state "is a spatial form", and Shah (2012: 65) holds that territory is "part of the state's existential identity". If the state is broadly construed as a centralised bureaucracy that upholds sovereignty within a clearly demarcated territory and is recognised by similar institutions[12], then a broad definition of its territory may be, in the words of Gottmann (1973):

> the unit in the political organisation of space that defines, at least for a time, the relationships between the community and its habitat on the one hand, and between the community and its neighbours on the other (Gottmann 1973: ix)

In this passage, Gottmann (1973), whose work remains central to current writings on territory, points to a central aspect of territory: despite their apparent timelessness, territories

[12] What constitutes 'the state' is a complex question in its own right. For a discussion of the state, see Jessop (2016).

are inherently ephemeral. As will be argued later in this chapter, this temporal quality of territory foregrounds the question of territory's production rather than simply its being – how territory is practiced and maintained over time and how it retains its air of timelessness. For now, however, it suffices to say that territory is a central component of the state as a political-spatial mode of organisation.

Sovereignty, jurisdiction, and the sanctity of borders

Alongside its associated concepts of sovereignty and jurisdiction, territory is now firmly cemented within international legal regimes as well as most people's consciousness as a cornerstone of what is widely considered 'normal' political organisation. A state's territory is perceived as a marker of the spatial extent (and the limits) of its sovereignty (Gottmann 1973: 49), and in international law, territory designates a portion of geographical space under the sovereign jurisdiction of a people commonly represented by a state (Brighenti 2006; El Ouali 2006). A state's territory signifies a distinction and a separation from adjacent territories, and even if a state or a polity does not itself define its territory, the states surrounding it are likely to do it for them (Thongchai 1994). As such, Strandsbjerg (2010: 25) argues that the significance of territory "lies in the spatialization of state sovereignty that served as a basis for the conceptualization of international politics as something taking place between spatially differentiated but similar (in that they are sovereign) entities" (see also Soja 1971). In other words, territory has become a requirement of legitimate political sovereignty (Shah 2012; McConnell 2010). The practices and institutions of international law firmly tie political sovereignty and territory together. Territory provides the spatial underpinnings upon which law is enforced, and sovereign territory is in itself an expression of the law (Brighenti 2010). The difference in legal status of spaces and the people within them means that when one crosses a border, one is automatically subjected to a different set of legal codes and the nature and intensity of power has changed (at least on paper if not in practice). Hence, the term jurisdiction, which brings together territory and sovereignty, "can refer *both* to the exercise of legal authority *and* to the territory over which such power extends" (Painter 2010: 1094, original emphasis).

The legitimacy of the international system of territorial states is self-referential as states afford each other legitimacy by mutually recognising each other's jurisdiction. What distinguishes the state from other political organisations or movements, influential as they may be, is this internationally recognised political legitimacy as the principal of territorial integrity (Shah 2012). Territorial integrity is a national-legal notion, which is central to how the relationship between state and the territory under its jurisdiction is generally understood. The basic premise of territorial integrity is that the state should remain sovereign in the sense that other states and institutions should not be allowed to interfere with domestic affairs. Territorial integrity thus combines an ideal of territorial stability with territorial sovereignty (Elden 2006a). El Ouali (2006) refers to territorial integrity as an "institutionalisation of territoriality" and sums up its principles as follows:

> In essence the principle of territorial integrity is the elaborated and sophisticated legal expression of territoriality. It is intimately linked to the state as a legal entity the main objective of which is to ensure its perennial existence within a specific territory whose borders have been established in accordance with international law. (El Ouali 2006: 630)

Elden (2009) discusses the ideal of territorial integrity in relation to the United Nations (UN) and its founding Charter, which has self-determination as its underlying principle, but refers to *territories* rather than *peoples*. Underpinning the UN Charter is a desire to prevent secessionist movements from changing the political map as this is seen as compromising regional and global stability. On the one hand, the UN does not want the political order to fragment because the fixity of the spatial-political order is seen as instrumental to international security. On the other hand, the UN wants to preserve the right to intervene in sovereign domestic relations if they are considered violent beyond the kind of state violence that is deemed acceptable, or if a state is perceived as 'weak' and unable to maintain control of its territory. Along these same lines, Buchanan (2006) notes how territorial integrity also relates to the responsibilities of the state to fulfil a series of basic functions to serve the interests of its citizens, and how states are seen as illegitimate if they violate a significant proportion of its population as exemplified by South African Apartheid. Furthermore, a strong state thoroughly in control may also be construed as a threat if it is seen as too powerful and perhaps unpredictable or simply alien (Elden 2009). Such exceptions put great pressure on the notion of territorial integrity, and it is a principle that has been violated in quite spectacular ways in recent years as exemplified by the ongoing warfare in the Middle East (Gregory 2004). The relationship between state and territory comes into prominent view when territorial integrity is broken. Such violation is considered an attack not just on territory, but on the state itself (Gottmann 1973).

As implied by the examples listed above, complications pertaining to the ideal of territorial integrity bring out tensions relating to the notion of territory and the way territory is performed internationally. Such tensions emphasise the significance of territory as something that *matters*. As the physical manifestation of the state, territory is more than a normative principle of political organisation and a legitimating factor of political rule (Shah 2012). Paasi (2003: 109) notes how "several important dimensions of social life and social power come together in territory: material elements such as land, functional elements like the control of space, and symbolic dimensions like social identity". Hence, state territories are not just administrative units. Constructing clear boundaries between citizens and non-citizens – those who are Same and those who are Other – has proved to be a powerful source of imagined national identities and feelings of community and belonging (Anderson 1991). While there is more to nationalism than the relationship between people and space (Closs Stephens 2013; Anderson 1991), territorial imaginaries may have the effect of making spatial identities which transcend the local scale appear self-evident[13]. As source and affirmation of political identities, territories are meaningful social spaces vested with an ideological power which can be harnessed and mobilised for political purposes (Forsberg 2003; Paasi 1996; Penrose 2002).

Bounded spaces in a borderless world

The strength of the emotional bonds between people and the body politic (understood in terms of state territory) are powerfully illustrated by how some citizens are willing to sacrifice their lives to preserve the corporeal integrity of the nation[14] (Penrose 2002). Nonetheless, the importance of territory beyond its emotive and symbolic value has been questioned in the face of the increasing internationalisation of markets, cultures, and politics

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[13] Notably, there are limits to this argument. As illustrated by the ongoing political conflict between the nations of Spain, multi-ethnic or multination states often struggle to form an identity that corresponds with state territory.

[14] Notably, the work of Rachel Woodward (2008) unsettles and complicates this idealised notion of the relationship between citizenship and sacrifice. Her research suggests that soldiers primarily feel loyalty towards their comrades in arms rather than abstractions like the state or the nation.

(Ohmae 1990; Taylor 1994). The somewhat idealised and simplified understanding of the relationship between state and territory laid out in the previous sections has given life to a series of assumptions in International Relations theory as well as Political Geography. Modern state territories are often seen as discrete spaces separated by clearly demarcated borders, state sovereignty is perceived to be uniformly dispersed across its territory, and since state power is geographically conterminous with its territory, the border in understood as "mark[ing] a radical rupture in the nature and intensity of power" (Painter 2010: 1094-1095). These assumptions rest on a conception of territory as a form of spatial fragmentation of the political world. Such fragmentation has, in turn, been construed as incompatible with an emergent global system characterised by the supposedly unrestricted mobility and flow of goods and people across a unified, global plane (Strandsbjerg 2010).

Globalisation theorists have claimed that social, political, and economic practices have been gradually detaching themselves from the spatiality of the state to be repositioned within larger global settings (Bethlehem 2014; Taylor 1994). What we are witnessing, it has been argued, is a move towards a 'borderless world' of networks, flows, and mobilities in which 'bounded spaces' play an ever-declining role (Ohmae 1990). Because of the normative links between sovereignty and territory, changes in the organisation of political power brought about by the growing influence of transnational business are often interpreted as a deterritorialisation of politics (Shah 2012; Sassen 2000). Ruggie (1993) has interpreted growing internationalism as an "unbundling of territory" involving a radical shift in political geographies, and Anderson (1996) suggests that said changes could be read in terms of an upcoming era of "new medievalism". Some commentators have gone as far as to proclaim that globalisation marks "the end of geography" (Bethlehem 2014; see Morgan 2004).

Within Political Geography, one of the most influential critiques of using the concept of territory as an analytical lens is John Agnew's (1994) warning against the pitfalls of what he has famously termed "the territorial trap". Agnew identifies three geographical assumptions which he sees as inhibitive to the analytical sophistication of studies seeking to understand the dynamics of the state. First is the reification of the territorial state as a fixed and stable container of sovereign power, which lends an aura of timelessness to the modern state. Second is a reliance on a false dichotomy between domestic/foreign and national/international. Such polarisation will, according to Agnew (1994: 59), "obscure the interaction of processes operating at different scales" such as the connections between localised practices of production and transnational chains of manufacture. Thirdly and finally, Agnew holds that the territorial state is too easily reduced to a container which precedes and defines society rather than the other way around, effectively masking the fact that the state is an inherently social construct. Understood in this manner, society is construed as a national phenomenon fixed in geographical space. The assumptions underpinning the idea of a 'territorial trap' are thus related to the ideal of territorial integrity and a stabilised political-spatial order – a conception of the state as essentially stable and immutable rather than a historically specific form of political organisation. Agnew's point is not to state that territory has (or had) no political purchase, but rather to suggest that his three 'traps' seriously hamper critical inquiry into the processes of intensified political-economic integration (a point more clearly developed in his subsequent discussions, see Agnew 2005, 2009).

Agnew's original paper alongside his subsequent engagements with the same thesis (Agnew 2005, 2009; Agnew and Corbridge 2002) represent a pushback against simplistic spatial determinism – the belief that space as such has a linear causal efficacy in relation to the state – and show that the state works in a myriad of ways, many of which are not necessarily territorial in character (see also Painter 2006b; Jessop 2016; Sassen 2000). Arguably scholars should not be blinded by the longstanding spatial category of the territorial state to the extent that non-territorial social and political formations and processes are rendered invisible. Neither should the relationship between sovereignty and territory be taken for granted nor exaggerated. Yet, it remains just as important not to let territory and its politics and mechanisms be negated by said 'non-territorial' processes. As Painter (2010) notes, the claims that the processes of globalisation were leading to a 'borderless world' were always exaggerated (see also Morgan 2004). For example, the territorial state remains the ideal toward which many national groups, including the people of Greenland, strive when seeking self-determination and sovereign rights (McConnell 2010). Furthermore, mounting concern relating to the perceived threats of terrorism and most recently the highly insular discourses surrounding migration and the current Brexit agenda are all contributing to rendering national borders increasingly visible (see Bachmann and Sidaway 2016). Even terrorist movements whose goals may appear antithetical to established state territories tend to promote their agendas through a politics imbued with appeals to and manipulations of territory (Elden 2009).

Agnew's warnings may, as suggested by Brenner and Elden (2009), have brought about some degree of reluctance amongst political geographers to engage with territory on a conceptual level (see also Strandsbjerg 2010; Elden 2007, 2010a, 2013a; Painter 2006a). Rather than receiving due attention as an analytical concept, territory has been construed as a hindrance to sophisticated understanding of geographical processes as other political forces and spatialities presumed to be ontologically different were granted primacy over territory (Antonsich 2009; Crampton 2010). Such critiques of territory may have the opposite effect of what the critics aim for. Rather than challenging the significance of territory or complicating its role in international politics, this critique seems to affirm a simplistic image of territory as fundamentally static. Hence, theories of globalisation and the idea of the 'territorial trap' contain their own implicit 'territorial trap' as they run the risk of causing the very reification of territory-as-state-space that they originally sought to destabilise (Shah 2012).

Although state power and political authority have undergone processes of restructuring and rescaling (Brenner 2004), the hybridisation and dispersion of political power and sovereignty associated with globalisation does not necessarily imply the 'end of territory' or the demise of the territorial state. In their respective analyses of the spatiality of territory, Elden (2005) and Strandsbjerg (2010) conclude that, as of yet, globalisation has not brought about the same kind of radical change in the way space is understood or the ways in which politics is spatialised as exemplified by the shift from medieval to modern spatial-political organisation. Rather, globalisation signifies a rearranging of territory, not the 'end of geography' (Ó Tuathail 1999). Globalisation of politics and trade does not imply an ontological shift in the way space is politicised, conceived, or acted upon. Rather, pre-existing spatialities are reconfigured and extended to the globe – albeit unevenly so (Strandsbjerg 2010; Massey 1994). Political space is still seen as divisible and quantifiable, only the lines of division are to some extent negotiable and malleable and the entity of the globe may, in theory, be ordered as a whole without changing the logics behind said spatial ordering (Elden 2005).

As Elden (2005) points out, questioning the power of globalisation to negate territory is not necessarily the same as failing to recognise the significance of analysing and making sense of for example the internationalisation of trade and manufacture, the hybridisation of culture, or changing constellations of the sovereign powers of the nation-state. Rather, questioning the transformative capacities of globalisation is to critique the idea that such changes necessarily imply a deterritorialisation of politics or a radical break with the so-called 'Westphalian model' of political organisation (ibid). At least for now, the principle of differentiation in politics is based on territorial divides (Shah 2012). The underlying logic of this is not necessarily challenged by the fact that (selected and privileged) goods and people move with relative ease across state borders. Rather, these processes of mobility and flow are themselves enactments of the border being crossed rather than a negation of said border (see Newman 2006; Johnson et al. 2011; Amoore 2006; Jones et al. 2017).

Theorising territory: critique of reductionist conceptions

As the previous sections illustrate, territory has received much scholarly attention in terms of what makes territorial orderings of the political world possible, what political functions territory serves, and how its role in politics may or may not have changed. Political Geographers, International Relations scholars, and students of Political Science have studied instances of territorial disputes, struggles to strengthen and secure territorial sovereignty, and the evolution of bordering regimes. Such studies have led to important breakthroughs in questioning, destabilising, and denaturalising territorial configurations (e.g. McConnell 2010). Yet, whereas territory is a key element of many such analyses, it is often assumed as a self-explanatory notion rather than critically scrutinised. At its most basic, territory is often defined simply as 'bounded space' or as the object of territoriality (Delaney 2005; Sack 1983, 1986; Taylor 1994). As will be explicated below, the former problematically assumes the existence of borders as well as the space within them, while the latter is a cyclical and self-referential argument which seems to defer the question of territory all together (Elden 2007, 2010a). As such, territory may be seen as at once an 'over-extended' notion as argued by Jessop et al. (2008) as well as a relatively 'under-theorised' concept of Political Geography (Antonsich 2009; Crampton 2010; Elden 2013a; Painter 2006a, 2010).

Beyond fears of the 'territorial trap', there are several possible reasons for the relative conceptual neglect of territory as state space within the discipline of Political Geography. Theorisations of territory in terms of animal ethology (Ardrey 1969), for example, may have contributed to making territory an uncomfortable notion for some Political Geographers. The suggestion that territory is a biological imperative that humans share with other animal species may naturalise territorial aggression and violently defensive behaviour (Delaney

2005). Furthermore, such assumptions will sit uncomfortably with academic geographers schooled in the history of the discipline since geographers of the past infamously used bio-geographical arguments to justify colonial repression and other forms of 'scientific racism' (Ó Tuathail 1996; Livingstone 1992).

Painter (2010: 1091) suggests that the relative neglect of territory by Political Geographers may stem from a perception of territory as a static spatial category and, as such, "something of an embarrassment" to progressive geographical thinkers. The arguments made by globalisation theorists that territory was losing its political saliency emerged during the 1980s and 1990s and thus coincided with poststructuralist movements within critical geography. The influence of poststructuralist thought led to a reconceptualisation of space as defined by formation instead of form. By unpacking the mechanisms which lead to the production of spatial formations, geographers argued that rather than being a passive backdrop of social and political life, space is itself a relational concept, inherently fluid, heterogeneous, and in a perpetual state of becoming (Rose 1999; Massey 2005; see also Murdoch 1998; Law and Hetherington 2000). "In these circumstances", Painter (2010: 1091) writes, "invoking the concept of territory risked being seen as either anachronistic (because the world had changed) or reactionary (because an insistence on seeing the world in terms of bounded and homogeneous spaces suggested a fear of Otherness and an exclusionary attitude to social and cultural difference)".

Indeed, basic definitions of territory do appear to be at odds with modern geographical thinking. As noted above, territory is often assumed to invoke a spatial understanding that poststructuralism is generally thought to have undermined (Painter 2006a: 3). Yet Agnew (2005: 441) explicitly conceptualises territory as "blocks of space". Similarly, Taylor (1994: 151) defines it as "bounded space", and in his textbook on the subject Delaney (2005: 14) describes territory as "a bounded social space that inscribes a certain sort of meaning onto defined segments of the material world". As will be substantiated below, such definitions are inherently reductionist and problematic as they fail to pay critical attention to the space between, beyond, and beneath the borders.

The border that supposedly defines territory may itself be seen as "a mix of regimes with variable contents and geographic and institutional locations" characterised by its own mobilities and flows (Sassen 2013: 30; see also Steinberg 2009). However, even when this complexity is recognised, definitions of territory as bounded space still rest on an unsubstantiated assumption that space-as-territory can be understood through bordering practices without reference to its own intrinsic qualities. As noted by Elden (2010a: 799), "boundaries are a second-order problem" as "boundaries only become possible in their modern sense through a notion of space, rather than the other way around" (ibid: 811). As such, the focus on borders as that constitutive of political space negates the question of territory and ignores how different ways of configuring space condition how borders can be invoked (Strandsbjerg 2010: 6).

Territory beyond 'the border': revival of a neglected concept

Over the past decade, territory has been undergoing a gradual conceptual renaissance as scholars are beginning to engage critically with the question 'sovereignty over what?' rather than focusing exclusively on the changing role of the state and possible challenges to state sovereignty. Territory, at its most basic, may be said to constitute a synthesis of space, power, and meaning. These three concepts have long been considered by Human Geographers as relational, fluid, and dynamic. Hence, there is no logical reason why territory, as a constellation which brings these notions together, should be conceived in terms of fixity, immutability, or inevitability. Over the past ten years in particular, developing scholarship has begun the process of pushing back against the analytical flattening of territory to construct a richer and more theoretically apt understanding of territory in terms of what it is and does and how it functions (e.g. Elden 2005, 2007, 2010a, 2013a, 2013b; Brenner and Elden 2009; Painter 2006a, 2010; Steinberg 2005, 2009; Steinberg and Peters 2015; Peters et al. 2018; Sassen 2006, 2013; Strandsbjerg 2010).

Rather than seeing territory as a concept that necessarily clashes with both theories of globalisation and relational theories of space, recent scholarship has instead sought to apply a more sophisticated spatial ontology directly to the territory concept. A particularly productive approach to the question of territory has come from engagements with Latourean network ontologies and interpretations of Deleuze and Guattari's (2013) concept of assemblage-as-*agencement*. Assemblage and network thinking imply openness towards what kinds of assemblages will emerge, their strength and durability, and the types of agents and relations which will sustain and draw them together. There are no a priori assumptions about the kinds of relationships agents will enter into. Rather, attention is on the labour involved in assembling and reassembling spatial formations, which are seen as contingent, diffuse, and entangled across and between multiple assemblages (Dittmer 2014). There is an intrinsic temporality to such formations. Elements are constantly drawn together only to come apart and realign in new formations. The trajectories of elements and assembled wholes may change as they temporarily converge with other elements or wholes. Yet due to their inherent potential for being otherwise, the trajectories will always exceed any assemblage formation (Anderson and McFarlane 2011; Massey 2005). This underlines the inherent fragility and provisionality of any such coming-together; any spatial formation entails the possibility within itself to be otherwise (Thrift 1996; Bingham 1996; Bennett 2010). Hence, assemblage and network thinking encourages scholars to attune to the possibilities of change within the constraints of historical-geographical trajectories (DeLanda 2011; McFarlane and Anderson 2011; Mol 2010).

Assemblage and network thinking allows for the conceptualisation of spatial orders as simultaneously fluid and fixing and thus goes beyond the seeming contradiction between the ephemeral and the structural. Order, structure, and durability require work and repetition to sustain itself and achieve an appearance of permanence and immutability (Doel 2010; Rose 2002; Law 1994; Latour 1999). As summed up by Anderson and Harrison (2010: 18), "there is no order, there are only multiple orderings, and practices are the contexts for and necessary condition of those orders, each of which must be actively composed or fail". Orders are expressed through iterative performances in moments of encounter between humans, worlds, and objects. At least in theory, this processual understanding leaves an opening for the possibility of change and negotiation in our worldly interactions without denying tendencies to adhere to relatively stable categories (see Anderson et al. 2012). Yet, as emphasised above, the stability and durability of any ordering depend on the constant co-functioning and work done by the elements of which they are composed and the relations between these elements. Heterogeneous elements may hold together in uneasy coexistence without ever cohering, but without necessarily fragmenting either (Allen 2011; McCann 2011; Mol 2002).

Following similar logics, Painter (2010) usefully illustrates how territory, in order to hold together, relies upon an intricate network of practices. Territory, according to Painter (2006a: 29), relies "on the rhizomatic connections that constitute all putatively territorial organizations, institutions and actors". Painter (2010) demonstrates how territory may be thought of in terms of a complex configuration of matter, objects, energies, and people by tracing one such network through the example of British administrative regions. Here, a whole suite of governmental technologies gets mobilised (accounting frameworks, tax returns, employment records, filing systems) to hold together a network of people (journalists, accountants, clerks, publishers, designers) and things (paper, pens, computer hardware and software). The territorial ordering of space and the effects that it produces may seem stable, but this stability is in fact the continuously (re)generated effect of complex, relational, heterogeneous networks (see also Brenner and Elden 2009; Strandsbjerg 2010). These configurations may "flicker and settle for a time and give the impression of territory" (Painter 2006a: 29).

Territory in terms of assemblage thinking constitutes a whole, but it is a provisional and contingent whole in a constant process of becoming. As argued by Steinberg and Peters (2015):

> The formation of (…) territory is one of emergence. It has no essence, and its trajectory is not linear. Rather, it is formed and reformed by the elements that add to the assemblage (reterritorialising it) and leave the assemblage (deterritorialising it). Key to an assemblage is that the parts that compose it are heterogeneous and independent, and it is from the *relations* between the parts that the temporary, contingent whole emerges (Steinberg and Peters 2015: 255, original emphasis)

Moving beyond the question of what territory *is*, assemblage and network thinking encourages a shift toward the question of how space *becomes* – a move from an ontological to an ontogenetic question. This suggests an inherent 'instability' of territory, as it underlines not only the socio-material production and contingency of space, but also its processual nature. Emphasising formation over form, it is argued that space (and by extension territory) never simply *is*, but rather *emerges* through a series of entangled enactments of and between human and nonhuman agents. In sum, space is in an endless state of becoming; it is a doing that does not pre-exist its enactment (Rose 1999; Massey 2005). Thus, these perspectives on territory and its becoming foreground the fibrous links, which have no linear or bounded character, but which hold such spatial formations in place, and which may continually evolve into new constellations in unforeseen ways (Steinberg and Peters 2015).

Territory's production: lessons from critical cartography

When insights from assemblage theory are applied to the concept of territory, it raises the question of what kind of work is required for territory to emerge as a seemingly stable and coherent spatial category. The ontological stability and coherence of territorial formations has often been associated with the practice of mapping and the associated emergence of what Strandsbjerg (2010) calls a 'cartographic reality of space'. Cartography is a mode of spatial calculation rooted in mathematics and astronomy; it brings together art and science under the premise that reality can be depicted mimetically and accurately (Biggs 1999; Cosgrove 2003; Wood 1992). This calculative spatial ontology informs and dominates modern imaginaries of political space and the advent of cartography is generally thought to have provided the necessary conditions for the emergence of the modern territorial system (Strandsbjerg 2010; Revel 1991; Ruggie 1993; Biggs 1999). As suggested in Chapter 1 and as will be elaborated on in Chapter 3, cartography is not the only calculative device used by states to cast unruly landscapes as logical extensions of the national geobody. However, the literature on critical cartography offers significant insights into the formative relationship between the production of territory and the production of calculative knowledge of space – i.e. the relationships that this thesis seeks to explore. Additionally, critical cartography helpfully destabilises and denaturalises modern conceptions of territory by underlining territory's historical contingency. As such, this literature merits some attention.

Territorialisation of state power

Although territory has emerged as the normative ideal of modern political organisation to the degree that is seems almost 'natural', the territorial state is a highly specific historical-geographical entity (Agnew 2009). While territory itself is neither a particularly 'Western' notion nor a necessarily modern concept (Gottmann 1973; Elden 2013a), the territorial state is said to have originated in Europe no more than roughly 500 years ago (Painter 2010). From there, this model of political-spatial organisation was spread across the globe in manners which were not always peaceful in character[15] (Thongchai 1994; Harley 1988, 1992; Harley and Woodward 1987).

The modern conception of political territories as clearly demarcated spatial units is a relatively recent phenomenon. Despite tendencies to project modern political imaginaries backwards in time (Biggs 1999), medieval constellations of space and power constituted qualitatively different territorial configurations[16] (Elden 2013a). Instead of a system of discrete political orders, medieval kingdoms were organised concentrically around multiple centres of localised power and ordered by hierarchical bonds (Neocleous 2003). The spatial extent of such kingdoms was defined by bonds of loyalty between monarchs and subjects, and was characterised by overlapping frontier zones as opposed to strict lines of separation. The kingdom was held together by carefully maintained networks of allegiance between the monarch and feudal lords (Sahlins 1989; Sassen 2006). Political identities were first and foremost local in character compared to the relatively abstract notion of citizenship defined by belonging to a centrally governed, geographically bounded polity (Gottmann 1973; Anderson 1991).

The emergence of a modern territorial order is commonly traced back to the shift in political structures brought on by the 'cartographic revolution' of Europe. This 'revolution' of human technologies of space is roughly associated with the period 1450-1650, ending with the signing of the Treaties of Westphalia in 1648[17] (Strandsbjerg 2010). Whereas the most

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[15] When Greenland was colonised by Denmark in 1721, Greenland became subject of territorial violence. For centuries, Danish territorial imaginaries and policies were forced upon Greenland's indigenous population. Most notably, Greenlanders were subjected to forced displacement and centralisation to ease the task over governance, and this significantly impacted their cultures and ways of life (Dahl 2000; Brøsted and Fægteborg 1985; Petersen 1981).

[16] Throughout human history, space and spatiality have played different roles in our socio-political organisation. For detailed historical engagements with different territorial configurations (particularly the shifting language of territory) see Elden (2013a) and Sassen (2006).

[17] Notably, as argued by Steinberg (2009: 470), "the association of the modern territorial, sovereign state with the 1648 Treaties of Westphalia is now widely recognized as a historically inaccurate simplification" (see also Elden 2005; Osiander 2001; Teschke 2003). What is important here, though,

comprehensive perspective that medieval rulers had had of their land was from horseback, the geometric map offered a new, panoptic 'way of seeing' and acting upon space (Revel 1991; Ruggie 1993). By reducing the material world to a series of geometrical properties, geographical space could be represented as a continuous and homogeneous plane, divisible and governable. Through such acts of calculation, the abstract notion of 'space' emerged as a seemingly autonomous phenomenon which could be possessed in its own right in accordance with its own metrics (Strandsbjerg 2008, 2010; see also Anderson 1991). This gave way to an image of state space (and territory) as a graspable entity embodied by the map, thus freeing territorial sovereignty from its former dependence on occupying bodies on the ground. Whereas sovereign power had previously been located in the body of the monarch, sovereignty could now be embedded in the territory itself (Sahlins 1989). Cartographic representations thus made it possible to move from a social definition of territory to a territorial definition of society (Soja 1971).

Map making is at once a destructive and a productive practice. By emptying space of any substance but its own, cartographic manipulations of space made it "possible to write things and features into space which did not necessarily exist" (Strandsbjerg 2008: 246; Wood 1992; Pickles 2004). The abstract notion of the border is perhaps the most prominent example of the productive powers of the map. Without material manifestations in the physical landscape (e.g. walls, fences, signs), the concept of a somewhat arbitrary and in itself insubstantial line of division is challenging to communicate. Once accepted as an accurate extension of the physical landscape, the geometrical map afforded a real and meaningful existence to otherwise immaterial lines which (in most cases) could not be found on the ground. In other words, maps did not simply *trace* borders, but actively brought them into existence (Neocleous 2003). The map may be nothing more than a spatial abstraction, but it can have very real, material effects on the ground (Pickles 2004; Harley 1988; Scott 1998).

The 'cartographic revolution' fundamentally changed the conditions of possibility for formalising political bonds between space, power, and meaning. Political governance gradually changed from being organised around multiple local seats of authority to being

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is not to date the emergence of the state, but to outline the process which is said to have led to the emergence of a modern concept of state territory.

"defined as it appeared from a single fixed viewpoint" (Ruggie 1993: 159, italics removed; see also Agnew and Corbridge 2002; Sahlins 1989). According to Neocleous (2003: 410), this "emergent political space not only separated the modern polity from feudalism, but did so by creating a territorial grounding within which constitutional discourse and political exchange could take place". Similarly, Steinberg (2009: 471) argues that the "rationalization and abstraction of space embodied in the act of territorial bounding permits a discourse premised on control and management, which in turn both reflects and enables the exercise of power by those who, through control of territory, organize the social processes that transpire within". In other words, the abstract spatiality of the map enabled a territorial spatial framework of political order and governance to take form (Shah 2012).

Calculation, territorial violence, and the rationalisation of spatial governance

As noted above, cartography is a spatial technology of calculation and it is its calculative nature which makes it a prominent technology of territory. Indeed, as will be explicated below, territory is itself based on a calculative ontology of space. The normalisation of a calculative ontology of state space had profound effects on political organisation. To this date, the spatiality of the map and the rationalisation of state practices afforded by the division of the political world into discrete units dominates our political imagination and our concept of territory (Revel 1991; Wood 1992; Strandsbjerg 2010; Pickles 1995, 2004). Territory in its modern form, it would seem, is a calculative enterprise.

The relationship between cartographic representation and territorial order has been explored in great detail. The most prominent theme of this literature is the map as an instrument of empire and postcolonial oppression (e.g. Edney 1997; Thongchai 1994; Burnett 2000; Harley and Woodward 1987; Harley 1988, 1989, 1992; Wood 1992; Huggan 1989; Crampton 2006; Wainwright and Bryan 2009; Said 1991, 1993). Challenging the scientific orthodoxy of the map, this literature recast the map as a form of human communication – as discourse – and exposed their underlying political statements. Rather than being innocent reflections of a pre-existing natural order, the map effectively governs what is visible in nature and, as such, what is ascribed political significance. Cartographic acts of exclusion and inclusion may, as postcolonial scholars have pointed out, be deliberately orientated towards political goals and desires and may thus use the guise of science to mask and naturalise territorial oppression. Early critical cartography may be criticised for treating maps as somewhat inert and stable objects as well as for adopting a rather instrumental notion of knowledge while uncritically reducing knowledge and its production to an instrument of power (Biggs 1999; Strandsbjerg 2010). However, this literature underlines a crucial point about territory as a calculative enterprise; namely that territorial contestation and violence may be epistemological as well as direct or physical (Neocleous 2003).

Valuable insight into the territorialising effects of the application of calculative logics to space has been generated by scholars focusing on the spatiality of the map rather than its content. In other words, instead of focusing on the spaces produced by the map, focus is on "the relationship between calculation as a territorial strategy and the production of space" (Crampton 2010: 95). What makes spatial calculation such a potent political device is the ordering and rationalising effects of the three levels of abstraction associated with it: the separation of space from bodies, space from time, and space from observing subjects (Strandsbjerg 2010). By reducing the geographical world to seemingly objective properties of extension and position, the map effectively separates the geographical world from the subjective experiences and sensations of 'being on the ground' (Steinberg 2009). In this sense, cartographic practice results in an ontological flattening of the richness of the physical and lived world. In the words of Biggs (1999):

> [The reduction of space to mathematical abstractions] objectifies the world as a mundane surface, no longer the hub of a sacred cosmos or a succession of tangible places. It differentiates the form of knowledge from its content (…) It is at once mimetic: It claims exact correspondence with the ground, and artificial, for it shows something that no one could ever see (Biggs 1999: 377–378)

As noted above, such simplification can be violently destructive. At the same time, the ontological flattening of the messy complexities of the world vastly simplifies and rationalises the task of governance. With geographical information readily available in a distilled and ordered form, activities such as taxation, military manoeuvres, and the planning of infrastructure can be carried out with much greater efficiency (Hewlett 2010).

As noted, its mimetic qualities and its foundation in the principles of science lend the map an air of objectivity. The map visualises a pure, 'natural' geography untainted by subjective experience and with no discernible author (Steinberg 2009). As the map captures and simplifies the physical world and presents state territories as discrete, contiguous, and homogeneous, it simultaneously presents these territories as fundamentally stable and immune to the touch of time. The map consolidates the physical form of the state and represents it as scientific fact. As such, the map implies a separation of space from time and thus affirms both the permanence and naturalness of the polity qua its territorial form. On the map, irrefutably social institutions are grounded in and rendered inseparable from the physical landscape (and vice versa), which lends states an organic appearance as "transhistorical units, defined by their unchanging, 'natural' boundaries" (Steinberg 2005: 255). Pointing to a map is to point to a series of evident, physical features of the geographic landscape. Such pointing may be used as a strategy to underline the 'naturalness' of the extent and form of the territorial state (Dodds 2010; Steinberg 2005).

The territorial dimension of the state not only rationalises power and eases the control and management of spatial relations; it also rationalises the very existence of the state and obscures its ordering practices. Having a seemingly fixed, physical existence makes the territorial state appear to be an almost 'naturally' occurring unit, and this lends the territorial state much of its legitimacy as a primary source of political authority. Being more or less firmly planted on the ground gives the state both a physical presence and an air of timelessness and naturalness (Shah 2012; Steinberg 2009). This is what Brenner and Elden (2009) have referred to as the 'territory effect', namely "the state's tendency, through its territorial form, to naturalize (at once to mask and to normalize) its own transformative, intensely patterning effects upon socio-spatial relations" (ibid: 354). Territory thus provides states with a means which allows them to represent the implications of their spatial policies and interventions as natural responses to the physical landscape or the built environment rather than as political choices and manipulations. Because of the perceived 'naturalness' of state territory, territory is a primary site of state power. This is only possible as a function of the power that is gained from the processes through which the state is physicalized[18] (Shah 2012). Somewhat ironically, the reduction of the physical properties of state space to the form of geometricised abstractions and representations (what may be construed as a *de facto* dematerialisation of the state) is what makes state territory appear to be an actual, material,

[18] As suggested in the introduction and as will be argued in Chapter 3, cartography and cartographic practices are not the only means through which state space is physicalized.

and fundamentally natural entity. Put differently, the state is effectively physicalized qua the reduction of its physical properties to a series of dematerialised abstractions.

Territory as a political technology

For Biggs (1991: 385), territory was literally "modelled on the map", and it was through the practice and representations of scientific cartography that landscapes were reshaped into territory. To support a similar point, Strandsbjerg (2010: 68) quotes Baudrillard's statement that "territory no longer precedes the map (…) Henceforth, it is the map that precedes the territory". Turnbull (1989) goes as far as stating that "maps *are* territories" (emphasis added). The argument that there is a strong relationship between the production of geographical knowledge and the territorial ordering of space is indeed convincing. As noted by Elden (2005: 15), the modern conception of territory "requires a level of cartographic ability that was simply lacking in the earlier periods, an ability that is closely related to advances in geometry". For Elden, however, conceptualising territory as space cartographically bound is not sufficient to capture the ongoing making and remaking of territorial orderings of state space.

Reframing the conceptual debate about what kind of work is required to sustain the territory effect, Elden (2010a, 2013a) conceptualises territory in terms of a political technology. Following Foucauldian notions of the relations between knowledge, power, and space, Elden views territory as a technology through which space is organised and made legible for the purpose of intervention and governance (see also Hannah 2009; Neocleous 2003; Strandsbjerg 2010). A technology, in this sense, may be loosely defined as a means of acting upon and representing spatial processes and activities. If territory gains its political potency at least in part from the territory effect (i.e. from appearing to be a stable object with integrity and coherence), then a political technology of territory is one which consolidates spatial processes and activities in terms of an apparently stable spatial ordering. Territory is construed by Elden (2010a) as a calculative enterprise that requires space to be made present in an abstract form. By comprehending space in terms of a series of calculative metrics, the material world can, in theory, be reduced to a series of seemingly objective properties (or material qualities as discussed in Chapter 3). Such quantification separates the material world from the messy qualities of experience and sensation, and thus represents a rationalisation of political rule (see also Scott 1998; Steinberg 2005, 2009).

As noted in Chapter 1, Elden's (2010a) conceptualisation of territory comprises two central components: land and terrain. As previously explained, land and terrain are not neatly separable, but are in many cases practically intertwined, and territory is always more than the sum of these parts. This coming-together of land and terrain suggested by Elden is similarly reflected in Gottmann's (1973) formulation of the basic role of the state as an institution which uses territory to ensure the wellbeing of its populations. For Gottmann and Elden alike, territory is a relation of security as well as opportunity and prosperity. The principal aim of territory is protecting the interests of a political community represented by the centralised body of the state by protecting them from those who are considered Other (and, by implication, mistrusted and dangerous) and by securing privileged access to vital resources.

Considered in terms of economic and strategic relations, land and terrain are both dependent on a calculative and abstract spatiality (Elden 2010a). The calculative abstraction of space not only enables the drawing of otherwise immaterial borders, but renders geographies actionable in a much broader sense and makes the control and command of territory possible (Hannah 2009). Elden (2010a: 810) argues that alongside the shift from people to population identified by Foucault (2009, 1991) in his engagements with governmentality and biopolitics, there is a simultaneous shift from land/terrain to territory. With this shift, territory is no longer defined only in terms of property or defendable area, but in terms of its own innate *qualities* (Braun 2000; Elden 2007). Territory is both connected to and exceeding land and terrain; it is a spatial relation of power which comprises techniques for *measuring* land and *controlling* terrain. Land is measured in order to ascribe value to it and rationalise its productive potential. Terrain needs to be controlled and rendered navigable to enable efficient defence of state space. As such, territory combines the economic (land) and the strategic (terrain) with the juridical (order, control) and the technical (measure) (Elden 2010a, 2013a).

Land

Land (a political-economic relation) is a finite resource which can be owned, distributed, and fought both on and over. The concept of land may be considered a political-economic relation of space in several related manners. Firstly, land implies "ownership, exchange and use value, distribution, partition, division" (Elden 2013b: 35). It is, in other words, a relation of property. Land is a commodity which can be bought and sold; an attribute which is dependent on its subjection to calculative logics (see also Hall 2013). Land-as-state-property is taxable and land-as-private-property can generate revenue through rent. Secondly, beyond being a resource in its own right, land is a source of essential life-supplies as land may be farmed to provide sustenance or revenue. Finally, land is the site of economic activities associated with industrial capitalism (Elden 2010a; Bakker and Bridge 2006; Bridge 2014).

Quoting Lefebvre (1974), Elden (2010a: 805) notes that *la terre*, which he here aligns with his own understanding of land, "is not solely agriculture, but also the subsoil and its resources". In other words, land as a political-economic relation is not only concerned with surface exchanges and activities such as taxation, farming, or forestry. Subterranean structures and the potential riches they may hold are of critical importance to both national and private economies. Mineral deposits which have been constructed as resources are often subject to political contestation, and in a similar manner to cartography, geological surveys aiming at resource identification and extraction have been used in the service of empire to dominate distant geographies (Scott 2008; Secor 1982).

Beyond relations of ownership and economy in a strict sense, land encompasses other qualities which are equally political in nature. Land is a highly emotive concept; it is the ground beneath our feet, the soil that sustains us (Paasi 1996). The aesthetics of landscape also has its own politics and potential economies (see Cosgrove and Daniels 1988). The possession of land holds great symbolic power and is in itself a relation of politics (Elden 2010a). A state's possession of land is a key aspect of territory due to the relatedness between such 'ownership' and political sovereignty and jurisdiction, where sovereignty is broadly understood in term of a relationship of exclusive political rule over space (Elden 2006a; Bridge 2014).

Terrain

Since conflict over and defence of land are central aspects of the struggle for political power, the concept of land is closely related to that of terrain. Terrain (a political-strategic relation) is defined by Elden (2010a: 804) as "a relation of power, with a heritage in geology and the military, the control of which allows the establishment and maintenance of order" – it is "land that has a strategic, political, military sense" (ibid: 806). Terrain emerges from a series of processes through which physical geographies are rendered actionable and opened up to the possibility for and realisation of military intervention. Terrain encompasses a series of relationships (or possible relationships) between humans and the physical landscape (Gordillo 2013). Strategies of terrain are varied. Some involve the construction of a landscape devoid of life – land reduced to a virtual plane as seen through the lenses of an unmanned drone (Gregory 2004). Others depend on mapping out the possible relations of direct contact between bodies, machines, equipment, and the physical ground (see Stephenson 2003).

Terrain is a concept which draws out the deep political implications of the materiality of physical geographies. Although terrain is not necessarily limited to militarised geographies (Gordillo 2014), the military lens is productive since analysis, management, and manipulation of material environments to render them actionable and operable has long been a key military-strategic objective (Underwood and Guth 1998; Squire 2016a). As such, the production of militarised landscapes offers a strong and explicit articulation of terrain and its defining components.

The notion of terrain connects territory to an explicitly violent form of power which is an inextricable part of military security and defence. Terrain concerns the ways in which violent power inscribes itself on the material landscape as well as within political discourse (Elden 2009, 2010a). For Elden, this reverts back to an etymological link between terrain and territory. The common root, *terra,* is often seen as referring to 'Earth' or 'dry land', but several scholars have discussed another possible etymological meaning and a relatedness between territory and the word *terrare* – 'to frighten' or 'to warn off'. Following this understanding, territory becomes a place from whence people are warned off (see Elden 2009; Neocleous 2003; Hindess 2006; Connolly 1994). As such, the process of bringing into being a spatial order that allows for efficient military intervention – i.e. the action required to 'warn people off' – may be seen as a central aspect of territory.

Notably, terrain is not just a question of how geography impacts the military, but of how the military impacts geography. Woodward (2014), for example, mentions physical changes to the landscape such as the construction of camp sites and other forms of infrastructure as examples of how landscapes bear the marks of militarisation (see also Woodward 2004, 2005). As will become apparent throughout this thesis (see in particular Chapter 6), military intervention also rests on the creation of particular knowledge spaces and practices of calculation, which may itself have a substantial impact on how different ecologies are envisioned (Gregory 2016; Bélanger and Arroyo 2016; Stephenson 2003).

As for land, the subsurface is equally relevant to the production of terrain. An example of this is provided by the construction of tunnel systems and bunkers for military purposes as discussed by Elden (2013b), Weizman (2002, 2007), and Graham (2004). Elden (2010a) explicitly links terrain and geology (see also Underwood and Guth 1998) – a science concerned with subsurface characteristics and volumes more so than surface area (Rudwick 2014; Frodeman 2000). Although Elden does not go into the details of this relationship, geological data is instrumental in a number of areas of military conduct, such as resource acquisition, field logistics, construction, fortification, and tunnelling (Underwood and Guth 1998). Several of these are specifically orientated towards the sub-terrain and incorporate similar political rationalities as discussed in relation to resource landscapes (ibid).

Concluding remarks

Beyond being a key concept of Political Geography and related disciplines, territory is central to the political legitimacy, identity, and many of the daily workings of the modern territorial state – an institution which, at least at this moment in history, remains key to political-spatial organisation. What can be drawn from the critiques of territory emanating from globalisation theory and critical geographical scholarship is a need to consider territory in terms of a historically and geographically reflexive spatialisation of political order and control. Drawing on the rich literature on space as a relational concept, it is possible to unravel the apparent inertness of territory and avoid the reductionist geographical assumptions of territory as a passive body of absolute space. Rather, territory should be considered in terms of a heterogeneous assemblage – fluid and dynamic – which brings the social institution of the state in contact with space. Considered as a process rather than a political unit, territory may be seen as an opening up of space to political action which allows for the mobilisation of space in both visible and invisible manners to control both space and populations. Territory is a technology applied to, as well as through, space in order to make spatialised governance possible. This may seem to bring territory uncomfortably close to the concept of territoriality defined as "the use of territory for political, social, and economic ends" (Agnew 2005: 437; see also Sack 1986). Yet, whereas territoriality is a strategy that presumes the existence of territorial space, territory as a political technology relates to the underlying structures that make territoriality possible. As noted by Elden (2010a: 803), territory may be existentially second to territoriality, but it is logically prior.

In order to function as a device which lends an air of simplicity and stability to complex categories such as political authority and cultural identity, territory itself has to appear as a relatively simple and stable phenomenon. Thus, by beginning to unpack the complexities of territory's production, its mechanisms and workings, aspects of the 'territory effect' (the masking and naturalisation of political authority and intervention) are gradually uncovered as well. In order to achieve that, it is necessary to move beyond the question of what territory *is* and *does* (its form) and think critically about how territory is *achieved* (its formation) and to what effect. Stuart Elden (2010b, 2013a) seeks to do just that by setting up a framework for doing a spatial history of territory. This framework necessitates that close attention be paid to the ways in which power and knowledge get mobilised onto and through land in its various forms – as a repository, as a terrain, as space, as a resource in its own right. The production and maintenance of territory as a mode of political-spatial organisation requires a calculative grasp of space; it takes knowledge and legibility to relate space and power.

As will be argued in the next chapter, what constitutes space as land or terrain is its *qualities*, discursive and material. Land is valued for its abundance of minerals, the richness of its soil, and the ease with which such resources can be harnessed. The strategic viability of terrain is similarly linked to the qualities of soil and rock – how susceptible the ground is to manipulation, if it will support military infrastructures, or sustain an army. Bringing these qualities into spatial and political existence and rendering them open to manipulation and governance require that they be mapped, not only in terms of the flat discourse of area nor along a third axis to indicate their three-dimensional form, but in terms of their deep, material properties. The economisation of land, for example, may depend on its ordering in terms of discrete, quantifiable bodies of ore, but also on the geochemical composition of said ore (see Chapter 5). Similarly, terrain is made controllable by rendering it known and knowable in all thinkable dimensions, both above and below the surface plane, and by knowing the intimate details of the processes that govern the solidity of the ground (see Chapter 6). The question of territory as a process, a technology, and a practice becomes a question of how its voluminous qualities are rendered governable.

If territory is a relation of prosperity and security, land and terrain, then the Earth and its metrics are arguably central to territorial configurations. The production of land and terrain both depend on the processes put in place to rationalise the productive potential of the political geo and, through this rationalisation, cast it as part of a territorial ordering. If we accept Elden's (2010a) conceptualisation of territory as a political technology that requires space to be made present as land or terrain in a calculable form, then it seems that scientific practices directed at the Earth play a key role in territory formation. The physical sciences are a key mechanism through which we have come to make sense of the world we inhabit; they play a central role in how humanity has continued to increase the efficiency with which the Earth serves us as land and terrain. Hence, as the next chapter will argue, by linking the conceptual debate on territory to scholarly insights on how science works as a practice of ordering the chaos of the physical world (Prigogine and Stengers 1990; Grosz 2008), including its inherent politics, we gain a deeper understanding of the mechanisms of territory as a political technology directed at the material Earth.

3. The Metrics of Territory

Scientific practice and the politicisation of Earth

Chapter 2 argued that the concept of territory continues to play a key role in modern political organisation and that it needs to be considered in terms of the same level of theoretical sophistication that geographers have afforded to other spatial assemblages. What is emphasised by assemblage/network approaches in geographical thinking is the significance of the practices, performances, and the ongoing work through which space is constantly reproduced. Thus, adding conceptual depth to territory requires attentiveness towards the ongoing processes of territory's becoming. As suggested in Chapter 1 and reiterated towards the end of Chapter 2, when territory is considered in terms of a political technology, then the calculative practices through which a voluminous and materially complex Earth is cast as land or terrain play a crucial role in the formation of territory.

This chapter argues that to add depth, volume, and matter to the concept of territory, it is useful to think of territory in terms of a scientifically anchored, geo-political technology directed at the Earth and its qualities. In contemporary political geographical thought, the political geo both exceeds and comprises the physical, and the Earth that is 'written' is as much a social construct as it is a material entity. This dual notion of the geo – an amalgamation of space and Earth, the social and the material – informs the concept of territory. Territory brings the state in touch with a materially complex Earth, which is both a source of power and of an agential force which pushes back against scientific practices of framing as well as against certain political interventions. Practices of territory as a political technology work not simply through geographical area, but through space in all of its dimensions. Territory is achieved through the control and ordering of volumes, and no interrogation of either land or terrain can escape their voluminous form.

Building on the discussions in Chapter 2, this third chapter begins to unpack the formative relationships between scientific practice and the production of territorial orderings. Using Stuart Elden's (2010a, 2013a) work on territory as a political technology of calculation as conceptual foundation, this chapter mobilises insights on the underlying mechanisms of scientific practice from Science and Technology Studies (STS) (Latour 1987, 1988, 1991, 1999; Law 1986, 1992; Callon 1999; Callon and Latour 1992) alongside geographical theories on the relationship between spatial legibility and spatial governance (Scott 1998; Hannah 2009; Strandsbjerg 2010). Drawing on Bruce Braun's (2000) significant paper on territory and geology and Elizabeth Grosz's (2008) reflections on Deleuzoguattarian geo-philosophy, this chapter makes the case for an understanding of territory that is firmly 'grounded' in the material Earth. In this manner, the chapter unpacks the mechanics and mechanisms of science and discusses how calculative science functions as a space-making practice and an application of power onto and through space. The chapter discusses the aspects of science as a way of knowing and acting upon space which make it an effective technology of spatialised governance – or, in other words, how science works as an effective technology of territory.

The politics of calculation: territory and governmentality

The relationship between spatial governance and calculation has long been a prominent theme of academic geography. During geography's so-called 'quantitative revolution', the mathematics of spatial technologies such as cartography were key objects of study (Crampton and Elden 2006; Barnes 2004). More recently, Foucault's (2009) lectures on governmentality and the related concept of biopolitics have informed a rich geographical literature exploring the relationship between calculation, governance, and space. To interrogate the "geographies of mathematization and calculation" (Crampton and Elden 2006: 681), this literature unpacks the many intersectionalities between numbers, metrics, politics, and space. Calculative logics, it is argued, are inexorably entwined with politics since statecraft is underpinned by the metrics and practices of calculation. In other words, calculative logics permeate every fibre of the state (Elden 2005; Hannah 2000; Crampton and Elden 2007). Foucault (2009, 1991) argues that territory is at least partially displaced by population as a technology of governance. However, as will be explicated below, insights from the geographical literature on the spatial aspects of governmentality are of particular relevance to the development of a conception of territory based on Elden's (2010a) formulations.

In brief, governmentality may be described as a mode of 'scientific governance' that works by producing political subjects which are at once objects and vehicles of power. Governmentality is a form of political rationality that draws on a simplification and rationalisation of governance by the means of incorporating immensely complex relations into standardised grids. In his lectures on governmentality, Foucault (2009) traces a long line of processes of calculation-based ordering and attempted standardisation of key aspects of social and biological life, including intimate matters such as medical health, eating habits, and reproduction. By rendering populations known and knowable, both as individual people and as collectives, it becomes possible for the state to extend its structures of domination *through* human bodies via disciplinary policies aimed at maximising the wellbeing of populations. In other words, populations become actionable as biological beings rather than as subjects of a territory. Hence, Foucault (2009) suggests that the emergence of a politics based on the principles of governmentality sees territory displaced by the problem of population as the principal target of state power.

The mechanisms of governmentality, however, are not only applicable to populations, but also to the governance of space. The governmentality concept articulates the calculative underpinnings of governance and, as will be argued below, is also entwined with the notion of a productive geo (Braun 2000). Since the welfare of populations is both the ends and means of governmentality, the governance of territory is not readily separable from the governance of populations (Hannah 2000, 2009; Braun 2000; Elden 2007). Security and prosperity are central aspects of the wellbeing of populations and, as previously argued, both security and prosperity have undeniable physical and spatial forms associated with the notions of land and terrain. In a passage which brings out the governmental logics underpinning the concept of territory, Gottmann (1973) writes:

> It [territory] involves a rationalization of the facts of diversity and complementarity observed in the various parts (…) of a partitioned world. Organization of space integrates the natural factors that govern the forces and the forms observed in physical space, and also integrates the many social, economic, and political forces that,

> manipulating the available technological lore, use the natural environment for the people's purpose. (Gottmann 1973: 12)

What Gottmann is suggesting is that the wellbeing of populations is meaningfully linked to the practices of mathematically ordering the physical world – the practices of enrolling 'natural factors' into the fabric of the state. Similarly, Hannah (2000: 39) argues that the operationalisation of governmental rationalities depends on "epistemological access to all parts of the territory and everything in it". By securing such access, governments can distinguish between different units of resources or other relevant qualities of the geographical world and make them susceptible to numeration (ibid: 39). Such knowledge of the territory is, as Hannah rightly notes, necessarily imperfect. Yet the continuity of territory is dependent on the continuity of knowledge. Gottmann (1973) writes:

> As it is defined by its accessibility, geographical space must be, first of all, *continuous*, allowing access from one point within it to another. This continuity must exist not only in nature, but also, more importantly, in recognized knowledge (…) A place becomes potentially accessible, once known, owing to its physical continuity with known territory. (Gottmann 1973: 10, original emphasis)

The rationalisation of space and political rule afforded by the production of this territorial knowledge is a central condition of possibility for the consolidation of state power and the 'mastery of space' (Hannah 2000, 2009; see also Rose-Redwood 2006).

Elden (2007: 562) too explicitly aligns his thoughts on territory with Foucauldian governmentality, noting that "the same kinds of mechanisms brought to bear on populations" similarly apply to territorial strategies. These strategies should be read as calculative similar to how strategies of biopolitics are understood. Biopolitics and geopolitics both work on the basis of calculation, and "[b]iopolitics *and* geopolitics can both be understood through processes and technologies of bio-metrics and geo-metrics, means of comprehending, organising and ordering" (Elden 2013b: 49, original emphasis). Rather than accepting the displacement of territory by population, Elden (2005, 2007, 2013b) thus calls for the geopolitical and the biopolitical to be folded into each other.

In this call, however, Elden's (2013b) examples do not go beyond man-made structures such as tunnels and road systems (see Bridge 2013). As persuasively argued by Braun (2000), the geo-metrics of governmentality that Elden is invoking may also apply much more directly to the deep, material structures of the Earth itself. In his paper on geological assays in late

Victorian Canada, Braun (2000) explicates how the emergence and normalisation of a 'geological way of seeing' state space made a new form of territorial governance possible. The science of geology rendered qualities of state space buried within the Canadian subsoil open to calculation and quantification. As such, the political realm became intelligible (and actionable) not just in terms of features visible at the surface, but in terms of its internal architecture. These new geological "forms observed in physical space" (Gottmann 1973: 12) afforded a similar kind of rationalisation of the governance of the Earth as do biopolitical technologies directed at populations. Earth was drawn into the realm of politics as a series of neatly ordered, distinct geological bodies with set physical qualities and associated values. By securing epistemological access to previously inaccessible parts of the territory, the science of geology had extended the territorial reach of the state into new spheres. In other words, governmental structures of domination were extended *through* the body of the Earth as the continuity of known territory was extended downward along a vertical axis (Braun 2000).

The geological survey is more than simply a practice of 'taking stock' of what is already there. The nominal bodies which the science of geology carves from the physical Earth do not straightforwardly pre-exist their enactment. Geology is a practice of framing the Earth – of bringing a particular set of material and epistemological qualities into prominence. As Braun (2000) writes:

> Geology did not simply exist 'in' a given territory. Rather, as a set of rules governing what was visible in nature, geology brought a 'territory' with its 'qualities' into being, and thus opened a space – simultaneously epistemological and geographical – that could be incorporated into forms of political rationality. (Braun 2000: 28)

Braun's (2000) study firmly cements how territory is vertical, voluminous, and material (a topic that will receive more attention later in this chapter). Furthermore, as will be argued below, his study underlines how the sciences of the Earth constitute important political technologies of territory. To understand the process of how territory is brought into being, how it is rendered functional as a political technology, and to what effect, it is thus necessary to understand the underlying mechanisms of the practices mobilised to bring epistemological and geographical spaces within the reach of the state, namely the practices of science.

Science, power, and spatialised governance: the world made flat

Scientific knowledge is traditionally distinguished from other forms of knowledge claims about the world, such as religious or cultural beliefs, by its commitment to a regime of rigid (scientific) methods. These methods are said to create a platform for dispassionate and objective observation rather than subjective interpretation, thus offering a privileged view of the natural world. Such knowledge is supposedly universal in character and will remain stable and applicable across space and time. If what was once believed to be true scientific knowledge is later proven false, the answer is simply that it was never truly scientific in the first place (Pickering 1992; Shapin 1998; Brown 1993).

To construct objective scientific truth, the figure of the scientist is seemingly done away with through the scientific process. Geographical, social, cultural, and political circumstances which may affect knowledge production are similarly rendered invisible in scientific representations of the world. What remains is pure, undistorted nature. This disembodied God's eye view from nowhere has long been challenged by scholars from a wide range of disciplines, such as sociology, anthropology, and geography, and of course science studies. Conversely, it is argued that scientific knowledges are contingent on a wide range of contextual factors and are, in fact, 'views from somewhere' (Haraway 1988; Livingstone 2006; Shapin 1998). Even if one disregards how knowledge production requires funds, and thus necessarily must attach itself to power, so-called 'objective knowledge' is always based on a series of choices – what to measure, which metrics to use, which technologies – none of which simply 'emerges' from nature[19]. In the words of Pickering (1995: 9-10), "scientific representations of nature have to be understood in terms of particular configurations of human agency" rather than mimetic representations of nature.

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[19] Emphasising the truism that science is always already political does not necessarily undermine the significance and relevance of scientific knowledges and practices. Science is, as Demeritt (1994: 33) writes, not a mirror of nature, but it is nonetheless an important tool which humans can use to engage the world critically.

The "production, evaluation, and use of scientific knowledge" is "structured by the interests and constraints upon real human agents" (ibid: 9).

As argued in the previous chapter, the technologies and metrics of territory function by reducing physical geographies to the idealised form of the plane in order to produce legible and actionable spaces of opportunity and security (Elden 2010a, 2013a; see also Strandsbjerg 2010; Gottmann 1973). As such, technologies of territory are often directly aimed at an ontological 'flattening' of the contours, volumes, and complexities of the physical Earth (Elden 2013d). Although Elden does not explicitly align himself with the STS literature, this last argument is in many ways similar to how, for example, Bruno Latour (1987, 1999) and John Law (1994) discuss the conditions of possibility which underpin spatialised governance. While neither of these two scholars engages the concept of territory in any explicit manner, Latour and Law respectively detail how scientific practices create and support the appearance of durable and stable orderings of political space, i.e. the 'territory effect'. For Latour and Law, the answer to the question of how to act at a distance upon places, peoples, and events – how territorial governance is possible – lies not only in calculable practices writ large, but in specifically *scientific* practices of quantification. Power and agency, construed as relational network effects, can be made to reach further than the immediate locality and the passing moment because of the way scientists are able to render a materially heterogeneous world *mobile*, *stable*, and *combinable*. These three effects stem from practices of translation and inscription, which result in the production of what Latour terms 'immutable mobiles'. In the following sections, these notions will be introduced in turn in an effort to unpack the territorialising effects of science.

Scientific translation and inscription

As illustrated by the example of cartography discussed in the previous chapter, the ability to reduce faraway geographies to a series of stylised inscriptions carries significant political force. In the terminology of STS, this territorialising move between world and representation is construed as a form of *translation*. At a basic level, translation can be understood as a move between equivalent words or forms. However, no two words or forms are exactly equivalent, which means that any translation necessarily implies change – a making and remaking of components (Law 2009; Latour 1983). Tracing the Greco-Roman etymology of the term, Law (2009) notes how translation shares its roots with the words *trahesion* and *traduction*, meaning betrayal. He takes this to suggest that translation always implies a betrayal of an original form or meaning. Hence, no translation is ever neutral.

Translation may be understood as creating convergence between otherwise different elements. Translation is a process of bridging the gaps between the heterogeneous components that scientific calculation seeks to bring together and to make them combinable (Latour 2005). For example, translation makes it possible to link the seemingly disparate entities of geology and economy. Through a series of calculative manoeuvres, a body of rock can be translated into the metrics of monetary value, thus rendering it combinable with otherwise dissimilar components of financial markets (Latour 1986). Similarly, processes of translation may connect geology and military security through metrics which convey, for example, the engineering properties of rock at a given location (see Chapter 6).

For Latour (1986), translation mainly refers to the move between messy reality and stylised inscription, such as the move between a mountain range and a piece of paper (see also Latour and Woolgar 1986). Scientists routinely make use of various forms of inscription, such as figures, diagrams, plates, texts, photographic images etc. According to Latour (1986), it is the very possibility of accumulating and combining knowledge afforded by inscription that makes a discipline 'scientific'[20]. Geology, for example, became 'scientific' when a unified visual language was invented, which allowed successive accounts of interactions with the strata of the Earth to be summed up through cyclical processes of inscription and fieldwork which rendered the strata visible (Rudwick 1976, 2014). The knowledge generated by, for example, one geoscientist from what is necessarily a limited number of empirical encounters that they have personally experienced is arguably different from the carefully codified knowledge that can be obtained from the combined records of thousands of encounters documented by thousands of scientists over long periods of time. Without the combinability afforded by formalised inscription across and between components, scientists would be starting over every single time a research project was initiated (Latour 1986, 1987).

[20] Notably, what qualifies as 'science' is not constant, but is contingent on social, political, cultural, geographical, and temporal circumstances. The meaning of the concept is under constant negotiation (Latour 1999).

Formalised inscription translates endlessly complex, three-dimensional objects into much simpler two-dimensional representations embodied by pieces of paper (Latour 1986). Through multiple stages of observation, "particularity, materiality, multiplicity, and continuity" of the object of study is seemingly done away with, as data is processed through instruments, entered into computers, subjected to calculation, and thus translated into paper form (Latour 1999: 70); a process which Latour calls 'reduction'. Each stage of reduction affords greater combinability, standardisation, and relative universality to the output, which gets closer and closer to the status of fact. Phenomena circulate between empirical observation and a generalised body of knowledge established as universal and factual. By making individual observations compatible with this body, observation becomes knowledge (Latour 1999). Thus, the concept of knowledge cannot be understood in and of itself, nor in relational opposition to concepts like ignorance or belief. Rather, it is necessary to consider the cyclical processes through which data is interpreted and accumulated through successive field expeditions and laboratory tests (Latour 1987).

Throughout such processes of reduction, scientists strive to maintain a linear perspective of the object of study so that the internal properties of said object remain unchanged. This is achieved by applying more or less homogenous disciplinary languages, which provide a grammar (codes, symbols, metrics) that makes it possible to sustain logical relations both within the representational system itself as well as between the system and its original referent object (see Cosgrove 1985). Thus, the linear perspective makes the transformations reversible and enables movement back and forth between object and representation (Latour 1986, 1999). This is a crucial aspect of scientific inscription, as translation without corruption makes it possible to accumulate, compare, combine, superimpose, bring together principally endless quantities of, for example, geographical information in one single place.

By the time a laboratory event or a discovery has been translated into a scientific text, most of both the social and material context in which the new knowledge was produced has disappeared. Method is distilled down into clean, formulaic statements that clearly lay out how one gets from data to knowledge about the natural world. In practice, however, the production of knowledge is characterised by a series of heterogeneous relations that guide research. Latour (1999) mentions casual conversations in break rooms as a common example of such a relation. Hence, *reality* is effectively separated from *knowledge of reality,* as the former is entwined in a series of intermediate social and material relations whereas the latter discards these through processes of purification and distillation (ibid). Understanding the scientific processes through which a territorial ordering is brought into being thus requires attentiveness to the multiple layers of practice which lead to the production of 'knowledge of reality' rather than a strict focus on representation (Pickering 1995).

(Im)mutable mobiles

A mountain range, a coastline, a population, or a grand cathedral cannot easily be transported from one part of the world to another. Inscriptions such as maps, demographic statistics, or blueprints are, however, highly mobile. Scientific inscriptions are not only mobile; they also retain their shape as they travel. Latour (1986, 1987) terms any object which either allows for the mobilisation and transportation of entities without changing their internal properties and/or is capable of retaining its shape as it travels an 'immutable mobile'. Mobilisation is, of course, not a property that is exclusive to inscriptions. Objects like rocks, soil samples, plant specimens, and live animals may also be displaced from their original context without changing their internal properties or forms – assuming that the samples do not wither, decay, or die. Notably, samples quickly become meaningless if insufficient contextual information is attached to them. Given the samples' role as pieces in a much larger puzzle, standardised practices guiding collection and logging (rules for taking field notes etc.) become crucial to ensure that the samples retain their meaning and combinability (Latour 1987). Although such data is supposedly the direct result of interactions with the natural world, their gathering and logging (following often strict protocols) also involve a form of translation. The network configurations of samples are changed the moment they are displaced into laboratories, museums, or other spaces of knowledge production where things are categorised and logged in accordance with the protocols and standards of the institution in question (Bowker and Star 1996; Latour 1999). For example, in a geological museum, samples from alkaline igneous rock formations from one part of the world may be placed alongside samples of similar geochemical composition from another part of the world. This displacement creates a new series of relations between bodies of rock based on geochemistry rather than geography (Bowker and Star 1996).

The concept of immutable mobiles applies to technologies as well as inscriptions and samples. For example, in his discussion of Portuguese imperialist trade, Law (1986) treats the ship as an immutable mobile. Law claims that the ability of the ship to retain its network configuration as it sailed back and forth between centre and periphery was critical to the success of the Portuguese empire. The immutability of the ship was dependent on a long list of heterogeneous allies (sailors, navigators, sails, nails, ropes etc.) to work together and maintain their network relations. For the ship to maintain its functionality, the network had to be performed in a stable manner. In other words, the success of the Portuguese empire was dependent on the ship's ability to move through *Euclidean* space while remaining immobile in *networked* space (ibid; see also Law 2002).

It is never a given that a network will retain its shape, or that machines and machinations will travel through Euclidian space. However, neither can it be assumed that the failure of an immutable mobile to stay immutable means that the network will simply fail or no longer fulfil its functional task. De Laet and Mol's (2000) work on the Zimbabwe bush pump is an oft cited example of this point. The Zimbabwe bush pump did not retain stable network syntax as it was transported and implemented in different local communities. Yet, it maintained its function as a technology for providing water. As parts of the installed pumps broke down, they were replaced by other materials with similar properties. Thus, shape invariance was secured through constant and gradual displacement of network connections by new connections. The continuity of the basic shape of the bush pump thus became an effect of discontinuity (ibid).

It might be said that the bush pump constitutes a failed network as it changed its shape in both Euclidian *and* network space. However, according to Law and Mol (2001), it is the relationality between network components which is of central importance rather than maintaining a rigid network structure. Shape continuity, they argue, demands gradual change and attempts to maintain a perfectly stable network of constant, immutable relations is often likely to erode such continuity (Law and Mol 2001: 7). Rather than an immutable mobile, the bush pump constitutes a *mutable mobile* or a *fluid object* (ibid; see also Mol and Law 1994; Law 2002; Hetherington and Law 2000). Networks are thus conditioned rather than fully determined by their relations as "a relation might change without the term changing" (Anderson et al. 2012: 178). This fluidity indicates that a network assemblage may exceed the relations which hold it together at any one time (McFarlane and Anderson 2011). Neither the technologies through which territory is brought into being nor the territorial assemblage itself is reducible to the sum of their parts, and their parts cannot be reduced to the fragments of a contingent and provisional whole.

Centralised governance at a distance

The ability to mobilise and manipulate the world through translation and inscription carries a series of advantages for scientists interested in understanding the Earth and its systems of forces and matter. At the same time, the mobility that science affords to the otherwise chaotic and infinitely complex material landscape fundamentally alters the possible relationships that can be formed between knowledge, space, and power (see also Turnbull 1989). The scientific process of translating physical geographies into metrics, numerals, sketches, and diagrams makes a new set of movements possible. As Latour (1986) notes:

> you can go out of your way and come back with all the places you passed; these are all written in the same homogeneous language (longitude and latitude, geometry) that allows you to change scale, to make them presentable and to combine them at will (Latour 1986: 7)

By 'bringing places back' and concentrating them at centres of political power (what Latour terms 'centres of calculation'), it becomes possible to act upon them at a distance. Through the production of immutable mobiles, spaces can be made simultaneously present and absent at centres of calculation. Greenland, for example, can be made present in Copenhagen or Washington via maps or photographs, but Greenland nonetheless remains absent from these places as Greenland is neither a map nor a photograph. What you have is "the form of something without the thing itself" (Latour 1987: 243). Because of the linear perspective employed by scientists, two-dimensional spaces on paper can be made continuous with its three-dimensional referent. This effectively allows for the manipulation of distant spaces 'out there' through work conducted on paper from a centre (Latour 1986). An actual first-hand encounter is no longer necessary to 'know' space. Again, *reality* is separated from *knowledge of reality*. For Latour (1987), the synoptic view of aggregated, concentrated, combined *knowledge* held by those at the centre places them in a superior position of power compared to those who merely have a first-hand *experience* of distant or local geographies. What those at the centre might lack in terms of detailed understanding, they make up for in breadth of perspective and the amount of information they are capable of processing and navigating.

In order to capitalise on the power of inscription and gain a superior knowledge position, it is not sufficient to accumulate an ever-growing collection of immutable mobiles. After a certain number of circles of accumulation, it is inevitable that the sheer quantity of data will become unmanageable and then the synoptic position is severely compromised if not lost. To maintain a synoptic view of the elements of empire, paper needs to be turned into *less* paper (Latour 1986). The practice of photogrammetric mapping offers an example of this process. The 'raw data' brought back from the field consist of a series of partially overlapping photographs covering the landscape that is being mapped. Through complex mathematical procedures, these photographs are translated into topographical data with set coordinates which are plotted on detailed maps. Finally, these maps are distilled into maps of a much smaller scale which may provide a bird's eye view of vast stretches of land on one single piece of paper. This is a process which greatly accelerates the mobility of the geographical world and increases its navigability (Latour 1986, 1987). As Latour (1986) writes:

> a location can accumulate other places far away in space and time, and present them synoptically to the eye; better still, this synoptic representation, once reworked, amended or disrupted, can spread with no modifications to other places and made available at other times (Latour 1986: 10)

As such, scientific calculation makes it possible to represent territory (and its qualities) in a way that renders it stable and durable across space and time. Scientific calculation may thus facilitate a naturalisation of the spatial identity of the state and affirm its ontological constancy – it produces the territory effect. At the same time, scientific calculation leaves the qualities of the Earth at least partially open to being reshuffled in accordance with changing geopolitical goals and desires.

Geopolitics and the political geo

The clearest articulation of the ties between the processes of science outlined above and the production of a territorial ordering of space is arguably found in the example of cartography (see Chapter 2). For Latour (1987: 223), the geometric map represents an immutable mobile *par excellence* and a particularly "dramatic example" of a technology that makes spatial-political orderings, such as territory, appear durable and extendable through time. As noted in the previous chapter, studies in critical cartography have thus yielded significant insights into the calculative underpinnings of territory.

As indicated above with reference to Braun's (2000) study of geological surveying, territory is not reducible to area alone. Territory is vertical, voluminous, and irrefutably material and human beings exist *in* space, not just *on* it (Adey 2013; Ingold 2009). The wellbeing of humans is, in different ways, entangled with and dependent on the rich, voluminous qualities of the Earth we inhabit, both above and below the surface. Hence, territory – the space that sustains states and their populations as land and terrain – is not governed as area alone. While cartography is frequently used to portray the deep, voluminous qualities of territory as exemplified by the geological map, the practices of mapping these qualities are not reducible to those directly associated with topographical surveying (Braun 2000). Rather, a long line of other geoscientific techniques and technologies of measure and representation are involved in, and sometimes precede, the flattening of the geological world associated with the geological map. Consequentially, as will be argued below, the production of territory *with its qualities* cannot be fully comprehended by studying cartography and its associated practices alone. Topographical surveying may, as Hannah (2009: 68) points out, be the most basic activity aimed at achieving spatial legibility, but a whole host of other calculative practices are also involved in making space present, navigable, and actionable to states (see also Revel 1991; Scott 1998).

Depth and matter of territory

Recent geographical scholarship has sought to reconfigure the notion of territory to better account for its vertical and voluminous qualities. Many of the contributions to this redrafting of territory are explicitly influenced by Eyal Weizman's (2002) significant interventions in Open Democracy in which he unpacks the inherent verticality of the territorial struggle between Israel and Palestine (see also Weizman 2007). Weizman's (2002) interventions engage the hilly contours of the landscape at the surface, the networks of water and sewage that run beneath, the airspace above it, and the hidden systems of tunnels through which Palestinian insurgents move. He demonstrates how the territorial struggle unfolds across this myriad of overlapping geographies, vividly illustrating how practices directed at bounding and controlling political space take place across multiple axes – height and depth alongside extent. Weizman exemplifies this multidimensionality of territory by outlining how the Oslo Accords granted the Palestinian Authority control over a series of disparate political 'islands', but simultaneously separated these rights to the ground from rights to the substrata below and the airspace above, both of which remained in the hands of the Israeli state. For Weizman (2002, 2007), this underpins the limits to understanding territory in terms of two-dimensional representations of space such as the map.

Weizman (2002: n.p.) critiques geopolitics for being "a flat discourse" which "understand[s] place only in terms of the map and the plan". Instead, he proposes a stratification of territory into "discontinuous layers" of air, land, and underground. In the years following Weizman's intervention, the concept of verticality and the multiplicity of political dimensions have received mounting attention, in particular from scholars concerned with security and military geographies (Adey et al. 2011; Williams 2013). Stephen Graham (2004), for example, uses the case of urban warfare in Baghdad and Weizman's concept of 'optical urbanism' to illustrate how the scene of armed conflict is not limited to the surface. Hence, Graham argues, this conflict needs to be understood in terms of a 'vertical geopolitics' which extends both above and below the surface (see also Graham and Hewitt 2013; Graham 2016). Like Weizman, Graham (2004: 20) argues that "the classical, modern formulation of Euclidean territorial units jostling for space on contiguous maps" is insufficient to account for the complex practices of territory as terrain.

The territorial politics of the 'view from above' has been explored in rich detail in studies of airspace as an important site of both political contestation and warfare (e.g. Adey 2010, 2015; Adey et al. 2011; Graham 2016; Gregory 2004). More recently, the territorialisation of the depths of the ocean has been imbricated in such discussions (e.g. Steinberg and Peters 2015; Lehman 2013; Squire 2016a). Notably, these geographies are not simply vertical, but *voluminous* – as are Weizman's subterranean spaces of territorial contestation (Elden 2013b). Picking up on Weizman's vertical vision, Steinberg and Peters (2015: 251) recognise his success in breaking with horizontalism, but at the same time critique his approach for being "somewhat locked to a lateral vision" (see also Graham and Hewitt 2013). Thinking in terms of volume reveals how contestation and politics may have attributes beyond depth, height, or extent (Elden 2013b). Opening up multiple axes greatly increases the possibilities of relative position in space, which affords additional means of control (Bridge 2013: 55). As Steinberg and Peters (2015: 254–255) note, this does not only apply to spaces which readily present themselves as both depth and surface such as the ocean or, one might add, to a 'hollow land' where spaces of occupation are carved out of rock and soil (Weizman 2007). As demonstrated by Braun's (2000) study, this volumetric concept of territory may be extended to *terra firma* as well[21]. In other words, volumes which cannot readily be inhabited by human bodies may be equally open to territorial technologies of political control (Latour 1987: 225).

Concurrent with the growing focus on territorial volumes is a similar rise in engagements with the material, physical, and elemental properties of the world we inhabit (e.g. Barry 2013; Jackson and Fannin 2011; Squire 2016b). In his response to Elden's (2013b) call for an understanding of territory as volume, Adey (2013) calls for a more explicit engagement with the stuff and matter that these volumes consist of. Put differently, rather than replacing 'bounded area' with 'bounded volume', the stuff between the boundaries merits critical attention. As Elden (2013b: 45) rightly notes, "the complexities of volume cannot be simply measured along a third axis. Issues such as reach, instability, force, resistance, incline and depth matter alongside the simply vertical." To account for the voluminous, material qualities of territory in our conceptualisation of its production, it is necessary to adopt a more nuanced understanding of what it means to 'map' state space.

Geo-metrics, Earth Science, and the political geo

The 'stuff between the boundaries' that are drawn around territorial volumes are components of a richly textured and materially diverse Earth comprising an abundance of physical properties that human beings may utilise. As Steinberg and Peters (2015) note:

> A *geo*political understanding requires that we be attentive to the rich variety of materialities that constitute the volume in which we live, and how each of them enables and complicates the construction of territory whilst exerting power in multiple dimensions (Steinberg and Peters 2015: 251, original emphasis)

While the materiality of territorial volumes should not be granted deterministic powers, there are important ways in which the physical properties of space condition our interaction with it and thus shape the kind of territorial ordering that is constructed. Because of these

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[21] Notably, Braun (2000) does not use the language of volume. Rather, his discussion is centred on the production of what he terms "vertical territory". However, the voluminous qualities of territory are implied throughout his paper.

‘grounded’ qualities of territory, the question of territory’s production is effectively positioned somewhere between the human and the physical sciences. The social and political work that feeds into any territorial assemblage is only part of the process of the production of territory; a deeper engagement with matter and its geometricisation is called for. To establish a geo-political understanding of territory, the concept must be understood as simultaneously geopolitical *and* geophysical (Steinberg and Peters 2015). Researching territory’s production thus means researching how the geophysical and the geopolitical are folded into each other. As will be argued below, one of the instances where this entanglement of the geopolitical and the geophysical plays out is in the production of scientific knowledge of the Earth.

In a series of talks and lectures, Elden (2013d, 2013e, 2013f) aligns his earlier theories of territory as a political technology with the physical metrics of the Earth. Exploring the relationship between the Earth and measure, Elden argues that to understand territory, it is insufficient to study ‘Earth writing’ (geo-graphing). Rather, it is necessary to study ‘Earth knowledge’ and what he refers to as “the geometry of the political”; that is the political implications of calculative interpretations and interventions in the material world. To approach a richer understanding of territory, Elden (2013e) suggests that it might be productive to rethink geo-metrics beyond geometry as an abstract mathematical concept detached from the physical realm. He traces geometry back to its origins as a measuring of the Earth in relation to its application in ancient Egypt where geometric principles were applied to re-measure fields after the seasonal flooding of the Nile plane. Elden suggests bringing back this sense of geo-metrics as the measuring of the Earth, not only as it relates to land surveying, but in terms of the metrics of other earthly qualities such as quantities of oil, soil fertility, or air quality. Exploring the relationship between the geophysical and the geopolitical requires attentiveness to the multiple volumes, planes, and materials of the Earth and how earthly qualities are brought into the realm of political rationality. Territory, as a political technology that is directed towards the production of legible and governable geographies, requires an understanding of how the matter of nature is rendered amenable to political intervention through geometry and measure.

As human beings, we find ourselves in a world that is acutely material and where matter is constantly ‘doing things’ independently of our interference (Anderson and Wylie 2009; Anderson and Harrison 2010; Bennett 2010). The non-human world has its own intrinsic agency and forcefulness, and our survival as a species depends on our ability to negotiate these exigencies – for example by protecting ourselves from the elements and also drawing on them for strength, prosperity, and sustenance (Yusoff 2014; Westbroek 1991). Efficient and rationalised governance of territory following the logics of governmentality outlined earlier in this chapter is predicated on bringing the material forcefulness of a vibrant and inescapably physical and elemental Earth into alignment with the state's territorial politics – or, reversely, finding a way of attuning to the Earth's material vibrancy. Pickering (1995: 6–7) writes that "we should see science (and, of course, technology) as a continuation of [the] business of coping with material agency" for the purpose of survival. Following Pickering's logic, scientific practice enables a rationalisation of the material agency and forcefulness of the Earth and as such enables a rationalisation of the state's spatial practices, including the enrolment of physical geographies as land or terrain. Scientific calculation of the metrics of the Earth is thus a key technology of territory because it renders the physical world graspable and governable and allows for the naturalisation of the state's spatial policies by aligning an irrefutably social institution with something that is perceived as fundamentally natural (see Steinberg 2009; Brenner and Elden 2009).

Scientists of the Earth seek to develop detailed understandings of the material properties, forces, and dynamics of the physical geo (as Earth broadly construed). The aim of such scientists is to unveil the inner secrets of the Earth and create knowledge of how its elements and components act upon and within a system of complex multiplicities and fluxes (Frodeman 2000; Westbroek 1991). Whether or not the practices of such scientists are directly associated with state power, no such act of knowledge production is entirely apolitical (Demeritt 1994; Massey 2006). Wittingly or not, scientists serve as 'engineers of space' (Barry 1993) as their enactments of physical landscapes inevitably change what Latour (1987, 1999) might refer to as the landscape's network configuration. In other words, by enacting physical geographies in accordance with a series of standardised metrics, grammars, and codes of conduct, a particular set of spatial (and territorial) orderings, formations, and imaginaries are brought into being or reaffirmed. Hence, there is a point of intersectionality between the material and political aspects of space which is brought out in the work of geoscientists. Through scientific enactments, the Earth is brought into proximity with a concept of state space construed as the material foundation of the polity and thus the Earth is imbued with a set political existence.

The work of geoscientists engages the material on all thinkable scales, from the immensity of Earth systems such as tides and plate tectonics to the microscopic grids that hold minerals together. Science opens up new epistemological spaces and thus allows for the extension of governmental logics of territory not just across, but *through* matter itself. Territorial power thus operates through the body of the Earth as its deep, material qualities are brought within the reach of the state and thus enrolled into the known realm of territory. Like the human body, the Earth may thus be cast as both the object and the vehicle of power.

Capitalising on the political geo: drawing power from the Earth

As indicated throughout this chapter, the territorialisation of the physical world through science is a practice of ordering the chaotic multiplicity of a materially forceful Earth. In her exploration of the intersectionality between Earth and territory, Elizabeth Grosz (2008) argues that chaos and Earth are closely related. She defines chaos "not as absolute disorder but rather as a plethora of orders, forms, wills – forces that cannot be distinguished or differentiated from each other, both matter and its condition for otherwise, both the actual and the virtual indistinguishably" (ibid: 5). For Grosz, territory and Earth are similarly entwined. What sets territory and Earth apart is that territory has had something added to it which transforms it from the state of mere Earth. Territory is brought into being when the chaos of the Earth is enframed to reveal a discernible order. The enframing of Earth is inherently transformative as it brings forth selected qualities of the Earth and in the process adds new qualities to it by imbuing matter with new sets of meaning – for example, by designating a body of rock as 'radioactive'. For Grosz (2008), territory only emerges to the extent that its physical qualities can be exhumed. "There is", she writes, "only earth rather than territory until qualities are let loose in the world" (ibid: 102).

Grosz (2008) stresses the importance of thinking about territory as a relation of a geo that in itself is active rather than a passive platform for human action (see also Yusoff et al. 2012; Clark 2011, 2017). This, she argues, is key to understanding how power is not just projected onto or through the Earth, but is actively *gained* from capitalising on its material forcefulness. Proposing the notion of 'geopower', Grosz (2008) argues that political power is drawn from engaging the clashing and competing forces of the Earth:

> The chaotic indeterminacy of the real, its impulses to ceaseless variation, gives rise to the creation of networks, planes, zones of cohesion, which do not map this chaos so much as draw strength, force, material from it for a provisional and open-ended cohesion, temporary modes of ordering, slowing, filtering. (Grosz 2008: 8)

By its very nature, the totality of chaos cannot be mapped in the strictest sense of the word. Yet by outlining the contours of 'zones of cohesion' amidst the chaos, by enframing its underlying material order(s), a temporary and open-ended territorial ordering is brought into being which allows the state to capitalise on the material qualities of Earth. Such capitalisation may take on a variety of forms. Capitalisation on the Earth may concern relations of land[22] (e.g. resource extraction, farming, wind power), but it does not necessarily have to be 'economic' in a literal sense. The transformation of land into terrain may also be construed as a form of capitalisation as, for example, the contours of the landscape are utilised for tactical purposes. As a political technology bringing together land and terrain, territory is a spatio-temporal ordering of the physical world which renders it productive and thus allows states to draw on and over the latent powers of the Earth.

For Grosz (2008), science is not the only means of capitalising on the Earth; her primary interest lies with the "less serious cousins" of science, namely art and philosophy[23]. Yet throughout her writings, science remains a key mechanism through which the Earth is enframed and thus emerges as territory. Pickering (1995), on the other hand, explicitly notes the role of scientists in allowing humanity to capitalise on the material world and its non-human forces:

> Scientists, as human agents, manoeuver in a field of material agency, constructing machines that (…) variously capture, seduce, download, recruit, enroll, or materialize

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[22] On the commodification of nature, see for exmple Smith (2010), Castree (2003), or Robertson (2006).

[23] Following Grosz (2008), art and philosophy each has a role to play in territory production. Several scholars engaging territory and its significance have pointed to the affective and emotional ties between people and territory as key to the durability of territorial orderings (Paasi 1996, 2003; Penrose 2002; Forsberg 2003). Such ties may find expression through art and philosophy. This is, however, beyond the scope of this thesis.

> that agency, taming and domesticating it, putting it at our service, often in accomplishment of tasks that are simply beyond the capacities of naked human minds and bodies, individually or collectively. (Pickering 1995: 7)

This rendering of the work that scientists do supports and adds to Braun's (2000) thesis on how science extends the reach of the state beyond the spaces that humans can physically reach. Through the enrolment of prosthetic technologies, territory is extendable beyond the capacities of human minds and bodies (Pickering 1995; see also Grosz 2005). Territory and its material substance may thus be construed as a form of 'enhanced nature' (Knorr-Cetina 1992); it is Earth that has had something added to it. By drawing out a series of qualities, properties, elements that were previously outside human grasp, the matter of the Earth is imbued with a new resonance that allows it to reverberate beyond the confines of its own existence (Grosz 2008). As noted by Braun (2000: 28, original emphasis), "what *counts* as 'territory with its qualities' does not precede this construction". Territory is more-than-human, but also more-than-material as it does not precede the human act of 'counting'.

As pointed out by scholars such as Nigel Clark (2011, 2012, 2013), Kathryn Yusoff (2013, 2014), and Simon Dalby (2013), because of the material agency of Earth's elements, there are limits to the capacity of humans to order the physical world to suit their own agendas. The strata of the Earth have a pre-political existence which is philosophically significant in and of itself, and the Earth might not conform to political projects (Clark 2011, 2017). In the words of Clark (2013: 49), "there is an important sense in which the strata composed in the past are not simply ours to 'recompose'". However, as indicated earlier, capitalising on the political geo is not wholly predicated on 'recomposing' the Earth. For Grosz (2008), territorial order does not necessarily require a subjugation of the physical world. Power can similarly be drawn from the Earth by rendering its rhythms and forces predictable and accountable, thus making it possible to attune to its pulsations and material vibrancy. Put simply, knowledge of the Earth makes it possible to adapt goal-oriented practices so that they are 'in tune' with Earth's materiality – a process which Pickering (1995: 21, original italics) describes as "*a dance of agency*" between human and non-human actors.

Grosz's (2008) argument about the territorial politics of spatial legibility has merits beyond the arguments made in the previous section of this chapter because of her strict emphasis on the inherent fluidity of the material world. She not only retains an openness towards what kind of territorial assemblage might be carved from the Earth; she simultaneously emphasises its contingency and temporality (see also Steinberg and Peters 2015). As noted, earthly chaos is perforated by 'a plethora of orders'. Which 'ordering' of the material is rendered politically dominant and brought into prominence through its enactment – which forces and forms are observed in physical space as Gottmann (1973: 12) worded it – is an empirical question. The answer to this question lies in the meeting between the human and the material; the point of physical contact between humans and Earth.

Concluding remarks

When considering the production of territory in the context of a multidimensional and materially complex geo, it becomes apparent that physical geographies are not simply incorporated into state space through practices of bounding. Although borders are powerful constructs in terms of communicating and performing jurisdiction, the political technologies that make up territory work in ways that are not strictly dependent on borders. The geography of the 'territory effect' fundamentally differs from the geographies of its production, which may reach across both space and time and relies on a suite of governmental technologies directed at rendering space calculative, abstract, and governable (Painter 2010).

Applying Grosz's (2008) insights on geopower to Latour's (1999) and Elden's (2007, 2010a) conditions for spatialised governance suggests that the *geo*sciences may play a privileged (albeit not comprehensive) role in the formation of territory. In many if not all cases, capitalising on the geo in relation to political-economic and political-strategic concerns will be dependent on the production of legible and thus actionable geographies. Territory in this sense is a political technology directed not just towards space, but towards the geo, the Earth. It is a geo-political question, a question of an earthly politics. The ontological politics of territory is thus a politics which concerns the framing of the political geo (as both space and Earth), how it is being "pushed and pulled into one shape or another" (Mol 2002: viii). A crucial question in relation to the problem of territory becomes *how* Earth is made available for capitalisation and economic and political calculation. This is closely related to geoscientific practice – a series of worldly interventions, which enact the object of analysis in accordance with standardised codes. Scientific enactments of the material Earth open up spheres to politics, allowing for the extension of power onto and through the body of the Earth beyond the spaces that humans can physically inhabit. It makes the Earth extendable into new contexts and enables a series of re-compositions of the Earth. Science is thus a central aspect of how geo becomes political.

Drawing on Elden's insights, territory will be understood in terms of a series of political technologies directed at the production of abstract, legible, governable geographies. This thesis approaches this as a process through which the material Earth is enacted *in accordance with a set of political goals* (cf. Latour 1987). A principal set of technologies informing and shaping this process is found in the geosciences (cf. Braun 2000), and power is gained from aligning the state with the physical Earth (cf. Grosz 2008). What emerges is a spatial ordering, an assemblage, which may appear stable, but is inherently ephemeral and holds within itself the potential for being other (cf. Steinberg and Peters 2015). Despite an appearance of stability, the work involved in (re)creating this 'territory effect' is continuous and repetitive. As noted by Painter (2010: 1105), "[d]elimitation, contiguity and coherence have to be constantly reproduced to sustain the effect of territory through time". The durability of territory stems from a myriad of networked practices – the ordering is embedded in durable materials such as a built environment (cities, infrastructure, physical borders), the everydayness of state practices/the daily performance of the state of its citizens (Painter 2006b), and not least the technologies which anchor the state itself to the physical ground.

Territory relies on a complex ecology of actions of which geoscience makes up but one set of aspects. What makes geoscience particularly significant is that it 'naturalises' territory by establishing a link between the state and the physical world which is forged as the latter is subjected to practices of calculation and abstraction. In this sense, geoscience is a technology which rationalises the very existence of the state as a spatially and materially anchored institution. The rationalisation of the state and its practices that comes from the building of vast governmental networks of knowledge renders the state more efficient and greatly expands its political reach (Braun 2000). Additionally, such rationalisation is also a rationalisation or concretisation of the state itself as a geopolitical 'unit' of authority (Shah 2012). Similar to cartography, geoscientific practices may be mobilised to anchor the state to the material Earth – it *grounds* territory. Such practices of grounding are manifold and varied, and the spatial realities invoked are bound to be quantitatively as well as qualitatively different.

Keeping territory as an open question is to be open with regards to what kind of ordering might emerge as well as the process of its emergence. As will become apparent over the subsequent chapters, the emphasis on 'political goals' is important. Elden (2013a), Sassen (2006), and Strandsbjerg (2010) all emphasise that there are different 'modes' of territory, but they restrict this line of thinking to the quite drastic shifts in the underlying spatial ontology. They seem to agree (Strandsbjerg and Elden more so than Sassen) that different spatial realities set different possibilities, modalities, and conditions for power. The 'spatial reality' of any would-be territory depends on its enactment (Hinchliffe 2010; Mol 2002), and *how* territory is enacted will be conditioned by a series of geopolitical and contextual factors. Depending on the geopolitical circumstances (and by extension the objectives) of territory formation, science is enlisted in different manners (different disciplines, metrics, prosthetic technologies, sets of expertise). As a result, one might expect that the construction of territory through scientific practice reveals different aspects of territory's underlying mechanisms. Different epistemic rules guide each discipline, and this determines how space gets written. The Earth enacted by the geologist, for example, is not the same as the one brought into being by the Earth scientist. What brings about the 'territory effect' in any given case cannot be assumed; it is an empirical question (cf. Law 1992). A whole series of questions thus arise concerning how calculative knowledges, sets of expertise and prosthetic technologies may be stacked together in different ways to make space intelligible. Over the remaining chapters of this thesis, these questions are addressed empirically by doing a comparative study across two different moments of territory production.

4. Methodological Reflections

Engaging the territorial archive

At the heart of this research stands 'the archive' in its inherent multiplicity: a repository of historical data, a destination, a practice, a mode of being, abstraction and metaphor, and a political technology in its own right. With his blunt observation that "the dead don't answer questionnaires", Baker (1997: 231) points out that the historical researcher, at a very fundamental level, depends on the recorded materials of archives. However, in relation to the question of territory and its formation, the archive is not merely a source of data or, to use a Latourean term, an obligatory passage point on the path to 'knowledge'. As noted by Richards (1993: 8), it is routinely taken for granted that the existence of any form of political power requires an underlay of documents, memoranda, licenses, and files used to organise, communicate, and affirm it. Similarly, the political technology of territory requires some archive. As will be argued below, archives and archival practices are themselves embroiled in the territorial process and are thus worthy of some consideration.

This chapter is written from an understanding of archives as sites of authority and meaning and as sites of geographical significance as opposed to unproblematic sites of either historic truth or knowledge production (Withers 2002: 303; Livingstone 2006). The chapter is an account drawing on days, weeks, and months spent attempting to extract meaning from archives, libraries, and museum collections situated hundreds of kilometres apart and embodying different social, institutional, and political norms. If, as Joyce (1999) suggests, the politics of archives is made present in the encounter between researcher and archive, then my experiences of archival spaces may be construed as a modest insight into the workings of institutions which play an active role in the making of territory. This chapter is written as a partial account not only of working in archives but also of constructing one, both in the form of this thesis and the dataset I compiled from the archives I visited as I sought to piece together and make sense of the surviving records of two parallel histories of exploration of Greenlandic physical geographies.

'The archive' as a political technology

Much academic labour has been devoted to the question of what the archive is, how it works, and what social, cultural, and political functions it performs. For some scholars, the archive holds the key to liberation and redemption of those whose voices and histories have gone unheard or untold. For others, it serves the opposite function as a tool of imperial power, colonial hegemony, and cultural oppression (Stoler 2009; Ballantyne 2001, 2005; Richards 1993). As the material and symbolic underpinnings of national memory, archives are cast as a political technologies of liberal governmentality (Joyce 1999), as "monuments to particular configurations of power" (Stoler 2007: 270; Foucault 1972; Steedman 2002), and as expressions and metaphors for the political apparatus of the state[24] (Edney 1997). What these accounts have in common is that 'the archive' is viewed as inherently political. The archive, in the words of Joyce (1999: 38), "is a place where authority resides".

Archives continue to serve important social and political functions. As a political technology in its own right, the archive orders the past through processes of selection, classification, and indexation in manners which influence how history gets written (Velody 1998; Ketelaar 2001). The archive is an apparatus which selectively collects and orders traces from the past which are "stained toward the future across a fabled present, figures we inscribe because they can outlast us, beyond the present of their inscription" (Derrida 1989 quoted in Till 2001: 70). As such, the archive communicates a sense of national and historical cohesion; it is a site where time and

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[24] Notably, not all archives are state archives. Archives may, for example, be owned and managed by private or corporate institutes and this arguably affects their political function. While some of the collections that this thesis draws on were assembled by private citizens or curated by institutions with their own corporate agendas, all the archives, museums, and libraries I consulted had a direct state affiliation. Hence, my approach to the abstract notion of 'the archive' throughout this chapter reflects that.

space are compressed and the national past is folded into both its present and its future (Manoff 2004; Till 2001; Sahadeo 2005). The archive is thus an important avenue through which state and nation are brought into alignment through evidence of a shared history, and the built structure of the archive itself gives physical form to the 'memory of the state' (Joyce 1999). As monuments to national memory and sites of active remembrance, national archives are often housed within impressive structures such as the awe-inspiring Greek Revivalist National Archives building in Washington D.C. – a popular tourist attraction complete with the public display of iconic founding documents and an extensive gift-shop[25]. Such buildings represent the drive to not only preserve, organise, and collect the national record (Manoff 2004), but also to communicate and monumentalise the idea(l) of national coherence.

In the archive, memory becomes an act of coordination (Robertson 2005). This is key to what makes the archive a powerful governmental technology (Joyce 1999). The archive does not merely store data in a neutral fashion. Within the archive, data is collected (or discarded), curated, and catalogued and thus organised into meaningful arrangements. The form and structure of the archive is coloured by technologies of record keeping, filing, and storage (Kurtz 2001; Robertson 2005; Manoff 2004). Through acts of classification, codification, and indexation, record-keepers actively create orders of value and systems of meaning (Sahadeo 2005). The identity of any referent is transformed through the process of being filed. Documents become signifiers which speak to set indexation markers as they are removed from their original context and become part of a network of referents which are deemed to be similar or related (Bowker and Star 1999). In this manner, "objects captured by archival practices are transformed into knowledge" and, by extension, into history (Robertson 2005: 70). The archive is, as Lynch (1999: 67) points out, "never 'raw' or 'primary'". As a system of meaning already assembled, the archive constitutes a "system of discursivity" which conditions what can and cannot be said (Foucault 1972: 129). The methods through which information about archival collections are transmitted thus actively shape the nature of the knowledge that can be

[25] The gift-shop sells 'archival kits' for researchers, thus encouraging visitors to actively engage the nation's past. Paradoxically, these kits are explicitly listed in the security information presented to researchers under items which are prohibited in the reading halls.

produced. As such, a system of classification and indexation produces history as much as it records it (Manoff 2004).

According to Osborne (1999), the archive shares certain characteristics with Latour's (1987) centres of calculation – i.e. sites where traces from faraway places are drawn together, organised, and condensed into a distilled and manageable form and territory comes together as a coherent and actionable whole. The archive, for Osborne (1999: 52, original italics), is a "*centre of interpretation*" where order is brought to a messy and unruly history. Such organisation may, according to Richards (1993), be considered inherently territorialising. In his book *The Imperial Archive,* Richards (1993) unpacks a series of archival logics and practices which he argues were crucial to the functionality of the British Empire. The British Empire, according to Richards, was built upon its growing archives of geographical knowledge (human, cultural, and physical) which were used to subdue excessive elsewheres by bringing the dangerously unknown into the familiar realm of territory (see also Edney 1997; Stoler 2009). The state, in Richards' account, may itself be considered 'archival' as it is rooted in a fantasy of controlled information where the archive functions "both to imagine territory as representation and realise it as social construction" (Richards 1993: 16).

As noted in the previous chapter, centralised governance at a distance is based on a political ontology of space (and its organisation and management) which is 'scientific' in origin (Latour 1987; Strandsbjerg 2010). Territory, it was argued, works as a political technology of calculation through which the state seeks to bring the Earth into alignment with a set of geopolitical goals; it represents an ordering of the political geo with its own inherent social and material politics. If, as Richards (1993) claims, the state is inherently archival because it is rendered functional by bringing an imagined sense of order to the social and material realm, then scientific practice may be conceived as similarly archival. As argued in the previous chapter, scientific practice is a practice of ordering the chaos of an infinitely complex physical world by means of its division into distinct, physiological categories (Prigogine and Stengers 1990). This is what makes science effective as a political technology of territory. Furthermore, as will be discussed below, the production of scientific knowledge both draws on and constructs archives (Edney 1997). In this sense, territory may be seen as an effect and a product of the archive (in its inherent multiplicity) and the practices which feed it. Hence, this thesis could be construed as research on and of archive-making as it draws lines of connectivity between the archival state and the scientific practices through which the Earth is archived in order to link both to the production of state territory.

Tracing fragments: navigating the archival maze

Reflecting upon the practice of doing archival work, Lorimer (2009: 251) notes how his first encounter with the archive gave him "the distinct impression that 'the archive' was somewhere between a labyrinth and an impregnable fortress." "Escape", he writes, "was not an option." Initially, tracing the fragments left behind by my chosen US and Danish expedition series in Greenland seemed no less overwhelming. Even the process of locating and narrowing down the list of relevant archives proved a challenge. The scientific contributions made by the two expedition series could, at least in their distilled form (i.e. field reports and scientific records), largely be traced back to two main institutions: The U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL, formerly SIPRE) and De Nationale Geologiske Undersøgelser for Danmark og Grønland (GEUS, Geological Survey of Denmark and Greenland, formerly GGU). Despite the significance of these collections both as sources of data and arbiters of territory (a topic I will return to below), the type of data that they offered was limited. Traces of institutional politics and decisions which had informed the fieldwork and related information which spoke to the experience of being in the field were scattered across multiple locales, not all of which could be located or accessed. In particular, records from the US expeditions were highly dispersed since many of the scientists involved retained affiliations with academic institutes in their home states where some of their records subsequently ended up.

Working with archival materials means working with fragments and making more or less informed choices about where to go and which collections to include or leave out (Till 2001). The work of (re)assembling the two sets of expeditionary histories involved physically drawing together traces and fragments which had been dispersed geographically across states, countries, and even continents. My data collection took place in Denmark, Greenland, and across four US states and involved a total of eleven archives, libraries, and records collections (see Tables 1 and 2). As will become evident throughout this chapter, some of these archival encounters were carefully orchestrated, others less so. The eleven locales were selected based on an extensive scouring of online archival indices, references in published records on Cold War science in Greenland, as well as correspondences with archivists, librarians, and academics specialising in

Cold War Arctic science studies[26]. Since Cold War history is exceedingly popular amongst amateur historians, a significant quantity of archival material from this era exists in digital form. Hence, I was able to access digitised copies of a selection of documents and accounts relevant to my case studies. This proved invaluable in identifying keywords which informed my search of archival indices. For example, I found that the mountain complex where the Danish uranium prospecting took place was referred to by multiple different names by politicians and scientists. I was also able to identify the names and affiliations of the key individuals involved in the planning and execution of both the Danish and US expeditions.

Archives often have limited resources for indexation. Hence, it was often impossible to know with any degree of certainty if an archive housed the kind of data I was looking for. For example, before travelling to Copenhagen, I knew that Rigsarkivet (the Danish National Archive) had collections from the Danish Atomic Energy Commission and the Greenland Geological Survey, but I knew nothing of their content. At the University Archive in Nuuk, my contact informed me that the archive "most likely" held records that matched my search criteria, but told me that if I wanted to know more, I needed to come to the archive[27]. In this

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[26] I am exceedingly grateful to the people who set aside time to meet and correspond with me to offer me valuable insights into the storing and the politics of polar archival materials.

[27] Travelling to Greenland to talk to an archivist who made no promises might seem excessive. However, at the early stages of my research, I also aimed to obtain interview data with Greenlandic politicians and policy makers about the relationship between geoscience and current territorial imaginaries that inform the idea(l) of Greenlandic independence as I wanted to draw connecting lines between my historical research and the present. I never obtained such data since the impeachment of the then Premier, Aleqa Hammond, led to the Greenlandic Government being overthrown only days after my arrival (see Nunatsiaq News 2014). Subsequently, none of my contacts were available to see me. I did not follow up on this line of inquiry as my research progressed in a different direction.

Although the data I obtained in Greenland ended up being of minor significance to my thesis, hiking the mountains that the geologists praise in their accounts, sailing the fjords, and flying over the seemingly endless Greenland ice sheet was inspirational. The time spent in Greenland was a potent reminder that space is more than an abstraction. As Lorimer (2009: 257) notes with reference to the significance of experiencing landscapes, "it might be said that archival method is boosted by a vivid imagination and an ability to inhabit imaginary, or parallel worlds".

sense, my archival research involved a structured leap of faith and a certain degree of willingness to try at the risk of failure.

Archive/library	*Collections*
National Archives and Records Administration (NARA) Site II, College Park MD	U.S. Army Transportation Arctic Group: Historical records and reports. Reports and other records relating to the Greenland ice cap traverses, 1953–1957. Records relating to polar activities in Greenland, 1953–1957. 1957 Corps of Engineers Greenland Research Program. Palle Mogensen Papers. Amory Hooper Papers. Philip M. Smith Papers. Motion Picture Records, Operation Ice Cap.
National Archives at Boston (NAB), Boston MA	Organizational History Files (SIPRE). Greenland Files.
Elmer E. Rasmuson Library, University of Alaska Fairbanks (UAF), Fairbanks AK	Carl S. Benson Papers.
Rauner Special Collections Library, Dartmouth College, Hanover NH	US Army Snow, Ice and Permafrost Research Establishment (SIPRE) Record.
Cold Regions Research and Engineering Laboratory Library[28] (CRREL, formerly SIPRE), Hanover NH	Operation Ice Cap field reports, Official SIPRE reports (digitised).
Miscellaneous	Oral History Interview (w. Carl S. Benson). YouTube (Operation Ice Cap promotional films). Digitised records from the US National Snow and Ice Data Center.

Table 1: Archives and collections consulted regarding Operation Ice Cap and Project Jello.

[28] As I was refused security clearance to enter the CRREL building, materials from this library were, with the help of an external librarian, sent to Lamont Library, Harvard University.

Archive/library	*Collections*
Rigsarkivet (Danish National Archives), Copenhagen	Grønlands Geologiske Undersøgelser Collection. Atomenergikommissionen Collection. Forsvarets Forskningsråd Collection. Vilhelm Valdemar Mouritzen Collection.
Statens Naturhistoriske Musem (the Danish Natural History Museum), Copenhagen	Arne Noe-Nygaard Collection. Henning Sørensen Collection. Assorted materials (unfiled).
De Nationale Geologiske Undersøgelser for Danmark og Grønland (GEUS; Geological Survey of Denmark and Greenland; formerly GGU), Copenhagen	Subterranean Archive Collections.
Den Sorte Diamant (The Danish National Library), Copenhagen	Media Records (micro film).
Polarbiblioteket (The Polar Library), Arktisk Institut, Copenhagen	Reports from Forskningscenter Risø.
Ilisimatusarfik/University of Greenland Archive, Nuuk	Greenland Administration Records. Grønlandsposten. Tidsskriftet Grønland.
Miscellaneous	Digitised periodicals from Tidsskrift.dk. Meddelelser om Grønland (lit. 'Reports on Greenland'), available from Bill Bryson Library, Durham University. Dansk Udenrigspolitisk Institut (1997b), archival data collected and published by the Danish research institute, Dansk Udenrigspolitisk Institut, as part of a state-prompted investigation into American use of nuclear materials in Greenland during the Cold War.

Table 2: Archives and collections consulted regarding the Danish uranium prospecting of Ilímaussaq.

Emphasising the fragmented nature of archival records, Steedman (2001: 1165) writes that working with archival material requires the ability to "conjure up a social system from a nutmeg grater" since no record is ever complete. Beyond the national and institutional politics which determine what gets archived and thus becomes part of national and local records, decisions about what is initially sent to the archive are, as noted by Robertson (2005: 69), often made by individuals for whom these documents have been everyday files. In such cases, what is preserved as part of history cannot be reduced entirely to an ordered governmental process as it depends on both personal choices and elements of chance. For example, in his autobiographical account of Operation Ice Cap the designated expedition historian notes how his own personal archive documenting the expedition was destroyed with the flooding of his parents' basement where he kept his files. He further notes how official records were lost when a fellow conscript, who was supposed to transport them to the Transportation Arctic Group headquarters in Willamette, forgot the records in a locker at the New York railway station from where they subsequently went missing (Boskin 2011).

In spite of its necessarily fragmented nature, I ended up with a rich dataset comprising institutional, personal, and political accounts of the two expedition series. Rigsarkivet houses institutional collections of the Greenland Geological Survey, the Danish Defence Research Establishment, and the Atomic Energy Commission. Similarly, fragments of the institutional records of SIPRE and the US Army Corps of Engineers were located across the National Archives and Records Administration (NARA) in Washington DC and Boston as well as at the Rauner Special Collections Library, Dartmouth College. In addition to the records compiled by the institutions involved in the exploration, several of the key figures in both the Danish and the US expeditions had, prior to their deaths, compiled private collections of documents detailing their research careers and gifted them to institutional and state archives. In these cases, the content of the files was determined by which materials the scientists had held on to through the years and what they personally saw as significant. As such, it is quite possible that they left out material which they perceived as somehow compromising their preferred version of history or material which they simply felt was too banal to be worthy of preservation.

My archive of archives

The institutions, scientists, and archivists who compiled the collections I consulted were not the sole curators of my dataset. As noted by Robertson (2005: 77), "[i]n writing about the past, we all produce our own archive". In this sense, the archival research that this thesis is based on represents my personal attempt at reducing endless heaps of paper, photos, and film from the eleven archives I visited to a manageable form and impose my own classificatory systems upon them. Like a scientist in the field, I documented photographically everything that I considered a significant trace. I noted my observations, and assigned each photograph classificatory markers so that it could be traced back to its point of origin. Whilst working in the archive, I gradually constructed my own system of classification corresponding with the aims of my research and the insight I gained from the files I encountered. I used this system to assign each document (my 'samples') a series of classificatory markers to make my growing dataset navigable for future analysis.

As noted in Chapter 1, the aim of this thesis is to interrogate how geoscientific practices function as geo-political technologies of territory and how mechanisms of territory were expressed through the scientific exploration of Greenland during the early Cold War. Hence, my archival research was aiming to locate evidence of the scientific processes and practices surrounding my two case studies. I sought data which allowed me to extrapolate information about the epistemic rules which guided how Greenlandic physical geographies were written, which signs and signifiers were construed as significant, how different knowledges (sets of expertise) and apparatuses were stacked together to create legible geographies, and how different elements and dimensions of the physical world were brought into conversation with each other. The principal sources of information used to address such questions were field reports (scientific and logistical), laboratory reports, institutional bulletins and reports, scientific publications, field journals, personal diaries, and memoirs.

Although my emphasis was on scientific practice, primarily in the field, it was still necessary to build some understanding of the political and institutional climate within which the fieldwork was embedded. Decisions on which practices were implemented in the field were directly impacted by such politics. For example, I found that the choice of technologies used to map the radioactivity of Ilímaussaq rested on political as much as scientific grounds (see Chapter 5). Such politics also provides information about the interpretive lens through which Greenland's physical geographies were viewed. As noted in the introductory chapter, the political climate at the scale of the state has been well documented with direct reference to scientific exploration of the North, both by the Danish and the American state. To establish a sense of the more immediate circumstances impacting the two scientific programmes, I consulted communications (letters, memos, transcripts), minutes from meetings of the parties involved, and personal diaries and memoirs of key figures. Finally, to build my knowledge of the popular significance ascribed to the expeditions, I consulted media and news archives. In addition to newspaper articles and photographic material for both the Danish and US expeditions, I accessed the extensive collection of movie reels recorded by the TRARG and SIPRE during their work in Greenland, which documents the scientific practice as well as the daily life of US conscripts and scientists in Greenland (e.g. Army Pictorial Service 1953, 1954; Army Audiovisual Center 1954).

My analytical strategy drew on the work of STS scholars such as Latour (1999), Law (1994, 1999), and Mol (2002) as outlined in Chapter 3, but it was also directly inspired by relational materialist geographies (Harrison and Anderson 2010; McFarlane and Anderson; Anderson et al. 2012). In particular, what I take from this literature in terms of my methodological approach is its emphasis on the significance of material practice in world-making and the insistence that the agential forces of the physical world are embedded in any such project. Representation, however, remains a significant part of the practices of any kind of science. As noted by Pickering (1995: 7), "one cannot claim to have an analysis of science without offering an account of its conceptual and representational dimension". Hence, much of the analysis which will follow in the subsequent chapters is directly concerned with the texts, images, and other representations that emerged at different stages of the process of translating Greenlandic landscapes in terms of land and terrain.

Most of the analysis presented in subsequent chapters of this thesis did not take place in the archives where the original data is stored. Rather, it happened after the data had been re-contextualised as part of my own archive of archives which spoke to the research agenda that I had put forth. Back in my own office, the process of ordering chaos continued. My attempt to create order within my newly digitised archive was not always successful as I found myself confronted with the irrefutable materiality of the digital (see Amoore 2016). The dataset I had compiled was of a considerable size (measured both in number of photographs of documents and in megabytes of data). Its sheer size undermined several attempts at using NVivo coding software as a means of further cementing the structural order I had started to build in the archives – the programme kept crashing under the pressure of the dataset[29]. Although I had left behind the archival dust (Steedman 2002), the vastness of the material archive had followed me home, albeit in a different form, thus underlining the interlinkages between the virtual and the material archive. Circumstance prompted me to expand on my 'analogue' coding system,

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[29] The problem not only pertained to the software itself; it also resulted from the limited storage space that I was allocated by the university IT-services. IT-services could only allocate a set number of megabytes of additional storage space per request, and each time NVivo crashed, it deleted all prior work. This meant that every attempt came with a risk of losing days and hours of coding, and I decided that this risk was too high. As such, the coding of my dataset was influenced by university policy as well as the materiality of the digital.

which came to include print copies of key documents occupying the floors and walls of my home and office in seeming defiance of the idea(l) of archival order.

Pickering (1995: 5) notes that reflexivity turns the methodological fears in science regarding the adequacy of scientific representation back upon science studies itself. Similarly, there is a subtle irony in researching and writing about scientific practices seeking to bring order to an unruly Earth by following and practicing a very similar epistemology. Like any scientific fieldwork, this research is based on a series of contingencies and practical decisions. These decisions were sometimes based on more or less arbitrary choices and were, at other times, highly situational, made in response to events and circumstances beyond my control. In this sense, the imperfect nature of my enactment of the territorial archive parallels the confluence of structure and its antithesis that brings territory into being.

The geological archive

What is considered a legitimate contribution to the archive changes over time (Burton 2005). One archivist working for Rigsarkivet informed me that the archive tended to give less priority to the preservation of scientific documents than to other textual records. However, this does not mean that there is no space for such records in Danish national memory. Rather, scientific records are allocated their own dedicated space as part of the active records of GEUS. Similarly, reports and other scientific documents pertaining to the US exploration of Greenland now form part of a vast archive of geological knowledge which is constantly growing, changing its meaning and shape, as new information is added and old knowledge discarded or reframed[30]. These geological archives are very much alive.

The archival collections of GEUS and CRREL are stored in nondescript office buildings, and neither is freely accessible to the public. Unlike other state archives, the social function of these archives is not to ensure the existence of a national population or a national history (see Joyce 1999), but rather to quietly affirm the deep, spatial underpinnings of the state – the existence

[30] The CRREL library is not the only US institution which stores such collections. Another notable example is the US National Snow and Ice Data Center.

of a coherent 'supporting ground'[31]. The archiving of the Earth comprises a mode of organisation which naturalises the powerful abstraction of a coherent, contiguous identity of the national geobody (see Latour 1987). If we concede that a scientifically anchored national geobody is a key aspect of territory (as suggested in the previous chapter), then the geological archive functions as a site which affirms, grounds, and naturalises this connection between state and Earth – not unlike the geological museum.

Archives may be heavily securitised spaces. This is particularly true when the archive has a military affiliation. Still an active research institution, CRREL sits somewhere between a civilian and a military facility. Citing my Danish citizenship as the reason, I was refused the necessary security clearance to access the CRREL collections *in situ*. Notably, the concern was not with the records themselves, but rather with the library building. What required protection was apparently not simply the records, but rather the apparatus which keeps them alive. With the help of an external librarian, I was able to access the records by having them sent to the Lamont Library, Harvard University[32]. Due to my limited access to CRREL, the following reflections are based on my experience working at GEUS.

As noted by Edney (1997: 41), "[t]he process of knowledge creation presumes some archive – literal or figurative – to which all new knowledge can be related". This process, in other words, requires something to draw and build on, compare with, and position in relation to. Knowledge of one part of the national geobody is valued both in terms of its specificity and in terms of its worth for the structuring of geological knowledge writ large (ibid). The geological archive and the filing cabinet where traces of the geo are organised thus play a significant role "in enabling a mode of representation where the powerful abstraction of coherent, organizational identities could be more readily imagined and naturalized" (Kurtz 2001: 34). In the GEUS collections, geological bodies are arranged by order of physical properties ascribed to each of them by

[31] A 1955 addendum to SIPRE's mission statement explicitly list as one of its main responsibilities that it "[d]irects literature search, maintains library facilities, compiles and disseminates annotated bibliographies, translations, etc. on snow, ice and frozen ground" (SIPRE 1955). In other words, the archiving of the geo was a central function of this institution.

[32] Since CRREL does not exchange data with institutions abroad, it was not possible to have the records sent to the UK. I am exceedingly grateful to librarian George Clark for his invaluable assistance.

geologists working in fields and laboratories. Characteristics such as the presence of uranium become structuring devices in quite a literal sense as uranium becomes a signifier and a classificatory marker that determines how a body of rock is filed and catalogued. This organisation not only establishes a visible link between bodies which may be many kilometres apart; it also conditions future geopolitical interaction with said body of rock which has been framed by the archive as radioactive.

Hallways adorned with images of an Earth effortlessly stripped of its upper strata (and of any signs of human inhabitation) affirm the thoroughly subterranean outlook of this institution. As such, the collections at GEUS did not contain material deliberately documenting the life of scientists or institutional politics. I was informed that all such documentation was handed over to Rigsarkivet, where it was either filed or destroyed depending on its 'value as history'[33]. As noted, the GEUS archive is not open to the public. In fact, according to GEUS' website, GEUS has neither an archive nor a library. What GEUS does have is their internal "subterranean collections", which contain documents that are considered of 'scientific' rather than 'historic' value. Field reports, field notes, calculations, and original hand-drawn maps are kept in house because they continue to inform ongoing research into the national subterrain[34]. The subterranean collections thus represent a 'model of duration', continually updated and kept alive as scientists (re)enact it by positioning old records in relation to new epistemic frameworks, each time reaffirming the link between state and Earth. This process rests on what Robertson (2005: 82) calls "an archival logic of anticipation", which requires information to be easily retrievable. The geological archive is premised on and embodies an "archival pact with the future" (ibid: 83) established through the archival rationalisation of subterranean geographies whereby evidence is classified and ordered for the purpose of creating a productive geo – or a geo that has the potential to become productive. In this sense, the archival rationalisation is founded on the anticipation of a future need to know. Based on a view of science as an accumulative practice, the subterranean collections at GEUS structure geological

[33] This claim is based on conversations with the collections administrator at GEUS as well as a researcher/archivist working for Rigsarkivet.

[34] My contact person at GEUS informed me that GEUS regularly hosts visiting researchers who come in to view their records.

records to produce a clearer, truer image of the subterrain and its possible futures. Due to this liveliness, the geological archive "affirms the past, present, and future; it preserves the records of the past and it embodies the promise of the present to the future" (Manoff 2004: 11).

The handling of records from GEUS' subterranean collections was not subject to any of the rigid restrictions of other archives I worked in. It was, however, marked by an expressed need to protect the interests of the state. As the material I accessed pertained to a potential national resource, I was not permitted to take photographs of the scientific reports although they were long declassified because instrument readings and calculations might, according to my contact, be of strategic value to private interests[35]. Nonetheless, I had permission to write down anything I wished, suggesting that perhaps the performance of security was of greater importance than achieving it. As noted by Richards (1993), keeping strategic knowledge under the jurisdiction of the state is a central aspect of imperial power as it provides the state with an effective monopoly to capitalise on the Earth, be it for strategic or for economic reasons. While they had all since been declassified, the scientific reports from the GGU's fieldwork at Ilímaussaq had initially been restricted. Similarly, reports and information pertaining to Operation Ice Cap and the Jello trek were initially classified as "confidential", "top secret", or as "secret security information", explicitly citing their importance as objects of national security as the reason behind these classifications.

Archival encounters

Archives can, as Rose (2000: 558) observes, be very different kinds of places and may thus influence the production of archival knowledge in each their own manner. In assembling my dataset, I worked across national archives, university records, museum collections, and the geological archive discussed above. Each was marked by its own distinct ecology, culture, and politics ranging from the almost militant discipline of NARA to the less structured University of Greenland Archive where I learned the true meaning of the popular Greenlandic word *ajungilak* (meaning 'it will be fine, take it easy'). The archive is not reducible to an inert

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[35] Notably, I was given permission on site to take photos of the personal field diaries and field drawings which are reproduced in this thesis (see Chapter 5).

repository or a technology which provides order and structure to history; it is also a 'mode of being', an embodied practice, which is configured through the encounter between archive and researcher (Steedman 2002). Hence, what Lorimer (2009: 249) calls "archival hermeneutics (…) include the context, encounters, and events that constitute research practice". The embodied experience of archival encounters impacts the narratives that researchers construct (Burton 2005) and also animates the politics of the archive – a politics which is always present in the researcher's encounter with archives and archivists (Joyce 1999).

Archival structure

As previously noted, the archive may be considered a disciplinary apparatus which works on documents and researchers alike, conditioning the relationship between them, and thus affecting the writing of history (Foucault 1972; Rose 2000). In many ways, my archival encounters affirmed this understanding of the archive as a highly formalised geography, albeit one which took on different forms.

The 'archival grid' not only serves as a structuring device for organising history. At Rigsarkivet, this grid also appeared to work as a means of keeping account of what kind of data was being accessed, what it was used for, and how it might be disseminated[36]. Accessing the collections I was interested in involved a time consuming application process where I had to elaborate on the purpose of my research, modes of dissemination[37], and a statement of what each box I wanted to access contained. The latter information was stored on small handwritten cards at the archive, the so-called *journalnøgler* ('record keys'), which noted the curator's impressions of the files at the time of indexation. The application process took several months and was delayed multiple times as I was asked to clarify parts of my application. From its online presence, it is clear that Rigsarkivet prides itself on being an open and welcoming institution, and it is noted on its website that the vast majority of applications are approved. Yet, the disciplining effect of the archival grid of Rigsarkivet was acutely felt. Which records I accessed was determined

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[36] On archival application processes as surveillance technologies, see Sahadeo 2005.

[37] The application form contained a strict cautionary message regarding the consequences of disseminating findings through other avenues or media or for other purposes than the ones included in the application.

before I started my archival work proper, and there seemed to be limited possibility for stepping outside the path I had already laid[38].

This experience at Rigsarkivet was in marked contrast to my initial encounter with NARA, where I was informed that no application was necessary – the exact words of the woman who advised me were "you can come tomorrow, honey". In practice, however, negotiating the archival grid of NARA proved no less challenging. Unsurprisingly, NARA is a heavily striated space sitting behind multiple security checkpoints which are in place to protect US national history (complete with metal detectors and airport-style luggage scanners). One floor houses textual records, another moving images, and a third photographic material. Civilian records are separate from state records and records pertaining to the armed forces are in their own category. A further subdivision separates army records from records of the navy and the air force respectively, and these collections are guarded by their own specialised archivists who assist researchers in navigating the extensive analogue indices and thus perform the role of gatekeepers of the collections. In a bizarre instance, this meant that before I was allowed access to the indices of the army records, I first had to convince an archivist dressed in a brightly coloured Hawaiian-shirt that the Greenland ice sheet was viable as a military terrain and that it could indeed be traversed by foot or by vehicle. Incessantly pointing to the fact that ice is frozen water, the archivist insisted that this material quality of the ice sheet made it navy rather than army territory.

In his attempt to enrol the physicality of the Greenland ice sheet as a classificatory indicator, the NARA archivist affirmed its material indeterminacy as simultaneously solid and liquid. At the same time this example illustrates how, as gatekeepers, archivists may impose their own sense of structure upon the archival grid. This became even more apparent in my encounter with the collections of the Danish Natural History Museum. Due to lack of funding, the museum's archival records are without indexation. They are curated only by the contributors to the archive and there are no funds to hire a designated archivist. I received help navigating the collections from a mycologist employed at the museum who took hours away from his own

[38] This proved somewhat problematic when I found that a series of records had been either lost or misfiled as I was not allowed to search for them across the parts of the GGU records that I had not explicitly applied for access to.

research to help me dig through countless unmarked boxes in a cluttered, unventilated, and dusty backroom – a painstaking process of establishing a sense of archival order out of archival chaos.

The corporeality of the archive

The disciplining effect of the archive not only works through systems of classification; it also works on and through the body of the researcher. Rose (2000) outlines how, in the archive, the researcher is embodied in a very particular manner. She notes how the strict policing of what is permitted in the archive produces a tension as the researcher's body is at once construed as "threateningly present and rendered as unobtrusive as possible" (ibid: 561) in relation to the records.

At NARA for example, this disciplining began before I was allowed into the archive proper. I earned my access card by sitting through a Power Point presentation, which informed me of the dos and don'ts of the archive. Heavy clothing and scarves were not allowed, neither was food and drink, researchers must write only in pencil (pens may leak), and may bring a maximum of 20 sheets of paper into the archive. Signs throughout the building ordered researchers to keep their hands clean and researchers were under strict instruction to use gloves when handling photographic material. The NARA reading room was policed by staff walking amongst the researchers, looking over our shoulders to make sure we were in compliance with all set rules[39]. The effects of these instructions and the visible surveillance was twofold (Rose 2000). It minimised the material presence of the researcher in relation to the records whilst simultaneously constituting the researcher as a physical body. Based on her research in the Victoria and Albert Museum Printing Room, Rose (2000) writes:

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[39] I was, for example, told off twice. Once for taking off my cardigan, and again for taking a photograph of the archive itself. Like Rigsarkivet, NARA keeps strict records on access to their collections and the NARA researcher identification card is used to record each box ordered. I learned that as a means of governing access, it is prohibited to take pictures of the reading room as the pictures may capture documents which you do not have clearance to see. Under the watchful eye of the archivist, I subsequently deleted the photo.

> They materialized me, and what a body they gave me: potentially mucky and clumsy, with sweaty fingers and leaking pens, with wet coats and poor eyesight, hungry and thirsty and dangerously threatening the photographs with all these dirty needs. (Rose 2000: 561)

Fragile documents are positioned in relation to a grotesquely human body against which they require protection. In my experience, the disciplining effects of highly regulated spaces such as NARA and Rigsarkivet became so deeply ingrained that I brought with me this image of my own threatening corporeality to spaces where the body of the researcher was not institutionalised in this same manner[40]. A sense of 'awe' of the documents had been instilled in me through the disciplining of my body, and the importance of the archive and the preservation of national memory was imprinted on my sense of my own physicality and being.

Archival entropy and the liveliness of archives

The ease with which I now list archives visited, records consulted, and types of data used hardly reflects my lived experience of being and working in archives. Similarly, my experiences seemed, on several occasions, to be in marked contrast to the abstract and somewhat idealised accounts I had read of 'the archive' as an ordered (and ordering) geography – a rendering which is, as most such accounts explicitly acknowledge, necessarily imperfect. As noted by Rose (2000: 561, original emphasis), "an archive is a *fantasy* of materials collected and united, and its order of things may be easier said than done". Archives are neither static nor inert. There are, as Rose suggests, slippages and fractures in the archival matrix; it contains elements which may disrupt or even exceed the archive itself. For example, Rigsarkivet was not only enlivened by strictly human forces. In one instance, the archive proved to be alive in quite a literal sense. My research was interrupted when I came across a field journal which immediately started crumbling between my fingers as I opened it. I was later informed that "a paper eating fungus" had taken residence in the field journal, which was swiftly sent off to a conservationist. As such, this journal was excluded from my research, adding to the fragmented nature of my dataset.

The archive is not only animated by archivists (or fungi), but also by the people who use it. Material gets damaged, goes missing, or is moved around. Documents in the GGU Collection

[40] Months after my visit to NARA in Washington, as I was drinking tea offered to me by a librarian at the Danish Natural History Museum, I found it hard to trust my own ability not to spill it.

at Rigsarkivet bore visible marks of ongoing processes of re-classification – one hand-written reference number imprinted directly on the material crossed out and replaced with another – and in some instances the classification number did not match the box in which material was found. Although I had meticulously recorded the content of each box from countless 'record keys' before accessing the collections directly, the box supposedly containing key field reports from the GGU exploration of Ilímaussaq was more or less empty. I subsequently met with several archivists, all of whom repeated the same sentiment: the archive is alive, it is inherently entropic (see Richards 1993). In a curious incident, I later encountered a report stored as part of GEUS' subterranean collections inscribed with the reference number of the missing records in the same handwriting using the same red ink as Rigsarkivet's GGU records. Although none of the people I asked could tell me how the report had travelled, the fact that it did travel is perhaps indicative of how these reports are positioned somewhere between national history and national knowledge. As such, they play multiple roles as political objects. Copies of some of the geological reports were also stored at the Danish Natural History Museum. As such, the reports are simultaneously treated as national history, natural history, and natural fact. The reports, their dispersion, and their crossings between these different institutional spaces are material reminders of the multiple roles of natural knowledge in relation to the state. The production of territory through the scientific geometricisation of Earth simultaneously draws on, plays into, and connects all these different registries.

Partiality of archives and the violence of territorial orderings

As I was scouring archival collections in Denmark, Greenland, and the USA, one thing struck me as curiously absent from the records I consulted. Across reports, diaries, and documents, there was barely any mention of Greenland's indigenous population or their involvement in or impact on neither the US nor the Danish scientific practices. Occasionally, the Danish records acknowledged the presence (if not the specific contributions) of a 'Greenlandic aid' and, if at all named, said aid was usually identified by his first name only – I found no traces of Greenlandic women. This absence may be explained, at least in part, by the 'modernisation' of polar science and exploration mentioned in Chapter 1. The idea that polar science had advanced beyond the need for technologies somehow seen as 'primitive' or 'less scientific' may have inspired a wilful choice to either ignore Inuit knowledge or to write Inuit involvement out of official narratives[41]. As such, it cannot be ruled out that the lack of recognition of the specific contributions which Inuit may have provided could be reflective of political decisions about what 'counts' as knowledge.

Anthropologists writing about indigenous communities in Greenland have suggested that the ways in which such communities connected space, power, and meaning were not always congruent with the Danish or American perspectives presented in this thesis (see Dahl 2000; Nuttall 1992; Petersen 1981; Brøsted and Fægteborg 1985; see also Gerhardt 2011). The right to capitalise on the Earth through the extraction of its resources was based on affiliation with semi-nomadic communities rather than on spatially defined land-ownership, and, according to anthropologist Jens Dahl (2000: 170), political-spatial units were often "non-fixed, 'instantaneous', and flexible". Notably, this is not to say that Greenlanders had no concept of spatial calculation or of territory. For example, Inuit produced wooden carvings mapping out prominent features of Greenlandic coastlines as aids to communicating geographical knowledge, and these may be considered calculative spatial technologies (see Holm 1886; Sølver 1954). Sophisticated and detailed geographical knowledge of Inuit homelands was traditionally preserved and passed on through oral histories rather than written records – a reflection of a different tradition of archiving Earth. These histories included intimate accounts of how to read the landscape, how to negotiate its material exigencies, and how to draw on the qualities of Earth (Aporta 2009, 2016; Bravo 2009; Krupnik et al. 2010). As such, it seems likely that Greenlandic territorial orderings which may also have been based on knowledge and calculation existed alongside (and prior to) Danish and US intrusions. However, as argued throughout this thesis, neither difference nor sameness across territorial orderings based on knowledge can be assumed.

While I did make some attempt at locating records within the archives I visited which somehow reflected Inuit perspectives on either of my case histories, my attempts were unsuccessful. The one-sidedness of the two sets of territorial records upon which this thesis is

[41] The search for British polar explorer Sir John Franklin's lost ships offers a prominent example of 'Western' scientists ignoring Inuit knowledge. In 2014, 166 years after Franklin's failed voyage, the first ship was found at the location where Inuit oral history had long said that a ship had sunk (Watson 2016; Worral 2017).

based is illustrative of the partiality of archives. It ultimately proved beyond this thesis to meaningfully engage local Greenlandic perspectives on and involvement in the scientific territorialisation of their homeland or to include calculative technologies from Inuit knowledge systems as part of my analysis. Any meaningful engagement with the territorial politics of indigenous Greenlandic geographical knowledge would arguably require a detailed understanding of Inuit languages and cultures as well as sufficient time and resources to undertake in-depth ethnographic research. My positionality as a Caucasian Danish woman might further complicate any such research[42] as well as raise a series of ethical questions about a 'Westerner's' claims of 'being in the know'.

This suggestion that an alternative territorial ordering of Greenland most likely existed but was discarded, ignored, or over-written serves as a means of pointing to the inherent violence of territory. Because of the multiplicity of territorial orderings, their potential to be otherwise, and their reliance on abstractions which emphasise select qualities of space at the expense of others, any such ordering is bound to be suppressive. The absence of Greenlandic perspectives from this thesis is neither a deliberate attempt at writing out such voices nor a careless accident, but rather a reflection of the partiality of the records of my two case histories and the particular focus of my research, but perhaps also of the inherent violence of territory.

Concluding remarks

As the liveliness of the geological records illustrate, the archival rationalisation of the subterrain plays an important role in the production of actionable, stable, and knowable geographies. The fact that records of historical research into the national subterrain are construed as useable pasts is also indicative of how territory and its material underpinnings has a history which continues to matter as it may directly impact current understandings of the Earth. In summation, this affirms that territory as a geo-political technology directed at the physical Earth is a continuous process of (re)framing. However, as argued in the previous chapter, this process is not limited

[42] While my interpersonal encounters in Greenland during my fieldwork were overwhelmingly positive, the tense post-colonial relationship between Denmark and Greenland did surface on one occasion when a drunken individual told me to "go back to my own country".

to the archive and its workings. Despite the significance of the archive, territory is not reducible to the archive; territory does not come undone when records are misplaced or attacked by paper eating fungi. Rather, the production of territory is embedded in the practices of archiving the national geobody which unfold in the field and in laboratories before becoming part of archival collections.

From across the archives and collections I consulted, I identified traces which spoke to the practices through which Danish and American scientists had brought the geological records into being. The resulting dataset was curated by layers of actors who have come into contact with the records at various stages, it is governed by the inherent politics of the archival grids of the institutions I visited, and it has been shaped in different ways by my archival encounters. As is true of any historical research, the archival dataset that this thesis is based on is both inherently fragmented and offers only a partial reflection of history. From these fragments, the remaining chapters of this thesis unpack the scientific practices of the Danish uranium prospecting and the US gathering of terrain intelligence in order to discuss the role of these expeditions in the territorialisation of Greenlandic geologies. The stories of US and Danish exploration are not told as comparative histories. Rather, the aim is to read across them to draw conceptual insight from two seemingly different expeditions guided by differing objectives, supporting different political agendas, and capitalising on the Earth in ways which were not always congruent. In the chapters that follow, I will read across and between these two histories to consider how the Earth was brought into alignment with two dissimilar political projects resulting in overlapping territorial orderings.

5. *Enacting the Substrata*

Uncovering the invisible geometry of radioactive mountains

Two hours' sailing outside the small, Southwest Greenlandic settlement of Narssaq in the Julianehaab District, a peculiar mountain complex visibly stands apart from the surrounding landscape. This is the Ilímaussaq intrusion; a geological formation which has intrigued scientists and naturalists as long as Greenland has been an object of geological attention (Bondam 1955, 1959; Sørensen 1966a). Geological accounts of the area date back as early as 1806 (Giesecke 1910), and the complex is praised by scientists for its "spectacular geology" and richness in unique and rare mineral formations, many of which cannot be found anywhere else on Earth (Sørensen 2010: 28). In the first comprehensive geological analysis of the area, Danish scientist N. V. Ussing (1912: 3) introduced it as "remarkable for the occurrence of complexes of highly differentiated igneous rock which afford extremely favourable conditions for geological study". Before Ussing published his analyses, the complex had attracted continuous geological attention since it was first 'discovered' by scientists[43]. Yet according to Henning Sørensen (1967: 12), who built his geological career on the exploration of Ilímaussaq, Ussing's work "made such an impression on Danish

[43] The use of the language of discovery is problematic in a postcolonial setting such as Greenland as it effectively empties land of any prior social meaning. Significantly, the Ilímaussaq complex was part of an Inuit homeland long before it was colonised (Gad 1970). The word 'discovered' is used here as the chapter is written from a Danish perspective, specifically that of Danish scientists.

geologists and was considered to be so complete that very little happened in Ilímaussaq for almost half a century". As the "atomic age" began dawning on the Kingdom of Denmark during the early-mid 1950s (Mouritzen 1955a), Danish geological imaginaries and visions of Ilímaussaq abruptly changed as it became the site of one of the most high-profile Danish geological expeditions of the time: the hunt for 'Danish' uranium[44].

This chapter examines the first years of the Danish state-prompted exploration of the Ilímaussaq alkaline complex from 1955 until the first drilling programme was commenced in 1958. The aspiration of this effort was to find mineable uranium ore amongst the rare earth components of the area. The complex of practices involved in the exploration of Ilímaussaq across four seasons of field and laboratory work is vast, and it is beyond this thesis to cover them all in detail. Hence, each section of this chapter focuses on a defining set of practices representative of each of the four years of exploration and unpacks how these practices served as technologies of territory. After briefly setting up the political and institutional context, the chapter engages the principal methods and practises through which the invisible geometries of the Ilímaussaq complex were uncovered. These practices include radiometric ground surveys, aerial scintillometry, geological observation and sampling, and finally core drilling. At Ilímaussaq, science was mobilised to materially augment Danish territorial sovereignty by rendering the political geo productive in the service of the state and by communicating active Danish occupation. In lieu of the failure of the Danish scientists to achieve their goal of successfully economising the uraniferous rock of Ilímaussaq, this chapter illustrates how territory as practiced through science is as much a performance as it is driven by results. The chapter also shows how technologies of land may be guided by logics of anticipation and the associated desire to expand the territorial archive and push the frontiers of knowledge.

[44] As with the language of discovery, the designation of uranium from the mountains of Greenland as 'Danish' is problematic from a postcolonial standpoint. However, during the 1950s, the Greenlandic subterrain and its mineral resources were perceived as Danish property.

Nuclear nationalism: Denmark's rush for radioactive resources

In the 1950s, thanks to Ussing's (1912) detailed work, Danish geologists had long known of the probable existence of uranium ore in Southwest Greenland (Sørensen 1956a, 1966b). Yet in spite of the growing economic significance of uranium in the years after World War II (Klinger 2015, 2018), this potential resource was initially ignored by the Danish state. Because of the severe political headaches caused by the sustained American presence under the 1941 Greenland Defense Agreement, the presence of mineable uranium was construed as a threat to Danish sovereignty rather than an asset or a means of communicating territorial sovereignty. At the time, the Danish Government was still hopeful that the American occupation of Greenland would eventually cease, and it was believed that the discovery of a heavily politicised resource like uranium might prompt them to stay[45]. Hence, to protect Danish territorial sovereignty, the Danish Government did not overtly support any exploration of radioactive minerals in Greenland for almost a decade after World War II ended (Nielsen and Knudsen 2013).

During the years after World War II, the international political climate surrounding fissionable materials remained tense due to the fatality of the Hiroshima bomb (Krige 2006). International security concerns limited who could partake in nuclear research without repercussions from the already established nuclear powers, most notably the USA[46] (Koch 1958; Helmreich 1986). The political climate, however, drastically changed when US President Dwight D. Eisenhower delivered his famous 'Atoms for Peace' address in the

[45] In fact, the US State Department had internally cited the presence of radioactive minerals as a reason for wanting to buy Greenland from Denmark. As such, these Danish fears did not seem entirely unfounded (Nielsen and Knudsen 2013).

[46] Because Denmark's most prominent physicist, Niels Bohr, who was a leading force of Danish nuclear research, had been involved in the Manhattan Project, Danish nuclear research was significantly impaired by these security related restrictions. Bohr personally played a significant role in establishing the Danish atomic energy programme during the 1950s (see Aaserud 1999, 2003).

spring of 1953. The speech generated widespread optimism and fostered belief that a world powered by nuclear energy was imminent (Krige 2006; Hecht 1998). Back in Denmark, nuclear optimism and techno-scientific nationalism soon came to overpower aforementioned sovereignty concerns. Denmark was still suffering economically after having had most of its energy resources depleted during the war, and the prospect of becoming self-sustaining whilst simultaneously establishing itself internationally as a technologically advanced nation proved highly motivating (Nielsen and Knudsen 2010, 2013). According to civil servant Hans Henrik Koch (1958), who was a prominent proponent of Danish nuclear science, a Danish nuclear research programme was only "natural". If Denmark was to secure its energy future and keep up with its neighbours, Koch (1958: 129) argued, then Denmark could "not afford not to engage in the effort to explore the opportunities associated with nuclear energy"[47].

In the spring of 1955, a provisional commission on nuclear energy, the Atomenergikommissionen (AEK, the Atomic Energy Commission), was appointed by the Danish Government to lead Danish research into the peaceful use of nuclear energy (Koch 1958). The AEK consisted of 24 members, approximately half of whom were scientists while the other half were representatives of Danish industry. This distribution is illustrative of the significance that the Danish Government ascribed to science. It is also notable that no politicians were assigned to this commission since its work was deemed too important to be affected by politics (Nielsen et al. 1998; Koch 1958). While the AEK positioned itself as an institution that was somehow 'beyond politics', it enjoyed substantial government support. This combination of scientific credentials and political sway lent the AEK a considerable degree of influence and autonomy. Koch (1958: 124), who was appointed chair of the executive committee of the AEK, noted that while it was unusual within Danish politics to ascribe such powers to a commission like the AEK, "new goals often require new means".

[47] Author's translation from Danish. Throughout the remainder of this chapter, all quotations have been translated from Danish by the author unless otherwise indicated.

Initiating the hunt for 'Danish' uranium

At the time when the AEK was outlining the contours of a new, Danish energy infrastructure based on nuclear power, a single nuclear power plant with a generating capacity of 300,000 kilowatt required an estimated 500 tonnes of uranium just to get started. After that, the annual consumption was predicted to be in the area of 25–50 tonnes of this costly matter (Koch 1958). Consequentially, in the words of Koch (1958):

> [A] Danish nuclear power programme requires such considerable quantities [of uranium], that it has been impossible not to gather information about the possibilities for procuring the uranium from within the national borders! (Koch 1958: 131)

Koch uses this double negative to underline the importance of what was one of the AEK's first initiatives: to instigate large scale uranium explorations on what was then considered Danish soil.

In April 1955, the AEK approached the director of the Geological Survey of Greenland, Grønlands Geologiske Undersøgelse (GGU), Arne Noe-Nygaard, to inquire about the available options for sending a Danish geological expedition to Greenland to locate radioactive minerals for extraction. Sooner would be preferable. Noe-Nygaard, however, found the AEK's ambition to piece together a new geological research programme for the 1955 field season, which was only weeks away, to be both rushed and unwise. In a sobering letter addressed to Koch, he explained that at least another ten years of basic geological mapping was needed before any such prospecting tasks could be meaningfully considered (Noe-Nygaard 1955). Only then would it be possible to carry out an economic assay, which in itself would take years to complete. Nonetheless, Noe-Nygaard reluctantly noted that if speed was of the essence and money was no object, then he and his colleagues at the GGU would recommend focusing on three areas in the Julianehaab District, most notably the Ilímaussaq intrusion, which was known to contain uranium carrying nepheline syenites (ibid).

Ignoring Noe-Nygaard's cautions, the AEK decided to press ahead with its ambition to find uranium in Greenland. In response, the GGU made it known that no geologists could be made available to undertake a feat which, on such short notice, they considered to be foolish and futile (GGU 1955). Rather than being discouraged by the GGU's strongly worded message, the AEK decided to look to the newly established Forsvarets Forskningsråd (FFR, the Danish Defence Research Establishment) for suitable personnel to undertake a 1955 field expedition. Here, they found Lieutenant Colonel Vilhelm Valdemar Mouritzen, who proved eager to take on what he considered an honourable and historic task (Mouritzen 1955a). Mouritzen staffed his expedition with conscripts from the FFR's so-called ABC-school, which provided basic training in the defence against ABC-weapons (Atomic, Biological, and Chemical) to recruits with mixed scientific backgrounds (FFR 1977).

Drawing upon all his available contacts, Mouritzen succeeded in procuring the necessary field equipment, securing a food supply, and collecting five different types of Geiger-counters to be tested in the field (Mouritzen 1955b). The GGU was forced to realise that a 1955 expedition was happening with or without them. To retain at least some degree of control of what they considered their geographical and professional arena and avoid conflict with the influential AEK, a disgruntled GGU agreed to assign a geological director to the expedition. The GGU appointed Civil Engineer Maagens Maag of the Mineralogical Museum, who lacked formal geological training, but did at least have practical experience of mineral prospecting (Noe-Nygaard 1958).

GEOX 55: "a test year"

On Sunday 26 June, only one month after the AEK had initially expressed its desire for uranium prospecting to take place in Greenland (AEK 1955), the first division of Mouritzen's 12-man team took off for Greenland. The expedition, known as GEOX 55, had been given only one single piece of direction: three areas in southwest Greenland marked on large-scale maps displaying very little detail of the landscapes in question.

Logistically, the GEOX 55 expedition depended on infrequent and sporadic networks of transportation involving the vessels of organisations such as the Danish Navy and the Royal Greenland Trade Company as well as private fishermen. Given their limited resources and their reliance on hitching rides from other bodies, the conscripts and their equipment followed different routes and travelled by different modes of transportation. As such, more than two weeks passed before the expedition was complete and could set up camp at their destined field site (Mouritzen 1955b).

Since much of the expedition's equipment had been supplied, boxed, and shipped by the Danish Navy, Mouritzen and his men had little idea of what to expect when they opened the boxes (Mouritzen 1955a). Somewhat to his surprise, Mouritzen found that the tents provided by the Navy were not well suited for the mobile camp that he had envisioned. In addition to seven small tents used for sleeping, base camp consisted of two large tents described by Mouritzen (1955a) as "the size of a barn". Equipped with amenities such as wooden chairs, tables, and kitchenware as well as enough heavy, wooden floorboards to "build at least two small vacation houses" (ibid), the tents were cumbersome to transport and ill-suited for Greenlandic field conditions. The floorboards refused to lay flat on the uneven, rocky surface of the Greenlandic terrain, and in the open valley where the expedition was to set up camp, the towering tents were exceedingly vulnerable to the strong katabatic winds blowing off the surrounding mountains (Mouritzen 1955b).

Figure 2: Image from the field camp at Ilímaussaq, 1955 (source: Mouritzen 1955b).

Despite his initial disappointment, Mouritzen (1955b) conceded that the tents offered high levels of comfort as they made it possible for life in the basecamp to simulate aspects of life in Denmark. Eating Danish foods, playing football (the Danish national sport), and raising the Danish flag, the GEOX 55 expedition was able to sustain not just life, but qualifiedly *Danish* life in the field (see Fig. 2). These mundane acts may be conceived as somewhat analogous to what Patricia Seed (1995) has called 'ceremonies of possession'. By replicating Danish living conditions, even when they were at odds with the terrain, the expedition had effectively established 'familiar ground' within an unfamiliar landscape. Although in an impermanent manner, the field had been domesticated and the lines between home and field, the normal and the excessive, had been muddied. As such, this mundane act of setting up camp was in itself an act of territorialisation – a physical occupation by which the national space was transplanted into a new context.

Bounding the field

On the morning of 15 July, the expedition members began readying the landscape for observation. The weather was sunny and clear and with an uninterrupted vista of all the surrounding mountain tops, the conditions for geographical observation were, according to Mouritzen (1955a), no less than perfect. The task at hand was to measure out and mark off a herringbone grid consisting of a series of baselines with accompanying perpendicular measuring lines along which data could be collected in a rational, ordered manner.

Orientating themselves on large-scale maps and a series of unprocessed aerial photographs (Lyngsie-Jacobsen 1955; Maag 1955), the conscripts broke down their field site into a series of distinct and straight line segments each identified by a letter. Each baseline was carefully measured out in sections of 25 metres, and for every 50–100 metres a wooden stake was placed to physically mark off the line in the landscape (Mouritzen 1955b). To ensure the visibility of the stakes, the fieldworkers equipped them with improvised flags made from the expedition's towels (Mouritzen 1955a). Each stake was fixed geographically by taking bearings to the stake before it and by using measuring bands and compasses to guide the direction of the traverse. For every 300 metres, the exact locations of the baseline stakes were verified by measuring the horizontal angle between known points in the landscape, thus ensuring that the grid was firmly anchored within the comprehensive mathematical framework of longitude and latitude.

Several steps were taken to ease the translation of the baselines onto the plane surfaces of the maps that the expedition aimed to produce. The height of each stake was carefully calculated to ease the task of estimating how the distance between points positioned on the steep slopes of the mountains would appear on a map while standing in the physical landscape, and all the baselines were documented photographically (Mouritzen 1955b). This visual archive was supplemented with detailed written accounts of the surroundings including the appearance and condition of the rock as well as landscape features such as slopes and lakes (Lyngsie-Jacobsen 1955). Beyond its practical significance, this logging practice cemented the scientific nature of the survey by ensuring its replicability[48]. Capturing the landscape in this manner was an important part of the territorial process. By producing these detailed records, the traversed geographies were rendered mobile, graspable, and stable which greatly increased their accessibility by allowing future Danish expeditions to approach the field as a 'known quantity' despite having never encountered it first-hand (Latour 1987; Strandsbjerg 2012). As such, the conscripts were opening up the field to future acts of physical occupation, allowing the Danish state to engage with this part of its national space in a more efficient manner – both at a distance and in direct, physical encounters.

As they positioned the stakes, the GEOX team aspired to translate the untamed landscape into an ordered space of observation by imposing upon it a geometrical herringbone grid; what Mouritzen (1955a) described as "sort of a star system" where the measuring lines radiated outwards from the baselines (see Fig. 3). The task, however, was undertaken on foot by men born and bred on the flat moraine lands of Denmark who "had never before seen a mountain, let alone climbed one" (Maag 1955). As such, the observations made by the fieldworkers on the ground did not necessarily happen in the same rigorously structured space that was later depicted on the expedition maps. Sometimes the perfectly straight line segments of the idealised grid were at odds with the ways in which the inexperienced fieldworkers engaged the landscape as they sought firm footing amongst rocks and debris on the steep mountain surfaces. The desired position of the base- and measuring lines sometimes had to be compromised on account of the challenging landscape, which often resisted the neat ordering structure of the linear grid. The measuring lines in particular were frequently determined by whichever route could be traversed by the fieldworkers. The practical geometries imposed on the landscape were thus not just appropriated from external sources, but to some extent extracted from the landscape itself. In his field report, Mouritzen (1955b) did not simply construe this as a necessary compromise, but rather described it as a practice of honouring the intrinsic and natural geometry of the field. The final expedition report concluded that a perfect grid was quite simply "impractical", but also noted with a degree

[48] As is still the case today, the dominant philosophy of science during the period in question valued replicability as one of the principal qualities of 'good science' (Powell 2007a).

of satisfaction that, although varying in length and unevenly spaced, in several areas the baselines were "almost parallel" (Mouritzen 1955b).

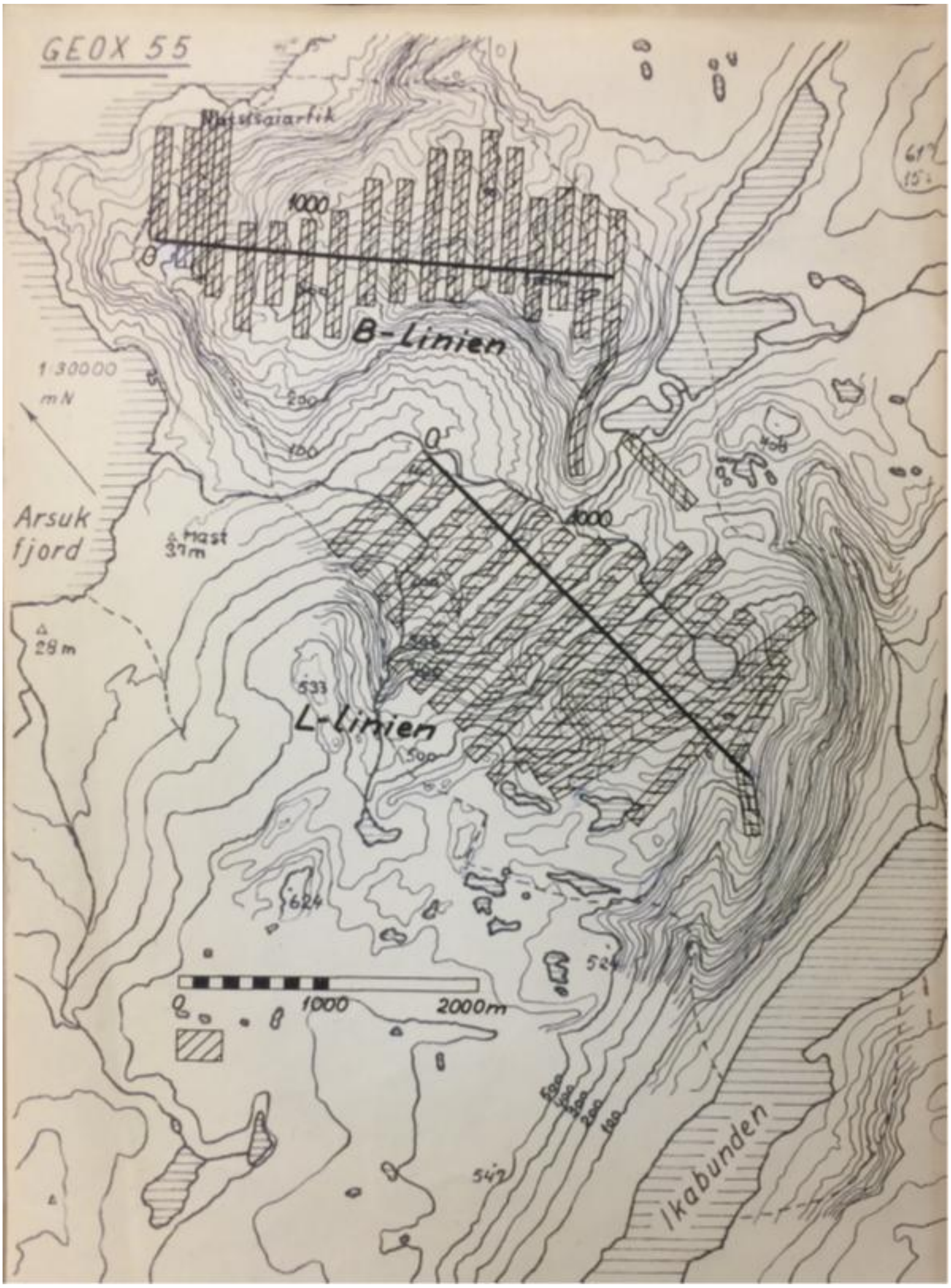

Figure 3: Map of baselines B and L at one of the three field sites (source: Mouritzen 1955b).

When the grid was complete, the expedition had constructed an (ir)regular framework for observation, which provided the conceptual knowledge space within which subsequent data points were fitted. The wooden stakes were concrete, material manifestations on the ground surface of the disciplined, geometricized workspace that the fieldworkers had brought into being. Residing in the physical landscape were the points of a graph; points which represented the convergence between the landscape and the abstract geographies of scientific representation (Lynch 1985). In its idealised form, orientation in the landscape was henceforth equated to orientation on a map as the stakes guided the fieldworkers' movement through and interaction with the topography (Mouritzen 1955b). Put differently, what has been referred to by Lynch (1985) as a 'proto-map' had been constructed onto the mountain itself, the stakes delineating its scale and form. By conducting their radiometric measurements within the framework established by the stakes, every discrete observation was automatically interconnected.

The proto-map affirmed the coherence of the territorial ordering of the field and the connectedness and continuity of the territory and everything in it. The proto-map was constructed to draw territory and its radioactive qualities together within the ordering structure of the grid, divide and position different qualities in relation to each other, and to situate them firmly on the surface of the Earth. Providing a frame within which the patterning effects of territory could be brought into being, the proto-map was a means of effectively rationalising both the territory and the practices of its production. As will be discussed below, the proto-map was a 'precursor' of a series of maps on paper charting the radioactivity of the field and, as such, affirming radiation as a valued quality of territory. While the radiometric work was still under way and data was still being collected, the physical structure of the proto-map was to be preserved as an impermanent marker of territory. In an effort to secure the durability of the proto-map until the geometry of the field site's radioactivity had been established (the geometry of the territory as land), Mouritzen (1955b) made sure that the stakes were placed under local police protection. The proto-map was a sign of intent, a marker of a relationship in the making between state and Earth. The temporary structures of the staked out grid visibly marked the landscape as a productive geography – or at least a geography with the potential to become productive. These temporary markers of a supposedly timeless relationship between state and Earth served as direct, physical evidence of the calculability and the geometric properties of state space.

Measuring radioactivity

Having forged an orderly workspace from the unruly field, Mouritzen and his team began their radiometric survey. Each day, the conscripts carried hand-held Geiger-counters, each weighing between three and five kilos, up the mountains alongside other equipment including locational devices and food supplies. During the unusually wet summer of 1955, these hikes were often rainy and miserable and frequently took as long as six to eight hours each way. Being able to overcome the difficult conditions in the field was construed as an indicator of a competence and reliability transferrable to the obtained data (see Mouritzen 1955b; Maag 1955; Sørensen 1955a).

At 50 metre intervals, radiation intensities were registered along the measuring lines. Unlike the distances between the stakes of the baselines, this 50 metre distance was not subject to meticulous measurement. Instead, it was defined by the individual fieldworker's perception of distance and direction as experienced *in situ*. Having partaken in positioning the stakes for the baselines, the fieldworkers had become skilled in determining distance using nothing but their trained eye. Their intimate, embodied, contextual knowledge of the particular landscape in which they had then been working for quite some time was deemed sufficient to ensure a reasonable level of precision (Mouritzen 1955b). While disciplining the landscape, the fieldworkers had also disciplined themselves, and a new practice of seeing had become ingrained within each of them. The fieldworkers no longer saw only the "immense Greenlandic nature" and the aesthetic qualities of Ilímaussaq that had first grabbed their attention (Mouritzen 1955a). What lay before them was still that, but something more: an ordered geography of points and the distances between them. Put differently, this change of perception may be construed as an embodiment of the geometric properties of territory. Inevitably, however, even the trained eye had its limits. Yet what the GEOX team strived for was not perfect precision, but an acceptable margin of uncertainty. When all individual measurements were eventually brought together, any observational errors would be smoothed out, revealing the true geometry of a radioactive mountain.

Defining radioactivity

The expedition not only engaged in practices of defining the geometry of the field site; the conscripts were also charged with defining the limits of what it meant for these particular rock formations to qualify as 'radioactive'. Although the geologists who had reluctantly advised Mouritzen knew of the presence of radioactive mineral formations, they had no information to pass on regarding what intensities of radiation might be encountered. Having no indication of what spans of radiation to expect, Mouritzen (1955b) set an arbitrary minimum 'bar of interest' at three times the background radiation – much lower than what would be emitted from potential ore (Nielsen 1981).

Although several of the Geiger-counters available to the fieldworkers were equipped with displays on which a needle automatically indicated levels of radiation, the only way they could register such low intensities was via the instrument's acoustic feedback mechanism. Pairing the Geiger-counters with stopwatches, the conscripts manually counted their irregular clicks while keeping track of the time. To obtain the desired level of precision, the procedure had to be repeated three times at every measuring point so that an average value could be obtained (Mouritzen 1955b). Although the practice was time consuming and tedious, the acoustic feedbacks of the Geiger-counter worked not only as an indication of radiation levels, but also to enthuse the fieldworkers and instil in them a sense of thrill and excitement of the hunt. An article published in the Danish newspaper, Berlingske Tidende (1958a), later reported how the fieldworkers described being driven by "Geiger psychosis" and "uranium fever" in their "pioneering work".

When the expedition later discovered sites where intensities surpassed 100 times the background radiation, their approach immediately changed. The time consuming mapping of minimal radioactivity was now deemed "technically insignificant" and thus abandoned as Mouritzen (1955b) realised that the significant intervals that were eventually featured on the expedition's maps were unlikely to depict that level of detail. The limit of what constituted radioactivity thus shifted. At these higher intensities, it was no longer humanly possible to make out and count the individual clicks of the acoustic Geiger-counters. Hence, with the changing understanding of radioactivity, the unit of measure changed as well since the visual displays of the Geiger-counters used milli-roentgen per hour. This marked a shift in what constituted a 'sign of existence' from an audible to a visual signifier (Mouritzen 1955b). The changing valuation of different levels of radioactivity is illustrative of how aspects of the defining qualities of territory remained, to some extent, open for negotiation and, in this instance, were based in part on a seemingly arbitrary choice.

From proto-map to paper map: charting radioactivity

During the 1955 field season, the GEOX team often found themselves confined to their campsite when the weather made their work in the mountains too perilous. The many rainy days were spent in the large basecamp tents bringing together the radiometric data, the staked out grid, and the landscape on which it was marked on a series of colourful maps (see Fig. 4). These maps divided the field into discrete zones of sameness and difference in accordance with their radiation, identifying each interval by a colour and each point of observation by a radiometric value. Across this uniform plane, any errors and anomalies were evenly distributed and, as such, absorbed. The maps thus embodied a rationalisation of a set of practices which were not as linear and stringent as what the orderly images conveyed. The maps were later published in reports using scientific language and providing detailed technical knowledge about the assemblage of instrumentation used as well as minute accounts of the field practices. Underlining the scientific image of the survey detracted attention from the way in which the survey itself had effectively defined radioactivity. The radiometric maps provided ocular proof of the radiance of the field area – a phenomenon which could not otherwise be seen or sensed without the help of prosthetic technologies. By making an otherwise intangible phenomenon sensible, measurable, and intelligible, these visual displays were effectively constitutional of the material form of radiation, which was presented as a dominant quality of territory.

In a sense, the phenomenon of radiation seems antithetical to stability; it is quite literally a residual product of matter's transformation, its radioactive decay. Yet, in fixing the unruly materiality of radiation cartographically and thus providing it with a seemingly fixed physical existence, the territory defined by its qualities came to appear stable and accountable. These zones of radiation divided by sharp, angular lines – somewhat in defiance of the materiality of radioactive decay – became markers of territory in a different sense than the proto-map. Such zoning marked a significant step towards imbuing the rock of Southwest Greenland with a political resonance which could reverberate beyond the locality of the field. Radiation became resonance as it was captured on maps which spoke to political and economic desires to draw on the physical properties of Earth – maps which political practitioners and decision makers in Copenhagen could point to. By affirming that the rock possessed valued qualities upon which the state could likely capitalise, the mobile and immutable radiometric maps provided a scientific rationalisation of further extractive activities.

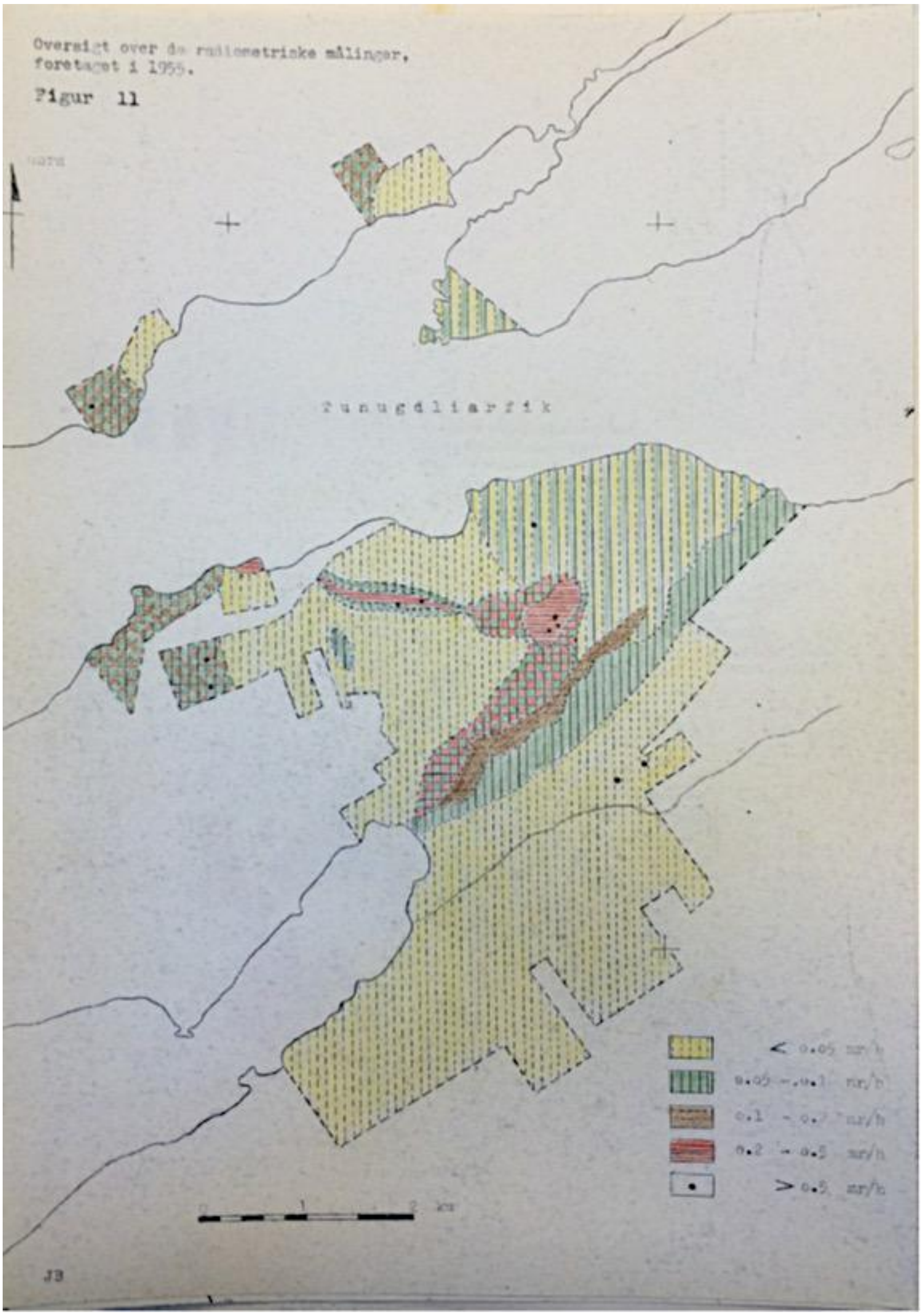

Figure 4: Radiometric map based on the 1955 field data (source: Bondam 1956a).

Bodies of knowledge

As the radiometric data was translated into scientific texts and representations, most of the social and material context of its production was written out. The reality of the landscape and its enactment was separated from knowledge of the landscape; the former was entwined in a series of intermediate social and material relations and embodied engagements with the Earth, whereas the latter discarded these through the kinds of processes of distillation and purification outlined in Chapter 3 (see Latour 1999). In some ways, the separation between bodily experience and knowledge of radiation seemed near perfect; other than the related excitement at hearing the Geiger-counters clicking and seeing high readings on the displays, the fieldworkers never felt the phenomenon which they were sent out to measure on their bodies. Instead, they encountered rain, wind, and hard rock. In the field, the conscripts were forced to negotiate and internalise the material excess of their encounter with the landscape – endure it, account for it, absorb it best they could – so that all they would bring back to Denmark were the contours of a radioactive mountain[49].

As emphasised by students of critical cartography, cartographic representations like those produced by the GEOX team entail two key features of the production of territory: an ontological flattening of geographical space and a separation of physical geographies from the experience of being on the ground (e.g. Revel 1991; Steinberg 2009; Biggs 1999). Importantly, however, the disembodied maps visualising the radiation of the mountains were only made possible by the preceding embodied engagements with the landscape. This point is illustrated by the multiple ways in which the limits of possibility of this physical interaction shaped the ways in which the mountains were known.

The human body had served as an instrument of science whose efficiency depended on being calibrated in the field through embodied experience of the landscape. Knowledge of the land – how to engage and interact with it – was a necessary first step in establishing territory through science. Because of the precarious nature of the Greenlandic environment – the

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[49] Not everyone involved in the uranium prospecting were able to endure life in the field. The fieldworkers suffered physical as well as emotional strain, and reports from several of the field seasons yet to be introduced mention having to replace men who found themselves "unable to adjust to Greenlandic conditions" (Kryolitselskabet Øresund 1958).

unpredictable and fast changing weather, the textures of the terrain – the fieldwork often required flexibility and adaptability. Throughout his diaries and reports, it is clear that Mouritzen (1955a, 1955b) took pride in his abilities to negotiate such local exigencies. The lack of understanding of the landscape demonstrated by the ill-suited expedition equipment[50] had been rectified through skilful engagement with the field.

Although the principal endpoint of the GEOX 55 expedition was the disembodied maps, human bodies had acted as a central component of the territorial process. Beyond serving as instruments and impermanent markers of Danish territorial sovereignty, the reciprocity between different bodies – biological and geological, cognisant and indifferent – was at the heart of the process of territory formation as the physicality of each prescribed both limits and possibilities of their encounter. The bodies of the fieldworkers required sustenance, shielding, and a solid ground on which to stand. There were necessary limits to their carrying capacity and endurance, particularly on steep slopes covered in treacherously loose scree and boulders. Hence, the landscape asserted its own non-human agency on the surveying practice as its materiality and physicality affected the fieldworkers' engagement with it. In summation, the sweat and exhaustion of the fieldworkers were embroiled in the territory-making process, as were the physical properties of Ilímaussaq. This entanglement is illustrative of how the lines between land and terrain become blurred through the practices of territory's production. Drawing out the productive qualities of Greenland's mountains and thus casting said mountains as land rested on an embodied encounter with the landscape as a terrain to be negotiated and overcome.

Amateur geologists 'take' the field

From its very conception, GEOX 55 had been framed as a "geological endeavour" (Mouritzen 1955b). Yet, amongst the expedition members, none had any comprehensive geological training. The four conscripts from the ABC-school who, in addition to Maag

[50] Mouritzen's expedition had been equipped like a military outfit rather than a scientific one. In addition to the ill-suited tents and a series of relatively minor issues with the campsite equipment, the expedition had been clothed in camouflage gear. Being less visible in the landscape was both an inconvenience when conducting observations between points and a security issue in case of emergency (Mouritzen 1955b).

and Mouritzen, made up the expedition's scientific personnel consisted of two pharmacists, a botanist, and a mathematician, all with master's degrees, but with no formal knowledge of Greenland or of geology. The remaining five conscripts were affiliated with the Danish Navy, and counted a fisherman, a tailor, a sailor, a hairdresser, and a baker (Maag 1955). On occasion, a local Danish school teacher based at the nearby settlement of Narssaq was also invited to participate in the radiometric surveying (Mouritzen 1955b).

As part of their "tactical retreat" (Nielsen and Knudsen 2013), the GGU had agreed to put geologist Henning Sørensen at the disposal of GEOX 55 during the first few days of their expedition. Over the course of three days, Sørensen led a series of excursions into the fells of Ilímaussaq during which he taught the conscripts about the geological makeup of the area and introduced them to its different kinds of rock as well as the most significant minerals that he expected them to encounter. Sørensen provided the expedition with a series of samples for the conscripts to familiarise themselves with. He also agreed to leave behind his master student, Fritz Lyngsie-Jacobsen, who conducted a rudimentary geological assessment of the measuring areas (Sørensen 1955b).

In addition to becoming skilled in estimating distance, the final GEOX 55 report also outlines how the embodied experience of the landscape gradually translated into a growing understanding and familiarity amongst the conscripts with its different geologies. Thus, after having spent a few weeks in Greenland measuring and logging, the work of GEOX 55 was expanded to include geological sampling. While no coherent sampling strategy was in place, each sample was carefully coded by its exact geographical location (Mouritzen 1955b). The scientific narrative through which Mouritzen recorded his expedition's geological observations of the Greenlandic landscape were not treated by the GGU as the kind of literal representation that he had expected. Instead, the attempt at geological sampling made by the GEOX conscripts was seen by the GGU as making a mockery of their profession (Pauly 1955; Bondam 1957b).

Throughout the 1955 field season, more than 200 'hand specimens' were gathered. Half of these had been collected by the student geologist, the other half by the conscripts. Whereas the geology student's samples were seen by the GGU as having "geological value", the remaining ones were best ignored so as not to obscure the sound data (Pauly 1955). According to the geologists, there was more to geological sampling than picking up rocks and noting where they had been found. Although both sets of samples were coded in a similar manner, the rocks sampled by the student geologist were qualitatively different from those which had been collected by the tailor or the pharmacist. Whereas the student geologist was seen as capable of situating his observations and samples within their correct geological relationships, the conscripts were deemed incapable of maintaining that same professional distance or of knowing what the sample might represent. As noted in a memo written by geologist Hans Pauly (1955):

> It is not easy to tell which criteria have actually been applied [in selecting the samples]. They could have been chosen because they yielded a high feedback from the Geiger-counters, but they could also have been selected because they were pretty (Pauly 1955)

The conscript was a mere spectator of the field – a passive witness unable to fully comprehend or rightfully interpret what he had seen. The geologist, on the other hand, was an active observer who 'saw' with a prescribed set of possibilities embedded in a system of observation (Crary 1992: 6). The practice of sorting between significant signs and signifiers in the landscape and those not worthy of remark required reason. Such reason required both formal training and experience – the only viable sources of epistemological certitude.

For Pauly (1955), there was an ontological as well as an epistemological difference between the radioactive rock enacted by the geologist and the amateur. As he noted in aforementioned memo, "the rocks are not composed of chemical elements, but of chemical relations, the so-called minerals" (ibid). The Geiger-counters might reveal the presence of a radioactive chemical element. It would, however, say nothing about the relational composition within which the uranium existed, or if uranium was even present. If one was to assess the economic value of the radioactive rock in terms of a resource, it was "under no circumstances sufficient to have a degree of knowledge of singular chemical constituents of these rocks" (Pauly 1955, original emphases). In other words, since the measure of radioactivity could not be translated into a measure of value, the conscripts did not have meaningful access to the true qualities of territory. For the conscripts, uranium was an isolated event. For the geologist, it was a component within a complex mineralogical matrix which had to be unravelled before its true geometry could be known. As such, the measures of land which GEOX 55 had produced did not provide access to the deep, material qualities of territory needed for the Danish state to capitalise on Greenland's substrata.

GEOX 56: an aerial experiment[51]

Despite the tensions and disagreements between the different institutions involved in the uranium prospecting, both the FFR field reports and the geological and geochemical reports compiled by the GGU all concluded that further fieldwork was desirable. The most prominent cause of optimism was the so-called 'Sample 20' (or Z 700/450 S). Sample 20 was one of four large samples each weighing 20-30 kilos which had been collected under the supervision of GGU geologists in four locations within the GEOX field areas (Sørensen 1955b). During the autumn and winter of 1955, these samples were subjected to both mechanical and chemical analyses across the laboratories of the Mineralogical Museum, the FFR, and the private company Kryolitselskabet Øresund[52]. The uranium content of Sample 20 had been found to be approximately 0.7 kilos per tonne, just short of what was considered economically viable for extraction in 1955. However, the unique mineralogical composition of the potential Ilímaussaq ore led the GGU, who had been in charge of interpreting the results of the geochemical analyses, to conclude that it was too early to throw in the towel (GARR 1955).

Despite the cautious optimism and the collective agreement amongst all parties involved that further prospecting of the area from where Sample 20 had been extracted was needed, neither the FFR nor the GGU anticipated that a 1956 field expedition would take place. Both institutions assumed that a critical condition of such an endeavour was the conclusion of the scientific analyses of the GEOX 55 field data. In the spring of 1956, these analyses had not yet been finalised due to a series of unique geochemical challenges that the sample material posed. Additionally, cross-institutional tensions had hampered the circulation of

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[51] The word 'experiment' is used here because this is how Mouritzen framed his 1956 field efforts. However, it might be argued that in accordance with "the contemporary strictures of the philosophy of experiment" as discussed by Powell (2007b: 1806) in his analysis of Canadian Arctic field science, Mouritzen's activities did not comprise an experiment in the strictest sense.

[52] Kryolitselskabet Øresund A/S was the company in charge of Greenland's most lucrative and long-running mine at the time, namely the cryolite mine at Ivigtut. As such, the company held significant expertise in Greenlandic geology and mining (Berry 2012).

data between the different bodies as each wanted to assert itself as an authority in this case which was deemed of exceeding national and potentially economic importance. However, given the high hopes that politicians, businessmen, and nuclear scientists alike had of establishing a nuclear programme that would be 'Danish' through and through, the AEK made speed its primary objective.

On 11 April 1956, the AEK gave notice to the Danish Ministry of Greenland that it had decided to support another FFR-led expedition to Greenland (AEK 1956a). Three days later, the Ministry granted its permission, and the planning was commenced for a field season which would launch only six weeks later (Ministry of Greenland 1956). Mouritzen once again found himself in a situation where time was a scarce resource. Quick on his feet, he managed to secure the necessary supplies from the same channels as the year before.

Sample 20 had been extracted from the black lujavrites of the mountainous Ilímaussaq complex, which had also shown the most promising levels of radiation. Due to its high altitude and peculiar geology, Ilímaussaq was by far the least accessible of the three areas that had been under consideration. The nepheline syenites which dominated the complex were highly susceptible to weathering, meaning that the top layers of rock crumbled into a lose layer of scree, thus making it difficult to find stable footing when traversing the landscape (Sørensen 1966a, 2001). From his encounters with the Ilímaussaq complex the year before, Mouritzen, who was once again put in charge of the expedition, knew that the terrain made a ground based survey difficult. Realising that an alternative method of obtaining radiometric data was needed, he decided to dedicate GEOX 56 to testing the viability of using aerial technologies in the hunt for Greenlandic uranium (Mouritzen 1956a). His personal friendship with the English nuclear physicist Dr Dennis Taylor of the UK Atomic Energy Research Establishment (AERE) enabled Mouritzen to negotiate the short-term loan of an aerial scintillometer – an instrument which had been used successfully to measure radioactivity in southern England[53]. In addition to the instrument itself, Taylor (1956) also offered training for relevant personnel:

[53] A series of letters documenting the negotiations between Taylor and Mouritzen can be found in the GGU Collections at Rigsarkivet, Copenhagen: Journalsager 1946-1971, Jn. No. T12, box 58.

> We [AERE] will naturally be prepared to give training to anyone you care to send over, but our own experience is that it is really essential for an economic geologist to take part in the planning and use of these aerial surveys; otherwise a great deal of useless data is produced (Taylor 1956, original English).

On the point of geological expertise, Mouritzen once again fell short. Feeling that they had been passed over for the second year in a row, the GGU refused to participate in the 1956 expedition. Although they eventually gave in to the strong appeals of the AEK, the GGU's consent to send along one of their geologists came only days before the expedition was due to set off for Greenland (Noe-Nygaard and Ellitsgaard-Rasmussen 1956). Consequentially, the AERE training necessary to partake in the aerial survey was allotted to two conscripts from the ABC-school (Vinther and Koch 1956).

Negotiating the geography of instrumentation: ground truth and aerial uncertainty

Hopes for the aerial surveying were high as it promised to extend prospecting in both space and time. However, transplanting this technology into a Greenlandic context was more than a simple matter of replicating the practices used elsewhere. The rocky West Greenland mountain-scape differed substantially from the rolling hills of Sussex where the AERE had conducted their tests of the equipment (Vinther and Koch 1956). Although aerial scintillometry, at least in theory, already possessed the power to enact the phenomenon of gamma radiation in a suitable manner, it still needed to be assimilated, tested, and interpreted in accordance with local exigencies. Since the epistemological value of the aerial scintillometer had yet to be established in the context of Greenland, the 1956 survey was considered by Mouritzen (1956a) to be "purely a physical and navigational experiment" – the first of its kind conducted by Danish science (ibid). Rather than necessarily yielding new radiometric data, the task of GEOX 56 was to bring the apparatus to a functioning state, test its settings under different conditions, and adjust operational practices to obtain results that matched those of the ground based survey from the previous year.

Instrumentation and practice

A scintillometer measures radiation intensities by mechanically counting scintillations (light flashes) caused as radioactive particles pass through a gamma sensitive crystal. A photoelectric cell registers as many light flashes as possible and converts them to electric impulses. An analytical count-rate meter then indicates the amount of radiation detected as an average of counts per minute, and an associated recorder provides a 'radiation profile' for the terrain showing any variation in the number of gamma rays detected in the form of a graph. Measuring this count rate as a function of time, the scintillometer 'scans' the surpassed landscape, in theory revealing any radiation anomalies (see Fig. 5) (Nuclear Chicago 1955a, 1955b). The ideal flying pattern for this kind of aerial survey was that of a regular, linear grid of perpendicular lines of flight (Vinther and Koch 1956). Knowing the topography of the Ilímaussaq field site, however, this strategy was abandoned before the surveying even began. Affirming that knowledge of the land is a necessary first step in territory construction, Mouritzen (1956a) concluded in his final report of the aerial survey:

> In the West Greenlandic mountain terrain, every area needs to be processed independently, and the lines of flight must be positioned where nature and the capacities of the aircraft make it possible. Experience shows that such a grid will become anything but regular. (Mouritzen 1956a)

Instead of a regular grid, the lines of flight were carefully planned and mapped out in accordance with prominent features in the landscape and the manoeuvrability of the aircraft

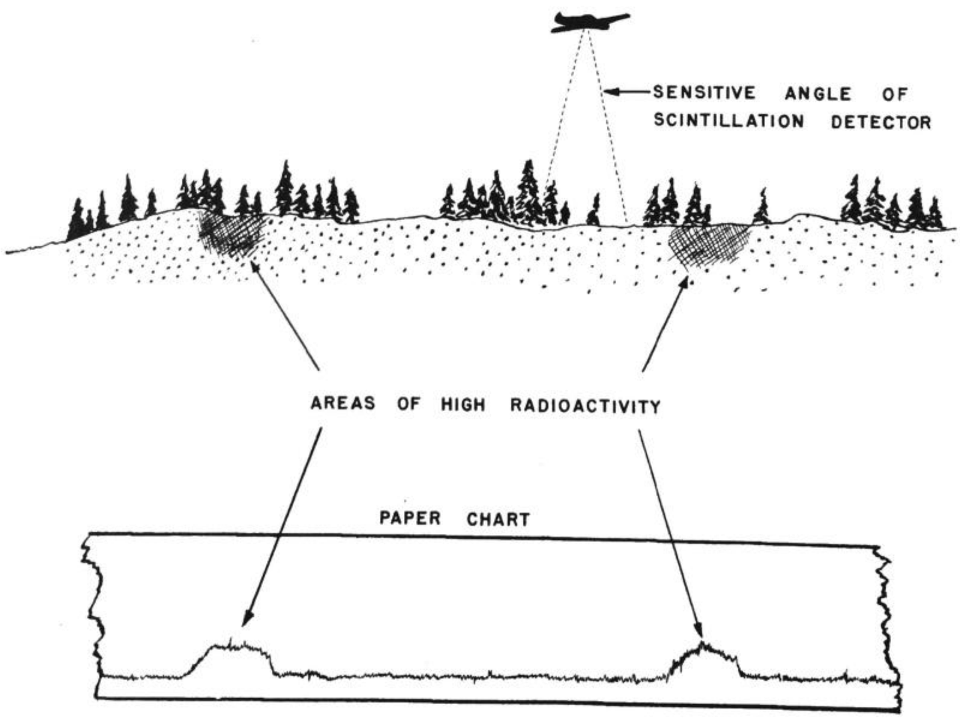

Figure 5: Diagrammatic depiction of the practice of aerial scintillometry (source: Nuclear Chicago 1955a).

on which the scintillometer was mounted – a heavy, amphibious Catalina 854 provided by the Danish Air Force. Taking on the role of navigator, Mouritzen lay flat on his chest in the bow compartment of the Catalina, armed with maps of the planned routes. From there, he used the airplane's intercom to guide the pilot through the perilous landscape whilst noting any changes to the routes on his map. Finally, he dictated prominent points in the landscape, ascribing each of them an identification number, which was marked both on the map and on the scintillometer's chart paper. The AERE trained conscripts kept a close eye on the count-rate meter and the recorder, logged the altitude, and monitored the scintillation detector itself whilst taking photographs of the landscape (Mouritzen n.d.).

The evaluation of the results of the aerial survey rested on an implicit assumption that the graphic and written representations of radiation based on the ground survey replicated the essential character of the registered object. Maintaining a distinction between the phenomenon of radioactivity and the instruments that had brought them to light, the 1955 datasets represented an essential 'ground truth' against which the aerial results could be measured despite their technological differences. It was this system of corroboration and reconciliation that prescribed the possibility of incorporating data obtained using only aerial technologies into the archive of radiometric knowledge (Mouritzen 1956a).

The practice of aerial surveying was not only affected by the landscape, but also by the limits prescribed by various parts of the assemblage of instrumentation itself. For example, the width of the chart paper and the reach of the charting needle of the automatic recorder at times determined the altitude at which measurements were taken in areas of high radiation. Registered radiation levels were, amongst other things, a function of altitude. Hence, in areas of high intensities it was sometimes necessary to fly higher than expected in order to register the full extent of any radiation peaks within the width of the chart paper. As such, the initial test flights were aiming at "finding the right combination of settings which would result in the most advantageous arch on the chart paper" (Mouritzen 1956a). This illustrates a co-constitutive relationship between practice and technologies of inscription.

As noted, an intimate, direct, and physical encounter with the land was a necessary precursor for any territorialisation on the ground. Similarly, it was necessary to build an equivalent knowledge base of how the qualities of territory presented themselves from above and to anchor this knowledge geographically by relating it to the results of the 'grounded' practices of measure. The rigid geometry of the proto-map could not be replicated in the air –

certainly not in the heavy Catalina which struggled to manoeuver through the irregular, mountainous landscape. The lines of flight snaking through the landscape (see Fig. 6) did not offer the same kind of coherent ordering structure of the qualities of territory provided by the radiometric charts (see Fig. 4, p. 113). However, capturing radiation in another dimension expanded Danish control of the phenomenon. At least in theory, this expansion enabled a horizontal extension of the Danish territorial ordering of Ilímaussaq defined by its radioactivity.

Figure 6: Results of the radiometric measurements along the "most significant" lines of flight during the summer of 1956 (source: Mouritzen 1956a).

Limits of naturalistic testing and the vertical politics of aerial scintillometry

The aerial survey promised a rapid and uniform radiometric assay of Ilímaussaq with the notable benefit of covering vast stretches of otherwise impenetrable terrain in a matter of hours rather than days. However, aerial scintillometry was perhaps not quite the easy fix that the AEK had initially hoped for. Establishing a stable fit between the apparatus and the phenomenon of radioactivity was fraught with difficulties, and substantial sections of Mouritzen's (1956a, 1956b) extensive reports on his aerial experiments are spent reconciling "peculiar" results of the aerial survey with the recorded 'ground truth'.

In topographically complex areas of Ilímaussaq, unexpected manoeuvres of the airplane were often necessary, which meant that the detector could not be kept perfectly level. Even when the plane was kept stable, the many changes in the terrain showed up on the scintillation charts as changes in radiation. The highly sensitive crystal registered radiation from any direction, not just the ground below, but also from close-by precipices. The lead shielding around the crystal that was recommended to counter this effect and ensure the directionality of the instrument had been deemed too heavy for the purpose (Vinther and Koch 1956). Finally, the data, which represented an average of a larger area, revealed no information about whether an area contained isolated spots of high activity or was emitting radiation at a constant medium level.

Aerial scintillometry provided a means of extending territory horizontally beyond areas that were traversable on the ground. Yet imposing a flat discourse on the most mountainous areas of the field required considerable work. Having removed the lead shielding, the expedition struggled to direct their radiometric gaze whenever they flew alongside rather than simply above mountains. Radiation was not bound to the horizontal surface, but exceeded the body of rock from which it emanated in all possible directions. Bringing the radiation down to the Earth – anchoring it to the geobody – was a lot easier with the handheld Geiger-counters, which had been placed directly on the ground, touching the rock. Registering the Earth's radiometric pulse from high altitudes in-between mountains meant registering the pulsations from multiple bodies at once and thus resulted in a distorted image. By bombarding the assemblage of the aerial instrumentation from multiple directions, the mountains resisted the ontological flattening of the radiometric survey by challenging and overflowing the grids of intelligibility that was imposed upon them.

Because of the uneven topography of the field, the aerial surveyors were forced to face the inclined nature of the landscape in order to negate it. The first stage of translation between field observation and the desired radiometric maps was a series of graphs depicting the relationship between topography, altitude, and radiation (see Fig 7, next page). Locking the surveyed area to a perfectly still, lateral vision, these graphs did not acknowledge the mountains surrounding the plane of observation. Understanding and capturing these relations in terms of mathematical equations allowed for a transition from graph to radiometric map – from one two-dimensional plane to another. As such, the aerial survey provides an additional example of how technologies of territory 'flatten' the geographical world (Steinberg and Peters 2015). Flattening the steepest mountains required approaching them from the air, and although the aerial dimension got written out of the radiometric maps, the aerial survey exemplifies how producing area can be an inescapably voluminous practice – albeit one which fails to capture and account for the full complexities of volume.

Employing aerial technologies was associated with a high degree of technological sophistication in Arctic science during the 1950s (Bocking 2009). Bringing aerial scintillometry to Ilímaussaq had not just opened up the field and extended the territorial reach of the Danish state horizontally, but had also allowed the GEOX team to demonstrate effective occupation of an additional earthly sphere by enacting the national airspace. Despite all its inherent uncertainties, at no point in his reports did Mouritzen's enthusiasm for this new technology waver (see Mouritzen 1956b, 1956c). He did, however, recognise that there were limits to his naturalistic testing, and that his practices had not always resembled the kind of rigid experiment he would have preferred. Before the aerial scintillometer could be used to discipline the landscape, a disciplining of the apparatus itself was needed to ensure a reliable coupling between instrumentation and phenomenon – what Golinski (1998: 141) describes as "an embodiment of knowledge in the hardware". The experiments had been conducted in an uncontrolled environment where it had been impossible to ensure that only one constant varied at a time. No single location had approached a perfect plane, none of them emitted even doses of radiation, and the heavy weathering of the surface layers in most locations meant that it was impossible to know the

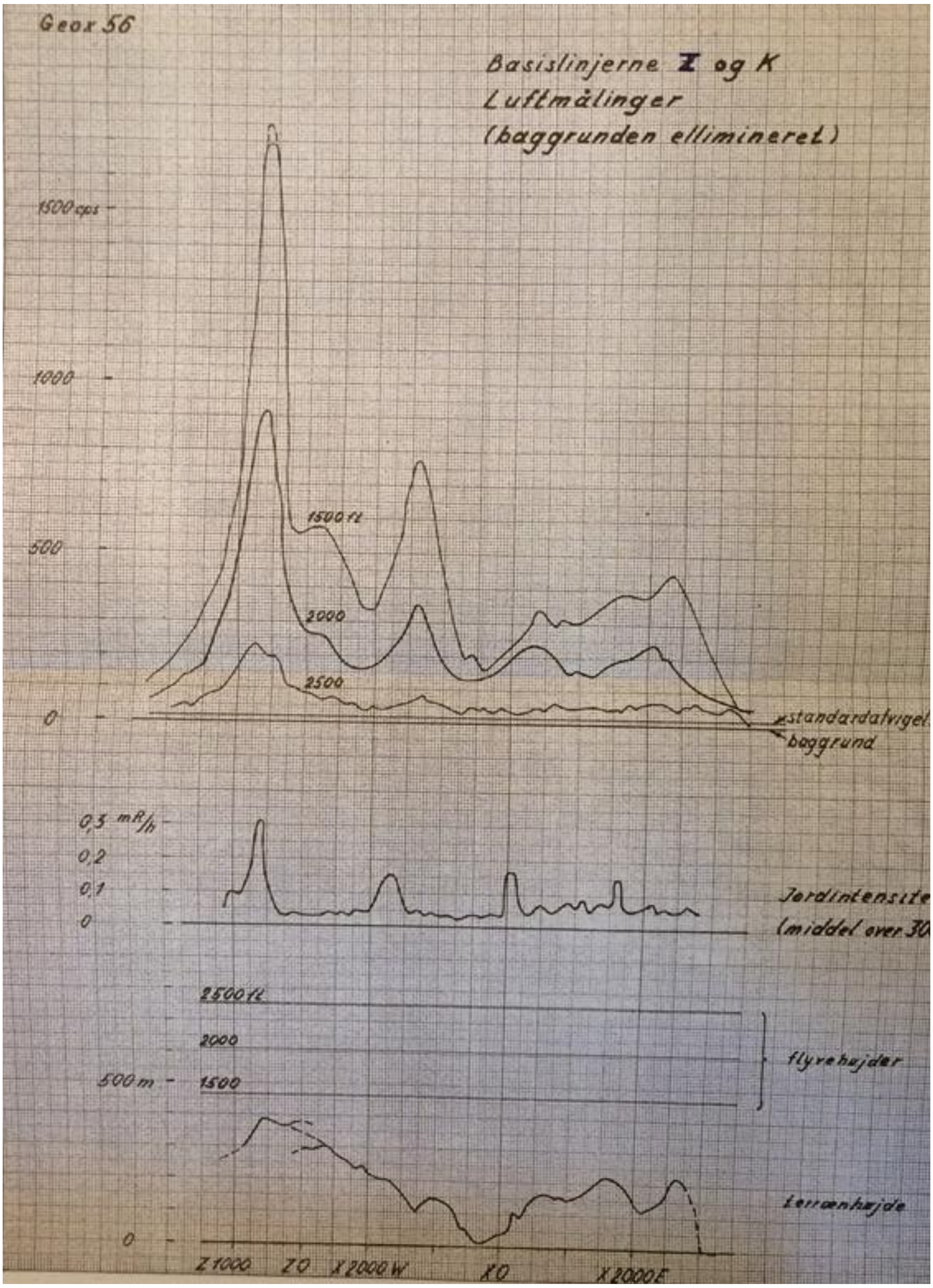

Figure 7: Radiometric chart based on surveying with aerial scintillometer (source: Mouritzen 1956a).

true surface area of any of the 300x300 metre measuring fields. "On the other hand", Mouritzen (1956a) concluded, the expedition had at least provided "an impression of the practical measuring conditions in nature". Experiential knowledge of Greenland was an expressed requirement for operating this kind of equipment in such a challenging landscape where the capricious weather conditions and steep mountains made flying inherently perilous.

In Greenland, different technologies of travel carried different authority and implied different epistemological standards. Aerial scintillometry was less precise and provided less detailed results than the ground based survey; it did not provide absolute knowledge of radioactivity but offered only an "indication" of technically interesting deposits (Bondam 1956a). Instead, aerial scintillometry embodied another set of values, encouraging an emphasis on efficiency, speed, and utility over rigorous and hard-earned accuracy in the Danish effort to extract wealth from and assert control over its most northern region[54] and establish a sense of territorial order of the land. Enabling the expedition to rise above practically any geographical barrier, the use of aviation technology had shifted the scale of observation. Although Greenland, in this case, had not been a perfect 'natural laboratory'[55], the unprecedented access and scale of the results had convinced both Mouritzen and the geologists that the aerial scintillation technology had travelled to Greenland unscathed.

Institutional tensions

The collaboration between the FFR and the GGU had been scarce throughout 1955, and the GGU's participation in GEOX 56 was reluctant. The reluctance and outright hostility with which some GGU geologists viewed the agenda that the AEK sought to impose upon them was particularly clearly articulated by geologist Hans Pauly in a memo of 8 June 1956:

> We [the GGU geologists] cannot agree to undertake extensive searches for uranium in Greenland for the simple reason that we cannot partake in defiling ourselves and Danish geology in the eyes of the world. (Pauly 1956)

In his writings and communications, Pauly concluded that due to lack of planning and geological expertise, the field seasons of 1955 and 1956 had been completely wasted. Across

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[54] During the 1950s, Greenland was considered a 'region' of Denmark under legislation of 1950, which marked the official decolonisation of Greenland (Beukel et al. 2010; Sørensen 1984).

[55] This is a turn of phrase which is often used to frame the Arctic (see Bocking 2007; Bravo and Sörlin 2002).

correspondences, internal memos, and minutes from series of meetings, the GGU continually distanced themselves from any scientific responsibility for these first two field seasons. The GGU considered GEOX 55 and GEOX 56 to be rushed, short-sighted, and lacking in scientific merit. The GGU suspected that the reason behind this was that the economic, strategic, and political objective guiding the research had simply gotten out of hand (Ellitsgaard-Rasmussen 1996). Although they reluctantly accepted that the technical grunt work of a very basic radiometric survey could be undertaken by amateurs, questions were raised within the GGU regarding both the military's agenda and the symbolism of military involvement in an endeavour concerning radioactive minerals (Maag 1955).

Regardless of the institutional tensions, the prospects of the 1956 season had initially seemed brighter than the year before. GGU geologist Jan Bondam had spent four weeks at the field site under strict conditions posited by the GGU that his position as 'geological leader' was recognised by the other parties involved (Bondam 1956a, 1956b). In the field, Mouritzen had been very protective of the scintillation equipment and refused consecutive requests from Bondam to join his aerial survey, leaving Bondam on the ground to map the area's geology and collect samples (Bondam 1956c). Nonetheless, Bondam, unlike his predecessor Maag, had gotten along fine with Mouritzen (ibid). However, as soon as they returned from the field, the cross-institutional tensions once again hampered collaboration. In his final report of the 1956 fieldwork, Mouritzen (1956a) continually express his discontent with the lack of collaboration and assistance offered by the GGU in interpreting his field results. Once again the AEK served as mediator between the GGU and Mouritzen who at this point appears to have lost some of his initial enthusiasm for the honourable task that had been bestowed upon him. Feeling belittled and depreciated by the GGU (Mouritzen 1956d), it appears that Mouritzen once again halted the circulation of field data[56]. Meanwhile, the GGU felt that their conditions for participating in the fieldwork had been violated as their

[56] A series of correspondences between Mouritzen and the AEK during the autumn and winter of 1956–57 document how Mouritzen was continuously asked by the AEK to hand over the GEOX field data. Although Mouritzen never refused to share the data, the letters he received from the AEK after having conceded to each of their requests suggest that the data sets that Mouritzen forwarded were often incomplete (see the GGU Collection, Rigsarkivet, Copenhagen: Journalsager 1946–1971, Jn. No. T12, box 58).

representative, Jan Bondam, had not been granted the status and authority that they saw fit. Unsurprisingly, the GGU was also disgruntled that Mouritzen had taken it upon himself to offer a geological analysis based on his aerial surveys (Ellitsgaard-Rasmussen 1956).

Imposing geological discipline

Each click of a Geiger-counter and each flash of the scintillometer represents an ionising event registered by the equipment. Neither provides an absolute measure of the strength of radioactivity and the events of radiation are only manifest in the readings of the instruments. What the instruments react to is the ionising radiation of high-energy photons or particles emitted as the nuclei of unstable atoms decay. In other words, what is registered is not the object of analysis itself, but rather one residual product of its gradual transformation into something other. The decay of a radioactive mineral is not a steady process; it happens stochastically, making the emission of ionising radiation highly irregular. The Geiger-counters and the scintillometer allowed the GEOX expeditions to indirectly 'observe' and map a thoroughly abstract phenomenon which could never be sensed by the human organism without the help of prosthetic technologies. An unruly and intangible entity had been captured in a rational and reliable manner in order to derive concrete, quantifiable fact. This application of territorial logics of stasis and stability allowed Ilímaussaq to be brought back to Copenhagen from where it could then be governed *as* a radioactive complex. However, the mostly horizontal perspective offered by the Geiger-counters and the untrained eyes of the conscripts revealed nothing about the abundance and quality of the ore, or whether uranium was even the source of radiation. As Pauly (1955) had fiercely argued in 1955, it was necessary to approach the rock as composed of matter and relations between different materialities rather than focus solely on the bygone event of radiation. Ascribing value to Ilímaussaq and thus framing it as land required an understanding of both the macro and micro geo-metrics of the physical rock as well as the internal structures of the complex. Soon, however, the time would come to go beyond the GEOX preoccupation with radiation – something emanating outwards from the body of the Earth – in favour of an inward looking gaze.

By early 1957, after another tense year, the AEK brought its collaboration with the FFR to a halt, effectively handing over the prospecting task to the GGU. In the summer of 1956, the GGU had drafted a five-year strategy for an intensification of the geological effort to locate viable uranium and thorium ore in Greenland. Unlike the GEOX expeditions, this strategy emphasised the need for a coherent, long-term effort rooted firmly in the geological discipline. In this manner, the strategy was explicitly in line with the GGU's ambition to construct a comprehensive geological map of Greenland (GGU 1956; Ellitsgaard-Rasmussen 1996). The 1957 field season was divided into two distinct, albeit connected, sections: fieldwork and laboratory work where the latter would take place both in and outside the field. The GGU took charge of the geological fieldwork, whereas the AEK and the private company Kryolitselskabet Øresund staffed a series of field laboratories and orchestrated the transportation of larger samples to Copenhagen for detailed geochemical processing (AEK 1956b). Spanning detailed geological mapping, tachymetric charting, systematic geological sampling, and further radiometric surveys, the 1957 field season promised to finally deliver the comprehensive geological effort that the GGU had been calling for from the beginning.

Visualising the substrata: geological maps and sections

Laboratory analyses of the different mineralogical formations that made up the Ilímaussaq complex had provided the geologists with a series of "geological indications" of what kind of bodies of rock required particular scrutiny (Bondam 1957a). The geologists' principal task for the 1957 season was to identify the intrinsic structural order of Ilímaussaq in order to estimate the spatial and volumetric extent of the most promising radioactive formations. Since many geological configurations cannot be adequately captured by words or equations, the science of geology has a strong visual tradition (Rudwick 1976). The quantification of the black lujavrites of Ilímaussaq was no different.

The subdivision of rock into mappable and quantifiable units in the field was a highly visual practice. Armed with topographical maps, compasses, altimeters, and most important of all notebooks and colour pencils, the geologists traversed the landscape, plotting their geological observations along the way. Where possible, the geologists traced the boundaries between mineralogical bodies by following their visible contours through the well-exposed sections of the landscape. However, given the severe weathering of the nepheline syenites, the most interesting areas were often covered by thick layers of scree, making direct observation impossible. Instead, the continuation of a body beneath such superficial deposits had to be inferred by extrapolating between observable traces in the landscape, such as visible outcrops and the contours of the terrain. Such geological interpretation is an inherently theory-laden practice. Far removed from straightforward observation, the trained geologist in the field embodies a series of complex visual conventions meticulously instilled through practice (Rudwick 1976). This was clearly evident from the field observations recorded by the geologists at Ilímaussaq. For example, on 20 June 1958, British geologist James Stewart who was employed by the GGU wrote in his field journal:

> Traced some trachytic dikes from cliffs behind Home Bay and Home Lake to the coast. The degree to which they are attacked by the syenites varies but generally some trace of their existence is discernable in the syenite even when actual dike form has entirely vanished. Where they have been metamorphosed by the syenite to a fairly advanced degree, they tend to weather a brown colour with chalky white phenocryst. (Stewart 1958, original English)

This section of Stewart's lengthy and detailed account illustrates how even geological bodies which had long disappeared did not escape the geologist's gaze. Expert knowledge of the weathering patterns and outputs of trachyte (an igneous volcanic rock) allowed Stewart to bring a long gone past into being. Any such indicators of the histories of formation – faulting, folding, intrusions, and processes of metamorphosis – were inherently important to fulfilling the economic goal of 'taking stock' of any interesting formations. Knowing how the complex had obtained its current form was crucial to constructing an image of the internal architecture of the formation. Combined with an extensive archive of geological information compiled over decades in places far from the particular field site, this situated knowledge allowed the geological eye to penetrate the solid strata of the Ilímaussaq complex and expose its hidden structures.

Both in and out of the field, this architecture was embodied in a series of geological maps and sections representing the ideal of complete transparency. Geological sections are diagrammatical visualisations of geological strata along a vertical plane. At Ilímaussaq, some of these sections were observed directly along exposed mountain walls. Often, however, the sections were drawn along imagined rather than real fault lines. Yet as noted by Rudwick (1976: 164), "however plentiful the evidence, the section inevitably embodies extrapolations derived from theory-based expectations". Figure 8 shows a cross section from a 1957 GGU field report. In the report, the section is paired with a geological map of the same area offering a bird's eye view of the immediate surface and shallow subsurface materialities of the Earth's crust (see Fig. 9). These visualisations do not readily distinguish between geological 'fact' (that which had been directly observed) and inferred geology. Showing the order, succession, and thickness of different geological strata and the intrusions between them, the sections provide a highly formalised view of the inner structures of Ilímaussaq.

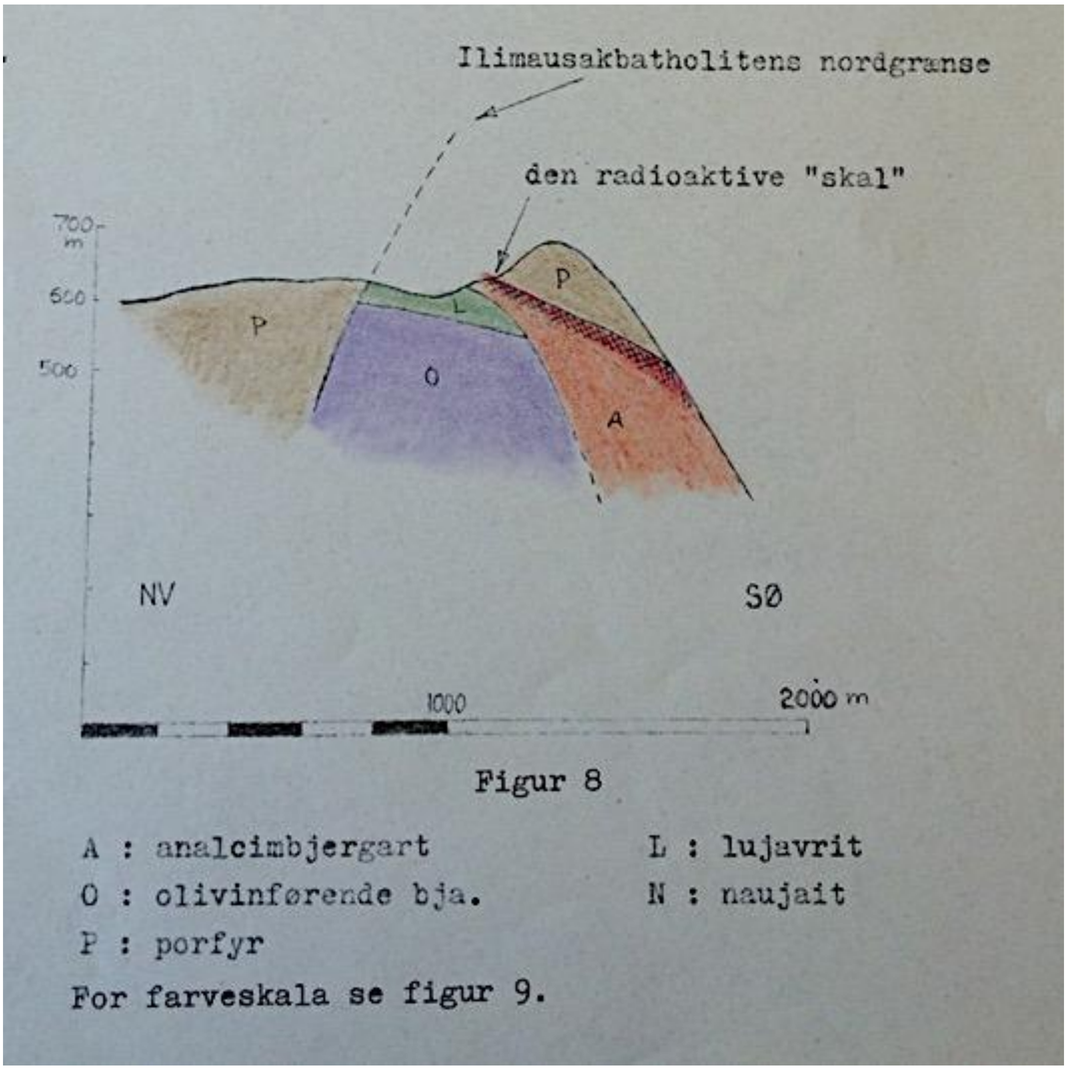

Figure 8: Geological section of Ilímaussaq (source: Bondam, 1957a).

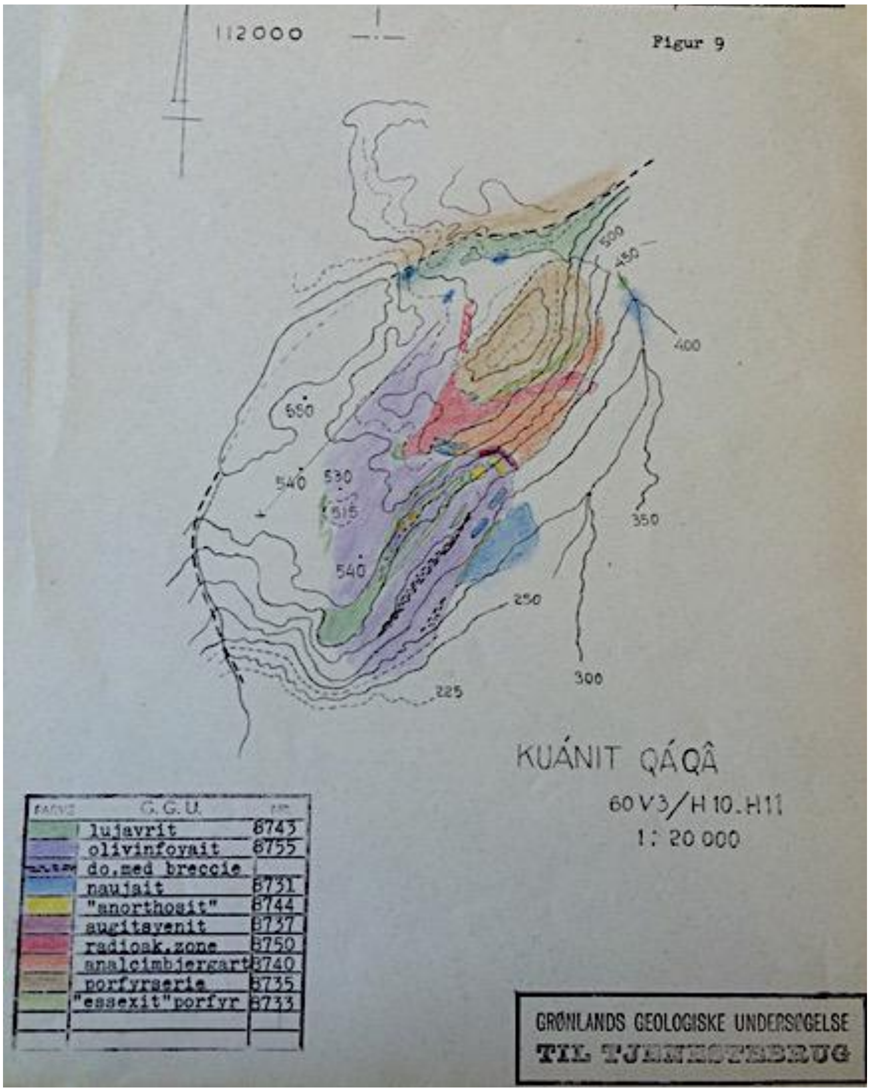

Figure 9: Geological map of Ilímaussaq (source: Bondam 1957a).

With a strong emphasis on clean boundaries, the visual form of the landscape was thus adapted to a set of predefined cognitive goals, namely to fix, locate, and quantify radioactive ore. Geological maps and sections were the syntheses of the geologists' interpretations and as such a piece of the puzzle that would gradually come together to reveal a truer image of the mountain than what had ever before been seen. By integrating the vertical succession of strata (Fig. 8) with knowledge of horizontal extent (Fig. 9), this imagery allowed for a first approximation of Ilímaussaq in three-dimensional, structural terms. As such, the geological bodies serving as markers of territorial order were gradually given a voluminous form. Unlike the aerial representations, the geological inscriptions retained their verticality, allowing for a territorialisation of Ilímaussaq along vertical axes as well as horizontal extents (Braun 2000).

Another important means of compiling a visual archive of the field (and thus of the territory) was photography. Photographs served both as instruments of scientific analysis as well as documentation *of* the field and activities *in* the field. The GGU (and the FFR) reports contained multiple images of scientists working within the landscape. Similarly, as is standard practice in field geology, most of the images of geological formations contained signs of a human presence, as tools and everyday objects such as hammers and matchboxes were positioned in the picture frame for scale. Rather than subverting the ideology of perfect separation between observed and observer, these images affirmed through documentation the rigour with which the geological survey had been undertaken. For this kind of fieldwork, cognition and knowledge production was an embodied practice (Bourguet et al. 2002).

As an analytical tool, photographs were used both in geological mapping and in drawing sections of exposed mountain walls. The photographs were implicitly accepted as truthful and reliable representations – perfectly mimetic bearers of objectivity. Still, a translation from photograph to stylised drawing was necessary as the former rarely showed the object of desire with sufficient clarity. By overlaying the photographs with partially transparent parchment, the structural geology of a rock formation could be traced directly with a pen, thus approaching the empiricist ideal of minimal distortion. Effectively reinforcing the ties between representation and an order of scientific objectivity, a geological 'essence' of the photograph was transferred into an even more truthful, transparent, and simplified image. What was valued in this instance was not the realism of the photograph, but its instrumental value in creating maps and sections through a mechanical process that could be regarded as objective and independent of human minds and bodies (Daston and Gallison 1992).

Annotating the field: capturing geological observation

The immediate product of the geologists' traverses and their observational practices were their field notebooks. These served as their most important records of evidence of their field encounters and their subsequent geological interpretations depended on these registries. Although subject to a series of non-negotiable requirements in terms of content, the style of record keeping was thoroughly subjective. Some field notebooks were neatly ordered into columns and rows of perfectly straight lines (e.g. Boesen 1957), while others were more rhizomatic, displaying little conformity with the structure provided by the chequered sheets of paper (e.g. Sørensen 1956b, 1957). While the field notebooks remained the property of the GGU and would later become part of the institution's permanent archive of Greenland, these diaries sometimes served as a therapeutic and artistic outlet for the geologists. 'Cabin fever' was not an unusual ailment in the isolated Greenland field sites, and sometimes the pages of the field notebook served as a confessional for personal frustrations and sorrows[57]. In its 'purely scientific form', the notebook was in the style of a journal with daily entries of observations. To fix the geological objects, observed coordinates, altitude, and estimated distances between formations were noted. Alongside the page margins, a series of numbers were noted, which corresponded to samples collected at the site of observation. To strengthen the fragile link between the samples and their context, the appearance of each numbered sample was also noted (Stewart 1958).

In his notebooks, Henning Sørensen (1956b, 1957), who was one of the geological leaders of the 1957 expedition, further cemented the traceability and intelligibility of his samples by adding their numeric codes to colourful hand-drawn sketches of the geological formations he encountered (see Fig. 10). These sketches not only added context to the geological samples, but also represented an important stage in the translation from field observation to scientific output. Using vivid colouring, the sensory impressions of Sørensen's skilled observation were exaggerated. Through this interpretive process, he ascribed each geological body its own individual identity, thus separating it from its neighbours. The mimetic qualities of Sørensen's drawings appear minimal, but that was never their intended function. It is unlikely that many of them would end up as representations of any unequivocal geological truth. Rather, the function of the drawings was to serve as an interpretive tool – a mind map of sorts – and an aid to data collection. As such, the drawings guiding the field practice and allowed the draftsman and his future colleagues to retrace his observations graphically. Although Sørensen was not unaffected by the beauty of the "peculiar moonscape" of the Ilímaussaq complex (Sørensen 1966a), he rarely engaged in any aesthetic valuation of the landscape in his field diaries. Rather, the

[57] Noting that the mixing of scientific observation and highly personal accounts is a common occurrence in such records, my contact at GEUS advised me of the therapeutic function of the field journal. She also noted that in order to preserve and 'depersonalise' the scientific records, the GGU sometimes had their field geologists transcribe their field notes upon their return.

diaries seem to demonstrate a desire for an objective and scientific assessment of what he encountered in the field and they contain no direct reference to the researcher subject.

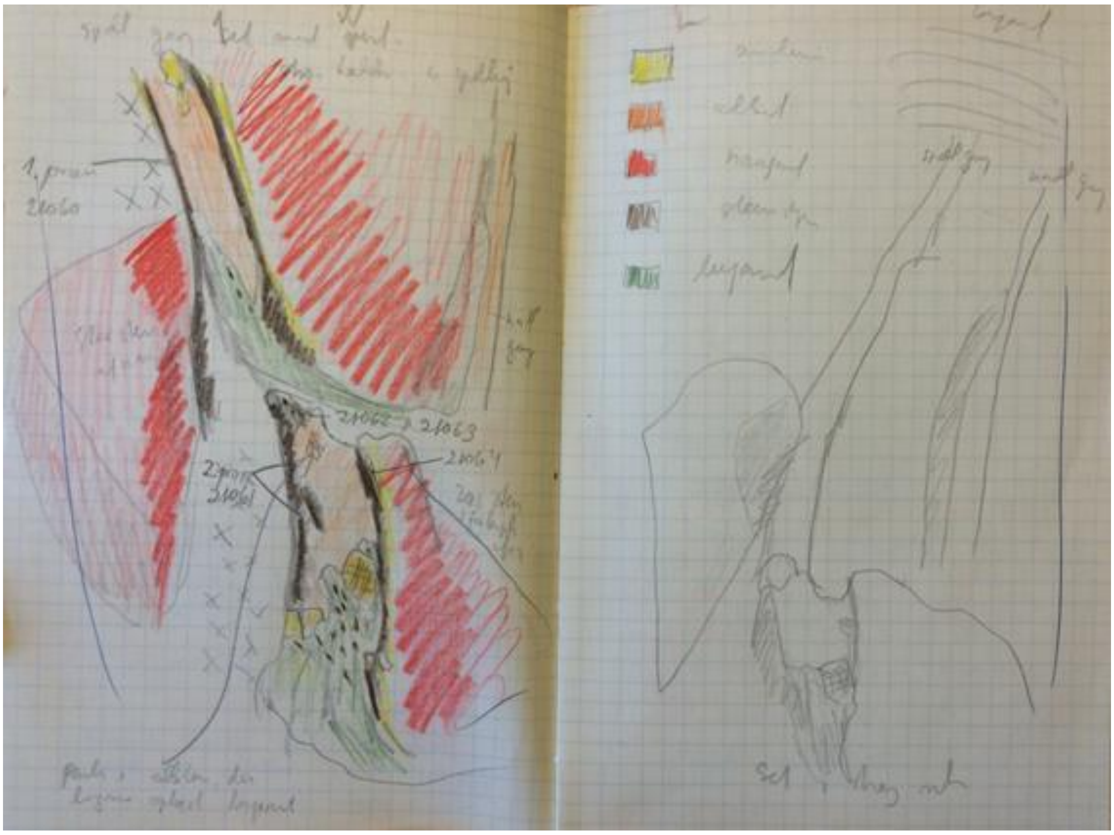

Figure 10: Example of one of one of Sørensen's field drawings (source: Sørensen 1957).

Mountains through the microscope: laboratory practice

From the very first uranium expedition, the short field seasons in Greenland which lasted only a couple of months, some years even less, had been supplemented with a complex of laboratory practices. Across the GGU laboratories at the Mineralogical Museum, the AEK's newly established nuclear research plant, Forskningscenter Risø, and the private laboratories of Kryolitselskabet Øresund the samples from consecutive field seasons had been analysed. Because swift laboratory results served as valuable aids in guiding the fieldwork, in 1957 two sets of additional laboratory facilities were erected in the settlement of Narssaq near the field sites: one radiochemical and one radio-physical.

No matter how informed and experienced the geologist, how meticulous the recording, the potential of any observation made on the rocky Ilímaussaq plateau could never be fully realised in the field. In their field journals, the geologists noted their impressions and reflected on what they had encountered. They would, for example, make estimates of formation history, rock type, or relationships between geological bodies. However, in the uncontrolled environment of the field, they were unable to perform the necessary analyses to reveal true geochemical and mineralogical compositions, grain size, or even accurate measures of radioactivity. All this required access to complex assemblages of instrumentation, many of which could not be transplanted directly into the field. In practice, this limitation to true cognition was expressed through a common distinction made in the geological field reports between the name by which a mineralisation had been known in the field and its proper scientific nomenclature, which had been revealed in the laboratory. This "semiotic purification" increased both the mobility and combinability of the samples, allowing Ilímaussaq to be positioned within wider networks of geological knowledge (Hinchliffe and Lavau 2013: 268). 'Truth' was not established in the field, but in the controlled environment of the laboratory. While in the field, the geologists performed the role of 'vanguards for the laboratories' (Latour 1999) – an important task requiring both a scientific mind and embodied experience as guarantors that protocol had been maintained.

Translating 100 square kilometres of mountainous landscape into a laboratory phenomenon was no simple matter. As representatives of the Ilímaussaq complex, hundreds of geological samples from small 'hand specimens' to boulders weighing several tons, underwent the long journey from Greenland to Denmark where they were separated, split between the Copenhagen laboratories (AEK 1956b). Some had been violently extracted with the use of explosives, others had been wrenched from larger bodies of rock using hammers and chisels, and others again had simply been plucked from the ground. What the samples had in common was the care with which they had all been chosen and subsequently coded. As noted above, the geologists constructed a coherent biography for each individual sample using several supplementary practices of indexation to ensure near perfect traceability. As they were extracted from their original context and placed into the makeshift compartments of boxes previously used for food supplies, each sample underwent what Latour (1999) describes as a 'moment of substitution' – a state change, where a material object (the sample) is abstracted from the body of rock and becomes a sign of something more than itself, a marker of territory and its qualities. The human component was important in allowing this change to take place. As previously noted, the GEOX samples had not been deprived of biography. However, because of the lack of geological training, the biography was not only incomplete, but the human element was irregular and uncertain. As such, it could not be accounted for and thus absorbed within the scientific narrative. Even the GGU reluctantly conceded that the task of mechanically registering the radiometry of the field could be left to non-experts. Any scientific enactments of the materiality of the Earth, however, required expert knowledge.

The laboratory practices fell into two main categories. The first was the "scientific analyses", which included a series of mineralogical and petrographic practices which uncovered the properties of each geochemical component, their mineralogical composition, and their natural occurrence. Secondly, a series of "technical analyses" based on the scientific results unpacked the texture of the rock and, through a series of experiments, investigated different methods of extracting uranium and thorium from the ore (GARR 1957). The lujavrites were subjected to a myriad of laboratory analyses (see for example Hamilton 1964). The following sections offer two examples.

"Scientific analysis": nuclear emulsion

The scientific work was in principle subdivided into physical, chemical, and petrographic analyses. The first determined the optical qualities, the hardness, the mass, and the idealised crystalline structure of the different minerals that made up the rock. The second included spectrographic and chemical analyses as well as more precise measures of radiation than what could be achieved in the field. The third brought together the first and the second and combined them with observations and analyses made directly in the field, thus 're-contextualising' the heavily deconstructed samples (Bondam 1956d).

One way of acquiring knowledge about the distribution of radioactive elements in different minerals and rock types was via nuclear emulsion – a technique using X-ray film to visualise the decay of α- and β-particles. The original rock sample was ground down to wafer thin sheets (thin-sections), which were carefully cleaned from any dust and left for one month to reach their radioactive equilibrium. The sample code and two crosses were ingrained on a small glass plate covered on one side with lightproof paper. In a dark chamber lit only by a dim, green light, another glass plate was covered with a highly sensitive X-ray film. Held in place with scotch-tape, a thin-section was placed between the two glass plates, ensuring intimate contact between thin-section and film. This assemblage of glass, rock, film, paper, and tape spent 230-350 hours in a light proof steel box before being carefully separated in the dark room, where the film, still attached to the second glass plate, was developed in a chemical solution. The lightproof paper was removed from the first glass plate with the thin-section still attached. The two glass plates were re-joined, this time glued together 'back to back', using the crosses ingrained into the first plate and visible on the developed film of the second to position them correctly. Through a microscope, with the traces of past radioactive events ('fission tracks') now visible on the semi-translucent X-ray film, it was possible to observe the correlation between individual grains of the rock sample and radioactive events (see Fig. 11). The results were noted in a journal, where every sample occupied its own page, and each grain was listed by its own set of coordinates within a grid imposed upon the thin-section (Buchwald and Sørensen 1957). After having observed the traces of each individual α-particle within each individual grain of 94 nuclear preparations, it was confirmed that only one mineral component displayed any significant level of radioactivity: Steenstrupine.

Figure 11: α-star of the thorium family as seen through a microscope (source: Buckwald and Sørensen 1957).

The sheer materiality of thinking was constantly stressed throughout the laboratory practices as otherwise invisible traces were given a tangible form (Greenhough 2010). To add substance to territory, the black lujavrite had to be understood at the atomic level. Microscopic particles and photons were imbricated in determining the geopolitical potential of Ilímaussaq, their enactment allowing the logic of territory to reach new scales.

"Technical analysis": liberating uranium sulphate

From the very start, the complex black lujavrite presented the geoscientists with considerable technical challenges (Pauly n.d.). Constituting "a remarkable geochemical anomaly" (Nielsen 1981: 382), the mineralogy of the Ilímaussaq intrusion was unlike any other known to geologists. Never before had anyone attempted to extract uranium from lujavrite (E. Sørensen 1966). Early experiments had shown that customary extraction techniques such as acid- or carbonate leaching were not viable. Hence, the purpose of the technical analyses was to explore different methods of separating the radioactive minerals from the rock as well as methods of extracting the radioactive elements from the minerals. This required large scale testing of substantial samples.

First, the samples were mechanically crushed into pea-sized nuggets from which a representative sample of six kilos was extracted. The sample was then sieved at 48 mesh[58], leaving the technicians with only a fine grind. The grind needed to be fine enough to liberate the Steenstrupine grain from the associated rock, but it could also be too fine. The -48 mesh grind was further subdivided into fractions, separating it in order of its specific gravity to sort out the lightest particles as these would only obscure further analyses. This process, called 'liberation', ensured that the minerals under investigation existed as physically separate grains (Pauly and Bondam 1956).

Through countless experiments, a method called froth flotation was found to be the most efficient means of sorting out the liberated Steenstrupine grains from valueless minerals. By mixing pulverised rock with water and introducing a chemical solution of sodium silicate and oleic acid, the Steenstrupine was rendered hydrophobic, unlike the other mineral components of the lujavrite. An automatic flotation device separated the wanted from the unwanted components by introducing a stream of fine air bubbles from below, forcing it through the slurry of water, grind, and chemicals. Shying water, the hydrophobic Steenstrupine grains attached themselves to the air bubbles and ended up as froth on top of the slurry from where it was then skimmed off. The net-loss of this process was potentially as high as 20-25 % of the radioactive mineral. Next, the remaining material was formed into pellets and roasted at temperatures of 630 °C with the introduction of a sulphuric gas. This rendered the uranium sulphide contained in the Steenstrupine soluble in water. At a loss of

[58] 'Mesh' is a measure of grain size. 48 mesh refers to a sieve size of 0.389 millimetre.

an additional 15-20 % of the uranium content, the final step was a chemical leaching of the roasted pellets using demineralised water[59].

After the conclusion of this final stage, "the extracted elements had been liberated from the rock and thus cut its ties with Greenland" (E. Sørensen 1966). This 'cutting of ties' simultaneously marked the construction of new ties between state and Earth – a re-formation of the rock into a marker of a grounded, territorial ordering of land as a national resource. Bound within the mineralogical matrix of the Greenlandic Steenstrupine, found only at this one single locale in the known geological world, the Ilímaussaq uranium had little value. For a literal capitalisation of the forces of the Earth, matter itself had to be severely redrafted, both materially and textually. Drawing on and over the earthly powers of Ilímaussaq (Grosz 2008) was thus bound up in the ability to efface the locality of the uranium, to normalise it and make it stable and accountable, so that it could subsequently be re-territorialised through Danish authority.

Uranium made (more) real: surveying the field at home

The geological samples, each a simplified fragment representing a much larger body, were re-contextualised within different laboratory settings as they were arranged on flat table tops and sifted through heavy machinery. Each fragment was separated into a series of conceptual knowledge spaces each revealing part of a larger truth – a truth which emerged once the fragments were eventually reassembled. Within the frameworks of the imposed orders, the samples were represented in a uniform manner with little regard for where they had originally come. Because of the care with which they had been extracted, the geological samples and their derivatives could with confidence be promoted to one level of quality. This meant that otherwise different samples having undergone different analyses could be equated. Within the laboratories, the geological samples from across the mountain were assembled into novel, meaningful arrangements, revealing the most intimate details of the Steenstrupine and discarding any elements that corrupted the value of the mineral.

[59] After more than 15 years of testing variations of this very costly and labour intensive method, it was eventually abandoned.

By enacting uranium within the controlled environment of the laboratory, the geologists confirmed that the radioactivity of the Ilímaussaq complex was not simply an artefact of the Geiger-counter or the scintillometer. The fieldworkers never encountered uranium in any direct manner. In the laboratory, however, it became real. Although physically divorced from the original context of their occurrence and existence, the links between the Ilímaussaq complex and the sample, no matter how distorted the latter had become, was maintained throughout the laboratory processes as the careful logging begun by the fieldworkers continued. This link allowed the knowledge produced in the laboratory to be transferred back to the solid rock of the field site.

The importance ascribed to laboratory truth illustrates how using science to construct territory required an ongoing de- and re-contextualisation of Ilímaussaq through which the physical matter of territory was constantly pushed and pulled into different shapes. Capturing and controlling the substrata was dependent on these cyclical movements between the field and the laboratory. Combining different sets of knowledge made it possible to reassemble Ilímaussaq in accordance with political and economic goals. As matter travelled through laboratories, machinery, and different institutional settings of its enactment, substance was gradually added to territory. Thinking across the geological maps and sections had made it possible to theorise this substance in volumetric terms. For the AEK, however, theories were not enough.

Extracting deep truth: the first drilling programme

1957 had been a productive year. Hundreds of geological samples had been extracted from the mountains. The field workers had filled countless notebook pages with observations. The chemists and technicians had ground, photographed, and deconstructed. Ahead lay a winter of intense data compilation, interpretation, and a long line of physical and chemical laboratory analyses. According to agreements between the AEK and the GGU, the winter's work was to feed into the detailed planning of the next field season. Since the GGU was "empowered by the state as the highest geological authority in the country" (Noe-Nygaard and Ellitsgaard-Rasmussen 1957), the GGU wanted full control over the geological fieldwork, which according to plan would be a continuation of the practices of 1957. Once again, however, the AEK introduced other ideas to rush the prospecting along.

At a meeting on 14 August, before the geologists had concluded their 1957 fieldwork at Ilímaussaq, the members of the AEK decided unanimously that a 1958 drilling programme was the way forward (Ministry of Finance 1957a). Still before the geologists had returned from Greenland, the AEK successfully applied for an additional two million Danish kroner from the Ministry of Finance for the 1958 fieldwork (Ministry of Finance 1957b). By drilling, it was argued, it would be possible to "put to rest most elements of uncertainty and efficiently follow up on the work of the geologists" (AEK 1957a).

Once again finding themselves cast aside, the GGU was enraged[60]. Not only was a drilling programme not part of the informal agreement between them and the AEK; it was also premature from a geological standpoint and had no scientific justification at this stage of exploration. Using the Danish state's financial resources in this manner was seen as reckless, and the GGU made it known that they would assume no scientific responsibility for the AEK's "costly experiment" (Bondam 1957b; see also Noe-Nygaard and Ellitsgaard-Rasmussen 1957). Accusing the geologists of not seeing the "bigger picture", the AEK (1957b) maintained that drilling was a "natural continuation" of the prospecting task; it was "simply irresponsible to leave an area before one had obtained the kind of negative evidence that drilling provides" (ibid).

Even if the GGU had been supportive, the AEK would still have been challenged by the lack of Danish geologists. As was typical of Danish geological research in Greenland at the time, great emphasis was placed on having a purely Danish workforce unearth the secrets of the national geobody[61] (Ries 2003). Enshrined in the Danish Mining Law[62] was a clause

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[60] The anger felt by the leading geologists is palpable when reading through correspondences and minutes from meetings between the GGU and the AEK (e.g. AEK 1957b). These communications contain several snappy and sarcastic remarks (see the AEK Collection, Rigsarkivet, Copenhagen: 1955-1960 Journalsager, Jn. No. 1957 12 28-15 b 8, box 50).

[61] As evidenced by the participation of British geologist James Stewart in the 1957 fieldwork, this principle was not always adhered to. Similarly, the Danish geophysical exploration of East Greenland was, at the time, heavily reliant on non-Danish scientists (Ries 2003).

[62] Law no. 181 of 8 May 1950, §4, 5.

specifically stating that resource prospecting should, on principle, be undertaken by Danish citizens (AEK 1957c). Given the particular national importance that was ascribed to the uranium prospecting, and the implicit sensitivity that fissionable materials still inspired, this concern had continually been raised by the GGU ever since the prospecting began in 1955. In addition to the necessary 'internationalisation' of the geological workforce, the fact that Kryolitselskabet Øresund – a private company – was set to supply geological expertise for the 1958 drilling programme did not sit well with the GGU. The GGU felt that the 'authorship' of radioactive areas was a *state* matter for *state* geologists.

The hostility between the GGU and the AEK continued for months with the general discourse of meetings and correspondences being at times sharp and sarcastic in tone[63] (e.g. AEK 1957b; Noe-Nygaard and Ellitsgaard-Rasmussen 1957; Bondam 1957c). The GGU remained adamant that a "drilling programme is unlikely to hand us the truth about the deposit" (Noe-Nygaard and Ellitsgaard-Rasmussen 1957), but for the fourth year in a row, they were left with no choice but to comply. The money had already been granted, and the AEK had made it clear that a drilling programme was happening with or without GGU involvement (AEK 1957b).

Observation in three dimensions

The 1957 field laboratories had been established in spare quarters of the canned goods factory in Narssaq, in rooms which doubled as a slaughter house (Mouritzen 1956a). The drilling programme, however, required a whole other level of infrastructure. Between January and May 1958, a team of local builders from Narssaq erected a permanent camp, further normalising and domesticating the field. The camp was erected at a place called Dyrnæs, where Erik the Red had famously attempted to establish a Norse settler society (Gad 1984). Consisting of nine wooden barracks, the camp provided housing for field personnel, work spaces, a mechanical shop, laboratory facilities, a dining hall, and a small power plant. To link Dyrnæs and the field sites, a network of roads was constructed to allow heavy four-

[63] One statement made by the AEK is cited across several documents as particularly "demagogical": "Will the geologists take responsibility for the possibility that there will never be drilled at the Gletcherelv deposit?" (Bondam 1957c).

wheel trucks to navigate the area. The road ended at the foot of the mountain where it was continued by a cableway. The cableway was used to transport heavy equipment and supplies to the mountain plateau where the drillings took place. At the plateau, a smaller camp of five temporary barracks were erected to house the drilling personnel (Kryolitselskabet Øresund 1958).

On 29 May, the drilling began, and between mid-June and mid-August, three drills were operating around the clock. The drilling programme had three general aims: 1) to confirm the theories expressed in the geologists' sections, 2) to establish a three-dimensional profile of known deposits of lujavrite, 3) to probe unknown areas geologically analogous with areas containing known deposits with the hope of 'striking ore' (Bondam 1958).

A drill bit set with diamonds attached to the end of a tubular pipe ground through the rock, extracting a cylindrical core. How deep each hole became was determined by ongoing geophysical assessments of the negative spaces of the boreholes. Using specially adapted Geiger-counters which could be lowered into the boreholes, civil engineers from the GGU estimated whether the radioactive shell had been perforated (Larsen-Badse 1958). The average depth of the boreholes was 100 metres and the deepest hole reached as far as 179.62 metres into the body of the mountain. Upon extraction, the cores were treated similarly to other geological samples; they were carefully coded, boxed, and transported to the laboratories. Guided by the results from the radiometric borehole logging, samples were extracted from the cores and subjected to the same kind of physiological and chemical testing as the geological samples had been the years before (Kryolitselskabet Øresund 1958). The cores later made the journey to Copenhagen, where they were further deconstructed. Their final endpoint was the geological archive at the Mineralogical Museum. Here traces of the 'Danish' geobody were stored, re-contextualised, and in some cases put on display to facilitate public engagement with far-away, subterranean state spaces.

Throughout the 1958 field season, a total of 3,728 metres of drill cores were extracted between 36 vertical boreholes spread across the mountain plateau. From the geologists' surface estimates, it had been suspected that the lujavrite was embedded amongst other bodies of rock following complicated and amorphous patterns. The composition of Ilímaussaq was greatly heterogeneous, and due to multiple events of folding, faulting, and in some places high levels of metamorphosis, the spatial analysis of the borehole cores was challenging. In many places, a reasonably secure correlation between neither the lithology nor the radioactivity of the boreholes was achieved.

The boreholes had been positioned in order of yet another grid projected onto the Ilímaussaq plateau. This time, it was a perpendicular grid of 50x50 metre cells. Although a closer approximation of the Cartesian ideal, this grid too had to comply with the landscape (see Fig. 12). The drilling grid had been positioned so that its lines were respectively parallel and perpendicular to the general axis of folding of the bodies of rock. Through radiometric and petrographic analyses of the strata of the core samples, the same strata could be traced across them. By extrapolating between the now related samples in the grid, "the 'true' folding patterns emerged" (Bondam 1958) (see Fig. 13 and Fig. 14). By accessing the very core of the mountain, extracting samples from it and bringing them to the surface, the inner fabric of the Ilímaussaq complex could be known with even greater certainty as it had now been observed directly.

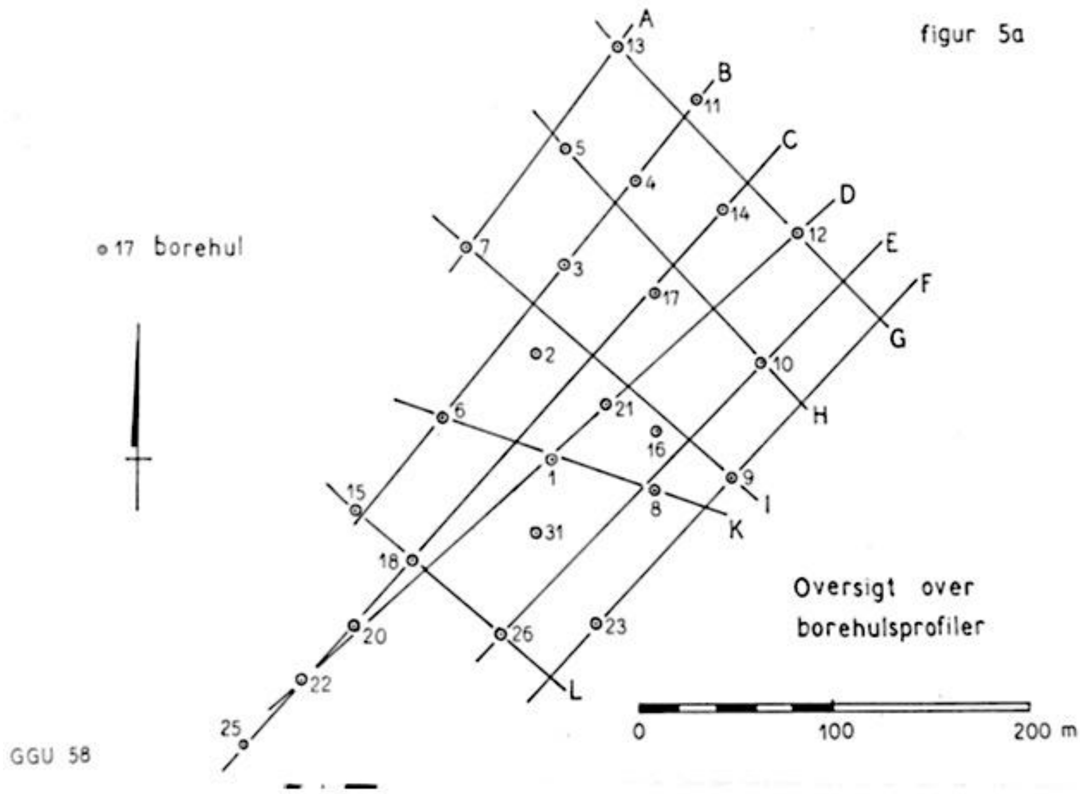

Figure 12: Stylised depiction of the borehole grid (source: Bondam 1958).

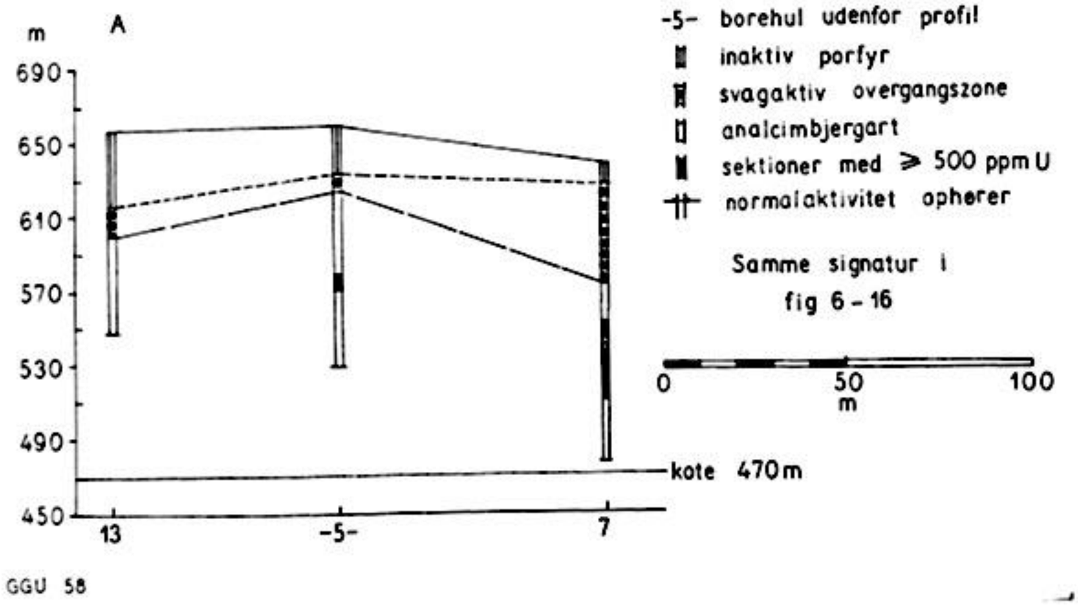

Figure 13: Stylised depicted of the borehole core samples (source: Bondam 1958).

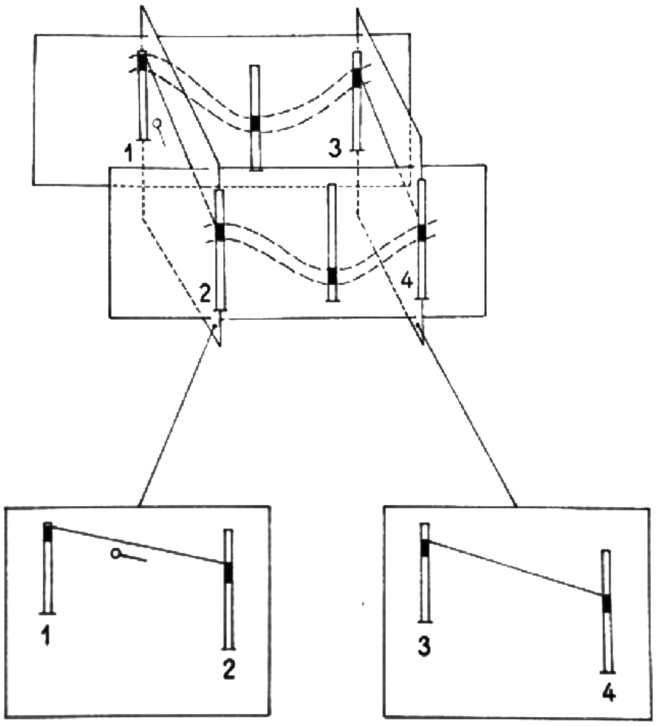

Figure 14: Stylised depiction of the borehole core samples (source: Bondam 1958).

The cores had given access to an approximate three-dimensional model for at least some of the areas of potential economic interest (see Fig. 15). In his geological report on the fieldwork of 1958, Bondam (1958) concluded that he considered the uranium carrying deposits to be "pinned down" as the "shape and location of the body of ore was roughly known". Believing the bodies of ore to be closed off in all directions, their total volume was calculated based on the borehole analyses. This volume was translated into an estimate stating that the body of the Ilímaussaq complex contained 4,000 tonnes of pure uranium. The volumetric calculations of the probed areas were further extrapolated to other parts of the mountain complex estimated to be of similar composition and formation history. Although less well known, these other parts were classified as "possible ore", bringing the potential uranium yield to an even higher level (Nielsen 1981).

Moving beyond the lateral vision of the radiometric maps and the vertical perspective offered by the geological sections, Ilímaussaq had now be observed as a three-dimensional volume. The aim of the drilling programme was not the same textual flattening of the landscape as had characterised the radiometric charting, but rather to add depth and substance to territory. The borehole imagery is approaching Weizman's (2002: n.p.) geopolitical ideal of an "Escher-like representation of space, a territorial hologram in which political acts of manipulation of territory transform a two-dimensional surface into a three-dimensional volume". The drilling programme may be seen as one such manipulation of the inner fabric of territory – an inherently transformative process through which unruly substrata are ordered in terms of their volumetrics. Following Bridge (2009), the boreholes effectively functioned as portals to another dimension. By drilling into the mountains, the geologists were able to establish a direct link between the plane of existence (the surface) and an otherwise impenetrable and uninhabitable subterranean geography (Bridge 2013: 55). If the boundaries of the territory are, at least in part, constituted by the boundaries of knowledge (Strandsbjerg 2012; Braun 2000), then the territorial boundaries of Ilímaussaq had been extended deep into the subsoil, increasing the sphere of state power and control.

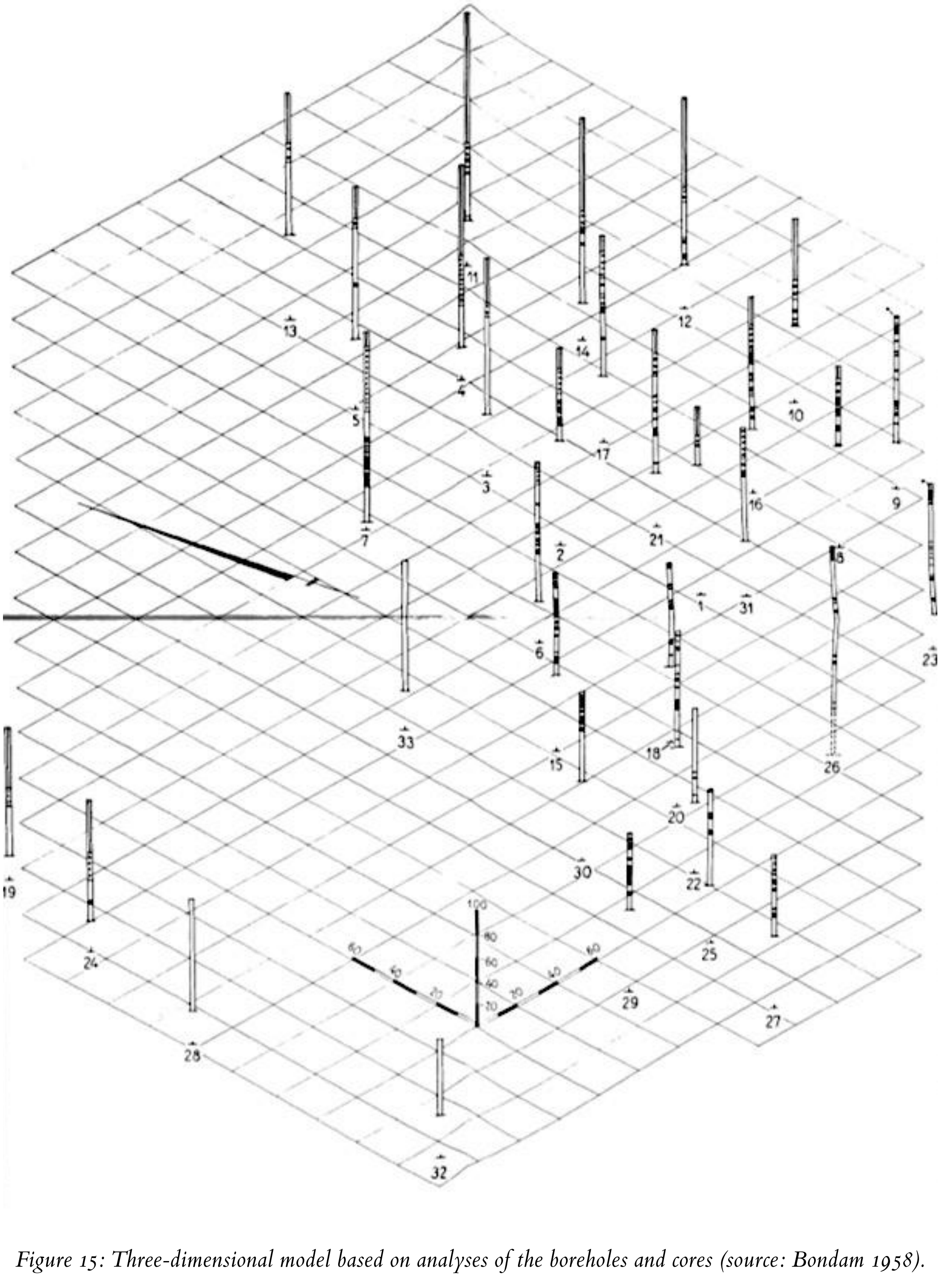

Figure 15: Three-dimensional model based on analyses of the boreholes and cores (source: Bondam 1958).

The radiance of 'Danish' mountains

Through what was described in the media as "a glorious, Danish pioneering effort, a remarkable victory over weather and climate" (Berlingske Tidende 1958b), the Ilímaussaq complex gradually appeared to be within the grasp of the Danish Kingdom. A Danish journalist visiting Dyrnæs in 1958 made the following observation:

> It is peculiar to be facing millennia in one single moment when standing with a living nuclear physicist to the left and the skulls of ancient Norsemen to the right. (ibid)

From the ruins of Erik the Red's failed settler society, the Ilímaussaq complex had been brought into modernity. Despite popular enthusiasm to see "Danish men in Danish mountains (…) both amongst those who emphasise the economy, and those who put the national aspects first" (Berlingske Tidende 1955), the first four years of uranium prospecting in Southwest Greenland had been turbulent. The AEK's desire for 'Danish' uranium for Danish nuclear reactors had encouraged an emphasis on speed, efficiency, and utility in the effort to extract wealth from and assert control over Denmark's most northern region. From the perspective of the GGU, short-sighted economic interests had continuously interfered with their work. Having endured the "untimely meddling by non-geologists in geological work" (Bondam 1957b) as well as having had their privileged access to Greenland's substrata undermined, the resentment never quite vanished[64].

Economising the Ilímaussaq complex

After four years of intense scientific work across laboratories and mountains, the economic results were less than promising. The richest 'ore' only contained half of what was then deemed economically viable for mining, and the uranium minerals were difficult and costly to extract. Reflecting back on the efforts to locate and extract Greenlandic uranium, economic geologist from the GGU B. L. Nielsen (1981) noted that if the project administration had followed strict commercial principles, the story would have ended with

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[64] Sørensen (2010), for example, notes how the AEK "treated us like children", and a similar sentiment can be found in Ellitsgaard-Rasmussen's (1996) reflections.

the 1958 drilling programme. Yet, the field- and laboratory work continued for decades before finally coming to a halt in 1981. Nielsen (1981) notes:

> It is believed that no private mining company would have maintained exploration for 25 years on a resource which to most mining people looks marginal or subeconomic (Nielsen 1981: 384, original English)

In the late 1950s, the geologists and laboratory technicians knew that in economic terms, their results did not merit much optimism. Yet, a central argument for continuing the effort was that the valueless rock might become valuable ore in the future as the markets changed. This meant that the geological archive of knowledge of the Ilímaussaq lujavrite allowed for a form of geo-economic securitisation of the future. The geological language of probability (in terms of quantities of uraniferous rock etc.) was translated and interpreted in terms of a political language of possibility and the uncertain language of value. A future where one tonne of rock might be valued for 500 grams of refractory uranium was not inconceivable[65]. As noted in Berlingske Tidende in June 1958:

> Rarely does anyone gain anything without putting in an effort. Fortunately, we are making an effort which carries great hope of considerable gains in the South Greenlandic fells. And beyond all economic and geological judgements, it is gratifying to witness how Danish geologists, Danish scientists, and Danish engineers investigate Danish mountains. (Berlingske Tidende 1958b)

One might conclude that the attempts to draw the Ilímaussaq intrusion into national (and possibly international) circuits of extractive capitalism had failed. Nonetheless, the expedition succeeded in two significant ways. Firstly, it established a noticeable Danish presence in Greenland during a time when science was of particular importance in extending the Danish state into the north and, more broadly, it increasingly became part of an international performance of Danish state presence. Secondly, the research generated a plethora of new knowledge about Southwest Greenland's geology. Within geological

[65] Indeed, the possibility of extracting the Ilímaussaq uranium has been subject to much debate (and controversy) in recent years – particularly since the Greenlandic Self Rule Government, Naalakkersuisut, lifted its zero-tolerance policy on the mining of radioactive resources (see Nuttall 2013, 2015; Bjørst 2016; Vestergaard 2015).

narratives, the Ilímaussaq complex was made out to be a seemingly endless frontier of new discoveries, including previously unknown minerals, such as Sorensenite named after GGU geologist Henning Sørensen (Semenov et al. 1965). Ilímaussaq was "new land" (Noe-Nygaard 1957), a "virgin area" (Ellitsgaard-Rasmussen 1962), which became part of a growing Danish archive of geological knowledge. Beyond issues of performative sovereignty, these expeditions thus brought new subterranean geographies into the reach of Danish political rationality.

Matter, elements, bodies: the material geo-politics of territory

Thinking about the production of territory through the example of uranium prospecting in Southwest Greenland clearly brings out Elden's (2013b: 49) point that the "political technology of territory comprises a whole number of mechanisms of weighing, calculating, measuring, surveying, managing, controlling and ordering". Rather than a singular technology, it is a "bundling of political technologies that constitute the performance of territory" (Adey 2013: 52). The Ilímaussaq complex had been photographed, blown up, probed, drilled, and reduced to a finely ground powder. It had been broken down into a more or less systematic series of maps, tables, graphs, reports, and countless scientific articles – the tangible results of vast quantities of data mathematically reduced to replicate the intrinsic essence of the mountains. Presented as geological artefact, a site of extraction, and a site void of other social or cultural meaning, Ilímaussaq had, in other words, been doubly redrafted into mountains of data.

To constitute the Ilímaussaq uranium as an epistemic object, the rock from which it was sourced had to undergo countless tests, first in the field and subsequently in laboratories spread across faraway Copenhagen. The black lujavrites had been severely deconstructed. In the field, they had been momentarily reduced to the clicks of a Geiger-counter. In the laboratories, the rock had been moulded into shapes that in no way resembled the original mountain from whence it came. Rather than simply isolating a fragment of a pre-existing reality, this was an inherently productive/destructive practice which produced certain entities and expended others (Golinski 1998). This underlines a different aspect of the inherent violence of territory as discussed by Elden (2009); territory is at once a constructive and destructive force.

Years of field- and laboratory work had uncovered the inner fabric of the Ilímaussaq intrusion, simultaneously exposing and imposing an underlying order of the land. The many complexes of instrumentation had allowed the scientists to transcend the knowledge that could be gained through sensory experience alone, thus opening up new epistemological spaces to political rationalities of territory (Braun 2000). The impossible vistas of the geological maps and sections qualifying the rock in terms of homogeneous horizons, the visualisation of the equally invisible radiation of the lujavrite, and the schematised laboratory results had brought a whole new mountain into being. Unlike the 'original' mountain, this one was largely transparent through and through and, importantly, it could be brought back to Copenhagen.

Ilímaussaq had been redrawn from a virtual *terra incognita* to a space of latent radioactive powers which could be harnessed to serve the well-being and prosperity of the Danish state. Nonetheless, the ideal of a truly sovereign energy infrastructure thoroughly grounded in the national geobody was never achieved. Although uranium was present, Ilímaussaq managed to resist being enrolled in extractive capitalism. Displaying an intrinsic material agency, the complex had affected the routes of traverse in the field and refused to release its radioactive components in the laboratory. Determining the points of convergence between the material Earth and what becomes internalised as 'state space' is an inherently political and material practice. In the case of Ilímaussaq, these points were negotiated both in the field, through embodied encounters between human and Earth, and in the laboratory, where complexes of instrumentation brought new micro-geographies within the reach of the state.

The Ilímaussaq case illustrates how a fundamentally *geo*-political understanding of territory depends on a long line of co-constitutional relationships, exchanges, and flows between human and non-human bodies. By prescribing the limits of possibility for interaction, these relationships had conditioned the geo-metrical form of Ilímaussaq as it was incorporated as Danish territory. In Greenland, the relationship between humans and mountains had been one of reciprocity. Just as Ilímaussaq pushed back against certain inscriptions, territorialisations, and economic desires, so too did the conscripts, scientists, and engineers push back against the mountains in order to overcome the refractive uranium both in the field and the laboratory. As such, the territorialisation of Ilímaussaq was forged through the bodies of conscripts, scientists, engineers and through the very matter and underlying structure of the complex itself.

6. Invading the Whiteness

US militarisation of the Greenland ice sheet

> The top of the world, the Greenland icecap. For countless ages it has been a frozen expanse, feared by man, shunned by animals, a white, cold, empty place. But today, more than ever before, there has been reason to invade this whiteness, to mark and explore it, for an urgent military purpose: that of finding a means of transportation across the icecap by which troops and heavy equipment could travel to potential bases protecting the northern approach to the western hemisphere. (Army Pictorial Service 1953)

Impressive and awe inspiring by virtue of its sheer size, its overpowering minimalism, the Greenland ice sheet arches over the island, a flattened dome reaching thousands of metres above the underlying bedrock. When Danish geologists were mapping and probing what they perceived as a Danish national resource, this immense body of ice and its rocky marginal zones were being inscribed by another intruding power with a different meaning: namely as a potential battleground. The Danish exploration of Ilímaussaq was representative of Greenland's position as a material and symbolic resource – a part of the Danish national homeland. At that same period in time, the US was approaching Greenlandic landscapes with military-strategic considerations guiding their territorial ambitions. Before the advent of long-range bombers which could reach Moscow directly from the USA, Greenland was of critical geostrategic importance to US Cold War defence (Archer 1988; Grant 2010). For the US, Greenland was a *terrain* within which it was crucial for the American state to establish a military logistical stronghold.

Both conceptually and in terms of practice, terrain is a relational notion which comprises and frames human-environment interaction. It is a space in which to dwell (albeit not necessarily permanently), a space of concealment, a relation of security and protection, and importantly a space of *mobility* (Doyle and Bennett 2002; Gordillo 2013). For the US, Greenland represented all of the above. Managing and manipulating landscapes has long been a key strategic objective, and the production of terrain is tied up in the procurement of terrain intelligence (Guth 1998). During the 1950s, the US responded to what it perceived as an acute military need for such intelligence by making unprecedented investments in the sciences of the frozen geographies of Greenland (Doel 2016; Korsmo 2010; Martin-Nielsen 2016). The ambition of building the necessary arsenal of knowledge to transcend the material complexities of the landscape inspired an approach that seemed totalising in its outreach. Unlike the Danish preoccupation with the production of geological knowledge, the US effort to know and master the new northern frontier represented a thoroughly interdisciplinary approach, cutting across sciences such as geology, glaciology, seismology, hydrology, and botany (see Ries 2012a, 2016). At a glance, the mobilisation of science directed at transcendence more so than valuation of volumes may seem radically different from Danish valuations. However, although the Danish and US research programmes embodied different notions of both science and control, the two approaches had more in common than what was immediately apparent.

Tracing a series of interlocking practices dedicated to achieving mobility, this chapter begins at the edge of the ice sheet, moving gradually inward to the centre of Greenland. Exemplifying how terrain gets made through science, the chapter moves between geographies and corpographies of the ice sheet to draw out the multiplicity of ways in which terrain emerged through physical encounters between man[66], rock, and ice. Calculative science was a prime mechanism through which the US military sought to unleash the geopolitical potential of the ice sheet at the surface and below and extend their territorial

[66] The role of women in polar exploration should not be forgotten. However, not counting the women that occasionally materialised as figments of the fieldworkers' imagination (see Christie 1995), the ice sheet was in this case occupied mainly by men. Rather than de-gendering what was a very gendered environment (and still is in some aspects), the word 'man' is used consistently throughout this chapter (on polar science and gender, see Bloom 1993; Carey et al. 2016).

reach beyond the three designated 'defence areas' allocated by the Greenland Defense Agreement (1951). By deconstructing some of the metrics and methods used to enrol the physical landscape as supporting ground, the chapter argues that terrain was brought into being as a compromise between human and non-human forces and corporealities negotiated through the application of calculative logics of space.

Military significance of ice, snow, and frozen geographies

Unlike the objectives guiding the Danish prospecting, US visions of enrolling Greenland as part of its Cold War military apparatus extended well beyond the seasonally ice free coastal zones. As Lieutenant Colonel Emil Beaudry of the US Air Force noted in a 1949 report on high latitude defence:

> The strategic value of Greenland is apparent and if one powerful nation was able to completely master the Inland Ice Cap to a point where she could operate within and through it at will while other nations could not, that nation could well dominate the North Pole routes. She would possess a new weapon that could not be countered or molested. (Beaudry 1949: 6)

Beaudry's Mackinderesque statement is indicative of the importance that the US armed forces ascribed to the Greenland ice sheet as a military terrain. Yet in the 1940s and 1950s, very little was known about the emergent geostrategic heartland of Greenland or, most notably, the body of ice covering four fifths of its land area. Even basic knowledge of glacial ice as a material substance was limited. As noted by prominent glaciologist Henri Bader (1949), in the past there had been few economic or political incentives to study the faraway and hard to access polar glaciers. This, however, drastically changed as Greenland was recast as a potential frontline for armed warfare, a proxy space for other Arctic battlegrounds, and a strategically valuable source of weather intelligence (Martin-Nielsen 2016; Doel 2016). Analysing past military failures in frigid environments such as winter warfare in Korea, World War II operations in Alaska, and the failed German attacks on Russia, the US Army recognised the military significance of understanding the peculiarities of frozen terrain. As observed by glacial geologist Richard Flint (1953), the problems were manifold:

> The presence of a general snow cover reduces the mobility and efficiency of troops and transport of all kinds. It makes concealment and camouflage difficult. It creates

> problems in siting heavy weapons. It changes the appearance and contours of terrain, and it creates obstacles to the continuous and efficient operation of airstrips, particularly where drifting snow is prevalent. (Flint 1953: 1)

When the US military first began to address the many problems of icy warfare, they found themselves facing "a nearly blank wall: scientific ignorance of many of the physical properties of snow and ice, and of the behavior of those substances under a variety of critical conditions" (Flint 1953: 2). As a response, a new unit of the US Army Corps of Engineers was set up in 1949: The Snow, Ice, and Permafrost Research Establishment (SIPRE). Integrating civilian and military research bodies, the SIPRE mission was to coordinate US research efforts aimed at solving specifically military problems as well as unravelling the basic properties and principles affecting the behaviour of ice and snow (SIPRE n.d.). The intention, it seemed, was to establish a truly militarised northern frontier ruled by an American military forces in complete control of the Arctic environment and its unruly elements (Korsmo 2007, 2010; Farish 2013). Once glacial ice became a known quantity, it was believed that the ice would serve as an important ally in an impending war against the Soviets (Beaudry 1949; Anon 1955; Hartzell 1953; Myler n.d.). As a building material, ice would provide fortification and cover and even serve as a weapon to entrap enemy forces (Flint 1953; Anon 1955). Before these ambitions could be realised, SIPRE had to take on the somewhat unusual task of conducting basic research into the properties of snow, ice, and permafrost as well as its occurrence and behaviour in nature. As noted by Flint (1953), this was a somewhat unusual mission:

> It is unusual for a military agency to have to deal with prime characteristics and values of a basic substance. Ordinarily military research begins at a point well along in the fabrication process and concerns itself only with more characteristics which affect performance. However, solid water substance is an important exception. Many of the physical constants and parameters on which its behavior depends are wholly unknown and must be laboriously determined before observed behavior can be understood. (Flint 1953: 3)

While many of the central properties of ice and snow could be simulated under laboratory conditions, Flint (1953: 3) emphasised that "certain aspects of basic research would have no value unless they were carried out by persons informed with detailed, special knowledge of field relationships". Hence, to adequately capture ice as a military agent and subdue the unruly northern environments, SIPRE cast Arctic landscapes as *de facto* extensions of their laboratories (Farish 2013). In other words, to understand the military properties of ice and frozen geographies a direct, physical encounter between man and Earth was required. Understanding the properties of ice and snow had wide-reaching military applicability relevant across multiple geographical locations. SIPRE's mission was to open a new geophysical environment, which had previously been outside the grasp of the US armed forces, to military intervention and control. In this context, Greenland and its ice sheet was perceived both as a 'natural laboratory' for conducting military experiments (Powell 2007b; Farish 2013), a likely future battleground, and a proxy space for the Soviet Arctic. Hence, gathering terrain intelligence on its ice sheet served the dual purpose of mapping a geostrategic heartland and addressing a lacuna in military scientific knowledge of ice as terrain. Put differently, knowing terrain was both about knowing a specific place, but also about establishing a knowledge base covering a 'category' of the environment which could then be applied elsewhere.

During the early 1950s, the northernmost bastion of the US defence, the Thule Air Base, was left vulnerable as the lack of terrain intelligence prevented the establishment of radar stations or proper contingency plans in case of an enemy attack (Benson 2001). For the Americans, this base was quite literally their *Ultima Thule* – the farthest end of the northern world (see McGhee 2004). The location of the base had been determined on the grounds that this was the northernmost point which could be reached by ship during the summer months, which was crucial in terms of getting supplies and heavy military equipment to the base. Finished in the summer of 1953, the Thule Air Base was at the time the biggest US over-seas base, capable of housing no less than 4,000 military personnel (Taagholt 2002). Yet, upon its completion, the terrain surrounding the base remained largely unknown and only crudely mapped. Knowing the hinterland of the base was critical to developing and maintaining the necessary infrastructure to secure the base against enemy attacks and render it an efficient military outpost (Benson 2001). US military scientists soon realised that experience gained in Alaska and northern Canada was not directly applicable to Greenlandic conditions, and so the Thule Air Base became the starting point for comprehensive technical and scientific field research of North Greenland's physical geographies (Fristrup 1966).

When the US first began establishing themselves in Greenland, the principal source of information about North Greenlandic terrains was small-scale dogsled expeditions. These expeditions had been carried out by naturalist-explorers in the beginning of the twentieth century with decidedly different objectives in mind, different expertise, and markedly different technologies at their disposal. As such, the expeditions had either been guided by academic pursuits or been engaged in quests of fame and glory (Ries 2012a). Establishing a military logistical stronghold in the northernmost corners of Greenland required the ability to move heavy military cargo as well as large numbers of soldiers first onto and then across the ice. At this point in time, however, the known routes across the ice were only suitable for skis and dogsleds, not heavy military swing operations (Fristrup 1966). The US Armed Forces were thoroughly underwhelmed by the knowledge and intelligence generated by the (mostly) Danish expeditions (Ries 2012a). As this data had not been collected with terrain in mind, existing data was not only lacking in precision, but also failed to address a long line of factors crucial to military operations, logistics, and mobility.

Science at the edge of the ice sheet: finding a route of access

The first step in militarising the ice sheet was to secure safe access onto the ice for both men and equipment. This required a cross-disciplinary approach to understanding not only the ice itself, but also its marginal zones including the ice-free areas. The task of locating safe passageways and mapping out the area in terms of a military terrain was led by the Transportation Arctic Group (TRARG) in collaboration with a whole host of civilian and military research institutions, including the US Geological Survey, the Stanford Research Institute, and of course SIPRE.

Securing safe passage was no simple task. Illustrating Gordillo's (2013: 5) point that terrain is "pure multiplicity", the North Greenlandic terrain was made up of a long line of unmapped material complexes. The terrain was treacherous and unreliable, comprising snow-bridged crevasses invisible to the eye, areas of mud and quicksand during the thaw season, weather that changed at the drop of a hat, as well as a long line of peculiar challenges to visibility caused by blowing snow (Hutchinson 1954). Finding a way onto the ice sheet which would sustain more than just a small field party consisting of a few men and comparatively light vehicles required a comprehensive classification of the terrain in terms of drainage, precipitation, meteorology, seasonal variation, and the impact of permafrost to name but a few of the parameters in question (see Hutchinson 1954; Nichols 1954c). The many potential effects of the landscape on military strategy and defence made a wide-reaching deconstruction of the landscape in terms of its material properties key to establishing a stronghold of power and control in northern Greenland. In contrast to the Danish combination of unidisciplinarity and technical data analysis used to determine the resource value of land to be controlled, the US adopted a calculated interdisciplinarity to capture the complexities of terrain.

The first year of TRARG led research of the physical characteristics of the ice sheet, its edges, and its marginal zones saw four mobile field parties working and travelling between field stations across Northwest Greenland. Collectively entitled *Operation Ice Cap*, the parties counted scientists from disciplines such as meteorology, glaciology, geology, botany, and seismology as well as military personnel from the US Army. Each of the scientific disciplines had their own objectives and research agendas, all of which were overlapping and entwined and aimed at furthering the principal operation: to secure the necessary intelligence to provide safe and efficient passage across the terrain. This coordinated effort consisted of the parties *Ramp*, *Norcut*, *Solo*, and *Solair*. Ramp worked in the Nunatarssuak area, focusing on the ice ramp connecting the ice free areas and the inland ice as well as the adjacent ice free areas themselves. Norcut and Solo traversed the marginal zones of the ice sheet, emphasising reconnaissance work, surface glaciology, and geophysical investigations of the ice. Finally, the Solair party undertook a geological study of the greater Thule area. Divided along geographical rather than disciplinary lines, the field traverses were thus adapted to fit multiple needs. Together, these multidisciplinary field parties comprised a coordinated effort to fulfil the military requirements of the TRARG with respect to trafficability problems and terrain intelligence (Hutchinson 1954; Nichols 1954c).

'Patterned ground': terrain in ice-free areas

The extreme cold of North Greenland carried with it concerns relating not just to ice and snow, but also a series of unique geological challenges. Before encountering the inland ice, any military expedition first had to cross a stretch of land which during the summer months remained largely ice free. Explorers' accounts combined with reconnaissance flights and close examinations of aerial photographs suggested that the landscape was rugged, characterised by imposing cliffs and gorges carved deep into the bedrock. Crisscrossed by glacial rivers of unknown depth, the mountain plateaus were rough, irregular, and dissected, and most of the surface terrain appeared to be covered in till, outwash sand and gravel, and fluvial boulder pavements (Nichols 1954a).

The expeditionary and aerial knowledge offered a first indication of the difficulties that the US Armed Forces had to overcome in order to make this landscape penetrable by its troops. By documenting the existence of vast areas of exposed rock, the initial reconnaissance had also affirmed that geologists had an important role to play in this struggle of material and logistics. Aerial geology was seen as the most valuable method of gaining relatively swift and easy access to the landscapes below (Colton and Holmes 1954). However, with virtually no knowledge of the physical character of the formations that were observed from the air, the photos could not be interpreted in any meaningful way. A grounded approach was a necessary precursor for making these geologies recognisable and intelligible from the air (ibid).

Travelling knowledge: embodied geologies of traverse

The rugged nature of the terrain meant that the primary mode of travel for the field geologists was by foot as it was impossible for motorised vehicles to navigate this landscape. Carrying heavy equipment through fields of boulders and loose debris, trained TRARG geologists from the US Geological Survey and universities such as Ohio State and the University of Missouri "saw nearly every corner of the land area and sampled much of it at close range" (Goldthwait 1954b: 3). In terms of their use of geologic methods, the US field practices generally did not differ substantially from the GGU geologists' practices applied at Ilímaussaq. Geological observations and impressions were noted and sketched in personal field journals, samples were systematically gathered and meticulously coded, a long line of photographs were taken to further cement and document what had been seen. Just like the Ilímaussaq samples, samples from the Thule area were sent to faraway laboratories where their intrinsic truth came to light – only these laboratories were located across multiple American centres of calculation, such as SIPRE's laboratories in Willamette, rather than in Copenhagen.

The Danish expeditions had been directed towards land as an economic (and symbolic) resource – a space from which power could be gained through direct territorial possession and control, not just at the surface, but through the body of the Earth. The primary concern of the US, however, was to construct Greenland as terrain – a logistical space where power and control came from the ability to move, dwell, and operate (Beaudry 1949). The distinction between these different outlooks goes beyond simple distinctions between a vertical and a horizontal approach – of depth versus surface. As will become apparent throughout this chapter, approaching Greenlandic physical geographies as terrain required a vertical and volumetric knowledge base which had many parallels with the knowledge gathered by the Danish expeditions in their effort to cast Greenland as land.

A key difference between the Danish and the US expeditions, however, were the ways in which human experiences and encounters with the landscape were incorporated into the scientific narratives. The amateur composition of the GEOX expeditions meant that the embodied experience of the fieldworkers could not form an explicit part of the scientific narrative. Before the GGU's geological interventions, this separation had left the geophysical data from the Geiger-counters as the only trustworthy account of the mountains. Even the physical bodies of the geologists were primarily construed as restraints to true, unimpaired cognition as the body limited the reach of the trained, geological mind. Within the Danish narrative of Ilímaussaq, physical encounters had simply been part of the methodological context of the field practice. By contrast, in the official (classified) TRARG reporting of the scientific results of Operation Ice Cap, reflective comments of the fieldworkers' traverse through the landscape were explicitly woven into the scientific narratives *as data* and embodied encounters were entwined with other technical accounts (see Victor 1953; Nichols 1954c; Hutchinson 1954). Beyond strictly geological observation and sampling, the *practice* of moving through the landscape was in itself an important source of information.

The field parties of Operation Ice Cap were much lighter than the tractor drawn trains of sleds that, according to US visions, were to carry military cargo and troops across North Greenland (the so-called 'heavy swing operations'). Nevertheless, moving through the landscape gave the scientist and the military personnel that accompanied them an important indication of what it was like to physically engage the landscape. The relationship between bodies and landscape was documented, rationalised, and generalised throughout the field reports. Alongside geological formation histories and descriptions of rock composition, these accounts broke down the landscape in terms of its stabilities and instabilities as encountered when men and machines engaged the surface (Victor 1953; Hutchinson 1954).

The reports noted the difficulties encountered when walking across fields of frost-shattered boulders, frost-mounds, or steep outcrops of the underlying bedrock. These were areas which the expedition had sought to avoid out of fear of broken ankles or similar corporeal damage – injuries which under Arctic field conditions could be quite serious as options for medical attention were limited. Traversing the landscape also revealed how certain terrains could not be trusted. Treacherous solifluction lobes, for example, appeared as stable soil cover, but were in fact perforated by invisible flows of runoff of rain or melting snow. The first man or vehicle crossing a solifluction lobe might encounter it as solid ground, but the act of crossing it would send vibrations through the soil, setting it in motion internally. These vibrations would turn the one-time passable terrain into quicksand, making it dangerous for others to follow (Colton and Holmes 1954).

The paths of traverse and the many different landscapes were registered through the bodies of the fieldworkers. In a haptic, tactile engagement with the landscape, their bodies were directly involved in the process of observation. The body was observed as it fumbled across boulders and frost-mounds, but it was also in itself *observing* with every insecure step. As such, the physical encounter (the body and its limits) was not reduced to a question of method, but offered its own data, its own terrain intelligence.

Because trafficability was the principal TRARG objective, it seems likely that *how* the ice-free landscapes were construed topographically was shaped by this embodied encounter (Gregory 2016). This encounter was mapped and textualised alongside other geological observations. Figure 16, for example, shows a map that was based on the field sketches drawn by a Norcut geologist. The map divides the landscape into areas whose trafficability is laid out in the accompanying text. Superimposed upon the rocky terrain where soldiers might misstep and break their bones is a legible geography where potential dangers are designated to certain areas where they appear to remain self-contained and manageable. This serialised landscape may function as a template of travel, an aid to safe and efficient movement.

The importance ascribed to the journey's impact on traversing bodies (both humans and vehicles) sat within a broader geological narrative which strived to position itself firmly at the surface. The principal geological 'sub-discipline' of Operation Ice Cap was surface geology and geomorphology – the study of the physical features of the Earth's surface, its formative processes, and their relation to geological structures. Maintaining that trafficability was "controlled by topography and by the characteristics of the material found at the surface" (Nichols 1954b: 145), the geomorphological intelligence reports appeared to

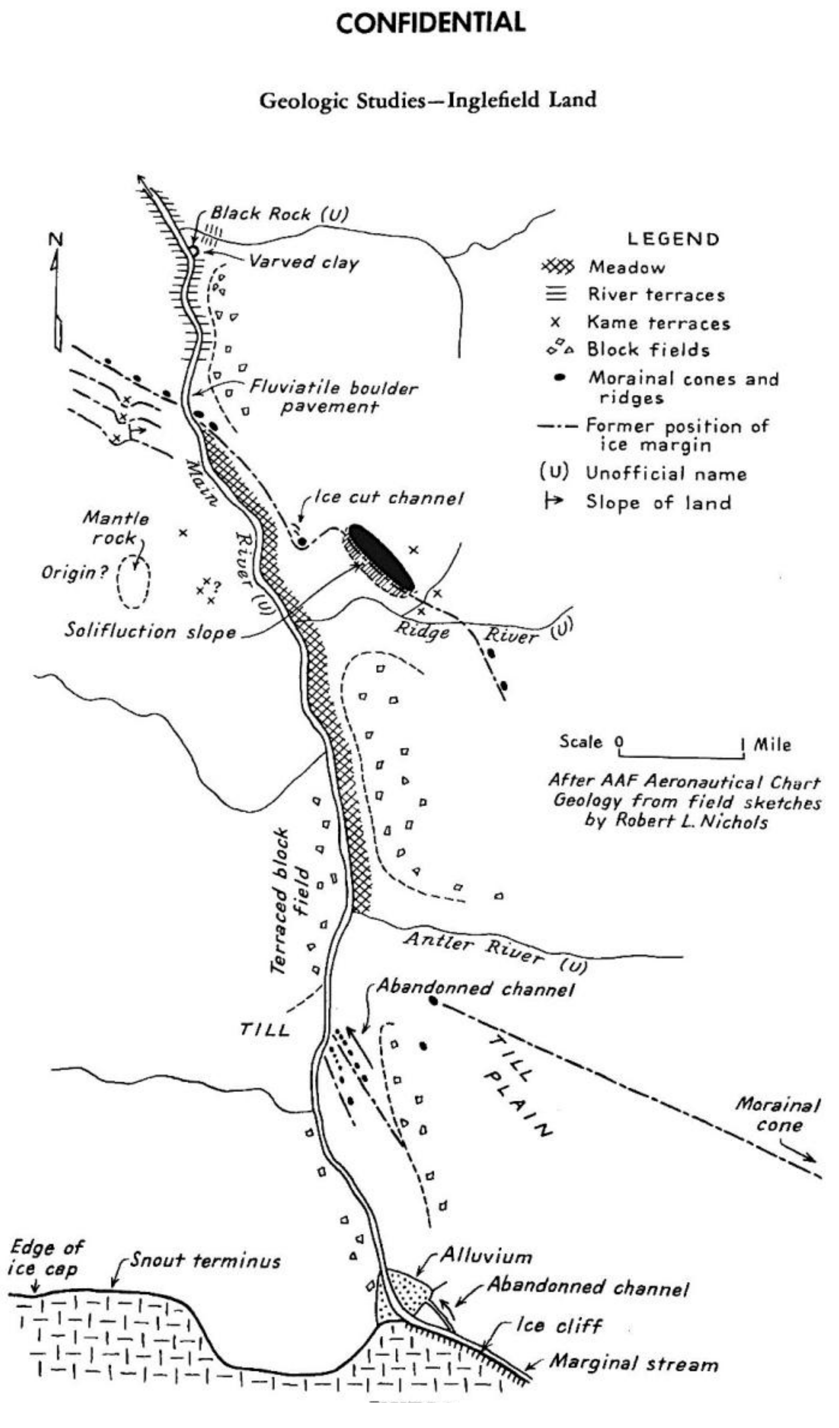

Figure 16: Geomorphological map of southwest Inglefield Land (source: Nichols 1954b). The place names in this map are unofficial names assigned by the military scientists to dominant landscape features. This exemplifies how naming was employed as yet another strategy used to create structure and stability, a navigable geography.

argue that understanding the deep properties of the underlying bedrock and the specificities of its folding and faulting was of little significance to establishing terrain – at least as long as it was reasonably certain that the rock constituted stable ground.

Herein lay an uneasy tension between an ideology of terrain-as-surface and the necessarily vertical and volumetric practices through which stability was ensured and through which the surface was bought into being *as* terrain. Even when the geomorphologists limited their accounts of the landscape to the surface, the surface was nonetheless understood as a plane that existed in an interactive and reciprocal relationship with volumes both below it and above (e.g. weathering forces[67]). The failure to uphold an image of the surface as an isolated event perforated the intelligence reports to the same extent as did the desire for a two-dimensional territorial plane. Although the geomorphological maps, for example, were "intended for use to a maximum depth of 50 feet below the surface" (Colton and Holmes 1954: 27), this statement in itself reveals how the geological gaze had indeed perforated the surface of rock and debris. This is indicative of how using science to consolidate terrain as a stable and trafficable surface could only be achieved by moving beyond the spatiality of the plane.

Engineering geology: serialised landscapes, ground, and foundation

The TRARG mobilisation of bedrock geology was similarly illustrative of the intrinsic tension between surface ideology and multi-dimensional practice. Sometimes referred to as 'solid geology', bedrock geology is the study of the main mass of rock forming the upper mantle of the Earth. Heavy frost acting on the top layers of rock meant that the surface terrain was dominated by the so-called block fields: "bare barren areas covered mainly with angular fragments of various sizes and shapes" (Nichols 1954b: 145). Such areas were difficult to traverse on foot and impossible by vehicle. However, the US Armed Forces' ability to traverse the landscape in terms of a military terrain could be greatly improved by the construction of physical infrastructures, such as roads and landing strips. As such, the TRARG geologists evaluated the landscape in terms of a foundation rather than simply a route of passage; they sought to understand the material components of the landscape, not just as obstacles to overcome, but as building materials.

In order to meet these needs, the geologists divided different geological formations into two series of numbered units. The geomorphologists classified surface formations in terms of the

[67] Meteorological studies, for example, explicitly fed into the geological studies to make sense of the reciprocal relationship between Earth and atmosphere (see Goldthwait 1954a).

manner of deposition, as this had a direct impact on the mixing and sorting of material. For example, out of the seven geomorphological units, two were classified as 'rubble', the distinction being whether it was talus rubble which had migrated down slopes or 'stationary' rubble derived from weathering of the bedrock directly underneath it. The bedrock geologists divided the underlying structures in terms of their dominant geological composition. Because the rock was evaluated in terms of mineable aggregates rather than geological specificity, some units consisted of complexes of different materials which were observed to occur together regularly (Fernald and Horowitz 1954).

In the field, the geomorphologists dug out shallow trenches of four to six feet to examine the vertical make-up of the units, locate the penetration depth of permafrost, and measure the speed of its thawing when exposed to the relatively warm summer air. The trenches were photographed and captured in shallow geological sections, which showed where samples had been exhumed. However, rather than simply retaining the locational specificity of the geologies they depicted, these sections were used to construct idealised, diagrammatic illustrations of what one might *expect* to find under similar conditions in this kind of landscape (see Fig. 17). Reduced to a series of perfectly even strata, this implied a standardisation of the military landscape whereby specificity and locality was effaced.

To subdue the landscape, the TRARG built a network of roads across the frost eroded block fields using the same rock whose erosion had rendered the terrain impassable in the first place. Doing so rested on geological knowledge of the erosion patterns, the effects of cyclical freezing and thawing, and the overall durability and engineering properties of the rock. To conduct a comprehensive 'engineering evaluation' of each unit, field observation was combined with mechanical testing of samples taken from each of the units.

Finer materials smaller than pebbles were subjected to 'sieve analyses', whereby they were sifted through increasingly finer sieves to determine their relative distribution of particle sizes. Once sorted in this manner, the differently sized particles were examined under a microscope to determine their geological composition and distribution. Larger samples of boulders and bedrock were subjected to crushing and stress testing to determine their durability and breaking patterns. Additionally, thin-sections were extracted from these samples, same as the Ilímaussaq samples, and these were microscopically examined. The resulting knowledge of grain size and mineral composition was then related to existing knowledge of such minerals, and could thus be translated into knowledge of the structural integrity of the rock.

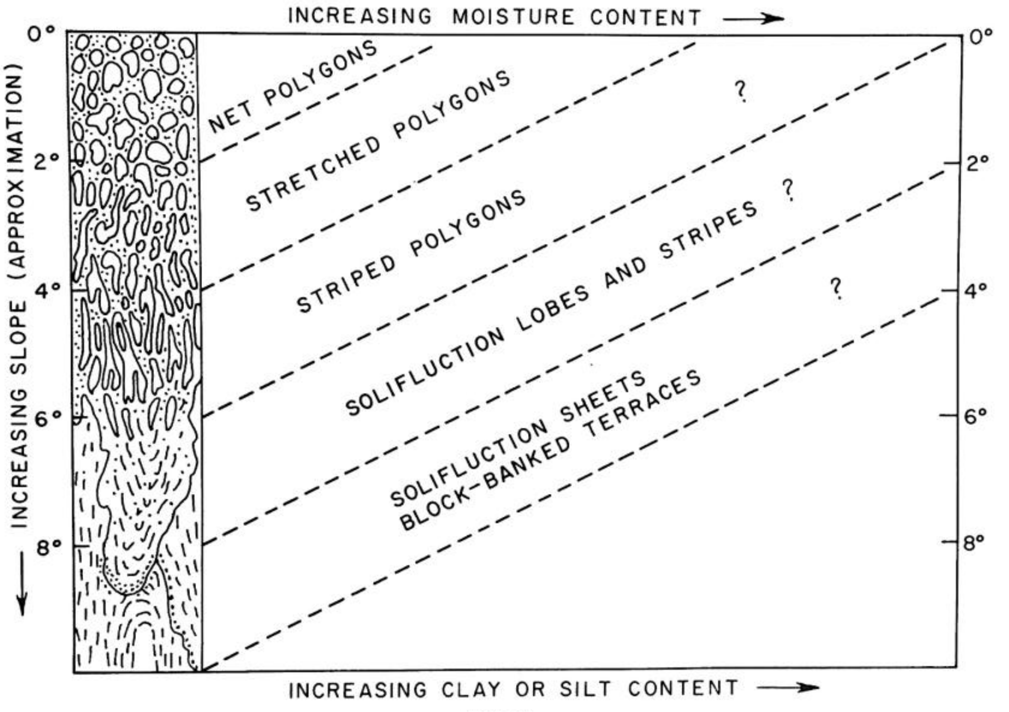

Figure 17: Diagram showing the relationship of polygonal forms and solifluction lobes to moisture content, slope, and clay or silt content (source: Colton and Holmes 1954).

This laboratory knowledge was transferred back to the field where each mapped unit was ascribed a set of engineering properties. The engineering evaluation addressed the following points:

1. Whether the material provided a solid foundation for construction
2. What was required to mine it (e.g. drilling, blasting, excavation) and whether tunnels through the rock required internal support
3. The abundance of potential quarry sites
4. What the material could and could not be used for in terms of construction

For example, Unit 5 of the bedrock geology series, which consisted of gneiss, provided a reasonably stable foundation for construction once the weathered rock debris was removed from the surface. It was abundant, easy to mine, and tunnels through it would only require little support. As a construction material, however, it was classified as "undesirable" because of its large content of pegmatites and widely spaced jointing, which rendered it relatively in-cohesive and sensitive to frost action and other forms of mechanical weathering (Fernald and Horowitz 1954).

By comparison, ground moraine from Unit 3 of the geomorphological classification system served a wide variety of purposes. Covering 35 % of the investigated area, Unit 3 was easy to recognise by its polygonal surface pattern resulting from frost action. Said frost action had shifted coarse materials towards the surface, resulting in reasonably well-sorted layers of till underneath. The patterned ground suggested that Unit 3 did not offer stable foundation, but in terms of construction, the larger particle sizes were suitable for rock armour and rubble masonry, and proper processing could render the finer material ideal as concrete aggregate[68] (Fernald and Horowitz 1954).

By numbering and categorising these different landforms along lines explicitly aiming at the practical ends of military engineering, the military geologists ascribed entirely new meanings to the terrain which differed substantially from the narratives of the explorers who had gone before them (e.g. Knuth 1948; Rink 1877; see also Bloom 1993; Spufford 1996). Knowing the engineering properties of different rock formations, for example, made it possible to actively calibrate the material forms of the landscape, pick it apart, and reassemble it. As noted by Gordillo (2013: 8-9), "political technologies of domination are created through the manipulation and transformation of terrain". The military geologists' engagement with and explicit engineering of the landscape is indicative of how terrain was a constructed geography which was actively being forged rather than one which simply emerged from nature. During the early 1950s, the edge of the ice sheet became, to some extent, a built environment consisting of more or less permanent and experimental infrastructures[69].

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[68] Notably, the fact that geologies were treated as resources (albeit in a different manner than the Ilímaussaq uranium) illustrates how land and terrain are not neatly separable.

[69] The extensive film material from Operation Ice Cap which can be found at NARA shows long sequences of road construction, both in snow covered and ice free landscapes. The construction of roads (as well as the operation of multiple different kind of vehicles) is a dominant theme of the films (e.g. Army Pictorial Service 1953, 1954; Army Audiovisual Center 1954).

Just as terrains cannot be reduced to what humans make of them (Gordillo 2013: 7), neither can they be reduced to mere properties of the non-human world. The terrain of Northwest Greenland was a manufactured geography, actively militarised, both by imposing a stabilising territorial logic that rendered the landscape thoroughly transparent and generalised/generalisable and through physical manipulation. Producing an actionable geography meant producing a geography that was to some extent malleable – a geography that could be moulded and manipulated to meet military requirements. Because the facilitation of logistics was of utmost importance to the US Armed Forces, engineering and the sciences that made engineering possible appeared central to the military relationship with land-as-terrain.

Legible geologies: a military reading guide

By applying an explicitly military imagination to the landscape, the geological gaze of the TRARG scientists seemed to exemplify a different geological way of seeing than the economically and scientifically motivated gaze discussed by Braun (2000) and Rudwick (1976), for example, or indeed evidenced by the Danish exploration of Ilímaussaq. Despite a significant degree of standardisation of practices and methods, the geological gaze is not a singular form of vision. This is not surprising, but it underlines the importance of considering the objectives that affect the directionality of the geological gaze when interrogating the manners in which geoscience opens up physical geographies to political action and control. The military geologists of TRARG not only saw the landscape through the eyes of scientists, but also sought to read it from the position of soldiers, military vehicles, and engineers. In short, they were deciphering the landscape in terms of 'field craft'.

Following Woodward (2004: 105), field craft relates to "military manoeuvres in the field, and these represent a military method for the construction and interpretation of landscapes for practical purposes". Her discussion of militarised geographies focuses on the ways in which soldiers read the landscape, and she builds on the notion that "military landscapes are texts to be read" (ibid: 124). The geologic militarisation of the Northwest Greenlandic coastal zones appears to have been directed at achieving the kind of legibility that Woodward refers to. When dealing with the excessive and unfamiliar geographies of northern Greenland, the landscape had to be written and textualised in terms of a military narrative before it could be read in any meaningful way.

Planning a heavy swing operation or a construction project required knowledge of the specificities of the landscape, but this was not the main Operation Ice Cap objective. The landscapes which the TRARG scientists analysed were chosen as representatives of much larger areas of similar appearance, and the detailed, local knowledge the scientists gathered was extrapolated across the vast stretches of North Greenland's coast. Rather than specificity and detail, the military geologists seemed to strive for a much more generalised view than what the Danish economic geologists had sought. The final reports of the scientific programme of Operation Ice Cap offer both an overview of the landscapes under analysis as well as a narrative which can be used as a 'reading guide' for similar geographies. For example, one report gave the following description of surface features which indicated that deposits favourable for road building might lie close to the surface:

> Polygons generally of medium size (10 to 35 feet in diameter), and stone rims or gutters that may occupy less than 50 % of the surface area. When rock types are present, it indicates glacial deposits rather than deposits formed from disrupted bedrock which would show only one kind of rock. (Holmes and Colton 1954: 50)

Similar notes on how to recognise treacherous landforms, how to seek cover and camouflage, and how to dig trenches were offered throughout the reports on the scientific programme (see Nichols 1954c; Hutchinson 1954). In a similar fashion, the Operation Ice Cap glaciologists rendered different types of snow legible to the untrained layman. Snow was, for example, classified in accordance with simple codes such as whether or not it was possible to make a snowball. This was a relatively straightforward indicator that could be used in teaching soldiers to read the landscape and also train them to register their own potentially useful terrain observations for further analysis (Victor 1953).

The geological 'reading guide' was not limited to observations that could be made on the ground. Part of the purpose of Operation Ice Cap was to study the features that the scientists had observed on the ground "on aerial photographs and thereby set up criteria for photo interpretation of other comparable areas" (Colton and Holmes 1954: 27). The aerial perspective could not replace ground surveying and did not offer the same embodied perspective which was important to *know* the land. Rather, the aim was to render North Greenland susceptible to 'speed reading' as a supplement to thorough 'textual analysis' similar to the function which aerial scintillometer had served at Ilímaussaq. Making it possible to effectively assess landscapes from the air greatly expanded the efficiency and reach of the US military. Speed appeared to be a primary objective valued above scientific accuracy, specificity, and detail. As the problems that Operation Ice Cap addressed were military rather than scientific problems, scientific concerns were secondary. In sharp contrast to the detailed geological investigation of Ilímaussaq, which continued for decades and yielded a plethora of scientific publications, all of the geological fractions of Operation Ice Cap concluded that no more research was needed to fulfil the task despite having spent no more than a few weeks in the field during the 1953 season. Whereas many GGU geologists built scholarly careers on their findings at Ilímaussaq, the fieldwork of the Operation Ice Cap scientists did not lend itself to academic pursuits[70] (see Hutchinson 1954). Scientific specificity had been largely cast aside in the pursuit of easily legible and generalisable landscapes, drawn with comparatively broad pencil strokes[71].

Vertical terrain: geophysical investigations of the ice sheet margins

The geological narratives through which the seasonally ice-free coastal zones of North Greenland had been captured and cast as a space of mobility presented these zones as a series of terrains consisting of mostly solid and dependable rock which by and far could be sufficiently rationalised in terms of its surface and immediate subsurface properties. As noted, however, the territorial ambitions of the US military extended far beyond these rocky shorelines. To cast Greenland as an operable terrain, it was necessary to engage its most prominent and dominant feature: the ice.

At a glance, the Greenland ice sheet presented itself to the US military as a smooth and solid plane, "a snow desert; broad and seemingly endless vistas of almost level snow" (SIPRE n.d.: 1). From experience, however, Operation Ice Cap scientists and conscripts knew this apparent monotony to be deceptive. Despite its mono-mineralic configuration, the material manifestations and properties of ice and snow were inherently multiple, resulting in varied

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[70] By contrast, an entire series of Meddelelser om Grønland (a scientific periodical dedicated to studies of Greenland) was dedicated to the investigations of Ilímaussaq. Only one of the Operation Ice Cap reports suggested that it might be possible to publish their results in an academic outlet.

[71] Ries (2012a) and Doel (2003) have noted that the US Army tended to hire scientists who were prepared to offer quick estimates and future projections.

and changing surface conditions across the sheet. More troublesome than shifts in the trafficability of the surface plane, however, was how the seemingly benign horizontality of the ice sheet masked a precarious subterranean geography which throughout the history of polar exploration had claimed both lives and limbs of explorers, scientists, and soldiers (Boskin 2011). During the thaw season, fluctuating glacial river systems, prone to sudden and unpredictable outbursts, formed within the ice. Friction between ice and the uneven bedrock below meant that the upper and nether strata of the ice moved at different velocities, the sheer stresses of this difference producing subterranean crevasses – deep fractures connecting the plane of existence to a perilous underworld of unknown depth. Blowing snow quickly hid the crevasse openings from view, leaving behind a deceptively calm surface (Victor 1953). Such hidden fractures had been known to swallow men and equipment whole, pulling them down seemingly bottomless voids so deep that those left at the surface never heard a crash (Boskin 2011).

The US project of creating a viable ice sheet terrain was inextricably tied to managing the risk associated with the "crevasse problem". To identify the safest and most efficient routes across the ice and map out zones of current and future risk along the routes, the Operation Ice Cap scientists engaged the deep, internal structures of the ice sheet rather than its surface features. To penetrate the thick layers of ice all the way to the bedrock, two different methods were used: seismology and gravity studies.

Seismology

The use of seismology to detect secret Soviet nuclear weapons tests during the Cold War is well documented in academic studies of Cold War science and technology (e.g. Barth 2003; Jacobsen 2016). This was, however, not the only way seismology was put to work in the service of American national security. Consisting of fractions of the Norcut and Solo parties respectively, Operation Ice Cap's seismic programme was a continuation of a comprehensive reconnaissance effort instigated by TRARG the year before (Victor 1953). The aim of the seismic expeditions was to obtain knowledge of the distributed thickness of the Greenland ice sheet, knowledge of the physical characteristics of the glacier névé ice, and to estimate the structure and nature of the bedrock underneath the ice (Holtzscherer 1954a, 1954b). These matters were key to the question of trafficability as they were assumed to be directly linked to the three variables used to estimate the risk of crevassing: ice thickness, ice velocity, and bedrock topography[72]. By rationalising these properties, predictions could be made about the patterns of change of any route. As noted in the final report of Operation Ice Cap:

> This [seismological analysis] embodies not only trafficability from the point of view of surface conditions, but also of when and where to expect new crevasses, steepening of the route, etc.; in other words, a prediction of the future course of events along this route. (Fisher 1954a: 149)

In search of terrain intelligence that was not merely horizontal, but vertical in its outlook, the seismologists travelled independently from the rest of the field parties they were part of. Operation Ice Cap travelled in tracked vehicles, the so-called 'weasels'[73], and the seismic fractions were assigned three each: one for navigation, one for positioning explosives in the field (the "shooting weasel"), and one in which a small seismic laboratory had been fitted (the "recording weasel").

The seismic principle is based on the fact that different materials of the Earth's crust have a different acoustic impedance depending on their density. Put simply, mechanical trepidations of the Earth called seismic waves travel through, for example, ice and rock at different velocities. By releasing a controlled source of seismic energy in the form of an explosion and measuring the ground movement caused by reflected seismic waves, Operation Ice Cap seismologists were able to extrapolate information about the properties of the substrata from the seismic pattern (Holtzscherer 1954c).

To generate seismic energy, the TRARG team fastened explosive charges (either dynamite or TNT) to wooden dowels, which were suspended above the snow surface by attaching them to evenly spaced aluminium stakes. The charges were connected in a series using

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[72] In personal communications with a leading glacial geographer, it has been suggested to me that only knowledge of the characteristics of the near surface snow-ice mixture is useful in planning a route across glacial ice. Ice thickness and bedrock topography are not useful from a trafficability perspective. Nonetheless, these were factors and methods which the Operation Ice Cap scientists explicitly connected with the prediction of the changing characteristics of future routes.

[73] Also known as United States Army M29C cargo carriers.

specialised seismograph caps to make sure that they all were fired within 1/10,000 of a second of each other. Upon detonation, seismic waves travelled through the ice, reaching the underlying bedrock. Because of the difference in acoustic impedance between ice and rock, some of the seismic energy was reflected off the interface between the two mediums while the rest of the energy refracted and dissipated within the body of rock. 12 geophones spaced exactly 25 feet apart and firmly pushed into the snow converted the ground trepidations caused by the reflected energy into a series of electrical signals, passing on the seismic information to electronic amplifiers installed in the recording weasel where it was photographically recorded over a set period of time (see Fig. 18).

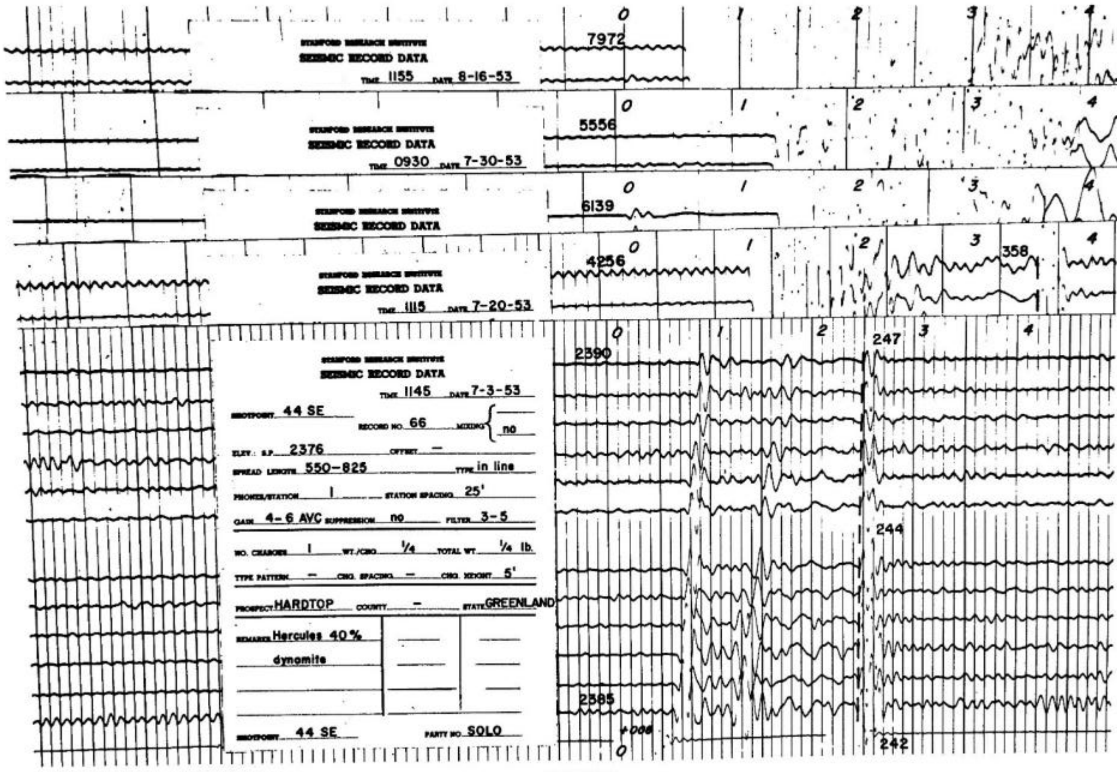

Figure 18: Example of the direct output of the seismographs (source: Allen and Miller 1954). These seismograms provide a written record of the motion caused by energy reflected off the interface between ice and bedrock.

Having first established the average velocity of seismic waves passing through ice and bedrock (their respective refraction profiles), the TRARG geophysicists applied this knowledge to the interpretation of the seismograms. Ice thickness could now be determined as a function of the mean vertical velocity through the medium, travel time of reflected wave, and the distance between the point of detonation and the differently placed geophones. By correlating between data points three to twenty miles apart, the result was a series of sections depicting the vertical structure of the traversed route (see Fig. 19). Drawing such profiles was a highly theoretical practice resting on a string of generalisations and assumptions about the invisible structures that were being mapped. For example, the number of shot points as well as the spacing between them was determined by estimates of ice thickness – the very metric that the seismic shootings were meant to obtain. Furthermore, the material complexity of the ice itself was completely overwritten, as it was assumed that it was perfectly uniform throughout. The same was assumed to be true of the underlying bedrock, which was extrapolated from visible outcrops in ice-free areas. Finally, the choice of interpretive framework applied in the translation from seismogram (Fig. 18) to idealised section (Fig. 19) was known to lead to markedly different results. Nonetheless, the seismic data was seen as offering "absolute depths" revealing a true image of the invisible substrata (Allen and Miller 1954: 369).

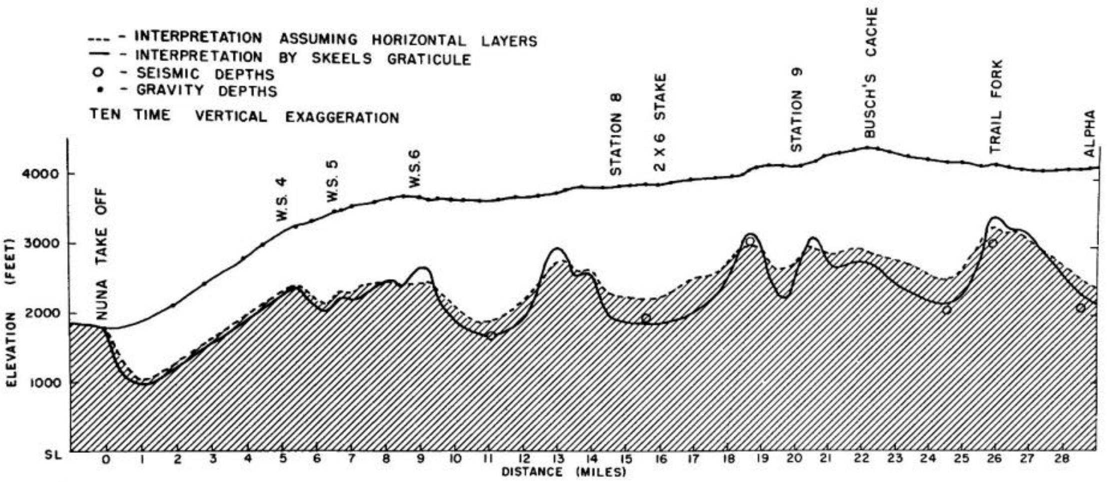

Figure 19: Gravity and seismic profiles (source: Zavadil and Barnes 1954).

In addition to the uncertainties associated with data interpretation, the actual measuring practice had its own limitations. The geographical position of each "shot point" was measured not with military precision, but by seemingly rough estimates. The coordinates of the field stations were known with relative precision, but at the time, the existing cartographic material of the area was found by the expeditions to be off by substantial margins across all the areas of investigation. This hampered precision, somewhat to the regret of the scientists. The trail had been planned out beforehand, and rather than having to orientate themselves using time consuming geographical measuring techniques, the distance between shot points was measured along the trail by the weasel odometers and coded in field journals as, for example, M75 for 75 miles from the camp. Based on this measure and the assumption that the route had been followed with some precision, geographical coordinates were only calculated later. This rough estimate of the relative position of observations were corrected by astronomical observation when time and weather conditions permitted[74].

Alongside the data collection for the seismic profiles, the seismic fractions conducted experiments directed at utilising the seismic principle for crevasse detection (see US Army Corps of Engineers 1957). The apparatus brought along for testing was, however, soon determined to be insufficient to secure the safe and swift progress of the expeditions. Hence, caution led the fieldworkers to resort to a less technical solution. Replacing the sophisticated crevasse detector was a conscript on skis, tethered to the weasel by a long rope, equipped with a long pole for poking the ice. If the pole went deep, the presence of a crevasse was likely, but even when it did not, there was no certainty to the matter[75] (Boskin 2011; Victor 1953; see also Army Audiovisual Center 1954).

Gravimetric studies

Each seismic measuring point required considerable resources, both in terms of time and material. A less precise, but far more efficient means of obtaining an image of the underlying bedrock was through gravity studies. As the Earth's gravity varies with the density of the material forming its crust, changes in gravity indicate changes in the thickness of ice cover, as ice is much lighter than the underlying rock. Using a highly sensitive gravity meter (a so-called Worden Meter), the slight variations in the Earth's gravity field were registered along

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[74] Despite all these uncertainties, the results obtained from early seismic estimates of the thickness of the Greenland ice sheet have since been estimated to be remarkably accurate.

[75] In his memoirs, TRARG expedition historian Joseph Boskin (2011) writes how the conscripts used to take bets on how long the designated 'crevasse-detector' would last, and how this man always made sure that his G.I. insurance was paid up. According to Boskin, no one died during the 1953 traverses, but one man did lose the lower half of his arm when his weasel dropped into a crevasse that was falsely presumed solid.

pre-planned routes across the ice sheet. The setup at each point of observation was a simple matter of placing the instrument on a three-legged wooden stand, making sure it was kept level, and then noting the value displayed on the Worden Meter. Favourable observation conditions allowed readings to be made as closely as every six to ten minutes. By making it feasible to obtain a more condensed data set, the gravity profiles made it quicker and easier to determine whether a potential trail crossed bedrock structures which were prone to cause crevassing of the ice. To identify the safest possible route onto the ice sheet, the gravity fractions traversed the ice sheet in a crisscross pattern of straight lines. Gravimetric data points were normalised and transferred onto a series of maps (see Fig. 20). Extrapolation between points of observation allowed for the drawing of gravity contours, which were theoretically congruent with the topography of the underlying bedrock.

The ease of data collection came at a price. In addition to the inherent uncertainties tied to the method itself, the gravimetric measurements were fraught with uncertainties and contingencies which the gravity readings had to be adjusted for – a complex mathematical process of data normalisation. First, there was the drift in the readings offered by the Worden Meters caused by the age of the instrument (measured in days), changes in temperature, and the effects of the changing gravitational pull of the moon. Despite being a well-established and highly standardised apparatus which had cemented its epistemological value over decades, each device had an identity of its own. As such, time and temperature drift had to be quantified for each individual apparatus. For example, it was found that Meter 113's reaction to changes in temperature was not only different from Meter 149, but opposite in direction (Barnes and Zivadil 1954). Another factor which had to be accounted for was decreasing gravitational pull at high latitudes caused by the flattening of the Earth towards the poles and the decrease in centrifugal force. Then there were the near-impossible terrain corrections to account for the rugged structure of the bedrock. Deemed too laborious, the bedrock at each measuring station was "assumed to be an infinite horizontal slab" even though this "subdue[d] the actual bedrock structure; in reality valley walls are steeper, valleys are deeper, and peaks and ridges are higher than indicated on the gravity profiles" (Barnes 1954: 103).

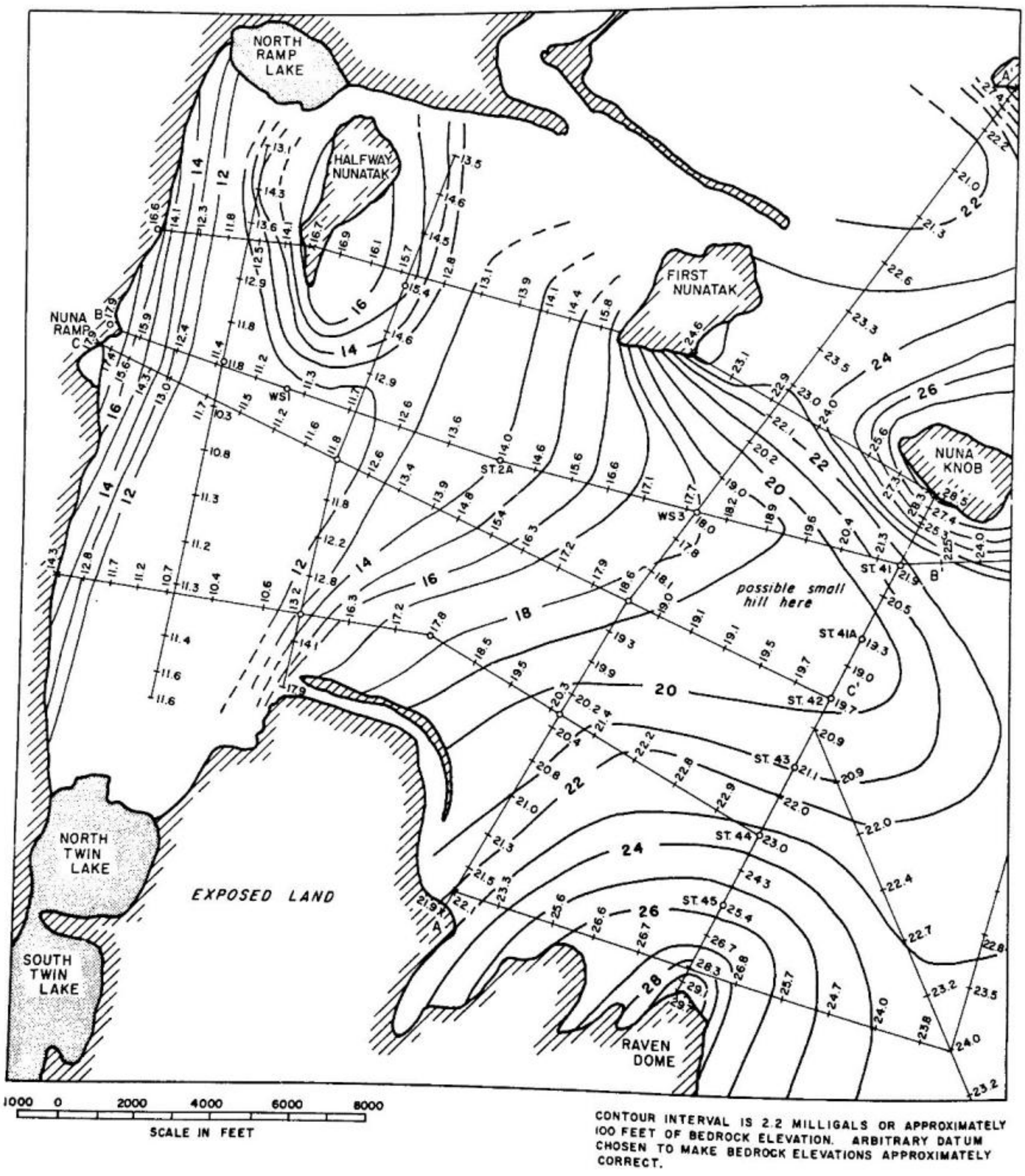

Figure 20: Gravity contours on Nuna Ramp (source: Barnes 1954).

By far the largest source of error, however, came from the altitude measurements. Because the gravitational force on the Earth rapidly decreases as the distance from its centre increases, altitude was a critical metric. Good elevation control was key, but the two separate gravity teams only consisted of one and two men respectively. Hence, they had no choice but to use the simplest method available, namely a barometric altimeter. This instrument determined altitude based on differences in atmospheric pressure, which made it highly sensitive to factors such as sudden changes in air pressure caused by passing weather fronts as well as changing air temperature. Hence, the elevation data had to be adjusted in accordance with meteorological data, which was only available from the base stations, which at times were as far as 100 miles away from the gravity observer. To account for the many sources of error, the expeditions rotated cyclically between measuring points, leaving two to three hours between observations to obtain a weighted average. During the 1953 field season, the gravity studies were plagued by stormy conditions and lengthy cold spells, which significantly interfered with the data. Waiting for conditions to improve had not been an option since the programme had to be executed without delaying the military operations. As a result, both gravity fractions found the replicability of their data to be poor as differences between readings suggested discrepancies of as much as 100 feet.

Despite the seemingly endless lists of potential errors and uncertainties, the gravimetric results were deemed to reveal a useful approximation of the location of hills and valleys underneath the ice sheet. Although the military and civilian scientists did make suggestions as to how uncertainties could be minimised in future operations, they simultaneously concluded that the fact that some of their recordings were believed to be hundreds of feet off was of little military significance. As noted in the final report, "the present profiles are believed to be sufficiently accurate for military purposes" as "the gravity measurements seem to be accurate enough to indicate safe and dangerous areas" (Barnes and Zivaldi 1954: 381). In other words, scientific precision was once again sacrificed in favour of utility and speed.

Dematerialised verticalities and relational horizons

The seismic and gravimetric studies offered a perspective that was simultaneously vertical and horizontal in outlook, producing both vertical cross sections showing the shifting depths of ice as well as horizontal maps of hidden bedrock topographies. Guided by the overarching TRARG objective of rendering the ice sheet trafficable, the contribution of these studies was a neat separation of the territory into essentially dematerialised, discontinuous layers matching Weizman's (2002) idea of a vertical territorial ordering. This division of the solid ground from the plastic ice – a separation of earthly components bound with the aid of refracted sound – allowed for the invisible ice-rock interface to emerge as a political boundary imbued with the power to determine the value of the surface as terrain.

The geophysical practices outlined above had enacted two entangled planes to determine the formative relationship between the plane of existence (the ice sheet surface) and the invisible bedrock topographies below. The reciprocity between the icy surface on which military personnel and equipment moved and the contours of the underlying bedrock plane tied the project of terrain making to the project of projecting territorial power both across these two quintessentially horizontal planes as well as downwards along a vertical axis through the ice.

Unlike the frostbitten rock in the seasonally ice-free coastal zones shifting at the slow pace of geological time, the comparatively fast-flowing masses of ice were less susceptible to being cartographically fixed. To achieve the Operation Ice Cap goal of consolidating the ice sheet surface as an ontologically stable space of crossing, the geophysical surveys anchored the movement of the ice to the stable bedrock in an effort to fix it geographically. The vertical representations of the ice sheet and the bedrock – static images of a world already formed – provided the scientists with a 'solid' frame for understanding a body in motion and predicting its future development. Framing the fluidity of the ice meant thoroughly grounding the bedrock – one captured in terms of its formation, the other as pure form.

Despite an expressed desire to frame the ice's plasticity through these geophysical surveys, the seismic and gravimetric reports represented ice as a uniform matter with no indication of its liveliness. The reports showed no distinction between different kinds of firn, and ice was approached as a monolithic mineral formation through and through. The seismic survey, which offered the most precise data, was a science based on vibration. Nonetheless, the uniform, white, planar sections seemed to rob the vibrant matter under investigation of both its inherent and induced vibrancy. The vertical representations of the ice sheet offered an essentially dematerialised view where the only thing that mattered was the relational distance between planes. What lay between was literally left blank (see Fig. 19, p. 176).

Dissecting the polar plateau: glaciology at the ice sheet margins and beyond

The dematerialised images of the ice sheet produced by the geophysical surveys were never meant to stand alone. The seismic and gravimetric studies revealed useful information about the thickness of the ice sheet and the topography of the underlying bedrock, but the internal architecture of the ice itself was covered by another discipline: glaciology. To create a network of stable and dependable routes across the ice sheet surface, detailed glaciological knowledge of the materiality of the subsurface was indispensable (Kucera 1954). As stated in the preliminary report on Operation Ice Cap:

> When it becomes clear how true polar ice moves, what its rate of movement is per unit time under any given set of natural forces, what its wastage is, and what its rate of accumulation and ablation is per normal year, then certain predictions can be made with regard to the dependability and permanency of any established route from an ice-free margin on to the ice-cap itself. (Victor 1953)

As a terrain, the ice sheet surface was constantly changing, not just seasonally, but sometimes at the drop of a hat. Understanding, capturing, and mapping the temporality of terrain – its seasonality, continuous flow, and effects of weather events – was instrumental in securing its functionality as a space of fixity and mobility. As exemplified through the geophysical surveys, the production of terrain required mappings of flow and formation rather than simply the form of the landscape. The ontological stability of the ice sheet terrain at the level of the surface rested on positioning the surface within a complex system of elemental reciprocities rooted deep within the fabric of the ice. Knowledge of the inner architecture and movements of glacial ice was, at the time, still in its early stages. As noted by SIPRE glaciologist Henri Bader (1949: 1309), pre-war glaciological research had seen "an orgy of hypothesizing on conditions prevailing inside glaciers and on the mechanism of glacier flow based on quite insufficient observational and experimental data".

To address this lacuna, the 1953 field season had included a glaciological programme gathering data on the properties of snow and ice along their routes. The glaciological studies of 1953 had benefited from the interdisciplinarity of Operation Ice Cap, particularly the geophysical studies, which had helped the glaciologists verify their mathematical theories of glacier motion (Fisher 1954b). Such interdisciplinarity had been at the heart of the Operation Ice Cap programme. Although each disciplinary faction of the four field parties had conducted their own studies and written up their own reports, these reports were not only collected into a single volume, but explicitly related the different bodies of work to each other. Botanical data[76], for example, was discussed in terms of how "they affected

[76] Military botany had been used both as an indicator of seasonal variations of the ice cover and possible areas of flooding. It had also provided important research directly applicable to the question of trafficability, as studies of so-called algal pits which formed in the ice sheet had been found to

problems of geology and glaciology" (Benninghoff 1954: 80). Similarly, meteorological work added "essential data to the material analyzed by scientists doing research in glaciology, geophysics, snow characteristics, and botany" (Toney 1954: 124). In the preliminary report on Party Solo it was concluded that "The Main scientific accomplishment of the SOLO Party as a unit was the *integration* of scientific work" (Fisher 1954a: 151, emphasis added). Nonetheless, the same report concluded that the integration of disciplines into single parties should be avoided in the future so that "no one unit would be held back by the different time requirements of the other units" (ibid: 158).

This interdisciplinarity of Operation Ice Cap had come at a price, particularly for the glaciologists. Because of the short time spent in the field and the constant pressure on the scientists not to slow down the expedition, it had been impossible for the glaciologists to "pursue problems of general interest to glaciologists" (Fisher 1954a: 158). The studies carried out had been purely for reconnaissance purposes. Stops at each measuring point along the route had sometimes been as brief as two to three hours. This had presented some difficulties "as the techniques employed by the different scientific groups vary so greatly in detail and in time required" (Fisher 1954a: 151). The SIPRE glaciologists in particular had felt that their work had been significantly impaired as they would have preferred longer halts at almost every occasion. Unlike the other scientific fractions, the glaciologists concluded in their reports that they had not yet fulfilled their objectives. They also concluded, however, that this was "neither surprising nor alarming" (Fisher 1954a: 154). Even before commencing their investigations, the glaciologists had known that to answer their research questions in a satisfactory manner, a long-term programme was needed.

Operation Ice Cap was envisioned as part of a five-year plan to uncover the secrets of the ice sheet (Fristrup 1966). Preliminary research in 1952 had provided proof of concept as well as some initial glaciological data, and based on the 1953 studies, it was possible to give a firmer shape to the remainder of the five-year programme. For the glaciologists of SIPRE,

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create substantial zones of weakness of the surface (Benninghoff and Robbins 1954). As such, the algae made up a composite element that disturbed the surface terrain. Hence, the algae may be considered a non-human lifeform pushing back against human domination of the ice sheet margins. This makes the algae an actor of terrain.

this meant making up for what was referred to in the preliminary report as the "emasculated program" of 1953 by launching a series of independent glaciological expeditions (Hutchinson 1954). The following year, SIPRE organised a seven-man glaciological field expedition in Northeast Greenland as a direct continuation of the Operation Ice Cap glaciological programme (Program 12) under the leadership of 26-year-old glaciologist Carl S. Benson, who had been a member of Party Solo and also participated in the fieldwork of 1952. *Party Chrystal*, as the 1954 expedition was named, yielded much important information, both with regards to the ice sheet itself and just as importantly about the well-being of the people traversing it (see Benson 1955a, 1955b, 1955c). The climax of Program 12, however, came in 1955 when Benson took an expedition beyond the marginal zones in northern Greenland into the deepest parts of the inland ice. Because the nature of the Greenland ice sheet varies significantly with altitude and latitude, any understanding of the overall physical environment, especially the structure of the upper layers of snow and firn, required climbing the ice dome to its very centre, a point known as *Eismitte* (lit. 'middle of the ice', see Fig. 1, p.xix). According to Benson (1962a: ii), such information was "essential to efficient operation on the ice sheet".

Preparing the Jello trek

During the 1953 field season, TRARG scientists determined that studies of the stratigraphy of the upper two to three metres of firn yielded valuable information which had bearing on trafficability. The value of stratigraphic knowledge was proven when a vehicle crashed through the surface into a crevasse. Upon digging a glaciological pit in the adjacent area, it was discovered that 60 centimetres below the surface, there was a thick layer of "rotten snow" (snow saturated with water), and this is what had caused the crash (Benson 1959a). The trafficability of the surface was directly relatable to the material qualities of the strata of the ice sheet. Constructing terrain not only depended on rendering the Earth transparent as achieved by the seismic surveys (see Bishop 2011), but on unearthing its deep, material qualities.

Given the practical significance of mapping the strata of the ice sheet Benson's expedition, codenamed *Project Jello*, received funding to continue the stratigraphic studies he had initiated the previous years and extend the reach of the project to the very centre of the ice sheet[77]. For Benson, Jello thus represented the culmination of years of research. For the vast machine that was the US effort to lay the ice sheet bare, Jello represented but one tiny piece of a puzzle coming together to reveal a truer image of Greenland as a terrain and an apparatus of warfare (see Korsmo 2010; Martin-Nielsen 2013a, 2016). Yet Benson's glaciological studies took the US Army further than they had ever gone before – no less than 1,200 miles across nothing but ice (see Fig. 21, next page).

The 1952 research, the 1953 Solo Party, and Party Crystal of 1954 had all been partially staffed by military personnel filling roles such as navigators, mechanics, and radio operators. Benson had found this to be quite detrimental to the research programme, as the non-scientists had been impatient, displayed very little understanding of the scientific requirements of the operation, and lacked what he described as the "proper motivation" (Benson 2001). The military fractions of the parties had operated with the simple goal of moving across the ice sheet and then turning back. The journey was their only objective. Benson had found it difficult to communicate to the non-scientists why it was necessary to stop every 10-25 miles and spend days doing research in any one spot. For the military personnel, "the idea of actually looking at the snow, measuring it, thinking about it, is just foreign" (Benson 2001; see also Benson 1956; Crary 1956). During the long halts, the non-scientists had nothing to keep them occupied and grew impatient and bored. Seeing it as crucial to the success of his operation to keep morale and motivation afloat, Benson had successfully applied to staff his 1955 expedition only with scientists, each of whom had their own side-project in addition to the overarching glaciological objectives of Jello.

Benson was accompanied by fellow glaciologist Richard Ragle who joined him in his stratigraphic studies of the ice sheet. Mechanical engineer, Alan Skinrood, served as expedition mechanic and also conducted his own independent studies of vehicle trafficability for his master's thesis. George Wallerstein, the navigator, was a Cal Tech PhD student of astrophysics, and studied magnetic declination across the ice sheet. The expedition medic, Dr Robert Christie, researched bacteria in the nostrils and skin of the

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[77] Reading across Benson's personal correspondences it is apparent that he was not motivated by the military applicability of his research. Rather, it seems that (like many scientists of the time) he was framing his research in those terms to secure funding and access.

expedition members. As was quite common for the US military scientific expeditions during the early-mid 1950s, the team was young and of limited experience. With an average age of 27 and a range of 21–31, Jello was hardly an exception. The Greenland ice sheet was at once a place to be incorporated into the realm of known territory and a training ground for young Americans (see Victor 1953).

Figure 21: The route followed by the Jello team (source: Benson 1960).

Although their departure was set for 1 May, the Jello team arrived in Thule as early as March to prepare for their traverse. Their primary mode of transportation was four weasels which Benson had had built to his own specifications. This, however, still left the team with the task of building their own sleds and wannigans (container-like constructions on skis) to serve as living quarters and field laboratories. Although funding was never an issue, the institutional and organisational bureaucracy at Thule Air Base made this task more difficult than Benson had anticipated. Upon arrival, Benson and his team found that their person of contact had a severe alcohol problem. This prevented him from doing his job and he was ultimately escorted off the base. This left the Jello team almost completely cut off from supplies and assistance, as representatives of other fractions of the US Armed Forces operating at the base refused to help them. Resorting to personal friendships and calling in favours, Benson managed to borrow equipment and space in one of the base's hangars. Materials were sourced by scavenging through dunnage heaps and by pretending to have the authority to sign off on requisition forms (Benson 2001; Christie 1995). Through ingenuity, rule bending, and personal friendships, Project Jello was eventually able to take off albeit two weeks later than scheduled.

Navigating an inland 'ice ocean'

On Friday 13 May 1955, Project Jello took its first steps onto Greenland's monumental ice sheet in bad weather but with high spirits (Christie 1995). Their carefully planned route consisted of five transects – perfectly straight line segments, each subdivided into 25-mile units. This surgical line drawn across the map of the body of the ice sheet represented the line along which the glaciologists planned on making their incisions. To allow easy correlation between data points along the route, each line was given an identification number and each 25-mile point was identified by a code indicating the course of direction and the distance from the point of origin of the line segment (e.g. 2-175 or 4-50, see Fig. 21 and Fig. 22). The route of the Jello expedition was fixed before departure. In representations of the route, the line moved smoothly and consistently between points, tying them together, masking the 120 days of hardship that was inevitably part of its materiality.

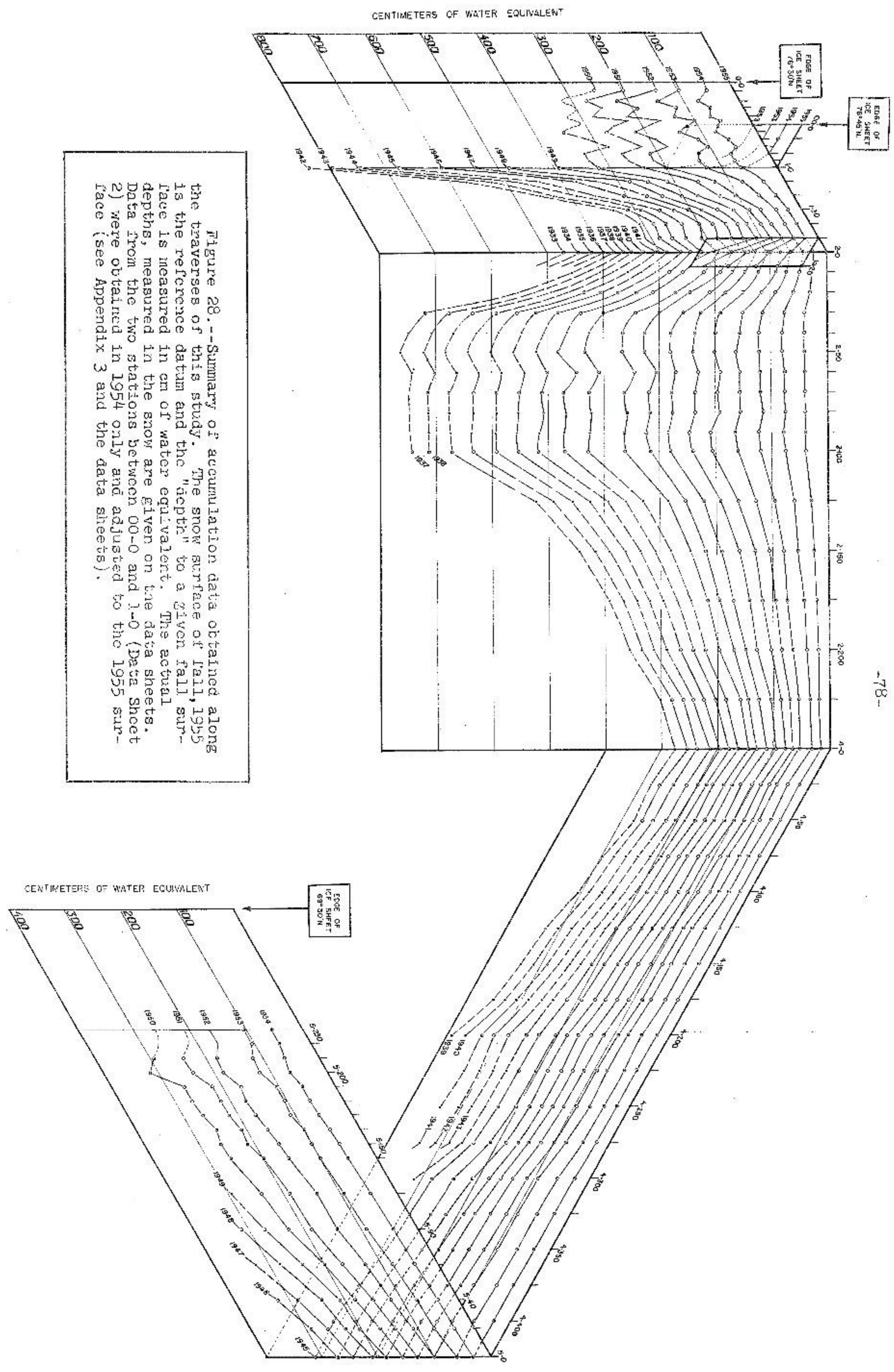


Figure 22: Dissection of the Jello route (Benson and Ragle 1956).

Keeping their course across the monotonous stretches of ice was no simple task. Despite the fact that the ice sheet was encountered as (mostly) solid ground, navigating the whiteness was more akin to travelling across an ocean than a landmass (Smith 1956). The report from the 1952 field season had summarised it as follows:

> The Greenland Ice-cap looks like a sea of ice and snow on which no land marks are visible. The navigation of a tractor or weasel train is therefore very similar to that of a ship on the high seas. It is therefore necessary to utilize the indications of the magnetic needle and to make astronomic fixes. (Victor 1953: 11)

Prepared to do just that, navigator George Wallerstein accompanied by one or two other expedition members travelled ahead of the glaciologists, leaving them behind to focus on their studies, in order to stake out the route. Driving on azimuth following a magnetic compass, the navigation team secured the linear progress of Project Jello by physically marking their trail by positioning evenly spaced bamboo stakes equipped with orange flags every half mile. On the contourless surface of the inland ice, stakes were easily lined up neatly by sighting through binoculars (Christie 1995). The high degree of visibility which made this practice possible was, however, by no means a given. Often blowing snow and whiteout conditions reduced visibility to practically zero, rendering any kind of navigation nearly impossible. On more than one occasion, the expedition thus ended up substantially off course[78] (Benson 2001).

Keeping a bearing in high Arctic conditions posed a multitude of challenges. The cognitive stability of the magnetic compass was constantly challenged by the low terrestrial magnetic component characterising high latitudes, the prevalence of magnetic storms, and the metallic mass of the weasels. All these factors could perturb the indications of the magnetic needle, sometimes violently so (Wallerstein 1956, 1956–57), and alternatives such as astro-

[78] The whiteout phenomenon was subject of US investigation in its own right. Experiments with different kinds of goggles, radar, and compass technologies were carried out by Operation Ice Cap scientists (see Victor 1953; Hutchinson 1954).

or gyrocompasses were often brought into play[79]. These technologies, however, all depended on particular meteorological conditions. As the perpetual daylight hid any stars from view, astrogeodetic corrections of the compass readings were only possible by taking bearings against the sun. Although the sun never set, it was often masked by blowing snow. When all the navigational techniques described above were ruled out, Wallerstein resorted to reading the physical terrain as best he could without the help of prosthetic technologies. On some surfaces, the dominant wind direction could be inferred by the directionality of sastrugi – hardened, wave-like ridges formed by wind erosion – and from this information, Wallerstein could estimate the position of north (see Fig. 23).

Figure 23: Sastrugi plagued surface terrain. This image exemplifies a dominant surface feature, which caused severe damage to weasels and sleds during the field traverses (source: Benson 1960).

Not all navigational errors were entirely accidental. Before the expedition had set off, Project Jello had been struggling to obtain the necessary permissions from the Danish government to operate outside the designated defence areas covered by the 1951 Greenland Defense Agreement (Benson 2001). Even after the expedition had set off, the exact route that the Jello team was allowed to traverse was still contested, and at one point this halted

[79] The 1953 expedition had been forced to manufacture an improvised solar compass and mount it on the front of one of the weasels because their mechanical equipment failed them (Hutchinson 1954).

the expedition for several days (Christie 1995). Eager to meet their scientific objectives, however, the expedition navigator sometimes made deliberate 'errors', ensuring that the positions he called in over the radio were always within the cleared areas (Benson 2001; Christie 1995).

Movement observations on the ice sheet

The bamboo stakes positioned by Wallerstein and his helpers were not only there to make the ice sheet navigable. Rather, they were there to bear witness. At Ilímaussaq, the wooden stakes had been placed under local police protection to secure the durability and shape of the GEOX proto-map (Mouritzen 1955b). The linear graph outlined by Project Jello's stakes, however, did not remain static, nor was it ever meant to. Rather than imposing a static geometry on the icescape, the bamboo stakes provided a registry of the 'liveliness' of the ice sheet – of its movement, directionality, ablation, and growth. This meant that a great level of trust was placed in the navigator's ability to construct an accurate biography for each stake comprising the metrics of its exact height and coordinates. This biography was passed on to future expedition aiming to relocate the stakes to measure how far they had moved and how deep they had been buried (Wallerstein 1957, 1958). If and when future expeditions located the bamboo stakes, they would be able to extract important information from them about the directionality and velocity of the ice sheet's flow. As such, motion could be incorporated into the material understanding of the ice. By rationalising the mutable ice sheet in terms of its velocity and accumulation, the chaotic underpinnings of the ice as fluid terrain were effectively rendered less chaotic. Through such movement observations, the scientists accounted for the flow of the ice itself unlike the seismic and gravimetric studies, which had focused on the bedrock frame within which movement took place. As such, these observations located an agential forcefulness directly in the matter of the ice. The stabilising factor of the movement observations were the abstract mathematical grid of longitude and latitude rather than the underlying bedrock.

The mapping of the ice sheet's mobility suggests that its territorialisation was not reducible to an application of cartopolitical logics of stasis to an environment that provided constant reminders of its material resistance to terrestrial ontologies of points, lines, and bounded zones (Steinberg and Peters 2015; Steinberg 2009; Strandsbjerg 2012). The plasticity of ice may have complicated territorial control by way of its shifting spatialities and the impossibility of placing permanent territorial markers (see Dodds 2010; Dittmer et al. 2011;

Steinberg et al. 2015). Yet, while the temporality of ice complicated the production of a stable plane of crossing, science provided a crucial aid in transcending flow by making it possible to capture and quantify the very fluidity and mobility of the ice sheet, render its movements predictable, and reduce change and immanence to a series of patterns. While the material instability of the ice could not be negated, it was possible to map and stabilise its motion and adapt military practices accordingly.

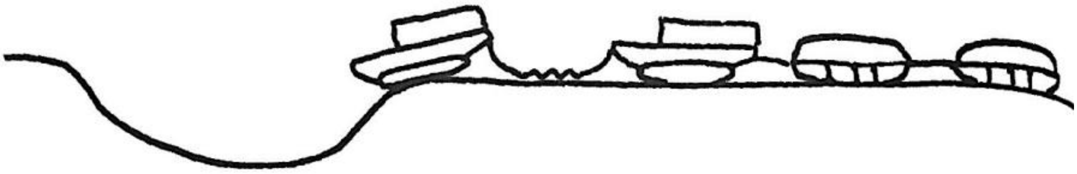
Indexation of ice sheet trafficability

Just like the Operation Ice Cap geologists had observed bodies and vehicles as they interacted with the rocky surface terrain, so too did Project Jello make the reciprocal relationship between man, machine, and landscape an object of study. This task mainly fell in the hands of student mechanical engineer Alan Skinrood. Skinrood's study was a continuation of work done by Operation Ice Cap mechanics, who had carefully monitored and documented the effects of cold, snow, and ice on the expedition vehicles – how blowing snow encapsulated vehicles and equipment in a matter of hours if not minutes, how frost undermined the gas feeding to the weasels, and under what conditions the caterpillar belts were likely to reach their breaking point (Victor 1953; Kucera 1954). Operation Ice Cap similarly explored different strategies of how to operate weasels in a less than plane landscape which offered very little grip, resulting in a detailed guide for navigating very specific topographies (see Fig. 24). Beyond such observations, Skinrood conducted studies of vehicle performance under different surface conditions and snow properties. Vehicle performance was quantified in terms of maximum drawbar pull as a measure of the ease with which a vehicle overcame the terrain (Skinrood 1957).

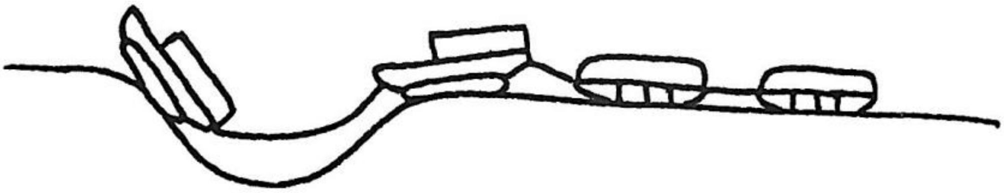
SECRET
SECURITY INFORMATION

L. CROSSING STEEP HOLLOWS OR CREVASSES.

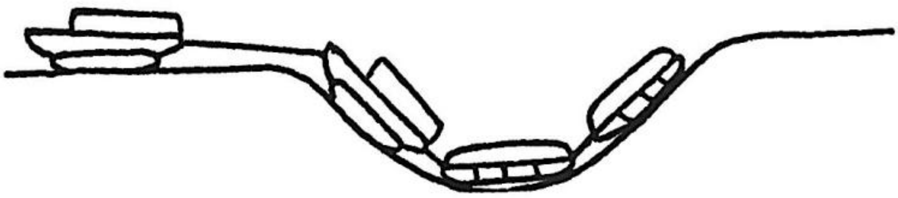
1. 1st step: - As the first vehicle approaches the difficulty, the second gives it some slack and pulls the load alone.



2. 2nd step: - The vehicle crosses the obstacle. The second one continues to pull the load, avoiding carefully any shocks to the first while it is in the difficult spot.



3. 3rd step: - The first vehicle is out of the difficult place. It pulls the second one and helps it to pull its load.



4. Note. - For difficult places, calculate the length of the cable in such a way that the two vehicles will not be in it at the same time.

Figure 24: Example of pictogram providing step-by-step guidance for weasel manoeuvres on uneven, ice covered terrain (source: Victor 1953).

Operation Ice Cap had clearly illustrated how terrain was brought into being by mapping the reciprocities between human and non-human bodies, and both the final and preliminary reports contain dozens of images documenting the tracks of different kinds of vehicles in different kinds of snow (see Fig. 25). Skinrood, however, took his studies one step further, illustrating how the military logistical ideal of terrain-as-surface could only be upheld by enacting geographies in multiple dimensions. Trafficability problems of the ice sheet had been found to differ substantially from those of other snow covered regions. Hence, Skinrood's study of the relationship between vehicle and surface was also directed at the immediate subsurface of the snow and ice.

Figure 25: Documentation of vehicle tracks in different kinds of snow (source: Victor 1953).

To thoroughly deconstruct the point of physical contact between vehicle and surface, Skinrood devised his own method of investigation. Like the Operation Ice Cap fieldworkers, he documented the tracks left by different vehicle types photographically, but he went one step further. Across the tracks, Skinrood dug two shallow pits, leaving a 4 centimetre 'thin-section' behind for analysis (see Fig. 26). This thin-section rendered the distortion pattern of the underlying strata visibly discernible and allowed Skinrood to determine at what depths different classifications of snow were affected by vehicular traffic and analyse the snow's pattern of compaction. By analysing the effects of vehicles on the surface environment and *vice versa*, Skinrood hoped to be able to construct a model that allowed the maximum drawbar pull to be predicted based on glaciological knowledge of terrain (hardness, density, snow temperature etc.). To his own apparent surprise, however, Skinrood (1957) found no consistent correlation between drawbar pull and any of his snow metrics. The extreme variations of snow profile properties that existed over distances of even a few metres meant that the unruly masses of the ice sheet proved recalcitrant to such levels of striation. Put differently, the materiality of the ice sheet posed certain limits to its enrolment as terrain through science. Skinrood's studies did, however, illustrate the importance of taking "vertical snow samples (…) to various depths rather than samples in horizontal layers" (Skinrood 1957: 13) when analysing vehicular trafficability. Here, sequence and relational composition was more important than individually separable strata to the construction of a trafficable terrain.

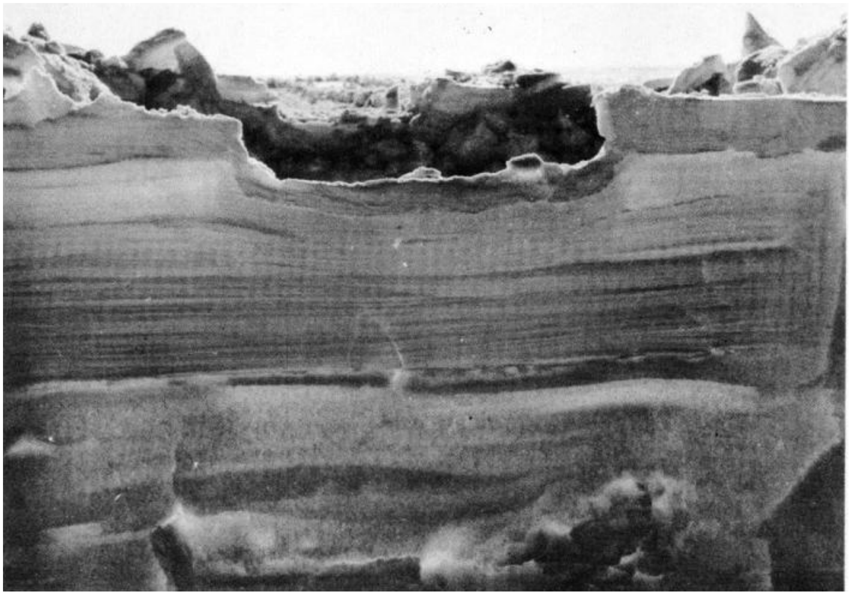


Figure 26: Thin-section profile showing deformation of the snow strata caused by a passing weasel (source: Lanyon 1959 [80]).

Deconstructing the ice sheet: stratification and striation

The main purpose of Project Jello was the continuation of Benson's three years of in-depth glaciological studies of the ice sheet névé. Variations in the conditions of deposition caused a discernible stratification of the ice sheet. Summer strata were less dense and the firn was coarser than the winter strata. Hence, the onset of autumn created a discernible stratigraphic discontinuity identified by an abrupt increase in density and hardness accompanied by a

[80] Because of the low quality of the available copy of Skinrood's (1957) report, an image from another source which closely resembles those taken by Skinrood is used here instead.

decrease in grainsize (Benson 1960: iv). Each annual sequence could be told apart by vision or touch, meaning that this seasonal record was traceable back in time as far as the scientists could physically dig (Benson 1959a). Significant data about movement, accumulation, and ablation was conveniently preserved in linear chronology within the body of the ice sheet – a material archive of past meteorological and atmospheric events. As noted by Benson (1962a: 3), "the ice sheet is an infinite set of automatically recording precipitation gages. It is only necessary to learn how to read the record".

To access and 'read the records' of the ice sheet, Benson and his team stopped at regular intervals and dug into the ice, exposing its strata. At each stop, the Jello expedition members took turns at the hard labour of digging out glaciological pits matching specifications provided by the glaciologists, Benson and Ragle (see Fig. 27). Each pit was at least four metres deep and required the removal of more than nine cubic metres of heavy firn. When a pit was dug, the glaciologists' reach was further expended by extracting an additional four metres of ice core from the bottom floor of the pits using a manually operated auger (Benson and Ragle 1956). Excavating the pits entailed gruelling labour under harsh climatic conditions with temperatures at the bottom of the pits reaching below −35 Fahrenheit (−37 °C). Preparation of the pit's test wall, however, was a matter of finesse akin to the work of an archaeologist. To ensure the perfectly vertical and clean wall necessary for stratigraphic observation, the glaciologists brushed and polished the test wall with great care before continuing with their incisions and diagnostic procedures.

A visual archive of the stratigraphic sequence recovered from each pit was meticulously preserved by removing sections of the test wall with a saw and bringing them to the surface. Here, the sections were trimmed down to a thickness of between one and two centimetres and cleaned with trowels and whiskbrooms until perfectly even and smooth. Finally, they were reassembled in chronological order and photographed with the sun behind them. As the Arctic sun shone through the thin-sections, the ice sheet was quite literally rendered transparent (see Fig. 28). By extrapolating between pits, the glaciologists extended this transparency across and through the vastness of the polar plateau (Benson 1960, 1962a). In this manner, matter was displaced from an opaque and unknown subterrain and 'brought to light' (Williams 1990). This process required clear weather and direct sunlight. On cloudy days, the strata were photographed directly in the pit, either by inserting a trowel behind the strata, or by rendering them "more photogenic by exposing a cleanly brushed section to the flame and smoke of a blowtorch" (Benson 1959a: 12).

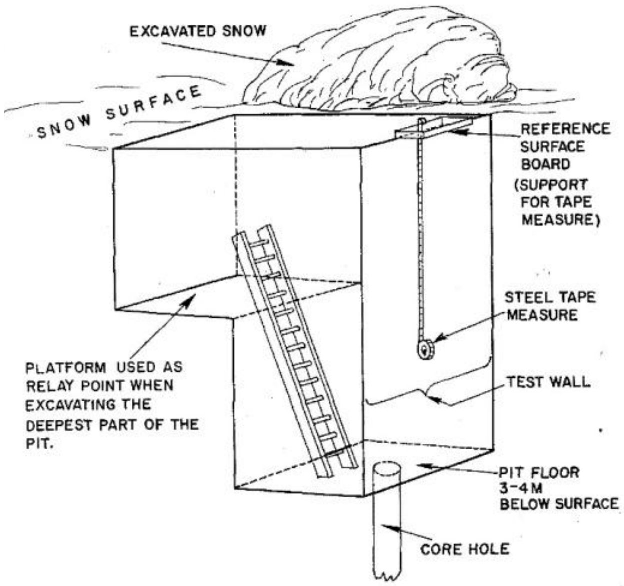


Figure 27: Diagrammatic sketch of a test pit (source: Benson and Ragle 1956).

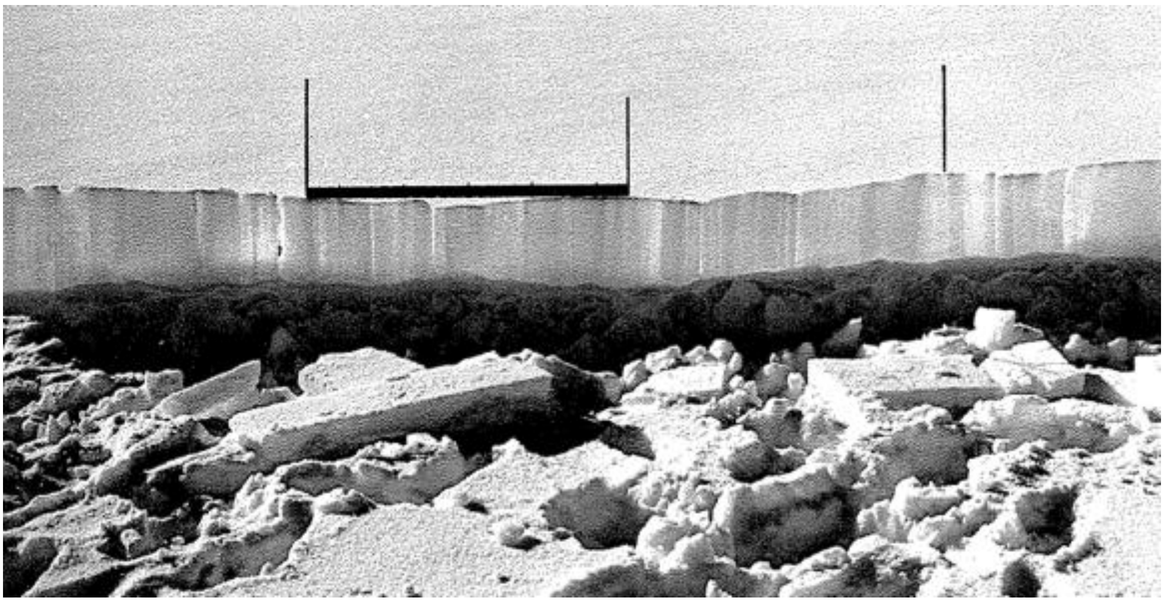


Figure 28: Stratigraphic thin-section assembled above ground (source: Benson 1960).

By taking photos of the stratigraphic sequences, the Jello glaciologists constructed an effective archive of an archive; a condensation of the vastness of the ice sheet into a form that was immutable across space and time (Latour 1987). By further solidifying matter which was already frozen solid, the photographic archive allowed the subterrain to maintain a more permanent presence at the surface without the risk of melting and deformation. As the strata travelled, they were able to reverberate beyond the confines of the underground and gain political resonance in places far from the ice sheet (Latour 1999, 1987).

To unlock the secrets of the ice sheet, each layer of the stratigraphic sequence was probed with thermometers, rammed by penetrometers to determine their hardness, weighed and crushed to examine their granular composition. Exposing the most intimate features of the firn, samples scraped and cut from the pit walls and ice cores were examined through microscopes and preserved in micrographs depicting the composition of the ice matrix (see Fig. 29) (Benson 1959a). Negotiating terrain meant negotiating a complex material assemblage composed of individual ice crystals acting as more or less coherent wholes. The shape, composition, and relationality between the grains of the ice sheet governed movement at the surface and below. The ice matrix acted on passing vehicles, determining the tractive effort required for a vehicle to move across and through it – a metric which Skinrood (1957) mapped alongside the glaciological studies. As such, the materiality of the ice conditioned this particular geopolitical engagement with the ice sheet, meaning that these grains had to be brought into alignment with the project of terrain making.

The surface topography of the ice sheet was in a constant state of flux, but within its annual strata time and space seemed literally frozen solid. Each stratum represented the spatial enclosure of a moment in time isolated from the continuum of history (Yusoff 2007). The ice sheet was a materialisation of linear time and the glaciological pits served as portals through which the scientists could access a bygone past (Bridge 2009, 2013). As an organising medium, however, ice did not only freeze the past, but also allowed for its reanimation. Collectively, the strata of the ice sheet were enacted as moments of clarity from which a distinct chronological trajectory could be extrapolated and projected into the future (Yusoff 2008, 2010). The glaciological programme organised the ice sheet both spatially and temporally, and terrain was rendered ontologically stable not just for the fleeting moment, but for years to come. Deep, material truth was constructed around the reanimated moments of the ice sheet strata. As gestures and technologies of the future (Yusoff 2008: 36), the ice cores and exposed pit walls shaped predictions of future patterns of ablation and accumulation. As such, the ice cores were imbued with a potential to affect the ways in which the ice sheet was enlisted as military infrastructure.

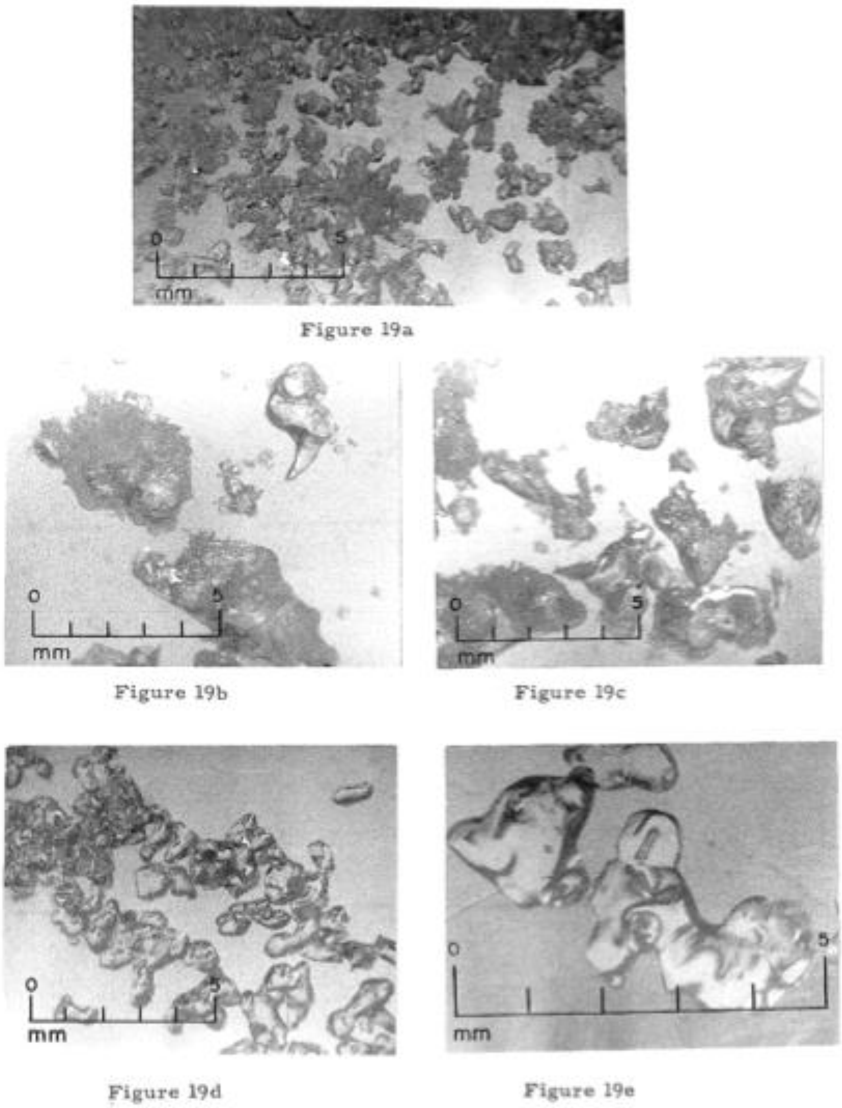


Figure 29: Micrographs of firn (source: Benson 1960).

The scientists' quest to know the ice sheet and bring it into being as terrain took on the dual form of a journey across the inland ice and a literal descent (albeit a relatively modest one) below the level of the surface. The material 'truth' about the ice sheet as supporting ground was buried, preserved, and frozen (both literally and figuratively), and truth was inextricably linked to the practice of excavation and the direct, haptic engagement it made possible.

Lines in the snow: facies of the ice sheet

Drawing together traces from multiple journeys, Benson's reports captured, consolidated, and homogenised the ice sheet as a coherent whole. One of the primary contributions of

Benson's studies was a system of classification of the ice sheet, which divided it into four 'diagenetic facies'[81] along three imaginary lines – the firn line, the saturation line, and the dry-snow line (see Fig. 30 and Fig. 31). By dividing the ice sheet according to spectra of melt action, accumulation, and flow, these models offered a quick, cursory indication of what the intrinsic makeup of the ice sheet looked like at a given location under a given set of circumstances (see Fig. 31). The position of each dividing boundary was determined based on Benson's physical measurements, leading him to conclude that the boundaries had practically emerged naturally. "Even a cursory glance at the data sheets", wrote Benson (1960: 47), "reveals regional differences in the physical properties of the upper firn layers".

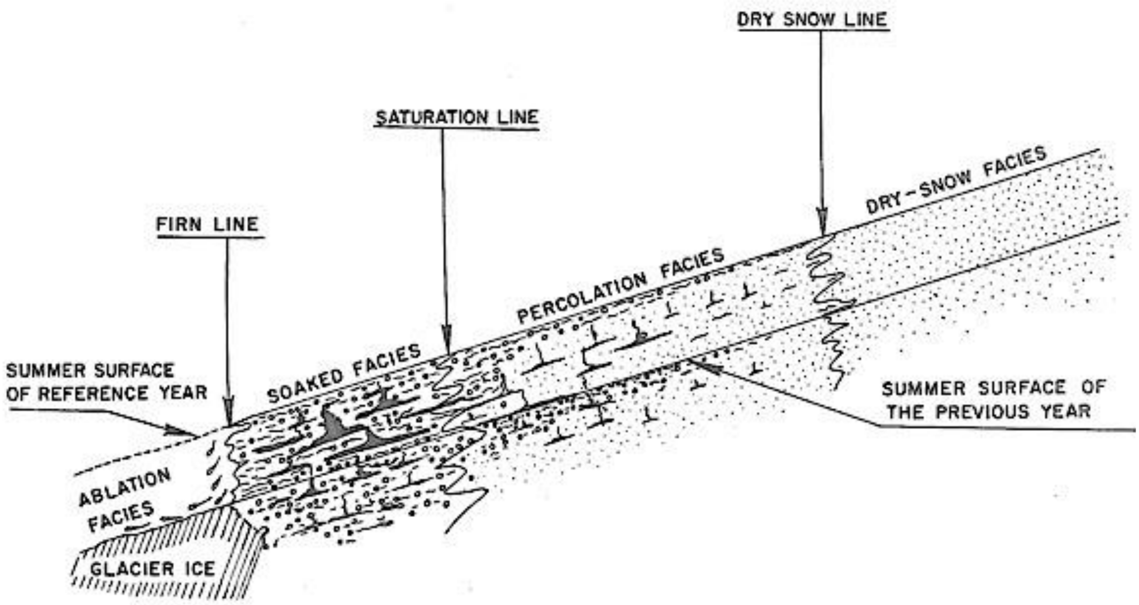


Figure 30: Benson's idealised sections (source: Benson 1960).

[81] 'Facie' is a geological term referring to the character of a rock (in this case ice) defined by its conditions of formation and its geophysical character.

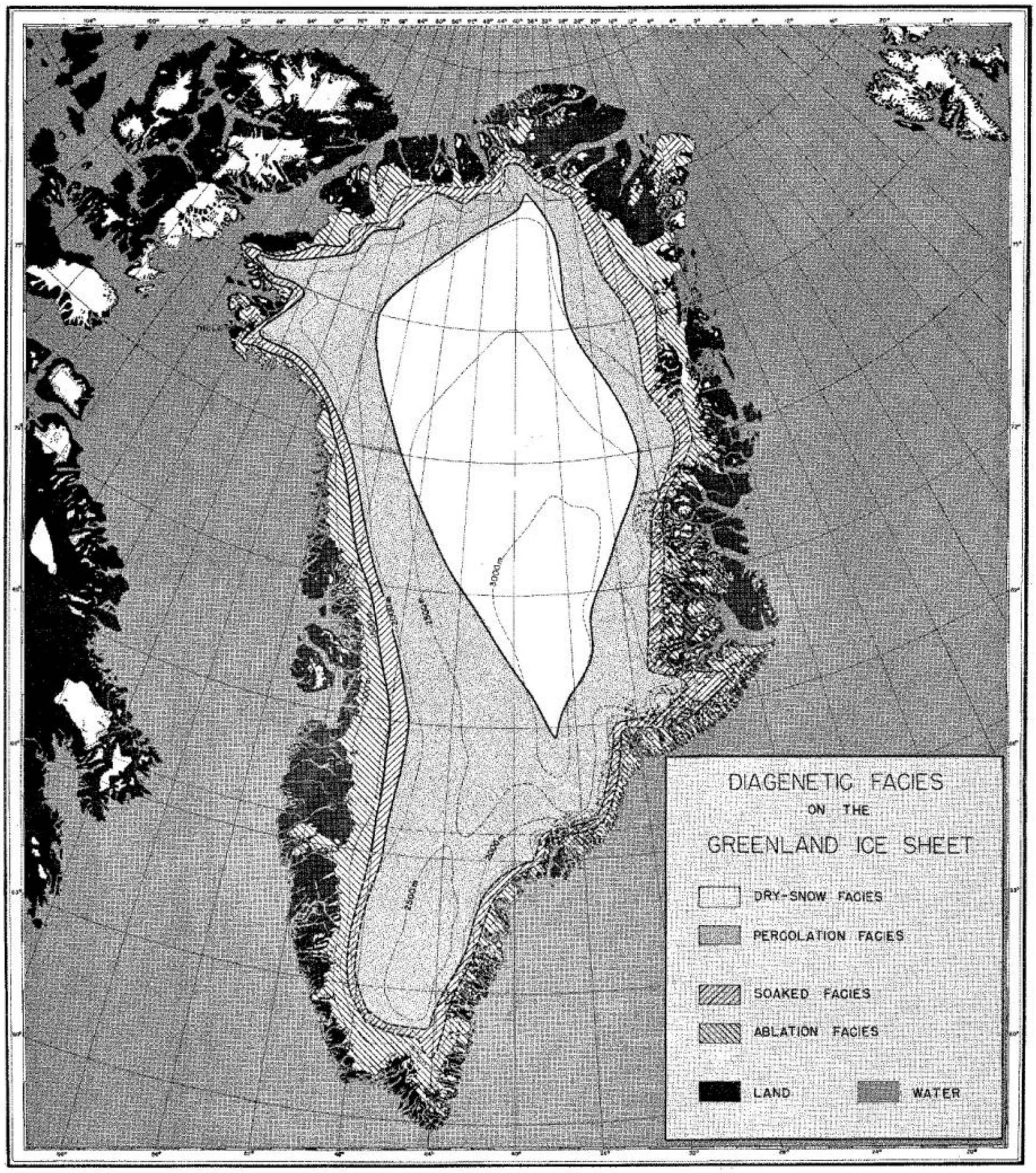


Figure 31: Benson's diagenetic facies {source: Benson 1960).

Detailed knowledge of subterranean ice structures extracted from countless hand-dug pits was fed into these large-scale classificatory models of the ice sheet (Benson 1960; Bader 1961). Benson (1960: v) described his models as "areal in nature", and as two-dimensional maps lying flat on desks and table tops they seemed the epitome of the flat geopolitical discourse famously critiqued by scholars such as Weizman (2002), Elden (2013b), and Graham (2004). In an important sense, however, these maps and models retained a direct link to the subterrain, consolidated textually and photographically in the reports detailing their production. This mapping of knowledge gained from observation of individual grains of iced firn retrieved from deep beneath the surface onto representations spanning the entirety of the Greenland ice sheet was a central component in achieving the military logistical ideal of terrain-as-surface.

Benson's glaciology of the Greenland ice sheet was a science of strata. Explicitly likening glaciology and geology, Benson (1960: v) conceptualised the ice sheet as "a monomineralic rock formation, primarily metamorphic, but with a sedimentary veneer of snow and firn". This 'geological' conceptualisation of the ice sheet imposed upon it an 'earthly' quality – a grounded materiality that could be enacted much like solid land as long as one knew its sequential and predictable secrets. By construing change as processual and stable, terrain's etymological link to *terra* appeared strengthened. Benson's static representations depicted the ice sheet as a theatre from which the possibility of anything happening had effectively been removed (Carter 2009: 5). Multiplicity, uncertainty, and excess were vastly reduced as the ice sheet was boiled down to a series of generalised diagrams, tables, and figures – representations of a sanitised geography.

Yet, recasting the ice sheet as terrain was not simply a matter of imbuing the fluid ice with a false sense of territorial stasis. Rather, the scientific programme of which Jello was a part was directed towards attuning the US military apparatus to the pulsations of the landscape. By reflecting upon, analysing, and dissecting movement and drawing out its mappable trajectories, movement was contained and rendered governable (Peters 2015; Grosz 2005; see also Bruun and Steinberg 2018). The pulsations of the ice were rendered repeatable and predictable (Steinberg and Peters 2015). They were not ground to a halt, but rather smoothed out and 'slowed down' to a pace within the range of human cognition (Grosz 2005). In short, transcending the material complexities of the subterrain depended on rendering it ontologically stable, not in terms of stasis, but in terms of predictability.

Winterising minds and bodies

Any expedition embarking on an ice sheet traverse inevitably found itself faced with an environment that was acutely elemental and whose physicality could not be ignored. The unforgiving cold seeped into invisible cracks, inserting itself, disturbing the material structure of vehicles and equipment. Batteries lost power, motors and starters easily got stuck, oils thickened, and metal components got brittle to the point of breakage (Victor 1953; Benson 1955a, 1955b). A vital part of the US Arctic trafficability studies consisted of a long line of detailed experiments, testing the limits and capabilities of such material components. However, if the ice sheet was to serve as a functioning terrain, "precautions [needed to] be taken in 'winterizing' both men and equipment" (Victor 1953: 157). Put differently, when it came to understanding Greenlandic geographies in terms of terrain, the problem of how corporeal beings could not only move, but also survive and thrive became important.

Ice sheet living

At the Thule Air Base, the Americans had by far surpassed Danish attempts at replicating national spaces amidst unfamiliar geographies. Amenities of the base counted a cinema, library facilities, restaurants, hospitals, and even a baseball field (Boskin 2011). The 'homely feel' of the airbase was communicated to distant audiences in photos and short films showing soldiers undertaking everyday recreational activities, such as eating nice dinners, taking hot showers, playing ping-pong, and writing love letters (USAF 1956). Once out on the ice sheet, however, things were markedly different.

As previously noted, the Jello team had built their mobile living quarters partly out of scraps. The wannigans were roofed by canvas covered metal hoops, and the insulation consisted of old discarded cardboard boxes with bits of fiberglass stuffed in between them. Fear of starting a fire or getting CO_2 poisoning prevented the expedition members from having their burners on overnight, and occasionally they had to sleep with frozen foods in their sleeping bags so that they could eat in the mornings (Benson 2001). Most days they woke up wet and soggy as their breath had condensed onto the insides of the wannigans as they slept and was dripping down from the fabric of the ceiling (Christie 1995).

During the daily traverses, the men experienced extreme fluctuations in temperature. Because the engines were positioned inside the caps of the weasels, it got exceedingly hot within the small, enclosed space that the driver was confined to. Weasel journeys went on for hours as their average speed was as little as five miles per hour depending on the texture of the surface. In his diary, the Project Jello physician described how the expedition members had once stripped to their underwear and travelled that way because their clothes had become drenched from heavy perspiration (Christie 1995).

Upon exiting the weasels and wannigans, the Jello team was faced with the sub-zero temperatures of the ice sheet. Adding to the cold was the wind chill factor – a quantification of the rate at which naked human skin loses heat when exposed to various temperatures at different wind velocities and levels of humidity. Taking the wind chill factor into account, the mean temperature during the entire Jello expedition was "essentially constant at a value slightly 'colder' than 'bitterly cold' according to the wind chill nomogram" (Benson and Ragle 1955: 4). At wind velocities of 30 miles per hour at −32 Fahrenheit (−35.5 °C), exposed flesh froze in a matter of 30 seconds, making frostbite a significant concern to the fieldworkers. Heat was not only lost through the convective transfer to the air, but also through the lungs with every breath, meaning that even with the skin fully covered, extreme cold still infringed their bodies.

In addition to the discomforts of ice sheet living, the intrinsic dangers of such a life were many and complex. During Operation Ice Cap a man lost his arm by falling into a crevasse (Boskin 2011), and the Jello physician registered a long line of health problems, including anaemia, muscle aches, altitude sickness, and diarrhoea (Christie 1957, 1958a, 1958b). No part of the body seemed immune to the intimate encroachment of the environment. The cold perforated every pore, seeped into lungs and joints, while icicles formed in their beards. Whiteness constituted its own problem. Ultraviolet light refracted off the snow and damaged the fieldworkers' corneas, causing temporary snow blindness, and so-called 'diamond dust' (blowing ice crystals) mimicked the symptoms of scotoma (Christie 1995).

Beyond any ailments that the physical body might suffer there was the ever pressing matter of the mental strain of ice sheet living. In his journals, Christie described the overwhelming feeling brought about by the uninterrupted views, 360° of whiteness, the sheer monotony striking him as almost unfathomable. The perpetual daylight did away with any sense of daily rhythm, and sleep became irregular and scarce. Resting was impossible during the long weasel rides across the sastrugi plagued terrain, leaving the men alone with their thoughts, which sometimes took a toll on their mental well-being (Christie 1957).

To make the ice sheet operable, it was necessary to sustain not only the human body, but the *morale* of an expedition as well. During the Jello trek, morale was "materially augmented" (Christie 1957) via regular airdrops of mail, but the most discussed morale factor was food. Because the expeditions travelled in motorised vehicles, the modern explorer was "an itinerant sedentary" who tended to afford himself the luxury of being picky as his energy consumption was considered to be lower than the explorer travelling by sled (Victor 1953: 136, original emphasis). Men over 35 years of age were seen as particularly fussy eaters. Beyond the nutritional value of the foods provided, factors such as smell, taste, texture, and variety were thus seen as vital components. Chewing gum was needed to provide "mental occupation", whiskey rations allocated based on nationality (seen as an indicator of personal need) brought "comfort and bettered morale" (Victor 1953: 144, 146). Vivid green colour of canned vegetables was "a good morale factor" (Benson and Ragle 1955: 10) as well, but the most important part of the ration was steak fried in butter:

> Fried meat has an appetizing odor. It allows one to chew (important for teeth and gums). It gives a real 'pep-up'. It betters morale. (Victor 1953: 145)

Smell, texture, colour, and consistency were all factors that needed to be taken into account alongside weight and nutritional value to govern the abstract phenomenon of morale on the Greenland ice sheet.

Unlike the rest of the expedition members, the Jello glaciologists appear to have somewhat rejoiced in living out an almost idealised version of the life of a polar scientist – a rough, minimalist, and deprived existence[82]. Christie (1995) noted his discontent with the way in which the glaciologists kept "spouting about the Spartan life (…) They seem to revel being cold, getting little sleep, etc., and even resent it when others don't appreciate this type of life". In his own reflections, Benson relates this embodied experience of the landscape to the validity of his glaciological observations. For him, spending a long time in the field and experiencing all aspects of the environment, good and bad, afforded a necessary "intimacy" with the landscape – a "feel for the country" (Benson 2001). For Benson, field experience, quantified in terms of miles travelled and number of seasons and days spent on the ice sheet, was stored in the fibres of his very being. Knowing the environment was, at least to a certain extent, related to 'living it' and connecting with it physically.

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[82] In his personal correspondences, Benson repeatedly writes how he was "mighty homesick for the beauty of interior Greenland" (Benson 1959b). Despite having lived four years of perpetual winter, the ice remained his preferred element.

Terrain and bodily encounters: the winterised body as an agent of territory

Like most scientific representations, the majority of the results from the US fieldwork were depicted as isolated events, writing out the human element – pain, frustration, disorientation – leaving an image of pure, undistorted nature. As indicated by the use of the word "winterize" in relation to the human body – a term which is most commonly applied to non-human objects such as vehicles – the perspective of the human element was somewhat mechanical. Yet throughout the expedition reports, the human body constantly inserted itself in both the scientific and the technical narratives. Several of the borders, lines, and zonal categories with which the landscape had been inscribed were not only reflections of the physical environment itself, but also reflected margins and conditions of certain kinds of human existence and of certain kinds of engagement and action. The act of classification was embedded not only in practice, but in the physical encounter between bodies – when boot met rock. Capturing the ice sheet in terms of a terrain, a potential battlespace, still depended on human bodies to internalise environmental excess same as the production of land had done for the Danish expeditions. Yet by documenting bodily encounters and incorporating these encounters as data, it became possible to ensure that bodies to come would be able to absorb environmental excesses with even greater efficiency, thus increasing the accessibility and actionability of space.

Throughout the reports, it is apparent that the winterised body was seen as very particular in kind. It was generalised, uniform, and had been disciplined through rigorous training regimes through which the terrain had been written into its very fabric. It was a body that sometimes seemed at odds with the bodies registered in diaries and memoirs. Just like the landscape, the winterised body had been measured and quantified, rendering it controllable and accountable. On the ice sheet, the body was under constant threat of fragmentation and by pushing the limits of biological, mechanical, and geological bodies these were continually plotted against each other (Yusoff 2007; Farish 2006).

Since the US Armed Forces were constructing a comprehensive military biography of the ice sheet, it was important to understand the material effects of the phenomenon of 'cold' in all its manifest qualities, as it affected landscapes, machines, and human bodies. As exemplified by the introduction of a wind chill nomogram, the *sensation* of cold was deemed important and the cold air was recognised as a formative part of the terrain itself. This underlines how the ice sheet was perceived (and being constructed) as a terrain to move *through* as well as across. The preoccupation with the human body is indicative of how the ice sheet was apprehended as a battlespace which was more than simply visual. Terrain, in this case, necessitated the integration of scientific knowledge and what Gregory (2016) refers to as a "corpography" of the landscape – a haptic geography where sight is not always the master sense.

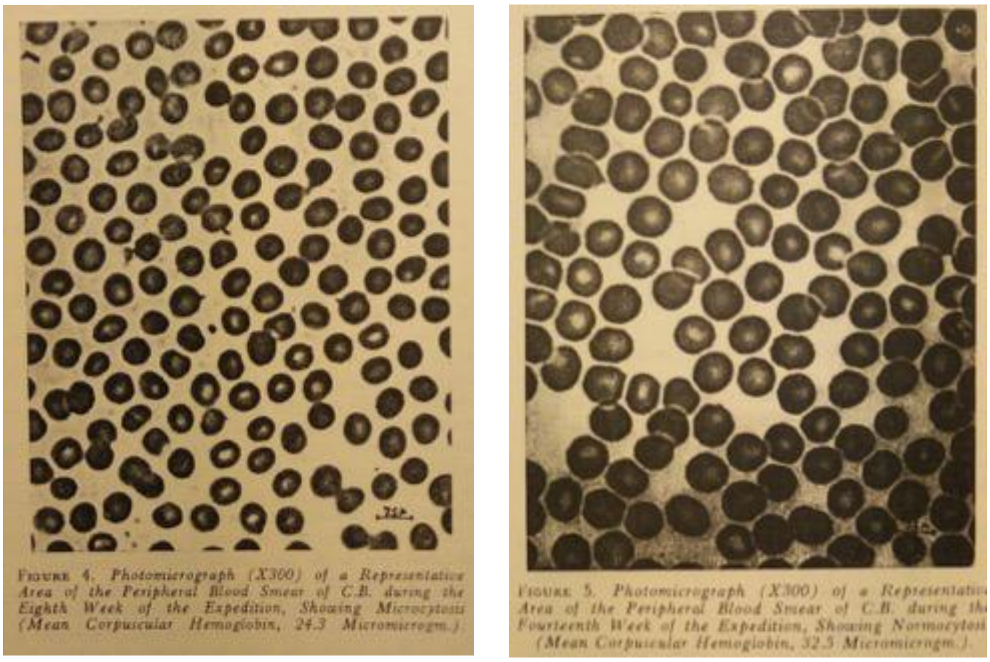

Figure 32: Micrographs of Benson's blood (source: Christie 1958b).

Terrain, however, did not only encompass a corpography of the landscape, but also a corporeal geography of the human body itself, its pulsations and inner workings. With Dr Christie's medical studies, the cold body was made the object of study in its own right (see also Farish 2013). Throughout the field season, Christie sampled and analysed the blood, stool, and urine of the expedition members and scraped bacteria from their nostrils which he cultivated in petri dishes in his pocket using his own body heat for incubation. Like the firn, the blood of the scientists was captured micrographically (compare Fig. 29, p. 199, and Fig. 32 above). The blood micrographs offer one example of how the landscape had inscribed itself onto the bodies of the expedition members just as they had inscribed the landscape. Another example was offered by the change in bacterial cultures of the nasopharynx of the men who, towards the end of the Jello expedition, had gone months without showering. The body served a dual function when it came to the production of land-as-terrain. It experienced the landscape, registered it, and through such terrain-making practice the body emerged as a 'terrain' to be mapped in its own right. As noted by Squire (2016a):

> if terrain is to be understood as a political strategic, or geostrategic, *relational* practice of power that encompasses both the physical aspects of the earth's surface as well as human interaction with them, then the human body as a relational actor must take a prominent position (Squire 2016a: 335, original emphasis)

On the ice sheet, terrain was both experienced by and generated through human bodies. In important ways, the scientific knowledge was generated for the direct purpose of managing the encounter between bodies and landscape (see Gordillo 2013). The military-scientific 'reading guide' was essentially directed towards this encounter. As will be argued in Chapter 7, this is key to how science makes terrain.

The ice sheet as voluminous terrain

Throughout the 1950s and beyond, the US effort set in motion to uncover the secrets of North Greenland and the Greenland ice sheet was of enormous proportions. Reflecting upon the American research programme, Danish glaciologist Børge Fristrup (1966: 146) commented that the number of men and the amount of equipment employed on the ice reached such high levels that it no longer constituted individual expeditions, but rather marked a permanent US presence of military scientists carrying out regular work on the ice.

Like the Danish exploration of Ilímaussaq, the US ice sheet efforts were of similarly symbolic significance. The purpose was not simply to gather terrain intelligence, but to be *seen* and known by enemies of the USA to be in a superior strategic position – a position of knowledge (Martin-Nielsen 2016). Much to the dismay of some of the scientists who wanted to publish their research[83], the intelligence itself was classified information[84]. Nonetheless, Greenlandic terrains were made available for external consumption through popular media such as newspapers, magazines, radio, and even film (e.g. Northbrook Star 1955a, 1955b). Reels and reels of film of all thinkable activities were shot during the short field seasons, documenting everything in minute detail. Operation Ice Cap was also the subject of a series of documentary films produced and distributed by the Army Pictorial Service of the Signal Corps (see Kinney 2013). Such films and radio programmes served at least two important functions in the militarisation of Greenland. Firstly, the popular broadcasts secured public support for the research programmes, and helped legitimise a military presence on the island, confirming the status and definition of Greenland as a necessary location for military activity (Kinney 2013). As such, being seen to do necessary science and construction work to keep the 'Free World' safe, the US was further cementing its territorial grip on the island. Secondly, broadcasting US scientific activities let the Soviet Union know that the Americans were operable in icy environments. Ice intelligence not only rendered Greenland itself actionable and controllable; as North Greenland acted as a proxy space for the Soviet High Arctic, ice sheet science also extended the reach of the US Armed Forces into enemy territory. As previously noted, the purpose of knowing Greenlandic landscapes as terrain was to expand the US theatre of operation both within and beyond the island itself. This was reflected in the scientific objective of Operation Ice Cap and Project Jello alike, which was to identify categories of space (and how to move across them or utilise them for military purposes) rather than to obtain specific knowledge of distinct spaces. The 'categorical' approach to the production of geoscientific knowledge

[83] For example, correspondences between Benson and his PhD supervisor reveal how difficult it was for Benson to share his work. Benson's supervisor was required to provide evidence that he could store the records safely (Benson 1954) and provide the FBI with detailed personal information, including a list of all his past addresses over a period of ten years (Sharp 1954). Benson also regretted that he was unable to publish all of his findings in scientific journals (Benson 1962b).

[84] The scientific reports cited in this chapter were originally marked as either 'classified' or as 'secret security information'.

of space meant that the US military scientists were creating a knowledge base which was relevant beyond Greenland (Flint 1953).

Interdisciplinarity and the 'volumetric surface'

In the words of Gordillo (2013: 5), the "pure multiplicity of the actually existing spaces of planet Earth is the foundational principle of a theory of terrain". For the US, multiplicity was not just embedded in theory, but something to be accounted for and managed through the practices directed towards terrain. The drive to manage and manipulate physical geographies for the purpose of power and control sought to transcend disciplinary boundaries in order to transcend environmental excess. Each of the rich material varieties encountered on the ice sheet and its margins both enabled and complicated the construction of an ontologically flat territorial terrain. The interdisciplinarity tied different material geographies together, promoting a form of territorial cohesion extending all the way from the American mainland from where troops and material were shipped, across the frostbitten geologies at the ice margins through to the very heart of the inland ice. The interdisciplinary approach resulted in a landscape that appeared fragmented, broken up into numbered units. Yet at the same time, this very fragmentation is what made it possible for military units of the future to enact the landscape as a coherent plane of crossing.

Throughout the intelligence reports, this plane of crossing seemed to be the ultimate endgame. Volume, multiplicity, complexity, specificity, and flow were qualities to be captured and subdued in accordance with a military logistical ideology of terrain-as-surface. Compared to the Danish investigations, the US expeditions encountered volumes with fundamentally different objectives guiding its construction. From the Danish perspective, geological volumes had been equated with value – volumes of ore within a mountain complex, volumes of Steenstrupine within the ore, volumes of uranium which could be extracted from the Steenstrupine. For the US, however, value did not emerge from the volumes themselves, but rather from the ability to *transcend* volume – to overcome the obstacles associated with the material complexities of Greenlandic geographies and engage terrain as an unproblematic, traversable plane.

Yet projecting power laterally could not be accomplished by remaining locked to a lateral vision. Greenlandic material geographies, most notably the ice sheet, constituted terrain which by virtue of its dynamic physical properties could not readily be captured and visualised using 'traditional' means of mapping and charting a potential battlefield (see Doyle and Bennett 2002). Topographical maps did not suffice if troops were to negotiate the deceptive openness of the seemingly monotonous ice sheet. Rather, terrain required a topological approach which took into account how the constituent parts of the landscape were entangled and arranged. Any strategic relation between the surface and traversing bodies had to be negotiated in terms of the properties of the sub-terrain. To fully 'map' terrain involved taking these opaque geographies, their vibrancy and flow, into account.

Despite the idealisation of the surface and the latent desire to negate the vertical and volumetric, the US scientists knew that that the plane of existence did not exist in isolation. Rather than reinforcing a 'flat geopolitical discourse' (Weizman 2002), the ice sheet reports illustrate how terrain-as-volume transcends inhabited geographies. Although the Greenland ice sheet was subject to tunnelling (see Bader et al. 1955; Rausch 1956; Weis 2001), volumetric terrain intelligence was important beyond the construction of any such subglacial structures. Metrics capturing the internal architecture of the ice sheet were critical for US projections of power and control over northern environments, even in areas which were only meant to serve as surficial spaces of transit. Underpinning the areal imaginary was a multiplicity of volumetric knowledge. As noted by Steinberg and Peters (2015: 259), volume not only exceeds the vertical, but may also allow for dimensions to represent themselves as *less* than vertical. Knowledge of the deep, voluminous structures of the ice, its movement, fluctuations, and capacity to support mass, reaffirmed and exacerbated the horizontal dimension of the ice sheet. Subterranean dynamics were translated in terms of an operable horizontality capable of responding to the material vibrancy of the ice. 'Securing the area' was thus folded into the securing of subterranean volumes (Elden 2013b). Hence, projecting military power *across* the ice sheet was inextricably linked to projecting power *through* its deep subterranean structures.

Agents of terrain, agents of territory

At no point during the Cold War did Greenland become the site of actual battle. Yet, as recalled by TRARG expedition historian Joseph Boskin (2011: xviii), "the war was there, incessant, intense, and imminent". Rather than fighting the Soviets, the ice sheet scientists and conscripts were pitted against the vastness of the polar environment. However, as Boskin cynically notes, there were no Purple Hearts for putting your life at risk and losing limbs to the ice sheet. The underground is often construed as a space of latent danger, a geography to be feared (Williams 1990), and so were the depths of the Greenland ice. Knowing the ice was a way of managing the risk posed to men and equipment (both valuable resources) and allowing them to operate. As such, the temporality of the ice sheet was meticulously studied, traced back decades, and captured in a seemingly endless series of complex diagrams and equations. As terrain, the responses of the ice sheet to varying temperatures, vertical and lateral stresses, were captured in terms of such serialised functions – terrain was a thoroughly mathematicised and predictable geographical construct. Yet, in practice, the multiplicity of terrain often escapes political capture (Gordillo 2013). There are many examples of how the ice sheet terrain managed to slip through the cracks of maps, graphs, and models. Snow-bridges measured to be solid collapsed, crevasses appeared in areas that had been mapped as 'crevasse free' based on seismic surveys.

As a thoroughly transient and materially vibrant geography, the ice sheet inevitably pushed back against the encroachment of the US scientists. It swallowed men and equipment, tore off an arm, penetrated corneas, and left expeditions stranded by enveloping them in blowing snow. The cold seeped into their lungs with every breath and even penetrated the minds of the fieldworkers. In the end, the ice sheet bore both visible and invisible imprints of human activity, but human bodies were also marked by the ice. The production of territory-as-terrain seemed to have taken on the character of what Bowker and Star (1998) refer to as an 'ontological dance' between classifier and classified. The ice sheet never took on the character of a passive or unambiguous entity awaiting classification by a unified agency. It pushed back, sometimes with deadly force.

Terrain was written with embodied encounters in mind. It was written in terms of how to preserve the body, how to disguise it and shield it from the enemy. The human body was indispensable to the production of terrain (as a knowing subject and an emotive and sensory registrar with a spatially limiting physicality). Similarly, the material forces of the ice sheet and its marginal zones were also agents of terrain. As summed up by Gordillo (2013):

> [A] theory of terrain seeks to unsettle anthropocentric-constructivist views of space but without being 'post-human,' in the sense that a political understanding of the 'agentive force' of spatial forms requires that the main vector of our analysis is, still, *the human body* and its mobility. This also means that terrain and territory cannot be separated from each other. The volume, forms, multiplicity and temporality of terrain affect human mobility and the spatiality of violence and are *constitutive* of territory, not

> as a determining force, but as its plastic, ever-malleable and contested medium. (Gordillo 2013: 8, original emphases)

In addition to terrain being both a bio- and a geo-political question, Gordillo (2014) suggests that the concept of terrain is not only spatial, but inherently temporal as the physical consistency of space changes as a function of the passing of seasons. This suggestion echoes recent calls to theorise territory to account for how the material fluidity of space imposes itself in ways that sometimes challenge the territorial ideal of stasis (Steinberg and Peters 2015; see also Chapter 3). The US militarisation of the Greenland ice sheet provides strong supporting evidence for the need to account for the deep materiality of space in its multiple dimensions, including the underground, to fully grasp the concept of terrain. The inherent changeability and rhythmic forcefulness of terrain-as-ice underline how terrain necessarily exceeds the relatively 'thin' spatiality of the surface; how it extends both above and below the horizontal plane including, but not limited to, spaces that humans can physically access or inhabit (Braun 2000). The shifting textures, the temporality, and its trajectories of change were key components of the ice sheet terrain. For the surface to exist in isolation, depth and volume had to be accounted for and stabilised. Topographical maps of the largely contour-less ice sheet did not suffice when it came to negotiating the deceptive openness of the seemingly monotonous "snow desert" (SIPRE n.d.: 1). Any strategic relation between the surface and traversing bodies had to be negotiated through the opaque geographies of the subterrain.

7. *The Science of Territory*

Geo-metrics, rhythms, and bodily reciprocities

Operating across different locations hundreds of kilometres apart, within materially different environments, facing different challenges, and guided by different objectives, the lines of division between US ice sheet science and Danish uranium prospecting might seem more obvious than their common grounds. Yet, as this chapter will seek to draw out, insight into the relationship between geoscientific practice and the mechanisms of the political technology of territory can be gained from honing in on the similarities as well as the discrepancies between the practices of constructing land and terrain. Returning to the writings of Elizabeth Grosz (2005, 2008), some of which were introduced in Chapter 3, this chapter seeks to mobilise the insights that she offers on how human beings negotiate and exist in a world defined by material excesses, many of which are beyond our control. As will be argued throughout this chapter, analysing the territorial practices of the sciences of land and terrain from such a perspective brings out formative insights into the workings of technologies of territory as they apply to the governance of and through the material Earth.

Using Grosz's insights to further unpack the territorial practices of the Danish and the US scientific expeditions, this chapter is loosely structured into three main sections. The first section unpacks how the two expedition series used science as a means of enframing the material qualities of territory, and how matter defined by its qualities served as territorial markers which inscribed the spaces of their existence as land, terrain, and territory. It is argued that these acts of enframing contributed to the 'territory effect' as they both rationalised and naturalised state intervention by affirming that these were anchored in naturally occurring phenomena and properties of the environment.

Moving from the qualities which were enframed to the human bodies which were both marking and being marked, the following section addresses the significance of the reciprocal relationships between biological, geological, and mechanical bodies in the making of territory as land and terrain. Expanding on the arguments presented by Braun (2000) and Elden (2007, 2013b) that territory is simultaneously bio- and geo-political (see Chapter 3), it is argued that the abstract separation of space from bodies and observing subjects that scholars of critical cartography have used to explain the emergence of territory (see Chapter 2) does not fully capture territory's workings as a political technology aimed at negotiating the material exigencies of a vibrant Earth.

The third and final section addresses another abstraction which has been considered significant in explaining the politics of territory and calculation, namely the abstraction of space from time. Reading across the Danish and US case histories reveals that both land and terrain were conceived and encountered as inherently temporal, and not only in terms of their enactment. In different manners, land and terrain each retained a sense of their temporality and this became part of their ordering as territory. Based on an understanding of the incessant fluidity of the material world as a dual function of the forces of space and time, this final section argues that the territorial orders brought into being by Danish and US scientists were not simply informed by a 'logic of solids' – i.e. the drive to present political space as inherently solid, stable, and immune to the touch of time. Rather, these orderings were supported by a mathematically rooted logic of rhythms and repetition. As will be argued below, the scientific dissection of Earth's rhythms and vibrations served as a critical means of territorialising the Earth by capitalising on its physical qualities and harnessing its intrinsic forcefulness.

Enframing the qualities of territory

While state borders are potent political technologies in their own right (see Newman 2006; Johnson et al. 2011; Amoore 2006; Jones et al. 2017), the Danish and the US production of territory as land and terrain affirm that territorial boundaries are not reducible to state borders (see Chapter 2). Because action *in* space is predicated by knowledge *of* space, the boundaries of territory with its qualities are linked to the boundaries of knowledge – and thus to the reach of the sciences which secure the state's "epistemological access to all parts of the territory and everything in it" (Hannah 2000: 39; Braun 2000; Latour 1987;

Strandsbjerg 2012). These boundaries are both affecting and affected by human access to the environments in question, and crucially they are determined by the practices through which access is achieved and negotiated.

As argued in Chapter 3, the ontological politics of territory is a politics which concerns the practices of framing the political geo, both materially and conceptually. It relates to how the geo as both Earth and space is pushed and pulled into different shapes in the pursuit of political objectives and desires. In important ways, scientific framings of the geo work as a practice of drawing lines, albeit a practice which does not necessarily construct borders but rather pushes the frontiers of territorial knowledge spaces while dividing the physical world into categories corresponding with valued material qualities. As will be argued below, while not all territorial configurations are defined by state borders or the practices associated with such borders (Elden 2013a; Gottmann 1973; Sassen 2000; see Chapter 2), calculative practices of enframing the qualities of the physical world played a significant role in the territorialisation of Earth in Greenland. In other words, while territory is not reducible to 'bounded space', processes of line drawing and enframing are central to the production of territory with its qualities.

The Danish prospecting of Ilímaussaq was not aimed at defining its mountains in relation to Danish state borders. The position of Ilímaussaq as a space sited firmly within Danish jurisdictional bounds was never questioned. Borders were not the root of Danish territorial anxieties and, as such, not the object of the Danish territorial practices at Ilímaussaq. What was at stake was the enactment and affirmation of the *qualities* of territory, the voluminous and material space *between* the borders. Similarly, the nationality and topography of the borders indicating the political status of the Greenland ice sheet and the northernmost shores of the island were not redefined by the US project of terrain making. Rather, US terrain making facilitated an effective extension of the territorial reach of the American state beyond its sovereign borders as the US military used science to enlist matter as allies of their territorial project.

Neither of these two territorial orderings were necessarily defined by borders. Rather, practices of enframing the material qualities of Earth were critical to the territorial processes unfolding at Ilímaussaq and on the ice sheet alike. As indicated in Chapter 3, scientific practices are practices of drawing lines of connection, division, and cohesion across transecting planes and materialities (Pickering 1995; Prigogine and Stengers 1990).

Codification and the application of concepts and systems of classification to the physical environment are practices of enframing earthly chaos and such practices are inherently territorialising (Grosz 2008).

A long sequence of lines, material divides and divisions, resulted from and characterised both the US and Danish Greenland expeditions. Ilímaussaq was crisscrossed by the lines of flight of the Catalina, the staked out lines of the GEOX proto-map, the contours of generalised radiometric zones, and lines of distinction between different geological formations. Even lines between microscopically enhanced mineral grains were mapped to obtain an outline of the fabric of territory. Similarly, the ice sheet was cut across by lines separating diagenetic facies and annual glacial strata, lines of traverse, and lines marking the topography and elevation of the subglacial bedrock. Some of these lines were inherently ephemeral, such as the fieldworkers' tracks in the snow, which were often erased the very instant that boot and snow-covered surface parted. Even as they disappeared from sight, these highly temporary inscriptions remained part of the territorial process and its acts of bounding as they were preserved as data in field notes and photographs (see for example Fig. 25, p. 194).

As illustrated by these two case examples of territory's production through scientific enactments of Earth, the practices through which territory was enframed were inherently multiple, as were the material qualities that were captured. Through acts of traversing, mapping, photographing, drilling, probing, and chemical enhancement of microscopic traces, Danish and US scientists organised Greenlandic landscapes in terms of a series of discrete, nominal objects enframed in terms of their material qualities. The US scientists separated winter ice from firn settled during the summer months, framing each such object in terms of its impact on surface mobility, and divided rock in accordance with its qualities as a building agent. At Ilímaussaq, the black lujavrites were separated from other mineral formations with no perceived economic value, and in the laboratories in Copenhagen, the lujavrites were themselves broken down into even smaller objects, both physically and intellectually.

As argued by Grosz (2005), the construction of such nominal objects – or 'things' to use her terminology – fulfils a crucial function in allowing human beings to navigate the teeming multiplicity of the world we inhabit. Following arguments presented in Chapter 3, this makes 'things' and the process of their coming into being central components of the territorial ordering of Earth through science. "The thing", according to Grosz (2005: 133), "is a certain carving out of the real, the (artificial or arbitrary) division of the real into entities, bounded and contained systems, nominal or useable units". It represents a compromise between a chaotic world that exceeds our abilities to grasp it and the world as we need it or would like it to be. Grosz (2005) writes:

> The thing is the point of intersection of space and time, the locus of the temporal narrowing and spatial localization that constitutes specificity or singularity. Things are the localization of materiality, the capacity of material organization to yield to parts, microsystems, units or entities. They express the capacity of material organization to divide itself, to be divided from without, so that they may become of use for the living. (Grosz 2005: 132)

Similar to the 'thing' as described by Grosz, the nominal objects that Danish and US scientists carved from Greenlandic Earth represent particular intersections of space and time – spatio-temporal constellations of matter and meaning captured and congealed as part of a stable, territorial ordering. Matter and its qualities were geographically fixed and localised as the nominal objects were mathematically anchored to particular sites by, for example, siting a body of lujavrite or an ice feature using maps or sections. This 'localisation of materiality' meant that the nominal objects took on the role of structuring devices, inscribing the spaces of their existence with a particular set of meanings and (im)possibilities of human intervention. Bodies of lujavrite inscribed Ilímaussaq as a space of resource acquisition while the nominal organisation of the ice sheet cast particular areas as more or less trafficable. The enframing of bodies of uranium ore or bodies of rock with particular engineering properties served as expressions of 'the capacity of the material world to divide itself' into distinct categories as well as its capacity to be divided by the application of the scientists' calculative logics. This capacity, in turn, allowed for a rationalisation of the productive potential of the political geo, making US and Danish capitalisations of Greenlandic Earth as land and terrain possible.

As indicated throughout Chapters 5 and 6, the Danish and US practices of enframing were inherently transformative; they were territorialising in their logic and character. Enframing matter by projecting upon it abstract lines of division, casting it as territorial markers defined by select material qualities, was to imbue it with a particular political resonance. In other words, through this organisational process, matter (cast as 'things' with set physical properties) was granted a political voice which simultaneously comprised, exceeded, and fell short of its innate material vibrancy and allowed matter to speak to the socio-political organisation of territory.

The territorial dissection of Earth was not merely the result of what scientists 'found' when they entered the field. Rather, the enframed objects represented what the scientists *made* of that which they encountered (Bowker and Star 1991). Matter was changed through the process of its enframing, redrafted in accordance with political goals and desires. Importantly, however, this is not a purely social-constructivist argument. Failing to take account of matter's agency and forcefulness risks reducing it to a result of the processes that this chapter seeks to explain rather than positioning it as a critical component of such processes. As noted above, the enframed objects represent 'compromises' between the political and the material world as matter has agency of its own and does not always adhere to the wills of humans (Bennett 2010). Emphasising the agential force of the 'thing', Grosz (2005) writes:

> The thing emerges out of and as substance. It is the coming-into-existence of a prior substance or thing, in a new time, creating beneath its process of production a new space and a coherent entity. (Grosz 2005: 133)

Put differently, the 'thing' neither begins nor ends its material existence as a purely social construct. Even as it is enframed, it retains a potential for being redrafted (see also Clark 2011, 2017). The black lujavrite, for example, pre-existed its enframing as a separate epistemic object. Yet by being framed *as* black lujavrite, a uraniferous mineral formation, both the object and the spatial assemblage it was part of changed. Matter abstracted from Earth, Earth distilled to the qualities of matter.

Across Greenland, physical space had served as a structuring medium significantly impacting the practices of enframing. Torrential rain made the Ilímaussaq mountains slippery and set the Danish fieldwork back days, and some bouldery mountain slopes were simply too unstable to traverse. Blizzards, whiteouts, and other difficulties associated with navigating the contourless ice sheet meant that the US Jello team were often significantly off their carefully planned course. These are examples of how Greenlandic physical geographies pushed back against scientific intervention and how Earth's agential forces impacted the form and formation of territory by determining where the fieldworkers could and could not go. Herein lies another example of how these two case studies illustrate that understanding the geoscientific underpinnings of technologies of territory requires attentiveness towards practices and physical enactments of territory. Studying practice rather than discourse and representation alone provides a meaningful way of engaging the production and politicisation of space without reducing said space to either a predefined material given or to a purely social construct (Pickering 1995).

The impacts of the agential forces of Earth of the practices of its enframing is, at least in part, an empirical question. Similarly, the acts of scientists operating at an isolated field site cannot always be predicted. Confronted with the elementality of the field and the almost inevitable material failings of some of their mechanical equipment, the sequestered Danish and US field scientists had no choice but to face whichever challenges came their way. Necessity may thus, in theory, lead to the implementation of creative and unexpected practices impacting the scientific practices of enframing. For example, Benson and his team found themselves at the Thule Air Base with no viable contacts or resources, which forced them to construct their own sleds and wannigans out of scraps. TRARG navigators were unable to navigate the 'ice ocean' using the technologies at their disposal, and thus decided to craft an improvised sundial. Without this improvised piece of equipment, the results of the 1953 glaciological programme may well have been different. Creativity (or lack thereof) may itself push the limits of territory as creativity is a factor which potentially conditions the kind of access scientists can obtain to the environments they study. What happens in the chaotic and unpredictable environments of the field and how this affects the lines of division that scientists draw between material bodies cannot be taken for granted.

Shifting materialities and territorial frontiers

Following Grosz (2005), 'things' (and, by extension, the spaces they inscribe) are not stagnant; they remain open to being redrafted, both materially and textually, in the form of a new 'thing' with a different substance or meaning. As such, the territory inscribed and defined by the 'thing' is similarly open to renegotiation and to having its material components reassembled in terms of a new territorial ordering; an ongoing process of de- and re-territorialisation of Earth which corresponds to whichever qualities of Earth are deemed politically significant at a given time.

The practices of enframing Ilímaussaq as well as the ice sheet and its marginal zones were directed at ensuring the epistemological coherence of territory and pushing its limits by drawing new materialities and spheres into the known realm of the state – a territorialisation of the inner fabric of mountains and the voluminous depths of the inland ice (Braun 2000). During the 1950s, the US scientists pushed the limits of their territorial reach far below the surface of the ice by means of synesthetic technologies such as the seismographs while Danish geologists extended their territorialisation deep into mountains using diamond drills and geological sections. Hence, even as the state borders delineating 'Greenland' on world maps remained unaltered, the topologies of the US and Danish territories were far from static. In both cases, the frontiers of 'state space' were being pushed and pulled in different directions to meet the territorial goals associated with land and terrain.

As this topological malleability suggests, any territorial ordering relying on science as a formative element of its production is inherently processual, ongoing, and open-ended. The territorial limits of state space remain fuzzy and open to negotiation not only because political needs and desires shift, but also because of technological change and scientific progress (see Naylor and Ryan 2010; Yusoff 2010). Although it is arguable necessary to remain critical of the conceptualisation of science as a linear process of accumulation and progress, science is nevertheless driven by a constant momentum towards change (Latour 1999). New technologies or changing political objectives might push intelligence gathering in unexpected directions. The US' strategically motivated desires for ice sheet intelligence, for example, led to unprecedented investment in research into the material fabric of Greenlandic geographies (see Chapter 1). This influx of capital allowed Benson and his team to travel in weasels of their own design and experiment with novel ways of capturing and documenting ice architectures. Danish nuclear nationalism similarly inspired government investment in more than 25 years of rigid scientific research of a body of ore which at the time had little if any economic value. New technologies such as the aerial scintillometer, which had not previously been used in Greenland, greatly extended the reach of the Danish state (even if the technology did not travel without issues).

At this particular juncture in history, the topologies of Arctic physical environments underwent substantial changes as scientific research became more systematic and 'scientific' whilst vastly growing in quantity (see Chapter 1). Both the Danish and the US written records from the two expedition series contain explicit musings on how Greenland at the period in question presented itself as more open and graspable than it had been to "[e]xplorers of by-gone days" (Victor 1953: 136). The fieldworkers' reports and diaries noted how technological change had altered Arctic exploration and opened up polar landscapes in unprecedented manners (Christie 1995; Benson 1960, 2001; Benson and Ragle 1955; Mouritzen 1955a, 1956b). The shifting materialities of Arctic exploration associated with technologies of travel, nutrition, clothing, and of course measurement had arguably extended the reach of knowledge and thus allowed the fieldworkers to shift the frontiers of the territorial realm.

In Greenland, territory was forged through practices directed towards the enframing of space, but in neither of the US nor the Danish case did such practices of framing relate to the construction, enforcement, or enactment of state borders. Territory was defined and ordered in terms of its material qualities, real and imagined. As will be explored further in the subsequent sections of this chapter, the territorial narratives did not end with the drawing of lines and frontiers. As already indicated, both non-human matter and corporeal beings played their own critical role in the techno-scientific grounding of territory.

Bodies: the corporeality of 'ground truth'

As noted above, access to Greenlandic geographies was negotiated in the physical encounter between mechanical, biological, and geological bodies. Neither the Danish nor the US scientists were able to construct a neatly geo-metrical, Euclidean, and governable geography cast as land or terrain without a point of contact between human and Earth. Since scientific interpretation of the physical landscape depended on processes of 'ground truthing', managing and manipulating the conditions of this encounter was a crucial component in manipulating the topology of territory.

As fleshy and sentient beings, humans are vulnerable to Otherness, and the power relation between human and environment is inherently asymmetrical. As argued by Clark (2011), this relation is resonated in the asymmetrical relationship between Self and Other, and the division between that which is Other and that which is not is at the heart of the notion of territory (Elden 2009; Strandsbjerg 2010). Overcoming the Otherness of the Greenlandic landscape and incorporating it into the known realm of territory depended on the ability of the fieldworkers to internalise this Otherness; it depended on their ability to do away with the 'excess of nature'. To build such a capacity, the bodies of Danish and US scientists and conscripts were disciplined both in and outside the field, across academies and training grounds. The TRARG conscripts, for example, were instructed in how to manage sweat in the field without losing valuable energy, given careful instructions on how to wear their clothes, and close daily shavings were mandatory for reasons of health and sanitation[85] (SIPRE 1958; Victor 1953; Boskin 2011). In theory, the disciplining of their bodies enabled the conscripts to internalise the Otherness of the ice sheet and exist in and on it without succumbing to its fragmenting forces. The Danish university trained geologists relied on years of field experience as a guarantor that they could similarly internalise the excesses of the landscape at Ilímaussaq and channel it productively into knowledge of the substrata. In this sense, the sciences through which Greenlandic Earth was territorialised seem to rest on Kantian ideas of space as a transcendental category where knowing space meant knowing *in* space. This sentiment was reflected in how both Danish and US scientists idealised the intimacy with the field that they gained from being part of it and immersing themselves in its elementality – an intimacy which, at least to some, resulted in 'truer' knowledge.

Across the official reports from the two sets of expeditions, Arctic minds and bodies were depicted as generalisable and homogeneous (see Farish 2006). Such a body had the advantage that it could be mobilised as an instrument of science and generate important knowledge. TRARG and SIPRE incorporated body-knowledge directly *as data* in order to explore new ways of compensating for bodily vulnerabilities across icy terrain. For the Danish geologists, knowledge was embedded in the very fibres of their trained bodies, allowing them to use touch, taste, and intuition to learn the truth about Ilímaussaq. In the first instance, the homogenous Arctic body provided generalisable data. In the second, it could be written out of the scientific narrative because it was a known quantity, leaving only 'pure nature'. Like Kathryn Yusoff (2007) has noted with reference to the cold bodies of Antarctic explorers, these standardised bodies were largely fictitious constructs, products of the field reports and instruction manuals:

> Indeed, the boundaries of the body are marked as a whole, but only fictionally so. From the outside and in its entirety, the body as representation maintains its borders in differentiation to the landscape. Thus, representational practice constitutes a refuge

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[85] The photographic and cinematic records from TRARG and SIPRE suggest that this last rule was not always upheld.

> against the material and psychic effects of an *environment of disintegration*. (Yusoff 2007: 224, original emphasis)

Bodies inserted themselves into the scientific narratives of the two sets of expeditions. Yet, the body that made it onto the pages of official expedition reports and became part of the territorial narrative was not necessarily congruent with the bodies present in the diaries and memoirs of scientists, conscripts, and expedition leaders. On the Greenland ice sheet and across its northern as well as southwestern marginal zones, territory was enacted at the cost of personal strain as well as elements of thrill and excitement. Some of the more intimate aspects of expedition life, including the challenges associated with basic bodily functions in extreme cold as well as sexual frustration, homesickness, and other challenges to mental well-being, were not explicitly inscribed into the official expedition narratives. Rather, these were examples of excesses to be internalised by the fieldworkers in search of 'ground truth'. Nonetheless, these 'hidden' or 'less visible' corpographies cannot be denied or ignored. While their impact on the territorial ordering of land and terrain may be near-impossible to isolate, these hidden corpographies remain embedded in and entwined with the practices of territory, albeit in manners which are not necessarily obvious. The embodied encounters of both 'official' and 'unofficial' Arctic bodies underline how territory is a practice, a doing, a complex process of becoming.

As suggested above, the desire to control and homogenise Arctic minds and bodies could not always be met. Both at Ilímaussaq and at Thule, the GGU and the TRARG respectively were forced to send home men who proved unable to adapt to the mental and physical strain of Arctic fieldwork. The failings of men (and machines) to internalise and accommodate environmental excesses were perhaps not countless, but as these two expedition series illustrate, there was more than one single corpography of the field. The impact of human vulnerabilities on practices of territory is yet another empirical question concerning territory's production.

These Danish and US processes of territory comprised a series of complex exchanges between biological and geological bodies. These included exchanges of physical matter: sweat, blood, even human limbs in exchange for rock samples, ice cores, or data in the form of instrument readings. Without bodies on the ground, without this physical exchange, there could be no mappings of the geometries of the Earth. Both the US and the Danish research programmes involved aerial technologies as ways of rendering data collection more efficient and thus minimising the direct contact between human and ground. Aerial scintillometry allowed the FFR to gather radiometric data from otherwise inaccessible landscapes, and ortho-photography helped the TRARG obtain an approximate outline of the northernmost terrains of Greenland. Yet both cases relied on physical contact with the material Earth to make sense of the aerial data[86]. Only by obtaining ground-truth data did it become possible to calibrate aerial data and make meaningful interpretations of that which had been remotely sensed (see Chapters 5 and 6).

Reading across the Danish and US case histories, it appears that the creation of an archive of corporeal knowledge serving as what Yusoff (2007: 224, emphasis removed) referred to in the quotation above as "a refuge against the material and psychic effects of an environment of disintegration" was of greater significance to constructing terrain than to constructing land. As discussed in Chapter 6, the American state explicitly sought to extend its structures of territorial domination through the bodies of conscripts via disciplinary policies directed at their well-being and preservation. As such, the US production of terrain in particular is illustrative of the inherent biopolitics of territory, even when territory is considered as a technology directed towards the geo and its metrics. The bodies of scientists and conscripts were mobilised as objects and vehicles of a mode of power which was simultaneously bio- and geo-political in that it aimed at disciplining human bodies, nonhuman elements, and the reciprocities between them. Controlling the landscape as a military terrain depended on controlling and preserving the human body *in* that terrain by building a repository of knowledge which made it possible to compensate for its bodily vulnerabilities.

The biopolitical dimensions of land were, in the case of the Danish uranium prospecting, less explicit since control of the body in the landscape was not a goal in and of itself. Yet, while the Danish scientists did not map their physical encounter with the landscape nor document their bodily decay, their encounter with the landscape as terrain was nonetheless significant. As a necessary condition of the prospecting task, land became a terrain that the

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[86] This is more than an historical observation. Similarly, current aerial technologies employed in the mapping and scientific exploration of Arctic environments (and beyond) rely on practices of 'ground-truthing'.

Danish fieldworkers needed to negotiate to assess its economic properties. Similarly, terrain became land when the US military scientists, engineers, and conscripts sought means of sustaining themselves (e.g. water supplies and building materials). In a sense, the human body served as a cross-over point between land and terrain, illustrating that the two are inextricably entwined qua their bio-geo-political traits.

Corporeal narratives of Arctic fieldwork underline how territory is an inherently physical and elemental space which transgresses the binary of the political and the material. The territorial orderings of Greenland were thoroughly relational – products of exchanges and reciprocities between biological, geological, and mechanical bodies. The cyclical movement between abstract and physical geographies – between representation and referent object, between map and world – was central to changing the topologies of territory and the landscape was territorialised in part through the concurrent territorialisation of human bodies.

Grounding the fluid properties of terra

Placing the Earth and its critical metrics at the centre of territory's production intuitively invokes a literal translation of its etymological 'prefix' *terra* as dry land, solid ground, and the seemingly stable components of Earth. As previously noted, this understanding of the terra of territory may underpin simple definitions of the concept, but it is inherently restrictive as it fails to account for territorial spaces which do not readily comply with this 'logic of solids' (see Steinberg et al. 2015; Peters et al. 2018; Peters 2015; Squire 2016a). At a glance, the mountains of Ilímaussaq supported a 'classical' territorial narrative resting on a binary division between solid land and fluid water. As an environment informed by the plastic medium of ice, the Greenland ice sheet, on the other hand, explicitly pushed back against the limits of such a division. As argued by Steinberg and Peters (2015: 248, original emphasis), territorialising such environments defined by incessant change involves "account[ing] for the chaotic but *rhythmic* turbulence of the material world, in which, even amidst unique events of coming together, there is a persistent, underlying churn – a dynamic pattern of repetition that provides stability and texture in an environment of underlying instability".

To construct terrain, the fieldworkers of Operation Ice Cap and Project Jello sought to stabilise and striate terra as well as its inherent mobilities and flows. Terra was not limited to 'dry land' in the strictest sense of the word. Terrain included vast stretches of glacial ice which was encountered and enacted as simultaneously fluid and solid – navigated like an ocean and traversed like (mostly) stable ground. On the ice sheet, snowflakes and ice crystals were considered part of the terrain and, as such, drawn into the territorial networks of geoscientific knowledge and were even mapped individually. The terra of terrain was a complex of interacting materialities and exchanges, which could only be captured through interdisciplinary collaboration such as the mapping of meteorological knowledge onto glaciological and geological knowledge. The terra of terrain was in flux, it was rhythmic, it was inherently temporal.

The US scientists sought to capture and striate the overlapping trajectories of multiple elemental bodies in motion, including the fluid ice. The Danish prospecting team, on the other hand, located terra only in areas free from ice and snow. When the expedition encountered unexpected masses of snow in the spring and summer of 1956, for example, work came to a halt (Mouritzen 1956a). Terra was found *underneath* the snow cover, and the snow effectively prevented access to the main object of Danish territorial desires: the solid rock. The Danish scientists did not aim to master the environment in its totality. Their ordering did not take into account the relationships between rock, ice, and cold or how one might change the material structure of the other. Like the ice sheet, however, the mountains of Ilímaussaq were also in a state of flux, albeit moving at the radically different pace of geologic time. Yet understanding the rock in terms of its fluid properties – how the mountains had moved over millennia – was key to the scientists' geological assessments of where bodies of uranium ore might exist and their assessments of the limits and voluminous forms of the buried bodies. In this sense, part of the Danish territorialisation of Ilímaussaq involved affirming and stabilising its form through knowledge of its formation. The liveliness and inherent temporality of the territorial organisation of Ilímaussaq was most pronounced in the practice of mapping its radioactive decay: stopwatches paired with Geiger-counters clocking the fast-pace, irregular bursts of Ilímaussaq's radiation. Even though this radioactive decay happened stochastically, its inherent irregularities were compressed and presented as smooth and rhythmic.

The construction of land and terrain alike rested on attuning to the pulsations of the Earth in order to rationalise and capitalise on its productive potentials. Both rock and ice were rendered epistemologically stable by accounting for their trajectories of movement and change, making their form and formation extendable through time. Through the construction of enframed objects (or 'things') which were simultaneously stable and fluid, the scientists had contributed to the production of territorial orderings of Greenlandic physical geographies which cast Earth as a solid foundation for state practice. To emphasise this relationship between time, space, and scientific mappings of motion, it is worth quoting Grosz (2005) at some length:

> The thing and the space it inscribes and produces are inaugurated at the same moment, the moment that movement is arrested, frozen, or dissected to reveal its momentary aspects, the moment that the thing and the space that surrounds it are differentiated conceptually or perceptually. The moment that movement must be reflected upon, analyzed, it yields objects and their states, distinct, localized, mappable, repeatable in principle, the objects and states capable of measurement and containment. The depositing of a mappable trajectory of movement, its capacity to be divided and to be seen statically, are the mutual conditions of the thing and of space. The thing is positioned or located in space only because time is implicated, only because the thing is the dramatic slowing down of the movements, the atomic and molecular vibrations and forces, that frame, contextualize, and merge with and alongside of other things. (Grosz 2005: 133)

Although Grosz in the book from where this quote is extracted is not concerned with questions of territory or science, this passage speaks to a central aspect of what makes science an effective instrument in the territorialisation of Earth. As illustrated by the Danish and US material framings of Greenland, the capacity of science to not only present the physical world as immutable and solid, but also to sort through the chaos of Earth and make its fluid properties actionable was crucial in ordering Greenland, more-so as terrain than as land. The US scientists in particular dissected movement by reducing it to a series of discrete spatio-temporal moments – captured and arrested points of intersection between space and time serving as data. Strung together to present a linear trajectory of change, the arrangement of these moments on graphs and diagrams allowed the movements of the Greenland ice sheet to be 'seen statically'. Similarly, the moments in the life of Ilímaussaq that the Danish geologists enlivened by analysing core samples and exposed sections of rock were used to make the slow movement of mountains graspable, albeit by 'speeding it up' rather than the ‘dramatic slowing down’ described by Grosz. In practice, these territories were not underpinned by a rigid ‘logic of solids’, but rather by a mathematically rooted logic of rhythms and repetition.

Grosz’s argument about the significance of movement is an argument about material agency. It is because of the liveliness and vibrancy of matter that the scientific mappings aimed at bringing an actionable, productive, and governable territory into being had to account for matter’s doings rather than just its being – how things were ‘taking-place’ (Anderson and Harrison 2010). For example, mapping the velocities of the ice sheet’s flow, its rate of accumulation and ablation, and the seasonally changing textures of its surface was, in effect, a mapping of the agential forcefulness of the matter of the ice sheet. It was a mapping of how matter could be expected to impact terrain at any given time. As such, territory was stabilised temporally as well as spatially as the two were folded into each other.

Temporalities of territory

As mentioned in the introduction of this chapter, one of the abstractions that produces the territory effect is the abstraction of space from time (Strandsbjerg 2010). As critical geographers have long pointed out, space is imbued with and inseparable from time (Massey 2005, 2006) and, as a spatial ordering, so is territory. Looking closely at the practices which fed into the territorial processes in Cold War Greenland reveals a myriad of underlying temporalities which affected the fieldwork in different ways. Much like the bodies which were gradually reduced to disciplined fabrications or distilled out of the representations of territory, so was time in its inherent multiplicity an element which had to be accounted for. However, as argued in the previous section, stability and a stable ordering did not necessarily emerge from a strict separation of space from time, but rather from a disciplining of time and its effects on the geographies of landscape. Grounding territory was not just directed towards its grounding in space, but towards its grounding in time as well. The temporal orderings of Danish and US territorialisations of Greenland were, as indicated above, not entirely congruent. Terra and its temporal configurations depended on the underlying ambitions of how territory was to be operationalised.

According to a journalist visiting Ilímaussaq in 1958, the fact that the Danish scientists had worked alongside the 1000-year-old ruins of Erik the Red’s settler colony had created a sharp divide between an ancient past and the modernity of the present which he described as bizarre and tauntingly obvious (Berlingske Tidende 1958b). Yet as the scientists drilled into the body of Ilímaussaq, they did not affirm this temporal schism. Rather, they constructed a sense of linear reciprocity between past, present, and future. By rooting land in deep, geological time, the Danish scientists at Ilímaussaq lent an air of timelessness to the Danish territorial ordering of the mountains. Using boreholes and theory-based geological sections, the scientists mapped out lines of connectivity between the past, present, and future of the territory and affirmed that the Danish national geobody was effectively solid as a rock.

In the US gathering of terrain intelligence on and around the fast-flowing ice sheet, on the other hand, geological time received very limited attention, not even in the mapping of the rocky coastal zones of North Greenland. Even here, the temporality of the rock was mostly limited to the short term effects of cyclical frost and thaw. US terrain was not rooted in deep time, but had comparatively shallow temporal roots. As discussed in Chapter 6, the glaciologists enacted the ice sheet as an extensive archive of seasonally organised meteorological data (precipitation, temperature, atmospheric carbon etc.). The linearity and seasonality of time was expressed in the strata of the ice cores, but it never reached 'deeper' than a few decades at most. The temporality of terrain was related to the changing textures of the landscape and the physical consistency of space as it changed with the seasons[87].

On the ice sheet, time was expressed by moving across the ice as well as digging into it. Travel time was, in and of itself, a critical metric of terrain. For the men of Project Jello, progress in terms of miles travelled and number of glaciological pits dug seemed more important than the passing of days. On the ice sheet, time often seemed abstract and dauntingly slow-moving. The landscape was thoroughly monotonous, and the sun never set, meaning that the men had little sense of daily temporal flux. Daily rhythms pertaining to sleeping, eating, and working were highly irregular. Hence, the temporal structure of the fieldwork hardly relied on clock-time at all, and in his diary, the expedition medic

[87] Long term changes in temperature and precipitation etc. were not granted significant attention in the reports on terrain intelligence. However, considering the growing prominence of the sciences of climate change, it is not inconceivable that long term effects on terrain could be enrolled in territorial narratives.

sometimes expressed confusion with regards to which date to add to his entries (Christie 1995).

A long line of archival practices carried out by the fieldworkers on the ice sheet and at Ilímaussaq captured the layered temporalities of the scientific fieldwork. Stopwatches paired with Geiger-counters clocked the fast-pace, irregular pulsations of Ilímaussaq's radiation. Sundials and gyrocompasses were used to calculate longitude – a practice relying on and affirming a geo-metrical relationship between space and time. Geological drill cores and ice cores were cast as time congealed and were, as such, mobilised as registrars of deep, geological time as well as time as seasonal and cyclical. Diaries registered time as it was experienced at the physical interface between human and ground; as did the Jello expedition physician's medical records, through which the fieldworkers' bodies were depicted as markers of time's passage documented through their gradual decline (see Yusoff 2007).

Geo-power and technologies of territory: Earth as prosthesis

As suggested in Chapter 3, the scientific enframing and ordering of the material world did more than simply allow the US and Danish states to project power onto and even through space. Whilst extending their governmental reach beyond the plane of existence, beyond the chaos of Earth, and beyond the spaces of sensory experience, the scientific practices simultaneously made it possible for the two states to capitalise on the Earth as land and terrain. As a result of this capitalisation, the physical Earth and its qualities became a *source* of power as opposed to a multidimensional body onto which territorial power was simply projected (Grosz 2008). The scientific mapping of the voluminous, vibrant, and material qualities of Earth made it possible to adapt political intervention to account for the exigencies of matter. As a means of allowing the state to "manoeuver in a field of material agency" (Pickering 1995: 7), science made it possible to work more efficiently *with* rather than against the forces of nature and effectively enlist matter and Earth as allies of the two territorial projects.

Geoscience facilitated a recasting of matter in terms of instruments of action or, to borrow Grosz's (2005: 139) terminology, in terms of "an immense organ, a prosthesis". In their effort to construct terrain, the US scientists actively sought out creative ways of mobilising the material properties of matter to serve their military needs. Rocks of the marginal zones, for example, became building materials while areas of permafrost became foundations for the construction of military infrastructures. The most dramatic example of the US capitalisation on the geo, however, came from their deployment of glaciological knowledge of the Greenland ice sheet. In addition to making it possible to transcend the voluminous depths of the ice sheet through the act of crossing it, knowledge of its geophysical properties inspired a series of experiments involving the establishment of large, subglacial structures (Bader et al. 1955; Rausch 1956). The unique malleability of the ice meant that digging out vast military infrastructures embedded in the ice sheet was both quick and cost efficient (see Clark 1965; Bader et al. 1955; Weis 2001; Petersen 2008; Martin-Nielsen 2013b; Nielsen et al. 2014). While the ice sheet, as noted in Chapter 6, incessantly pushed back against the US project of terrain making, its unique physicality was simultaneously enlisted as a source of territorial power; a prosthetic technology enabling the extension of the territorial reach of the American military apparatus.

Further south, the Danish prospecting teams were similarly charged with drawing out the intrinsic earthly powers of Greenlandic physical geographies to serve the state. The radioactive mineral components of the disciplined mountains of Ilímaussaq were assessed economically and imagined as a source of energy (and territorial power) which could literally be extracted from the ground. The chemical analyses of the black lujavrites were attempts at making this capitalisation possible. In their laboratories, Danish scientists searched for a way of casting the forcefulness of matter (its radioactive properties) as a viable source of (geo)power by liberating uranium from the other components of the mountains.

Framing the Earth in accordance with military visions and economic-nationalistic desires respectively, the two expedition series each sought to make earthly elements work *for* the state whilst also making it possible to work *through* them. As such, physical geographies became prostheses in their own right. Earth was refashioned through the enframing of matter and its transformation into 'things' which might serve as instruments of political power. Such framings, which in different ways allowed the states to draw on and over the power of the Earth, captured a critical element of the territorial effects of these geoscientific field practices. Territory as a political technology was an inherently transformative process; it involved the transformation of Earth into a prosthesis, an organ, from which power could be drawn (Grosz 2005, 2008).

The power gained from grounding the state using geoscience as a technology of territory may, as previously suggested, also come from aligning and creating an intimate relationship between an overtly social construct (the state) and something which is considered natural, reliable, and even eternal (Earth) (see Steinberg 2009). Such grounding of the state and its territory is, as indicated throughout this chapter, explicitly linked to the spatio-temporal ordering of territory's qualities. It offers a partial explanation of how the state is able to use its territorial form to disguise the politics of its spatial interventions (see Brenner and Elden 2009).

Speaking to the structuring effect of scientific orderings of the world, Grosz (2005: 132) notes how the 'thing' is both the result *of* action and the provocation *to* action. There is intentionality behind the division of the physical world, its striation and enframing in terms of discrete spatio-temporal categories – it is a deliberate act of framing aiming to deliver on human (and political) wants. At the same time, once these 'things' are brought into being, they pose "questions to us, questions about our needs and desires, questions above all of action" (ibid: 132). The 'thing' is a provocation and a promise. Its carving out is guided by logics of anticipation: anticipation of a prosperous mining future, anticipation of the need to defend the homeland. Yet through the process of its enactment, the 'thing' also feeds this anticipation, naturalises it. Because of these effects of the 'thing', the scientific practices of enframing the physical world and order it as coherent territorial geographies simultaneously naturalise territorial intervention. By bringing order to the chaos of Earth, science plays a crucial role in providing a stable, territorial backdrop against which state policies can be presented as logical responses to the forces and qualities of the material world. The sciences of the Earth thus feed the territory effect by increasing the state's ability to mask political intervention through its territorial form.

Scales of territory

As indicated by the discussions of the practices of Danish and US science in Chapters 5 and 6, the deconstruction of the political geo to produce land and terrain – the separation of the physical world into 'things' – was based on the procurement of in-depth knowledge of the most intimate details of the properties and qualities of territory. To negotiate the exigencies of matter and its agential forcefulness and capitalise on it, multiple scales of territory were folded into each other.

As land, the mountains of Ilímaussaq were enacted as anticipatory spaces of extraction. To enable this territorial fantasy, Danish scientists observed and documented the invisible traces of radioactive decay of individual α-particles and examined the mineral components of the mountains microscopically. Knowing how to map the mountain as a space of extraction depended on this intimate knowledge, as did any hopes of ensuring that the Ilímaussaq uranium could be separated from the lujavrite. By mapping knowledge of its microscopic chemical and physical properties onto the bodies of rock residing within Ilímaussaq's substrata, the bodies of lujavrite were imbued with radioactive properties, changing their political resonance from mere rocks to a resource.

As a terrain, the ice sheet was cast as a space of crossing, concealment and subterfuge, and even as a possible weapon (Beaudry 1949; see also Petersen 2008). The materiality of ice, the molecular bonds holding the ice masses together, made this geopolitical engagement with the ice sheet possible. Each unique grain of iced firn contributed to the strength and flexibility of glacial structures and routes of traverse, each playing the role of a binding agent in a coherent (albeit inherently temporal) material assemblage. Putting these grains under intense scientific scrutiny, both as individuals and as collectives, served as an important means of assessing how the ice might challenge or enable political projects.

Any strategic relation between the ice sheet and the US military had to be mediated through the matter of the ice itself just like economic relations between Ilímaussaq and the Danish state were mediated through the rock. In both cases, scientists performed the task of 'mediators' by rendering matter expressive in strict negotiation between matters physicality and geopolitical goals. The functional geometries of these territories were direct functions of the material qualities of matter buried deep below the surface as these metrics inscribed Earth as spaces of set possibilities and impossibilities (Elden 2013e, 2013f; Dalby 2013). The territorial politics of the ice sheet terrain and the land of Ilímaussaq rested somewhere between the physicality of these geographies and what the scientists, engineers, and planners made of it; how they interpreted and framed matter and its inherent vibrancy, how they negotiated the temporality and liveliness of matter, and how they subsequently (re)assembled Earth as coherent territorial wholes.

Concluding remarks

As this chapter has sought to illustrate, territory is a temporal, grounded, corporeal, and multi-scalar ordering of the political geo. By enframing valued material qualities of

Greenland's physical landscapes, anchoring them geographically, and mapping their fluid properties, the Danish and US scientists cast these landscapes as land and terrain. In other words, these landscapes were inscribed as spaces of war and extraction through the scientific enactment of their deep, geophysical properties. Geoscientific enactments of Greenlandic geographies allowed said geographies to become politically expressive and reverberate beyond their material existence. Through such practices and the associated circulation of traces, these geographies gained a political presence and existence which they were formerly without. This was not merely the result the manipulation of material bodies of ice and rock (in the field and in faraway laboratories), but also of their imbrication in far-reaching and more or less durable political networks. Buried matter had taken on new shape and been brought into the realm of the political.

Matter, however, did not simply undergo such transformation by its own volition. Across these two cases, a point of contact between humans and Earth was key to the practices of enframing. The corpographies of these two orderings were inherently multiple. They were both physical and mental, official and hidden. The relations between soft flesh and hard rock, warm bodies and cold ice, were inscribed in the territorial narrative, albeit not necessarily explicitly so.

Across these two expedition series, time was registered, felt, and perceived in multiple ways: through the rapid clicks of the Geiger-counter, as time congealed in the strata of rock and ice cores, and through the fragmentation of the fieldworkers' bodies which became markers of time's passage (see Yusoff 2007). Many if not all of these temporalities were inevitably interwoven in the fabric of territory, even if the threads are invisible or intangible. The production of the territory effect was linked to managing, framing, and ordering the temporal dimension of space – it was more than a consequence of the abstract separation of time from the territorial narrative.

The political technology of territory not only works through the triple abstraction of space from bodies, space from time, and space from observing subjects (Strandsbjerg 2010). Territory works on and through human and nonhuman bodies; it utilises the intersectionality of time and space to draw on and over the powers of the Earth. The overarching argument of this chapter is that if we are to account for how the complexities of the geophysical world are incorporated into the territorial ordering of space, then it makes sense to approach the political technology of territory as the attempt of states to negotiate, internalise, and utilise the material qualities of Earth. As it is practiced through science, territory comprises a constellation of political technologies through which the geophysical is rendered meaningful, productive, and expressive and brought into alignment with the political projects of the state.

8. Conclusion

Territory as a geo-political technology

At the root of this thesis is the question of how, in practice, territorial orderings of the political geo are forged in strict negotiation between human interests and a materially vibrant Earth whose physicality and agency exceeds us. Using two contemporaneous histories of state-prompted science in Cold War Greenland as the empirical focus, this thesis has offered grounded insights indicating that the sciences of the Earth play a significant role in this process of negotiation. Following Elden's (2010a, 2013a) conceptualisation of territory as a calculative political technology, this thesis has thus examined what territory's production might look like as it unfolds 'on the ground' in order to gauge what that reveals about the underlying mechanisms of the territorial ordering of space. Methodologically, this research rested on an instrumental division of territorial orderings of land and terrain, one an economic and the other a strategic relation between state and Earth. The economic and the strategic aspects of this relationship are not neatly separable. Yet while such a division is necessarily imperfect, the dual case study has been productive in that it has illustrated an apparent multiplicity of territorial formations, modalities of grounded power, and mechanisms of enlisting the political geo as an agent of the state.

The political, symbolic, and practical significance of the Earth that sustains and supports all human life can hardly be exaggerated. If territory is a relation of security and prosperity (Gottmann 1973; Elden 2010a), then the Earth and its critical metrics are deeply entwined with the territorial ordering of the world we inhabit. Drawing on recent scholarship on elemental and new materialist geopolitics, Science and Technology Studies, as well as Elizabeth Grosz's (2005, 2008) philosophies of how human beings exist in the world, this thesis has argued that the sciences of the Earth are at the heart of territory's production. The reason is that science is a critical means through which the state is able to establish the necessary infrastructures of knowledge to allow it to "manoeuver in a field of material agency" (Pickering 1995: 7) and to capitalise on the material qualities of Earth for the prosperity and security of its citizens. The focus on materiality, practice, and performance establishes territory as a process which is in a constant state of becoming. The boundaries that scientists draw to construct or direct difference between earthly elements are always incomplete, partial, and changing. This incompleteness is a function of factors such as the objectives guiding research, the state of technology, or other factors limiting human access to the natural world including bodily limitations. Not least, it is a function of the material agency of an Earth which does not always bend to the wills of humans. Framing territory as a geo-political phenomenon is thus to view territory as a *compromise* between human goals and desires and more-than-human forces and agencies. Territory, in brief, is a geo-political technology which allows the state to attune to the rhythmic forcefulness of Earth and draw on and over its latent power.

This final chapter draws together the key insights which have been gained from tracing the Danish and American expedition series alongside those gained from drawing conceptual lines of connectivity between the two sets of practices. In doing so, the chapter returns to the empirical and conceptual questions raised in Chapter 1. The first section of this concluding chapter picks up on the empirical questions which have guided the historical research upon which this thesis draws. In doing so, this first section reiterates how territorialising mechanisms were expressed in the two instances of scientific exploration and outlines the modalities of power that each territorial ordering facilitated in the context of Cold War Greenland. Drawing on and following from the current scholarly debates on territory as discussed in Chapters 2 and 3, the second section rehearses the conceptual points raised in Chapter 7 in order to outline the conceptual contribution of this thesis. The section thus returns to the main question of this thesis, namely the relationship between science, Earth, and territory. Since the 1950s, Greenland has undergone significant changes – politically, socially, and materially – and 'change' is still very much the order of the day. The third section offers a brief outlook on what the geographies territorialised by the Danish and US scientists look like at the time of writing[88]. This outlook brings out a final point about territory, namely that even as it is practiced through science, territory is an inherently violent practice. Of course no piece of work is ever final, and the aim of this conclusion is not to provide definitive answers nor to shut down the debate on territory's production. As such, the closing section offers a brief discussion of some of the limits of this study and draws out some of the questions for further exploration that this thesis has opened up.

Territorial orderings of Greenland: modalities of power and control

The modalities of territorial power that emerged from the Danish and US scientific orderings of Greenland were, in most instances, remarkably similar. Yet some notable differences nonetheless set them apart. From the rhetoric surrounding the Danish prospecting of Ilímaussaq, it seems evident that the question of sovereignty and the affirmation of the national identity of the political geo was a key objective of the research. While forging a bond between the state and the subterrain in order to effectively 'ground' the state, the Danish scientists expanded the epistemological realm of the Danish state – what Dodds and Nuttall (2016: 80) refer to as "a sort of volumetric expansionism". The scientists affirmed that the national geobody was a source of energy and fortune as they arranged Earth into vertically and volumetrically organised goods (Klinger 2015, 2018). Key to this act of grounding was the construction of a link between deep time and the future modernity and prosperity of the Danish nation. The temporal ordering of land was based on the notion of geological time – slow and stable, barely discernible. The prospecting affirmed that the national territory was 'solid as a rock' and served as a significant marker of Danish territorial sovereignty by communicating the state's superior knowledge position and its ability to render the geo productive.

Affirming the submissive relationship between 'centre' and 'periphery', the Danish territorialisation of Greenland bore the marks of an archetypical colonial relationship. In other words, the territorial ordering of Ilímaussaq took on the form of an "old landed

[88] This chapter was written in October 2017.

empire" (Oldenziel 2011: 15). The US scientific insertions in Greenland, on the other hand, cast Greenland as part of a vast territorial network which stretched across the Arctic region and beyond (ibid). Scientific knowledge of the deep, material qualities of Greenland greatly expanded the scope and efficiency of US military action and positioned Greenlandic geographies as logical extensions of American state space. This networked power has been described by Hart and Negri (2000) as essentially 'post-territorial'. However, as argued by Oldenziel (2011: 34), such "territorial blindness" effectively "casts America as a topos without geography". In other words, it thoroughly dematerialises both state and territory. Considering the network effects and properties of territory does not mean reducing Greenland (or other geographies within this territorial network) to nodes on a graph – to mostly virtual political spaces with no significant material existence. As illustrated in Chapter 6, Greenlandic geographies were mobilised, drawn, and acted upon in manners which by far exceeded the 'thin' spatialities of the point.

The territorial ordering of terrain beyond the boundaries of the US defence areas was pronouncedly malleable. Unlike the Danish territorialisation of Ilímaussaq, this extra-sovereign extension of territory was not meant to establish the same deep temporal roots within the material body of Greenland. Greenland was an extension of national geographies, not a part of the US national geobody. The US territorial ordering was defined by its malleability and flexibility rather than by creating an impression of permanence and timelessness. This schism was articulated through the difference in the territorial archives produced by the US and the Danish scientists. Whereas the Danish scientists spent decades forming a detailed at place specific knowledge base, the US scientists seemed more preoccupied with obtaining knowledge of categories of space or, in other words, building an archive which they could draw on beyond Greenland.

In a technical-legal sense, the US networks of knowledge cutting across and through the Greenland ice and its northern marginal zones did not *expand* formal US territory. It did, however, *extend* the territorial reach of the American state, both horizontally and vertically, beyond the borders of US sovereign state space. Science, in other words, served as a potent mechanism through which the American state extended its territory in extra-sovereign manners. The territorial mechanisms of the US research programmes in Greenland provide cause to question the necessary causal link between territory and sovereignty. It appears that it is possible to extend state territory beyond the borders of sovereign state space without a literal territorial expansion.

Both the Danish and the US instances of territory making support Elden's (2010a) claim that conceptualising territory in terms of a political technology counteracts Agnew's (1994, 2009) 'territorial traps'. This rings particularly true when one takes into account the practises of the territorial ordering of Earth through science. In neither of the two cases examined in this thesis did territory emerge as a fixed unit of space, it was not straightforwardly linked to sovereignty, and it did not take on the form or function of a 'container' of political practice. Reading across these two territorial orderings reveals that complicated relationships may exist between domestic and foreign geographies rather than them being in binary opposition. Finally, the territorial ordering of space may, as Agnew (1994: 59) suggests, obscure the interaction of political processes operating at different scales. However, as this thesis has illustrated, the political geometry of territory is not only inherently multi-scaler; it is rendered functional by the very practice of drawing lines of connectivity between scales and by folding the microscopic and the macroscopic into each other.

Although the Danish state viewed the US presence in Greenland as a threat to Danish territorial sovereignty, these two modalities of territory – landed and networked – somehow coexisted. While there was only one physical island, it seems that it was enrolled in multiple territorial orderings. The multiple temporalities, spatialities, orderings, and materialities of Greenland did not necessarily add up neatly, and tensions between these two orderings were evidently present. For example, the Danish government frequently attempted to mobilise its formal territorial sovereignty to hamper the processes through which US extra-sovereign territory was brought into being by rejecting US research applications (Borring Olesen 2011, 2013). Despite such tensions, the Danish-American 'struggle' over territory did not appear to be reducible to a zero-sum conflict over a fixed quantity of space. This suggests that as political technologies of land and terrain, territories are not necessarily discrete, but may indeed be inherently multiple and may perhaps even overlap.

Territory beyond 'the logic of solids'

Over the years, the concept of territory has occupied a somewhat ambivalent position in geographical thinking. It has either been assumed to be a privileged 'container' of politics or seen as an outdated concept which is neither in keeping with modern political organisation nor compatible with poststructuralist conceptions of space, power, and meaning. Territory, in other words, has often been either taken for granted or dismissed (Elden 2010a; Painter 2006a; Strandsbjerg 2010). Conceptually, this thesis has argued that it is necessary to re-orientate territory towards process (Elden 2010a, 2013a; Steinberg and Peters 2015; Peters et al. 2018; Painter 2010). These include 'human' processes, be they social, cultural, or political (Paasi 2003). Yet, as this thesis has demonstrated, as a geo-political technology, territory is also a compromise between human and non-human agencies. This means that the territorial ordering of space raises questions of how this compromise is negotiated and reached (or not reached as it may well be). The section above presents an empirically anchored (if somewhat simplified) account of the orderings and relations of territorial power that emerged as a result of the calculative practices of the Danish and US expedition series. In addition to these empirical insights, the deconstruction of the practices of these two territorial projects have also generated information about the mechanisms of territory which may be relevant beyond the context of Cold War Greenland.

Building on the work of Braun (2000), the first conceptual argument is an affirmation of the basic premise that this thesis is based on, namely that the sciences of the Earth are potent technologies of territory. By presenting the material world in terms of a series of qualities, trajectories, systems, and exchanges, science brings order to the chaotic multiplicity of the physical world (Prigogine and Stengers 1990; Grosz 2008). Science is thus an efficient means of carving out spaces of legibility and intelligibility within which human beings can make sense of the world, act upon and exist in it with greater proficiency, and draw on the material properties of space as sources of prosperity and security (Latour 1999; Scott 1998). Science brings the deep, material qualities of Earth into the known realm of territory and thus renders them open to political intervention and governance (Braun 2000). Science, in other words, holds a privileged position as a mediator between the human and the physical world. Yet, no such act of mediation is ever fully neutral, nor is it without consequence. The scientific ordering of physical geographies is, in part, a response to socially and politically guided valuations of Earth's material qualities. Hence, while the spatial orders that scientists enact are not wholly social constructs, they are not entirely 'natural' either (Pickering 1995; Demeritt 1994; Massey 2006).

State-prompted practices of science are enactments of human valuations of the physical world which somehow reflect national-political interests (Doel 1997, 2003). However, the territorial ordering that such science brings about is also a reflection of what kinds of action in space the Earth will support. Scientific experiments are means of pushing the boundaries of such action and thus pushing the frontiers of territory. Yet they are also mappings of Earth's material agency – a rationalisation of how the Earth might challenge or enable geopolitical intervention.

Earthly bodies are changed in the process of their enframing and division into categories which inform a scientifically produced territorial ordering; they become 'things' defined by their material qualities and their metrics become markers of territory. These bodies are imbued with new political resonance which allows them to reverberate beyond the confines of their geographical existence. According to Grosz (2008), territory is the ordering of earthly chaos, but it has had something added to it which transforms it from mere Earth. The scientific process of framing Earth – dividing it into nominal objects defined by valued qualities – added a voice to it which, as noted, at once comprised, exceeded, and fell short of matter's inherent vibrancy. Calculated to speak directly to questions of the socio-material and political organisation of territory, the 'thing' is capable of travelling to places far from its origin where it becomes a technology of spatialised governance at a distance (Latour 1999, 1987). The 'thing', in other words, is a prosthetic technology of territory; it is an instrument of action which in crucial ways defines the parameters of political-spatial intervention. The scientifically anchored production of territory is linked to rendering the qualities of Earth expressive, casting them as well-defined and geographically rooted 'things'. These 'things' become markers of territorial order which inscribe the spaces of their existence as, for example, spaces of extraction or spaces of war.

Territorial power is derived, in part, from the latent powers of Earth itself. Territorial power is, in other words, related to Grosz's (2008) notion of geopower. Land and terrain are relations of prosperity and security, and both of these modalities of territory can be enhanced by capitalising on the material properties of Earth. This is very much linked to Earth's deep, material properties, some of which can only be registered at the molecular scale such as the internal material relations which make the unstable uranium capable of nuclear fission.

Science is an effective means of opening up these otherwise hidden geographies and bringing them into the political realm.

Effectively harnessing the material forcefulness of Earth is more than simply a question of somehow mastering and manipulating its material qualities to suit political needs and desires. As has been repeatedly noted throughout this thesis, even the solid rock is in motion. As a geo-political technology, territory needs to encompass this material fluidity and account for the complexities of the geophysical. By geometricising the very fluidity of Earth, the trajectories of change of its material qualities, these fluid properties may be incorporated into the territorial ordering of space. Technologies of territory are not necessarily informed by a 'logic of solids' – the projection of territorial logics of stasis onto inherently changing environments. Rather, technologies of territory may also draw on a mathematically rooted logic of rhythms and repetition to obtain an image of stability over time. Territory is an ordering which allows the state to attune to the vibrancy of Earth by explicitly capturing space as a function of time. The material world is inherently unstable, so for territory to appear permanent and reliable, it needs to account for this instability. In other words, stability and texture may be derived from the territorial striation of motion and from creating territorial orderings which are adapted to the material premises of the geophysical.

Attuning to the material forcefulness of Earth not only makes human-environment interaction more efficient, it also makes state intervention seem like a logical and perhaps even inevitable response to the 'natural' order of the Earth. In this manner, science contributes to what Brenner and Elden (2009) called the 'territory effect' – the state's ability, through its territorial form, to mask spatial intervention. This is a key aspect of the powers of territory.

Territory emerges as a momentary and highly temporal ordering as a result of processes through which space and time were momentarily brought into equilibrium. A potentially infinite number of different objects may, in theory, be carved from the chaos of the material world. Yet due to shifting materialities of science, changing political motivations, and unforeseen ruptures of the elemental world, any territorialisation represents a geographically and historically specific ordering.

Arguing that territory is a geo-political technology means acknowledging that territory is more-than-human. As this thesis has evidenced, however, the territorial ordering of Earth relies on both geo- and bio-political mechanisms of control (Elden 2013b; Gordillo 2013, 2014; Squire 2016a). The concept of territory is at once bio- and geo-political in at least three senses. Firstly, the disciplining of human bodies and the Earth that sustains them are not neatly separable (Braun 2000; Elden 2007). Secondly, while the epistemological boundaries of territory exceed the spaces that human beings can physically inhabit, human access to the material properties of space are at times limited by their own physicality. As this thesis has illustrated, the question of where scientists can and cannot go has a direct impact on the knowledge that they produce and, by extension, the formation of territory since territory requires a point of direct physical contact between human and Earth. This need for a haptic engagement with the landscape is part of what makes territory a grounded practice. Thirdly, the very objective of a territorial ordering of space may be to create a habitat where human beings can exist and act. In such cases, controlling the landscape is not separable from controlling the physical body *in* that landscape. As such, the reciprocal effects that bio- and geo-logical bodies have on each other may, in some instances, be a critical metric of territory.

Territory's production is a process of un-earthing in a double sense. It is a practice of scientific revelation – the 'bringing to light' of the material qualities of Earth. Yet, at the same time, the production of territory is a practice of separating these qualities from Earth to become markers of territory – like the uranium which, in the words of the geophysicist, "cut its ties with Greenland" (E. Sørensen 1966). The political resonance of the earthly bodies separated them from 'Earth' as chaotic multiplicity – a resonance which is a politically charged reflection of the material agency of nature caught up in human attempts to harness its latent power in the service of the state. What is produced, then, is a territorial ordering which carefully maps the material vibrancy and qualities of Earth as a function of the interests of the state – a mapping of the political world represented as a function of the material qualities of Earth. This mapping is crucial to how territory functions as a political technology which masks and naturalises territorial-political interventions. Ilímaussaq becomes a natural space of extraction, the ice sheet a geography defined as a site of war. These are political organisations of space – orderings which, *at least for a time*, define the relationship between people and habitat (Gottmann 1973: ix). Territory always exceeds the bounds of the present as it is informed both by its history and by the anticipation of possible futures. Examining its articulation and production through practices of science opens up the dynamics between territory's being and its becoming.

The persistent violence of territory: Greenland today

Much has changed since the 1950s. Greenland was formally decolonised in 1953 and gained Home Rule in 1979 (Beukel et al. 2010). The years following the institution of Home Rule saw growing Greenlandic (and Danish) opposition to nuclear energy. According to Nielsen and Knudsen (2016), opposition to the mining of radioactive minerals at Ilímaussaq was construed by Greenlanders as a way of resisting Danish colonial intrusions. Shortly after, in 1981, the prospecting of Ilímaussaq came to an abrupt halt. In 2009, Home Rule became Self Rule, and the following year, the Self Rule Government, the Naalakkersuisut, officially claimed the sovereign rights to Greenland's underground and its mineral resources. Meanwhile, the material qualities enlivened by Danish scientists at Ilímaussaq did not entirely lose the political resonance of a space of extraction. In recent years, rare earth prospecting at Ilímaussaq has once again emerged as a means of communicating effective territorial sovereignty, but this time the Danish state is the intended 'audience' rather than the 'author' of such performances. Prominent Greenlandic politicians see the uraniferous rock as paving the way towards full Greenlandic economic and political independence from Denmark (e.g. Hammond 2013; Qujaukitsoq 2016) – a topic which continues to spark lively debate within and beyond the borders of the Danish commonwealth (Nuttall 2013, 2015; Vestergaard 2015; Bjørst 2016; Dingman 2014; Milne 2013; Tianen 2016).

From a US perspective, the 1950s represented a high point of Greenland's geostrategic significance (Archer 1988; Fogelson 1989). At the time of writing, the US presence in Greenland has been significantly scaled back, yet the American state has not yet given up its northernmost base at Thule. Despite growing discontent from the Naalakkersuisut, the Greenland Defense Agreement of 1951 is still in effect and will, according to the Agreement, remain so "until it is agreed that the present dangers to the peace and security of the American Continent have passed" (Article X). In the summer of 2017, it emerged that the USA had spent 40 million US Dollars upgrading its radar systems at Thule without directly informing Greenlandic and Danish authorities (Lindqvist 2017; Newell 2017). At the time of writing, tensions do not seem to be lessening and there are no overt indications that the USA plans on giving up its northernmost stronghold or that it will recognise any indebtedness to Greenland's people or its government.

While the American military presence in Greenland is now mostly limited to the Thule Air Base, the landscapes that they left behind remain scarred by their past intrusions. From SIPRE's reports, it appears that it was common practice to set up temporary research camps in the vicinity of a crevasse, which was then used for waste disposal. Similarly, mobile expeditions left behind trails of discarded and ruined items in order to travel as lightly as possible (although note Fig. 33). The extensive US pollution of Greenland illustrates how, in effect, the Danish state failed to retain a monopoly of violence against its sovereign territory. Currently, the matter is subject of a UN investigation, mapping out the human rights violations associated with US toxic waste in Greenland (Tuncak 2017; Turnowsky 2017). Of primary concern is the thousands of tonnes of waste left behind within the body of the ice when the US abandoned their subglacial installation, Camp Century, in 1967. The waste, much of which is radioactive, has retracted deeper into the ice, moving slowly with its fluid masses (Colgan et al. 2016). Financially, Greenland depends on an annual block grant from the Danish state and, although the matter has been raised by members of the Naalakkersuisut, Greenland does not yet have its own national geological survey. Hence, the process of 'reterritorialising' the ice sheet and cleaning up the sites marked by past US intrusion has fallen to the Danish state.

Figure 33: Screen-shot from a silent film documenting the practices of the Transportation Arctic Group in northern Greenland, 1955 (source: USAF 1955).

Greenlandic landscapes have been left physically scarred by the practices through which Danish and US scientists cast them as land and terrain. The seemingly benign objectivity of the geometricisation of Earth and the gentle hand of the scientist does not do away with the inherent violence of territory. As suggested by post-colonial deconstructions of imperial maps, such violence may also be epistemological (Harley 1988, 1989, 1992; Harley and Woodward 1987; see also Neocleous 2003; Crampton 2006). The Danish and US expedition series both represented instances of 'intruding' powers, with more or less legitimacy, forcing themselves upon Greenlandic landscapes. Denmark, as the official colonial power, held formal sovereignty over Greenland, whereas the US legitimised its presence with reference to an imposed declaration, which Danish politicians had found themselves powerless to refuse and on which no Greenlander has had a say (Lidegaard 1997; Borring Olesen 2013). Greenland was, in a sense, doubly colonised and Inuit ontologies of space did not appear to have been taken into account in the territorial ordering of Inuit homelands[89] (Dahl 2000). The remnants of this colonial relation – including the political resonance of the geobody of this small island nation – are still proving difficult to shake.

The territorial politics of Greenland is no less complex now than it was 60 years ago. Growing concerns regarding climate change as well as the anticipation of an Arctic resource bonanza has sparked the interest of nations much further south of Greenland than either Denmark or the USA (Steinberg et al. 2015; Dodds and Nuttall 2016). The prospecting of Ilímaussaq is now in the hands of the Chinese-Australian owned private company, Greenland Minerals and Energy, and critics are often claiming that the Naalakkersuisut cannot simply sacrifice the mountains of Greenland – its national geobody – in the name of independence (see Bjørst 2016; Vestergaard 2015). This price, it is argued, is simply too high. At the same time, the ice sheet has taken on new meaning as a repository of important climate data. The scientific orderings of the ice sheet today thus form part of an attempt at mapping the material agency of Earth and its systems on a much larger scale than what was the case in the 1950s. While such emergent orderings of these spaces are not necessarily territorial in character, the changing dynamics of scientific research both at Ilímaussaq and

[89] On the possible tensions between the territorial logics 'inherited' from the Danish colonial administration and the spatial ideals toward which the Naalakkersuisut appears to strive, see Gerhardt (2011).

on the ice sheet raises a series of pertinent questions about how geo-political technologies of territory will be applied to support a future Greenlandic state.

Future avenues of research

As argued above, territory is a scientifically anchored geo-political technology which the state uses to draw on and over the forcefulness of Earth. Territory is inherently temporal, it is fluid and materially vibrant, and it is brought into being in strict negotiation between human and nonhuman forces. However, as is so often the case, this thesis and the historical research and practices from which it is assembled raise at least as many questions as it can hope to address. This final section briefly entertains some of these questions, and discusses how the findings of this thesis might be advanced in future research.

The premise of this thesis is that Earth and its material qualities are at the heart of the question of territory. The Earth which human beings draw on as a source of political potency, however, comprises many constituent parts beyond those strictly belonging to the realm of the geological. Terrain, for example, comprises a complex multiplicity of Earth systems, and the vast US Cold War research programme in the Arctic spanned an impossibly wide range of experimental practices aimed at mapping weather patterns, telluric currents, and the refraction of light in northern environments to name but a few examples. In other words, as a terrain the ice sheet did not exist in isolation, but was part of a complex system of elemental forces. Terrain existed at the point of intersectionality between these multiple trajectories of movements, flows, and forces and the corporeality of the human and mechanical bodies that terrain was meant to support.

Similarly, land is not limited to the (more or less) solid rock or the subterrain. For example, factors such as a warming climate have led to the formation of a small farming industry on the plains near Ilímaussaq, which serves as a reminder of the multiplicity of ways in which the Earth sustains us. Like military intervention, farming is similarly dependent on an environmental *system* – one which comprises nutrients in the soil, sun and rainfall, and of course the plants themselves. The biosphere – plants, insects, animals – are also constituent ‘elements’ of land, terrain, and territory. This is exemplified by Operation Ice Cap’s military botanist who carefully examined algae on the ice sheet and how both Danish and US scientists, when possible, relied on local fish stocks to supplement their food rations. For the sake of depth and clarity of argument, this thesis has focused on a 'geological way of seeing' (Braun 2000) and territorialising Earth. However, further insight into the mechanisms of territory might be gained by opening up some of these question of intersectionality by engaging the practices directed at drawing on and over the material qualities of the biosphere as well as the geosphere more broadly construed.

Relatedly, much more remains to be said about the bio-geo-politics of territory. As Matthew Farish (2013) has illustrated with reference to US attempts at militarising Arctic landscapes, experiments on human bodies' reactions to cold went well beyond the cultivation of nasal bacteria or the analysis of fieldworkers' blood. Farish (2013) documents a series of deeply problematic US experiments conducted on native Alaskans in attempts to unlock the physiological secrets which supposedly allowed these people to withstand the harsh northern environments. The purpose of gathering this body-knowledge was to further increase US military access to the North – an attempt at extending their territorial reach using biopolitical technologies. While Farish does not engage the question of territory, his findings, alongside the findings of this thesis, suggest that there is scope for much closer scrutiny of the scientific mappings of the intersectionality between human bodies and physical environments (see also Gordillo 2014; Squire 2016a).

Countless examples exist of how scientific data has been manipulated to serve a political end. Such examples illustrate how supposedly 'immutable' mobiles may change as a function of the many journeys they undertake through political, popular, and scientific realms and communities. The territorial ordering of Greenland did not end with the practices of their enactment despite the significance of these practices in opening up the landscape to territorial governance and control. As such, a fuller picture of territory's formation might be gained by tracing the explicit mobilisation of Earth – how the 'thing' travelled, whereto, who encountered and drew on it, and how it changed as a function of the journey. As argued, the political resonance of the material world is a central part in the territorial ordering of Earth. It seems likely that this resonance, which both exceeds and falls short of the geophysical, is malleable to social and political processes beyond its initial enactment and framing. Hence, a study which engages directly with the representational politics of scientific results and how scientific reports were translated into spatial policies might reveal different aspects of the geo-politics of territory.

Budding questions such as these point towards the vast multiplicity of the practices of territory. The list of open questions is much longer than what has been indicated here. As of yet, there is still scope for further conceptual and empirical engagement with territory, land, and terrain as the ever-shifting media which underpin human life.

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A light layer of dust covers the cabinets at the Geological Museum in Copenhagen. Many of the colours appear less vibrant than they perhaps used to, and the museum's permanent Greenland exhibit bears the distinct imprints of time past. Much has changed since the rock behind the glass was extracted and brought to the museum. Denmark and Greenland's ongoing renegotiations of the political (if no longer the national) identity of the rocks on display at the Geological Museum in Copenhagen coincide with an ambitious project to expand, modernise, and collectivise the Danish natural history exhibits. What this redrafting of the publicly displayed narrative of the national geobody of the Kingdom of Denmark will look like remains to be seen.

Territory has history, it is malleable and changing, and it is in part a practice of grounding. Like the Earth, territory is formed through a mixture of slow processes of sedimentation and eruptive events. It is layered, but also subject to metamorphic distortions as a function of the forces of time. Entire sequences of territorial strata may partially or even fully erode, erased from political consciousness. While the territorial ordering of political space is not determined by the physical geo, its power and efficiency is strengthened by enlisting Earth as an ally, accounting for its critical metrics, and attuning to and drawing on its material vibrancy. Territory, in other words, is a process as well as a compromise. It is always, in part, an empirical question and at root a geo-political one.

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