Arctic mineral futures: tracing geoscience knowledge from field to community in the Northwest Territories, Canada

Matilda Becker

Keble College

University of Oxford

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Abstract

This thesis explores the 'becoming' of mineral resources in the Northwest Territories (NWT), Canada, and the role that geoscience knowledge and bodily-material relations play in that process. Mineral resources are assembled through a diversity of practices and knowledges which enable their identification, bounding and circulation within global economies. Existing literatures have explored the circulation, valuation and demands for commodities largely from a cultural perspective. In response, this thesis presents another approach which focusses on the relations between geological materials and the bodies and emotions of scientists and citizens. This is done by drawing on literatures from cultural and resource geographies and science and technology studies.

The 'becoming' of resources is examined at three sites. **First**, this thesis follows the production of geological bedrock maps (which are the first step in finding minerals) by applying ethnographic methods of shadowing geologists working both in the office and field in the NWT. There, the movement of geologists through geological spaces and their enchantment with geological materials are shown as being crucial to the production of geoscience knowledge. This contributes to our understanding of the significance of bodily-material relations in the production of geoscience knowledge, which has been unrecognised in existing resource geography literatures. **Second**, this thesis digs into how a mineral potential map (MPM) was created for part of the NWT with the intention of supporting an all-season road to the Arctic coast in Nunavut. There, using interviews with economic geologists and comparisons with industry best-practice guidelines, a critique about how well the MPM allows us to understand what minerals lie underground is delivered. As a result, existing literature on volume and resource accounting is developed with nuanced understanding of how geological materiality challenges resource accounting methods, and the mechanisms geoscientists use to counter this. **Third**, this thesis explores a site where geoscience materials are used by the Government of the Northwest Territories (GNWT) within a public engagement context to improve a community's receptiveness to mineral resource development. There, the thesis shows how the GNWT applies a public deficit model and utilises geoscience materials to try to 'educate' community members and influence their emotions around the extractive industry. The GNWT is shown as siting the problem of resource development mistrust not as an issue of the government's communication and engagement technique, but rather as one of public ignorance and mistrust in science. As a result, existing literature on public engagement, materials and emotions are developed.

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AANDC	Aboriginal Affairs and Northern Development Canada
BCGS	British Columbia Geological Survey
CBC	Canadian Broadcasting Centre
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
EIA	Environmental Impact Assessment
FIFO	Fly in Fly out
GNWT	Government of the Northwest Territories
GNWT-ENR	Government of the Northwest Territories – Environment and Natural Resources
GNWT-ITI	Government of the Northwest Territories – Industry Tourism and Investment
GSC	Geological Survey Canada
HBC	Hudson Bay Company
IBA	Impact Benefit Agreement
MERA	Mineral and Energy Resource Assessment
MPM	Mineral Potential Map
MVRB	Mackenzie Valley Review Board
MVRMA	Mackenzie Valley Resource Management Act
NRCan	Natural Resources Canada
NTGS	Northwest Territories Geological Survey
NWT	Northwest Territories
PDAC	Prospector and Developers Association Canada
PWNHC	Prince of Wales Northern Heritage Centre
REDI	Resource and Energy Development Initiative
SDG	Sustainable Development Goals
SEA	Socio-economic Agreement
SGPC	Slave Geological Province Corridor
TRC	Truth and Reconciliation Commission
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
YKDFN	Yellowknives Dene First Nation

1. Introduction

It is shortly after 1am yet my jetlag tells me I should be rising for breakfast. I make an effort to finish my field notes from today's work: "lots of people with big money ambitions", I write. This note is not especially insightful to me now, but at the time reflected the overwhelming feeling of excess and represented the industrial behemoth I found myself encountering. I had come to Canada on this occasion to prepare a path towards fieldwork later in the year. It was early March 2018 and around 25,000 people were congregating in Toronto for geological worship at the Prospector and Developers Association of Canada conference (PDAC). I was there to learn more about how the mining industry operates and make connections with operators in the Northwest Territories of Canada. At the event, attendees discuss what they've found, where they've found it, how they did so, how there might be more to find, how YOU - the investor - will reap a reward *and the local people will benefit too*, *of course*, and how the 21st century mining industry works within modern philosophies of sustainability, corporate social responsibility and environmental protection, *even in Guatemala and Peru!*

As I attended corporate presentations, I tried to get beneath the superficial posturing that occurred between speakers on panels and bolstered mining executives' investment pitches. What, exactly, holds this system together apart from money and words? "If we look at the map…" became the password for "we have established an investment reality" that circulated at nearly all presentations about mining projects and different jurisdictions' mining opportunities. My hunt for maps, these enabling creatures, began as I made my way along the many kilometres of booths spread throughout the conference centre to understand better what mapping in the geosciences industry comprised. I found small geological surveys from

Canada with traditional paper maps hung up around their booths. Then, I would turn a corner to see flashy images and models from high-end tech companies who had designed new GIS visualisation tools for mining companies to map their deposits in 3D. One company invited me to try their virtual reality headset to experience an underground mine. The multitude of technological approaches and scales of mapping geology unfolded before me, and I realised the diversity of ways to know and represent the subterranean was as great as applies to the surface world. The subterranean revealed itself to me as a fully-fledged, industrialised space with its own knowledge economy and affiliated assemblages of infrastructures, technologies, languages, pedagogies and epistemologies. This was a fruitful site indeed.

1.1 Putting maps back on the table

This thesis explores the work that is done using geological maps to sustain and create mineral resource economies in the Northwest Territories (NWT), Canada. As such, this thesis asks what geological map work comprises, how the process of mapping and the institutional practices around it contribute to defining mineral resource futures, and who gets included and left behind in the process.

I approach the topic of mapping by looking at the practical things people do to reduce the diverse, complex geological world into one that is simplified within circulatable maps. By understanding *how* people map, this thesis intends to shed new light on how territory is made, including by exploring the link between Arctic infrastructure development and estimations of mineral resource potential using mapping projects. Related to these themes, this thesis will consider what power dynamics emerge as a result of using geoscience as a tool for territorial expansion via mining, and for persuading publics about the possible rewards of supporting mining in the NWT. To produce new understandings and perspectives of how the global resource economy is linked to the individual labours of geologists and how these in turn stand to affect the day-to-day lives of those whose lands mineral resources are found on or near, I deploy the following research questions:

RQ 1: How do geoscientists produce cartographic representations of geological space?

RQ 2: How do the methods of 'knowing' geology affect how it can be enrolled into future-making?

RQ3: What outcomes do these enrolments have on power dynamics in a resource landscape?

The remainder of this introduction sets the scene for this thesis, justifies its intent, and outlines the key literatures and methods used to conduct the research. First, I describe and explore the role mapping has played in expanding European influence into North American Arctic territories. Second, I discuss the main themes and directions of subterranean literatures to date, outlining where new contributions can be made. Next, I outline the key literatures used to generate a guiding framework for this thesis and identify the primary gaps it seeks to fill. Then, I introduce Yellowknife as my field site and give a brief background to the methodologies used to conduct the research upon which this thesis is built. Lastly, I provide the reader with a structure of how this research has been assembled into a thesis.

1.1.1 Imagining the Unimaginable/Making the Invisible Visible

European cartographic representations of Arctic lands, seas and human and other-than-human inhabitants have been generated since at least the 1500s. Gerardus Mercator's 1595 map, the *Septentrionalium Terrarum* or 'Northern World', is famous for its depiction of four landmasses with four rivers flowing into a whirlpool at the North Pole – itself a magnetic rock. A short time later in 1599, the Dutch navigator Willem Barentsz replaced Mercator's fictional northern landmass with a 'blank' Arctic Ocean, whilst mythical sea creatures continued to hound traders' ships in the open ocean. North America's coast was not yet represented in these cartographies, and where the shape of coasts was unknown, they were drawn to tail off gently.

Later in 1701, at the start of the century when European desire to discover the Northwest Passage as a trade route to China swelled again, Heinrich Scherer had mapped much more of Canada's Arctic coast. This was due in part to the increased presence of the Hudson Bay Company operating in north-eastern Canada, producing maps of coasts and waterways as it traded with local people (Simpson, 2019). Scherer's map alongside others produced on the cusp of the Enlightenment Era still blended known and imagined contours of landmasses and, for example, pictured the fictitious island of Frisland which was still variously drawn to exist somewhere between Iceland and Greenland.

These centuries-old maps prompt consideration of what the process of mapping does, especially for European or Western imaginations of space and opportunity. These early maps clearly combine truth with fiction; however, it is only with hindsight we can distinguish between these. This mixture of the imagined and reality demonstrates the trick that mapping can perform that enables it to sustain itself. By depicting enticing places and inhabitants (like bear-hunting people drawn in maps' margins, or spiked sea creatures swimming the seas), people were encouraged to explore and make adjustments to what was known about the landmasses in the north with each iteration of their journey there. As such, these maps acted as invitations for tradesmen and explorers to people places that were fresh to European encounter, and through their iterative renditions of those spaces gradually enrol them into expansionist visions of control and extraction.

Many mysteries of the shapes and extents of Earth's landmasses were clearly erased with the advent of satellite imagery, yet tricks and enticement with semi-realities still exist in cartographies today. Although there are no mythical sea creatures drawn now to adorn maps, the shapes, forms and types of land are still very open to imaginative filling-in. This is especially the case with subterranean space, where the challenge of knowing and depicting what is invisible from the surface creates a need for techniques that can smooth out gaps in knowledge and produce an image that appears 'whole', or at least informed by geological reality. In part, we draw a space that we want realised.

This thesis frames the subterranean as a space that is still in the making and whose constitution is not yet settled. It views the activities and products of geological mapping as generative processes that enable us to imagine the subterranean, expand down into it and draw it up into our surface worlds. As I will show in this thesis, geological maps of the Arctic today, as nearly 500 years ago, contain reflections of societal meanings and aspirations of what could or should become of a place, and resultingly, become a mechanism to invent and produce (economic) spaces.

The production and realisation of imagined spaces is crucial to the curation of socio-political and socio-environmental relations with place. As political ecologists have noted, mapping has worked to rationalise colonial interventions into colonised lands and supported the transformation of lands' existing ecosystems or communities into supporting more European, 'rationalised' forms of spatial production (c.f. Peluso, 1995; Tsing, 2005). These actions enabled forestry, mining, military or agricultural use to become established and allowed capitalist modes of accumulation by dispossession to occur (Harvey, 2003). While volumes and the subterranean emerge in contemporary geographic literature as relevant to territorial expansion, the extension of nation-states into new geological frontiers using geological mapping techniques is sometimes discussed as if it were a practice of the past, restricted to early-stage (colonial) politics and histories of territorialisation (Braun, 2000; Scott, 2008; Himley, 2019; Marston, 2019). However, geological mapping, and indeed mapping of frontiers, is not something that's finished. Geographers have certainly not exhausted the critical leverage that new perspectives in territorial politics and materiality offer to understand the meanings and implications of different cartographies.

Geological mapping is not finished because many places that were inaccessible 30 or 50 years ago have been brought closer to global networks of geological knowledge and practice via a combination of technological advances, changes in land tenure regimes, and climate change opening up previously ice-covered spaces. Examples of this include deep sea geologies (Childs, 2020), Antarctic landmasses (Yusoff, 2005) and parts of the Canadian Arctic, as discussed in this thesis. Expansion of human knowledge into new geological frontiers is therefore an ongoing process: geological territorialisation and enrolment into expansionist imaginations is not over, nor are the practices that enable this to happen.

Since geological mapping in 'remote' areas of the Earth (such as parts of the Canadian Arctic or the sea floor) draws the natural environment into closer contact with human interference, areas that previously avoided intense industrial activity now stand to be impacted by it. As such, there is increased pressure to evaluate not only what 'work' geological knowledge is doing to rationalise expansion into new (subterranean) territories, but also a need to understand what trade-offs are made during the great pinching together of surface and subsurface space. After all, geological knowledge production and the desire-driven philosophy of resource extraction occurs against a backdrop of other land use values and philosophies (Simpson, 2019). Political ecology is well equipped to untangle what happens when these things meet: where communities, environment and resources come into contact. However, the story does not end, nor necessarily begin, there. There is, for example, a need to understand who is making the knowledge we have about geology and resources, how this happens and to what effect. How is the practice of geological knowledge production supporting contemporary regimes and dreamscapes of state-making, and who benefits and gets left behind in the process?

As geographers, we need to continue looking at the processes that enable expansion and control over geological spaces, because there are places where rights and access to land are unsettled or where negotiations of Indigenous land claims are ongoing. In these instances, knowledge of geological resources (as established through mapping) is important in helping define the boundaries and land uses of disputed territories. This is particularly the case in northern Canada, where aspirations for Indigenous land-based self-determination meet with the desire to settle land claims in areas where Treaties made in the 1800s and 1900s rest on dubious legal grounds.

Since the 1980s in the NWT of Canada, Indigenous governments have been making progress in asserting their rights to access and govern their traditional territories by making land claim agreements with the Federal and Territorial governments. Geology comes into play during negotiations for these agreements because minerals known/thought to exist beneath the surface affect the value of the land and what industrial land use options different parties want to keep open. One of the areas of the NWT where land claims have been ongoing the longest is where the Akaitcho First Nations assert their traditional territories. It is also part of the mineral-rich Slave Geological Province (SGP), a geological area focussed on in this thesis, which receives a lot of attention for geological map work and which the Government of the Northwest Territories (GNWT) is keen to keep open to drive its economic development via mining (Government of the Northwest Territories, 2019b).

Although settled land claim agreements create certainty for mining investment by establishing a clear 'landlord' and therefore stability around long-term land use and restrictions, creating settlement agreements is not without risk since Indigenous governments can decide land use plans and therefore whether they wish to open up or protect their traditional lands from industry. Primarily, however, increased knowledge (as well as knowledge gaps) opens up subterranean territorial politics and places pressure on the Federal government to maximize access to high-value geologies for mining companies to exploit. As such, geological mapping in the NWT is crucial in helping both Indigenous, Territorial and Federal governments in negotiating and deciding areas and uses of land, as well as the assignment of surface and subsurface title between Indigenous and Federal government. The Inuvialuit Settlement Region in northern NWT is an example of how a multi-tenure system has been negotiated, offering some surface and subsurface rights to the Inuit Regional Corporation and in other cases splitting the tenure between Federal and Indigenous governments along surface/subsurface lines[1].

A second reason why geological mapping and its practices of production remain important is because of increased global demand for new types of raw materials for the low-carbon energy transition and continued digital revolution (e.g., rare earth metals which are used in magnets, catalysts, batteries and electronics). These demands, combined with improved

[1] See https://irc.inuvialuit.com/sites/default/files/Inuvialuit_Settlement_Region_Map_0.pdf for a high resolution map of land tenure in the ISR.

extraction and processing technologies, create opportunity and incentive to mine from marginal or remote deposits and geologies (Bridge, 2009). Added to this, geopolitical concerns stemming from Chinese threats of restrictions to, for example, rare-earth exports add extra motivation to facilitate and generate domestic mining that can replace loss of imports of such minerals and reduce dependence on a volatile trade partner (Sun and Sevastopulo, 2021). The NWT hosts a diversity of minerals, and its first rare-earth mine is making strides towards production (Avalon Advanced Minerals Inc., 2021).

Thirdly, and related to the above, junior mining companies are major consumers and producers of geological information relating to an area's mineral prospectivity[2]. Understanding the role of government mapping programmes in incentivising and supporting these companies' mining endeavours is critical in understanding the connection between government-generated science and capitalist extractive economies. This is important from both environmental (c.f. Hoogeveen, 2006; Sandlos and Keeling, 2016a, 2016b; Parlee, Sandlos and Natcher, 2018) and social justice perspectives.

From a social perspective, the bulk control and profit of Canada's mineral economy sits with settler-Canadians and foreign investors: to my best knowledge, there is only one Indigenous-owned junior mining company in Canada (Renders, 2015). This company, DEMCo, is based in the NWT and is Dene-owned and at the time of writing has had limited success in developing its mineral property. Howitt (2012) expresses the importance of Indigenous involvement in upstream mining activities, including ownership of companies and contractors involved in the extractive process. He argues that without meaningful economic

[2] 'Mineral prospectivity' is used as a term that describes the likelihood of minerals being found in an area.

participation in the production of resources, Indigenous communities stand to continue to depend on Impact Benefit Agreements and government transfers rather than be active participants in the generation of mineral wealth. Darrell Beaulieu, CEO of DEMCo, summarised this by saying:

> If there's a project and a property of merit that we could get and we could attract major investors and there's a demand for it, and there's an opportunity to generate your own source revenue rather than begging from somebody else; if it's possible to be masters of your own land, what would you pick? For many decades we wanted to be full participants in the development of our territories. This is the one way you can do that. Otherwise, you sit back and wait for the Australian or the European or the U.S. investors to come in. And then the local people say, "what are they doing, taking our resources and leaving us with environmental disasters?" (Beaulieu, in conversation with Renders, 2015).

Contra this, Rose (1999) argues that the creation of narratives that base Indigenous self-reliance and self-determination on economic independence from government transfers is a form of 'deep colonising'. For Rose, deep colonising is the subtle ways that government institutions ensure that "the practices of colonisation are very much with us", for example by creating primacy for capitalist extractivist lifeways and pigeonholing communities into a dependence on such economic practices (ibid., p. 183). Nevertheless, there is, I argue, a link between who is producing information that enables extraction to occur, and who stands to benefit from it. Where non-traditional land users hold valuable knowledge about geological assets, a power dynamic emerges wherein opportunity to benefit from resources and mining is dislocated from the people who actually have generations-long relations with that place.

Motivations therefore abound to control and maintain openness of Indigenous traditional territories for exploitation, as has happened in the NWT around the city of Yellowknife. In the Treaty 8 agreement of 1923 between the Dene and Cree of southern NWT and northern Alberta and the Federal government, signatories agreed to set aside land around Yellowknife solely for hunting and trapping. However, as knowledge of the mineral wealth in this protected area grew as a result of prospecting and mapping, restrictions on mining in the area were dismantled under pressure from prospectors and geologists (Morritt-Jacobs, 2021). Yellowknife subsequently boomed with the production of gold from at least twelve mines in the region between the 1930s and 2000. Evaluations of the Giant Mine Remediation Project outline in detail how local Dene people were explicitly harmed and continue to experience harm as a result of historic mining on their traditional territories around Yellowknife (Mackenzie Valley Review Board, 2013; more on this in Chapter 4).

1.1.2 Subterranean discourses so far

Significant volumes of literature come together about the resource economy, territory and colonial expansion, stemming from traditions of political ecology, political geography and resource geography. Together, this work ranges from addressing resource extraction as a form of nationalism (e.g. Bolivia), to interrogating territorial dispossession of Indigenous and local peoples within the nexus of capitalist (and colonial) systems of land governance (e.g., Emel, Huber and Makene, 2011; Bebbington *et al.*, 2013; Rincón and Fernandes, 2018; Vela-Almeida, 2018; Pérez and Melo Zurita, 2020). However, this work has also largely retained an above-surface perspective that places primacy on understanding the socio-cultures and political regimes which enable, are enabled by, or are shut down by resource extraction activities.

Yet, as political geography and political ecology have evolved, the subsurface has emerged as a site that warrants greater attention within the discipline. The subterranean has become recognised as a site of territorialisation (Bridge, 2013; Elden, 2013b; Dodds, 2019), opening the spaces where we consider territorialising practices to take place and shape. Subterranean spaces are important because they are the 'other half' of European land tenure regimes and are therefore as much a part of the assemblage of what makes land a resource as the stuff that happens on the surface (Bridge, 2014; Li, 2014). Indeed, as Macfarlane (2019) describes using global examples of human-underground interactions, just because the subterranean is not widely peopled does not reduce its significance to our cultural and political lives.

With this borne in mind, the offshoot of political geology has developed since the early 2010s, and alongside it an intention to account for geological materiality and its vibrancy as affecting forms of geological control and enrolment into society. Unique and fresh perspectives of how geological formations, activities and knowledge influence regimes of power have emerged. For example, Donovan (2021) discusses how volcanic activity rationalises British control of an Overseas Territory; Clark (2017) adopts a Deleuzian approach to understand how geological strata enable particular politics to emerge and be resolved. Slesinger (2020) demonstrates how geological materiality thwarted Israeli military ambitions for reconnaissance over Palestinian tunnellers; while Macfarlane (2019) speaks to the vibrancy of emotion and affect that accompanies subterranean encounters, drawing a bridge between political and cultural geographies.

The opportunities of subterranean politics are vast, and, inspired by this transition to political geology, I suggest that a materially driven analysis of how geological matter impacts our capacity to know it for resource extraction is both missing and warranted. How can we unpick what is 'true' and what is 'fiction' in the maps of promised frontiers like the Canadian Arctic today? While critical cartographies wear well-worn shoes that have greatly advanced geographers' capacity to understand the subjectivity and politics of space making (e.g., Wood, 1992; Peluso, 1995; Wainwright and Bryan, 2009; Kitchin, Gleeson and Dodge, 2013), those shoes have not carried us down the shafts that lead into the subterranean and allow us to resolve this question. An attention to the human-material practices of creating geological maps offers such an opportunity because these practices are the lynchpins holding the global mining industry together and result in the production of highly political objects that render the subterranean imaginable, boundable, circulatable and investible (Richardson and Weszkalnys, 2014). Geology's vibrant materiality motivates human intervention into the subterranean, even if we do not fully understand it, thus issuing an invitation for critical geographers to closer inspect the geological 'stuff that makes us do things'. As a result, a primary question that flows from these dynamics is how geological materials themselves allow or prevent geologists from knowing the significance of geological landscapes as sources of mineral resources, and in turn how they are able to share this information with policymakers, the public and investors via maps.

1.2 Between a rock and a hard place – filling the literature gap between materiality, cartography and resources

In this section, I identify several gaps that exist in the academic literature that can tell us more about how geological mapping practices sustain the expansion of global resource economies. The literatures presented provide an overarching framework to this thesis, as well as informing the choice of research questions which in turn structure the three empirical chapters of this thesis.

First, relating to how we understand the making of geological maps on the basis of field-based activities conducted by geoscientists, I take inspiration from Powell (2017, p. 6), who writes that "the practices of environmental and geophysical sciences have not enjoyed the same levels of research attention from social scientists as other arenas of modern science". Added to this, since discussions of geological mapping in geography seem to take a historical perspective of analysis (e.g., Braun, 2000; Winchester, 2001; Frehner, 2011a; Himley, 2019) the contemporary examination this thesis offers will enable a closer discussion of what such practices comprise today. Importantly, the contemporary analysis provided by this thesis enables us to understand what demographic is producing geoscience knowledge, identify areas of knowledge contestation, and more generally assess the balance of state/private knowledge production of the subterranean.

Second, added to a need to grasp geoscience practices used in mapping, there is also a lack of understanding about the human-material relations that enable representations of geological landscapes to be made. While resource geographers have discussed the significance of materiality in enabling resources to become circulatable, the perspective that has dominated has so far given primacy to the role of materiality in affecting market value, waste production and speculative accounting (c.f. Bakker and Bridge, 2006; Bridge, 2009; Mitchell, 2009; Weszkalnys, 2015; Hird, 2017; Kama and Kuchler, 2019). However, these accounts have not examined what happens when we come into contact with geological materials and want to enrol them in our economies. What affective reactions, practices, or affordances emerge when body and material meet? These encounters are crucial in underpinning the materialist accounts that resource geographers have so far pursued, and as I will demonstrate in this thesis, have implications on the types of representation and subsequent imaginations that can flow from geology.

Additionally, within this kind of geographic literature, an attention to the bodily labours that help produce geological accounts has been missed. Powell (2017, p. 22) notes the significance of capturing "the importance of actions by bodies-in-space" as a mode of enquiry around the production of field science. Yet, so far, an overwhelming focus on cultural rather than bodily practices has hidden some of the ways that geoscience comes to be made and circulated (c.f. Weszkalnys, 2015; Kama and Kuchler, 2019). A geographical intervention that places primacy on the body as scientific instrument has been highly fruitful in other contexts for understanding what bodies do that enable science to be made, and therefore merits expansion into the geological (Fox-Keller, 2000; Lorimer, 2008; McCormack, 2012). Thus, a gap exists in understanding how the physical and mental labour of geologists working with geological materials produces cartographies used to underpin geological extraction.

Thirdly, relating to how geological maps are used to prop up resource futures, Kama and Kuchler (2019) and Weszkalnys (2015) reflect on how political ambitions create an imperative for speculative geological objects to be produced and circulated amongst policymakers and government to enable certain (resource) futures to be pursued. These authors have paved the way for empirical critique (after Latour, 2004) of geoscience objects to understand what they are actually composed of. In doing so, Kama and Kuchler and Weszkalnys invite an interrogation into the practice of composing representation from realities that are often very poorly known or understood. By establishing the basics of what geological mapping comprises, I wish to take their work further and untangle the epistemologies and ontologies that enable speculative representations to be created and ask what are they made of, if not geology? Here, I will hold recent academic discussions of geography and volume in tension with materialist resource geographies to try and produce explanations of this, centring materiality within stories of scientific production. Added to this, although political geography and geology have forged a path to understand the subterranean as a territorial platform, what is missing in these accounts is how materiality of geology *disrupts* this process. Thus, I will generate a discussion and understanding of what this disruption entails, what it is caused by, and how geologists and politicians have sought to circumvent its interruptions to their territorial development plans.

Lastly, what is also curiously missing in resource geographies and political ecologies is an understanding of how geoscience and geological ambition get mobilised within public engagement spaces in which geologically supported/driven territorial expansion occurs. Therefore, I will examine how geoscience objects including geological maps become communication tools and help underpin government imperatives for territorial expansion and control. As a result, I will make a connection with Science and Technology Studies' (STS) discussions of public understanding and engagement in science since I want to recognise that, despite my materialist intentions in this thesis, resource expansion does not occur within neutral social geographies. How people feel about resources matters. To understand how geoscience objects like maps function as enablers or controllers of resource economy emotions, I will explore a community engagement space which the GNWT uses to address citizens and generate support for its philosophy of land use and economic production.

As such, in order to fill these gaps of practice, form and politics, I draw on diverse literatures from political, resource and cultural geographies as well as STS. Together, these literatures provide me with the arsenal required to trace and examine the bodily labour that creates geological maps (Latour, 1999; Lorimer, 2008); the political-material insights to understand the significance of geoscience outputs on imagining and making resources (Bridge, 2009; Richardson and Weszkalnys, 2014); and in turn explore how these outputs might circulate within government-public domains of science communication (Wynne, 1993, 2006; Bickerstaff *et al.*, 2010; Chilvers, 2012).

Together, these literatures and the gaps I intend to fill provide me with a unique perspective through which to understand industrial life in Arctic frontiers and the research questions outlined on page 10.

I argue that by examining these research questions through a cultural geography/STS/resource geography lens, my thesis will usefully enable us to understand the ways in which economic futures in the NWT are being imagined and brought about through day-to-day practices and politics. As will unfold through the course of this thesis, my approach to these research questions will provide us with tools to dissect and critically evaluate infrastructure and economic proposals for Arctic development. In particular, this will enable us to understand whether narratives of northern development via a mineral economy might hold true in their promises to benefit northerners' ways of life and realise increasingly prevalent societal values around e.g., Indigenous reconciliation or Arctic ecological conservation.

In the remainder of this introduction, I will introduce the NWT as my field site and outline the methods I used to generate data for this thesis.

1.3 Rationale for choosing the field site

On a personal level, my rationale for choosing the Northwest Territories as a field site for understanding geological mapping stems from three things. First, I wanted to conduct research in a country where English was the primary spoken language, where there was a longstanding history of mining, where it was safe enough for me to feel comfortable spending a year there, and where there was the possibility of me resettling permanently. Australia and Canada fitted this description but wanting to go somewhere more easily/affordably accessible, I chose Canada. Second, I wanted a field site where the politics, environment and economy were dynamically evolving. Arctic regions and the rapid changes they are experiencing provided such an opportunity. That left the decision of which Arctic Territory in Canada to place myself. Since Nunavut does not have a locally based geological survey, that was ruled out, and the NWT won over Yukon for hosting DEMCo., the company introduced earlier. Therefore, I decided to focus on the NWT and go to Yellowknife, the Territorial capital, to conduct my research.

1.4 A brief introduction to the Northwest Territories

Climate change has created new access points for expansion into fresh geologies by enabling movement through spaces that are becoming newly traversable, like the Arctic's seas and territories, and has concomitantly generated new means and motivations for territorial control and occupation by Arctic nations (Kikkas and Romashkina, 2018). The Canadian Arctic is one such area – changes in permafrost, shortening in 'cold snap' (colder than -30ºC) events, and more ice-free months in the ocean enable and shut-off different ways of getting to and through the area. On mainland NWT, changes in the permafrost regime threaten infrastructure by causing slumping and collapse in roads and housing, while shortening of the ice-road season due to shorter spells of cold snaps means that how and when northerners are able to access their communities, hunting grounds and industrial sites like mines is changing (Bennett, 2018; Williams, 2021b). In response, the GNWT has begun ambitious plans to ensure access to communities is maintained (e.g., by building the Inuvik to Tuktoyaktuk all-season road in 2018, replacing the winter ice road that became increasingly unreliable and unsafe) while expanding its infrastructure to new (geological) spaces such as the Slave Geological Province.

The latter ambition is of particular interest to this thesis – the Slave Geological Province Corridor (SGPC) project intends to improve year-round access to the Slave Geological Province, an area of land about 250,000km^2 that spreads down the eastern third of the NWT and crosses into neighbouring Nunavut. This is where all of the NWT's existing mines are found. If constructed, it would eventually reach Gray's Bay in Nunavut, creating a continuous road network from the Arctic Ocean to southern Canada and providing a port from which extractive resources could be shipped out, and supplies for communities shipped in.

To rationalise the SGPC project, the GNWT is seeking to expand its geological knowledge of the province and is using cartographic tools to speculate about what minerals might be found there. Parts of the SGP are in the nascent stages of having geoscience knowledge coverage, and only 15% of the 213,000km^2 SGP has mapping that is of sufficiently high resolution (1:25,000) to enable a good understanding of the geological complexity and mineral possibilities to be established (*field notes, read from maps hanging at the Northwest Territories Geological Survey*). The GNWT's endeavour to expand its geoscience knowledge and accompanying access into remote Arctic territories occurs alongside Federal Government plans for Arctic development that place industrial development and community connectivity and wellbeing in the foreground. Geological knowledge production via mapping is therefore intrinsic to the network of Arctic territorial expansion and is critical in enabling the subsoil to become "the rationalised realm of the state" (Government of Canada, 2016; Marston, 2019, p. 1).

Alongside being a site of geological development, the NWT is a highly political space, particularly with regards to land, resources and communities. Since settlers began colonising the Territories in the mid-late 1800s, tensions around the development of extractive resources have existed, particularly in relation to the abandonment of mines and mismanagement of mining waste (c.f. van Wyck, 2010; Sandlos and Keeling, 2012; Beckett, 2020). Accompanying this was the colonial politics of assimilation and attempted cultural and social genocide which, as mandated by the Indian Act 1876, sought via the Residential School System and other apparatuses to eliminate Indigenous communities and their lifeways, in particular their relations to land. Indigenous lifeways are intrinsically linked to land, wherein land is integral to supporting Indigenous peoples' health; food provision via hunting, fishing, trapping; local language, stories and knowledge; and land-based rituals, movements and migrations (Legat, 2012; Lines, Yellowknives Dene First Nation Wellness Division and Jardine, 2019). Together, these associations and relationships with land sustain community integrity and cohesion. Yet Indigenous peoples' relationships with their land have historically been threatened at every turn, via the Indian Act, Treaty agreements, free-entry systems of mining access and more recently climate change. The impacts of these threats need to be seriously considered.

In light of this, the geological mapping taking place in the NWT today is part of the longer-term settler-colonial project of control over territories traditionally belonging to Indigenous people. Desires to expand mining activities by improving infrastructural access and enhancing the geological knowledge economy perpetuate modes of extraction and dispossession that have been embedded in settler-colonial relations with the NWT. Where colonial interventions into traditional lands exist (such as via the SGPC project), land and resource-based politics surfaces. The NWT therefore provides an ideal research site from which to consider the processes and implications of geological mapping, and due to its geopolitical and colonial history is a place of potential contestation and power dynamics between different groups. As such, the NWT is an appropriate site to answer the research questions raised in the previous section of this introduction. It is also a place where the outputs of my research may help address controversies around natural resource extraction and traditional territories by expanding the perspectives from which matters of concern in the Territories are considered.

To understand the processes of geological map and resource making in the NWT, this thesis uses data generated from an ethnographic study carried out over a 12-month period from September 2018 to August 2019. These methods are inspired by the multi-sited fieldwork of Richard Powell's work with the Polar Continental Shelf Project in the Canadian Arctic (Powell, 2017). Here, Powell sought to deploy "social analysis in understanding environmental research" to outline what comprises "quotidian production of scientific activity in the Arctic" (Powell, 2017, pp. 6–7). What is particularly pertinent about Powell's approach for my own is his use of ethnography to explore the assemblage of scientific practices that allows productions of space and spatial understandings to develop. I use ethnographic methods to understand the social life of geoscience, and in doing so allow the focus on bodies and geological materials to emerge. My work is not purely a 'field' ethnography, but rather is sited predominantly within a government institution where 'the field' was a space largely talked about, rather than lived in during my time there.

As a result, the core of the ethnography in this thesis is based on observing and interviewing government geologists as they conducted their work at the Northwest Territories Geological Survey in Yellowknife, where I sought to understand the day-to-day practices and discussions happening there that allowed mapping to take place. Recognising that the resource assemblage is also created through policy and lobbying from different interest groups, I conducted interviews with representatives of the GNWT from three departments – Industry Tourism and Investment (ITI), Environment and Natural Resources (ENR) and Lands; as well as with industry representatives and Indigenous governments. Mini fieldtrips were made to British Columbia and Alberta to learn from mappers in these provinces who had historically conducted work in the NWT. Additionally, I spent three days in Norman Wells, NWT at an GNWT-ITI organised public engagement event to gauge how geoscience knowledge and ambitions were being communicated to the public.

1.5 Layout of this thesis

After this introduction, this thesis begins by establishing a theoretical outline that underpins the methodological and analytical means by which I have conducted this work. In **Chapter 2**, I expand on the literature briefly introduced in the above sections to provide myself with a springboard of conceptual theories about subterranean space, scientific practice and science communication to tackle my research objectives. That chapter therefore sets up the theoretical ethic with which I have approached my research subject and creates rationale for the methodological practices and intents I describe in Chapter 3.

In **Chapter 3**, I present the methodology and methods used to generate data for this thesis. I describe and explain the methods I chose, contextualising their appropriateness for enabling me to answer my research questions. Here, I also discuss themes around research ethics, how to include Indigenous voices, tackling issues of mental health in the field, and the merits of volunteering as method.

Chapter 4 meanwhile presents a socio-political and historical context to the NWT which I feel is important for the reader to know to place the empirical chapters against a backdrop of lived reality in the north. Here, by presenting a historical account of settler-Indigenous relations and policies of governance over the last 100 years, I create a basis from which to understand many of the tensions, difficulties and also imperatives that accompany industrial development in the NWT. It is a chapter that recounts the shadows over the jurisdiction's people and environment. I therefore give detail about the institutions that govern the NWT; historical regimes of dispossession and agreements over rights to land for Indigenous and settler communities; discuss the dependence of the NWT on a mining economy and the opportunities and pitfalls that accompany this; and lastly provide some demographic data about the make-up of the NWT's population.

In **Chapter 5**, the first chapter of three that is born out of my field research, I address Research Question one. In doing so, I describe the practices that geologists put to work to render the geological world knowable and represented as cartographic form. In this chapter, I take the opportunity to explore what it means to use walking as a scientific method, and in particular what bodily-material relations and coproductions flow from such activity. The roles of geological storying, balancing contrasting accounts of geological form, assessments of expertise and finally 'playing' with geological hypotheses and theories are discussed. As a result, this chapter provides the reader with an understanding of bodily practices that places "knowing" geology at the scale and responsibility of individual geoscientists. The details of this chapter and the associated understandings of what it takes to produce geological maps informs the arguments and analyses of Chapter 6.

Chapter 6 therefore picks up the talisman of geological representation and carries it into the political geography domain. Here, bolstered by an understanding of how geological bedrock maps are produced in the NWT, I critique a mineral potential map (MPM) that was produced by the GNWT with the intention of attracting investors to the territory and rationalising the expansion of an all-season road from Yellowknife to the Arctic coast. As a result, I demonstrate that the MPM is a speculative invitation to industry investors that relies upon proxied understandings of geological form to create evaluations of mineral potential. That is to say that the MPM is not a map about minerals, but rather a map that evaluates historical social relations to land. By uncovering this, I engage with political geography and geology literatures about volume and discuss why it is so difficult to produce mapped representations of geology that are actually true to the materials and minerals that might be found there. Therefore, I place materiality as a direct challenge to our volumetric conceptualisations of and engagements with subterranean space.

Chapter 7, the final empirical chapter, follows the movement of geoscience objects (including maps) out of the institutional space where geologists work at the NTGS to the public domain. Here, drawing on observational fieldwork at a public engagement forum in Norman Wells, I explore the work that facilitators do to convey geoscience information to publics and the intentional politics with which they do this work. Here, I frame issues of public support and trust in resource development not as stemming from scientific misunderstandings or ignorance, but rather as outcomes of historical-institutional relations. As such, Chapter 7 recounts a space where present, future and history meet. Drawing on archival accounts of public consultation events for resource development in the NWT since 2010 and interviews with the facilitators of the engagement programme, I highlight the importance of shaping and controlling emotions around resource development. In particular, I harness Indigenous scholars' work on colonial affect to understand this dynamic better and present ideas for how trust might be nurtured between settler-colonial governments and communities.

To finish, **Chapter 8** carries forward the main findings of my research in a concluding discussion. Here, I ground my findings from the empirical chapters within a discussion of what knowledge about geoscience production and resource futures does narratives espousing the inevitability of mining in the NWT. Additionally, I generate a conversation about what it means to be producing knowledge about a frontier space, and how different knowledges are evaluated against one another in a way that considers social justice elements for those involved as knowledge-holders. In this chapter I also outline what potential avenues for future research exist, as well as clarifying the contributions I have made to academic discussions on the topics of geoscience knowledge production, speculative resource accounting and public engagement for mineral development.

The chapters of this thesis should be thought of as building upon one another. My literature review provides the lens through which the research and analysis of the thesis was conducted. Similarly, the empirical chapters are deliberately ordered to give a sequential, spatially ordered (from individual, to institution, to community) understanding that allows us to trace the movement of geoscience objects from their creation to their application in policy and public arenas. Chapter 5 is crucial for providing an understanding of how geoscience knowledge comes about, which informs our knowledge of Chapter 6 so that we can realise the caveats and conditionalities with which geoscience objects often need to be approached. Lastly, Chapter 7 carries the evaluation of geoscience knowledge conducted in Chapter 6 into community contexts. In doing so, it highlights how the politicisation of geoscience happens in spaces where mining is a matter of concern and science is used to try and influence individuals' emotions and relations to the mineral resource industry.

In summary, the remainder of this thesis deploys a diversity theoretical literatures to enable its ambition to understand the processes and implications of producing knowledge about geological space. As the reader will discover, these provide me the unique opportunity to understand:

- The reliance upon the expertise of individuals for the production of geoscience knowledge;
- How cartographic and geoscience objects that appear to represent half-truths about subterranean opportunities are created; and,
- How the carefully constructed roll-out of geoscience knowledge into communities to supports territorial ambitions for sustaining the existing resource economy.

Taken together, these perspectives provide a novel view of the quotidian practices that underpin one of the most vital global industries of our time. It offers new entry points to discover more socially just and equitable ways of producing, imagining and realising economic futures, not only in the NWT but across all spaces where geoscience plays a major role in creating and sustaining land-based relations and markets.

2. Literature Analysis

This thesis is concerned with understanding how geological worlds and futures are produced that institutions and publics are inclined to trust and endorse. In this thesis, geology is considered as an assemblage of practices, materials, knowledges, ontologies and politics (Li, 2014) whose constituent parts enable the 'becoming' of geological resources and their extraction (Richardson and Weszkalnys, 2014). As a result, this literature analysis brings together literatures from geography and science and technology studies (STS). From geography, I use cultural, resource and political geography literatures. From science and technology studies, I draw on literatures concerning the production of science and the public understanding and trust in science.

This chapter is structured along five key themes:

2.1 A short history of Canadian cartographic enquiry and Arctic science

2.2 Resource geographies: making and knowing resources

2.3 The politics and materiality of volume

2.4 The production of science and scientific objects

2.5 Public understanding and trust in science.

2.1 Canadian Cartographic Enquiry and Arctic Sciences

The evolution and spread of (geological) cartography as a key scientific enterprise undergirding the British and French colonial settlement of Canada has received much attention from historians and historical geographers alike. Work by Suzanne Zeller, Andrew Stuhl and Bruce Braun are especially useful for contextualising the motivations and processes of Canadian expansion within view of the socio-economic and geopolitical factors affecting Canadian and western society since the 1850s. Zeller (1987), in her detailed review of the nascent days of the Geological Survey of Canada (GSC), illustrates the significance of geologists such as William Logan in responding to and maximising the strategic scientific opportunities brought about by Canada's growing desire for independence from Britain in the mid-1800s. Zeller reads Logan's transatlantic ambitions to establish and fund the GSC as a direct response to Canada's wish to emulate Britain's successful industrial development pathway, whilst proving the capacity of Canada to govern herself. For Logan, the work of the GSC provided scientific reason for the extension of Canadian territory, and the discovery of iron ore (and early on ambitions to find coal) were believed to provide the material foundation for social and economic development for all (white) settlers.

The GSC was part of a wider scientific project underpinning a utilitarian Victorian value system that "aimed to improve the quality of life through detailed fact gathering" (ibid., p. 5). This fact-gathering included the collection of data on land, its geology and its associated industrial and energy potential. In measuring potential and inventorying land, Zeller explains how the project of statistical gathering "became the gauge by which Canadians assessed what their country and, through it, they themselves could one day become" (ibid., p. 6). Science and geoscience were, therefore, part of ideological frameworks of purpose-setting and sense-making in Canadian society. The inventorying of land in a way that should benefit wider society can still be seen in contemporary legislation in the Northwest Territories. There, in the Mackenzie Valley Resource Management Act (a key document for defining the processes of Environmental Impact Assessments in the Territories), the importance of accounting for the possible benefits/impacts on 'all Canadians' in decision making on land use applications is sprinkled throughout the document (Government of Canada, 1998) and is testament to the sustained belief that resource development are central to the wellbeing of modern Canadian society (cf. MinesCanada (2019) for further contemporary evidence of this).

Yet Zeller's account of the GSC's early years is also important for situating the organisation within geopolitical rationales for resource discovery and development. Themes of sovereignty, nationhood, and economic independence weave through the mappings of Canada that historical geographers have since recounted. For example, Bruce Braun's (2000) seminal work on mapping vertical territory in British Columbia, influenced by Zeller's account of the individuals who brought the GSC into being, focusses on the intersections between science-as-knowing territory, industrial expansion and settlement.

For Braun, the work of the geologists charting the underground expanded the rationality and extent of settlers' control and exploitation of Canada's landmass. One critical element for Braun was how the materials and scientific accounts produced by geologists working in Canada's frontiers generated national and international interest in the new nation and encouraged investment for exploration or exploitation for minerals. Braun's account gives significance to the 'immutable mobiles' (Latour, 1986) on the development of an extractive industry in Canada, which can also be seen today centring empirical evidence as preface to any industry investment (see Majury (2014) for a contemporary review). Braun's attention to the movement of knowledge and things through networks of governance and institutions encourages a focus on how geological space can be 'captured' and translated into scientific materials and circulated to entice investment for further investigation or mineral development.

Together, Braun and Zeller provide detailed accounts of the motivations that drove the settler government to invest in the GSC, and indeed the individuals and their socio-institutional networks that enabled their success. However, Simpson (2019) and Stuhl (2016) add further nuance to approaches by exploring the wider geopolitical context of geological mapping and inventorying. Importantly Stuhl and Simpson make clear that minerals were not settlers' first resource foray into Canadian marine and landed territories, particularly in its northern regions. Simpson, for example, explains how early maps of Canada's rivers charted the supply chains of fur traders across the continent. These knowledge infrastructures (which unlike geology relied upon and included the knowledge of local Indigenous peoples to a much greater extent) created a skeleton of inland geography for later prospectors and geologists to use and learn from. A narrative cartography of inland Canada was drawn within the diaries of fur traders, which later served to incentivise and promote more scientific, geologically motivated explorations.

Similarly, Stuhl recounts how whalers' diaries and reports of lands and Arctic peoples generated fever for further marine exploration and scientific accounting of people and place. Stuhl explains how in the first fifteen years of the 20th century, a flurry of marine expeditions was launched into the Arctic Ocean. According to Stuhl, the motivation for them was to prove the existence of a 'Polar Continent' and 'Blonde Eskimos' [sic], whose presence entered the imaginative narratives of southern Canadian, American and European popular culture. Canada's marine expeditions were generously funded by those with the dual motivations of 1) finding the Polar Continent and indeed claiming it as Canadian in a feat of Western-colonial triumphalism, and 2) finding 'untouched' Blonde Eskimos who for philanthropists, anthropologists, politicians and civilians would slot into Darwinist imaginaries of evolutionary development, and whose documentation would 'complete' the comprehensive surveying of Canadian subjects. Although neither of these were found to exist, the dependence within expeditions upon geologists, anthropologists and meteorologists highlights the importance and legitimacy placed by government and society in science and scientific record for expanding and justifying the geopolitics of the region. What Stuhl and Simpson's accounts therefore describe is how resources (furs and whales) beget resources, and how the physical and institutional infrastructures of colonial presence in Canada were incrementally built upon and over one another as global economies, and indeed political imperatives, changed.

However, missing across all the historical geopolitical accounts by Zeller, Braun, Stuhl and Simpson are the everyday practices and emotional registers that accompany cartographic exercises. Yet literatures within political geography do build upon non-representational geographies (expanded upon in section 2.4) and feminist geographies to provide the scholarly equipment to enrich these understandings of map-making with the everyday politics of emotions and affect. Carter and McCormack (2014) for example consider what the work of images (like maps) is on the day-to-day emotions and subsequent political framings of those who engage with them. Whilst, feminist scholar Jennifer Hyndman (2001, p. 212) evokes the multiplicity of geopolitical experience being felt in "localised, everyday embodied ways" by different bodies, people and communities. These political geography literatures signal that the project of 'nation building' can and should be understood from the perspective of those individuals involved in the daily crafting of scientific accounts about it. It is worth considering that individuals' practices can be affected by the values of the institutional structures within which they operate. This creates links between the value systems joining social and national 'progress' with geological inventorying, and the day-to-day work bringing that inventorying into being. Therefore, the emotions and bodily experiences driving those at the frontier of mapping is a crucial element of a long-term settler-colonial project that requires further study and analysis, as presented in this thesis.

The role of individuals aside, the inventorying of geology and 'nature' in northern Canada must also be understood in the context of international pressures and domestic desires to display sovereignty and control over Arctic landmasses and peoples. While Dittmer and Sharp (2014) warn of the masculinist, institutionally centrist traps of centring geopolitical rationales solely as products of strategic and military imperatives, in northern Canada, science, defence, sovereignty and economy have dominated governmental discourses necessitating presence within the region.[3] Dittmer *et al* (2011) and Dodds (2008) provide detailed summary of the contemporary militarised geopolitical contestations that sizzle in Arctic waters. For Dittmer *et al* in particular, the historical framing of Arctic regions as somehow sensationally unique in comparison to other geographies has mediated contemporary political and analytical beliefs that the Arctic subsequently requires some out-of-the-ordinary geopolitical management and consensus for the maintenance of peace. Meanwhile, Dodds (2008) and others such as Powell (2008, 2017), note how science serves as a particular tool to rationalise the protection and assertion of sovereignty in liminal Arctic areas, in particular within the context of Russian territorial threats. Science, for these authors, therefore comprises a critical contemporary method adopted for peace-keeping in Arctic

[3] The Canadian Arctic and Northern Policy Framework (2019), centres security and defence as a key reason to for maintaining government presence and for investing in infrastructure and development initiatives in the region, especially within contexts of environmental changes as a result of climate heating.

Canada. Stuhl (2016) and Cronin (2007) provide two examples of how science, security and expansionism have historically intermarried to produce Arctic politics in the NWT.

First, Cronin (2007) focusses on the history of air transport and inter-institutional government relations in the expansion of scientific range for the GSC from 1918 onwards. Unable to afford charting their own aircraft, the GSC and corporations interested in the geological character and mineral potential of northern Canada relied upon the Royal Canadian Air Force for assistance. The development of military technology enabled the opening up of the Canadian Shield region, which is characterised by its expansive, challenging terrain comprising thick jack pine and birch forest, muskeg, rocky outcrops and lakes. Aerial mapping therefore enabled geologists to quickly capture images of northern lands and identify major geological features without having to traverse on foot. These photographs and the skeleton geological outlines they provided helped geologists to pinpoint places warranting further exploration, in particular for mineral identification.

Similarly, Stuhl outlines the significance of Arctic militarisation during World War Two not only for creating technological and governmental presence in the region, but for reinforcing the region's centrality in international politics, defence and security. Military presence was supported by detailed cartographies of possible hydrocarbon resources. The hydrocarbon demands of WW2 led to the development of oil supplies in, for example, Norman Wells in the NWT. There, an ambitious, rickety and costly oil pipe – the CANOL trail - connected oil fields in the Mackenzie Valley over the Mackenzie Mountains into the Yukon to fuel aircraft defending against Japanese attacks (Sahtu Reneweable Resources Board, no date). Later, during the height of the Cold War, military and administrative stations (such as that in Inuvik) scattered the Northwest Territories and northern Canada. Military reconnaissance produced geological cartographies of, for example, the sea floor and continental shelf around the Mackenzie delta which hosts abundant gas supplies.

Lastly, it is worth noting also how resource mapping fits into the anticipatory politics of Arctic futures which rationalise continued and expanded scientific and governmental presence in the region. Anticipatory politics - as discussed by Massumi (2007) and Anderson (2010) from affective perspectives – creates emotional infrastructures that articulate and materialise the needs for particular interventions that should 'ward off' possible economic decline. Considered from this perspective, geology has recently been served as an apparently resilient answer to the bio-insecurity suffered by the 'natural' world, portrayed as vulnerable to the manifestations of the Anthropocene on Arctic life (Yusoff, 2009, 2019). While the forces that drive the Anthropocene ought to force a change in direction to our relations and understandings of land as resource/commodity/relation, in the NWT, this narrative has been mobilised amongst policy makers and industry representatives as ever more reason to stick to the 'solid ground' that geological economies apparently promise for the region.

2.2 Resource Geographies: making and knowing resources

This section outlines how geographers have historically and contemporarily related to resources, setting the literatures used in this thesis within longer and broader context of resource geography.

Historically, resource geographies have placed emphasis on how resources are used and managed through space and time (Bridge, 2001) and how they relate to economy, people and environment. Thomas Malthus (2008 [1798]) helped inspire 19th and 20th century discussions around resource availability and demand, which became an early concern for resource geographers. One area where this was particularly visible was around water management and the associated need to create inventories for supplies and sinks in, e.g. the USA and Spain (Swyngedouw 1999, 2014). Thus, early on, resource geographers' main concern was the practical task of working out how much of a resource existed where, and the opportunities for its consumption.

Later on, attention shifted to the institutions that managed resources, and within this body of work, scholarly debates began to emerge as to whether bad resource management resulted from market failure, and whether diverse management options were being fully considered by decision makers and relevant publics. Again, the field of water management provides formative literatures on resource management decision making, with Gilbert White's (1964) famous paper on flood management and behavioural/societal adaptation provoked thinking that more-than-engineering options were available to flood managers. In parallel, Garrett Hardin (1968) wrote his seminal article 'The Tragedy of the Commons' which became a bastion for those who believed that individuals could not be trusted as maximum-utility decision makers to use resources in sustainable ways without causing mass depletion. As later critique levelled e.g. by Elinor Ostrom (2000) and Sarah Cox (1985) showed, commons resources do not inherently attract mismanagement, but that formal and informal institutions exist between groups of people which prevents their overuse. Unfortunately, the narrative that Hardin's paper develops is one that has too often translated into (racist) assumptions that individuals or groups of people extracting from shared resources cannot be trusted to govern themselves. Such approaches to resource conservation and management are evident in the NWT and Nunavut in Canada, where Hardin's work served almost as science itself in supporting a view that Indigenous people's hunting practices should be monitored and curtailed, of course with significant impacts on their lifeways and life chances and spilling into racist assimilation agendas (c.f., Sandlos, 2001).

Later strands of resource geography developed from the 1980s onwards presented critical thinking around the political economy of resource use and the environment. Here, Bridge (2001) records that political ecology, radical hazards research and environmental justice work emerged and flourished. The intention of this strand of geography was to directly respond to those (within government institutions, mainly) who were inventorying and planning for resource usage within formal governance and management structures. There, the concern of resource geographers expanded to explore the political implications of these resource frameworks on inequality, environmental quality, degradation, and increasingly from the 1980s, climate change and biodiversity loss (Wescoat, 1991). Within these bodies of work, Piers Blaikie's and Harold Brookfield's (1987) seminal work helped spur the creation of political ecology. Their book 'Land Degradation and Society' considered the failures of land management under colonialism and socialism on environmental degradation and social inequality and poverty. Their work therefore began an academic tradition levelling critique at the socio-economic networks within which resources are exploited.

In tandem, at the turn of the 1990s, critical geography began to deconstruct the discursive formations that held together the idea of 'resources' by looking at what 'nature' meant to humans. Inspired in part by the work of Margaret Fitzsimmons (1989) who argued that the matter of 'nature' had been neglected by human geographers and relegated to the domain of physical geography, resource geographers began to engage with discussions about what 'being' a resource actually meant. This served to counter the inevitability that resources should, indeed, be resources. Erich Zimmerman's famous quote from the 1930s that "resources are not: they become" (quoted in Bridge, 2009, p. 1220), demonstrates that the fixity of resources was under question even in the early 20th century. This work married with texts from Marxist economic geographers such as David Harvey, who critiqued the propensity for capitalist/neo-liberal governance and finance systems to commercialise the natural world and turn it into commodifiable resources. This Marxist perspective and the concern with the creation and measurement of environmental 'value' remains a concern to geographers approaching resource management from a political ecology perspective today (Huber, 2018). Post-1990, a plethora of new, critically informed resources geographies germinated. The following sections briefly maps the variety and breadth of these geographies under discussion today.

First is the concern with enclosure and the commodification of resources as property. Here, geographers have explored how natural assets come to be commodified as property (Blomley, 2007) through traditions of the English legal system and often under colonial systems of control. Closely related to this, work within political ecology critically explores how the enclosure of resources through the definition and making of property lends itself to the dispossession of certain (often Indigenous or marginalised) groups and forces damaging environmental and social transformation (c.f., Peluso, 1995; Tsing, 2005; Bebbington, 2009; Hoogeveen, 2015). Yusoff (2019) has highlighted the interrelation of making Africans into property for sale as slaves and the implication on resource production from the 1400s to late 1800s. Yusoff's work extends the tendrils of what we understand 'resources' to mean, and to understand that resource economies have historically been (and in some geographies, continue to be) made through slave economies, where the de-humanisation of individuals and enclosure of bodies as property allows for economies' success.

Relatedly, geopolitics, resource control and resource security are cross-cutting concerns. Geographers working in this domain explore not only how resources are controlled, but how resource production becomes embroiled in politics of the nation state (c.f., Childs, (2016) – on resource nationalism; Kuchler and Bridge (2018) and Kama (2013) on discursive resource politics; and Mitchell (2009) on resource dependency and democracy). Resource security is aligned with geographies of vulnerability and conflict over quality and supply of resources and associated performances of resource nationalism and inter-governmental or inter-organisational negotiation over access and provision (Bakker, 1999; Cook and Bakker, 2012; Wheeler *et al.*, 2018). Resource security and government policy responses to supply pressures have drawn attention to how control is exercised, particularly in contexts of climate change or conflict (Billon, 2014; Childs, 2016). Concerns around informational transparency and environmental/human security as relating to resource extraction and transport are addressed by Barry (2013), whose work broadens the consideration of 'security' as more than an issue of supply and control, but rather of material, infrastructural and fiscal soundness (see also Majury, 2014, on this).

Meanwhile, under the domain of resource consumption, geographical interest circulates the social construction of resources as (consumer) goods, the material economy, and societal ethics that accompany this process. Key directions within this literature include Bridge (2009), who explores resources as a social category from a Marxist perspective, and considers how resource production, transformation and consumption are related within a material economy. Here, Bridge focusses on the transformation of materials into commodities and waste within a materialistic economy. Within the category of 'consumption', geographers such as Cook (2004) explore in detail the supply chains of commodities between places, allowing a focus on the politics and economics of commodification through different space-times. This work also serves to make visible the human lives implicated in the commodification process that are often hidden in complex networks of globalisation and distance of consumption from source. Reflective that consumers are becoming more aware of the ethics of supply chains and their consumption demands, scholars such as Marres (2012) work to understand how material practices within daily life serve as articulations of political engagement and forms of material ethical valuation. Literature that approaches resources from these angles opens up the possibility of de-naturalising the status of resources, refocusing sites of accountability in resource use, and making visible worlds that are otherwise hidden such as waste (Hird, 2017), material production (Jones, Heley and Woods, 2019) and labour (Barua, 2017).

The final area of note within resource geography of particular pertinence to this thesis are critiques of resource measurement and accounting (as opposed to early geographers who did that measuring and accounting themselves). The following section probes this area in depth, drawing out the importance of materiality and knowledge production mechanisms for resource imagining, identification and production.

2.2.1 Becoming a Resource – definition through measurement and accounting

Literature from resource geographies, STS and political geography highlights how becoming a resource comprises a combination of socio-technical and cultural practices that relies upon constructing meaning of the geological in the relation to its material life (Bobbette and Donovan, 2019). "Material" can mean as substance with particular physical qualities (Ingold, 2007), but the term is also used by others like Bridge (2009) to refer to a resource's life as a commodity.

Tanya Murray Li (2014), via her work exploring how land becomes an investible resource, provides a helpful framework for thinking through the socio-technical, economic and material apparatuses required to make land circulate in an economy. Geology, a feature of land, must therefore also be assembled through diverse practices in order to be rendered a resource. Li, highlighting the provisionality of land as resource, explores how becoming a resource is neither a linear nor stable process, with diverse meanings and practices influencing how it is subsumed into human life. 'Being' a resource is therefore not natural but a *process* that happens to something.

Bridge, exploring the changing meaning and use of resources in society argues that "all resources are cultural appraisals about utility and value" and uses political ecology/economic geography perspectives to understand how things become commodified in society (Bridge, 2009, p. 1219). The cultural appraisals that Bridge describes include evaluations within socio-economic and cultural contexts as to the marketability of a material, via for example the survey and creation of demand and markets, and measurement of resources' availability, quality and location. Bridge's (2009) perspective is a useful lens to understand the societies that brought the resource into being, enabling a focus on the politics and economics embedded in resources' creation. His work also delivers an understanding of how the materials we deem to be useful, and therefore consider to be resources, change throughout space and time and are relational to other things such as technology, infrastructure, laws and policies. Bridge's work informs this thesis by prompting a consideration of what drives speculation about resources' value, putting at risk the inevitability of resources' worth and utility to society. However, for this thesis, a political ecology approach is inadequate because it underemphasises how resources' material constitution – i.e., what they are made of and their quality – affects our ability and willingness to enrol them into social networks.

Meanwhile, Li's (2014) work builds on Bridge's cultural appraisal framework, by asserting how making resources like land is critically dependent upon materiality. That is to say, the material features of the land – its soil, hydrology, biodiversity as well as the material artefacts used by humans such as farm machinery or measuring devices – impacts how and to what end land is made into a resource. Other resource geographers such as Bakker and Bridge (2006), Richardson and Weszkalnys (2014) and Kama and Kuchler (2019), also emphasise the importance of materiality in making extractive resources. Bakker and Bridge (2006, p. 11) acknowledge the "high degree of internal differentiation within what gets called the natural world" which as a result requires a diversity of methods and rationales to make things into resources. Indeed, the authors add that embedding materialist perspectives into resource geographies is critical to "challenge the reductionist notion that the social life of commodities can fully be understood by interpreting it as a product of social relations" (ibid., p. 12).

Supplementing Bakker and Bridge's focus on the materiality of extractive resources, Richardson and Weszkalnys (2014) assert that resources are a combination of material assets (e.g. geological type) and the capacity to render that asset knowable and its potentiality distributable within resource networks. From this perspective, the authors scale the micro into the macro, explaining that the mobilization of (geological) resources within a resource economy requires the abstraction of their material qualities into something that can be circulated within socio-economic networks. They use the term abstraction to mean the literal separation from its host environment/material and also the reduction of its properties to a series of data, images or diagrams, similar to Latour's (1999) descriptions of transformation and circulation. Importantly, Richardson and Weszkalnys invite the possibility that the abstraction process should not be bounded by inevitability, but that it is possible to change if and, importantly for this thesis, *how* resources 'become'. Exploring this idea further, Kama and Kuchler (2019) examine how geoscience data is used to generate resource imaginaries around unconventional fossil fuels. In particular, they address how geoscience data for European shale gas reserves make imagined resource futures politically possible and socially mobile. The authors undermine established shale gas reserve projections by exploring how the materiality of reserves' host geology affects estimations about their potential. They therefore unsettle the inevitability of unconventional fossil fuels to be realised as feasible energy resources as a result of their abstraction and circulation as geoscience data.

2.3 The Politics and Materiality of Volume

'Volume' and its politics and materiality have gathered significant attention in the last 15 years and is usefully applied to resource geographies in that it expands the spaces in which we understand resources to be imagined and extracted. Volumes are both spaces of resource formation and contestation, as well as currencies (Bridge, 2013). Volume comprises an integral component of resource estimations used to generate speculation and financial endorsement for exploration and development operations, yet an in-depth analysis of materiality and political volumes in resource geographies largely limited to work by Kama and Kuchler (2019)[4].

[4] Although Barry and Gambino (2019) discuss materiality in relation to a gas pipeline across the Adriatic Sea, their work relates more to the materiality of the sites where the pipeline passes through, than the demands of gas as a volumetric material in and of itself.

As such, this section brings together work on territorial volumes found in political geography (e.g. Elden, 2013a, 2013b; Williams, 2011), urban geography (e.g. Graham and Hewitt, 2012) and resource accounting (e.g. Richardson and Weszkalnys, 2014), to provide a fleshier framework to understand the implications of volume-based thinking on critiques of resource making.

2.3.1 Politics of volumes

One way geology can become political is when attention is paid to the subsurface as a component of state- and territory-making processes. Bebbington (2012) explains that geological knowledge comes to be the "political lining in ideas of development and progress," and can comprise an articulation of "state power in material form" (Bobbette and Donovan, 2019, p. 15). The link between territorial expansion and geological exploitation is stark in Canada (Braun, 2000). Here, assessments of lands' potential for hosting valuable geological volumes motivated settler-expansion across the continent, and was a key driver for making state-affirming treaties with Indigenous people in the country. Volume therefore motivates political action and thus to acknowledge the subterranean as a political space creates opportunity to understand geology as a generative element of territorialising processes.

As Elden (2013a) explains, volume matters because it stretches territory into new dimensions and thus opens up spaces to new forms, rationales and politics of territorialisation. By territorialising subterranean volumes, geopolitics meets the geophysical (Elden, 2013a). Graham and Hewitt (2012), from the perspective of urban volumes, add that working through the vertical generates shifts in experiences of spatial form and topological socio-politics and power. Hence, a focus on the volumetric and more-than-horizontal disrupts perceptions of geopolitics and relations in (lived) environments as purely 'flat', unilinear performances. A focus on the volumetric thus also draws space-times into consideration. As Steinberg and Peters (2015) describe of seawater, Dodds (2013) of Arctic permafrost, and Dalby (2013) on atmospheric layers and carbon emissions, the shifting/cyclical materialities of volumes through time, space and seasons affects the political infrastructures and imagined futures and management of the environments they comprise. The implication of these literatures taken together is that volume (including the apparently steady-state subterranean) should be considered as having change imminent to their constitution, which in itself creates an open-door for critical geographers to put at risk the geopolitical, social and scientific assumptions or conclusions we make about them.

A critical component of literature on volumes is the work of Israeli architect Eyal Weizman who speaks to the multi-dimensional reality of territorial expansion. Weizman's (2008) description of Israeli road tunnels beneath Palestinian settlements highlights how territory can be articulated both above and below the surface. He also describes how Israeli road building programmes allow the possibility of territorial space to be expanded and adds to the web of existing nation-building and sovereignty asserting infrastructures. Bridge (2013) adds that splitting land into surface and subsurface legal regimes has the potential to create tensions and opportunities between and within political and social groups. Hoogeveen, (2015) shows how splitting land tenure into surface and subsurface regimes generates twice as much territory to be negotiated, putting more at stake than if only surface rights were under discussion

Weizman's (2008) analysis of how territory and volume are controlled in Israel and Palestine leads him to explore how military space is created within aerial, surface and subsurface geographies. His approach is important to this thesis because he highlights how the subsurface can be assembled through observation and measurement. In particular, Weizman asserts that the assembly of volume via a matrix of interlocking and overlapping lines, points and surfaces grants the Israeli military vantage and access points over contested Palestinian/Israeli territories. In similar vein, Derek Gregory (2011a, 2011b) explores how remote 'views' (or indeed the remote discursive constructions) of 'terrorist' targets in Afghanistan and Pakistan from the USA operationalise and rationalise territorial incursion and control via drone warfare. Alison Williams's (2011, p. 254) discussion of plural military/civil airspaces in the UK highlights the "myriad of ways that the aerial dimension impacts upon the human experience and how this is represented and performed", highlighting the diversity of ways that (air) space can be conceived or contrived to various political ends with manifold impacts on civilian day-to-day life. Williams and Weizman's work compared with Derek Gregory's shows how territorialisation relies upon the carving up of space through imaginary and sometimes infrastructural lines, whilst Gregory describes how territorial infringements occur *through* the medium of airspace, carving up and attributing identities to enemy and non-enemy.

The practicalities of this visioning within the context of subterranean space is taken further by Weizman. His descriptions of a network of watchtowers, roads and tunnels beneath and above Palestinian territory depicts a space controlled by a patchy network of vantage points in space. Similarly, the sometimes-false identification of insurgents or 'enemies' targeted by US drone strikes in Gregory's examples encourages us to realise that there are gaps between the lines, points, people and materials holding a space together. These gaps are of particular importance since they remind us that a complete view of the subsurface cannot easily be attained, with implications on the measurement and estimation of resource volumes and qualities. In the context of geology then, although one might be able to broadly map target areas in subterranean volumes, it is only via directly 'hitting' the target rock that we know exactly what it constitutes, enabling us to qualify and materialise a picture of the volumetric whole (Singer and Menzie, 2010).

Spinning out from this, we must consider how volumes *do* come to be classified, accounted for and hence attributed meaning. Within urban geography literatures, emphasis is placed upon urban volumes as mutually constituted and responsive to the phases of transition, re-articulation and contestation by those who inhabit and/or have stakes in the politics of those places (Graham and Hewitt, 2012; Harris, 2015; McFarlane, 2016). However, herein lies a challenge for our engagement with subterranean, geological spaces. Although Macfarlane (2019) describes some subterranean spaces as places of human significance for burial, ritual, art or sport, they are not typically contested for meaning on a quotidian level. Rather, the meaning, politics and constitution of the subterranean is an exclusive project: the work of scientists, military, industries and governments, rather than the product of people's day to day lives.

Considered from this perspective, we also realise a further challenge of subterranean vertical territories. Critical geographers throughout their engagement with volumes have expressed how the sanitised, top-down view 'over' space should be rejected for multi-dimensional living 'in'. Yet, quite obviously, unless existing in liminal worlds of bunkers, tunnels, caves or sewers (Garrett, 2016; Slesinger, 2020), we retain a top-down perspective on geological life. Maria Puig de la Bellacasa's (2019) work on soils challenges us to consider what we are missing collectively and ethically by being disengaged from a space that is crucial to our modern existence on Earth through its provision of the materials for our contemporary lifestyles.

Peter Adey (2013, p. 53) poses a similar question – what if we think about subterranean volumes as more-than-political and remove our "state/technocratic gaze"?

Thinking about geological volumes as spaces where meaning is articulated and curated, can lead us to consider how resources come to be accounted for and controlled. Bridge (2013) in response to Elden (2013) states that "volume is a primary metric of anticipation and potential: calculations of what space contains (cubic meters of gas, ounces of gold), and what contained materials mean that space could become, are essential to the performance of resource landscapes" (ibid. p. 56). By being a subject of accounting, volume therefore becomes a thing to control (see Richardson and Weszkalnys, 2014), a frontier where the resource-state nexus is performed, and provides an incentive for interventions into planning and securing subterranean space (Bridge, 2014).

Calculable volume assists in the circulation of things such as quantum-based land or resource rights. It also enables the trade of spaces and things that have not yet been extracted but whose potentiality has been transposed into the global extractive economy through numeration – i.e. has become a speculative circulating reference (Bridge, 2013; Majury, 2014). In Canada, the 19th century surveying of British Columbia's geology for resources enabled its successful rendering of geology into reproducible reports and maps that enabled regimes of control to emerge (Braun, 2000). Geologists' work scoping national mineral reserves was critical for measuring the extent and possibilities of Canada's frontiers and rationalising settler-expansionism into resource rich areas. In particular, the use of geological scientific objects like maps and geodata generated investment fever that spread from resource hot spots to financial centres like London, Paris and New York helping finance and internationalise this expansion.

However, settler expansion along geological lines in Canada was driven by geopolitical ambition, as outlined in the first section of this chapter. From this perspective, volumes are born out of socio-economic and ontological circumstances that create the geopolitical worlds of their production. Exemplifying this within a European context, Kama and Kuchler (2019) describe how energy security concerns for making the EU more independent of Russian gas imports motivated the production of questionable shale gas volume estimates. Kama and Kuchler criticise the extrapolation of US shale gas estimates into European countries on the basis that similar geologies will exhibit similar reserve behaviours. They demonstrate that efforts by the United States Geological Survey (USGS) to quantify gas reserves rely on extrapolation of poor local data and drawing inaccurate similarities between US and European gas geologies. These methods of resource accounting therefore produced potentially misleading or unfounded political plans for securing energy resources independent of Russia.

Critically, Kama and Kuchler demonstrate how creating dubious numeric accounts of the subsurface "implants powerful geopolitical imaginaries that creates a possibility for new forms of political strategy, action and contestation" (ibid. p. 109). They therefore demonstrate a strong link between shale deposit drill data which has been enrolled into British and Polish geo-political imaginaries to allow the "prospective extractive economy [to be] anticipated and become politically operational in the present" (ibid. p. 113). It is helpful to think about geometric/geoscientific objects as what Kama and Kuchler (2019, p. 108) term "performative devices" or enablers of particular futures: they are both a product of and corral multiple epistemic and political communities around them. Kama and Kuchler (ibid, p. 112) explain that "resource estimates should therefore not be understood as representing physical objects, but rather as social constructs which are necessarily *performative*, insofar as such projections themselves begin to create new objects and realities for resource and energy governance". In being performative, geometric objects are understood as things which both assemble and are assembled, linking the idea of making volumes back to previously discussed theories about 'becoming' a resource. However, what Kama and Kuchler are missing in their analysis is how the *quality* of resources varies within reserves. Unlike oil and gas where a reserve may have a relatively consistent quality, the quality (or grade) of mineral deposits may internally vary.

Thus, with the constitution of political volumes under question, we must turn to understand what makes volumes inherently uncertain and diverse things which present challenges to those trying to measure, frame and extract them – their materiality. The following section helps understand that.

2.3.2 Materiality of volumes

Elden (2013b) tells us that we "need to think about the materiality of the geo", and similarly, Simon Dalby (2013, p. 43) states that "the materialities of spaces matter, not just the volume". Critically, the volumes under geographers' attention – e.g. ice, water, air, rocks – are heterogenous in their material composition – their quality is diverse. Bridge (2009) describes how with higher demand for natural resources and improvements in extractive technologies, humans are now able to extract lower-grade (i.e. lower quality material per volume) resources. One implication of considering quality, Bridge argues, is an understanding of the volumes of waste materials are produced per volume of resource. Hird (2017) emphasises this problematic balance by describing how 95-99.9995% of mined rock in Canada is considered waste – resource extraction therefore has low productivity when considering the volume of inputs to desireable outputs, and this hinges on the materiality of the resource.

Demonstrating the implication of geomateriality on politics is Mitchell's (2009) paper *Carbon Democracy*. Mitchell argues that the properties of oil and coal must be understood to recognise the implications on political systems, in particular the development of democratic politics. Mitchell highlights how the materiality of different fossil fuels breeds certain kinds of human relations with it – opening up and closing possible "connections and alliances" (ibid., p. 401). Coal, for example, is a labour-intensive material to extract and transport across the landscape. Historically, this has allowed workers to gain political power in their control over its movement by conducting strikes within networks of labourers that its transport joins up. Meanwhile, Mitchell argues that oil's materiality (it flows) meant that teams of miners were not required to extract the resource and were replaced by machinery. Similarly, railways and canals that transported coal could be replaced by pipelines through which oil can flow. As a result, with oil, a networked form of labour organisation was eliminated, and resource production and movement was less vulnerable to interruption. What Mitchell demonstrates is that materiality matters – it impacts how a geological resource can be enrolled into an economy, how it is rendered political by the people that produce and consume it, and the political alliances it can draw together. Mitchell's paper is a reminder that one must pay attention to the 'what' of resources, rather than just 'how much'.

Slesinger (2020), using the example of Gazan tunnels dug into Israel, demonstrates again how the materiality of geology affects political control of/within volumetric space. He explains how "the subterranean layer presents a significant challenge for a totalising political knowledge of territory by the state" (ibid., p. 34). Here, Slesinger accounted how the salinity of soil interrupted the ability of Israeli geophysical technologies to penetrate, read and produce data on the shallow geology that could be converted into cartographic representations of Gazan tunnels. As a result, Slesinger notes, there is a reliance upon "supposition [which] destabilises the confidence of state security actors to identify with any certainty the potential security threats concealed within the soil of the territory [the Israelis] are tasked with managing" (ibid, p. 35). The opacity with which the subterranean overflows in turn transforms a technological/geophysical concern into a geopolitical/security concern. Slesinger's analysis highlights how what cannot be seen is often more politically meaningful than what can be. What is invisible has the potential for speculative narratives built around it to meet political agendas, as also described by Weszkalnys (2015) and Gregory (2011a, 2011b).

Weszkalnys (2015) outlines how speculative politics and economies generate a fragility in the imagination of resource futures. She writes in relation to First Oil in Sao Tome and Principe, where over decades an oil economy has been built on infrastructures of hope, and where an anticipatory political economy has become increasingly challenging to maintain and requires creative perpetuations of the imagined resource to be sustained. Weszkalnys demonstrates how various tools (or what she terms 'gestures') are used by governments and companies that indicate potentiality without creating a concrete resource outcome. These gestures materialise the subterranean, e.g. through contracts between exploration companies and governments, through the designation of 'exploration zones' and installation of test wells. What these gestures do, Weszkalnys argues, is create a materiality for something "not-yet-actualised" (ibid., p. 615) and entirely contingent on surficial social relations. The impact of these gestures is that they create an atmosphere of anticipation and hope which perpetuates itself and produces a resource imaginary that becomes socially and politically sustained, despite limited capacities for the realisation of these resource dreams. Weszkalnys' work highlights the importance of digging-down into the substance of resource economies and in doing so puts its foundations at risk of dissolution. This is necessary to separate geological speculation from 'fact'. Weszkalnys' analysis of Sao Tome and Principe's situation prompts looking beyond the shiny poster-pieces produced by companies and governments promoting exploration and asking what is really going on underground.

Adding to the idea of volumes being diverse in their quality and therefore vulnerable to change, refutation or speculation is Steinberg and Peters's (2015) work on oceans and Peters *et al* (2018) on the more-than-territorial[5]. They remind us that the composition of volumes is not stable, and that this temporal and material instability is crucial to their vitality and value to us. The material flux of Earth's constituent environments results, for Peters *et al* (2018, p. 7) in a "specificity of environments for challenging territorial knowledge". Ingold (2007, p. 6, 11) adds to this the idea that "materials…are the active constituents of a world-in-formation" and that "as with the Earth itself, the surface of every solid [or liquid, in this instance] is but a crust, the more or less ephemeral congelate of a generative movement". Thus, volumes are material capacities – they can hold some*thing* within them, and what is inside can be made and remade, either through changes in material states or human understandings and engagements with them. Steinberg and Peters's material contribution to volume literatures demonstrates that the potentiality of volumes is a balance between what has been produced through geologic time, and as Kama and Kuchler (2019) and Weszkalnys (2015) describe, what can be produced through capitalist time within resource markets.

2.4 The Production of Science and Scientific Objects

The resource geography literatures above, in particular Richardson and Weszkalnys, signal the importance of 'knowing' something in order for it to become a resource. Yet resource

5 Peters *et al* (2018) consider Earth 'beyond terra' – beyond land. Their collection of essays looks at Earth as comprised of multiple materials whose constituency, liveliness and spatial formation are always undergoing or liable to change.

accounting is "not independent of the apparatuses that produce reports of reality" (Law, 2004, p. 31).

Ingold (2011) approaches the production of knowledge in a way that centres the importance of practice, affect and embodiment for coming to know something/somewhere. Ingold contends that knowledge is storied and should be considered the product of action, movement and practice. Ingold is therefore more concerned with the '*how*' of knowledge, rather than the '*what*', and frames knowledge as "perpetually 'under construction'" (ibid., p. 159). However, this prompts the question of how knowledge comes to be stabilised if it is always in motion and under construction. The work of Fujimura (1992), Law (2004), Anderson and Harrison (2010) and Barry (2005, 2013) are important for establishing how that occurs.

In both cultural geography and STS, the role of practice in producing knowledge is of paramount importance. As will be explored in subsequent sections of this literature review, practice amounts to both socio-technical engagements and affective relations with the world. Important here for understanding how knowledge aids the making of resources is recognising how scientific materials, such as resource value estimates or geological maps, are the product of scientific knowledge which is often hidden within them. The following literatures help to reveal which knowledges and associated practices constitute the fabric of geoscientific objects such as maps, whose representations of 'reality' is often taken for granted by those who use them, but whose meaning and value is potentially unstable when critiqued.

Productive in helping us understand the relation between knowledge and scientific materials are hinterlands (Law, 2004), background worlds (Anderson and Harrison, 2010) and informed materials (Barry, 2005, 2013). These terms refer to the knowledges, practices, affective relations and social norms that become invisible but underpin structures and theories that enable society to function as it does with the aid of (scientific) technologies. These are necessary tools for critiquing the socio-political landscape within which geoscientific objects are used and the ends which they are posited to represent since it can indicate intentionality. Simultaneously they acknowledge the significance of peer review and linguistics (hinterland), the importance of reciprocal relations with a world in formation (background worlds), and the production of trust in science and techno-social objects (informed materials).

Hinterlands are described by Law (2004, p. 33) as a collection of 'standardised packages' which "produce more or less routinised realities and statements about those realities". Law draws on the work of Fujimara (1992) who outlines a theory of standardised packages to describe things that are the product of scientific theories and practices. These practices create stabilised facts about the world and can be used in social spaces beyond those where they were produced. They are founded (alongside valorised scientific methods and theories) on statements about the world that have become unconditional and which can be made without qualification. This knowledge then becomes so routinised that its constitutional theories and methods are not called into question, but instead the statement becomes enrolled in generating new knowledge about the Earth (Fujimura, 1992). Thus, this literature presents a set of realities assumed through linguistics and practice.

Related to hinterlands is the work by Andrew Barry (2005, 2013) on 'informed materials', which explores how scientific materials are the cumulative work of a network of knowledge, regulations, funding and political agendas. Barry's insights are particularly helpful in encouraging us to unravel what scientific materials are made of, and by whom, and what 'work' these materials do to inspire institutional trust by those evaluating e.g. their safety. Barry's (2013) Material Politics is particularly significant for creating an interrelation between materials and the production of trusted information. For Barry, when trust in materials comes under question, we look to the multi-layered information embedded within an object, where that layering speaks of past behaviours, ethics and socio-scientific intentions (Barry, 2006). These objects become matters of concern when their informational quality and composition is called into question. It is through the juxtaposition of transparency/trust-building initiatives and the opaqueness of materials' informational composition that Barry taps into contradictions of how easily scientific materials can be opened-up, and from that, how transparent our transparency processes actually are. Barry's contribution is crucial in prompting an examination of how things like maps come to be informed materials that carry with them narratives or sit within institutional or political contexts that are designed to provoke particular ethical responses of approval for e.g. a resource development project.

Meanwhile, 'background worlds' are drawn from non-representational/cultural geographies and as explained by Anderson and Harrison (2010, p. 3) are also avowedly Latourian in their "relational-materialism for thinking about the composition and nature of the social". Background worlds, explain Anderson and Harrison, is a term used to describe the complex, invisible assemblages of practices and activities that "we do not consciously notice [but] are always involved in and caught up with" (Anderson and Harrison, 2019, p. 7). This approach frames humans as always in reciprocal relations with the world, wherein an emphasis is placed on the importance of embodiment for living in and with the world. It therefore enables a focus on the intermediation between world, body and brain to produce knowledge. Background worlds stretch discussions of active knowledge making further by digging into what these actions comprise, including affective feelings and motions of and between body and world (Thrift, 2004). This approach is important for understanding what knowledges help constitute mineral resources because it forces the recognition of geoscientists as people who have individualised as well as institutionalised responses to the stimuli that the geological world presents them with. It is therefore a particularly pertinent starting point for framing a science which is reliant upon the expertise of individual scientists and understanding the significance of the breadth of their capacities – e.g. intellectual, affective, technological – for understanding and rendering the geological knowable.

2.4.1 Abstractions and scientific objects

STS and cultural geography literatures offer two entry-points to understand how abstractions or scientific objects such as geological resource estimates or geological maps are made through practice. First, in STS, the work of Latour (1999) attends to the technical-material and methodological approaches of scientists in producing 'circulating references', or scientific objects that are universally recognised and understandable. Second, McCormack (2012) and other non-representational geographers invite an attention to individuals who make science, and how their experiences and affective relations to their study has material impacts the outputs they deliver.

In his 1999 work on soil scientists in the Amazon, Latour follows a group of scientists into the field to understand how questions around a scientific controversy are approached and begin to be resolved. In doing so, Latour pays particular attention to the methods and tools used by the scientists to reduce the boundary of the savanna/forest into data, charts and maps which can be circulated in scientific centres ('centres of calculation') beyond the field site. Latour's approach enables him to capture how material transformations (e.g. from a physical soil horizon into a list of colours and textures using a 'topofil') take place and occur following methodologies that are trusted by peers reviewing their work. As a result, Latour focusses on how authenticity and 'reality' is retained through various stages of material transformation which allows for the content of circulating references to be unpacked and retraced as to rebuild the field site elsewhere. Circulating references are things that can move between places and scales without losing their meaning, even if they are transformed from one format into another (Latour, 1999, p. 311).

However, to give adequate attention to the detailed material practices in his example, Latour explicitly does *not* do a sociological examination of the production of science and its political motivation, nor does he attend to the affective registers of the scientists involved in its production (Latour, 1999, p. 27). An issue identified by Star (1990) in missing out the sociological is that the politics of science production can be overlooked. A further absence in Latour's Amazonian work is the analysis of how work comes to be trusted and how this is linked to the individuals who produced it and their framings of the world, not just their methods of working. Massey (2003, p. 13) argues that a more reflexive view would have enabled Latour to bring light to "the concepts and categories, the discursive regimes" in play. What his approach therefore misses is what the bodies of the scientists, their motivations for being there and their epistemological perspectives about their subject mean for the production of science.

McCormack (2012) provides the toolkit to understand how humans' heterogenous experiences of making science influence what and how science is assembled. McCormack argues that in order to understand scientific objects, it is necessary to apply a Marxist approach that connects human labour to the final products of peoples' efforts. By re-humanising the making of scientific materials like maps, opportunities are created to understand the human experiences and competencies that influence materials' composition. As a result, McCormack's approach multiplies the possible meanings that abstractions have as a result of the individuality of the people who made them. This is especially important in resource geography where the work of reducing geology into abstractions is often done by individuals or small groups of people who are experts in their field and who may be the only people occupying a particular geographical space or geoscience discipline. Yet McCormack's work can be pushed further still to account for the significance of scientists' positionality within a scientific community, thus making more of the socio-political and institutional in relation to scientific knowledge production.

2.4.2 The body, affect and materials

Braun and Whatmore (2010, p. x) and Thrift (2004) emphasise the significance of understanding the affective force of 'things' and the implications thereof on the politics and knowledge production and thinking through the body. Braun and Whatmore's collection of works focusses on "the material propensities, affordances, and affectivities of nonhuman phenomena and the amplification of embodied human activity". Meanwhile, for Thrift (2004, p. 90-91), "only the smallest part of thinking is explicitly cognitive…it lies in the body" and therefore, understanding the body's affective relations to what the world is made of indicates the "sheer materiality of thinking".

Fox-Keller (2000) provides an example of this dynamic at work by focussing on McClintock's bodily labour and the relations she had with her corn plants that enabled her discovery of new genetic processes. Fox-Keller demonstrates how McClintock was only able to produce new science by combining genetic theory with a close relationship to her subject over many years and generations of the plants' reproduction. McClintock's method's resonate with Latour's (2004, p.213) description of how people "learn to be affected" and thus understand their subject matter through long-term exposure to and sensitivity to differences of their object of study. In particular, Fox-Keller's account of how McClintock "listened to the material" in order to "reveal its secrets" details the challenges of this method of work when she was working in an environment where simplified models took primacy in explaining genetics (Fox-Keller, 2000, p. 180).

Yet looking, listening and being attentive to the life of the material was antithetical to how the discipline was developing through the twentieth century. McClintock's methodological approach was perceived as outdated, belonging in the 1800s, and generated barriers in communicating her work and gaining trust in her discoveries. Thus, Fox-Keller's work highlights how lab-based sciences place value on the severing of body and science and how methods that rely on such subjectivist approaches unsettle the rationalist grounds of scientific process. For laboratory scientists, work should be reproducible using a particular set of methods, tools and models, rather than relying on the skill of the individual that has been coproduced with the object of study (Greenhough, 2009). However, in field sciences, this is often not possible and instead a reliance upon the subjective expertise, judgement and feelings of scientists is required that is predicated on their longstanding and nurtured relation to their subject/object of study.

Fox-Keller's account also reveals relationships between individual scientists and the institutions and cultures within which they operate. McClintock's eccentric, sometimes abrasive personality was part of the reason why her ground-breaking work on plant genetics was for decades rejected by other scientists. Fox-Keller establishes how the social and political circumstances within which scientific discovery are globalised and accepted and circulating references become endorsed. This text supports the creation a framework of analysis that can account for the socio-material relations of scientific practice without neglecting the role of the body, affect or scientific institutions in enabling the creation and circulation of scientific objects and fact.

Speaking at the interface between body and institution, Brian Frehner's (2011) work "Finding Oil" is also interesting within this context. Brian Frehner's (2011) work "Finding Oil" is also interesting within this context. Frehner describes how 'oil-seers', a sort of pseudo-prospector, relied on affective, subjectivist practices to look for oil in the USA in the late 1800s. Oil-seers' practices had implications on how the work of actual prospectors was accommodated within geological institutions. Oil-seeing, work often performed by women, relied on superstition and individual's 'sensing' of the material: "An Italian woman named Augusta Del Pio Luogo felt "little shocks passing from her feet to her head, causing distinct pain" when she walked through a field containing oil or water…[and] when the seer Evelyn Penrose walked over an oil field she felt a "violent stab in the soles of my feet like a red-hot knife."" (Frehner, 2011b, p. 29). The proclivity for con artists to take on prospecting work reduced institutional and public trust in their activities. Naturally, the relative 'unknowability' of what is underground and where bred methods of encounter that fed off this invisibility and potentiality; but it also generated scepticism and a desire for greater empiricism in geologists' and prospectors' field methods.

Frehner goes on to outline how actual prospectors' skills were often a combination of basic geological knowledge and affective performances of encountering oil. He uses the example of divining rods (a tool also used until recently by Thames Water for finding leaks in water pipes) which were endorsed by geological surveys in the USA at the turn of the 20^{th} century for finding oil close to the surface. Divining rods have no scientific backing for their effectiveness but are a demonstration of how legitimacy for 'feeling' the geological could be attributed to particular knowledge production methods. What Frehner's work ultimately demonstrates is that being in bodily relation with the geological had to happen along certain institutionally recognised lines, and that the primary generator of trust was the correlation between prospectors' field methods and their ability to find oil. Frehner's work prompts questions about the kinds of relation endorsed by institutions, in particular which ones are considered trusted methods, and which are shunned. This broadens the discussion that Fox-Keller generates because it seeks to establish whether or not there is a typology of approved affective methods that generate trust in different sciences and why.

In addition to Frehner and Fox-Keller, Lorimer (2008) demonstrates the importance of the body and affective relations with non-human research subjects. During an ethnography of a corncrake counting campaign in Scotland, Lorimer recounts how the RSPB's researchers apply their in-depth, locally gained knowledge about the birds' habitats, behaviours and movements to survey and count them. Lorimer demonstrates how an affective relationship with the birds – e.g. coming to recognise individual calls – leads to a proximity between researcher and subject and creates an individualised skillset and capacity to recognise and account for different members of the species.

Thus, supplementing Latour's material focus, Lorimer emphasises how affective work – listening and sensing – is a critical method in the production of ornithological data. In particular, this work enables a form of translation to occur, where the human body is used as an intermediary enabling the illusive, challenging-to-capture birds to be measured and inscribed as data transferred to centres of calculation beyond the field site. Centres of calculation refer to sites where calculation using materials abstracted from 'reality' takes place (Latour, 2004, p. 305). However, it is not only the researchers' knowledge of the birds that allows this dynamic to emerge, but the physiology of the corncrake that enables this bodily relationship to be developed (other birds do not have such distinctive calls) allowing the scientists to harness features of the organism to carry out their work. Lorimer's work demonstrates how humans generate information about the world which is driven by its heterogenous way of making itself known, and are reliant upon a multiplicity of signals, whether material, sonic or visual.

Similarly, the work of Maria Puig de la Bellacasa (2019) expands the application of this 'affective learning' into the apparently non-lively world of soils. Here, Puig de la Bellacasa (2019) demonstrates how for soil scientists, it is crucial to use senses such as touch, taste and smell to elicit an understanding of the materials they are working with. Through Puig de la Bellacasa's work, we learn of the foundational significance of sensory relations with materials like soils, and how the resonance between soil and person builds a particular ethical imperative for those engaging with it. De la Bellacasa understands this affectively grounded form of learning to be critical in intensifying the relationship between human and soil, where soil is vital to the provision of food and where attention to soil's lively diversity 'animates' the material into something that can be spoken about with intimacy. It is here that science (the classification/assessment of soils) overlaps through affective methodologies with building an ethics of soil and supports its popularisation in the public domain.

Similar to Lorimer (2007), Latour (2004) and de la Bellacasa's (2019) approaches is that of Jane Bennett (2001) who presents the idea of 'enchantment' and the enthusiasm with which humans engage with and understand the natural world. For Bennett, enchantment is an emotional state of being which can either be encountered or learned and allows an individual to be completely present in a moment. For Bennett, the suspension of bodily movement and complete attention to the subject is significant because it allows a relation to be built between the individual and that which has caught their attention. Bennett writes predominantly around the concern of generating joy and provoking joyful interventions in an otherwise disenchanting, over-rationalised world, which paralyses people from affecting change. However, Bennett's approach prompts us to consider *what* specifically is happening when learning to be affected and enchantment takes place, and to look out for what is capturing the attention of the scientist when this happens. As such, an attention to detail of the material emerges – allowing us to ask what feature of the object of study is of particular significance that allows it to be set apart from other things, and why this particular aspect of the world is being accounted for and recorded in abstractions. In combination, these literatures bridge the material world with the affectively driven scientific performances of the individual that McCormack posits as important in creating opportunity for multiplicity and diversity in the generation of abstractions and scientific objects.

2.5 Public Understanding and Trust in Science

2.5.1 Science, trust and institutions

Jasanoff's (2004) idiom of co-production argues that scientific knowledge is embedded with societal norms, values and practices which inherently imbue knowledge with politics and power. Later, Jasanoff (2010), after Shapin (1994), observed how virtue (or trust) in science could not be separated from trust between social groups. The links between science, trust, politics and society help generate an institutional focus that attends to the positionality of organisations communicating science in relation to publics. After all, as Jasanoff (2010, p. 240) notes, scientific facts about the environment "never take root in a neutral interpretive field". Also affecting how publics may perceive and trust science is how science and politics influence one another. Science has implications on power, which within certain contexts such as the Canadian settler-colonial landscape, has direct implications on how science is received and the assumptions that its audience has of the intentions of institutions mobilising it.

The relationship between public understanding of science and trust can be viewed from two perspectives – from institutions and publics themselves. Wynne (2006) explains how, despite institutionalised motions from less educational towards more democratic discussions of scientific controversies, science communicators can often remain stuck in the pattern of imagining an ignorant audience with whom they must communicate. Specifically, Wynne identifies how communicators consider publics' lack of trust an issue of misunderstanding science itself, rather than as a product of historical relations and situations of their institutions in society. Wynne notes how communicators do not discern diverse experiences of science which compromises their capacity to recognise some of the causes of mistrust. As such, he argues that long-term assessments of the relation between science, scientists and publics are required in order to identify and address sources of public scepticism. Wynne therefore asserts that institutions must consider themselves as central to the issue of (mis)trust and reflexively consider what role they play in breeding mistrust in science by understanding their positionality with politics and in society.

Shedding light on this dynamic, Karen Bickerstaff's (2012) examination of nuclear disposal proposals in West Cumbria demonstrates the lingering impacts of historical relations between government institutions, waste disposal companies and local publics on management plans. In particular, Bickerstaff's adoption of a historical perspective of long-term matters of concern allows the relationships between publics and institutions to be traced and understood. Bickerstaff explains how historical attitudes towards producing and communicating scientific information about nuclear disposal plans in the 1980s created local fears of poor transparency around risk and lack of accountability towards public opinion and priorities. Relations between community and corporation in the 1980s seeded sustained feelings of resentment, fear and being taken for granted by decision makers in the present day. Historical relations and emotions therefore seriously colour conversations around contemporary waste disposal plans.

Meanwhile, understanding institutions' motivations for generating trust in science becomes a question of politics. Stilgoe *et al.* (2014) raise questions about the political necessity for public engagement and ask why it is used as a method to increase public trust and understanding in science. They argue that whilst critique has been levelled at the practice and implementation of engagement, it has examined less closely the political context within which engagement programs take place. Thus, it is necessary to examine the deeper political dynamics at play underpinning engagement campaigns (Irwin, 2014; Stilgoe *et al.* 2014). Using this approach, Braun and Schultz (2010) explore genetic testing engagement protocols in Germany and the UK to examine how the framing of publics by governing institutions allows facilitators to enable certain narratives to circulate, whilst shutting down or suffocating others that might put agendas at risk. The authors demonstrate how engagement campaigns can become spaces where the direction of public debate is strictly controlled to adhere to the hegemonic narrative supported by governing institutions. This ingenuine form of public debate facilitated by the politicisation of scientific knowledge within the engagement domain has the opportunity to erode trust. Where consultation or participation is too scripted, doubt emerges (Braun and Schultz, 2010).

2.5.2 Facilitators

There is a lack of focus in academic literature on the role that facilitators as intermediaries representing scientific materials (Braun and Whatmore, 2010) play in public engagement fora. Facilitators aid information dissemination and make decisions around how to cater and frame scientific knowledge for public audiences (Felt and Fochler, 2010; Chilvers, 2012), and STS scholars increasingly angle public participation events as "a legitimate object of study *in itself*" (Irwin, 2006, p. 310, quoted in Chilvers, 2008). Through this study, which has been limited, authors such as Chilvers (2012) and Felt and Fochler (2010) explore the assumptions that organisers of public engagement events have of the publics they are talking to and how they construct participating publics. Here, concerns around geopolitical and social-justice implications emerge (Felt and Fochler, 2010).

Stirling (2008) explains how the positionality of the facilitator affects how and why science is communicated. For Stirling, a focus on who is doing the communication – be it scientists working as scientists; scientists in a governmental/institutional role; or non-scientists in a governmental/institutional role – is to consider what the *intentionality* of public engagement and communication is and the subsequent power dynamics that may evolve from these situations. As Stilgoe *et al.* (2014) note, it also opens up critique as to whether an engagement event is designed with the purpose of being a scientific campaign (supported by policies enabling its occurrence), or a political campaign supported by selected aspects of scientific knowledge. The purpose and therefore the application and utilisation of scientific information by facilitators within these contexts has direct implications on the possible trust that might be expected from those attending public engagement campaigns. As Rowe and Frewer (2005) outline, the choice of engagement mechanisms is a reflection of the desired outcomes for facilitation that organisers and facilitators have identified.

Michel Callon (1999), although omitting to discuss the roles and rationales of facilitators, provides a useful typology of engagement approaches applied by scientific knowledge holders/facilitators. Callon's framework also helps us consider some of the intentionality behind practitioners'/facilitators engagement. His typology comprises the Public Education Model (PEM), the Public Debate Model (PDM)[6] and the Co-production of Knowledge Model (CKM)[7]. In each of these models, a hierarchical positionality is created between the science communicator and non-expert.

In the PEM, "scientific knowledge is the opposite of lay knowledge, which is shaped by beliefs and superstitions" whilst scientific information is framed as a "source of progress"

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[6] In the PDM, the non-expert has the knowledge-potential to fill gaps in the scope and real-life application of scientific scholarship, whilst holding science as superior to public knowledge. To obtain this knowledge, publics are given space to discuss scientific matters so that practitioners or facilitators can obtain adequate information to fit the shape of the hole in science's puzzle.

[7] In the CKM, the hierarchy between scientific and lay knowledge is flattened, and knowledge is produced with cooperation between scientific and non-scientific experts. Together scientists and non-scientists produce new knowledge about phenomena and collaboratively identify new avenues of research. Trust is strong between both groups.

creating a hierarchy of epistemologies within modernist perceptions of science and rationality (Callon, 1999, p. 82-83). A focus is placed on creating structures of engagement where a public can rationalise scientific risk by being educated so that their emotional associations with matters of concern can dissolved. It is within this structure that Wynne's (1995) deficit model proliferates. There, mistrust in science is believed to stem from a lack of understanding on the part of public groups. It is an approach to public engagement which positions members of the public as barriers to supporting scientific endeavours or science-supported policy ambitions, and again omits identifying (scientific) institutions as the source of concern and the object of mistrust (Wynne, 1993).

Adding to both Callon and Wynne's models, Irwin (2001) highlights how facilitators of engagement events have the power to choose *what* information is selectively passed on to educate audiences. As a result, he argues, with the public framed as empty vessels waiting for education, political ingress is enabled during the selection of information for sharing. The power of intent in information sharing rests with the facilitator or the institution they represent. Irwin (2001, p. 14) describes for example how the education of publics attending an engagement exercise involving sharing the 'facts' about a matter of concern involved "an inevitable judgment on the part of the exercise's promoters… [as to] the selection of what counts as hard fact" which "can be viewed as an attempt to limit rather than enhance discussion of the core issues". Thus, these literatures demonstrate that the intentionality with which information is shared with publics positions facilitators working at the science-public boundary as individuals who are bridled with ensuring trust in or support of science. As such, facilitators who have "remained largely invisible in…studies of science and participation" deserve significantly deeper attention for their role in sculpting of engagement events than is presently given in STS scholarship (Chilvers, 2008, p. 3005).

2.5.3 Non-European voices in STS and PUS literature

The need to recognise the political conditions of knowledge sharing and facilitation in PUS initiatives is critically important within the historical context of Canada, where as the Truth and Reconciliation Commission (2015) note, science has been used as a tool of cultural genocide. Thus, in this context there is an *existential tension* between science, Indigenous publics and politics, which should demand a politics of science communication that builds a transparent, two-way relationship for scientific advancement and implementation without reinforcing or relapsing into historical modes of Indigenous dispossession.

However, PUS literature within the STS domain does poorly to account for the types of tensions that are encountered during public engagement events, particularly in relation to communities where participants non-Western knowledge has historically (and contemporarily) been side-lined to make way for Western ways of thinking (Green, 2008). Taking account of this requires empathy with the epistemological positionality of participants and understanding of their structures of knowing and being in the world. Related to this, Green (2008) explores the binaries that have emerged between 'Western' and 'Indigenous' knowledges, and in particular explores what 'Indigenous' knowledge constitutes, turning to conclude that 'knowledge diversity' rather than Western/Indigenous dualisms should be pursued.

Yet although scholars at the interface of decolonial studies and applied sciences such as conservation like Green (2008) and Nadasdy (2004) write about the fluidity of Indigenous and Traditional Ecological Knowledges, and their diversity and overlaps with Western epistemologies, this has not been well recognised by those scholars writing about engagement at those boundaries. Indeed, PUS literature does not do well in discussing how engagement can be structured from a position where the non-Western voice/experience is used to guide engagement and participation, rather than the other way around. Questions abound as to why the dualisms of engagement (science/non-science) remain the hegemonic starting point in STS literatures on this subject.

Zoe Todd (2016) provides potential answers to this question. Operating within a European academy, STS and PUS literatures do poorly to acknowledge different ways of 'doing' or framing engagement, as they are (Todd argues) relatively deaf to the voices of non-Western thought. The implication of this, as outlined by Todd (2016) Davis and Todd (2017) and Yussoff (2019), is that Indigenous and non-white/Western experiences of phenomena such as climate change, are erased and overwritten by hegemonic accounts of human-nature relations. For example, Davis and Todd (2017) criticise narratives that suggest that Indigenous people in the Americas are, for the first time, experiencing the impacts of man-made climate and environmental change. Instead, they argue, "the Anthropocene is not a new event, but is rather the continuation of practices of dispossession and genocide, coupled with a literal transformation of the environment, that have been at work for the last five hundred years" (Davis and Todd, 2017, p. 761). Yusoff's argument is similar – the Anthropocene is not new, and it did not begin during the Industrial Revolution of the 1800s, rather, it began with the extraction and forced (dis)possession of black bodies from Africa to the Americas.

Taken together, this scholarly work highlights that the contentious political backdrop to those matters of concern which European scholars take to be sensational and novel, and grounds them within much longer-standing structures of violence of which Indigenous/non-white/non-Western people are deeply aware. Engagement practices that seek to draw in the views of or work with Indigenous and marginalised communities whilst framing these issues as ‘new’ or somehow coming to matter because Western life-ways are now impacted, erases the historical experiences of those groups being engaged.

The significance of this literature is that it marks an imperative for those scholars within the PUS domain to tackle the complexity of mistrust felt by some participants when engaged with by organisers within hegemonic institutions or demographics. Furthermore, this literature also prompts consideration of how PUS literature and public engagement interventions intended to democratise engagement can actually serve to reinforce inequalities, silences and dispossessions by virtue of not producing means to give meaningful space to the integration of the diversity Indigenous/non-Western knowledges, histories and experience.

2.6 Conclusion

This chapter has brought together diverse literatures from geography and STS. Together, they create an overarching framework to understand how geological knowledge is produced and circulated. The literatures engaged with create a lens through which to understand the role of the individual within the wider geopolitical resource context in producing geological science. Here, by engaging with Latourian literatures and cultural geography contributions on affect, a means is given to understand how individuals’ relations with their subject matter informs and inflects on the manner in which the geological ‘out there’ is transformed into the geology ‘in here’. In tandem, by setting out the historical context of geological mapping in Canada and issuing an analysis of how science can be communicated to publics, the tools are provided to understand how historical socio-political relations can produce particular relations in engagement fora. Through discussions of cartography, resource geography and accounting, volume, knowledge production and science communication, several gaps in the literature have been elicited.

First, a major omission in analyses of materiality and geology is how the *quality* of the material – e.g. the purity, consistency or distribution of resources within/amongst other materials – affects how the volume itself is valorised, made political and available for extraction within expansionist worldviews. Reflecting this, a major contribution that this thesis therefore seeks to make is around 'geodiversity'. Geodiversity is a term that "refers to the variety of the geological and physical elements of nature, such as minerals, rocks, soils, fossils and landforms, and active geological and geomorphological processes" (IUCN, 2021). The term is typically used in relation to geoheritage (i.e. the conservation of diverse geological forms) but has not realised its potential as a term in resource geographies for describing the diverse material qualities of geology. Geodiversity has particular leverage for discussions around resource accounting and volume and should be considered absolutely inherent to the political, economic and social potentialities volumes have. Importantly, opportunities abound for understanding how geodiversity influences geoscience knowledge production by creating affective relations between scientist and mineral, and how geodiversity influences calculations and estimations of mineral resource availability.

Second, the literature analysis has also made apparent that the quotidian experiences of mapping and production of geological objects via individual scientists' affective relations with their research subject has been overlooked within contemporary literature. Yet literatures brought into discussion in section 2.4 highlight that *how* knowledge is produced – i.e. via practice and affect – is critical for influencing the kinds of politics surrounding the knowledge produced. Additionally, *who* is producing geological information provides consideration of the ethical and political-economic intentions of scientific materials' creations. This thesis brings these literatures together by focussing not on the political economic structures within which geological materials are produced/brought into circulation (as a political geographer or political ecologist might) but rather the embodied relations between scientist and geology. Through this, new discussions are brought to the fore about what it means to be 'intimately' engaged and enchanted with geological volumes.

Although this thesis does not adopt the historical geography approach used to synthesise the literatures in section 2.1, in a context such as the NWT, an eye on the historical situation of the area is necessary. Thus, a novel focus on the facilitators of events within a geopolitical context such as the NWT enables assessment of the motivations that drive facilitators to communicate scientific information and how. This has significant implications on how STS literatures that assess engagement initiatives can consider the ethics and effectiveness of outreach activities, particularly for marginalised or minority communities. In turn this may have implications on the framing and planning of activities designed to democratise science and decision making.

3. Methods and Methodology

This chapter outlines the methodology and methods used to generate data for this thesis and recounts the nine months of ethnographic fieldwork carried out between September and December 2018 and February and August 2019 in Yellowknife, Canada (figure 3.1). Here, I describe and justify my use of a multi-sited ethnography which incorporated semi-structured interviews, event ethnography and work shadowing as methods to generate data to understand how geology is mapped by geologists and with what implications on resource politics. I will also describe how I applied aspects of the Grounded Theory Method (GTM) to guide my overall activities and thought processes and discuss how the theoretical literature outlined in Chapter 2 grounds my choice of methods and methodology. I will go into detail of how I generated data with participants in Yellowknife, how I analysed my data and verified my empirical conclusions. I also use this chapter to address some of the challenges and shortcomings of my work in the NWT and the implications on my thesis.

Figure 3-1: Location of Yellowknife, NWT, on the Great Slave Lake in Canada

3.1 Applying a Grounded Theory-inspired method

Without following the Grounded Theory Method (GTM) to the letter of the law (e.g. as discussed by Bryant, 2019), I used the spirit of GTM to approach my research with a reflexive, adaptive and iterative openness. I chose this inductive approach because I originally only had loose ideas about the theoretical contributions I wanted to/could make with my work, and my general research aims. As my research progressed, I used tools popular in GTM such as note-making and coding in the software NVivo to establish the core themes around which my chapters have come to be structured – movement, mineral potential and historical mining legacies. As such, I used strategies from GTM (e.g., Bryant, 2017) to ensure that I approached my research topic reflexively and iteratively, with fieldwork and analysis continually building upon each other:

First, I began my doctoral work with a research agenda I was willing to have put-at-risk by the conversations and encounters I had with people in academia and the field. This method played out by exploring research opportunities and allowing myself to be steered in different directions in response to how my engagement with my field site evolved alongside my understanding and exploration of theoretical literature. This enabled me to become "entangled in relations and objects" which made "actions and thoughts inseparable" (Vannini, 2015, p. 15) so that "there [was] always the possibility for subtle and sometimes not so subtle shifts in trajectory" (Hinchliffe, 2000, p. 576).

Second, although antithetical to the approach that Glaser and Strauss advocate in their early work on GTM (Glaser, 1978), I stayed 'in touch' with theoretical literature throughout my research. As Bryant (2017) and others (e.g. Wiener, 2011) discuss, keeping an eye on emerging literature in a context where new work is frequently produced is necessary for keeping on top of empirical developments. Furthermore, claiming that I separated literature from fieldwork would contradict the assertion I made earlier that our framings of reality are based on background worlds. Since undergraduate study I have cultivated certain theoretical-political views of the world, the study of geography and research as practice which both informed my choice of thesis topic and are largely inseparable from how I embed myself in and construct the world around me. Thus, to reject an iterative return to theoretical literature throughout fieldwork and allow my understandings and actions to be informed by this would have been artificial and practically impossible.

Returning to literature or exploring new avenues was also important for bypassing or overcoming intellectual impasses during fieldwork, data analysis and write up stages. Indeed, exploring new literature – e.g. Graham Harman's Object Oriented Ontology (2018) – allowed me to experiment with different ways of framing or thinking about an issue with my interviewees. It allowed me to take risks and was a small way I played with experimentalism in my research (Dewsbury, 2010). For example, I sat with one geologist, *Interviewee 33*, who was the most patient participant I interviewed. I presented my philosophical musings to him and played with some of the ideas that Harman discussed and tried to apply these to how geologists understand and approach their work. Eventually, Harman's framing seemed to add little to answering the questions I had, but one of my most useful interviews was generated off the back of this ad-libbing and the shaking-off of previously semi-structured approaches I'd had towards generating materials. Straying from traditional GTM therefore enabled me to 'keep it fresh' and not remain stuck in the circular, sometimes seemingly monochrome findings I was getting with my research.

Third, I did stick to more classical GTM approaches and tools such as writing memos and keeping a daily research diary. These methods were important for reflecting on what I had seen, heard or felt that day, and enabled me to recognise fleeting ideas that reappeared throughout my fieldwork. It also helped me keep abreast of the wealth of information and new experiences I was encountering on a daily basis. The collective force of my memos over the months enabled me to understand the significance of different themes and explore ideas further in subsequent interviews. The memos therefore allowed me to start with general observations from my ethnography and spiral in and focus on "the powerful abstractions that can encapsulate significant aspects of the detailed data" (Bryant, 2017, p. 28-29).

Memos were important throughout my research – both during data generation and in data analysis. In the later stages when I was colour-coding key themes in interviews in NVivo, I wrote memos to accompany this process to 1) understand what was emerging in the data and 2) rationalise how and why I was coding, for later reference. Memos were critical during the analysis stage, particularly for writing Chapter 5, since my empirical data was a tangle of descriptive verse and interviews about geologists' working lives. I went through multiple cycles of coding and re-addressing my empirical materials, first working generally and then homing in to make refined definitions between interviews and interviewees' statements based on key ideas that emerged around the theme of bodies, movement and lines.

3.1.1 Applying the GTM and drawing on the ethic of theoretical literature

The research ethic with which I prepared myself for an entered the field was critical in enabling me to answer my research question and achieve the aim of understanding how geological space is constructed and enrolled into resource futures. GTM enabled a multiplicity of worlds and analytical openings to emerge, providing colourful perspectives on my three research questions (page 10).

To answer these research questions required digging into the background worlds/hinterlands that underpin geoscientific knowledge and framings of geological reality and space. This 'digging' underpinned the production of Chapter 5 and created a knowledge base upon which I grounded Chapters 6 and 7. Opening up the background worlds therefore created a pathway through the complexity of geological information to help understand how geologists' ways of knowing the world shaped the framings of geological space and resource potential as communicated in public and policy spheres. Thus, the reader of this thesis will note how Chapters 5, 6 and 7 sequentially build on each other, where understanding the nuances of geoscience creation is necessary to understand *how* that science is used and with what potential political implications. My methodology therefore seeks to ground environmental-political critique in empiricism (Latour, 2004).

To answer this thesis' first research question: '*How do geoscientists produce cartographic representations of geological space?*', I sought to understand how scientists describe and relate to the things in the world that are "complex, diffuse and messy" (Law, 2004, p. 2). The Earth with a 4.6 billion year-old architecture of tectonic, sedimentary, erosive and climatic processes scattered across and creating landscapes, is a messy subject and is "more excessive than we can theorise" (Dewsbury *et al.*, 2002, p. 437). Geologists are dealing with a vibrant subject that has been continually in the making and undoing for millennia. To understand geology therefore requires certain framings, practices and compromises about what to take notice of and draw into stories about how the Earth's landscapes came to be.

An ethnography is suited to understanding these rationalisations because it enables a focus on the processes and meanings that geoscientists give the world that underpin and hold their discipline together (Herbert, 2000) as well as focus on the more-than-human (geologic) actors that generate their scientific material (Whatmore, 2003). Ethnography therefore lends itself to understanding the cartographic representations that flowed from geoscientists' engagements with the world not as reflections of a reality, but as outcomes of processes involved in the 'doing' of cartography. This approach to understanding material-bodily relations in scientific production practices has been readily used in geography, in particular by Lorimer (2008) and Powell (2017). I drew inspiration from these two authors because they apply cultural geographies to look beyond the Latourian mechanics of producing science, and do so using ethnographic practices that involved shadowing and interviewing scientists in their places of work. Their approaches allowed for colourful and diverse research outcomes that enabled a balance between understanding the practical processes and implications of what was happening on the ground with a wider networked view of how science was being enrolled into structures of power and epistemological control.

3.1.2 Finding materials that matter

In order to give credence to the significance of the material world in influencing how geologists worked, I had to learn to recognise the moments and things that caught geoscientists' attention (or, after Bennett, 'enchanted' them). Using Bennett's (2001) work on enchantment and the more-than-human, I tried to notice those things which held geologists' focus: the Earth's elements and histories that kept them asking questions or returning to the field to understand more. This enabled me to identify what it was about geology's materiality that was significant to hold geologists' attention in a moment. Thinking about the materials in this way was a methodological choice made to frame geology as an active agent in its constitution and translation into 'fact' by humans.

However, gaining an understanding of "how the world makes itself known" (Whatmore, 2003, p. 4) through its materiality required me to build long-term relationships with the geologists working at the NTGS via participant observation in order to gain a familiarity with key principles and concepts in geological science. Owing to the Arctic climate in Yellowknife, I spent much of my ethnography with the geologists in their offices rather than in the field. Access to the geological library at the NTGS enabled me to use geoscience resources to understand basic principles that geologists would have been trained in to conduct field research. Back in Oxford, I also attended first-year undergraduate classes in geological mapping on the BSc Earth Sciences course to help me better understand some of the basic principles I had encountered geologists using during my fieldwork in Yellowknife. I therefore generated a lexicon of the methods geologists discussed with me and began to be able to broadly relate them to different methods of generating geoscience data discussed in geoscience literature.

Added to this, it was my expectation that what geologists say they do and what they actually do when they map would be different (Powell, 2017). This prompted me to look out for (material) themes that consistently emerged in conversations or interviews, but perhaps weren't placed centre stage by geologists during our discussions. These 'quiet' themes, the practices which seemed so quotidian they didn't warrant special attention in geologists' accounts of their work, were what I wanted to look out for – the practices that were holding the whole together. Added to this, by spending many months in the geologists' company, whether at the NTGS offices or in other situations like the pub, shooting range, kayaking or on hikes enabled me to establish 'scales' of enthusiasm and ways of talking about their research and the world around them, or what Dewsbury *et al.*, (2002, p. 437) call "processual registers of experience". Therefore, when I followed the geologists into the field or when I conducted interviews about work geologists were doing or had completed, I was able to gauge levels of excitement, interest or frustration about their work against what I already knew of their personalities.

3.1.3 The Background World Underpins the Rest

To establish answers to RQ1 required an inspection of the background worlds that quietly underpinned the work geologists did. RQ2, *'How do the methods of 'knowing' geology affect how it can be enrolled into future-making?',* required examining the link between science and policy. Working from Latour (1999) and Braun (2000) that scientific representations – such as geological maps – are utilised outside their centres of calculation, I wanted to know what sort of story science was being used to tell. Therefore, I focussed on the Mineral Potential Map (MPM) of the Slave Geological Province which was a culmination of geologists' maps sewn together using a method of mineral potential evaluation. Here, two background worlds met in this cartographic representation – that of field geologists and of economic geologists.

A non-representational approach that attended closely to the process and practices that brought the MPM together was vital in enabling me a critical perspective on how 'readings of the Earth' were being entrained in the NWT's resource futures (Vannini, 2015). This critical reading of the Mineral Potential Map therefore required an understanding of how the geological representations were assembled and why. The work of Kama and Kuchler (2019, p. 108) was important for understanding how the map worked as a "performative device", promoting a particular future, and assessing how the map's message of mineral wealth in the

NWT married with policy objectives around expanding territorial control and resource extraction in the region. Kama and Kuchler's work created the methodological bridge between non-representational geographies and STS with political geography and resource geography.

With the background world of geoscientists established in Chapter 5, and the performative devices of their work assessed in Chapter 6, using STS literature Chapter 7 examines how science is made political in the public realm and thus asks *'What outcomes do these enrolments have on power dynamics in a resource landscape?'*. Here, I used methodologies stemming from Public Understanding of Science literature to focus on *why* intermediaries conduct public engagement events – i.e. their rationale for communicating science with publics; and the *content* of their communications (Irwin, 2014; Stilgoe, Lock and Wilsdon, 2014). In particular, the foundational knowledge generated in Chapters 5 and 6 enabled a critical evaluation of the types of information being shared and political framings they were given, as discussed in Chapter 7. There, bearing in mind Wynne's (2006) work of historical trust issues between publics and institutions, I drew inspiration from Bickerstaff's (2012) geographical method that combined the use of archival methods to place public-institutional histories and contemporary matters of environmental concern in tension with one another. As a result, this approach enabled me to draw links between historical relations with resource extraction and public engagement processes and contemporary resource extraction plans.

3.2 In the Field

Fieldwork was carried out under Aurora College research license numbers 16396 (2018) and 16444 (2019), which allowed me to conduct an ethically approved ethnographic study in the city of Yellowknife and surrounding towns.

Yellowknife was originally chosen as a field site because the only Indigenous-owned mineral exploration company in Canada – DEMCo. – is based there. Early in my research, I tried to target DEMCo. to understand how Indigenous corporations can be better involved in/become central to the development of (mineral) resources on their traditional lands. This geopolitical issue drew my attention to the NWT as a place where unique political, social and geological activities were in play. Some months before fieldwork I realised it was unfeasible to focus on DEMCo. as a case study for my whole thesis. However, I had already conducted significant background research into the NWT and had begun making local contacts whilst attending the March 2018 Prospectors and Developers Association of Canada conference in Toronto. Through this preliminary work, I began to recognise the scope of exploring how geological space is mapped, by whom and with what consequences. Simultaneously, in early 2018, the GNWT was proposing changes to the NWT Mineral Resources Act (MRA), in particular changing the way in which geological data is collected, stored and made public. I sensed an interesting intersection between legal geographies, the production of economic space/territory, and industry/public/academic information on public goods. Once I arrived in Yellowknife and pursued these questions, I found that work on the MRA went on behind closed doors and government representatives were unwilling to discuss its development and implications in any meaningful depth. I very quickly lost interest in this subject area but the implications and methods of space-making through geoscientific practice began to open before me as I conducted more interviews. These early false starts helped me understand the legal-institutional context of the NWT and helped inform my understanding of some of the socio-political and economic relations around the resource development nexus in the NWT.

During my early explorations of how geological space is made, I was discouraged from pursuing a private industry perspective during informal conversations with geoscience managers at Rio Tinto (part-owners of the Diavik diamond mine in the NWT) and Aurora Geosciences Limited, a consulting firm in Yellowknife. They suggested that non-private organisations, such as the NTGS, would be easier to access and would be more accommodating to the academic interests I expressed. As such, my research resulted in focussing on the GNWT's construction of geological space and geological/political-economic territory, and their making of geo-economic subjects in citizens. In hindsight, I believe this was good advice for a number of reasons.

First, accessing and staying at one of the remote diamond mines would have been prohibitively expensive and would have meant my fieldwork would have only lasted weeks, rather than months. Second, the geological mapping that industry geologists do and often the methods they use are proprietary information and it is unlikely I would have been able to publish or discuss any of the findings of my research with my peers or publicly. Third, governmental organisations in Canada have an obligation of transparency towards their citizens, making it easier to ask questions about what they do and why, whereas private companies do not. This means that the incentive to share information with me, a researcher with no benefit to them, was nil. However, I would suggest that future research *does* look at the industry side of geological knowledge generation since it is the major contributor and holder of geoscience knowledge, and it therefore is important that those groups that hold vast amounts of information about public goods (geology) and sustain a multi-billion-dollar global economy should not escape critique. I would recommend though that other researchers choose sites that are less remote and therefore more feasible to access.

The ethnography I conducted in Canada was multi-sited and relied upon several methods to generate research including interviews, participant observation, work-shadowing and event-ethnography. The following sections will explore each of these facets of the ethnography in turn.

3.2.1 Ethnographic sites

Following the suggestion of industry representatives in Yellowknife, the majority of my time in Canada was spent conducting an ethnography at the NTGS offices in Yellowknife. After preliminary meetings with team leaders there, I quietly settled in to the 'visiting researcher' desk and set about learning about the work the NTGS does.

The NTGS is the Northwest Territories' office that deals with all things geoscience. It is part of the GNWT's Department of Industry, Tourism and Investment (GNWT-ITI). The Survey is responsible for conducting original research and primary data gathering, as well as storing and managing access to industry data that is submitted to the GNWT. As such, the NTGS works as an intermediary between geoscience and geoscience users by providing access to historical data via their online data registry and physical geoscience library. The NTGS has a broad mandate of generating geoscience knowledge about the territories (including through mapping, mineral deposit assessment, petroleum analysis, GIS services, and permafrost and infrastructure monitoring), and providing outreach services to communities and schools (Government of the Northwest Territories, 2017). Not only this, the NTGS is also a regional 'hub' for collaborative work, with students and researchers coming from universities across Canada and beyond to be supervised by and involved in the NTGS' field work. The NTGS is separate from the Geological Survey of Canada, which has different mandates and research objectives for the Territories which feed into national resource strategies (Natural Resources Canada, 2018). The GSC does not have the same reliance on the NTGS' infrastructures (transport, tools, field planning) as academics do, thus enabling them to work more independently of their Territorial cousin.

Figure 3-2: Main entrance to the NTGS offices in Yellowknife. Image source: Author

Richard Powell's (2017) work "Studying Arctic Fields" helped guide my work conducting an ethnography amongst scientists. Powell complements his ethnography in Resolute Bay with interviews from Government of Canada employees elsewhere in Canada and archival research around the politics of doing science and claiming territory in the high Arctic. During his time in Resolute Bay, Powell slowly generated data by spending time with scientists conducting research at the station – both during 'down-time' e.g. in the canteen, and while they were working in the field gathering data. This multimodal approach facilitated my thinking about how I should engage with my research informants and expanded my view as to what 'counts' as research.

I translated Powell's approach into my own in Yellowknife by attending both work and 'down-time' activities at the NTGS such as staff meetings, brown-bag lunch presentations (which I also presented at) and a field trip to the local Giant Mine property. More obscure activities outside the office included 'Bear Defence Training' (shooting a high-powered rifle at a photo of a bear while shouting "BEAR! BEAR!! BEAR!!!") and taking part in a snow-shoe relay marathon with some geologists in -40ºC in March 2020. Pub trips, dinners, hikes and canoe trips were also formative in my understanding of how geologists related to the world around them. Through this mixture of approaches I gained an insight into the political, epistemic, technological and socio-cultural practices and negotiations occurring amongst the geologists in the office.

In practice, my ethnography involved me spending on average three days per week at the Survey, where I was offered a desk which was in the middle of their office. My physical position in the office's main thoroughfare was fantastic for allowing me to get to know and speak to the different staff working there. It allowed short, informal conversations to take place while staff used facilities like the coffee machine and photocopier. This was very beneficial especially when engaging with a group that was time-pressed, and also for overhearing conversations between geologists.

Whilst at the NTGS, I worked most closely with staff in the Mineral Deposits and Bedrock Mapping (MDBM) and GIS groups. Other working groups were also present at the NTGS including Environmental/Permafrost Science and Energy Geoscience, but I did not have extensive working contact with them. I was kindly invited to join some of the meetings for the MDBM group which allowed me to understand some of the organisational priorities of the Survey, particularly in relation to data management and fieldwork plans. The staff at the Survey were welcoming and curious about a non-geologist being in their midst asking them strange (and for them very basic) questions about maps and field methods. My fieldwork thus constituted what Nader (1974) and Gusterson (1997) termed 'studying up' (which Powell (2017) also discusses in his work) – having research subjects at a higher power level to myself. I was aware throughout my ethnography that at any moment my not-quite-invitation-but-accepted-presence was liable to rejection which did create a sense of vulnerability when I spoke to some of the NTGS staff about topics that were political, like the Slave Geological Province Corridor.

3.2.2 Event Ethnography

I attended the Yellowknife Geoscience Forum conference in November 2018 where I listened to three days of presentations relating to (amongst other things) regulatory developments in the NWT regarding resource extraction, recent government mapping and research programmes, academic geoscience presentations from Canadian universities, and industry updates on exploration and development of their mineral properties in the NWT. The Geoscience Forum provided an important platform from which to network with different mineral interest groups and reach individuals who were not normally resident in Yellowknife. It also gave me chance to establish a more detailed landscape of the different actors, agendas and ambitions at work in the NWT.

In addition to this conference, I attended an investor luncheon in April 2019 organised by the Yellowknife Chamber of Commerce for the local gold exploration company TerraX (now GoldX). This provided me with a flavour of the speculative narratives with which junior mining companies try to promote their properties to potential investors. The luncheon also highlighted the importance of potential mineral development projects to local business, several of which were Indigenous owned, with representatives attending from the catering, transportation, construction, and general contractor industries.

3.2.3 Work-shadowing

I was also able to join some geologists and prospectors in the field. First, I joined a Yellowknife-based prospector for an afternoon in the bush in mid-October 2018 before the first snow fell. This allowed me to understand the importance of 3D imagination and movement through the field in pursuit of geological clues. This trip was crucial in making me pay attention to things that drew geologists across the landscape in particular movements. In summer 2019, I attended the Mine Training Society Prospector Course, which was a two-day long classroom and field workshop designed to show beginners the basics of prospecting, from staking and recording a claim to identifying potential minerals on the ground. Again, this trip emphasised the ways in which geological materiality affects the methods of geologists and prospectors in the field, and the institutional structures within which resource extraction takes place.

I also spent a day with two geologists from the NTGS at the old Giant Mine site, where we spent time slowly moving over the geology and puzzling together how it came to be deposited there. This trip did not represent 'primary' geological mapping, since geologists have worked on the area and generated considerable knowledge about its evolution since mining began in the 1940s. However, it did offer the opportunity to understand the different methods that are used by the geologist in the field to create a 'story' of the area and allowed me to make note of and learn the material signals that enable geologists to make cartographic representations.

3.2.4 Beyond Yellowknife

I supplemented my work in Yellowknife with a short trip to Vancouver and Calgary, where I carried out further interviews with individuals working at the British Columbia Geological Survey, Geological Survey of Canada and as private consultants. These geologists had experience of working in the NWT, but their perspectives came from different institutional settings which helped highlight some of the particularities of work produced in the Arctic by geologists based at the NTGS.

I remember in particular the geologist at the GSC in Vancouver showing me a map he had made of part of the Rocky Mountains in Alberta. I was struck that the maps had much more complexity portrayed, and were overflowing with references to human settlement, which were absent on maps in the North. The reason being not because they did not want to convey human presence in the NWT, but rather because there was no human infrastructure to mark on the maps they were producing. Although obvious in hindsight, it highlighted that maps are usually more-than-geological and are embedded within cartographic representations of human economies such as infrastructure and settlements. Furthermore, it demonstrated the detail with which mapping could be done in areas more easily accessible to researchers, underlining the importance of access geology for production of geoscience knowledge. Another example was visiting the BCGS offices in Victoria, I realised that the scale of their institution was much larger than the NTGS, highlighting both a larger pot of funding in BC, but also a greater diversity of geological research within the institution. Meanwhile, the GSC offices in Vancouver were eerily empty and the geologist I met with seemed to work alone on his floor of the office space. Having these points of comparison as well as the additional interview resources was important for contextualising how mapping is done in the

Northwest Territories, and contributed an understanding of how much institutional culture, size and geography contributed to the methods[8] and outputs the NTGS made.

In February 2019 I also visited the town of Norman Wells in the NWT on the Mackenzie River. I was hosted by the GNWT and thus enabled to attend the GNWT-ITI's Resource and Energy Development Initiative (REDI) outreach event in the town. Here, I observed participants and facilitators as they discussed natural resource development, and also interviewed the facilitators of the event to understand their rationales for conducting the REDI programme. I discuss this event and my methods there in greater detail in Chapter 7.

3.2.5 Interviews

Ethnographic methods such as interviews enabled me to bring "meaning and construction to the foreground" (Holstein and Gubrium, 1995, p. 73) and push for discussions about the constitution of the geological world by asking interviewees to explain the assumptions they made of the Earth from their geosciences backgrounds (Plesner, 2011).

Interviews were conducted both within the NTGS and in organisations beyond it. All interviews were semi-structured, since I had plans for what I wanted to establish from our conversations. I organised interviews after informal conversations to obtain data to answer RQ1 and develop sufficient geological knowledge that I could answer RQ2. I spoke primarily with the geologists working in the Mineral Deposits and Bedrock Mapping and GIS working groups who were on the 'front line' of the NTGS' mapping projects. To provide traction

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[8] For example, field projects run by NTGS staff were often large, but had perhaps one or two NTGS staff geologists but many more 'imported' from the GSC or academic institutions.

and enable empirical critique for RQ2 and the Mineral Potential Map, I carried out interviews with geologists at the NTGS and within GNWT-ITI who had deposit modelling and economic geology backgrounds. These informants provided me with an understanding and perspectives of how 'best-practice' and 'top of the range' mineral resource maps compared with the MPM produced of the NWT. I supplemented their knowledge with academic literature in economic geology that provided me with global case studies and processes of mineral resource mapping (Singer and Menzie, 2010).

To supplement my time at the Survey, I also conducted semi-structured interviews with non-governmental employees in Yellowknife and beyond, including industry, NGOs, other academics and advocacy groups. These interviewees were identified through snowballing or from published reports or local news articles and were important for balancing the government/policy perspective on resource extraction with an understanding of industry and non-industry priorities in the NWT.

Table 1 outlines the breadth of individuals spoken to during my research. In total, interviews were carried out with 59 people, some of whom were interviewed multiple times, and each of whom I asked to audio-record. Ten participants preferred to have written notes taken during their interview. I note the recording method when using quotes or ideas in my empirical chapters. In both instances, the transcription/typed notes were shared with interviewees in the days after interview via email for them to check and make any comments on. This was an important step in ensuring trust, working ethically, maintaining a rapport and sustaining a conversation after a meeting. Transcribing interviews soon after I conducted them also enabled me to revisit pertinent aspects of conversations overlooked during the interview itself, allowing me to reflexively sculpt my subsequent research focus and interview questions.

I also spoke with government workers such as policy makers and implementers. In particular, I made strong contacts at the GNWT-ITI. More widely within the GNWT, I also conducted exploratory interviews with representatives from the Departments of Environment and Natural Resources (ENR), of Infrastructure (INF) and Lands, to try and understand some of the possible economic and environmental impacts of the proposed Slave Geological Province Corridor (SGPC). ENR's perspectives helped me balance some of the potential socio-environmental risks and benefits of Arctic infrastructure development promoted by the GNWT-INF and GNWT-ITI.

In addition to GNWT representatives, I also interviewed representatives from the Yellowknives Dene First Nation and Members of the Legislative Assembly (MLAs) of the NWT to discuss the SGPC proposal. Interviews with the former provided the perspective of an Indigenous stakeholder in the project, contributing an evaluation on the potential economic and labour benefits of a long-term construction and road maintenance programme for their Yellowknives Dene-owned businesses and employees. Conversations with MLAs sitting in the 2015-2019 assembly and representing Yellowknife constituents and other ridings highlighted the overall political support for the SGPC project within the Legislative Assembly. It also furthered my understandings about the developmental priorities of different ridings. In particular, themes around Northern employment and contracting opportunities for Northern business were dominant in these interviews.

Beyond government, I also spent time interviewing environmental regulators, NGO representatives, and pro-mining lobbying groups to understand key issues facing/caused by the mining industry in the North. Primarily, infrastructure access was a concern to all parties – either through a lack thereof (pro-mining lobbyist) or because of threats to tundra ecosystems (ENGOs and regulators).

Table 3-1: People interviewed for this research

Interviewee Type	Subgroup	Count	Description	Total Count
Geologists	*Government Geologist*	14	Geologists employed by NTGS, BCGS, GSC	28
	Industry Geologist	9	Geologists working at mining companies and geoscience consultancies	
	Geology Student	2	Geologists completing MSc and PhD research degrees	
	Prospector	1	Individual experienced in prospecting industry	
	Mining-Associated Business	2	Individuals working in industries secondary to mining such as construction, logistics, catering.	
Governmental	*GNWT Policy and Services*	8	Individuals working in policy and services for the GNWT Departments of Industry Tourism and Investment; Infrastructure; and Environment and Natural Resources	15
	Indigenous Government Representative	2	Individuals speaking on behalf of the Tlicho Government and Yellowknives Dene First Nation	
	Member of the Legislative Assembly	5	Individuals sitting in the 2016-2019 Legislative Assembly of the Government of the Northwest Territories	
Other	*Environmental Regulator*	4	Individuals representing local regulatory boards responsible for processing mine development and remediation applications	12
	Lobby Group	3	Individuals representing local and national pro-mining lobby groups	
	Environmental NGO	3	Individuals representing environmental charities based in the NWT	
	Academia	2	Individuals engaged in academic work at the mining/environment interface in the NWT.	

Total	**59**

3.2.6 Volunteering and extra-curricular activities

From February until August 2019, I also spent time (2 days per week) working in the offices of the environmental NGO, Ecology North, based in Yellowknife. I did this not only for a change of scene, but also to integrate myself within different communities in the city. At Ecology North I was able to contribute to volunteering efforts, for example helping organisers of the NWT Bee Symposium (unrelated to my research but an excellent networking opportunity). I helped research and write Ecology North's responses to proposed changes to petroleum and mineral extraction legislature and gave my time to Earth Week. A diverse set of satellite groups was involved in Ecology North's activities, particularly during the legislative campaign, including Canadian Parks and Wilderness Society (CPAWS), WWF Arctic, and Alternatives North. Building rapport with and holding informal conversations with representatives and members of these communities was critical in providing me with perspectives of land-based activities that stretched beyond the geological/extractive industry. In essence, it provided some balance to the strongly pro-mining message that I heard within geology networks.

In July 2019, I volunteered for three days at the Yellowknife music festival 'Folk on the Rocks', one of the highlights of the city's cultural calendar that many residents attended. Although also unrelated to my research, it was a very effective way to show face and support a community-organised event. Together, volunteering at Ecology North and Folk on the Rocks helped me settle into the community and demonstrated that I actively wanted to contribute to the environmental priorities and cultural events that were important to (some) Yellowknifers.

I also joined the Yellowknife broomball teams the 'Swamp Donkeys' and 'Nunatics', to play a sport apparently invented by bored ice-rink janitors. In addition to being good fun, the sport gave me access to a demographic I was otherwise not reaching through my volunteering and interviewing work – individuals working in sectors such as construction, mine employees, firefighters, lawyers and accountants. Making friends with my teammates allowed me to learn about members of the Yellowknife community I would otherwise not have met.

Although hugely fun, I strongly believe that my volunteering and sporting activities were critical in giving me a more rounded perspective of life in Yellowknife. It fleshed out my ethnographic methods by 1) expanding my network of 'concern' so that I could see how far my research topic stretched into different community areas; 2) improved my renown within the community so that people would recognise me and say, 'this researcher is contributing and not just taking'.

On the flip side, however, this social intimacy did create challenges as I began writing my empirical chapters. Part of me felt an imperative to tell a story that was 'morally' right (from whatever perspective that may be) and take a normative stance on resource development in the Territory based on the fact that so many people's lives are dependent on its existence, and because many people stand to be positively and negatively impacted by it. It took diligence to retain an academic voice that did not try to make normative judgements about the Territory's future, but rather retain a perspective that spoke to what was happening, what politics were in play, rather than where is should go. I strongly believe and continue to (despite encouragement from some research participants) that it is not my place to make any commentary about whether the resource economy in the NWT is good or bad, for example, since I do not stand to be affected by it. What my work will do is enable others to make that judgement for themselves.

Lastly, although not hugely discussed in ethnographic methods books, I found that volunteering and sport were of critical importance for me to be able to conduct successful research in this small town. Just as Flachs (2013) describes of his experiences volunteering in a community garden, for me, these efforts helped level the imbalance between myself and those who I was interested in working with or learning from, helping dissolve division between subject and researcher. It allowed me to produce a new identity within the community: team-mate, volunteer, colleague, rather than solely being a researcher and carrying around the burdens of expectations that potential research subjects might have of me.

3.3 Engaging with Indigenous perspectives and research participants

An omission you may have noted in the above description of my methods is the relatively limited attention Indigenous groups, governments and people were given in my thesis. This omission is important because "the ways in which scientific research is implicated in the worst excesses of colonialism remains a powerful remembered history for many of the world's colonized peoples" writes Maori scholar Linda Tuhiwai Smith (2012, p. 1). Smith describes how, growing up in a Maori community, "research was talked about both in terms of its absolute worthlessness to us, the indigenous world, and its absolute usefulness to those who wielded it as an instrument" (ibid. p. 3). Throughout fieldwork, I was cognisant of my positionality as a foreign, uninvited researcher entering Indigenous traditional territories with my own research agenda, and the potential I had to reproduce extractive research practices and deliver damaging (or at least unimportant) research outputs. I was, and still am, concerned about engaging in research as extraction, rather than research as collaboration or coproduction. You will have noticed that my engagement with Yellowknife's communities was primarily with white settler groups. This reflected the demographic of those in geoscience production and government policy making around mineral resources.

Despite my repeated attempts to reach out to Indigenous organisations throughout my fieldwork period and prior to it, a primary challenge during fieldwork was the lack of collaboration I was able to generate with Indigenous research organisations or governments, and the lack of alignment of my work with the research priorities of these groups. My research topic concerns a knowledge economy that informs an industry that impacts Indigenous traditional lands and contributes a significant source of income for northern Indigenous businesses and families. I felt therefore that Indigenous perspectives should inform my work, however this was challenging to achieve. This challenge also reflected the relative exclusion of Indigenous people from sites where science and policy decisions about extractive resources were being made. Yet, my primary interest was on how the subterranean is enrolled into *Western* structures of knowing, bounding and exploiting mineral resources. Therefore, acknowledging the complexity of land and geology as a socio-cultural-political assemblage by accounting for non-Western relations to it was beyond my research objectives. This was a tension I felt throughout my research and it took time to accept that focussing on Western knowledge production did not mean that I was dismissing, discrediting or undervaluing Indigenous knowledge, but rather that Indigenous knowledge was not actually a component of geoscience knowledge production.

I sought therefore to recognise that Indigenous peoples in the NWT may have different experiences of, relations to, or knowledges about geology and resource economies than settlers or geologists themselves, without trying to represent exactly what they were. I was nervous of enacting performative and shallow rather than meaningful engagements with Indigenous peoples that such representation might require. As Mushkegowuk scholar Michelle Daigle (2019) notes, although performative engagements acknowledge the pre-settler presence and rights of Indigenous people, spectacles of engagement do little to actually positively change or challenge relationships between settlers and a colonised people. Instead, such actions work only to assuage settlers' (or researchers') anxieties about consulting and engaging with Indigenous people.

I discussed this dynamic with Allice Legat and Joanne Barnaby. Allice is an anthropologist working with the Tlicho Dene and long-term Yellowknife resident, and Joanne a Dene consultant working out of Hay River in the NWT. We discussed how I should engage Indigenous perspectives without it being purely performative, since I was unsure how exactly they could be involved in my research, and what space I could make for a meaningful engagement with Indigenous perspectives whilst retaining my focus on distinctly European ways of knowing and living in the world. These questions were less pressing while I was working with geologists at the NTGS but became pertinent when I drew my attention away from the institutional level and looked for example how at geoscience knowledge was moving within communities and to what effect. This was particularly pertinent when discussing the potential impacts of the SGPC on caribou migration (a theme I did not pursue but danced with for some time). Allice and Joanne suggested I make use of the 1970s Mackenzie Valley Pipeline Inquiry (MVPI) archives for Indigenous voices about resource development and relations with other-than-human beings and the land, and to allow for some of the Indigenous experiences and perspectives about land-based relations to emerge. The MVPI archives provided richer, more detailed accounts of First Nations, Metis and Inuit life from across the NWT in the mid-twentieth century than I could have gained through poorly planned, aimless and questionably unethical discussions with Indigenous people in my research. Their suggestion to focus on the MVPI archives also encouraged me to look through the archives from more recent public consultation events held by the Mackenzie Valley Review Board. These archival materials provided more contemporary perspectives on resource development proposals, and similarly to the MVPI, provided me with perspectives from communities outside Yellowknife, whose experiences of resource development differed to those I had heard echoes of in my time in the city.

A final challenge I encountered concerned the methodological approach I had entered the field with. Using Grounded Theory-informed methods and embracing John Law's messiness (2004) created difficulties of setting concrete research agendas which I could discuss with Indigenous governments and researchers early in my work. Of course, I knew broadly what my research interest was in – how we understand the geological world – but only after I worked and reworked the data I gathered did it become apparent why my findings mattered. I felt it was therefore impossible to say, during the early stages of my fieldwork, what the exact objectives of my research were and communicate these clearly with representatives of Indigenous governments and research institutions. My vagueness mattered less when I was discussing this with the geologists at the NTGS, who mostly seemed amused by my poorly defined research objectives, rather than affected by it. Yet I learned from informal conversations at the Yellowknife Geoscience Forum with Tlicho and Yellowknives Dene government representatives that their staff were often so overwhelmed with volumes of work that they would have limited time to participate in my research, which had unclear benefits to them. Understandably, they wanted clear and succinct answers as to how their potential involvement in any research would be of benefit to their communities and how it married with their research agendas. These were answers I could not give, especially during the first 6 months of my work when building working relations would have been crucial.

Related to this, an aspect that I should have better anticipated before entering the field was the time it takes to build relations and trust with Indigenous community members relating to research production, as a result of the historical power dynamics that Smith (2012) explains. The capacity of different Indigenous governments varies, depending on whether they have their own research division and dedicated staff (like the Tlicho government does) or whether they are in the nascent stages of developing such capacity (like the Yellowknives Dene). I do not believe that it is possible to nurture authentic relationships with Indigenous communities during the course of one field season or academic year, when it is known your presence on their land/in their community is temporary. It prompts the question as to whether graduate students should expect to be able to do good research with Indigenous groups without an established relationship, when not working as part of a longer-term project or unless invited to address some of their research agendas.

Despite these shortcomings, I do believe that the research I have produced is relevant to a broad range of actors, including Indigenous communities and governments. Whilst writing, I have sought not to take a tone that seeks to represent or presume the positionality of different Indigenous groups in relation to resource development but have used public statements and archival materials that comes from their governments and communities. I think this approach authentically reflects the complex diversity of perspectives and feelings around resource development in the North (c.f. Sacco, 2020 on this). I hope I have therefore produced a thesis that, although not contributing directly to governments'/communities' research agendas, acknowledges Indigenous peoples' position as traditional land users and as autonomous, self-governing groups who should be treated as major players in the extractive agenda, rather than as 'just another stakeholder' in a given geographical area.

3.4 Reflecting on the validity of my empirical findings

To ensure that my research outputs were valid and meaningful, I invited research participants to read my empirical chapters in their final draft stages and also presented my initial findings from fieldwork to the NTGS staff in August 2019 and again in March 2020. This enabled me to confirm that my factual understandings of, for example, geological processes and methods were accurate and assured my research participants of the credibility of my work (McGinn, 2010). This in turn adds to the broader trustworthiness of my work since it demonstrates internal validation and highlights that my ethnographic methods were effective at capturing aspects of geoscientists' professional lives that appropriately and accurately reflected the mapping work they do. Whether the results of my research would be replicable beyond my field site is more difficult to say. Should I or someone else repeat my field methods in another institution, or within an industry mapping project, they would find different social dynamics and political priorities guiding the mapping process from those I identified at the NTGS. However, from what I observed at PDAC, the Yellowknife Geoscience Forum as well as learned from Earth Science classes at Oxford University, the central idea of walking-as-method that I discuss in Chapter 5 is integral to geoscientific practice in the field.

My research was not without bias, since human objectivity is impossible (DeRoche and DeRoche, 2010). I took a social constructivist view about how knowledge of the world is produced and decided prior to fieldwork to focus on the materiality of scientific practice. As a result, this brought particular perspectives and practices to the fore which might not have been picked up on had I approached the research aim from, for example, the perspective of gender. Clearly, it also means that I miss out other aspects of understanding the role of mapping in resource development that are pertinent to the political landscape. A closer attention to the demography of my research participants for example would reveal a story of space-making with different nuances, histories and implications. However, my academic priorities still enable me to deliver a fresh perspective on the production of science and invites a conversation about the objectivity of scientific objects in the resource development domain. Therefore, the focussed approach I have taken is not negative, but adds to the wider conversation about how we understand what science and scientific practice are and how they relate to our socio-political lives.

3.5 A note on mental health and wellbeing in the field

Shifting briefly to discuss fieldwork on a personal level, I found my initial move to Yellowknife in September 2018 incredibly mentally challenging, since I struggled to set up networks not related to the NTGS and had not yet integrated well into the Survey's team. From mid-October, the days quickly drew in shorter and come mid-November, I was faced with six hours of daylight per day, temperatures of -30ºC, and a permanently grey sky, land and lake. I lived alone for the majority of that time, looking after my flatmate's dog while she travelled. I found this aspect to fieldwork in the first three months hindered the capacity I had to engage with and make productive use of my time in Yellowknife from September to December 2018, and in hindsight and at the time too, the progress I seemed to make with data collection and networking was depressingly pedestrian. The open-endedness of the GTM during the initial stages of fieldwork was demotivating and generated the feeling that the time I was spending in Yellowknife was being wasted.

Although speaking in reference to teaching in the field, Tucker and Horton (2019) describe the feeling of 'fieldwork-as-ordeal', whilst anthropologist Alix Johnson (2017) reflects on how "for many, depression manifests as precisely a lack of interest; a chemical inability to care. If we are, ourselves, our own research instruments, what happens when our attention escapes our control?". This observation is a dynamic I struggled with during the first period of fieldwork. It strongly impacted the confidence I had in my ideas, my capacity to reach out to potential research collaborators, and dampened the persistence with which I pursued aloof interviewees. Most often it felt like Grounded Theory working at 50%. It strikes me that there is little conversation within field subjects about the impact of researchers' mental wellbeing – the capacities that human research instruments have – on the ability to carry out good, theoretically grounded work. When we plan our field research as social scientists, we do not tend to plan for our primary instrument – the brain – to let us down. Meanwhile, physical scientists would struggle to go into the field without a contingency plan for their monitoring and measuring devices breaking. Why do social scientists not have backups, and why do researchers and supervisors (this is not a pointed statement!) imply that methodological theory and practice can be easily lifted straight from the textbook and applied to field situations by students without some intermediary malfunction?

I raise this issue not for sympathy or as an excuse for poor progress over my first three months, but to create a discussion about how we affect our methodological practices in ways that are often beyond our control in the moment yet have the potential to severely impact the data we collect or the theoretical intensions we seek or are able to follow. Grounded

Theory research is challenging when one struggles to stay with the troubles the study site/subjects present. Depression, for some, involves a distancing and a reduction in productivity around issues that require constant cognitive attention. I fear that I missed many opportunities to follow up on or pursue research avenues due to an inability to be in the moment and stay with my field site as it unfolded in front of me. Thankfully, with this experience under my sleeve and with support of family and friends, when I returned to Yellowknife in February 2019, I was armed with an arsenal of strategies to ensure soundness of mental health to allow me to do good, productive field research.

3.6 Conclusion

This chapter has outlined the methodological apparatus that I used to generate and understand data for this thesis. It reflects my positionality as a researcher focussed on the materiality of geological matter, the relations between geologists and that materiality, and the manners in which geological form gets made political. In the next chapter, I provide a more in-depth context of the NWT's history as a mining jurisdiction which sets up the socio-economic and socio-political context within which Chapters 5, 6 and 7 sit.

4. Economic, jurisdictional and social context to the NWT

4.1 Introduction

This chapter is intended to provide an historical background to the economic, jurisdictional and social setting in which this thesis' research took place. I present an historical account because of the evolving settler-colonial relations to land that have produced the context within which the geoscience and mining industry is performed today. This must be understood to recognise the shadows which inflect contemporary resource decision makers' actions and obligations. In this chapter I:

- First, present details about the significance of mining to the Canadian and NWT economy and discuss some of the historical legacies of mining in the NWT;
- Second, outline the landscape of land rights, access and tenure in the NWT used after settler-Canadians arrived and framed the land through a lens of extraction;
- Third, describe how the negotiation of Indigenous/settler-colonial relations to land underpins the assemblage of institutions, regulations and practices within which the mining economy now functions; and
- Fourth, finish by introducing the people of the NWT and outlining the physical geography and geology of the Territory.

4.2 Industry and economy

Mining and the mining industry have historically been significant for people living in what is now termed Canada. Since at least the first century A.D, metals were integrated into the cultures and technologies of Arctic people's lives (Cooper, 2016). Early inhabitants of the central Arctic used native copper (copper of high purity) for the manufacture of "knife blades, projectile points, and awls" (Cooper, 2016). In the eastern Arctic and around the Bering Strait respectively, iron tools made from flotsam (shipwrecks) and traded from the Siberian peninsula and beyond have been found in the archaeological record (Cooper, 2016). Later, settler Europeans brought with them extractive technologies and economic priorities which expanded the rationales for mining and the materials and applications of extracted goods. Today, Canada is an international mining behemoth and the destination of choice for companies seeking preferential regulatory regimes and tax benefits (Deneault and Sacher, 2012; Majury, 2014). In 2020, almost half the world's mining companies were listed on the Toronto Stock Exchange, with the majority operating outside of Canada (TSX, 2021). Canadian mining companies are also global in their reach, as figure 4.1 shows.

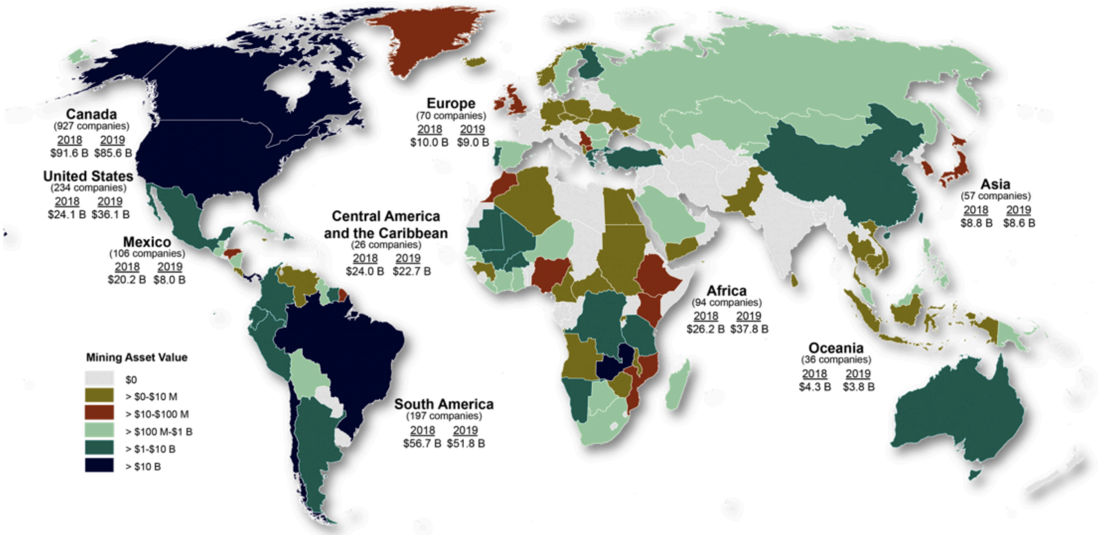

Figure 4-1 Geographic distribution of Canadian mining assets in 2019. Source: NRCan, 2021.

In terms of mineral production, Canada is a significant global player, however its international dominance is dwindling in the face of competition from countries like Australia and China. Canada, like other jurisdictions, finds itself on the cusp of an international economic transition towards lower carbon technologies and economy. In practice, this means that the types of minerals and metals that the global economy requires is changing with greater focus on sourcing battery materials like nickel, cobalt, lithium and rare earth elements, of which Canada has deposits. National strategies such as the Canada Minerals and Metals Plan (produced by Federal department Natural Resources Canada, NRCan) contribute to establishing a pathway towards developing stronger global presence in extracting and supplying these materials by supporting infrastructure development, improving on the clarity and navigability of national, Provincial and Territorial regulatory apparatus, and investing in research and development (MinesCanada, 2019). Figure 4.2 outlines the key priorities of the Federal government for sustaining and enhancing Canada's

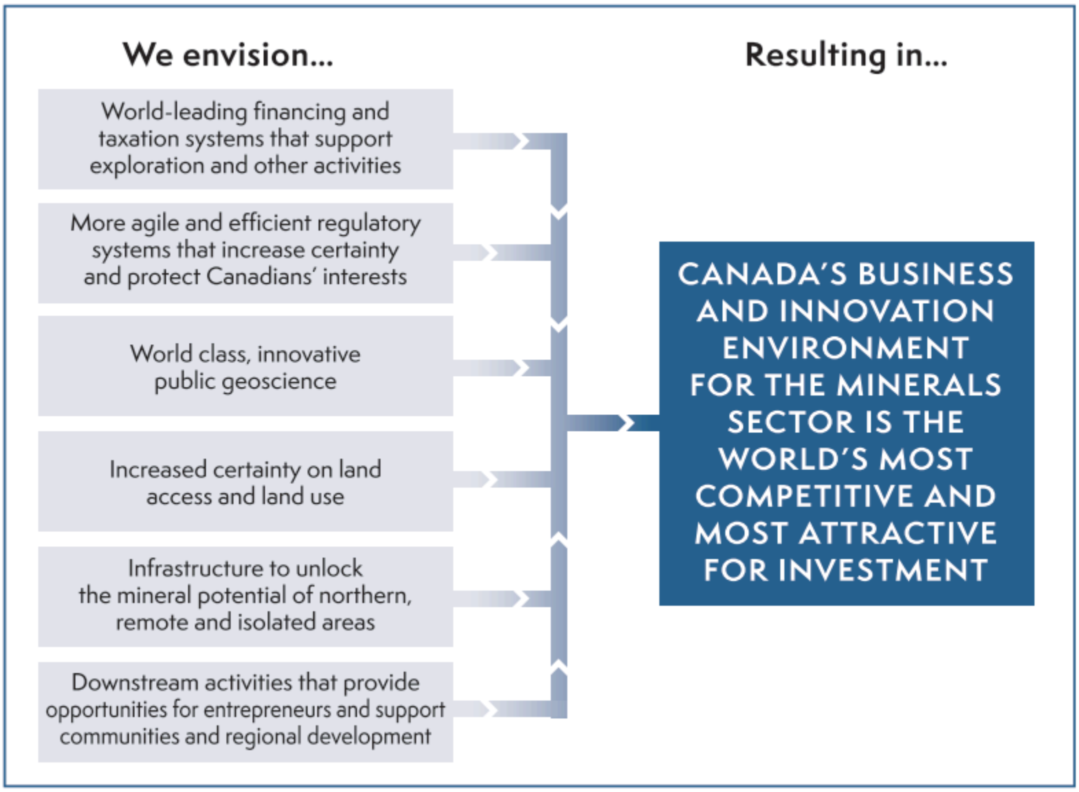

Figure 4-2: Key aspects to improve Canadian economic development and competitiveness in the minerals and metals sector. Source: MinesCanada, 2019, p. 7.

international mining competitiveness, which overlaps with the concerns of lobbying groups such as PDAC and the Mining Association of Canada (Prospectors and Developers Association of Canada, 2017).

In terms of mineral production and in comparison to other global players, Canada is the largest volumetric producer of the fertiliser potash, and second largest producer of gemstones (including diamonds) and uranium. Ontario, Quebec and British Columbia are the top provinces for mining production value within Canada. The NWT ranks seventh of thirteen Provinces/Territories in the value of its mineral production. Despite this, over the last 50 years, the volume of metals calculated to be contained in mineable deposits in Canada has dropped significantly, with the exception of gold (lead (-98.7%), zinc (-93%), copper (-51%) and nickel (-72%) (The Mining Association of Canada, 2020)). This speaks to the increasing liminality and lower quality and grade of deposits that are being discovered today as well as more challenging land access regimes. Meanwhile, the mining industry has improved extraction and processing technologies since the 1970s, allowing lower quality deposits to continue to support a high production value and maintain significance as a source of employment.

Economically, the mining sector (including mineral extraction, processing and fabrication) contributes 5% of Canada's GDP, yet there has been a 50% drop in its value since 2014. In 2019, the value of taxes and royalties to Canadian governments from mining was CAD$4.7billion. This figure does not include the value of income taxes from the over 700,000 direct and indirect employees (The Mining Association of Canada, 2020). However, some scholars have argued that once the capital expenditure and grants given to the mining industry by Canadian governments are accounted for "what the Canadian people are getting for their valuable minerals is negligible" (Deneault and Sacher, 2012; Glum, 2014, p. 122). The value of Canada's mining industry remains much smaller in comparison to its oil and gas industry. The total mining and mineral manufacturing GDP in 2019 was approximately CAD$70 billion while oil and gas accounted for over CAD$130 billion.

In terms of financing and regulation, the expenditure and financing of junior exploration companies shrunk in the last 15 years. Exploration company expenditure is necessary in allowing new mines and deposits to be found. Exploration companies do the 'groundwork' that includes detailed mapping and drilling of project areas. These projects are typically then sold to majors such as Rio Tinto, BHP or Glencore. Few juniors will go on to produce the mine they found, owing to difficulties in having the capacity in terms of financing and human resources to deliver the extraction project, and because they have less resilience than multi-mineral/metal companies like the majors who are better able to weather market volatilities by having a diversified project portfolio.

4.2.1 Mining and economy in the NWT

The NWT is a resource-dependent economy (MiningWatch Canada, 2017). That is, in the last six out of seven years, over 20% of its annual GDP came from the mining, quarrying and oil and gas extraction sectors. In 2018, this proportion reached a high of 38% (StatsNWT, 2021). After the extractives sector, public administration – Federal, Territorial, municipal and Indigenous government – was the second largest contributor to the Territory's GDP (figure 4.3). The NWT's resource dependency means that the GWNT invests in promoting the continued exploration for and development of mines in the Territory and encourages its residents to gain extractive industry-related qualifications via apprenticeships.

In 2020, COVID-19 and the resulting reduction in operations at the Territory's mines due to depressed diamond markets affected GDP. For example, the Ekati mine was mothballed

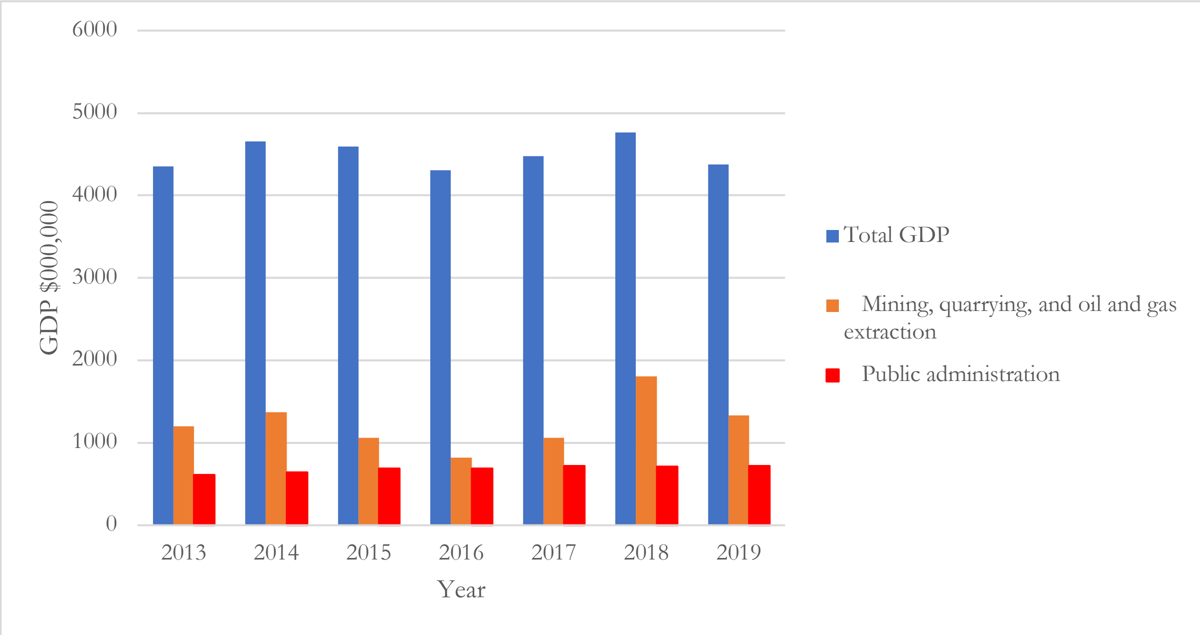

Figure 4-3: Annual NWT GDP contribution by sector 2013-2019. Data Source: StatsNWT, 2021

from March 2020 for 9-months after its owner Dominion Diamonds was declared insolvent (Lasley, 2020). With the rebounding of diamond markets, Ekati restarted operations in December 2020 (Leotaud, 2020). However, issues at Ekati coupled with a disastrous year for tourism[9] are two reason why the NWT's economy is forecast to have contracted by 7.6% in 2020, and rebound only 4.6% in 2021(The Conference Board of Canada, 2020).

Meanwhile, the number of jobs provided by the mining sector does not match the contribution to GDP – more than double the number of individuals worked in public administration than in the extractives industry (figure 4.4). Of course, the secondary impacts of the resource extraction sector on other industries such as construction, utilities, and services must be acknowledged. This employment data does not show that the number of people employed in the extractives industry in the NWT is also bolstered by the number of southern Canadian fly-in-fly-out (FIFO) workers working at the NWT's mines. In 2016,

[9] In 2018-2019 fiscal year, tourism brought $210 million into the NWT. It is a fast-growing economy with tourists mostly from Asia visiting to see the Aurora Borealis (Peacock, 2019).

Northern employees at the NWT's diamond mines constituted 44% of the total number of employees, and 21% of total employees were Northern Indigenous (NWT and Nunavut Chamber of Mines, 2017). Establishing a high rate of Northern employment at NWT mines is a core mission of the Socio-Economic Agreements made between the GNWT and mining companies to allow them to operate. This is being sought by the GNWT because of the high-value jobs that the mining-sector promises, increasing the GNWT's tax base, and because of the secondary benefits to local businesses and communities when mining wealth stays in the north rather than flowing south with FIFO mine workers.

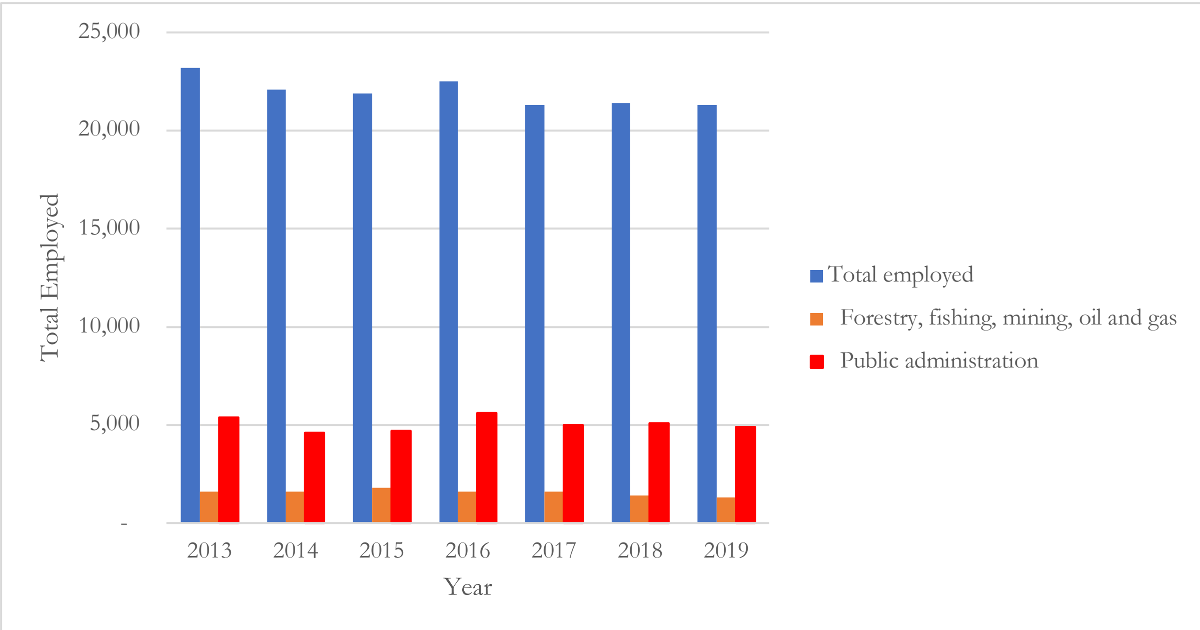

Figure 4-4: Total NWT Employment by Industry 2013-2019. Data source: StatsNWT, 2021b

The NWT has three operating mines – all producing diamonds in the Slave Geological Province – Diavik (22 years total production ending 2025), Ekati (36 years total production ending 2034) and Gahcho Kué (12 years total production ending 2029). These all operate on Crown (Government owned) lands. Meanwhile, other projects closest to reaching construction and operation are the proposed Prairie Creek zinc-lead-silver mine in the southern Mackenzie Mountains, and the NICO cobalt/gold/bismuth/copper mine in Tlicho-governed lands just south of the Great Bear Lake in the Slave Geological Province.

A lot of exploration projects are required to yield a single mine. For example with diamonds, there is a 1-in-1000 likelihood that a diamondiferous kimberlite pipe reaches production, and it takes an average of 10 years for a mine to go from discovery to production (Bain & Company, 2011). Figure 4.5 outlines this process. The NWT has few projects close to starting production, and Prairie Creek and NICO alone will not make up for the loss of revenue and employment of the diamond mines' impending closures, leaving an imminent revenue and employment gap for the GNWT to try and fill elsewhere. The NWT has struggled with getting new mines into production for a number of reasons – cost of access, land tenure and lower exploration and prospecting levels (*Interviewee 7, NWT Chamber of Mines representative, 12.10.2018*). The government is trying to address the cost of access with the proposed Slave Geological Province Corridor (addressed in Chapter 6). Land Tenure uncertainties are being addressed with the ongoing land claim negotiations with the Akaitcho First Nations in Treaty 8 territories. Dwindling exploration in the Territory is being targeted with an increase in funding for the Mining Incentive Programme[10], administered by the NTGS.

[10] The Mining Incentive Programme has invested CAD$3million into NWT mineral exploration projects 2014-18, and the GNWT claims that this spending has created a total spending from funded projects of CAD$15 million in the Territory (Government of the Northwest Territories, 2020a).

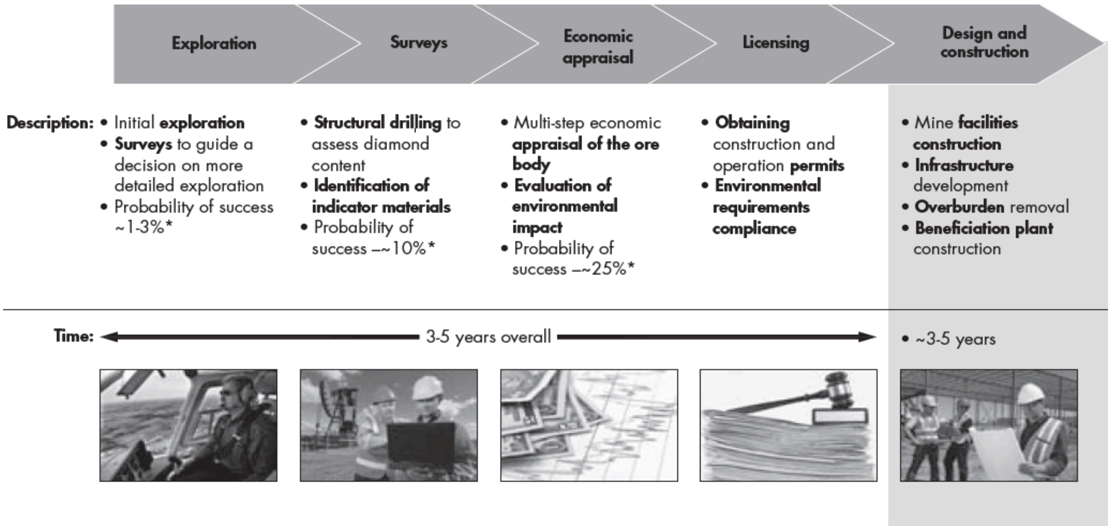

Figure 4-5: Development cycle of the diamond mine, showing the probability of success at each stage. Source: Bain & Company, 2011, pg. 23

Therefore, over recent years the NWT has struggled to maintain a high level of mineral exploration, while its neighbours the Yukon and Nunavut have consistently done better. Excluding 2020, where exploration expenditure dropped around 50% in all three territories in comparison to 2019 due to territorial COVID restrictions, the Yukon and Nunavut have had significantly higher exploration expenditures since 2016. Table 4.1 compares the exploration expenditure of the territories and with the rest of Canada.

Table 4-1: Exploration plus Deposit Appraisal Expenditures, Provinces and Territories, 2016-2020. Source: (NRCan, 2020). *Ca =Canada*

	2016		2017		2018		2019		2020	
	($ millions)	**(% of Ca. total)**	**($ millions)**	**(% of Ca. total)**	**($ millions)**	**(% of Ca. total)**	**($ millions)**	**(% of Ca. total)**	**($ millions)**	**(% of Ca. total)**
Rest of Canada	1260.8	77.4	1748.6	79.9	2035.4	81.8	1924.2	84.2	1959.9	91.5
Yukon	90.4	5.5	168.7	7.7	182.3	7.3	166.2	7.3	76.9	3.6
Northwest Territories	73	4.5	91.2	4.2	112	4.5	79.8	3.5	36.6	1.7
Nunavut	204.5	12.6	177	8.1	155.6	6.3	116.4	5.1	68	3.2

Table 4-2: Total Mineral Production Value 2019, territories vs. provinces, Source: (Natural Resources Canada, 2020a)

	Total Mineral Production Value 2019
Yukon	169,824
NWT	1,817,924
Nunavut	1,315,978
Provinces	44,854,460

Table 4.1 therefore highlights the struggle of the NWT to get exploration that will lead to new mines being found, even though currently, as table 4.2 demonstrates, the total mineral production value of the NWT in comparison to the other territories is significantly higher, owing to the high commodity value of diamonds.

4.2.2 Mining history and legacies in the NWT

As Silke (2009) records, there have been almost 100 mines in operation in the NWT since the 1930s. Many of these mines were small and open for only a few years. However, some of these mines, due to the mineral production processes used and lack of post-mining remediation, have had significant long-term legacies on environmental, human and cultural health. Featuring particularly strongly in local memory are Giant Mine (described below) and uranium mines in the Port Radium formation (see van Wyck, 2010, for a discussion of their legacy).

The Giant Mine sits within the administrative boundaries of the City of Yellowknife and produced gold for over 50 years. The gold that is hosted in arsenopyrite at the Giant Mine site is present at a microscopic level and sits in compounds with other elements. This means that to extract the gold from the mined ore, the rock had to be crushed and roasted at a high temperature to separate the gold from other chemicals like sulphur (Keeling and Sandlos, 2012). During this roasting process, the arsenic in the ore was oxidised causing the highly toxic, water-soluble compound arsenic trioxide to be produced. As a result, the Giant Mine is unfortunately notorious for its arsenic pollution legacy, wherein arsenic trioxide released during ore processing has contaminated the environment including soils, lake sediments, animals and vegetation around the mine.

Initially, from 1948 to 1953, the arsenic trioxide was allowed to travel up the roasting stack directly into the atmosphere and was transported in the air and deposited on nearby lakes and lands. After 1953, technologies were installed in roasting stacks to capture arsenic trioxide, and as a result, emissions dropped from 7,500kg/day (1949) to 5,500kg/day (1953). Emissions were reduced again to 200-300kg/day in 1959 (Keeling and Sandlos, 2012). From the 1950s onwards, arsenic trioxide dust was pumped into mined out chambers and stopes underground for storage, so that today 237,000kg of arsenic trioxide dust remains sitting directly under the mine site. Unlike other hazardous wastes – e.g. radioactive waste – arsenic does not decompose and become less toxic over time, creating an issue in perpetuity for safely containing and managing the Giant Mine pollution problem. As a result of the high mobility of arsenic trioxide (how easily it is made soluble in water) and the toxicity of even small quantities to the environment and humans, it is considered too dangerous to remove from its current underground storage position and transport for reprocessing elsewhere in southern Canada (Mackenzie Valley Review Board, 2013).

As a result of the historical mining process at Giant Mine, soils and lakes have been contaminated with arsenic trioxide. Within 20km of Yellowknife, arsenic contamination in fish (Cott *et al.*, 2016), rabbit (Amuno *et al.*, 2018), and muskrat (Amuno *et al.*, 2020) has been recorded, and therefore the Yellowknives Dene recommend their people to travel away from their local area to hunt, fish and gather medicine plants and berries. Further afield, sediment analyses from the Slave River Delta ~140km south of the mine, show elevated arsenic concentrations from the 1950s when arsenic releases from the mine were at their highest (MacDonald *et al.*, 2016), highlighting the geographic extent of aerial pollution. The Federal and Territorial governments now responsible for the mine plan to start remediating the surface of the mine site and freezing the arsenic in its current storage location, underground, in 2021.

This work will begin after 20 years of planning, including five years of Environmental Impact Assessment (EIA) from 2008-2013, which involved a public hearing where community members, subject matter experts and advocacy groups were able to challenge the Government on their remediation plans and present suggestions for improving the public acceptability of the project. As a result of the EIA, the Giant Mine Oversight Board was created in 2015, which reports on the activities of the Giant Mine Remediation Project. Additionally, changes in water effluent disposal location were made, alongside adjusted parameters of risk acceptability and management, and requirements for a public health effects study that was completed in 2019 (Mackenzie Valley Review Board, 2013). Since the EIA, the Yellowknives Dene First Nation (YKDFN) have continued to lobby the Federal government for an apology and financial compensation for the loss of human life and interruption to traditional land uses as a result of the Giant Mine. At the time of writing in March 2021, the YKDFN had made progress in entering dialogue with the GNWT and Canada to achieve this (Paulson, 2021).

The impacts of the arsenic waste problem are multiple and not just environmental. First, the owner of Giant Mine – Royal Oak Mines – went bankrupt in 1999 leaving the responsibility to remediate the surface of the mine including the 95ha of tailings and 237,000kg subsurface arsenic waste to the department of Indigenous and Northern Affairs Canada (AADNC, 2018). The remediation project will have an initial estimated cost of CAD$1billion for the site clean-up, with an estimated CAD$2million in annual funding required in perpetuity to maintain the technologies that filter arsenic out of ground and surface waters and keep the arsenic trioxide frozen underground (Minogue, 2020a). Thus, the Giant Mine is a huge public cost burden.

Second, the legacy on local communities, in particular the Yellowknives Dene who have subsisted off the land around Yellowknife since time immemorial, is overwhelming. When the mine was opened in 1948, the Yellowknives Dene were not consulted on whether they wanted the mine, nor did they receive any reparations for loss of traditional economy or royalties from the mine which made its owners CAD$867 million in profit (O'Reilly, 2012). Just over a dozen Yellowknives Dene were employed there, meaning the benefits from employment were small (Keeling and Sandlos, 2012). Since opening, the mine has had traumatic impacts on the Yellowknives' physical and mental health. In the 1950s, deaths of children who contracted gastroenteritis from arsenic poisoning were reported, and persistent sickness within the Dene community who were reliant upon melting snow (with arsenic deposited in it) in the winter months for their drinking water (Keeling and Sandlos, 2012). Today, the psychological trauma of living with a 'monster' underground at the mine, with contaminated local waters, soils, animals and plants, has alienated local communities from their traditional territories (YKDFN, 2020).

The Giant Mine, through its disproportionate environmental impacts on the Yellowknives Dene, has left a significant legacy of mistrust between settler institutions and industry and Indigenous people. The atmosphere of fear and anger that hangs around the Giant Mine has left a sour taste towards other resource development applications. Traces of mistrust in industry and government stemming from Indigenous experiences of the Giant Mine can be found at public hearings for the Mackenzie Valley Pipeline Inquiry in the 1970s and the Ekati Diamond mine and the Nico Mine in the 2010s. Chapter 7 explores these legacy links between Giant Mine and contemporary resource development further.

As a result of the legacy of Giant Mine and other mines in the Territory, the GNWT, regulators and developers are keen not to reproduce the regulatory environments that enabled them to happen. For example, as will be detailed in the following sections, the Mackenzie Valley Resource Management Act (MVRMA) requires Environmental Impact Assessments to be done on projects with potential environmental and community harms. As such, the Giant Mine would likely not be approved for operation were an application to be made for it today. Land and Water Boards also set security deposits payable by the project proponent to ensure that sufficient funds for closure and post-mining reclamation exist without burden to the Canadian tax-payer (Government of the Northwest Territories, 2020c).

4.3 Land and resource extraction in the NWT

Since Europeans began settling in mainland Canada in the 1600s, the NWT has been an extractive landscape hosting fur traders, mineral prospectors and miners. In addition to resource extraction, it is also viewed as a geography where international trade infrastructures can be expanded through. Today the NWT is presented as a connecting space between international Arctic shipping routes and southern and central Canadian mineral and natural resource producers (Fellows, 2018). This recent ambition is highlighted with the proposed construction of the proposed Slave Geological Province Corridor (Chapter 6). Thus, it is important to recognise that since Europeans began engaging with the Northwest Territories (or Denendeh, to the Indigenous Dene), its framing as an extractive space has dictated how law makers and settlers have approached its Indigenous inhabitants and rights to lands in particular.

After nearly 200 years of the Hudson Bay Company (HBC) operating as the fur trader in the North, in 1868 the British Government bought the area the HBC traded in for £300,000. This was hugely significant for Indigenous peoples in Canada because the British Government/Dominion of Canada thereafter began making treaties with Canada's original inhabitants, with wordings in the agreements that caused Indigenous people to cede rights to their territories including their rights to hunt, trap and fish. These treaties were created so that property could be traded, resources extracted, and settler communities established. As will be outlined in the following sections, it took over 100 years for Indigenous groups in Canada to reassert their rights to traditional lands and activities.

4.3.1 Treaties 8 and 11, and Land Claim Agreements

Treaties and land claim agreements are important to the extractives industry because they determine where companies can explore and develop mines. The Government of Canada only entered treaties with Indigenous peoples when it really had to: i.e. when an economic benefit to the Crown was established because treaties also bestowed upon it a fiduciary duty towards Indigenous signatories. Although some Indigenous people, missionaries and HBC employees wanted Canada and the British Government to form treaties with those living in remote northern areas due to the poverty and harsh living conditions, the government resisted until it knew their traditional lands had resources of benefit to the nation state (Tesar, 2016a).

Two treaties cover(ed) the Northwest Territories. In 1899 the Dene in northern British Columbia, Alberta and Saskatchewan and in the area south of the Great Slave Lake in the NWT ceded rights to their traditional territories to the Federal government under the Treaty 8 agreement. In 1921, the Dene in the Mackenzie Mountains ceded their traditional territories to the Federal Government under the Treaty 11 agreement. Both these treaties were motivated by Canada's desire to explore and exploit natural resources in the NWT, and boundaries of the treaty area were determined by the known presence of hydrocarbons and minerals. The signing of Treaty 8 in Alberta, the largest treaty by area in Canada, coincided with the Klondike Gold Rush in the Yukon, where conflicts with First Nation groups were increasing and that government wanted to avoid in Alberta/NWT. Canadian interest in establishing an agreement under Treaty 11 emerged when Europeans realised the scale of oil and gas plays in the Mackenzie Valley in 1920. The Canadian Government was motivated to enter a treaty with Indigenous peoples quickly, before they realised the value of their land for mineral resources and heard from other treaty-holders in southern Canada that promises were not kept by Government (Tesar, 2016b).

Critically to the story of Indigenous self-determination and self-government in the NWT, in signing Treaties 8 and 11, First Nations people did not believe that they were ceding their rights to hunt, trap and fish on their traditional territories, but rather were making an agreement of 'friendship'. Meanwhile, the Government of Canada maintained that traditional land use rights had been extinguished, and it was only until the mid 1960s during the Regina v. Sikyea case in Yellowknife that the terms of the treaties came under scrutiny and the rights of Indigenous peoples to use their land was reasserted.

On the grounds that Treaty 8 and 11 were understood as agreements of friendship with Canada, rather than land secessions by First Nations and Inuit people, in 1973 Justice William Morrow of the NWT Supreme Court agreed that the Indian Brotherhood of the NWT could file a claim for ownership of over 1 million km^2 (Tesar, 2016a). Although this original claim was rejected, it opened the doors for land claim agreements to be made between Dene and Inuit people and Canada. Adding to the pressure to clarify land rights was the Mackenzie Valley Pipeline Inquiry led by Justice Thomas Berger. The Inquiry held from 1974-1976 established that before any pipeline to transport gas out of the Mackenzie Valley should be approved, land claims in the NWT should be settled first. This decision highlights the primacy of land tenure in developing natural resources in the north, and weaves together subsurface mineral wealth with the negotiation and creation of traditional and Crown

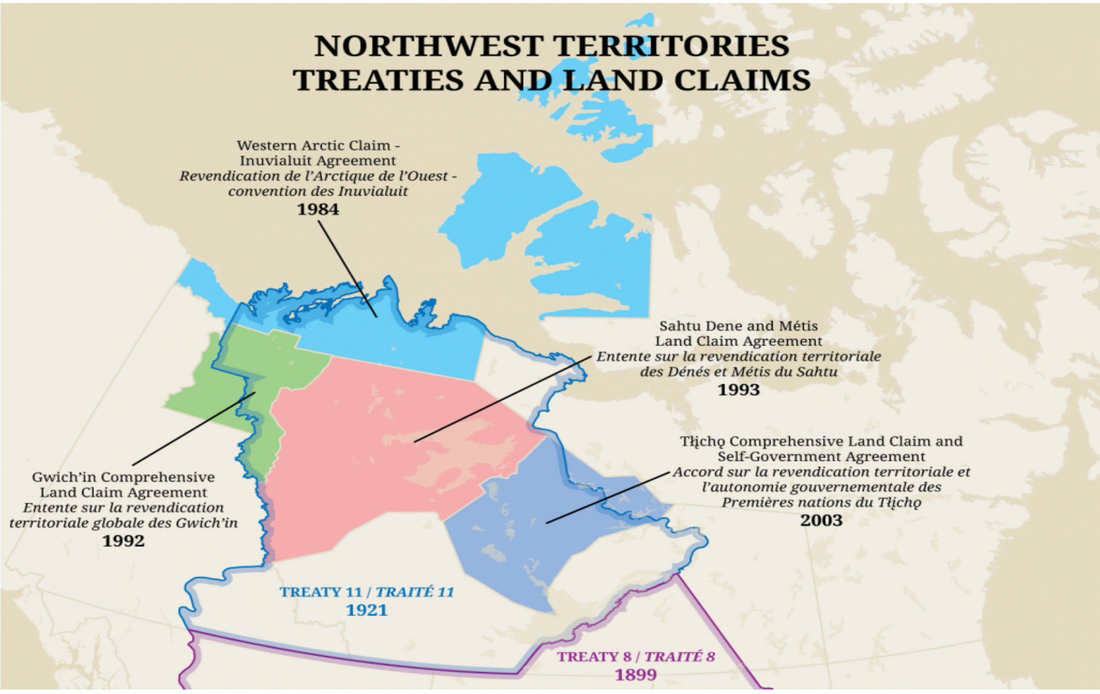

Figure 4-6: NWT Indigenous Land Claim Agreement areas as of 2020. Source: PWNHC, 2018

territories. It also exemplifies the Canadian Government's motivation for agreeing land rights in the Territory.

The first agreement over land title was the Inuvialuit Final Agreement in 1984, with Inuvialuit self-governance agreed in 2007. Meanwhile, throughout the 1970s and 1980s, the Dene Nation (formerly the Indian Brotherhood of the NWT) and Métis Nation sought an Agreement in Principle for settling land claims with the Canadian Government. Negotiations broke down in the late 1980s when disputes between the constituent Dene Nations over the terms of agreement emerged. As a result, the Gwich'in and Sahtu Dene sought to make their own land claim agreements with Canada, and these were ratified in 1992 and 1993 respectively. Significantly, neither of these two agreements provided scope for obtaining self-government. Later, in 2003 the Tlicho were able to negotiate the Tlicho Land Claims and Self-Government Agreement. Meanwhile, the Dene nations in the Akaitcho Territory (Agreement in Principle signed in 2019) and the Deh Cho First Nations – both part of Treaty 11 – are still in negotiation with Canada and the GNWT to settle land claims and self-governance rights. Figure 4.6 maps the areas covered by land claim agreements and treaties.

The agreement and settling of lands claims are significant to this research because it informs the land tenure regime within which the extractive resource industry is able to function. Where land tenure is certain – for example where its status has been agreed through land claim agreements – industry and exploration companies are able to enter these areas (when legally allowed) with greater security about the land's long-term legal status. In parts of the Slave Geological Province and areas south of the Great Slave Lake under negotiation with the Akaitcho First Nation today, insecurity and uncertainty around land tenure present a challenge to attracting and retaining exploration and mining investment. A particular issue, from the perspective of industry, are land withdrawal areas – or lands under negotiation – which, as will be explained in Chapter 6, industry is unable to work on and whose value and prospect for exploration decrease as it becomes legally 'untouchable'. With land claim agreements, land use plans are made which define areas permissive or restrictive of industrial activities including mining. As such, a representative from the NWT Chamber of Mines remarked how "when there is a land use plan, everything is much more certain" (*Interviewee 7, NWT Chamber of Mines representative, 12.10.2018*).

Thus, resource development happens in the NWT against a backdrop of Indigenous-settler relations to land. Minerals and resources have been central to defining Indigenous peoples' rights to their territories and settler-Canadians' desires to secure clarity and freedom to explore and exploit subsurface resources. In the next section, I will map the key governmental institutions operating in the NWT and affecting the extractive resources industry.

4.4 Governance and Institutions

The institutional governance of the NWT relating to land and water is arguably complex. In addition to a system with split Federal/Territorial obligations, the NWT also has devolved some governance responsibilities to First Nations and Inuit Government. Thus, this structure of governance creates some complexity for industry working in the Territory – it must be cognisant of the different levels and responsibilities of government when exploring and planning a mine. Figure 4.7 outlines this hierarchy.

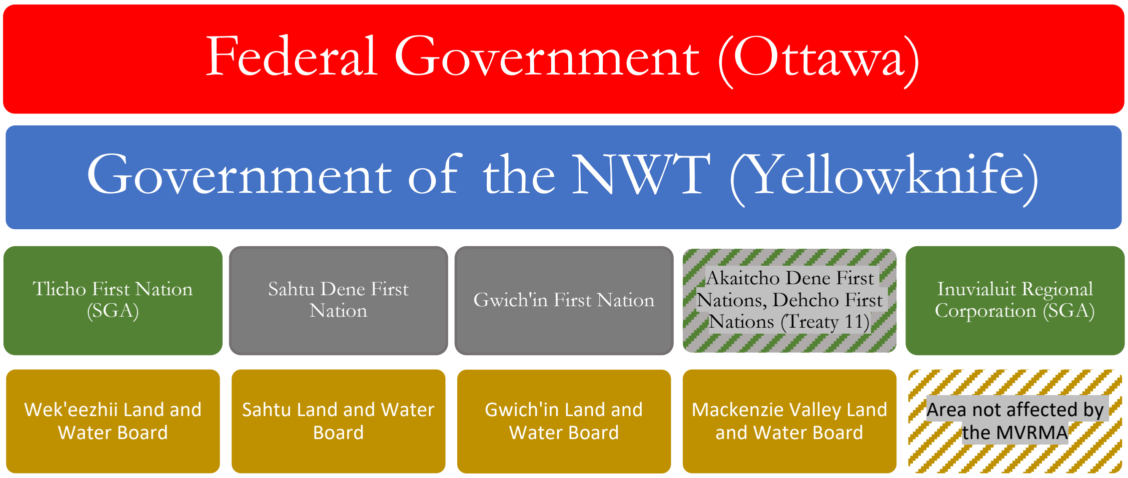

Figure 4-7: Tiers of government in the NWT. Green = Self-Government Agreement (SGA) negotiated. Grey = no SGA negotiated. Hatched = terms of land claim and governance under agreement. Yellow = Land and Water Board for the region per the MVRMA.

Since the GNWT's creation in 1967, an increasing number of responsibilities have been devolved to the Territorial government. Most recently in 2014, responsibility for the governance of onshore land, water and natural resources was devolved from Federal to Territorial level. This means greater financial and political control over how these resources are managed; the ability to collect royalty payments from mining; the right to negotiate Socio-Economic Agreements (SEAs) with companies; and the ability to change and create new mining laws and regulations (as was done in 2019). In December 2020, a significant agreement was reached wherein any future legislation relating to land and resources will be co-written by the GNWT and Indigenous Governments on equal footing (Pressman, 2020). Previously, the GNWT had to consult with Indigenous Governments but ultimately had the final say on what legislation looked like. This decision is precedent-setting within Canada and signals a move away from centralised/dislocated control over resources to a more deliberative democracy approach to resource development. As such, mineral futures in the NWT may no longer be legislatively set by the hegemon in power – the GNWT and Canada. Speculatively, this shift in the balance of power has the possibility to contribute land use perspectives that are not solely embedded in colonial-capitalist epistemologies or ontologies. The direct impact of this governance decision on extractives industries remains to be seen.

4.4.1 Implementing Land and Water Regulations

One institutional 'baseline' across all settled land claim agreements that affects natural resource management is the creation of regional Land and Water Boards which, under the 1999 Mackenzie Valley Resource Management Act (MVRMA), are the first hurdle to pass for getting approval for development projects. Those wishing to use natural resources in a way that may affect the land and water must make an application to the regional Land and Water Board that their project sits to obtain a land use permit or water license. If the application is believed to pose threat of an adverse environmental impact or if it could cause 'public concern', then the application is triaged to the Mackenzie Valley Review Board (MVRB) for environmental assessment to see the extent of these impacts and concerns. Should environmental impact and concern be upheld by the Review Board, then the application goes to Environmental Impact Review. The Public Hearing phase is one of the final stages of an environmental assessment (Mackenzie Valley Review Board, 2010).

Thus, the Land and Water Boards provide First Nations with some control over development projects proposed on their lands. Primarily, because projects must first pass through the relevant regional land and water board review system, it can be ensured that First Nations governments are informed of what is happening on their lands. It also means that board members with knowledge of the geographies where projects are proposed can weigh in on decision making, meaning that local, traditional knowledge is used to inform how appropriate a project is for the area at an early stage.

One particular aspect that Land and Water Boards and the MVRB focus on in impact assessments are caribou. Caribou are integral to Indigenous traditions, their lifeways and historical survival in northern Canada, and archaeological evidence of caribou hunting has been found around the East Arm of the Great Slave Lake from 8,000 years ago (Gordon, 2005)[11]. As migratory animals, they frequently cross paths with the extractives sector and therefore feature heavily in impact mitigation planning and often in evaluations of the value of a project for local people. In the east of the Territory, three barren-ground caribou herds – the Bathurst, Bluenose East and Bluenose West – migrate between the Arctic coast at the NWT/Nunavut border and the East Arm of the Great Slave Lake[12]. Each of these herds, but in particular the Bathurst Herd, have suffered dramatic declines in population numbers in the last two decades. Although sometimes controversial, the population counts of the Bathurst herd estimate a drop in numbers from around 472,000 in 1986 to 8,200 in 2018 (Government of the Northwest Territories, 2020; *Interviewee 38, 05.06.2019*).

The Bathurst Herd is particularly important to this thesis since the impacts of mineral resource exploration and development in the Slave Geological Province in the Taiga and Tundra Shield regions is often hotly debated for its impacts on caribou population numbers. Ungulate biologists cite a number of interrelated factors placing pressure on their populations, including habitat changes due to climate change affecting access to preferred food sources like lichen; and extreme weather conditions creating challenging grazing habitats during calving season (Rickbeil *et al.*, 2018). Insect harassment caused by earlier

[11] Gordon (2005) describes the close historical interlinking of human with caribou migratory patterns, and the significance of caribou migrations on human demographics. Gordon provides evidence of how human conceptions in autumn and births in the springtime matched caribou migrations across the NWT, since they provided both food and materials (e.g. skins, sinews etc.) and a reason for different Indigenous groups to meet up to hunt and find partners to have children with.

[12] Migratory extents vary annually and by herd. The Bathurst are recorded to have travelled as far south as Saskatchewan, and the Bluenose Herds less extensively to the east of the Great Bear Lake (Gordon, 2005; Government of the Northwest Territories, 2020).

springs forces migration to poor grazing areas (covered in ice/snow) which increases energy expenditure (Witter *et al.*, 2012), thus poor fecundity and calf survival prevents herd recovery (Boulanger *et al.*, 2011). The most controversial and political of causes is the role of human behaviour – overhunting/harvesting by Indigenous people and mining. On mining activity in the Slave Geological Province in Nunavut and the NWT see Parlee *et al.*, (2018a), Nishi *et al.*, (2018) in response, and Parlee *et al.,* (2018b) again in response to that. On the impacts of see recent news reports by e.g. Williams (2021), and in opposition to this perspective see Sangris (2012)[13].

Caribou are therefore at the forefront of discussions of industrial development in the Slave Geological Province, as well as in other ecoregions of the NWT. However, the pitting of caribou against mining in the Slave Province has created debates over the Territory's socio-cultural, environmental and economic values and intentions into the future. As such, it is noticeable that discussions around caribou in relation to industrial development in the Territory works as a proxy for the discussion of traditional versus Western lifeways. This was no more apparent than during the Mackenzie Valley Pipeline Inquiry of the 1970s, and in contemporary discussions around resource development, e.g. the public hearing about the expansion of the Ekati diamond mine in Lutsel'ke on the East Arm of the Great Slave Lake, discussed in Chapter 7. At the Ekati hearing, the livelihood and cultural significance on the migratory route of the Bathurst herd was emphasised, with Roger Catholique, a member of the Lutsel'ke Dene First Nation wildlife youth committee, raising concerns about the proposed mine expansion stating "Any last caribou impacted -- impacts us also" (Mackenzie Valley Review Board, EA1314-01 Jay Hearing, 19.09.2015, pg. 77). The mine developers

13 Harvesting restrictions (often controversial within Indigenous communities) agreed by Indigenous governments with the GNWT-ENR have been implemented to try and prevent a further decline of numbers. Yet some local activists have debated the significance of traditional harvesting on wider population decline.

were required to mitigate impacts to caribou migration in their development plans (Mackenzie Valley Review Board, EA1314-01 Jay Hearing, 01.02.2016).

4.4.2 Consultation requirements in the NWT

Another aspect of working in the NWT for resource developers is the need to carry out consultation. This is facilitated in the NWT through the MVRMA and the MVRB. Under Indigenous people's Section 35 rights in the Constitution Act (1982), when Aboriginal or treaty rights may be affected by Federal and Territorial government decisions, there is a duty to consult. This applies to lands that have treaties, settled land claims and unresolved land claims. Newman (2017) writes how the duty to consult can incentivise industry to make direct, private agreements with Indigenous communities and governments in the form of Impact Benefit Agreements (IBAs), as have been reached with Indigenous governments in the NWT (Government of the Northwest Territories, no date). The duty to consult lies with Government or its regulatory/administrative arms. It is not possible for Governments to offload their duty to industry. Internationally, the UN Declaration on the Rights of Indigenous People (UNDRIP), of which Canada is not a signatory, makes reference to establishing 'free, prior and informed consent'. While not ratified in Canada, UNDRIP has been taken up on a Territorial level by the latest 19th government of the Legislative Assembly (Government of the Northwest Territories, 2020d), and their move to equalise land-related law-making rights in 2020 reflects this sentiment.

However, Mathiesen (2015) explains how the duty to consult creates pressures for both Indigenous governments and communities and for industry. Governments and communities are often overwhelmed by the number and technicality of consultation documents. As a result, First Nations do not always have the financial or technical capacity to evaluate proposals that are given to them. Meanwhile, for industry, it can be challenging for project proponents (especially when small operations) to have the regulatory understanding of engagement best practice and capacity to carry it out. Similarly, where projects overlap different land claim areas or territorial boundaries, added complications arise. Consultation *should* mean more than just explaining and telling communities and Indigenous governments what a proponent's plans are, but rather responding to and accommodating local concerns and suggestions. The sentiment of consultation can determine how legal it is – e.g. the Clyde River v Petroleum Geo-Services Inc. ruling of 2017 – where "deep consultation", including for example oral hearings, participant funding and access to technical evidence of development impacts on treaty rights, were ruled as necessary (Supreme Court of Canada, 2017).

4.5 People

The Northwest Territories is home to Indigenous peoples including Dene, Inuvialuit and Métis as well as non-Indigenous settler populations. According to the 2016 national census (Statistics Canada, 2017), the NWT had a population of 41,800, roughly half of whom (20,860) identified as Indigenous. Again, roughly half the population of the NWT lives in the urban centre of Yellowknife. In the same year, 73% of people between 25 and 64 held a high school diploma, compared to 86% in Canada. There has been an increase since 2006 in percentage of residents with a bachelor's degree (up from 20% to 24%), yet less than a quarter of those studied STEM subjects (such as geosciences). This is significant for reducing the pool of local people who are able to become geoscience knowledge holders about their Territory, as discussed in Chapter 5.

4.5.1 The 1894 Indian Act and Residential Schools

Although not directly related to resource extraction, the Indian Act of 1894 was crucial in setting the tone of Indigenous-settler social, cultural and economic relations that impact Canadian society today and affect contemporary socio-political relations between settlers and Indigenous people. Significantly, the Indian Act stipulated that Indigenous children between 7 and 16 years old must attend school. This was part of a broader aim to assimilate Indigenous people into settler-Canadian society and erase their traditional languages, cultural practices and beliefs. Due to the remoteness of many Indigenous communities, residential schools were the only way they could comply with this law. However, these schools were chronically underfunded, often run by individuals with limited teaching or childcare experience, operated in dilapidated overcrowded buildings that were conducive to the spread of diseases such as TB, and often had insufficient food to maintain their students' health. In addition, "neglect was institutionalised, and the lack of supervision created situations where students were prey to sexual and physical abusers" (Truth and Reconciliation Commission of Canada, 2015, p. 4).

As such, until record keeping became sparse in the 1920s, the Government of Canada department responsible for these schools estimated that between 25-46% of children entering or leaving the schools died, where there were between 5-10,000 children were in schools at any one time (Truth and Reconciliation Commission of Canada, 2015). In total, around 150,000 children are believed to have passed through the system. In the NWT, over half of Indigenous adults were estimated to have attended residential schools, the highest proportion in Canada (Statistics Canada, 2001). The last residential school closed in Saskatchewan in 1996. As such, the Truth and Reconciliation Commission (2015) concluded in their summary report that the actions of Canada against Indigenous people amounted to cultural genocide. Yet, as the TRC points out, "Aboriginal people have refused to surrender their identity" (ibid., p. 6).

Accompanying the assimilation of children into settler-society, through its treaties, land seizures and occupations, Canada also ensured a land-based alienation of Indigenous peoples from their traditional territories with social and economic impacts today. The long-term impacts of this schooling system fractured Indigenous communities, erased social cohesion and drove many away from their homes (Mountain, 2019). Many of those who experienced the schooling system struggled to deal with the traumas of abuse and community dislocation, resulting in substance abuse, increased community and domestic violence and mental health issues. The system's impacts are also reflected in the disproportionate number of Indigenous children in government welfare and high rates of Indigenous incarceration (TRC, 2015). These impacts have been intergenerational, with the fall-out of the cultural genocide committed through residential schools affecting individuals, families and communities today (Sacco, 2020; Belcourt, 2020).

4.6 Physical geography and geology

Figure 4-8: Looking south onto the Great Slave Lake from a basalt outcrop of the Taiga Shield. This photograph shows the cross of Old Fort Providence, one of the first Hudson Bay Company fur trading posts in the NWT, operational until the early 19th Century. Photo by author

The Northwest Territories cover approximately 1.144 million km^2 (almost 5 times the size of the UK). Bordered by Yukon to the west, British Columbia, Alberta and Saskatchewan to the south, and Nunavut to the east, the NWT hosts diverse physical geographies, ecologies and geologies. It has two major lakes – the Great Slave Lake (the 10th largest in the world and deepest in North America) (figure 4.7), and the Great Bear Lake (the 8th largest in the world). Slicing along the foothills of the Mackenzie Mountains in the west is the Mackenzie River which has the second largest watershed in North America, and which drains the Great Slave Lake and Great Bear Lake into the Arctic Ocean. The lakes and rivers are frozen between six and eight months of the year.

However, the NWT and Arctic Canada have experienced and are projected to continue experiencing radical environmental changes as a result of climate change (Bush *et al.*, 2019). Three particular changes can be identified relating to temperature increases, sea and lake ice cover reduction, and permafrost thickness and thaw. The NWT, Yukon and Nunavut have the highest observed increases in annual temperature change in Canada between 1948 and 2016, recording a 3ºC increase across this period (Bush *et al.*, 2019). Increases in temperature have led to both reduction in sea and lake ice cover and increased permafrost thaw.

Relating to lake ice cover particularly, a reduction in cover during the 'shoulder seasons' (October to December, and April to June) has been recorded, and this is projected to continue to reduce. Lake ice break-up is projected to be 10-25 days earlier and freeze-up 5-15 days later by 2050 (Derksen *et al.*, 2019). The temperature and ice cover of lakes is important for regional energy and water cycles and can cause changes to the ecological productivity of lakes, methane emissions of lake-beds and changes in ice-jam and meltwater flooding (as seen on the Mackenzie River this spring in Fort Simpson) (Derksen *et al.*, 2019; Sibley, 2021). Concerning sea ice, Canadian Arctic marine areas are projected to have annual periods which are ice free and will experience a decrease in perennial sea ice cover and increases in seasonal sea ice. One impact of the latter is that annual break-up of seasonal sea ice will interrupt and create hazards for navigation in the Northwest Passage. Concerning permafrost, which underlies 40% of the Canadian landmass), has been observed to warm throughout the NWT and Nunavut (Derksen *et al.*, 2019). Permafrost warming is significant in that in increases the active layer (that freezes and melts annually) meaning that ground instability is created, generating challenges for existing and developing infrastructures.

Socio-economically and infrastructurally, the changes in lake ice and permafrost cause challenges to engineers maintaining and constructing roads, bridges and culverts in the NWT (Pendakur, 2016). Related to the mining industry, the Tibbitt-Contwoyto Winter Road (TCWR) (which is the busiest winter road in the world) serving the SGP diamond mines is projected to have its operating season reduced by up to 15 days by 2050 (±6-8 days) (Pendakur, 2016). For the TCWR to carry the heaviest of loads (42 tonnes) the ice thickness across lakes must be a minimum of 107cm.

Ecologically, changes in temperature, permafrost, precipitation, sea and lake ice are recorded as having impacts on forests and vegetation (c.f. Price *et al.*, 2013; Cameron and Lantz, 2017), species distribution and migration (c.f. Dunmall *et al.*, 2013; Rickbeil *et al.*, 2018), and disease and pests (c.f. Kutz *et al.*, 2009; Parkinson and Evengård, 2009). These combined impacts upon ecosystems and people create challenges for resilience and adaptation of northern communities to climate change, and compounds the existing socio-economic difficulties described earlier in this chapter (Derksen *et al.*, 2019).

In accompaniment with the Arctic's changing climate and environment, the NWT's diverse geography and geology creates opportunity, but also challenges, for those looking to extract resources. The varied geology creates opportunity for different mineral and hydrocarbon resources to be extracted, while the geography and climate creates landscapes that affect infrastructure development and vulnerable habitats that impact contemporary resource development licensing opportunities.

There are three main geological 'zones' in the NWT. Most simply, the Cordillera of the Mackenzie Mountains in the west, the central Mackenzie Valley, and in the east part of the Canadian Shield. The Canadian Shield is also home to the Slave Geological Province, where the Slave Geological Province Corridor discussed in Chapter 6 is to be routed through. The Canadian Shield is a vast mass of eroded volcanic rock stretching from the NWT across to Greenland and down to Newfoundland. Some of the rocks there are over 4 billion years old, and their volcanic origins deep within the earth's mantle mean that there are many mineral deposits in this region, including silver, gold, copper and zinc. The erosion and movement of the Shield over millennia has produced a largely flat yet rugged topography, leaving a maze of lakes and rivers (covering around a third of the area) contoured by rocky outcrops and glacial deposits known as eskers (long, thin deposits of sand and gravels). Thus, this geologic and glacial history has created complex Arctic ecosystems, difficult-to-access geographies, and a mineral rich territory.

West of the Shield, in the Mackenzie Valley area, the sedimentary geology is remnant of the waning Laurentide Ice Sheet and overlies geologies with oil and gas plays[14]. The Mackenzie Valley area is where the first Mackenzie Valley Pipeline was proposed in the early 1970s, and again in the early 2010s. In the Mackenzie Mountains, west of the Mackenzie Valley, are the northern extension of the Rocky Mountains and are comprised of uplifted and deformed sedimentary and intrusive (volcanic) rocks which host minerals such as tungsten, lead, zinc and gold.

[14] A 'play' refers to a group of oil or gas fields or prospects that share a geological history.

4.7 Conclusion

This chapter has described the socio-historical, jurisdictional and economic background of the Northwest Territories which this thesis sits against. Evidently, complex historical land tenure regimes create challenging environments for resource development and settling land claim agreements. Colonially, Indigenous people's recent history of attempted cultural genocide alongside a shift from traditional land-based to industrial economies creates tensions in the value systems of planners and policy makers in the Territory. The NWT is at a difficult crossroads in which it requires the sustained income from the high-value mining industry in order to support schemes to increase the breadth of participation and access to benefits from the mining industry (e.g. through STEM education, apprenticeships), yet it must also balance these socio-economic needs against the settler-colonial backdrop of half its population historically having been marginalised and alienated from their lands, and allowing land-based and economic self-determination to occur on part of Indigenous people. It is therefore easy to understand what makes the NWT such an interesting case study, where many contemporary and historical wheels drive the Territory into uncertain futures.

5. Assembling Geological Space

5.1 Introduction

This chapter will address the question of how geological space is assembled through the production of geological maps. The aim of this chapter is therefore to reveal part of the practices and knowledges that underpin geoscientific data production which go on to inform land use planning and regional mining ambitions (as addressed in Chapter 6). To glimpse these geological hinterlands or background worlds (Law, 2004; Anderson and Harrison, 2010), I examine the affective practices employed by geologists in their efforts to identify, bound and story geologies as cartographic representations. Hinterlands and background worlds can provide a context or rationale grounding other aspects of decision-making in resource-politics assemblages, which might otherwise be overlooked or taken for granted. In particular, the ways of knowing and interpreting geological space enable particular renderings and constructions of geological realities to be translated into geoscientific objects such as maps. Through this, knowledge frameworks therefore enable geology to be transformed into a resource (Richardson and Weszkalnys, 2014). In this chapter, I thus seek to cleave open the hinterland and background worlds comprising routinised, everyday practices, languages and assumptions made in relation to geological landscapes that enables geological histories and patterns to be represented within mapping projects which go on to inform mineral resource extraction.

To enhance this approach of looking at the hinterlands of geologists' work, I also examine geologists' field-based methodologies by focussing on the practices that enable them to understand geological form and render it circulatable. To do so, I analyse qualitative data sources collected through participant observation in the field at the Giant Mine site and semi-structured interviews with geologists at the NTGS, BCGS and GSC. In doing so, I am inspired particularly by the work of Fox-Keller (2000), Lorimer (2008) and de la Bellacasa (2019), as detailed in Chapter 2. Their attention to individual scientists' relations with other-than-human beings generates a critical lens through which to understand the importance of long-term human-material relations in generating expertise and environmental knowledge. Added to this, their work encourages an attention to the role of the body in navigating and grasping complexity found in the more-than-human world, thus allowing me to provide a unique insight as to how (geo)science is produced in the field. This fills an analytical gap in accounts of geological mapping in Canada, which have typically focussed on the role of institutions in producing maps, rather than the lived experiences of the geologists themselves (e.g., Braun 2000, Simpson 2019, and Zeller 1987). However, my observations and interviews with geologists also produce an understanding of the institutional setting within which produced knowledge is legitimised and circulates. Here, I flesh out understandings of credibility of geological field sciences through readings of trust, expertise and place, which offers a discussion of how maps are received post-production (Shapin, 1994; Driver, 2001; Gieryn, 2018).

In this chapter, I also recognise that individuals' encounter with geology at sites of scientific knowledge production are imbued with elements of subjectivity and contingency. I therefore directly contribute to advancing existing resource development literatures by expanding the critique around the 'making' of resources via geo-logical and geo-metric methods (Bridge, 2013; Elden, 2013a). Although academic literature has attended to the fallibility of resource accounting in the oil and gas industry (Kama & Kuchler, 2019), it has examined neither the link between geoscience information production and resource accounting methods, nor simply the production of the geoscience data itself. This chapter deals with the latter issue, exploring the role of professional geologists in producing representations of space, and how geological materiality influences their methods of knowledge production. In the context of this chapter, paying attention to bodily practices and the significance of individuals' knowledge generates a critical understanding of what natural resource estimates in the Slave Geological Province in the NWT are grounded on (generating a basis for my discussion in Chapter 6, and enabling me to address the link between knowledge production and resource accounting).

This chapter is structured as follows. First, I introduce why geological maps are produced, contextualising the importance of cartographic products within the political/resource development domain and grounding their application in the 'taming' of geological frontiers. I also outline how Indigenous people are significantly underrepresented and excluded from the geoscience data production process and discuss wider implications of this in the resource development nexus. Next, I examine the individual skill geological cartography requires by exploring how geoscientists experiment with assembling geological histories by developing, following and testing hypotheses in the field and through their maps. I also examine how geoscientists' feeling for geological storying relies on affective relations with geological materiality, and how their renown and field methods precipitate or erode socio-institutional trust in their work.

5.2 The context of geological map production

In this section, I will explore in turn why geological maps are made and where, and who is involved and excluded in the process of their construction. Politically, geological maps serve the purpose of bounding territories with the aim of deciding on how the land should or should not be used. Historically, geological maps were produced in Canada by the Geological Survey of Canada (GSC) with the purpose of identifying, quantifying and extracting geological resources as the young nation developed at the turn of the twentieth century (Braun, 2000). Today, regional geological surveys such as the Northwest Territories Geological Survey (NTGS) serve similar purposes inasmuch that they seek to know, bound and enrol different geological strata and formations into socio-economic assemblages, whether for permafrost slumping detection and prevention, or for development of hydrocarbon and mineral resources. The NTGS' principle aim is to "provide geoscience information about the Northwest Territories to inform decisions by governments, industry, and the public concerning the responsible development of mineral and energy resources, use of the land, and environmental stewardship" (Government of the Northwest Territories, 2017, p. 1). This Territorial agenda marries with Natural Resources Canada's remit in the North and projects like their Geo-mapping for Energy and Minerals programme which will "continue to advance our knowledge of the North… [and] contribute to better exploration investment decisions in the Arctic and more informed land use decisions within northern communities" (Natural Resources Canada, 2019, p. 12).

At the NTGS, the emphasis on resource geology rather than environmental geology is demonstrated by the fact at the time of writing in 2019, 11 of the 13 staff involved in producing primary geoscience information on the Territory (i.e. non-administrative personnel) are energy geoscientists and mineral deposits and bedrock mappers (Northwest Territories Geological Survey, 2020). Only two members of the team are dedicated to permafrost mapping and environmental management, despite the fact that changing permafrost conditions are a critical threat to existing built infrastructure and communities in the North, causing an estimated CAD$51million of damage annually to the Territory (Beers, 2017). This allocation of resources and expertise within the NTGS by the Department of Industry Tourism and Investment (GNWT-ITI), emphasises the position of the Survey as an organisation for expanding extractive resource knowledge, rather than for managing contemporary challenges associated with climate change at the geological/environmental interface.

Academically, mapping is a method used by geoscientists to communicate a story of the geological history of an area. Maps are produced to convey a coherent representation of a geological area, to "bring the whole together" (*Interviewee 31, Government Geologist, audio recorded via Skype, 30.04.19*), and to understand and demonstrate the relationship between rock types and geological structures. Geologists therefore use mapping as a methodology: a means to an end rather than the end itself.

A geological map is thus not only a product, and more than just a process (Gerlach, 2014): it is also an experiment of time, space and material composition. Producing a map is less about presenting 'what geology is' but is rather to pose a question to Earth – 'what have you been doing to yourself?'. To map is to recognise Earth as a busy agent producing a rocky mess that is at times mish-mashed together and at other moments neatly stratified. While geologists produce maps "to show the distribution of rock types" (*Interviewee 31, ibid.*), geological maps show more than just geological units, disconnected from the other constituents of their cartographic assemblages, but rather function "to portray…the *relationships* between those different rock types" (*ibid.*).

Thus, rather than resolving questions like "what is…", geological mapping is done to understand "how does…" something fit into a wider picture. *Interviewee 33* explained that one reason for producing maps was to ask, "how does this map help me explain my theory about XYZ?", introducing the idea of the map as a site of experimentation for establishing geological relationships through time and space (*Interviewee 33, Government Project Geologist, email communication, 21.05.20*). The relationships a geologist can portray are contingent upon the geologist being able to understand the setting of a rock, its spatial and temporal relativity to the geology around it, and the historical processes it may have undergone within the wider tectonic setting. This affects how the individual moves across the terrain and the intentions that drive them through space. Mapping is therefore an enjoining of geologist and material to reveal answers to the Earth's history. The geologist cannot answer this from a distance but must use bodily relations with the material as their toolset for understanding and cartographically representing geological landscapes.

Furthermore, mapping is not done where geologists know all they want to about an area, it is done to problematise what they do not (*Interviewee, 36, Government Geologist, audio recorded in person, 09.05.19*). It was explained to me that mapping is the "first question to get there [to an understanding of geology]… any time that you want to go into to why it [a geological feature] is there, how it works, the genetics of it, the modelling of it, those bigger questions" (*Interviewee 33, audio recorded in person, 16.04.19*). Mapping is therefore used as a methodology to identify and fill in gaps in knowledge relating to geological structure and history and contributes to the classification of rock types. Sticking points in completing this three-part puzzle of structure, history and classification stem from absent data and different stories being presented of geological history and present form. Mapping is therefore a method used by geologists to identify what they do not know about geological development and creates a platform to try and resolve that.

I asked many of my informant geologists how they chose the areas they studied in the field. These were defined by earlier 'problems' or unknowns as presented by previous mapping exercises or project work. Two examples below, the first, a student geologist working on a government-funded project for their PhD research in collaboration with the NTGS, the second a project geologist at the NTGS, gave insightful explanations:

> I spent a lot of time along this linear feature, the Wholdaia Shear Zone… It had never been described in the literature before and looked like an obvious feature from the magnetic maps… the reason I was spending all this time on these large shear zones was because my supervisor is a structural geologist and part of what we wanted to add to this larger project was to understand how these shear zones aided in the larger tectonic history of the region *(Interviewee 34, Student Geologist, Audio Recorded in Person, 08.05.19).*
>
> ****
>
> MB: How did you choose your traverses to start off with?
>
> 28: On the map (and I checked air photos as well), I looked, and I thought "aha I can walk from the Sekwi formation to this other younger unit. I can walk from the oldest unit across the middle unit to this younger unit [to differentiate further between them] …". I was looking to cross that blue area [on the map] in a lot of different places to resolve what was inside it…but when you get on the ground there's actually no rock [exposed] there at all… I picked routes to traverse but when I was in the field I thought "well I'm here maybe I'll go over there along strike and figure out what's happening over there". *(Interviewee 28, Government Project Geologist, Audio Recorded in Person, 04.04.19)*

These excerpts present a key similarity that is found throughout my interviews with geologists: project area and the traversed path is defined by (the lack of) previous work that is represented on a map and the questions it prompts. The geological material also defines the path taken during fieldwork: the PhD geologist wanted to follow the shear zone (an area of strained/twisted rock), make recordings and take samples along it to explain the developmental story of the area; while the government geologist wanted to add detail to the definition of rock unit types in her area and understand how they sat together structurally. The selection of the sites to walk across stems from historical/secondary data that exists in the form of maps produced by other government geologists as well as industry, academic, and wider geoscientific literature on an area. Thus, the motivation of both these geologists' mapping in the field was to add nuance to or problematise existing information.

In the NWT, the areas being mapped are largely a political decision taken in collaboration between departments of the GNWT, although geologists are able to select zones/features within those areas which are of interest to storying the area as a whole. These decisions decide whether the project's intention is to in-fill gaps in existing geoscience data (e.g. to improve data available for mineral potential mapping as described in Chapter 6), to provide greater information to draw extractive companies to focus their exploratory efforts in a certain area, or to explain the genesis of a certain mineral deposit or geologic structure. Yet project geologists are constrained in where to go by geography (e.g. lake or lichen coverage); by location (remote areas are lower priority than areas closer to infrastructure, since there is greater chance of mapping being utilised by industry: see Chapter 6 for implications of this); by funder and funding; and by government policy agendas.

Thus, on project work funded by government agencies, geologists are usually restricted to moving through geological areas in a way that allows them to gather the maximum data possible relative to the scale at which the map is being produced with the funding and time available to them. This affects where geologists move, how far, and with how many stops for recording or collecting geological information/samples. Informal discussions with geologists highlighted that they would prefer to stick with the trouble of the geological puzzle, rather than being led by predications of geopolitics of project work related to field access and funding. In reality, resource politics and funding limitations constrain the freedom of the geologist in the field.

When asking 'who' is mapping the NWT, it should be considered that the NTGS's presence in the North occurs against a backdrop of a nationwide conversation around 'Reconciliation' and the legacy of Indigenous Canadian's brutal experience of attempted cultural genocide. The Truth and Reconciliation Commission (TRC), which bore the investigation into residential schools, references the importance of land to traditional cultures and Indigenous well-being and highlights the significance of socio-cultural and environmental damage done by the industrial development of traditional territories for resource extraction purposes (TRC, 2015, p. 359). As such, the TRC recommends that "economic reconciliation will require finding common ground that balances the respective rights, legal interests, and needs of Aboriginal peoples, governments, and industry in the face of climate change and competitive global markets". One of the four pillars of achieving this goal involves the development of "human capital by removing barriers to education, training, and skills development for Aboriginal entrepreneurs, workers, and leaders" (ibid, pg. 359).

There is no Indigenous representation at the NTGS, although there has been historically, demonstrating that at the frontier of primary geological knowledge production about traditional Indigenous territories in the North, all knowledge is produced and held within the settler-community, thus not achieving the aim of integrating Aboriginal labour into this component of the resource development industry[15]. Engineers and Geoscientists British Columbia (EGBC) has taken steps to understand how it can meet the recommendations of the TRC, and one of its aims is to "eliminate educational and employment gaps between Aboriginal and non-Aboriginal Canadians" within the geoscience and engineering disciplines (EGBC, 2020). The northern compatriot of the EGBC, the Northwest Territories Association of Professional Engineers and Geoscientists (NAPEG), has made no public attempts to address the inequalities within the disciplines it governs, and collects no data on the ethnic background of its members (*NAPEG spokesperson, email communications, 04.08.20*). Nationwide, the proportion of Aboriginal people working in the natural resource sector including the geosciences profession is only 1.5% of the sector, while Aboriginal people represent 5% of the national population.[16] Data is not broken down by ethnicity in NWT labour statistics.

Thus, this chapter serves not only to highlight that the expansionist context within which geoscientific data production occurs in the North, but also that this expansionism occurs with the exclusion of Indigenous labour at the sites of knowledge production. Geological knowledge production is focussed within Federal, Provincial and Territorial Governments, as well as in junior and senior mining companies and major engineering consulting firms. Distribution of knowledge and expertise is important in the NWT, since major infrastructure projects such as the Slave Geological Province Access Corridor (SGPAC, see also Chapter 6) hinge on the support of Indigenous governments such as the Yellowknives Dene First

[15] It should be noted that the NTGS does participate in outreach programmes in northern communities alongside the Yellowknife-based Mine Training Society and Mining Matters, to encourage Indigenous school children's interest and participation in geoscience subjects. However, the majority of those registering an interest at the Mine Training Society are for apprenticeships at the mines (Field Notes, 20 February 2019). Both Rio Tinto and De Beers commit funding each year to a programme encouraging women from the NWT to enter into STEM subjects.

[16] Nationwide, the number of Aboriginal people in natural resources professions including geoscience was 24,200, while for non-Aboriginal people it was 1,542,300.

Nation (YKDFN). The YKDFN withdrew their support for the construction of this road in August 2020 after the $20,000,000 contract for initial works for the Environmental Impact Assessment phase was awarded to Golder Associates Ltd and Stantec Architecture, multinational consulting firms rather than an Indigenous owned company from the North (Open NWT, 2020). The YKDFN said:

> Det' on Cho Environmental (a Yellowknives Dene First Nation Company) was unsuccessful in their bid to provide services... While we recognize the qualifications of the two successful bidders… we also are aware that these companies were deemed to be most qualified through a lens that did not benefit from Yellowknives Dene First Nation input… if RFP requirements were developed based upon input from the Yellowknives Dene First Nation, Det' on Cho Environmental (and their partners Hemmera and Dillon Consulting) would have demonstrated that they were best suited to advance this project. (*YKDFN Press Release, 01.08.20).*

Although the YKDFN later lent their support to the SGPC project despite not being allocated the tender for the project (YKDFN and GNWT, 2020) the excerpt above highlights two things: First, a lack of technical capacity at the local level in the NWT, signalling a lack of geoscientific expertise within this Indigenous-owned company, and second the importance and neglect of inputs as to what is important in developing infrastructure within the context of Indigenous traditional territories and Northern economies. Thus, without the technical capacity within local organisations and companies, Indigenous governments and communities remain on the back foot in negotiations with the Territorial government and in competition against multinational companies during major public works processes that are part of the resource development assemblage such as the construction of the SGPAC. In conversation with the CEO of Det' on Cho, I was told that harnessing the opportunities of the SGPAC was critical to the economic self-determination of the YKDFN (*Interviewee 46, 14.06.19*).

In a similar context, Richie Howitt describes the circular trap where Australian governments rely on large-scale mining corporations for the trickle-down of benefits to Aboriginal communities, rather than engendering self-determination and economic independence from the bottom up (i.e. from within Indigenous communities) (Howitt, 2012). This in turn, Howitt argues, reinforces a dependence of Indigenous Australians on government transfers and multinational corporations' exploitation of traditional lands. Similar patterns can be seen in the NWT, where impact benefit agreements and annual pay-outs by mines are lucrative sources of income for Indigenous communities.

Now that this chapter has established *who* is tasked with producing geoscience information, *where* and *why*, this chapter will turn to examining *how* these individuals produce knowledge that is trusted and reproduced beyond their geoscience offices. The following section therefore outlines the affective, experimental relations that geoscientists build with the landscape to produce geological stories of an area to translate into maps and discusses socio-institutional measures of trust that geoscientists use to determine the reliability of their colleagues' work.

5.3 Building bodily relations with geological materials

In this section, I explore how geologists used 'walking-as-method' to generate geoscience data from geological materials in the field. I therefore consider walking as the subject of research wherein walking is the mode of enquiry used by the geologists which "[leaves] distinct impressions, both corporeal and materially substantive" (Lorimer, 2011, p. 19). Walking, as identified by many geographers and anthropologists before (c.f. Anderson, 2004; Ingold and Vergunst, 2008; Middleton, 2011; Pierce and Lawhon, 2015; Bonnett, 2017), comprises the entanglement between body, place, materials and knowledge. It is this entanglement that produces the rich stories of place and associated knowledge (Ingold, 2011), that I explore further here. Most notably, walking-as-method and bodily movement are integral to the production of trust and credibility in contemporary geoscience settings. In this context, I consider what it takes for geologists' work to be evaluated to ensure that it 'makes-sense' within a broader context of practical and theoretical geological knowledge and becomes credible and institutionally endorsed.

Whilst following prospectors and geologists in the field, the significance of movement within their methodological toolkit became apparent, and speaks to Lee and Ingold's observation that "to participate [in the field] is not to walk *into* but to walk *with*" (Lee & Ingold, 2006, p. 67, Italics in original). Geologists followed the materiality of the geology with anticipation of being interrupted by the different, unusual or arresting. Geologists pursue difference as something that informs their mapping and storying of landscape. For example, earlier we read of *Interviewee 28*'s aim to split larger units of geology into smaller units, which involved identifying something which set a unit apart from the wider area – e.g. age or composition of the rock. Establishing difference can therefore involve disrupting, unsettling and sometimes reorganising the whole. As geologists pursue difference, new becomings such as geological (re)categorisation or (re)structuring occur.

During my conversation with geologists, the instigation of movement was dislocated from the site it actually was enacted. This is evidenced by the pre-drawing of lines and paths for walking whilst planning fieldwork. For example, some of the project geologists who I interviewed identified large undifferentiated geological units on maps as areas that had been mapped at low resolution and required further work to add detail. On a map this homogeneity would be seen as a large block of one colour (e.g., figure 5.1):

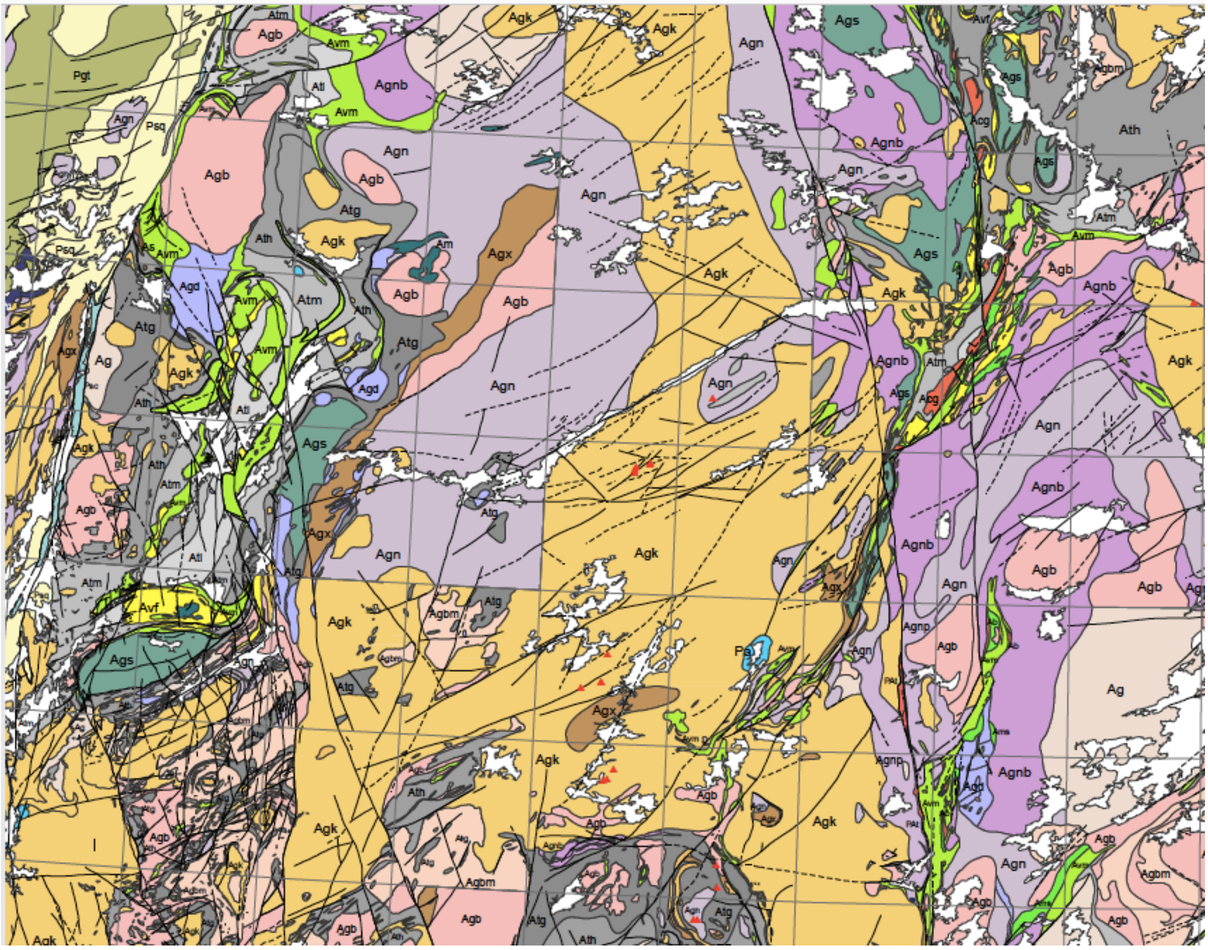

Figure 5-1: Zoomed in portion of the compiled Slave craton bedrock map to demonstrate poor differentiation that exists in parts of the region. Note how the yellow and purple sections have much less detail than those to the east and west of that central band (Stubley and Irwin, 2019).

> These are huge swaths of land, and these are granites, these guys have subdivided this granite and these guys haven't. So, you see how they [who subdivided] put the light pink one in there, the dark purple one in there. Those are different types of granite… They [who didn't subdivide] probably just put 2 or 3 observations on it and said it's all granite and missed everything in between. (*Interviewee 26, Government Geologist, audio recorded in person, 29.03.19*).

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> You realise at the centre [the unit is] all one colour, so that's where we're going back and then trying to provide more detail. (*Interviewee 29, Government Project Geologist, audio recorded in person, 09.04.19*).

These excerpts tell us that geologists know to be aware of large homogenous units, especially within a wider context of geological complexity, and therefore become targets for extra work to identify their geological classification in greater detail.[17] We heard earlier that *Interviewee 28* intended to differentiate an area by walking a line to transect an amalgamated/homogenised space. The line the geologist wanted to use was imagined in the office – a line *through* time – older to younger. However, because the units were very poorly visible and covered in vegetation, the geologist opted instead to walk along a strike – the direction in which a bed of rock is sitting in relation to the larger mass – which is a line representing a moment *of* time. Using the latter line and looking at a moment of time, the geologist was forced to assemble some of the structural geology of the area, establishing historical processes along lines (such as faulting and folding) that caused some of the differentiation in the geology in the first place. The geologist's movement on the ground in pursuit of the units they were able to see shifted the type of storying the geologist did of the whole.

I experienced the importance of walking-as-method for storying, encountering and pursuing difference in the landscape on a day trip with geologists from the NTGS to the disused Giant

[17] This kind of nuance is not well translated through the map to users who are not geologists. The implication of this in economic geology, as will be demonstrated in Chapter 6, is that models that might be applied to create predictions as to the potentiality of an area for resource development could miscalculate the mineral potential of poorly described and differentiated units. The compilation map of the Slave Geological Province examined in Chapter 6 is a mishmash of maps with diverse scales, densities and qualities of data informing their depictions.

Mine in Yellowknife. Creating stories of a whole via affective relations with geological matter is critical in allowing difference to be recognised and harnessed. I was told by the lead geologist that "a good geologist pays attention to that which they do not understand" and that we would be "continually walking with multiple stories at the same time" (*Interviewee 42, field notes, 05.07.19*).

This way of learning draws together arguments made by Latour (2004) on learning to be affected and Massey (2005) on the storying of space. First, Latour highlights the significance of difference when learning about an object of study, wherein an individual accrues and deepens knowledge by learning to be affected by an object's many nuances and differences. These differences build upon one another and are teased out of the whole through gradual sensitisation of the body to the object's complexity. Meanwhile, for Massey (ibid, p. 265), space is a series of "stories-so-far", with places becoming "collections of those stories".

What is evidenced in this context is how these earth-stories are mediated, assembled and translated into circulatable form thanks to the human body. Non-representation geographies help us 'flesh out' what affects and emotions allow this spatio-historical geological 'learning' to literally take place. Understood through Jane Bennett's work on enchantment, we can understand the places we were walking across at the Giant Mine as generating "a state of wonder" where "the temporary suspension of chronological time and bodily movement" took place (Bennett 2001, p. 5). The enchantment of the geologists by the geological story unfolding before them was evident. The geologists paused, examined, recorded and storied the landscape, and their passion for geology was expressed in those moments through their fervent descriptions of what they were seeing, spoken with bright eyes and bold gesticulation. The 'taking place' and connection between thought, place and materials are integral to the production of affects like enchantment (Thrift, 2004; Anderson, 2006). Understanding enchantment and its accompanying sensual interventions in the following examples allows for a closer reading of the affective tensions that emerge between humans and material through the method of walking, and links together how place, story and time are woven together or are pulled apart by the geologist.

The field trip to the Giant Mine was intended to show me and another geologist some geological features called pillow basalts (figure 5.2) which are "a volcanic igneous rock that forms when lava of basaltic composition is erupted underwater. The rapid cooling of the lava by cold water on all sides forms the pillow-shaped bodies" (US National Park Service, 2015). The geologists also showed me the evolutionary history of the area which allowed gold to be discovered and mined, the successive iterations of geological work that the area has undergone, and the general methodologies used by a geologist mapping in the field.

Figure 5-2: Pillow basalts (with a pillow circled) on the iron-red rock. Note the clarity of the lines at the edge of the rock. Photo by author.

As we set out on foot from the truck, the first geological events we encountered had pillow basalts as their artefacts. Pillows are identifiable by their dark outlines because they are a product of the rapid cooling and production of a glassier surface in comparison to the magma inside. I was told that these were "world-class pillow basalts" (*Interviewee 42, field notes, 05.07.19*), and that by implication I should prepare myself to be enraptured by the quality of the geological material we were about to encounter. The quality of the pillows was mediated in part by the sulphuric acid that had washed over the basalt during the Giant Mine gold processing days, bleaching the rock from black to red and thus emphasising the contours of the material. Luckily, I am a rock enthusiast, so my enthusiasm did not take much to muster an appreciation of their form. It became clear as *Interviewee 42* described to me the volumes and types of environmental information that may be derived from pillows that learning to be affected by geological signals is a critical element to walking-as-method and the enchantment process (Latour, 2004).

In particular, *Interviewee 42* became especially enthusiastic as he showed us small details – the fissures through which gasses had passed along the top of the pillows, the clarity of pillow walls and their overall shape, each contributing to our understanding of the direction and orientation in which the magma had been flowing. The geologist leant down to feel the fissures, so that as if via touch, the historical reality of this event might be better understood by himself and us. The intricacy of detail encased in this archaeology of events appeared to inspire particular captivation. We dwelled with the pillow basalts for some time, learning about how their morphology told a story about their becoming. During these moments, we traced the shape of the pillows with our eyes, registered colour contrasts, and felt the gaps that gasses moved through by touching their crumbling walls. Here, echoes of Puig de la Bellacasa's (2019, p. 399) incitement of "material intimacies through bodily closeness" are heard, highlighting the capacity of apparently inert and unlively materials like rocks to initiate a sensual and bodily response. The criticality of place and material in divining the direction of scientific enquiry is clear so that geological field sciences, are, quite evidently, enlivened and animated by the place where it is produced.

In these moments, *Interviewee 42* also showed us evidence of how the pillows had begun to cool, but where fresh magma pushed a new glug of hot rock forward, so that the resulting pattern was similar to the images of open valves of an artery in a biology textbook. The materiality of the rocks in these places provided us with a direction in which the events proceeded, giving us an entry point and orientation within the story we were encountering. These not-quite-enclosures provided us with a temporality for the making of these features, and the pace and persistence of the volcanic activity that produced them. The example of pillow basalts demonstrates a diversity of becomings over different time scales that are captured by geology. Imagine there is a dial that you can use to slow or increase the speed of magma moving, and as such the kind of assemblage the geological material builds with the environment around it changes, and so do the ways humans interpret its form. The material comprising the rock is the same, but temporality allows difference to occur, to be actualised in diverse ways that we see today through the archaeology of lines, colour and texture of the rock which the geologist reads as indicators of conditions of temperature, pressure, moisture and geological materiality. These differences tell us about how long magma was being extruded into the sea, with how much heat, with what viscosity and carrying what chemicals. These features enclosed within these bubble-like capsules provide immense detail for the deposition of geological matter over days/weeks around 2.7 billion years ago. This detail allowed us to place ourselves within an unfolding 4D geo-scape, transporting us into imaginary once-real underwater worlds where different materials, temperatures and pressures tangled together to form a very specific rocky mass seen today.

For geologists, pillows are a fairly elementary physical feature to identify, but it demonstrates more generally how a close reading of the rocks is necessary to build a story of succession and to begin to narrate the becoming of the whole which can then be translated into a mapped depiction. Our pillow basalts gave us a story that included the direction of deposition (i.e., in which order to read the rocks/assemble the storyline), the background environment (volcanic/oceanic), and the speed of deposition (rapid).

This baseline story was put to use some moments later as we walked and encountered a new geology at the Giant Mine site:

> We walk off the pillow outcrop and down to some new rock. We ask, 'what is it?' as it looks so different, then we look for a contact to see how it sits against the other rock we just walked from. We move back and forth to compare the two masses.
>
> We see a variety of shapes of materials which are discordant from the host material, like blobs and some squares. Some are jagged pieces that look like the pillow rock, and some are much lighter with well rounded edges that look like granite. They're hosted in a dark rock of ash. We notice how the band of conglomerate is sorted, with the larger materials in the upward side, and the smaller materials at the bottom. [42] tells us that in debris flows (a lahar) the denser objects tend to float along the top and the smaller materials at the bottom. An abrasive flow would account for the tearing off of pillow segments and entrainment in the load. Imagine the messiness of a mudslide after an ashy volcanic event that you see in Indonesia. We move off the conglomerate and pillows are seen again. *(Field notes, 05.07.19)*

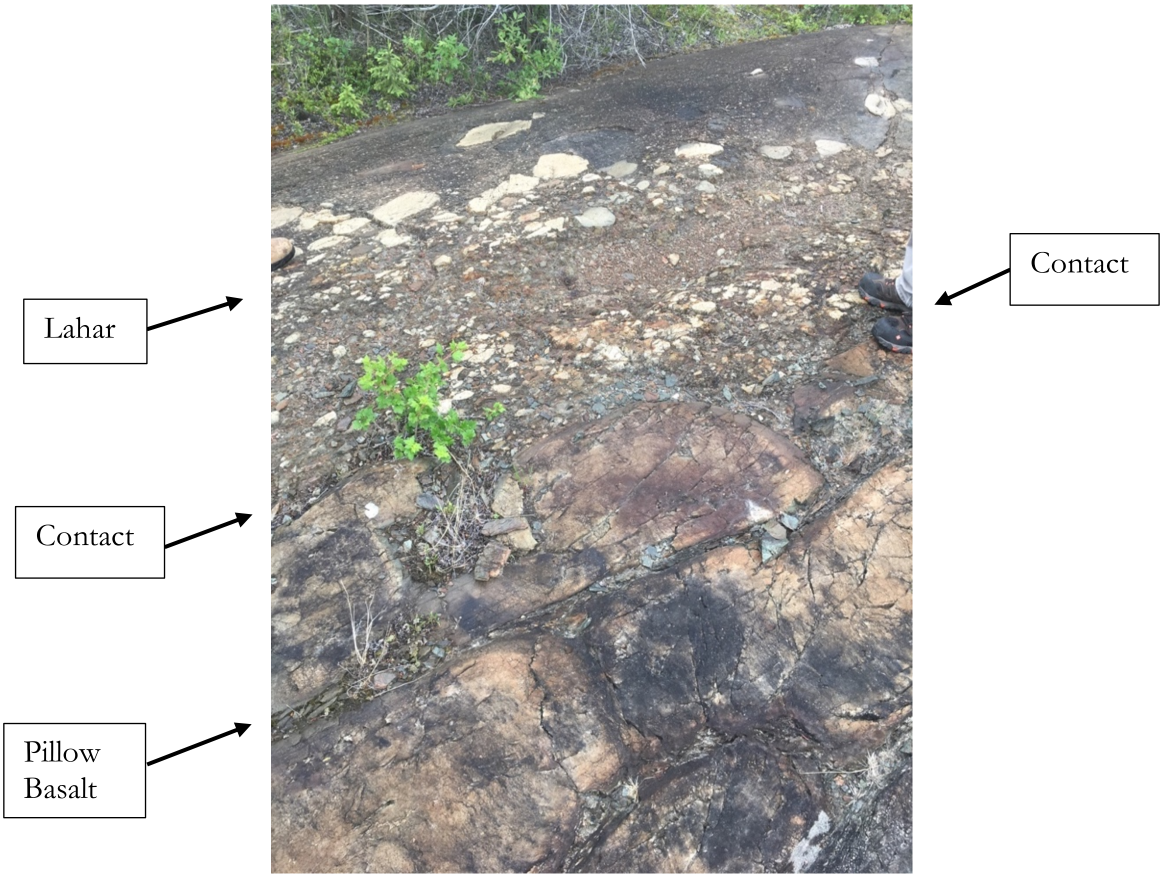

Figure 5-3: Photograph of the contact between the pillow basalts and lahar encountered during the walk at Giant Mine. Photo by author.

Stopping and noticing difference involved the deployment of what could be termed an 'enchantment toolkit', which I suggest captures the learned affective skillset geologists use to understand what they are looking at. This 'toolkit' required what Thrift describes as "thinking as a set of geographies of the sensible" (Thrift, 2004, p. 91). During these moments of earth-reading, our bodies were open and ready to be affected by that which we came across, initiating "thought imbued intensities" which emerged when we crossed the contact where two rock-types met (Anderson, 2006, p. 737). These intensities initiated our reflection on what we were seeing in relation to what we had already storied. Paying attention to the contact's roughness encouraged us to consider highly abrasive movements over the surface of the pillows when they were not fully cooled. The materiality of the band of rock fossilising the mass movement provided us with a tension that invited us to change the storyline and allow a new character to enter the mix from afar. The pattern of larger material settling over smaller confirmed the feature as a lahar flow and forced us to stretch our minds 'upstream' to where this flow had come from and imagine an environment beyond that which we were directly encountering. In this other geological environment, granites (which we know to sit around 10km north of the site) were therefore also given a temporality since they could be confirmed as being older than the pillow basalts over which the lahar had flowed with its load. Thus, the tension created by our enchantment with difference allowed us to add new temporalities, materialities and geographies to our story, which could then be noted on a map of the area (figure 5.4).

This example demonstrates how the exercise of mapping geology is not emotionally or materially abstract from the space being rendered cartographic. Recording geological space is not as simple as writing what rock is where. Writing a geological story in cartographic form requires a wider understanding about the sequence of events, both in the scale of eons and eras, but also at the scale of seconds, hours and days. This work demonstrates that ordering geological materials' relational space-times is critically dependent upon geologists' abilities to step into moments where their emotions and resonate with the environment, and - as Thrift (2004) describes it - think through their bodies. With this knowledge, one might provoke geological map reading as not just a topological collection of lines points and polygons, but as a topology of emotions.

Meanwhile, from an economic geology perspective, dissecting the events we walked over was important mineralogically because the events inscribed in the earth help determine the possibility that certain minerals such as gold might be deposited there. Gold in the Yellowknife greenstone belt is associated with certain geological environments (i.e., hydrothermal) and particular geochemistry and pressures (*Interviewee 9, ex-government geologist, audio recorded in person, 10.10.18*). Thus, when exploration geologists or prospectors look at a map, reading the symbol for pillow basalt (upside-down bowler hats in the dark green unit in figure 5.4) helps to home in on a geology that is permissive of mineral deposition.

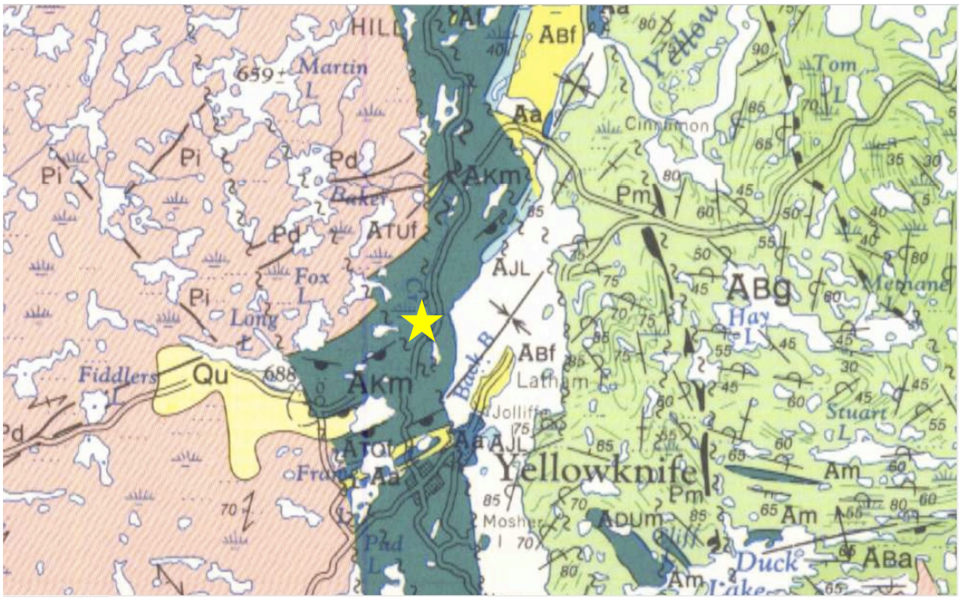

Figure 5-4: Zoomed in section of bedrock geology map by Henderson (1985) showing the pillow basalts symbolised as upside-down bowler hats in the dark green band. Yellow star marks the Giant Mine site

Yet following the movement of geologists in the field demonstrates the compromises that are made by scientists in producing the map. Figure 5.4 demonstrates pillow basalts on a map of the Yellowknife area, but not the lahar, even though the lahar was an event encountered at the same spatial scale as the pillows and is critical to our knowledge of the historical environment of the place. This example demonstrates that geologists are doing more than just reducing 'reality' into 'representation', they are also tasked with filtering a story to tell highlights for a specific audience. In so doing, what occurs is a series of displacements and silences – the exclusion of particular sites, their meanings and geological histories – resulting in the omission of alternative geological stories which might, in a non-extractive economy, hold their own value and meaning.

One product of this translation is the map in figure 5.4, which demonstrates the intention of 'earth reading' in this context as intended to work for economic geologists. We see a valuation of importance of certain geological features over others, with features in this specific area highlighted as signifiers of environmental conditions for mineral occurrence. Therefore, not all differences encountered in the field are considered equal, even though they are all critical in storying the area. Only by walking with the geologists and understanding what was left *out* of the reduction and translation into cartography do we understand what is *included* in the reduction and why, and in doing this we recognise the ways in which the map is not a 'neutral' scientific artefact but rather embedded with intentionality and echoing with silences of things-left-out. As such, the hinterland behind scientific objects is given a politics – what is assumed to reflect fact is actually a reduction of information based on factors thought to be politically and economically pertinent to the object's users.

As well as allowing for spatial storying, where gaps in the geological record exist or where unexpected geological patterns unfold, walking-as-method enables geologists to construct and test hypotheses. Once a geologist is attuned to difference and is interested in using difference to fill in gaps, they can also use the map as a surface to experiment with possible geological histories of an area. *Interviewee 36* explained how they and their research partner (*Interviewee 31*) followed geological patterns through the field which they saw unfolding before them and were significant to the geological storying of the area:

> You'd be walking along, and you'd see this unit, then you'd walk a bit further along and you'd see a calc-silicate unit, and you'd see gneiss. Then you're somewhere else and see the calk-silicate, then marble, then gneiss, then quartzite, then gneiss. And it became predictable that when you saw one of these units… that you could turn left or right depending on what was proximal to that unit and you'd see gneiss. What is that? It's an unconformity… You could find that unconformity everywhere through the area and it became the hypothesis and the test. If every time you find those units, you find the gneiss then your prediction and hypothesis start to be correct. [31] and I crawled over outcrops looking for the contacts of this thing and found it. This was over 50km, not crawling over 50km, but [crawling] in key locations going to find this. And because it is an important stratigraphic unit in the area, it allows us to tell a story of what's going on in the evolution of that area. (*Interviewee 36, Government Project Geologist, Audio Recorded in Person, 09.05.19).*

Here, walking through difference encouraged the building and testing of geological hypotheses of evolution, change and development. The geologist above describes how they crawled, figuratively and literally, across kilometres of outcrop to trace a pattern that had been unfolding before them and indicated that they had found an unconformity (figure 5.5). They were following an imagined line through time that was accessible to them as a result of historical folding and subsequent glacial erosion of the top layers of rock which revealed the repeating, folded pattern. The folding meant that the strata comprising gneiss, calk-silicate and marble were upturned from the horizontal into the vertical, allowing the geologist a 4D view into the geology. By following the repeated pattern of difference seen in the unconformity, knowledge was generated that could be replicated and transferred into new areas, where they can be applied to understand similar geologies: "there have been a number of key studies documenting various aspects of Slave-related deformation in the Neoarchean and that in many cases these provide a framework that can be applied to many unstudied areas" (*Interviewee 31, Government Project Geologist, Audio Recorded via Skype, 30.04.19*).

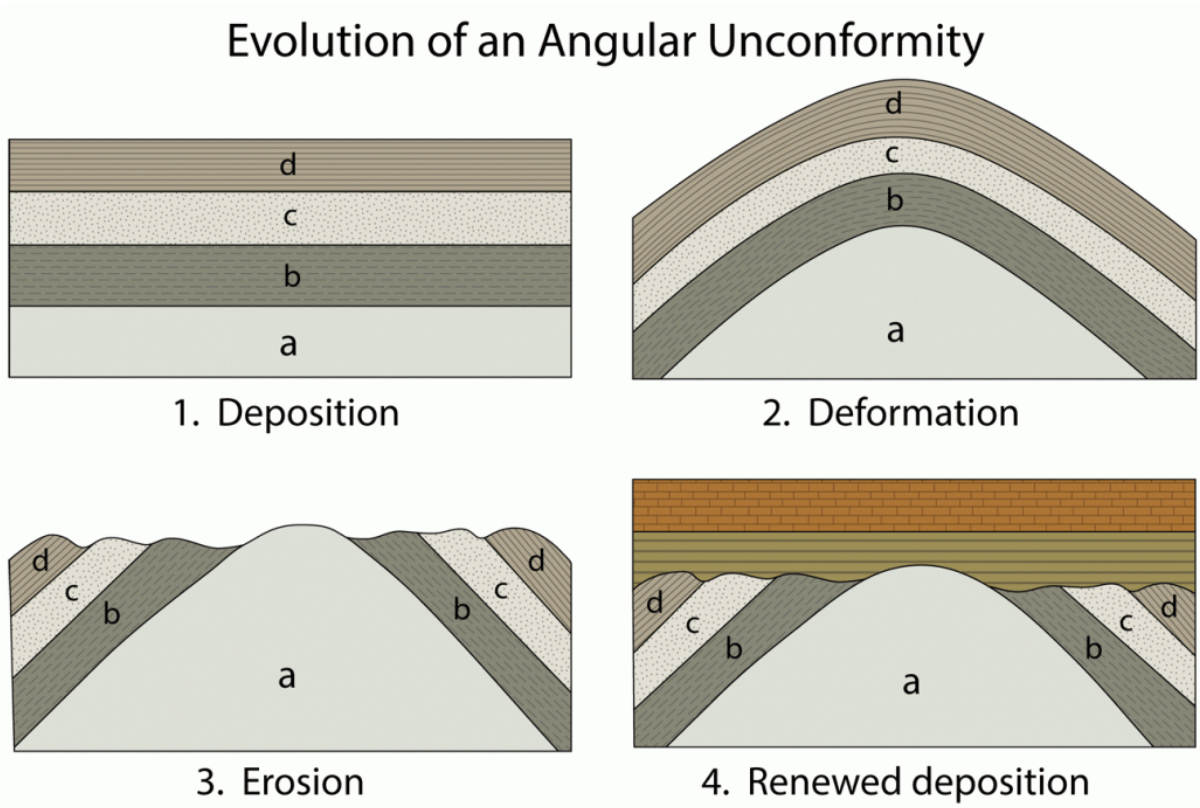

Figure 5-5: Simple diagram of an unconformity which is the boundary between deformed layers (a, b, c, d) and the new deposition. It signifies a change in geological regime (Image source: Utah Geological Survey, 2018).

The emphasis the geologist placed on the crawling motion for their discovery during our interview highlighted to me the bodily labour and diligence that had been involved in their research, and how their body was tied to the materiality of the landscape. However, this account also has implications on how we understand the interconnection between place, affect and trust. The implication of their description was that because there was a slowing of pace, a closer contact between self and rock enhanced the authenticity and trustworthiness of their hypothesis. Not only were the geologists' feet and eyes carrying and tracing them across the field in pursuit of the unconformity, but the whole body (including knees and hands) was deployed to mediate an intense affective relationship between rocks and imagination at particular moments. A critical component of learning, experimenting, and puzzling is the application of body to problem solving. The slowing of pace and deepening of connection between place and geologist emphasises the importance of time in the field to the production of geological 'fact'. Thus, like when we slowed at encountering the lahar at Giant Mine, the pace of movement was integral to allowing these discoveries to be made, engaged with and recorded. The connection between trust, credibility and fieldwork is returned to in the next section.

5.4 'Making sense', trust and credibility

The last quote from *Interviewee 36* describes 'hypothesis testing on-the-go'. This method of geological enquiry can be understood as similar to experimentation in that possible evolutionary/depositional models are tested by geologists to assemble stories of their study area. As discussed earlier, a geologist may choose to map an area because it poses problems – it does not make sense. Mapping is used both as a methodology to problematize the geologic, and to experiment with scenarios to understand what best 'makes sense'. *Interviewee 36* (*ibid.*) explained that "the whole thing with mapping is that you don't know what the problem is. Or perhaps you have a hypothesis then that's quickly going to change. If you know all the answers in there, you shouldn't be mapping, because it's a waste of resources".

Meanwhile, after the initial encounter between geologist and material, it is necessary to 'make sense' both of the geology, and geoscientific work. 'Making sense' was alluded to by many geologists I interviewed, and I was intrigued to explore what this meant in practice. I learned that making sense involves telling a story which is geologically feasible within the context of the information available for an area and scientific theories of Earth Science. A map compiler working with two maps, one from the GSC and one that *Interviewee 31* produced, explained that different sources must hang together in order to tell a story that is plausible. The compiler explained how it was possible for a map to 'make sense' geologically, yet still be false when compared with other evidence on the region:

> …This is a GSC map that was done in 2000… The guy who ran this programme, he was near retirement and he had a huge crew for three summers they covered the whole belt. They released this at 1:100,000 and they stayed in the industry camps and supposedly had access to helicopters and anything that industry had for them. This map was widely praised as being the final thing this guy did. He was one of my mentors until I started working in the belt, [but] it absolutely makes no sense. That's because he never went out and he was just, he had all these people go out and he made a nice map from all the data they brought back, but it just doesn't make sense, the industry that works there don't use it at all, they just use it as a pretty thing on the wall to show the lakes, and that's about all that it's worth.

I probed him further to understand what he meant by the map not making sense even though it initially appeared to. He responded:

> When I first saw it, it looked great, but then when I looked at the details it's not quite there…He's got it all backwards, but it does make sense for the most part.

He then compared the GSC map to one produced by *Interviewee 31*, then an early-career scientist twenty years earlier, which covers the same area:

> This is [31's] original map: these are the outcrops; this is a river. And I'll put it on the GSC map [~*Overlays the maps*~]. And anywhere she's made a measurement she's put it on. [~*Zooms in*~]. So, you can see the quaternary where they [the GSC] said there's no outcrop, but she puts outcrop. She hasn't put any contacts… at the end of her career she doesn't do much interpretation, she just presents the facts…The other thing is, they [the GSC] said there was nothing there, but there's heaps

> of data [on 31's map]! So that's kind of scary. *(Interviewee 13, Regional Map Compiler, Audio Recorded in Person, 13.05.19).*

This conversation revealed a number of things about the relation between making sense, trust, field methods and geologists renown. In combination with other interviews, this demonstrates how trust in individuals, as discussed by Shapin (1994), translated into trust in their science. While Shapin reveals the importance of integrity of character (associated largely with class in the 17th century) for engendering trust in information, my work with the geologists highlighted the importance of the diligence of geoscientists' field methods and their ability to accurately record observations and utilise and reference appropriate existing source materials. The dynamic of trust in information generated in the field and in the office as articulated by *Interviewee 13* can also be viewed through Driver's (2001) account of the field/cabinet as knowledge sites in the late 19th century. We can interpret *Interviewee 13's* disdain for the mistakes in the GSC's map as relational to the effort taken to actually enter the field on the part of the individual who signed off the map. As Driver (p.51) puts it "the credibility of claims to empirical knowledge was said to depend on accurate observation above all else". Here, *Interviewee 13* offers clear judgement that the map's unreliability is a product of the individual's reliance upon others to generate field data and his theoretical, office-based geological understanding to process and represent that information. This mirrors well the tension within the RGS in the 1800s described by Driver, where the reliability of 'explorers' gathering data in the field for the consumption and re-presentation by 'experts' in the cabinet was a hotly discussed controversy. Just as Driver describes, for *Interviewee 13*, the boundary between field and cabinet is not fixed. Although the geologist in question was at the field base when this data was collected, his physical presence in place was insufficient to 1) produce reliable and accurate data and 2) to convey authority of his work to its readership. This highlights that the labour of 'doing science' remains foundational to the trust and confidence that others place in it. This stands even against the esteem held in that geologist as a result of his illustrious career.

In comparison, praise was levelled at *Interviewee 31's* mapping who was regularly referred to by other geologists as having gold-standard field practices. A simple but critical component of their work was the marking of sample locations and reference numbers on their final map. As such, trust was engendered as knowledge tied *directly* to place, making it traceable and accountable to a defined 'reality'. The significance of place to trust and knowledge is explored by Gieryn (2018) in his book 'Truth Spots'. There, Gieryn explores the capacity of particular places to become places where truth is located. For him, "the truth, it seems, is where you find it" (ibid. p 171): it is the direct attachment of our stories to place (via sample locations) and accompanying narrations/stories (geological explanation) that inspire trust. I think Gieryn's "epistemic significance of place" (p. 172) can be taken further in this context as the 'epistemic criticality of plac*ing*', which attends to the gravity of both the practical exercise of deriving knowledge from place and of making that knowledge accountable to a specific material context.

Interviewee 29 discussed how attention to locational detail is crucial in the production of maps and allows for knowledge to be built upon itself. This detail can be included in data packages for maps viewed on ArcGIS:

> In this map we used a lot of information that was published by industry. It has an index source, so it shows you where there's previous maps available and the source of the data, and then it shows where we went [with the crosses], so we didn't go in here, but we still have detailed geology because we used the previous maps and our extrapolation of what we have… And then we have a solid line that goes across the

> outcrop [seen], and then we have a dashed line [unseen] and then we have a point of observation and then our structural measurements… And the thing too is that you can say in the background [blurb/note] that this contact was drawn from this map, and this contact was interpreted from air photos, this contact was walked over. The level of certainty can be added to the database." (*Interviewee 29, audio recorded in person, 09.04.19*).

The conversation with *Interviewees 13* and *29* shows a balance in placing trust in precise and accurate annotations on maps and the triangulation of information between different pieces of work (e.g. that all maps will categorise a specific area as Quaternary material rather than as Archean, for example). Yet it also highlights the background against which this information is produced. The GSC's mapper received criticism for his reliance on a large team, rather than mapping the area himself. The presence of a large team of (potentially inexperienced) field workers offers opportunity for error or contradiction in the identification of different rock types, rather than lots of people using their collective judgement to accurately categorise a rock type. Where only one or two geologists conduct the mapping for an area, there is a consistency in method and knowledge within that map. I asked *Interviewee 13* (ibid.) how responsible the large team size was for the inaccuracies in the map: "I think that would be a problem. That bigger crew, you're using inexperienced people, and trying to do the best with what you're bringing back. And unfortunately, the bigger the camp the harder it is to control".

Furthermore, as alluded to by both *Interviewees 29* and *13*, the GSC geologists made inferences about what rock might be there, but presented it as 'fact' (i.e. as seen). Meanwhile, *Interviewee 31* uses sample location points to demonstrate they stood at a particular point and were able to see the geology and make an assessment of what it was. Although it is not unusual for geologists to make interpretations of what the geology could be when they cannot see it (e.g.

if it's hidden under lichen or a lake), I learned that it is best practice to clearly differentiate between inferred and seen geology through hatching or dashed lines on a map. Trust also comes from the map-reader themselves. They apply their own knowledge of the area to the map to weigh-up which the story can be considered plausible or correct. Lastly, socio-institutional reputation is also critical: I was told an anecdote about a geologist working in the NWT in the 1980s who was known to be a keen drinker. When their field notes were later read, it was possible to gather what had been written in the morning (feasible/correct geology) and in the afternoon (made up geology and rock types) on the basis that the individual had become more inebriated as the day wore on!

Yet the process of making sense is not just about deducing from available evidence the most likely story of geological development and placing trust in it, but also about filling gaps through interpretation where evidence might be missing. Recall *Interviewee 28* discussing their intention to map the units of the Sekwi formation, but then struggling to find exposed bedrock to classify the geology. Figure 5.6 depicts the sketched scenarios they were working through after their encounter with geology forced them to follow along strike (a moment in time) rather than along a contact (where two rock types meet). We spoke about the challenges of telling a story when limited evidence was available:

> MB: You were talking about how you were finding it a challenge to figure out… [I point to three hills on the map, see figure 5.6]
>
> 28: Yeah, I don't have enough information for that area yet. It's structurally really complex and there's so many possibilities. I can show you all these different possible solutions to what's going on there [~ *shows me about 12 map sheets with sketch scenarios*~]. None of them actually works well, one works enough, but nothing is quite right and I've, I mean there's a fault here, but does it go here, here, here, or end here with a cross cutting fault? I just don't have enough information. My observation points aren't

> dense enough to resolve this area because it's so complex. *(Interviewee 28, 04.04.19).*

I asked *Interviewee 28* how they decide whether the sketch maps they draw do make sense. I had heard from other geologists about the use of geological models which provide a theory or framework for the creation of certain geological features. Did they feature in *Interviewee 28*'s experiments?

> I don't tend to use too many geological models. I just tend to check whether it's reasonable to put two faults next to each other like that. Can that happen? And so I have to check, has it happened before? This book has lots of examples of… [~*flicks through book*~] ok those are experimental, theoretical, then you get into some real-life examples. There are examples of faults diverging in the way I'm trying to pretend that they diverge in my map…. You need existing explanations. I could explain this by putting a cross-cutting fault but the reason that bothers me is why would you have that? *(Ibid.).*

The map is therefore a surface on which the geologist can experiment and puzzle solutions to the unknown: "you do the mapping and you figure out what problems that mapping presents, and how you can resolve them" (*Interviewee 31, 30.04.19*). The upper image in figure 5.6 demonstrates how the geologist places the puzzle they are figuring within the broader geological context, and the lower image demonstrates how they move into the third dimension to visualise the potential faulting beneath the ground that would allow the geological expression on the surface to exist.

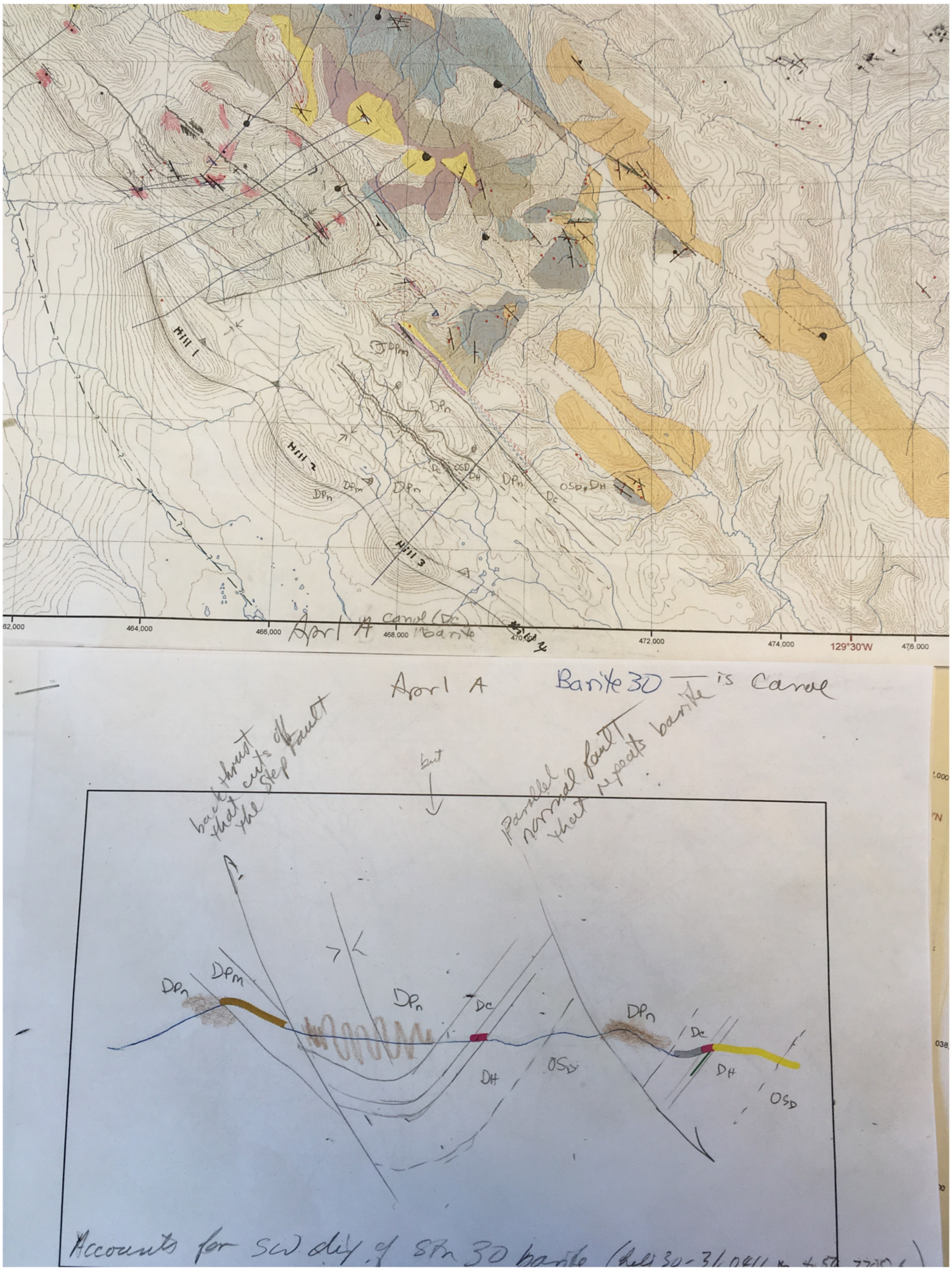

Figure 5-6: Annotated topographic map and hand drawn sketch map by I. 28. The bottom sketch is a cross section of the line drawn through 'Hill 3' in the top map.

This example demonstrates that a geologist never deals with geology only a horizontal plane, even though it becomes represented as such[18]. A geologist will be drawing for representation in the 2D but will be puzzling through the third and fourth dimensions simultaneously. I used the analogy of a 4D Sudoku cube in my discussion of this with *Interviewee 28*. When placing a number in one spot, it affects the possibility for any other number to be placed on the cube at any given time. Therefore, shifting the system in geologists' mind requires motioning through possible and impossible scenarios within depth and time. For example, the geologist must ask if they draw a stratum at a certain angle, is it possible for other strata to sit next to it at that angle, given that XYZ events of deformation are known to have occurred? The geologist is therefore required to exist *with* their work, unfolding and refolding the cross-section of their study site, creating a laboratory of possibilities between their mind and paper.

This process resonates with the one described by the artist Ólafur Eliasson quoted in Jellis (2014, pg. 373): "sometimes you also have a feeling that hasn't quite crystallized into an idea but you can still base an experiment upon that feeling, and in this way push the experiment in front of the idea." This is what *Interviewee 28* was doing in this case – experimenting through practice and checking back on the feasibility of their ideas within known geological possibilities. Later, *28* informally reflected on the pressure that experimenting placed on their work, revealing that their past experiments had all been proven correct when others had later gone back to the field to check them, compelling them to produce accurate maps that would remain trusted by industry and other geologists.

[18] Although cross-sections also accompany some maps where sufficient data is available.

As *Interviewee 28* settled out elements of the map they were working on, they annotated the main map to reflect this, drawing onto the main map by hand, scanning the map into the computer, and georeferencing the line within ArcGIS to digitise the elements that had been settled as 'making sense'. The map was then printed again and annotated in the next iterative revision. Map building was incremental and required several attempts to get the geology 'just right' to allow it to make sense and tell a reasonable story. Certainty was gradually inserted into the map and through repetition and experimentation, a feasible story of geological form was being aligned within the map. However, the process of making this geoscientific product was less one of data and testing, of statistics and geochemical analysis; this aspect of geology was reliant upon storying and affective relations with geological possibilities to bolster ideas of what the rocks' structure is or is most likely to be.

This encounter with *Interviewee 28's* office-based mapping reveals new frictions and nuance around the task of mediating between being in and away from a place and producing knowledge. The geologist in this situation was constrained by the opportunity to 'see' the geology – both because of the logistical cost of entering the field to conduct more mapping, and because it was physically covered by vegetation and sediment. Here, the geologist used fragments of knowledge about a place, collected on previous field trips, to assemble geologies of the unknown. The geologist demonstrated a dance between fact (the observed/field), theory (the deduced/office) and cognitive relations with an impossible number of lines, angles and planes to construct possibilities of a reality that might 'make sense'. This conversation with *Interviewee 28* was important for demonstrating that despite my emphasis on attending to the affective and bodily in this chapter, evaluations of geological reality *are* embedded within parameters of scientific theory and explanation about the world, rather than guided purely by subjectivity. Although interpretative subjectivity plays a significant role in geology, the subject does ground itself on empirically tested, peer reviewed, theoretical sciences.

Thus, we might ask why *Interviewee 28's* work is seen as credible, despite not being grounded in field observation (contra the GSC mapper described above). Ultimately, this credibility and trust is levelled at the capacity of the work to be tested against 'reality' as found in the field and proven to be correct. As Latour (1999) notes, where word and image can be reproduced by other geologists upon visiting a site, trust is generated for scientists' work and builds their reputation within networks of knowledge and practice.

5.5 Conclusion

This chapter has contributed an insight into what the hinterland and background worlds of geological materials comprises and how that impacts the way we know geological landscapes in the NWT. By exploring the motivations for mapping, a political emphasis on knowledge production for mineral deposit identification was established. It also became clear that hinterlands conceal within them vibrant associations between geologists and materials where geological map making is dependent on individuals' skills and capacities to render bodily relations and encounters with geology productive for cartographic representation. As such, this chapter demonstrates that unlike other sciences which have been studied in STS, geology remains a field science in which interpretations by the individual precipitate particular understandings of geological reality.

This chapter makes a series of contributions to the literature engaged in this thesis in the following ways:

First, this chapter has taken an original perspective to understand what scientists are doing in the field to produce geological maps. This develops existing (historical) geography literatures which have so far been limited to exploring the role of geological mapping in relation to broader socio-institutional relations – e.g. between geosciences and territorial expansion (Braun, 2000; Simpson, 2019) and geoscience and institutional relations and structures (Zeller, 1987) – as opposed to the affective and relational experiences I put forth here. My research therefore suggests that affect as a territory-making practice should be taken more seriously and considered as integral to (expansionist) territorial programmes, particularly in (post)colonial situations such as Canada. Here, science studies and cultural geography could meet with feminist scholars' work e.g. Cvetkovich (2021) to understand how affect is integral to the day to day rationalisations of living in, making and expanding settler spaces.

Second, the focus on the relations between geoscientists and geological material that has emerged through this chapter highlights the contributions cultural geography can make to better understand how resources come to be made and scientific materials produced. I have therefore expanded on work exploring how geological resource accounts get circulated in an economy (Kama and Kuchler, 2019; Weszkalnys, 2015) and highlighted the significance of the preliminary stages of geoscientific production. More specifically, the importance of individual geologists' mapping methods is shown to provide particular geological understandings and spatial renderings which have implications of the quality and reliability of broader resource accounts and decision making.

The third contribution this chapter makes to existing literatures is around the material heterogeneity of the geological world – what I term geodiversity – and its impact on how scientists produce geological knowledge. Literatures from anthropology and psychogeography (e.g. Lee and Ingold (2006) and Bonnett (2017)) highlight the significance of walking-as-method. However, when combined with work on enchantment/embodied learning (Bennett 2001, Thrift 2004, and Anderson 2010) we learn that for walking to be a productive geoscientific method, paying attention to and becoming enlivened by geodiversity is crucial. Whilst Peters *et al* (2018), Steinberg and Peters (2015) and Bakker and Bridge (2009) highlight the significance of material heterogeneity in constituting (resource) volumes, they do less well to articulate how that diversity speaks to the specific processes and outcomes of how we come to *know* that volume. I have therefore shown how geodiversity nurtures affective relations in turn prompting the use of particular geoscientific methods, and consequently, have explored how those relations come to speak for the trustworthiness of geoscientists' work within institutional settings.

Fourth, geodiversity (and the intimate relations required of geologists to understand it) serves to add nuance to STS works relating to trust in science by exploring the socio-material relations between scientists and geology both in the office and field. Consequently, my work demonstrates that STS studies exploring the role of the individual and place in the making of 'credible' science (e.g. Gieryn, 1983; Shapin, 1988, 1994; Driver, 2001) remains relevant and fruitful ground for understanding how knowledge comes to be circulated today. Although perspectives grounded in Actor-Network-Theory concerning the spaces within which knowledge sharing and translation take place are vital to understanding the globalisation of trusted (geological) knowledge (e.g. Latour, 1983, 1999; Callon, 1986; Latour and Woolgar, 1986; Stengers, 1997), this chapter demonstrates that attention to institutional structures *and* inter-personal dynamics of trust and reputation are critical for understanding how knowledge comes to be widely distributed in the first place. Therefore, this thesis re-centres the importance of the individual and their 'scientific' identity in making science and shows that this type of trust dependency is contemporary rather than found only in Enlightenment-era and 19th century scientific politics.

A final implication of paying attention to geodiversity and the methods deployed by geoscientists to render them knowable, is that the outputs of geological interpretation have the potential to be diverse, contradictory and of varying quality. This aspect is absolutely crucial in considering how geoscientific data affects things like mineral resource estimates and mineral potential maps and is one of the reasons why such estimates should be treated with caution (more on this in Chapter 6). The potential for difference in geological interpretation and the dependence upon individual skill and expertise necessitates a cautious approach to evaluating which part of the geological story told by geologists is 'heard'. This is especially relevant in the assembly of compilation maps that sew together multiple geological cartographies.

Important to remember for the next chapter is that a large, regional-scale geological map is a set of compromises, rather than absolutisms, between different cartographic source materials. Thus, geological maps, in particular compilation maps which are critical to informing the evaluation of mineral potential for the Slave Geological Province, are also embedded with uncertainty which is not uniformly spread throughout the area the material represents. As will be demonstrated in Chapter 6, the communication of these intricacies and conditionalities to non-geoscientists can be challenging. Yet as a result of geodiversity, it is not yet possible to fully map geology in a standardised manner (using for example artificial intelligence or remote predictive mapping), rather it necessitates a close, on-the-ground reading and following by individuals, foreclosing the opportunity to eliminate subjectivity.

A final comment must be made about the methods used to generate data for this chapter: had I spent a field season with the geologists camping in the bush and walking geology daily watching maps being made and data being collected, a different socio-institutional understanding may have emerged in my work. It is possible that in such a context, the socio-politics of fieldwork as a negotiation between project-members' hierarchy and funding would have emerged, allowing me to make closer comments about the politics of where is mapped, how well and to what end. Likewise, the pace of field mapping and what can be paid attention to are likely different when conducted over weeks rather than days, and as such my short daytrips into the bush with geologists only scratch the surface of representing their labour in intense field campaigns. I would therefore suggest that further research may also find fruitful ground beyond the offices where I conducted my majority of my research and may speak to some of the socio-cultural as well as scientific complexities of geoscience knowledge production.

6. Making Mineral Volumes

6.1 Introduction

This chapter builds on the previous by scaling geographic analysis up from the individual (i.e. the geologists) to the regional level (Slave Geological Province). The chapter builds on the epistemic and technological work done by geologists in Chapter 5 which explored some of their behaviours as they mapped the region. The regional scale presents a perspective from which to consider the role of geological areas more widely and the impact of their material heterogeneity on the making of socio-political space, in particular on Arctic mineral futures and infrastructure development.

The purpose of this chapter is to use volumetric thinking as a theoretical lens through which to understand the opportunities and challenges of mineral resource futures in the NWT. I do this by deconstructing a Mineral Potential Map (MPM) that was produced for the Slave Geological Province in 2019 which represents both mineral aspirations and possibilities for the region and offers a pathway to learn more about minerals as a type of volume. As a result, this chapter expands our existing understanding of the diversity of subterranean space (Peters *et al,* 2018; Slesinger, 2019), in particular the manifold ways in which geological materials can be distributed and constituted within and as volumes, and the subsequent challenges that mineral substances present for resource accounting in particular. As such, this chapter offers nuance to existing geographic knowledge and thinking about 1) how resources are 'made' and 2) how subterranean geodiversity affects political and economic assemblages of resource exploitation.

To achieve these aims, this chapter takes inspiration from Andrew Barry's (2005, 2013) work on informed materials, in that it seeks to understand how rationalisation of road infrastructure for resource extraction is nested in information production and sharing. Barry's work is important here since it raises the question of how information in- and of-itself creates legitimised and governmentally endorsed infrastructure plans. To do so, I unfurl the creation of the MPM and examine the socio-economic, epistemic and legal networks that are being embedded into the map as it is constructed. This is important because it sheds light on what biases might be included in and amplified through the map, and also gives insight as to what it is about the map's constituent parts, materially speaking, that forces it to be assembled in this particular way, rather than another.

Unlike Barry's example of the Baku-Tbilisi-Ceyhan (BTC) pipeline, the case I explore in this chapter is not (yet) a public controversy, and this impacts the types of public questions that are being asked of the information constituting the MPM. At time of writing, the information presented by the map was taken at face value at e.g. conferences, and had not yet accumulated counter-narratives, critique or opposition. Again, different to Barry's example, science and the political arena have not yet been mixed in this case study – the digital, physical and epistemic spaces of data and scientific production are at arms-length from the main spaces of public debate in the NWT. Once the MPM becomes the concern of the Mackenzie Valley Resource Board and NWT Legislative Assembly, it will be evident how this material/scientific object opens the door for discussion of other controversies such as caribou, land entitlements and climate change. For now, this chapter seeks to introduce a voice into an arena that has, for the most part been publicly quiet, by framing 'mineral potential' as an absolutely non-inevitable geological phenomenon for the region.

Added to the informational-material framework generated by Barry's work, I use emerging political geology and geography literatures on earthly materiality and the politics of volume as a platform (Elden, 2013b; Andrew Barry in Powell *et al.*, 2017; Bobbette and Donovan, 2019). I write this chapter with the understanding that volume may be used as a tool to rationalise speculative resource accounting and that geology is a material force with political implications on its management and access (Bridge, 2013; Weszkalnys, 2015). As a result, analysis in this chapter recognises how speculative accounting methods allow subterranean resources to become politically operationalised and are used to bolster territorial claims and expansionist ambitions (Zeller, 1987; Braun, 2000; Kama and Kuchler, 2019). To make space for the geodiversity that began to be outlined in Chapter 5, this chapter flexes materialist approaches to territory and volume, their calculation and control (Mitchell, 2002; Gregory, 2011c, 2011b; Elden, 2013a; Slesinger, 2020) as it seeks to understand how mineral potential estimations are made in the NWT.

The MPM of the Slave Geological Province provides a tool via which to understand how subterranean space is speculatively assembled into cartographic form. This map was produced by the GNWT to showcase the region's mineral potential, to choose a best-fit infrastructure route, and to support funding applications for the Slave Geological Province Corridor (SGPC). As will be explained further, the SGPC project envisages the construction of an all-season road from Yellowknife to the Nunavut border and subsequently to the Arctic Coast at Gray's Bay in Nunavut (figure 6.1).

Although the MPM does not purport to offer a volumetric assessment of mineral resources in the NWT, it is useful as a tool of volumetric thinking precisely because it highlights some of the challenges involved in reducing mineral resources into calculated/quantitative form. In a sense therefore, the MPM highlights the things that minerals' geological situations *prevent* geologists from doing, and the behaviours they force geologists to take up in order to render the subterranean knowable and circulatable in some form. By analysing the epistemic and techno-legal practices used by geologists to understand and map the material quality and distribution of minerals, I argue that geodiversity raises challenges for knowing and representing geological space that are overlooked in existing resource geography literature. As a result, this chapter will make clear why (owing to their materiality and distribution in space) mineral resources need to be treated differently to other geological resources such as shale gas or oil by geographers. Resultingly, this work presents new avenues along which to understand the mineral resource economy's production, sustenance and challenges to its success.

The diversity of mineral occurrences within geological volumes are shown to create both political opportunity for supporting resource imaginaries whilst undermining the cogency of government aspirations for territorial expansion in the Canadian Arctic. By critiquing the empirical basis of the MPM, unsettling it as a reliable circulating reference and demonstrating the difficulty in tracing claims represented in the map back to geology in the ground, I put at risk the speculative claims the map enables the GNWT to make about mineral potential (Latour, 1999). I contrast the process of making the MPM with the production of mineral deposit evaluations in commercial settings in Canada. This comparison highlights the significance of practice, language, funding and scale in enabling the production of substantiated, trusted valuations of mineral potential and draws an architecture of the broader zone of qualification that mineral resource assessments occur within (Barry, 2006).

This chapter is structured as follows:

- First, I will outline the geopolitical context that motivates the proposed SGPC;
- Second, I deconstruct the practices used to compile the MPM to scope some of the complexities involved in giving minerals a volumetric assessment; and
- Third, I explore how volumetric data is generated for mineral deposits in commercial settings.

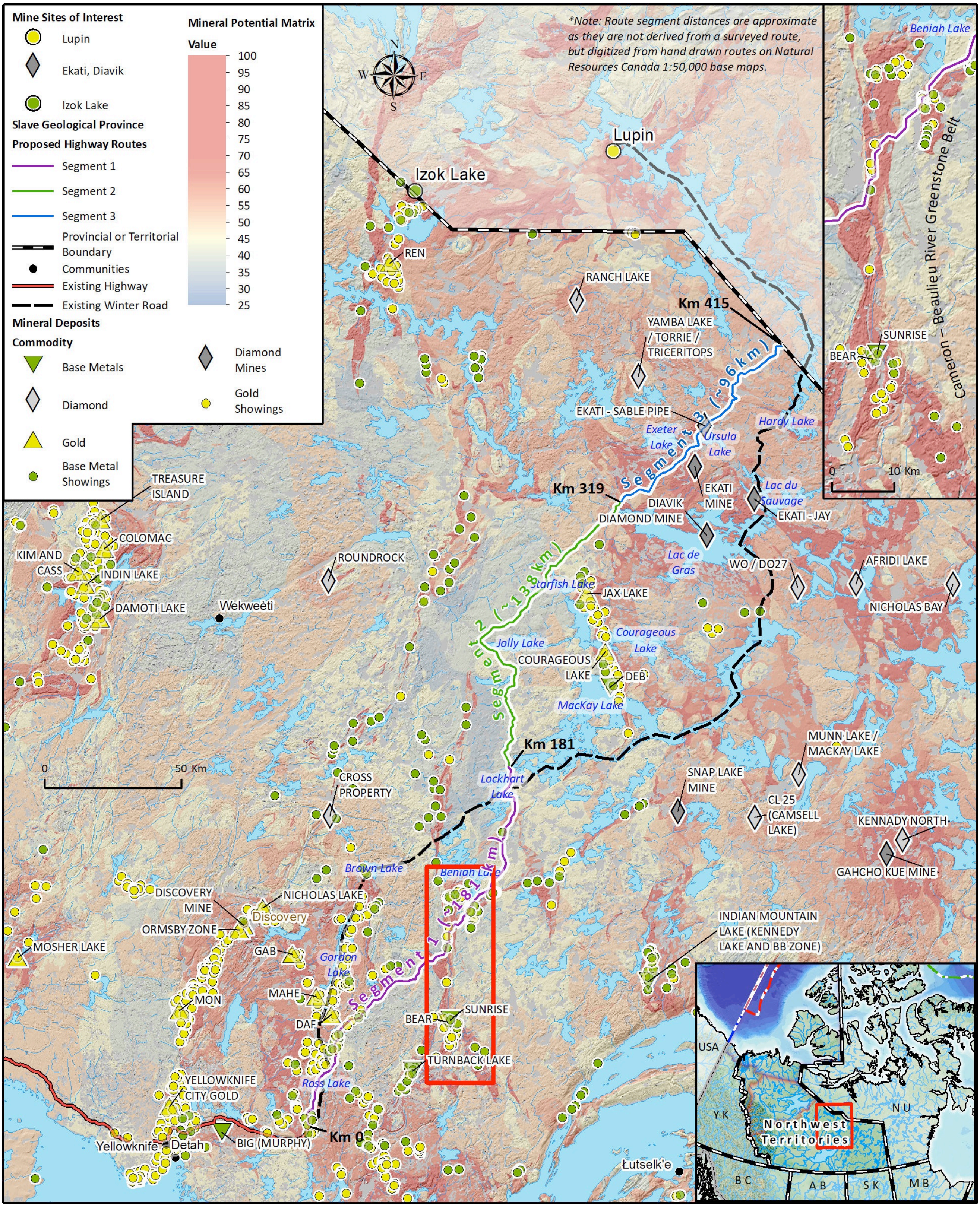

Figure 6-1: "Slave Geological Province Corridor - Mineral Deposits". Heat map taken from GNWT-Department for Infrastructure, March 2019, comparing the potential for mineral discovery of the SGP. Note the poor resolution of the Mineral Potential Matrix scale bar; inclusion of mineral occurrences as point data; and exclusion of internal boundaries such as Tlicho governed lands and lands withdrawn from staking.

6.2 Arctic Geopolitics and Infrastructure Expansion

Historically, the exploration of Arctic landmasses since the 1700s cemented the Canadian north as a "primary commodity frontier" in corporate, government and popular imaginations (Keeling and Sandlos, 2016, p. 266). Since President Diefenbaker's 'Road to Resources' programme of the late 1950s, major infrastructure projects have been conceived for the NWT by consecutive Territorial governments (Isard, 2010). Whether trading fur, caribou harvesting or mining, access to and the management of natural resources has been integral to Canadian government involvement in the region. Today, the low-population/high-landmass Canadian Arctic remains a space for nation-building and sovereignty assertion (Powell, 2017), with expansionist projects underpinned by imaginations of mineral wealth and accompanying economic development.

The GNWT's Department of Infrastructure (GNWT-INF) explained that nation-building (i.e. peopling and asserting judicial control over space), enhancing Arctic sovereignty, and encouraging mineral development were key aims of the SGPC (*Interviewee 43, written proofed notes, 07.06.2019*). These aims mirror the objectives of the Federal government's 2019 Canadian Arctic and Northern Policy Framework (Government of Canada, 2019), which adds that Canada's Arctic policies, investments and decision making should "restore Canada's place as an international Arctic leader" and enable the "promise of the Arctic and the North" to be realised. The SGP is framed as a space of opportunity and has become a theatre in which multiple regional and national geopolitical agendas are being played out. Agendas include access to international trade routes; economic security and development through mining; climate change resilience with all-season (gravel) roads; north-south territorial connectivity; and enhancing safety and security for shipping and tourism in maritime areas.

The idea of expanding the NWT's road system into the SGP was first floated in the early 1990s, yet failed to gain sufficient government, industry and community support (*Interviewee 40, former GNWT infrastructure planner, audio recorded via Skype, 05.06.19*). Today's SGPC plans were re-opened in 2014 under the GNWT's Mineral Development Strategy, and since then the GNWT has been commissioning studies into the road's feasibility. The Federal Department of Transport's National Trade Corridors Fund contributed CAD$30 million to the early stages of the SGPC's development in August 2019 (GNWT-ITI, 2020). The Fund is designed to support Canada's three Territories (Yukon, NWT, Nunavut) to focus on accessing resources, connecting communities, and promoting economic growth and job opportunities (Garneau, 2018). The road proposal stems from a vision expanding Canada's economic agenda deeper into the Arctic by encouraging industry there and connecting it and southern Canadian markets to an anticipated major shipping lane in the Arctic Ocean (Milne and Foy, 2018; Woodhouse, 2018). Meanwhile, a northern road connection to Arctic ports (such as that planned for Gray's Bay, Nunavut) via the SGPC may also help to relieve some of the trade bottlenecks across the US border and at east- and west-coast ports (Fellows, 2018).

Locally, climate change and increasingly unpredictable winter temperatures pose a challenge for mining companies operating in the SGP. They are reliant on seasonal ice roads built every January and operational until around late March. Aside from the cost of construction (between CAD$20-25 million/annum), the ice road season is unpredictable in length creating logistical challenges and potential safety concerns for mines having their annual supplies trucked in. The lack of reliable, year-round infrastructure is considered by lobbying groups a turn-off to investors and exploration companies thinking about operating in the NWT (*Interviewee 7, executive director at northern mineral lobbying group, audio recorded in person 12.10.2018*).

The SGPC proposals have been taken on tour to major mining conferences in Vancouver and Toronto by GNWT representatives to attract private and government investors in the region. "Touring" the SGPC proposals and MPM is designed to generate speculative interest in the NWT and demonstrate that the GNWT takes mineral expansion and supporting the mining industry seriously. The MPM is a representation of resource opportunities the SGP is believed to hold and which the GNWT wants industry to help become realised. The advertisement of the SGP occurs within an economic context where exploration expenditure in the NWT is dwindling and closure of the Territory's diamond mines comes closer on the horizon. At the 2018 Prospector and Developer's Association of Canada event, the GNWT hosted a well-attended "Unlocking our Potential: Invest NWT" afternoon during which representatives from the GNWT showcased the Territory's infrastructure plans and other financial initiatives to attract exploration projects. During this event, the GNWT invited exploration companies doing work in the SGP to demonstrate the success their projects had in finding encouraging mineral signals to further generate interest in the region (*Field Notes, 04.03.18, PDAC, Toronto)*.

The SGPC proposals have also been promoted by northern policy makers, lobbyists and politicians during Federal Standing Committee meetings in Ottawa to obtain commitments for further funding for the project. Presenters to the Standing Committees advocated the geopolitical asset that the road would be for local communities, Territorial and Federal Governments:

> For Canada, the primary economic rationale to support this project is that it will lower the cost to access, explore and develop the mineral-rich Slave Geological Province, part of which falls within western Nunavut. With abundant and known gold, diamond, base metal and rare earth deposits,

> the Slave Geological Province is recognized as one of the most promising mining regions in Canada. However, having great mineral potential does not on its own result in a prosperous economy. We know that, compared to their southern counterparts, northern resource developers face significantly higher costs at all stages of the development cycle from exploration all the way to reclamation… Put simply, the north's infrastructure deficit is a bottleneck to development that must be addressed if the full potential of this region of Canada is ever to be realized. (*Patrick Duxbury, speaking on behalf of the Kitikmeot Inuit Association and Nunavut Resources Corporation, Federal Standing Committee for Indigenous and Northern Affairs, 17.10.2018).*

Duxbury, speaking from the position of a pro-industry lobbying group in Nunavut, highlights the missing components precluding a functioning resource extraction assemblage in Canada's North. His comments have been supplemented by Wally Schuman (Minister for GNWT-ITI 2015-2019) and Peter Taptuna (Premier of Nunavut 2013-2017) who, when speaking at Federal Standing Committees, emphasised the potential of the road's construction to deliver regional jobs, improve Northern economic independence, and increase the resiliency of Northern transport networks to climate change. Various interest groups from Nunavut and the NWT have thus aligned Territorial aims for economic development and tax revenue creation with Canadian aims for greater trade connectivity and reduced NWT dependence on Federal money transfers. Their arguments build on many years of political strategizing, which synonymise frontier infrastructure construction with territorial development and the imagination that northern Canada could be a resource powerhouse (*Interviewee 40, former GNWT infrastructure planner, audio recorded via Skype, 05.06.19;* Isard, 2010).

It must be noted however that although support has been found today in the GNWT and amongst some community corporations in the NWT and Nunavut, a 1999 public consultation about developing the SGPC in the NWT and Nunavut raised mixed feelings in communities. During that consultation, some communities (especially in Nunavut) welcomed greater connectivity to the south, while others (particularly more traditional communities) were more hesitant because of the feared potential disturbances to caribou, aquatic life and traditional lifeways in the region (Ferguson Simek Clark *et al.*, 1999). Combined with more recent conservation concerns about the link between road access, hunting and the decline of the threatened Bathurst Caribou herd (Pruys, 2020), a challenging path may lie ahead for the project should it advance to the environmental impact assessment stage where public consultation must be carried out again.

With the political economic setting and rationale for mineral resource and infrastructure development laid out, the following section explains how the MPM serves as a tool to substantiate and make economically viable the opening up of the SGP (and its minerals) via road building.

6.3 Establishing Mineral Value in the Slave Geological Province

The MPM of the SGP was commissioned to the geo-environmental consulting firm Aurora Geosciences Ltd. in 2019 for CAD$60,000[19] by the GNWT to identify a 'best-fit' route to construct a road from Yellowknife to the Nunavut border along zones of high mineral

[19] This sum is incredibly low when the cost of other Mineral and Energy Resource Assessments previously conducted in the NWT is considered. For example, the NWT Thaidene Nëné National Park MERA cost over $2,071,650.00, which included salaries and fieldwork costs over a period of two years (*GSC Canada Northern Division Chief, pers. comm., 02.06.2021*).

potential (Government of the Northwest Territories, 2019a). The GNWT intends to construct the road as close as possible to geologies favourable for mineral discovery, encouraging exploration and mineral development in hard-to-reach geographies that would otherwise remain geologically low-value owing to their remote location and undeveloped.

In addition to identifying a best-fit route, the MPM could be used to attract exploration companies by helping them identify land which might yield mineral deposits, in turn encouraging the production and submission to public record of geological information. Evidence of this successfully happening as a result of other MPMs and mineral deposit analyses by the USGS in e.g. Alaska and Colombia, are given by Singer and Menzie (2010). This strategic form of calculation echoes Mitchell's (2002) description of the self-perpetuating and validating geographical data produced in Egypt in the early 20th century. In Egypt, as the GNWT wishes to achieve in the NWT, even poor-quality statistical data demonstrated its worth since it functioned as an enabler for industries and government departments to control domestic activities and in turn produce further, more useful related data and information.

While it is too early to conclude whether mineral claims have been made in the NWT by exploration companies as a direct result of the MPM in figure 6.1, the opening up of prospective geologic spaces by providing road access self-evidently increases the opportunity and likelihood of staking (as it is intended to). The intention is to make mineral reserves more likely to become mineral resources.[20] As will be explained, the MPM is therefore an invitation

[20] Important to note here is that a mineral resource is a mineral body that has been measured to exist, but which is not economically mineable as a result of (inter alia) poor infrastructure access and low market value, while a mineral reserve is one whose material existence is measured and has proven economic viability for mining (CIM, 2014).

for mining companies to engage with land *believed*, rather than *proven*, to be permissive for containing mineral resources. The MPM can therefore be thought of as a tool that circulates speculative resource accounts in support of the construction of territorialising infrastructures like roads and mines, similar to the 'gestures' described by Weszkalnys (2015).

Usually, mineral and energy resource assessments (MERAs) are used to help make public land use decisions (e.g. whether a national park should be established in an area or whether land should be invested in for mineral exploration) or act as evidence of the mineral/energy value of exploration companies' properties. MERAs therefore work as scientific and financial decision-making tools. The MPM for the SGP is not the same as a MERA since the MPM is not making assessments of specific mineral and energy resources, but rather the potential of a general area to host any mineral. Singer and Menzie (2010) (whose work was informally described by one of my Interviewees as the 'Cadillac of mineral resource assessments') outline how MERAs, which are quantitatively grounded, should be used by decision makers in government and industry to make mineral-related land-use decisions. Meanwhile, the MPM of the SGP is a qualitative assessment of potential, which Singer and Menzie argue is a type of appraisal "typically *subjective* and so *poorly defined* that implications of such statements as "high potential for X" cannot be documented and defended in an adversarial situation" (ibid., p. 4, emphases added).

What the MPM does is compare the presence of different data types for their perceived usefulness (e.g. geophysical vs geochemical vs drill core vs mineral occurrence data) and overlay these onto ranked valuations of bedrock geology types for their perceived potential to contain minerals of economic value (e.g. kimberlite high value, sandstone low). Thus, what makes the MPM qualitative is the reliance on comparing data *type* rather than data *content*. The

MPM of the SGP is therefore not an assessment of what rocks the region has, but what we know about them. It could, therefore, also be thought of as a state of geological knowledge review. As will be shown, the MPM also primarily frames mineral potential within the context of socio-economic global resource networks (as described by Bridge, 2009). The map, I argue, is thus foremost a product of relativist assessments of social relations between humans, data, and resource economies rather than the material substance of subterranean volumes themselves. It is important to understand how the MPM has been made by the GNWT because it is used to support cost-benefit calculations of deposits (that are only speculated to exist) to inform infrastructure planning decisions. As such, something highly speculative, relativist and liable to change is being used to help generate infrastructure plans that are highly immobile once committed to.

What I will demonstrate using the MPM of the SGP is that even though the map enables us to talk about the subterranean, a lot remains unknown about the underground's actual constitution. The MPM is intended to invite us to imagine the SGP's mineral assets without providing the parameters by which to closely define what those assets might comprise. To demonstrate why this methodological approach to constructing the MPM was necessary, the next sections dismantle some of the criteria used to make the map. In turn, this untangling highlights the challenges that the geodiversity of minerals creates for our ability to engage with rocks' materiality, pushing the map's creators towards speculation. The specific role of materiality and geodiversity in speculative resource accounting is something that existing resource geography literatures are yet to explore.

The MPM is, I argue, a speculative object whose uncertain nature stems from geodiversity and the scale of the geological area under evaluation. Geodiversity and uncertainty in the

SGP result from the heterogeneity of geological units and their complex geological histories of formation and deformation (i.e. structural/tectonic history). Uncertainty in the MPM is a product of the diverse, individualised methods of knowing and measuring complex geology and the spatially uneven modes of data generation through field projects (as described in Chapter 5). Diverse geological knowledge production methods result in mixed standards and distributions of geoscientific data in the region which can be challenging to compare.

Interviewee 42 (mineral deposits specialist at the GNWT, audio recorded in person, 03.06.19) outlined how this is manifested in reality:

> One of the things that happens is we have tonnes of information around Yellowknife. There are…drawers and drawers of assessment files, filled with data and drill holes tightly spaced. And you go 10km out of town and there's one map that shows you one dip symbol and that's it. So again, how do you compare the potential for something in downtown Yellowknife versus something 10km away? But the rocks are the same basically, it's the level of data that's different.

Uncertainty emerges where geological predictions and extrapolations are made across large areas, particularly for regions that have seen a significant number and variety of processes affecting the geology within them, or where areas have had limited surveying and poor geoscientific data (Singer and Menzie, 2010). This makes reducing the geology into "facts" that can be integrated into evaluations of mineral potential especially challenging and error prone. Similar to Mitchell's (2002) discussion of surficial mapping of nineteenth century Egypt, scale and its manageability by humans and available technologies affects how reliably and responsibly we are able to map space. The interruption of resource accounting by the scale and size of areas to be mapped is poorly recorded in existing geography literature, even though it is critical to the production of volumetric space. It provokes questions of how decision making is applied to contexts where limited data is available as in parts of the Arctic or deep-sea geologies, and where the potential impacts of interventions based on that decision making threaten to have significant local or regional environmental or social impacts. The possible implications of decision-making in low-data scenarios are discussed further in Chapter 8 of this thesis.

Meanwhile in the SGP, instead of taking up the task of generating evenly spread data across the nearly 200,000km^2 of the region which would be both extremely cost and time intensive, the MPM uses proxies to infer geological potential. Figure 6.2 outlines the workflow process and different data types compared to produce the MPM. In the next sections, I will discuss the use of **bedrock geology, mineral tenure** and **mineral occurrence** as factors indicating mineral potential and evaluate how these proxies are used whilst discussing some of their potential socio-political and economic implications. I have chosen these factors to discuss because they are embedded with diverse epistemic practices, politics of land, and connections to commodity markets. They tell us interesting things about how the production of mineral resources comes to be distributed amongst epistemic, legal and economic networks of practice.

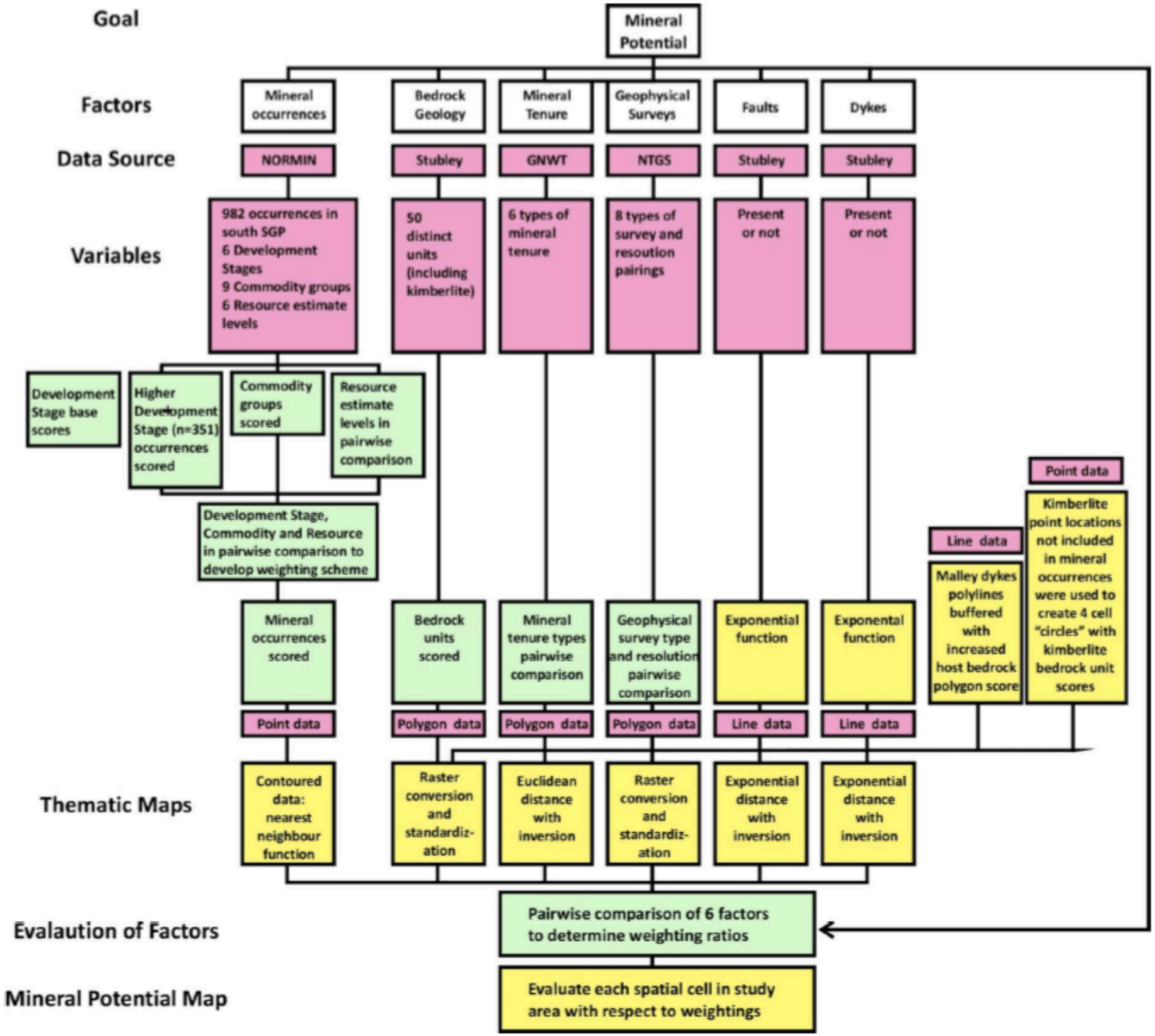

Figure 6-2: "Simplified workflow of mapping project". Green boxes highlight subjective inputs, pink are quantitative data, yellow are GIS processes. Taken from Aurora Geosciences Ltd (2019, p. 16).

6.4 Indicators of mineral potential

First, **bedrock geology** is the product of historical geological processes which can variously generate different mineral deposits. Broad understandings of these bedrock histories and their association with different minerals are used to evaluate the possibility that minerals might be hosted within them. The diversity of geological formation processes and the contingency of mineral deposition upon local environmental conditions (e.g. pressure, temperature, humidity) and tectonic/structural activity means that each mineral deposit is different from others in some way (Singer and Menzie, 2010, p. 30). This makes copying patterns of mineral expression in one geological setting and applying it to another challenging and open to error.

To exemplify, greenstone is associated with hosting metals like gold, zinc, copper and lead and is a mainly basaltic rock formed in an underwater environment by volcanic activity. As the earth's crust moved, gaps in the greenstone (such as thrust faults and shear zones) emerged into which hot volcanic liquids could flow. When these liquids made contact with water, the cooling made the gold drop out and be deposited. So, exploration geologists often look for crustal disruptions in the greenstone belt as sites where gold may potentially be hosted. Evidently there are many environmental and geochemical parameters that can influence how much gold and associated minerals might be hosted in the greenstone and where.

Similarly, kimberlite pipes are a magmatic rock with potential to host diamonds. They are often 'carrot shaped' owing to the fact they are relics of ancient volcanoes and had eruptive environments that allowed for the growth of diamonds. The presence of kimberlites at the earth's surface is an indication that diamonds might be below, but doesn't assure of their presence: "of approximately 10,000 kimberlite pipes discovered around the world to date, only about 1,000 have proved to be diamondiferous, and only about one hundred were economically viable to develop" (Bain & Company, 2011, p. 24). The temperature, timescale and pressure of magmatic movement to produce kimberlite affects whether diamonds survived the journey from the mantle into the kimberlite pipe or not. These examples are to say that strict correlation between bedrock type and mineral presence cannot be drawn. While this is borne in mind by the geologists making comparative evaluations of bedrock units' potential for hosting valuable minerals, achieving such nuance in a reductionist scientific object like the MPM is challenging, and communicating the conditional relationship between bedrock unit and mineral presence is impossible through the map alone.

It must also be noted that using bedrock geology as the basic raster of the MPM assumes that all data contained within it is of equal quality. As demonstrated in Chapter 5, this is not the case across the NWT as the distribution of geological data in the SGP is not even but clustered and the quality and scale of its production variable. Although significant steps were taken by the bedrock data compiler to identify and smooth out unreliable or contradictory data sources, as described in Chapter 5, the method used for the MPM that comparatively evaluates the bedrock map by geological unit cannot address the mixed quality and scale of the data that informs it. Although a seasoned geologist with a familiarity of the types of work done in the NWT would read the bedrock map knowing that some areas were better mapped than others, decision makers who apply the MPM to inform infrastructure planning may not be aware of such nuances.

What this insight adds to political and resource geography literatures on volume is the extent to which the quality and potential economic value of geological volumes is dependent upon historical geo-environmental processes of change and material transformation. Our capacity to understand this is dependent upon geological theories, technologies and socio-institutional alliances. Change through deep time, and the possible mineralogical assets associated with those changes, transforms something that is geological into an epistemic, geo-political, and potentially economic issue to understand.

Second, **mineral tenure** is key in affecting land value, access to minerals and the capacity to generate geodata. The assessment of land tenure by Aurora Geosciences Ltd. reflects the perceived significance of historical and contemporary exploration as indicators of mineral potential. If land has an active mineral lease or claim, then it is regarded as higher potential than land that has had only past prospecting permits or minerals claims. Activity on land is used as a proxy for potential because 'work'[21] is required to be carried out on claims and leases, and where work has been done, data will have been submitted into the GNWT geological database. Additionally, where others have staked claims or converted properties into leases, it reflects a company's evaluation that the land's geology may have potential and is worth investing in to maintain, through work, as a lease.

Meanwhile, if land has had no permit, claim or lease for prospecting/exploration, it is considered lower potential because a) geologists at exploration companies may not deem the land to be geologically permissive of minerals to warrant the expense of work to be done;

[21] 'Work' is defined as geological activity undertaken to assess mineral potential of a property. Both prospectors and exploration/mining companies must produce reports of activity back to the GNWT. Holders of land claims must conduct and report on $10 of work per hectare in the first two years of the claim, and $5/ha in every subsequent 1 year.

and therefore b) there is likely less geological data available for it because of less work done; or c) it may not be stakeable because it has been withdrawn from development, e.g. for Indigenous land claims or for protected areas zoning.

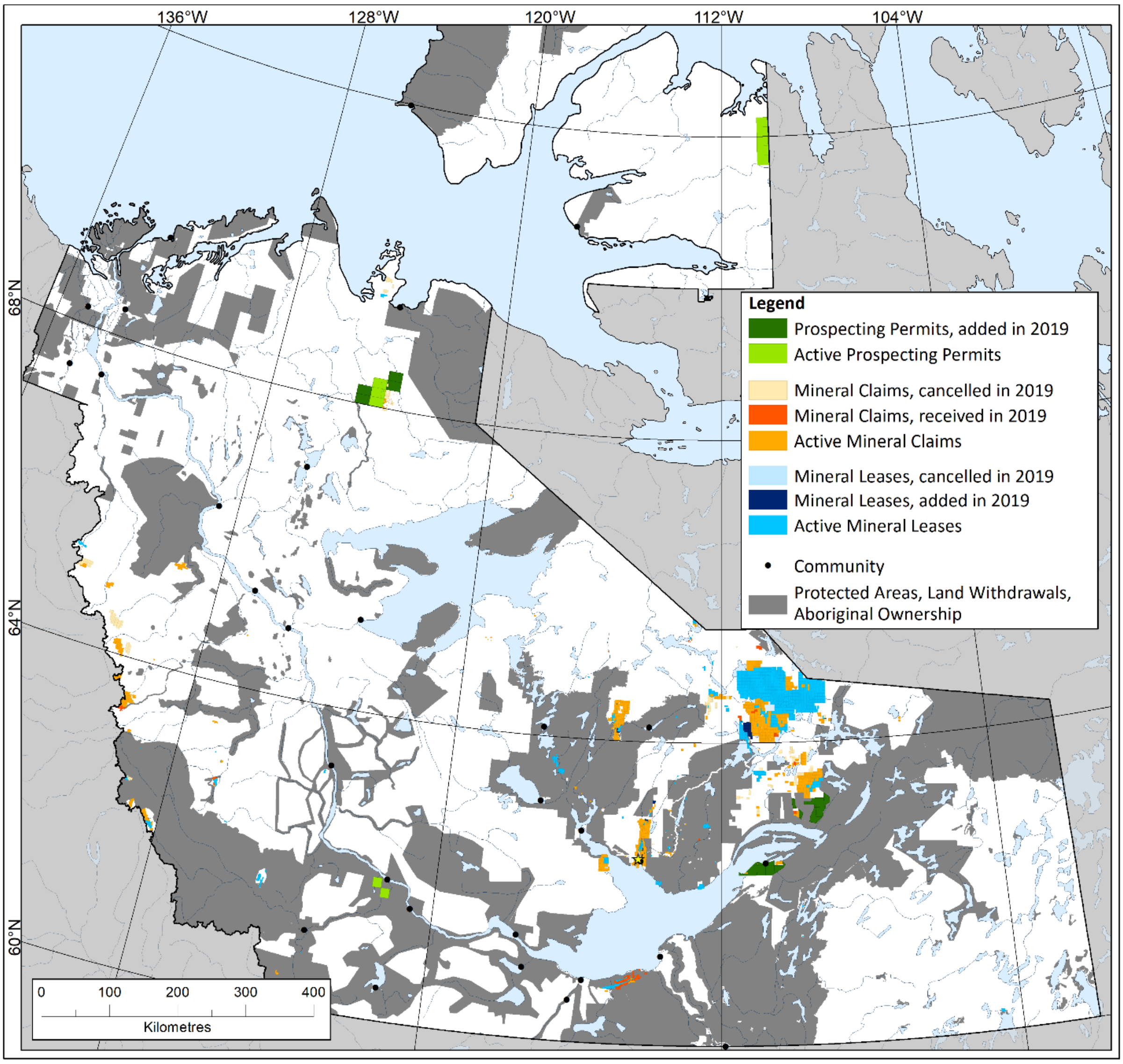

Figure 6-3: Map of land tenure for the NWT including protected area, land withdrawals, aboriginal ownership and mineral tenure. From Falck, Cairns, Elliott, & Powell (2019).

However, the NWT's land tenure regime creates an uneven territory of inferred potential. For example, there are some areas of the SGP that have been withdrawn for 30-40 years (such as within what is now the Thaidene Nëné National Park on the East Arm of the Great

Slave Lake, or lands withdrawn for Indigenous Land Claims). Lands that have been withdrawn cannot have mineral tenure and no mineral exploration is allowed by industry. However, just because staking has not been permitted on land does not mean the area is of low mineral potential. What land withdrawal prevents is data generation, lowering the land's calculated prospectivity within the MPM and increasing the potential investment risk of withdrawn lands if they open up again for staking. Similarly, where land is withdrawn from staking, government surveys are less likely to dedicate resources to mapping because (as outlined in Chapter 5) a mandate of the NTGS is to enhance geoscience knowledge to promote exploration activity (Government of the Northwest Territories, 2017). This means that the opportunity for the MPM to generate corporate interest in an area to produce volumetric information, or indeed for the volumetric potential of lands to be realised is *a priori* compromised through this method of land tenure evaluation. *Interviewee 42* explained that:

> [Withdrawn areas] become self-perpetuating as well. If you take for example the East Arm, which was declared a potential protected park in the '70s so it was walled off, there was no prospecting or exploration done in it, so now when they want to make it a National Park there's very limited information in that area because for the last 30 years no one has gone in there, no new technologies, no new science has been applied, no new investigations have been seen in there. And so, it's a barren ground because you don't look there, and you don't look there because you think it's going to be a park, and it's a park because it's a barren ground. **So, we're not really looking at the rock, we're looking at the knowledge we have of those regions.** *(Interviewee 42, mineral deposits specialist at the GNWT, audio recorded in person, 03.06.19)*

As a result, lands which have been withdrawn for significant lengths of time, while Indigenous Land Claims or protected areas negotiations were ongoing, risk unrealistically low evaluation for potential. These evaluations have nothing to do with volumetric information about minerals underground, but rather are tenure-based risk assessments. An additional point is that since the all-season road is steered by the MPM, lands ascribed a low potential could be doubly disadvantaged when the road bypasses them, ensuring continued inaccessibility and hence lowering the likelihood again for staking and work.

Third, **mineral occurrence** is used to reflect commercial values within the resource development assemblage. The MPM compares three aspects of mineral occurrence data – project development stage[22], commodity type and resource estimate levels[23] (figure 6.2). One of these factors – commodity type – involved the grading of a spectrum of minerals according to market value and also their materiality. For example, diamond was given a high score and industrial minerals like asbestos low scores (Aurora Geosciences Ltd, 2019). An informal discussion with one of the government geologists who contributed to the assessment revealed that rating mineral occurrences for their potential is challenging since commodity values fluctuate (*Interviewee 58, government geologist, informal discussion with notes made, 15.07.19*).

To rate a mineral for its 'potential' in this context is not to rate its likelihood of existing underground, but rather to assert its current market value relative to other commodities if a deposit were to be developed today. However, it is reasonable to assume that diamonds will

[22] Gives a ranking (high to low) depending on whether an area is currently mined, has historically been mined, has been explored, drilled, locally examined or undergone reconnaissance.
[23] This latter parameter reflects whether a deposit has been evaluated (lowest ranking = no evaluation), is an inferred reserve (middle-low ranking), a proven reserve (mid-ranking), an inferred resource (upper middle ranking) or a proven resource (top ranking).

likely maintain a higher value than industrial materials such as asbestos. This demonstrates again that the label of 'potential' that brings a resource into being through imagination is subject to changes in international commodity markets (Bridge, 2013). In a sense, this conundrum of evaluating mineral potential based on market value forms part of what Mitchell describes as "the impossible character of calculation" that stems from an ever-changing environment under study (Mitchell, 2002, p. 102).

In addition to market value as a component of commodity type, the quality or materiality of the commodity which affects its mode of extraction was also considered by the MPM evaluators. For example, diamond requires minimal onsite processing - the host rock (kimberlite) can be crushed onsite and the diamonds extracted and flown out:

> In many ways you can argue that diamonds would be more flyable in an environment where there is no infrastructure because there is such a small amount of commodity itself. It sits in the proverbial coffee-can so you can fly it out no problem whereas if it is nickel concentrate you can't. *(Interviewee 48, diamond exploration company CEO, audio recorded via Skype, 03.07.19).*

Conversely, base metals such as nickel, zinc, lead or copper require much more processing, which is often done off-site. It is necessary to factor in the cost of accessing a processing mill, where the metal can be extracted from the host rock (CIM, 2014). Access to market and mills is needed year-round, and therefore a reliance on existing ice-roads is infeasible. The additional infrastructures required by different minerals for their extraction and delivery to market impacts the marketability of the resource, and thus the evaluation of its valuation on the map. In remote areas these costs can prevent extraction projects being developed into producing mines. The Izok Lake Project, owned by Chinese company MMG, sits on the

Nunavut side of the SGP and is a major lead-zinc deposit. Its owners hope it can benefit from Federal investment in the SGPAC which would create "access arteries" for the product to be taken off-site for processing and sold on the international market via the Gray's Bay port on the Nunavut coast (Ragsdale, 2019). As of May 2020, the property remained unmined because of these obstacles.[24]

As I discussed infrastructure access for base metal deposits with the senior geologist for a major lead-zinc mine in Alaska, I was given a warning that reflected the challenges with remote mining base metals in particular:

> When Red Dog [mine] started it was at the surface 60 million tonnes of 24% combined zinc and lead. There's places they're mining underground at 6%, ok? … So you see we had a deposit that wasn't even world class, it was universe class, so it could support a lot of things that a lot of other deposits couldn't. I say that, because despite when Red Dog went into production zinc went up [in market value] there was a spike and um, it immediately dropped, and it took 15 years for payback at Red Dog despite its paygrade. *(Interviewee 44, senior geologist at a producing mine, audio recorded in person, 19.06.19).*

My informant's reflection demonstrates that significant resilience is required for mines and infrastructure to remain economical and weather market downturns. Minerals and their material distribution and constitution can support the development of infrastructures such

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24 The NICO lead-zinc mine located 50km from the Tlicho community of Whati is benefitting from the construction of an all-season access road which will allow it to transport mined materials to a mill and market. Yet this is only able to happen because the GNWT and Federal governments are co-funding the road's construction to link-up an otherwise isolated community suffering from increasingly irregular seasonal access and unpredictable ice-road seasons due to climate change. Without the community-factor motivating spending money on constructing the road, it is unlikely the mine would have the paygrade to fund CAD$400million for the road's construction (Minogue, 2020b).

as the access road now owned by the Indigenous Alaskan shareholders of the Red Dog mine. Resilience and capacity to support accompanying infrastructure comes from the grade and the tonnage of the resource, plus location within the earth's crust (hence whether it's extractable through surface mining – cheaper, or requires underground mining – more expensive). What *Interviewee 44's* perspective also does is challenge the contemporary trend towards extracting lower quality ore from larger volumes of host rock (as described by Bridge, 2013). It demonstrates that in remote geographies such as the Arctic, the quality and distribution of minerals is still crucial in defining the feasibility of extractive projects. Volume as a metric, i.e. how much of something there is, is therefore inadequate for understanding the complexity of the materials, their placement within the earth's crust and value within commodity markets. Volume alone lacks the nuance and detail of materials' existence and the possibility of their economic realisation.

This insight builds on the work of Slesinger (2020) who describes the importance of saline rocks at particular depths disrupting the ability of geophysical technologies to identify Palestinian tunnels in Gaza, demonstrating that it matters how and where minerals are distributed within a volume, and that imagining minerals as varying between dispersed or concentrated, shallow or deep, is important. Again, after Ingold (2007), the composition of the material is brought into focus: any assessment of a mineral is useless unless it includes its distribution within volumes of rock and its grade of composition, yet this cannot be accounted for in the MPM. Reinforcing this aspect of geodiversity is important. Although Kama and Kuchler (2019) demonstrate that material differences occur *between* gas reserves, the challenge of accounting for difference *within* the mineral reserve is critical to the viability, lifetime, safety and profitability of a mineral resource or mine. This also expands Steinberg and Peters's (2015) discussion of volumes as spaces of ongoing composition. The meaning and potentiality of volumes changes as their assemblages de- and re-territorialise to reflect societal and market conditions, forcing adjustments in human-mineral interactions and calculation. Miners must therefore adapt constantly to where and how a mineral is situated, even changing their extraction and processing methods.

The evaluation of mineral occurrence alongside project development stage and resource estimation levels also suffers from a potential epistemic trap. Deposits can remain undiscovered or are sometimes ignored because exploration companies will enter an area looking for specific minerals. Since commodity values fluctuate in time, what was valuable in the 1960s or even 2010 may not carry the same market value today, meaning that the focus on finding different minerals changes through time. However, although geologists may look for one mineral does not mean there is an absence of other minerals, though the trail of evidence leading to their discovery may not be pursued.

A prospector discussed how geologists' framings of the world can affect what they are able to find and how they find it:

> Geologists get blinded to what's really there. I was working in Kuwait looking for uranium. One company they wanted the undeformed layer, that's where they were looking for deposits, the other one was looking for uranium deposits in dikes. They each had a model and so the one crew were exploring the area with one model, and the other crew were concentrating on the other model…Big companies tend to have blinders on. They're so focussed on a type of mineral, a type of deposit, a model, they forget to explore the country. See what you can find and then see

> what model it fits in, but don't go out with blinders on and ignore everything else! (*Interviewee 8, prospector, audio recorded in person, 11.10.18).*

This was demonstrated in the NWT in the early 1980s. From the early 1900s to the 1990s the focus had been on discovering gold and base metals. Prior to the 1980s, it would have been unimaginable that the NWT could host three world-class diamond mines, since it was believed that the geology was not permissive of diamond production given what was known theoretically about kimberlite pipes. It was taken as a 'truth' that the NWT's kimberlites were barren, yet it required a pioneering geologist – Chuck Fipke – who had generated knowledge elsewhere to apply new methods of engaging with and understanding the diamond potential of the NWT for the diamondiferous kimberlite pipes to be discovered (Frolick, 1999).

This starkly identifies how geoscience knowledge about mineral deposits and occurrences is strongly dependent on the geoscientific knowledge (or Law's hinterlands (2004)) through which processes of mineral deposition are understood. As a young science, geology's understanding of the earth and its formational histories is a constantly evolving matter, affecting how we understand how minerals are deposited and can be found. Therefore, a mineral potential map produced 30-40 years ago would produce a different heat map of mineral potential than the one seen today, solely based on *what* people looked for and via which practical and epistemic methods. As such, the MPM should be considered to have a shelf-life, as is stated by Aurora Geosciences Ltd (2019), because it is possible that the map in figure 6.1 is potentially overlooking or underestimating geology with unrecognised mineral permissiveness. This exemplifies that the MPM is not a reflection of grounded truths, but in part an outcome of geological 'hinterlands' of knowledge and theories about the relationships between geological history and minerality.

But why can't we just produce a volumetric assessment for the SGP? It is currently not possible to make a MERA of the SGP that compares what is actually underground because there is limited, uneven and poor data availability. This indicates the challenge of creating volumetric information about minerals: filling the space that volume presents is too large, would cost too much and generate too much data for institutions to manage. Creating a volume, and therefore padding out a third dimension so that it is materially "full" requires us to attain verticality through drilling, blasting, cutting and mining.

Generating 3D data comes at great financial cost – whether in terms of the flying hours required for conducting airborne geophysical surveys, or the cost of teams and equipment to take drill cores or geochemical samples. Drill cores provide the "most precise information on the extent and quality of the mineralisation below the surface" (Association of Consulting Engineering Companies - Canada et al., 2015, p. 26) and are therefore carried out at virtually all exploration sites to understand the mineralisation quality. The SGP covers an area of 190,000km^2 and the MPM uses GIS squares of 100m^2 to produce the heat map of mineral potential (Aurora Geosciences, 2019). Therefore, to obtain vertical samples across the whole region to compare minerality at depth, one would need 19 million evenly spread points of drill data across the region. This would cost between CAD$50.7-76.1 billion[25,26], between 20 and 40 times the cost of the road's construction.

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[25] This estimate uses data from "Levelling the Playing Field" which calculates the all-in cost of drilling for different exploration projects in remote regions north of 60 degrees latitude (Association of Consulting Engineering Companies - Canada et al., 2015). I make a very modest assumption of drilling depth to be 100m but recognise that some projects will drill down much deeper up to 3km.

[26] A benefit of having equally distributed drill data would be that the actual mineralisation could be compared across areas, rather than an area having history of drilling being a proxy for perceived potential.

Clearly, obtaining vertical information for a large area would be economically undesirable. Nevertheless, even if such money could be spent, the generation of huge volumes of data would be prohibitive to the producers of the MPM. I was told that such large amounts of data would require artificial intelligence or machine learning to meaningfully process and compare the data points (*Interviewee 33, NTGS geologist, email correspondence, 06.01.20*). Furthermore, even if such data could be processed, drill cores remain point data: just because it is below the surface does not mean it constitutes a volume. Connecting and interpolating between points, even 100m apart, would still introduce error into estimates of potential within the 3D. Even at this scale, key mineral indicators within the spaces of the web of data points may be missed. Thus, the idea of creating vantage points which enable economic and mine geologists to understand and view the subterranean constitution of geology is riddled with challenges and offers a leaky web of knowledge. The need for vantage points is also determined by the materiality of the substance under question and the typical depositional patterns of resources being looked for. Interviewee 42 explained this dynamic:

> If we were looking for granite, I'd probably need 3 drill holes over the next kilometre to know what that granite looks like – they don't vary a lot through space, they're always relatively homogenous and so I don't need a lot of information to make a reliable guess at what the rest of it is going to look like. However, when you're dealing with a shear-zone hosted gold which is a very complicated highly variable type of a mine, you need a drill hole every 25ft, so the spacing is much smaller, the cost is much higher consequently, and you may start with ones that are 200-300ft apart, but then that gives you a level of confidence only, which may be enough to say, yeah there's probably enough to be looking for but not enough to

make it worth calculating a volume to start mining. *(Interviewee 42, audio recorded in person, 12.03.2020).*

Interviewee 42's contribution begins to hint at the iterative process that making volumes for deposit identification entails. Volumes come to be made by slowly homing in on the deposit through ever-denser drilling and testing. Interviewee 42 identifies that getting to the advanced stages where volume can be calculated requires a high level of confidence that the investment in such work will deliver a mine. The calculation of volume is a back-and-forth dance between companies and investors wherein successful data begets more data. Without serious investment, volume never becomes actualised through geological data. In the next and final section of this chapter, I explore the iterative dynamic between geology, companies and investors and how speculation around volumes is institutionally controlled within the minerals industry.

6.5 Filling out Mineral Volumes

This section marks a shift in perspective, from the proxying of mineral potential and volume in the SGP to the production and 'filling out' of mineral volumes that occurs during the later stages of mineral exploration and mining in Canada. I include this section in juxtaposition to the previous since it demonstrates how volume can be materialised yet emphasises that institutional regulations are required to manage the speculative language that accompanies geoscience data and ensure its quality control. Here, Barry's (2013) work provides a particularly useful perspective since it speaks to a context where information and its transparency comes up for public scrutiny. This section adds to resource geography literatures by demonstrating that the establishment of volume is something that happens incrementally and iteratively, and as Barry (2005, p. 15) describes, "whose integrity is formed and progressively transformed through multiple layers of information production".

In Canada, a fine balance is sustained between proving and anticipating mineral resource volumes. This occurs within 'technological zones' (Barry, 2006) where informed materials have particular values based on their relations to other entities and information within an assemblage. Within these zones, important distinctions are made about the 'quality' of geological substances in exploration project reports (through grade-tonnage ratios), as promulgated by the National Instrument (NI) 43-101. The NI 43-101 stipulates the completion of a geological report by companies seeking investment on the stock exchange. These reports are submitted to the Canadian Securities Administrators and the Canadian Institute of Mining and Metallurgy (CIM) and is then publicly available for potential investors or interested parties to read. The NI 43-101 regulations control the anticipatory language and prospective claims a company is able to make about a property that it holds. This is to ensure that levels of geological certainty around a mineral deposit are established through sampling, and that economic feasibility studies for mine development are completed. These must be submitted as reports prior to companies being able to claim that they have a mineable resource. As such, the Canadian mining industry demonstrates how volume is gradually and iteratively built from geological evidence, whilst speculative language is tailored to levels of certainty about a volume.

Interviewee 42 outlined some of the work that needs to be done in order to produce a volume in practice. They clarified that the subterranean only becomes a physical rather than imagined 'volume' once work to add three dimensions to a piece of rock has been done, by drilling holes to obtain cores and blasting or digging cross sections. This work happens quite late in miners' engagement with geology in comparison to the very preliminary work represented by the mineral potential map of the SGP. The geologist explained that:

> The job of a mine geologist is to look at a volume of rock and say this is the portion of the rock that has value to it, and we want to extract that portion of the rock and leave as much of the rest behind… Every time you work on a volume of rock it costs money… What the mine geologists' job is is taking a look at the rocks and extrapolating where, through using drill holes and whatever other clues – mapping, previous experience – how best to identify the volume with the most potential. And then they take that information and then they give it to an engineer and the engineers draw a big rectangle round it and then the miners go in there, drill a bunch of holes, blow it up and get shovels in there. And then the geologist comes in with a can of spray paint and says, 'okay this is the area that we want, and this is the ore, this is waste', and it's very simple and cut and dry and then the process happens again. The guy goes in with a drill hole and pulls out the next block and so the geologist steers the miner to extract the most valuable material. *(Interviewee 42, audio recorded in person, 12.03.2020).*

Here *Interviewee 42* discussed how rock is removed from a mine or exploration site. A skeleton geometry of veins, seams and layers must be filled in to establish extent and quality. The 'fullness' of a mineral deposit is only realised incrementally as it is exposed. Exploration and government geologists will use clues also used in the MPM (including favourable bedrock geology and structural geology) to inform where they begin to build the "geometry of what [an area of] mineralisation looks like" (*Interviewee 42, ibid*).

Related to this, *Interviewee 42* explained how geological complexity and diversity is met with an adjustment in technical and epistemic methods to grasp the geodiversity volumes at hand (as explained in his quote on page 212). Geology is actively political here in that it forces adaptation and compliance within structures of governance and regulation. Although the NI 43-101 regulations do not require samples to be taken at specific intervals, it is expected that sampling and estimation of continuity of a mineral's quality through space should reflect the materiality of the substance and the known distribution patterns of particular deposits. It is therefore for the investor to infer from information including the geological setting, mineralisation and deposit types and sampling/exploration activities whether the work done adequately allows for extrapolations of quality and volume about a body of rock and hence investment potential claims to be made (CIM, 2018).

The delivery of these metrics to investors as part of mining company reports is crucial in maintaining trust and integrity within the mining industry. The NI 43-101 regulations were developed in response to the falsification of geological information by the company Bre-X in the late 1990s, which led to major financial losses for investors and a fall in investor confidence (Majury, 2014). The Canadian Securities Administrators therefore function as a critical centre of calculation, enabling a functioning trading system to revolve around standardised geological data approved for circulation by a qualified geologist, who vouches for their quality. Therefore, we could consider this dynamic as one where the informational transparency is a building-block in the extraction of geological materials, wherein geological materials produce information, but information in turn allows for the further production of geological materials as commodifiable good to take place (Barry 2005, 2013). However, caution is necessary – although NI 43-101s provide geological detail – what is equally important is what information is left *out* or is not accounted for.

To ensure integrity of mineral estimations, detailed regulations outline the levels of certainty and work a company must do in order to determine whether a mineral resource is "proven" (most certain) or just "inferred" (least certain). Figure 6.4 outlines the process whereby a project attains "proven resource" status. Companies' reports under NI 43-101 must therefore realistically reflect their qualified geologists' understandings of a property's assets, as well as the strength of the market for a given material at a certain time.

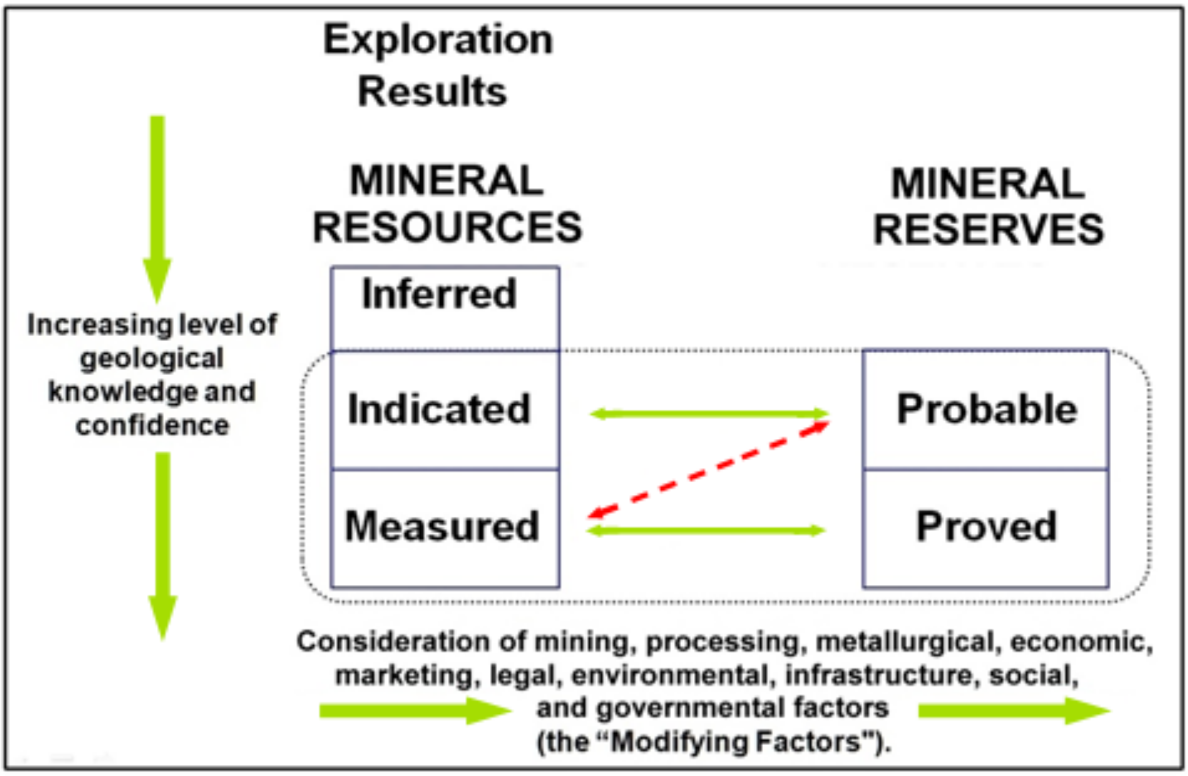

Figure 6-4: A flow path that demonstrates the changing terminology given to a mine project depending on the level of geological knowledge/confidence had about a property vs. the economic feasibility for its development. Taken from CRIRSCO (2021)

Using the above framework, companies are able to make claims about the prospectiveness of their projects. An "inferred mineral resource" has an *implied* but not verified geology or grade (quality) – that is to say that there is low certainty about a project's subterranean assets bar the available surficial data and perhaps some limited drill core data availability. Meanwhile, an "indicated mineral resource" has enough data points from drill cores to *assume* a grade and its continuity between data points (i.e. to give it a grade-tonnage estimate that reflects quality and volume). With added sampling through drilling, a "measured mineral resource" has *confirmed* continuity of grade-tonnage between data points, with limited variations in grade-tonnage estimates across a deposit so as to allow for and not change economic viability studies of the deposit (CIM, 2014). Deposits move between probable and proven depending on the confidence the chief project geologist has about the impact of human factors on mine viability. As outlined in the previous section, even a world-class mineral deposit may just stay underground without enabling ("modifying") factors at the surface, including a market, infrastructure and sympathetic governance regime, and this nexus of constantly moving parts is necessary for geographers to understand to grasp how the mineral resource industry changes through time and space.

6.6 Conclusion

This chapter used the Mineral Potential Map of the Slave Geological Province to explore two things: first, the rationale for extending road infrastructure into the NWT Arctic to support mineral resource development, and second, the constitution of mineral volumes. By exploring these issues in tandem, the MPM has given us leverage to understand the work done by economic geologists in support of bringing particular resource futures into being in the NWT and expanding territorial control into currently sparsely populated/occupied areas. The Map was commissioned by the GNWT as an 'empirical' device to deliver legitimacy to political ambitions for infrastructural expansion into the Slave Province. This chapter has highlighted how geologists 'make-do' with limited amounts of data to generate valuations of geological space and therefore how the 'becoming' of mineral resources and the internment of imagined reserves into future economies hinges on speculative, heavily nuanced accounts of mineral potential.

This chapter has expanded understandings within literatures of resource accounting and volumes of how minerals force particular visions, representations and framings to take place.

First, this chapter highlighted how geodiversity is expressed in relation to minerals and explores its empirical and political consequences. By implication, it demonstrates that particular materialities produce particular challenges for territorial knowledge production, as suggested by Peters *et al.* (2018). The chapter has shown the impossibility of applying the same methods of 'knowing' to different mineral types in the hopes of generating volumetric data. This therefore expands on the work by Kama and Kuchler (2019) by highlighting how crucial materiality is in producing resource accounts. While Kama and Kuchler demonstrate that shale gas estimation models cannot easily be transplanted between geological settings, this chapter has brought to life what exactly it is about geological histories that confound our attempts to do so.

Second, unravelling the MPM has shown how volume is challenging metric and theoretical concept to apply to geology and minerals. How does one define a volume when one is restricted to being 'outside' it? The chapter has demonstrated the dependence of economic geologists on transforming subterranean space (volume) into something represented by social metrics of potential in lieu of widespread geoscience data. This highlights how fungible actual mineral resources can be for other factors to which humans ascribe value, and reinforces Li's (2014) assertion that land and its many constituent parts sit within an assemblage wherein the value or meaning of one elements is affected by/affects others. We are therefore prompted to ask whether 'volume' as a theoretical lens is appropriate for geology? I would assert that yes, it is, because it enables us to identify what we do *not* know about a space, and therefore put at risk any narratives that claim to know something sufficiently to make major decisions about it with far-reaching impacts.

Third, this chapter enables us to consider how materiality and geodiversity influences political and territorial control. The chapter has demonstrated how geology as a material agent should be taken seriously as influencing and forcing particular scientific and political behaviours. Whilst Mitchell (2009) discusses the interconnections between materiality and democracy, this chapter speaks more to how understandings of geological materials fit within regimes creating narratives of hope, expectation and anticipation, that underpin longer-term expansionist ambitions. In doing so, this chapter brushes with discussions by Gregory (2011a, 2011b) of how decisions are underpinned where imperfect information about political volumes exist. Like in Gregory's accounts of war-time decision-making in Afghanistan and Iraq, in the NWT similar rationalisations of action based on poor quality data become possible because they are founded on longer-running stories about territorial control and resource opportunity. Thus, this chapter has demonstrated that the importance of objects like MPMs is not necessarily the data itself, but the stories that it rationalises to support broader regional geopolitical ambitions. Allowing my work to be influenced by Barry's (2005, 2013) analysis of informed materials presents questions as to what role the MPM should play if and when the SGPC becomes a matter of public concern. Will the map still be used as a foundation to justify expansion into the region, or will it have served its role in generating and bringing to life expansionist narratives, both politically and for voters? Therefore, this chapter prompts consideration of 'what next' for informed materials like the MPM, and highlights that these materials have roles to play at particular points in a project and political development workstream. It is possible that the MPM has 'just enough' detail to allow the next iteration of the scientific story to be told and brought into being (as described by Mitchell, 2003, and Weszkalnys, 2015), thus enabling the "resource desiring machine" to remain fuelled for expansion (Simpson, 2019, p. 1).

Fourth, this chapter provides opportunity to reject the view that geological volumes and their political meanings can necessarily be mutually constituted by multiple actors, as is argued in literatures around cities and 'above surface' volumes (e.g. Graham and Hewitt, 2012). Here, I have shown that the meaning (or value) of geological volumes is not contested by broader demographics who might relate to geology as a public good, but rather remains a story told within top-down narratives of territorial control and economic expansion. It raises questions of what a counter-mapping exercise about geological spaces and volumes might look like, and who might constitute them. Might those exercises enable what Adey (2013, p. 53) calls for – a removal of the "state/technocratic gaze"? What new human-material relations could be found or amplified if we framed geological value and volumes not through a resource lens but rather, for example, through one that maps the millennia-long relations of humans and non-humans to place and landscape? If we traced the physical grooves of migratory caribou using the same routes for millennia, would non-resource-based meanings for geological spaces and land emerge? My argument is, therefore, that geological volumes understood as resource volumes necessarily exclude relations and meanings of geological spaces and resultingly narrow the scope of vision for what potential futures areas like the SGP might hold. Therefore, in combination with Chapter 5, this chapter has created consideration of the 'democracy' of geological knowledge production, and I hope will inspire further research into how story-making about geological volumes can be opened up to wider demographics.

My play with ideas around volume has provided a demonstration of how other geographers can also critique mineral resource assessment claims and ambitions. This work and its understanding of mineral volume as something iteratively constructed through diverse socio-technical engagements with geology should enable geographers and others to pinpoint what, exactly, might make a resource assessment speculative, and in doing so increase the critical purchase that geographers' interventions can have in circumstances where promised mineral futures have dubious foundations.

7. Geoscience, public engagement and the legacy of extractive industries in the NWT

7.1 Introduction

In previous chapters, I explored 1) how geoscience information is produced by individual geoscientists and 2) how geoscience information is used to inform government resource-policy ambitions for infrastructure development in the NWT. This chapter takes another view of the spaces in which geoscience information is mobilised and explores the science/public interface using the example of a public engagement event. Within this context, I examine how information about natural resources and the risks and benefits of their development are presented, framed and discussed by facilitators representing government departments.

The GNWT's engagement programme, the "Resource and Energy Development Initiative" (REDI), is designed to generate public support for resource development in the Territory amongst settler and Indigenous publics. This context is an important point of study since Indigenous peoples' relations to resource development, science and technology in Canada have historically been traumatising and dispossessing, and as the Truth and Reconciliation Commission of Canada (2015, p. 360) asserts: "natural resource development is linked to a broader reconciliation agenda". Thus, understanding how geoscience knowledge comes to be embroiled in the publicization of resource-development policy agendas is important from social justice and decolonisation perspectives.

By conducting interviews with REDI's facilitators and organisers, I explore the preconceptions and expectations carried by facilitators into an engagement event in Norman

Wells, NWT. In doing so, I demonstrate how their perceptions of public concern are misaligned with the issues that publics raise at other public hearings, recorded by the Mackenzie Valley Review Board (MVRB), for example. In particular, I show how facilitators follow a classic public deficit model (Wynne, 1995), believing that opposition to resource development stems from public ignorance and lack of geoscience literacy. However, I argue that perception misses the heart of the issue in the NWT, and instead highlight how public concerns relate more to institutional mistrust, than mistrust or ignorance of geoscience information per se. REDI facilitators' emphasis on public ignorance and education is an oversimplification of the complex, sometimes fractious socio-political landscape in which resource extraction projects are pursued in the NWT.

Building on Science and Technology Studies literature (in particular Bickerstaff (2012), Wynne (2006) and Davies (2014)) I discuss how REDI uses objects and geoscientific materials as communication tools aimed at altering or guiding participants' emotions and perceptions of resource development. Sarah Davies' work in particular offers connections between public engagement initiatives, the building of emotional relations, and responses to materials used by facilitators. Davies (2019 p. 90) inspires an attention to materials and affect by bridging STS literatures with cultural geographies, stating that "we should understand public engagement with science… as not only spaces in which language is at play, but as processes constituted by embodied experience, objects, and emotions." This approach to critiquing public engagement also provides space to account for Indigenous scholars' concerns of colonial affect within the context of settler-colonial governments' approaches to reconciliation (Milion, 2009; Coulthard, 2014; Simpson, 2016; Belcourt, 2020).

Using these works as inspiration, I highlight how attempts to change publics' understandings of geoscience functions as a technique to define, control and alter what Indigenous people feel in relation to developments on their traditional territories. I do this by focussing on the narratives facilitators use to accompany geoscience materials, and in doing so demonstrate how REDI uses geoscience materials to perpetuate extractivist settler-colonial relations between government, Indigenous people and their territories within a capitalist landscape (Goven, 2006a).

Additionally, by exploring how REDI's organisational format causes certain publics to be shut down while others are nurtured, I expose how spaces of public conversation and debate have been constricted (Braun and Schultz, 2010; Felt and Fochler, 2010; Selin *et al.*, 2017). I therefore argue that the move *away from* rather than *towards* public debate is particularly problematic. I suggest that the disguise of public education as public dialogue at REDI threatens to further damage relations between publics and government, deepening (negative) emotional connections towards government-led resource development. The GNWT's lack of active reflexivity about the institutional mistrust that lingers around resource development (as evidenced at other engagement events) misses the crux of the trust issue that interrupts a smooth reception of the extractives industry in the NWT's communities. In combination, REDI's format, the political agendas of facilitators and their politicisation of geoscience materials could hinder efforts for reconciliation between publics and settler-colonial governments. Further, the desire to control emotions around resources patronisingly quashes vital spaces which have been proven to ignite and guide historical Indigenous self-determination causes in the NWT.

This chapter is structured as follows:

- First, I outline the methods used to research this chapter;
- Second, I introduce the REDI scheme and present some of the materials that facilitators relied upon to communicate geoscience information;
- Third, I discuss how REDI facilitators defined geoscience and resource development mistrust in the community, and projected their understandings of mistrust onto Indigenous attendees at the engagement event;
- Fourth, I explore evidence of mistrust in resource development as stemming from institutional-colonial relations, rather than geoscientific ignorance; and
- Lastly, I explain how REDI produces a particular space of public engagement that closes down public debate and discuss the ramifications of this on democratic natural resource development.

7.2 A note on methods

I was funded by the GNWT to attend the REDI tradeshow in Norman Wells, Sahtu Region, on 21 February 2019 (figure 7.1). In addition to interviews with facilitators before and after the event, I carried out participant observation, listening in on conversations between residents from Norman Wells and facilitators at information booths. I also had informal conversations with members of the public while we ate lunch provided by the GNWT. Attendees from Norman Wells were very reluctant to speak on record, and half of the 50 attendees were school-aged children who I did not have ethical approval from the University of Oxford to interview. Thus, I chose to focus my questions on the organisers and facilitators – to understand why and to what end they were conducting the initiative, rather than seeking to understand attendees' perceptions of it.

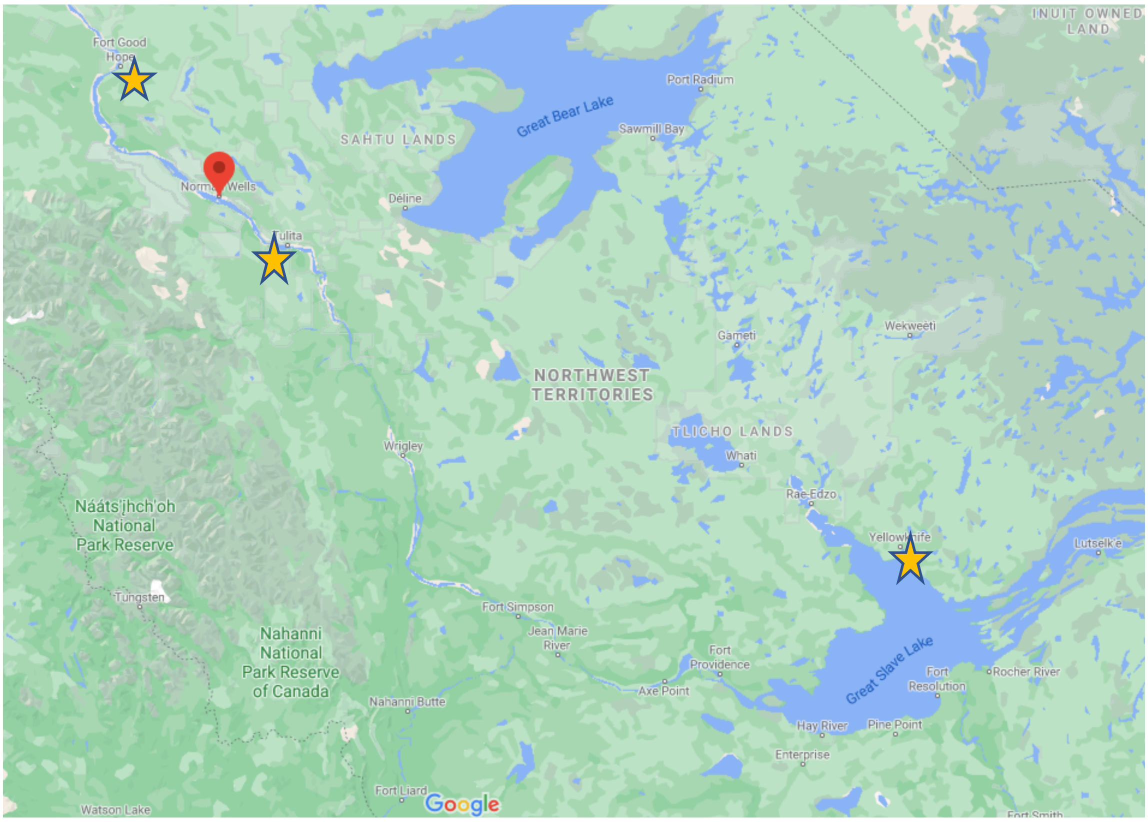

Figure 7-1: Map of the central NWT showing Norman Wells (red pin) and its neighbouring villages Tulita and Fort Good Hope; and Yellowknife, 600km south-east of Norman Wells.

Naturally, this perspective limits the critique or discussion of the effectiveness and reception of the scheme in the community, yet it does provide an account of the ontological assumptions and approach taken by REDI organisers, enabling me to ask more "why" questions. Furthermore, I was only able to attend REDI in Norman Wells, which having a long history of oil extraction since the 1940s, provided a different audience for the REDI event than other communities without such history. Norman Wells' dwindling hydrocarbon economy and local unexploited shale gas resources meant that there was a particular focus on these resources by facilitators.

I have supplemented empirical material from REDI in Norman Wells with archival materials from the Mackenzie Valley Review Board (MVRB) public hearings for resource development and management projects held since 2010. These materials are found online on the public registry at www.reviewboard.ca. Whilst engaging with the archives, I wanted to examine the tones and content of discussions (Lorimer, 2010; Hannam, 2013). Contemporary public hearing transcripts were used as a point of comparison against what REDI facilitators reported of their impressions of public meetings when I interviewed them. The MVRB archives comprised transcripts from hearings across the NWT. I used examples from Whati in the Tlicho region, Yellowknife and neighbouring community Dettah, and Lutselk'e, in the Akaitcho territory on the East Arm of the Great Slave Lake. One limitation of using this data source is that public hearings for mine developments often do not hear from local companies and contractors who might be supportive of and benefit from mineral resource development. I acknowledge that there is strong support amongst some Indigenous community members for resource development, as Joe Sacco (2020) accounts, and as highlighted to me during my interviews with the CEO of the Yellowkives Dene First Nation and President of the YKDFN-owned contracting company Det'on Cho. However, I do not make efforts to represent their voices in this chapter since my focus here is on what emotions Government tries to make civilians feel in relation to geoscience, rather than to summarise the general consensus of opinion towards development within communities.

A final limitation is that no transcriptions of public hearings regarding resource development in Norman Wells or in neighbouring settlements in the Sahtu existed on the MVRB's digital archives, reflecting that no projects in the region had reached the formal public consultation stage of the environmental impact assessment process. However, I was able to gain some insights of the themes discussed at fracking consultation events in Tulita, Fort Good Hope and Norman Wells in April 2015 (figure 7.1), using Tweets posted live by CBC North journalist Peter Sheldon and CBC News reports of the meetings. As demonstrated, these meetings were pivotal events in motivating the creation of REDI and are therefore worthwhile drawing on.

7.3 The Resource and Energy Development Initiative (REDI)

REDI[27] is a public engagement programme that seeks to educate the public about the opportunities for natural resource and energy development within the Northwest Territories and its regions. Initiated in 2017 under the 18th Legislative Assembly, it moves as an 'information tradeshow' between regional centres and communities throughout the NWT and has a budget of $100,000 annually (Government of the Northwest Territories, 2019b). REDI comprises part of the GNWT Department of Industry, Tourism and Investment's (GNWT-ITI) mandate to support a knowledge economy (NWT Legislative Assembly Hansard, 27.02.2018, pg. 3512), but also its mineral development strategy (NWT Legislative Assembly Hansard, 06.03.2019, pg. 5248, Government of the Northwest Territories, 2018). This latter mandate includes promoting "awareness of the opportunities associated with the mining industry and of the importance of the industry, as well as how the industry is managed and regulated in the public interest" (Government of the Northwest Territories, 2019b). The Minister for Industry, Tourism and Investment, Wally Schuman, described in 2017 how REDI was launched to provide:

> fact-based information based on risks and potential of resource and energy development in the Northwest Territories… It is not about promoting resource development. It is about *informing the general public of what concerns they can have*, and have one-on-one conversations with

[27] REDI run by the GNWT should not be confused with the Government of Canada Renewable Energy Development Initiative (REDI), which was a funding programme for renewable energy systems nationwide from 1998-2007.

geologists, land inspectors, water inspectors, regulators, regulatory bodies, and that is what the initiative is, to help inform the public. (*Hon Wally Schuman, Minister for ITI, NWT Legislative Assembly Hansard 3.10.2017, pg. 2877-8*).

As stated above, the format of REDI is designed to encourage one-on-one conversations between community members and representatives from different Territorial Government departments and non-Governmental organisations. It was introduced to replace spaces of public debate which were perceived by the GNWT-ITI organisers places to get "screamed at" (*Interviewee 14, 21.02.19*), and taken over by "vocal people [who] stand in front of a mic…we wanted to hear from more than just one person" (*Interviewee 19, 21.02.19*). In particular, facilitators recalled public consultation events concerning hydraulic fracturing in 2015 as particularly heated spaces in which there was no room for government to have "conversations" with members of the public (*Interviewee 14, ibid.*). The implications of changing the format of public engagement will be addressed in a later section.

Figure 7-2: REDI facilitators with their booths set up waiting for attendees in Norman Wells, 21.02.19. Photo by author.

A secondary aim of promoting the mining industry to communities in the NWT via REDI is to try and smooth the path for potential future public consultation events for environmental impact assessments for project approval. The ambition to create a mining-friendly jurisdiction with mine-positive citizens was evidenced at the PDAC event in Toronto 2018, where REDI was named as one amongst several initiatives such as prospector training, the Mining Incentive Program and development of the SGPC to promote resource development in the Territory (*Field Notes, PDAC Toronto, 04.03.2018*). As such, REDI is an initiative that seeks to aid the expansion of mining opportunities within the Territories by creating a supportive public who ease rather than hinder government and industry development proposals in the region, increasing the NWT's competitiveness as an exploration and investment destination.

REDI hosts facilitators from different governmental and non-governmental organisations:

- GNWT Departments of ITI, Lands, Environment and Natural Resources, and Executive and Indigenous affairs
- Mackenzie Valley Review Board – MVRB (*regulator*)
- Local Land and Water Board (*regulator*)
- Office of the Regulator of Oil and Gas Operations - OROGO (*regulator*)
- Mining Matters[28] and the NWT Mine Training Society (*non-profit, mainly industry funded organisations*).

At REDI events, representatives from these departments and organisations are given booths to communicate their role in the resource development industry. They are encouraged to

[28] A Prospectors and Developers Association of Canada (PDAC)-led charity supported by mining majors to deliver mining propaganda to schools across Canada.

initiate conversations with attendees by telling them about their sector's involvement in resource development, as well as answering or triaging any questions (*Interviewee 18, GNWT-ITI facilitator, 26.02.2019)*. Facilitators espoused the benefits of having a large travelling tradeshow that representatives of different aspects of resource and energy development attended. For OROGO, the scale of the tradeshow ensured a higher footfall than usual public engagement events experienced, and increased the organisation's exposure to members of the community:

> if OROGO went out and held a community information centre, I might get some people, might not get others. But if there's 10 different government departments holding an information session then you're more likely to get people who have come to talk to one, but they make the tour around the room and they might and stop and ask a question if they have one. In that sense it's helpful and in some ways, it reduces the burden on communities as well because it's not endless government departments wanting to show up and talk to people. (*Interviewee 21, OROGO representative, 05.03.19*).

Another benefit of the tradeshow format is the capacity for facilitators to seek immediate answers from other departments or organisations when they are unable to answer attendees' queries:

> There was concern about, you know why do we have all these abandoned wells and what does that mean? The really fun thing about REDI is that I can say "I have no idea because that's not where my background is", but I just walk them down to *19* who was in the petroleum booth, and they were like, "well that means that they've been closed and we keep track of the integrity of those sites, but you should really go and talk to OROGO

> across the room, the regulator". And this is where the magic of REDI comes. There is too much for one subject matter expert to know, but you kind of know that it probably has something to do with this and you should probably go talk to [that person]. (*Interviewee 18, ibid*).

What these excerpts highlight is the benefit of bringing multiple departments together into one space, giving a platform to multiple agendas at once by creating a big 'event' out of a public engagement programme. This is especially helpful in the resource development context where knowledge and responsibilities around bringing a mine into operation is distributed amongst government departments. The attendees benefit from multiple knowledge-holders available to answer questions, enhancing the capacity of hosts to adequately respond to concerns or queries the public may have and increasing the opportunity to gain a more holistic overview of the resource development process.

7.3.1 Facilitating REDI

REDI is not comprised purely of experts in the science and technology of resource development, but rather presents a group of facilitators (also known as knowledge brokers) who are able to simplify technical information and deliver it to community members. In STS critiques of public engagement with science, it is often assumed that scientists are speaking directly with laypeople; the identities of groups doing the communicating is unclear (e.g. Wynne, 2006); or facilitators are identified as working purely at the science-policy interface (e.g. Bednarek *et al.*, 2016). Yet at REDI, the reliance upon facilitators (who have a familiarity with or possibly a professional background in science and technology) to speak with lay people demonstrates a science-communication boundary that should be better accounted for in STS literature and considered political. For example, Chilvers (2008) explores how facilitators represent different interests and how they choose to communicate information and why. At REDI, it is challenging for Government-selected facilitators who have information sharing responsibilities to find a balance between informing and promoting via the content it shares with members of the public. Government-selected facilitators must ensure that an institutionalised digest of resource and energy development is delivered within the purview of organisations' and governmental departments' mandates and responsibilities. Thus, the information coming through these facilitators is framed in ways that supports policy agendas for the regions and Territory, rather than with the intention of opening a dialogue about the risks and benefits of resource development, for example. Science, in this sense, is therefore not straight from the 'horse's mouth' but rather adopts a political orientation as it moves through the facilitators to members of the public.

This space of information transformation, framing and communication is also important to examine from a geoscience perspective because it enables the pathways and applications of knowledge produced about the geological world in the NWT to be traced. As we have seen from following the production of geoscience information and its application to infrastructure planning in previous chapters, geoscience knowledge comes with complex conditionalities which, rightly or wrongly, changes how we treat land and geology as a resource. The embroilment of geoscience with public engagement around resource extraction inevitably draws in conversations around risks, costs, benefits and opportunities of resource development. How the knowledge that underpins government aspirations is communicated, and whether geoscience remains conditional or becomes 'fact' is an important consideration on grounds of transparency and accountable decision making.

By looking at the space that facilitators occupy, we are able to examine what aspects of science are being communicated using what tools and what the intention of doing so is. In particular, the reliance upon geoscientific materials to work between science, scientists and publics as information and mediating objects emerges (Becker, 2018). To demonstrate materials' use, two booths presented quite different approaches to geoscience information sharing – the NTGS and the Petroleum Resources divisions of GNWT-ITI. I asked them to describe the materials and intentions of the information they were sharing:

> We are there to answer questions about the science behind resource development. Why we have certain deposits within the territory, why they're located where they are [shown on a map], how they form, you know, what they can be used for [demonstrated with objects like cans and toys], that sort of thing is the main messages that we're sort of bringing. We can answer anything general about geoscience that any person in the community or organization has on their territory. Whether that's related to permafrost, or diamonds, or aggregate, we're available to help. We're available to help as well to encourage students to pursue careers in geoscience…
>
> …I had quite a few people engage with the map of the region, the geology map of the deposits. I'll make sure to have those available for the next REDI programmes (*Interviewee 18, NTGS representative, 26.02.19*).

*****

> What I find particularly with that poster behind us, when they see how far companies are drilling into the ground to do hydraulic fracturing they realise "oh you're going way further [down] than I thought" … then you get to the idea that we're not drilling into your water table, it's way below, and that doesn't make it easy for stuff to fill into your water table, so that's

> been a benefit. And that 3D model on the desk, that's really paid off in terms of people going "wow I didn't realise how thick, how far they go to prevent things from leaking into the soil!" (*Interviewee 19, Petroleum resources division, 15.03.19*).

While the NTGS representative sought to give more objective information about the types of resources in the Territory and used objects to initiate such discussions, the petroleum resources representative presented geoscience information in a way that was designed to reassure attendees about the processes and technologies enabling fracking. *Interviewee 19* brought models of drill-hole casings and posters of cross-sections of fracking wells relative to the water table with them. These materials were a direct response to concerns they perceived members of the public had about fracking, namely water contamination from fracking liquids and fears from watching the US documentary 'Gasland'. Materials in this context therefore took on a political role, placing the participants in particular relations to the science with which they are being asked to engage (Marres, 2012). *Interviewee 19's* materials sought to aid the displacement of misconceptions around fracking, by grounding participants in a material 'reality' of the subject that supported eroding disbelief. Thus, one could argue that these materials were a way to direct conversation and create a commonality between facilitator and attendee by discussing a 'real' rather than hypothetic example of a matter of concern. Young (2001, p. 687) would describe this use of materials as a means to "rupture a stream of thought rather than weave an argument". The petroleum resources facilitator therefore used methods that seek to interrupt attendees' perceptions about aspects of the fracking process. It comprised what Davies (2019, p. 95) describes as an ordering of knowledge and emotion through "material practice". *Interviewee 19* thus relied on geoscience materials as a tool to build new affective relations with fracking, to replace feelings of reservation and scepticism towards fracking technology with trust.

Meanwhile, in my fieldnotes I reflected on the use of materials in a game format by the Mining Matters representative which created a natural conduit into conversation about remediating mine sites. Here one had to match pictures of mines during and after operation. For a moment, the game caused me to check the assumptions that I had about mining – surely, they always just left behind a mess? – but these images and the way I was engaging with them in discussion with the facilitator, dared me to consider another possibility. Having physical objects is important when tackling large, unwieldy subject matters because it creates an entry into a topic that might otherwise be intimidating to those who know little about it. Thus, the material context of public engagement at REDI worked with the dual purpose of engaging individuals with mixed educational and English language levels, and for encouraging a realignment of association and thought between political matters (e.g., fracking, remediation) and attendees' assumptions or emotional responses to them. A representative from the Mine Training Society discussed the importance of materials as mediators:

> It's really interactive [having mineral samples], it's not just me looking at something, I'm actually putting my hands on it, and playing through my learning, which deepens your understanding… I mean we have those pamphlets which are great, and I think it's a great tool to use. But again, if you walk up to somebody and you have all these papers, it's a bit intimidating, and then they start talking to me in their language rather than mine. And then I'd sit there and feel stupid or ashamed, and like, okay well I'm just going to leave because it's not benefiting me. (Interviewee 16, Mine Training Society representative, 6.03.19).

Although some REDI facilitators did well at engaging attendees through material tools (despite whatever emotions they wanted to generate), others were dependent upon printed materials and literature which was perhaps mistargeted at the lay audience REDI was trying to reach. One facilitator described how:

> some of these groups' posters are used for industry events and I know the Territory attends various things like the Geoscience Forum, then there's roundup in Vancouver and then this week there's PDAC in Toronto, and maybe they're taking these things and putting them into REDI and maybe it doesn't quite suit the same audience and purpose. (*Interviewee 20, MVRB representative, 04.03.19*).

Thus, if REDI wanted to be more effective at engaging participants, its organisers should require that different departments and organisations prepare materials that are better targeted at the types of people attending the REDI meetings. One of the target audiences of REDI is children (Government of the Northwest Territories, 2019b) and nearly 50% of the attendees at Norman Wells were school-age children whose appetite for and understanding of technical geoscience information is likely limited, if not non-existent. Thus, a tailored communication package is especially important given that the facilitators do not necessarily work as dedicated communications personnel and perhaps lack the experience or training of engaging with different publics (as described by Chilvers, 2012).

Despite this shortcoming, the organisational structure of REDI should be praised for its originality and its capacity to capture the attention of and involve often engagement-fatigued community members (Mathisen, 2015). As proof of this, in some communities that REDI visited, nearly 10% of the towns' populations attended (Government of the Northwest Territories, 2019b). However, where the GNWT is able to reach such a large audience, understanding public communication as a product of a power dynamic is especially important. As Stirling (2008, p. 275) emphasises the "framing [of information]… reveals the enormous latitude for inadvertent, tacit (or deliberate, covert) influence of power". At the REDI tradeshow and as evidenced during interviews, facilitators appeared to work within a 'public deficit model', as described by Wynne (1995), wherein attendees were assumed to mistrust resource extraction because of their lack of education and scientific understanding. During these interviews, two key themes emerged: 1) the desire to dispel 'myths' and 'misconceptions' about the extractive industry, framed within public deficit-style discussions of public ignorance; and 2) linked to this, the aim of increasing trust in science and regulatory processes that accompany the industry.

7.3.2 Defining the issue: a case of institutional legacies or public ignorance?

In this section, I will explore how the framing of resource information which sought to guide attendees' experiences at the tradeshow made direct assumptions about their concerns and knowledges of resource development. As Wally Schuman was quoted earlier as awkwardly saying, REDI "is about informing the general public of what concerns they *can* have" (Hon. Wally Schuman, ibid). As *Interviewee 19* showed with their fracking casing and the Mining Matters stand with their remediation game, geoscience materials played a key role in mediating and rewiring emotional responses to aspects of resource development. Additionally, the assumptions made by facilitators of communities' knowledge or emotions translated into government telling Indigenous people how they should and can feel about different processes and events affecting their communities, families and livelihoods. Together, this approach perpetuates rather than improves unequal relations between the colonial-settler state and Indigenous people in the NWT, reinforces colonial affects, and undermines efforts for reconciliation (Simpson, 2016).

There was an anticipation by facilitators that those attending REDI would be anti-resource development, or at least ambivalent. From my interviews, REDI facilitators appeared to believe that anti-development sentiments stemmed from a belief in 'myths' around resource development proposals, in particular hydraulic fracturing in Norman Wells. Their presumptions are problematic in that they assume a lack of evidence-based critical thought on the part of communities and that with 'facts' individuals will make non-emotional decisions about land that is intricately tied to their socio-cultural well-being and identity. It suggests a concern that layperson's perceptions of resource development are without merit or foundation in reality. Their approach separates science and technology from the lived experiences of Northerners. Facilitators' broad-brush approach was accompanied by an almost complete lack of reflexivity about the role of institutional-public relations as affecting public uptake and trust in information. Interviewees (bar one, *Interviewee 18*) did not reflect on the intricate, sometimes fractured, dynamic of Indigenous and settler support and opposition for resource development that exists within in the NWT and between communities[29] (see Sacco, 2020 for greater detail of this dynamic in the Sahtu).

An example of how facilitators may have mistaken local concerns about natural resource development in Norman Wells is in relation to fracking. Speaking at the GNWT's fracking engagement tour in 2015 in Fort Good Hope, Fred Grandjambe said "we want to have a good discussion. We are not altogether against development" (Quoted in CBC News, 2015). While facilitators at REDI described the tradeshow as a response to shouting-matches occurring during the fracking tours, news reports from these three meetings suggests a more

[29] I acknowledge that just because the facilitators did not discuss this with me, that they were not acutely aware of it.

nuanced series of events, where what upset communities was not the subject of the meeting – i.e. fracking – but rather the GNWT's approach to engaging them on this topic.

Figure 7-3: Screenshot of live Tweets by Peter Sheldon from the Norman Wells fracking hearing, 15.04.15

Communities visited during the consultation tour felt disrespected by the engagement approach, calling it "shameful" and "a practical joke" (CBC News, 2015). Peter Sheldon, reporting for CBC North, Tweeted the exchange (figure 7.4) between the Norman Wells Land Corporation and Assistant Deputy Minister for GNWT-ITI Deborah Archibald. The exchange highlights the institutional confusion and lack of clarity about what kind of meeting was being hosted – whether it was a formal consultation mandated under Indigenous people's Constitutional Section 35 rights (see Context chapter for further information on this), or an unlegislated community engagement meeting. The consequence of messing up consultation and engagement processes for a matter of concern as divisive as hydraulic fracturing is that the opportunities to 'get it right' a second time around become limited. Such mistakes or miscommunications become doubly significant when understood within legacies of settler-colonial governance and exploitation of Indigenous traditional territories, and histories of absent, non-meaningful or untransparent engagement and consultation practices.

Yet, during my interviews, there was a sentiment that opposition to resource development, in particular fracking, was fed by scientific illiteracy and ignorance. Quotes in the previous section made by *Interviewees 14* and *19* in reference to the fracking consultation tour demonstrated that REDI organisers perceived the events as attacking the geoscience information the GNWT was trying to provide, rather than understanding it as an issue with the consultation process itself. As such, facilitators took the approach that the public needed to be given facts, their emotional arguments rationalised and most importantly, myths and misconceptions about resource development industries dispelled. For example, *Interviewee 19* argued how

> People fear what they don't understand, how mining works, how remediation is required, how environmental protection that's required [sic]. Everybody sees the evil things, the bad things, they see the leaks, the stuff that's sitting in their communities leaking. So, what we're trying to show with this is that if they have questions, the benefits of them, what's so good about it, how they can be impacted [sic]. (*Interviewee 19, GNWT employee, audio recorded in person, 21.02.19*)

Similarly, *Interviewee 14* aligned fear with ignorance of how the resource development process operates, arguing that with direct exposure to different regulatory departments, people would be keener to participate in the extractives process. The quote from *Interviewee 14* below also highlights how the facilitator believed that the presence of regulatory bodies and frameworks should be sufficient to assuage fears or eliminate historical experiences of unaccountable, cowboy-style mining. The approach of relying upon regulation of resource extraction for legitimisation ignores that although resource governance institutions, bolstered by their apparatuses (such as regulations and laws) may believe they have progressed from the almost lawless days of the 1950s-1990s, the effects of these resource experiences are still very real and within living memory of many community members:

> Well, I'm hoping that REDI will help educate people so that if we do ever get another project in the community, as that project is working through the regulatory system we will have informed discussions. People won't be afraid to participate in the regulatory process, and they'll understand as the project moves through the process, they'll remember "oh yes I spoke to so and so at ENR and this is what that's all about", or "I spoke to the board member and they told me what this is all about". So, then there won't be a fear but an understanding that there's a system there and it works and it's holding the company accountable. (*Interviewee 14, GNWT employee, audio recorded in person, 01.03.19).*

What this quote misses is what Usher (1993, p. 116) discusses in relation to the outcome of the Mackenzie Valley Pipeline (Berger) Inquiry in the 1970s, namely that it is unhelpful to frame industrial development in the North through a framework of change, but rather he asks "whether the problem might not better be seen as one of control over change". Although beyond the remit of discussion in this chapter, asking such questions opens up questions of how well communities influence decision-making through regulatory bodies such as Land and Water Boards and the MVRB, despite their mandated representation, and how well their epistemologies are accounted for in environmental assessments (c.f. Usher, 2000; O'Faircheallaigh, 2007; Hall, 2013; Eckert *et al.*, 2020). This would highlight were some reservations around regulation and consultation stem from. What the above literatures discussing Indigenous involvement in regulatory processes agree on is that just because consultation is legislated for and Indigenous board members sit on environmental assessment boards, does not necessarily mean the balance of power between settler- and Indigenous-people has been redressed in a manner that alters the capitalist-accumulative mode of production that functions in the North.

Related to the history of mining experiences in the NWT, the Mining Matters representative outlined how they perceived the core issue of public opposition to mine development to be situated around the long-term impacts of mining operations, in particular site care and remediation[30], and a lack of understanding about the requirements for reclamation today:

> What we'll be doing for REDI is activities that illustrate the importance of mining in your everyday life and also addressing some misconceptions. One is called reclamation matching. You'll have a set of cards. You'll have red cards and blue cards, and one will have a photo of a mine taken in the past while it was in operation, and another will have a picture of it now after reclamation. Basically, they have to match them up… Oftentimes, especially being North, there's a lot of issues regarding environmental issues with mining, and there's also still, a lot of people don't realise that reclamation is something that is required in Canada. (*Interviewee 15, Mining Matters representative, 20.02.19*).

My discussion with the Mining Matters representative demonstrated most clearly how publics were delivered 'facts' (i.e. that sites are returned to good conditions after mining) that brushed over or overlooked far more complex geotechnical or geo-social realities. *Interviewee*

[30] Remediation and reclamation are different geotechnical processes of dealing with the disturbances to the land after mining – see (Lima *et al.*, 2016) for a detailed comparison. I use the terms interchangeably here to describe a process of aftercare or site management carried out once the extraction processes has been completed.

18 (ibid.) critiqued Mining Matters' approach to describing remediation: "I took a bit of issue with the Mining Matters activity, the before and after reclamation sites. I was like so what's the water like, what's the soil chemistry?". This case demonstrates the selective presentation of resource and geoscience information to frame the industry in a positive or zero-impact light.

In relation to the Mining Matters booth, Goven's (2006b, p. 565) perspective on engagement and capitalism, in particular "how public dialogue is placed in relation to the cultures and structures of regulatory science and neoliberalism" helps us understand how and why facilitators present information at an event and frame geo-environmental realities within a neutralised light. One of Mining Matters' funders is PDAC whose priority is to help "industry to access the capital, land and skills required to responsibly discover and develop deposits of the minerals and metals" (Prospectors and Developers Association of Canada, 2021). Mining Matters does not reveal its other donors, but I was told by *Interviewee 15* that they included mining companies with interests in the NWT. Thus, there is a demonstrable financial stake in presenting information in a manner that helps smooth the reception of resource extraction projects in Northern communities. Mining Matters' work operates within a capitalist network of power, wherein through influencing (young) people's perception of mining through misleading imagery, the process of gaining community support for extraction projects is improved. *Interviewee 14 (01.03.19)* explained how young people from school age to 30, were "the age group that we really need to target. Anyone over thirty, they kind of have their own ideas of what the world is like and they start to narrow their minds a little bit and they have their opinions, anybody younger, their minds are open". Within this context, Stirling's (2008) analysis of information framing and power in public engagement becomes even more meaningful, as impressionable children and young adults are targeted by corporate ambitions for resource development expansion. It raises the question of whether careers and opportunities in mining are being effectively promoted through REDI and by Mining Matters to young adults and children, as promised by the GNWT, or whether information is used with the primary aim of improving the image of mining for communities' future decision makers.[31]

The Mining Matters' reclamation game (in addition to providing a simplified environmental aesthetic after mine closure) completely ignores the long-term socio-cultural impacts of mines on communities, both spatially and temporally. Within the context of arsenic remediation at the Giant Mine in Yellowknife, Beckett (2020) critiques the overemphasis and focus on technoscientific solutions, and the absence of institutional reflexivity about the long-term social-environmental scars left in the local community after the surface of the Giant Mine site has been remediated. This broad attention to the focus on science and technology at mine sites, gas and oil wells overlooks the importance of place to people, particularly in communities historically dependent upon the land for their sustenance, and drives an artificial wedge to separate environment, culture and economy. The REDI programme oversimplifies the matter of concern (here, reclamation and fracking) and does not allow for sufficient account to be taken for the multiple socio-economic and cultural dynamics between the legacies of extractive industries, communities and institutions[32].

[31] The organisation 'Mine Training Society' also attended REDI and sought to attract school-leavers and link individuals up with employment and apprenticeships. Their work does not extend to providing geoscience/Earth Science education to school-age children.
[32] For a discussion of socio-economic/cultural impacts of mining on an NWT community, see Davison and Hawe (2012).

7.3.3 Recognising institutional legacies

As Bickerstaff (2012) explains for communities in West Cumbria, publics' (sometimes traumatic) memories of historical actors and events involved in attempts at radioactive waste management strongly affects the capacity for institutions to implement new policies and plans that echo past experiences. This is especially problematic when the institutions do not have the same memory around process, place and industry that publics do. Similarly, in the Northwest Territories, this lack of recognition of historical relations of power between government, industry and publics was concerning at the REDI tradeshow and created a sentiment that suggested that because the GNWT and industry had moved on from the past, so should communities and concerned publics. REDI facilitators seemed to overlook how the 'science' and 'facts' they wanted to use to gather support feed into Foucauldian structures of biopower that have historically been used as instruments of governance, colonisation and control over Indigenous lands, bodies and cultural practices (c.f. Sandlos, 2001, 2018; Smith, 2012a)[33], and as such may receive a steely reception (Wiseman and Daniel, 2019).

Simpson (2016, no page) makes a distinction between "settled and unsettled matters" and how "a struggle of and for history" has emerged in interactions between settler-colonial governments and Indigenous peoples. Settler-colonial governments, Simpson argues, continually work to define the boundaries, temporalities and affective natures of Indigenous peoples' histories and relations. As a result of this dynamic in which the terms and spaces of anger, memory and emotion are dictated to Indigenous people, colonial relations controlling and extracting from Indigenous bodies and lands are perpetuated. This works to reinforce power inequities between different actors. Memory, fear and anger, Yellowknives Dene member Mary-Rose Sundberg describes in relation to the Giant Mine in Yellowknife, are

[33] Debates around biopower and scientific control of Indigenous lifeways can most recently be seen in relation to caribou and other wildlife management (Parlee and Caine, 2018).

critical not only in informing people's reactions in the present, but also in sculpting their relations with landscape, place and environment into the future (quoted in Benoit, 2015). Honouring memory is therefore critical in producing futures in which the public has greater control over relations with place (Landström and Kemp, 2020).

While REDI seeks to simplify the terms of discontent (i.e. a mistrust of science), examples from contemporary public hearings about mine developments demonstrate that the past is a raw wound for some and continues to provide a source of community mistrust in proposed extraction projects. In the examples I give below from three public hearings on resource development and remediation proposals since 2010, we see that a mistrust in science and technology (especially around long-term impacts) are facilitated and sit within structures of broader mistrust in settler-colonial institutions that govern these processes.

First, Elders and community members in the Tlicho settlement of Whati had particular criticisms about Fortune Mineral's (the proponent) claims that their base metal mine would have no impact on aquatic life and water quality:

> As some of [the Elders] say, [the proponent's] not– they're not really telling the truth, I don't think. There -- there is no 100 percent guarantee. Wherever here's a mine, there's going to be damage. You know that. You know, all the sites you see [in] the past. There's no – there's no 100 percent guarantee that the land and -- and the environment's going to be safe. We know that. (*Mr Michael Rabesca, speaking at the Fortune Minerals Nico Hearing in Whati, 27.08.12, translated from Tlicho into English*).

Here, Michael Rabesca describes how risk from the past seeps into risk in the future – why should risk management be any different today, and should the regulatory system be enough to console people's fears? After all, the presence of a regulatory system does not mean that the information presented within it is any more risk-free than before regulations existed. At the Dominion Diamond Jay Pipe hearing in Lutsel'ke on the East Arm of the Great Slave Lake, similar concerns were raised about the impact of rock extraction and processing from the proposed new pipe. This statement sat within broader discussions of reduced caribou numbers at the hearing, a culturally-critical species whose decline some have associated with the increased mining activity in the Slave Geological Province (Parlee, Sandlos and Natcher, 2018), and the long-term history of a lack of transparency about the risks of mining:

> I'm going to go back into a little -- a little bit of history here, Giant Mine, for instance. Did they know that the chemicals that they were using, arsenic, did they know that it was going to be a hazard, a health hazard? They never told us. Only later that we knew what arsenic can do to people. There's enough arsenic at Giant Mine to kill the world two times over.
>
> And you're telling me that there's going to be no pollution, nothing, no damages or whatever? You don't even know what chemicals you're putting in to separate the diamonds and stuff like that. Maybe it's twenty years down the road a scientist might find something wrong. There's something in the chemical that's affecting us, affecting the animals, affecting the air. So, you know, when you -- you tell us something, you -- you promise us something and then you break it. I'm totally against Jay pipe. (*Ms Cathy Marlowe, speaking at the Dominion Diamond Mine Jay hearing in Lutselk'e, 19.09.15*).

The examples above demonstrate a mistrust in the use of scientific information to convey a sense of security and safety. Cathy Marlowe's quote also hints at the feeling that diamond mining in the SGP has impacted caribou populations, but that community concerns have not been listened to. The speakers quoted from these hearings do not mistrust the content of the information per se, but rather how science is used by institutions and industry to persuade community members about the safety of their mines in the long term. Historically, as Cathy Marlowe describes above, Western 'trust' in science had devastating consequences for Indigenous communities and their traditional lands, and thus leads some to treat claims of safety with scepticism.

One of the most damaging mining projects in the NWT for causing strained and broken relations of trust between communities and government institutions was the Giant Mine in Yellowknife. Here, since the 1950s, consistently inadequate communication between government, industry and residents, as well as poor transparency about the risks of arsenic in the environment has done considerable damage. Not only has the management of the Giant Mine resulted in deaths and ill health of local residents and environment, particularly members of the Yellowknives Dene First Nation, it has also created a disaster of institutional mistrust and a long, difficult path for reconciliation between residents and government (see Chapter 4 and Keeling and Sandlos, 2012):

> For many people, Giant Mine is an engineering problem. For me, Giant Mine is a story of relationships failed: relationships towards the people, the land, and especially future generations. Trust has been eroded, and it will take many years for it be restored, if ever. To be restored to what you referred to, Mr. Chair, earlier today as the sacred trust, an apology must first take place. It is within this context of missed trust and failed

> relationships that you [the developer] need to navigate. (*Ms France Benoit, speaking at the Giant Mine Remediation Project hearing Yellowknife, 11.09.2012*).

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> Dene children died because of the sulfur trioxide and arsenic trioxide in the atmosphere, and we haven't had any inquiry…We need to know who was responsible, and why there was so many ammonia [sic] and trioxide release in the air and water even though Native people were living right across the Bay here. I don't know if there was a chance for us to be exterminated once and for all, and it seems like that to us, even to this day. Do we trust Canada? Do we still trust Canada today after all those years? Can we continue building that kind of relationship? It's really hard because we -- again and again and again, Canada has failed, has told us many things but, then again, the -- the trust is not there anymore because it's – it's been too long, you know. (*Mr Fred Sangris, speaking at the Giant Mine Remediation Project hearing Dettah, 12.09.2012*).

As the Mining Matters representative acknowledged, the North has a toxic legacy of mining, and these historical experiences deeply inflect contemporary responses to resource development and management proposals. The quotes from Giant Mine most strongly demonstrate how Territorial and Federal governments operate within an environment of institutional mistrust. The issue with REDI is that by failing to account for the institutional nature of resource development challenges, it places Indigenous peoples' knowledge of the industry as the central issue, rather than their history with it. This works to position "Indigenous subjects [as] the objects of repair, not the colonial relationship" (Coulthard, 2014, p. 127). It follows what Wynne (2006) marks as the envisioning of mistrust to stem from singular events and public ignorance, rather than from long-term institutional relations and practices. It is the event- or subject-based narrative adopted by the settler-colonial government that undermines the authenticity and relationship-building potential of the REDI programme and prevents a long-term reflection about the role of institutions in enabling mining disasters to occur.

The hearing excerpts from Whati and Lutselk'e also demonstrate the risks of oversimplifying socio-technical relations and presenting extractives controversies as issues of (not understanding) science and technology. Instead, space should be provided (although perhaps not at the REDI tradeshow itself) to acknowledge the breadth of issues (and benefits) related to extractive economies in the North and how they were embedded in settler ambitions of expansion and control of land. It presents a challenge to the organisers – how to develop a relationship between institutions and community within a relatively informal setting (REDI) whilst making clear that the past is acknowledged, understood and informs government's decision-making processes in the present. REDI alone cannot therefore be an engagement tool for the GNWT to rely on.

Acknowledgement and reflexivity needs to be provided of these histories in ways that go beyond what Daigle (2019, p. 704) describes as a "spectacle of reconciliation", but rather in ways that affect deep institutional change in attitudes and practices around resource development on Indigenous territories. Perhaps, as Landström and Kemp (2020) suggest for the British nuclear context, a non-governmental led reconciliation project needs to be organised in which institutions and industry listen and respond to the memories of communities' involvements with resource development, and how this affects their attitudes today. This may help produce, as the Tlicho Government has done (Tlicho Government, 2019), a set of Territory-wide consultation guidelines to ensure that institutions and industry are consulting appropriately with Indigenous governments about works potentially affecting their territories, specifically on their terms. Similarly, the current GNWT's commitment to implementing the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) may also provide an avenue for building relationships of trust between types and levels of government and Indigenous people.

7.3.4 A space for public debate?

REDI's focus on facts, misconceptions and regulatory safety nets to assuage fears about the risks of mining gives inadequate space to discuss their lived realities. As *Interviewee 18* highlighted of the Mining Matters' reclamation game, serious omissions imbued the organisation's propaganda about reclamation. In the shut-down structure of engagement at REDI, it was not possible for *Interviewee 18* or other attendees to openly challenge what was being presented and thus offer alternative evaluations of risk that others could hear. Indeed, as was demonstrated from the hearings quotes in the previous section, doubts ingress when risk, safety and impact management seem too good to be true.

The public is aware that mining occurs within a landscape of risk, yet this is downplayed by governments and developers. This attitude together with the absence of spaces to discuss the issue threatens to cast stronger dispersions on proposed projects by creating a sentiment that communities are trying to be hoodwinked into accepting projects on their land that could threaten their environments and lifeways. *Interviewee 18* recommended that the engagement programme should adopt a more transparent approach:

> We should be saying "this is fracking, this is why there were issues, this is how we are dealing with those issues, this is how things could happen, and this is the regulatory steps that are in place to deal with those things", rather than, "you don't have to worry about fracking". Because clearly jurisdictions are shutting down fracking and this isn't because they watched a YouTube video. So why are some jurisdictions shutting them down and others are open? Maybe there's something bigger behind it you know. (*Interviewee 18, ibid.*).

With the same REDI facilitator I discussed how the legacies of historical mining activities were approached during the tradeshow. They responded by calling for greater transparency, accountability and honesty on the part of government representatives:

> I feel like we need to be really upfront and honest… and say that Giant Mine is a disaster. Like that is terrible what we have to deal with and what the Canadian government is paying for, and we don't want another one of those to happen, and mining does have risks, and how do we mitigate those risks so that we can reap the benefits…I think as facilitators we need to get our messaging on the same page and spend some time with that message and spend some time with each other to talk about these things and hear about some of the issues from different perspectives because people know when you're whitewashing something. (*Interviewee 18, ibid.*).

As *Interviewee 18* points out, REDI facilitators' attempts to rationalise publics' concerns about development risks adopts a method that shuts down a debate that needs to be opened up. It also raises questions about *where* such debates can take place. REDI should be used as an opportunity for facilitators to better understand and listen to people's concerns and fears, rather than pursuing the public education approach which allows little room for facilitators to learn from the public.

The quotes from Whati, the Jay Pipe hearing and Giant Mine demonstrate the importance of having a space for public debate. However, such space does not exist in the REDI format. Coulthard (2014, pg. 109, 111) argues that "Indigenous peoples' individual and collective expressions of anger and resentment can help prompt the very forms of self-affirmative praxis that generate rehabilitated Indigenous subjectivities and decolonised forms of life in ways that the combined politics of recognition and reconciliation has so far proven itself incapable of doing". Meanwhile, Milion (2009, p. 54) explains how public narratives work as "political acts in themselves". After closing down spaces of public debate between communities and Government, where can the public or Indigenous governments go to voice their concerns, emotions, hopes and fears? What space is given to discussing "how wounds should be known"? (Simpson, 2016, no page).

REDI's dependence upon the public education model has removed a space of public debate. Examining this transition raises questions about the assurance of democratic process and institutional accountability. Creating the 'tradeshow-style' event falsely gives the impression of a flattened hierarchy between government and citizens, whereas actually it is a structure of control that enables certain publics to emerge with particular narratives instilled (Felt and Fochler, 2010). What the REDI structure has done is enable the government to "[close] down uncertainties and mask the contingencies of knowledge production" which becomes "a matter or institutional and political survival" (Chilvers, 2012, p. 303). REDI is therefore a reactive, rather than proactive response to institutional mistrust and not, I argue, a meaningful, reconciliatory way to deal with historical institutional relations.

A concern about REDI is that it attempts to remove the voice of a public that is opposed to or doubtful about resource development by closing down the space in which it may speak. REDI facilitators imagine and therefore try to create passive recipients of information that are unable to publicly and directly share concerns with Territorial representatives about policies that affect them. Thus, in imagining an ignorant public that it can only reach through one-on-one conversation, it also eliminates spaces for concerned members of the public to organise themselves. In shutting down and flattening spaces of engagement, the REDI format curates a space for a public to emerge that can more easily be mollified and controlled, and that is less resistant to the ideas and policies that Government representatives bring along.

The importance of a collective space for shared emotions, experiences and anger was demonstrated during the 1975-77 Berger Inquiry hearing, during which Justice Berger heard evidence from communities throughout the NWT relating to the proposed Mackenzie Valley Pipeline. Sacco (2020, p. 71) accounts Patrick Scott, a camera man for CBC North recording these proceedings, as saying "by people telling their stories, expressing who they were, and being listened to – not just by Berger, but by each other and the greater community of Canada – they decolonised themselves, they re-claimed their own sense of identity". Importantly, the Berger hearings created a singular Dene voice that said "No, we don't want a pipeline…because we have our own plans…we want to get back control of our land, we want to develop our own economy…we basically wanted to seize control of everything that had anything to do with ourselves" (*Stephen Kakfwi, ex-premier of the NWT, quoted in Sacco, 2020, pg. 72*). Public hearings are therefore powerful tools for amalgamating collective energies and can be pathways to establishing community aspirations. Milion (2009, p. 54), speaking about Indigenous women and the colonial affect of shame, explained how the voicing of their wounds "transformed the debilitating force of an old social control…into a social change agent". As such, I suggest that REDI's format should be pursued in conjunction with public debate forums to honour emotions and give space for collective aspirations to emerge.

In relation to public debate as a democratic process, I discussed REDI with a Member of the Legislative Assembly. They said:

> If you have this open house style event where you have no single person in charge, everything gets diffused. If there are people who do want to talk about stuff they get shunted off to a table and there's no real focus. That's a real conscious effort to diffuse the situation… so someone comes to an event and they have legitimate concerns and they want other people to hear them, there's no avenue for that to happen… [REDI] could be done in a way that is more participatory than one-on-ones. This is not what they're doing or want to accomplish. If you have 50 people flow through in an evening, how do you know what they said? How are their feedback sheets recorded and tracked? And a lot of the people at the tables are there to promote what they do and not necessarily provide objective information about the risks or downsides of some of that stuff. (*Interviewee 22, Member of the Legislative Assembly 2015-, 15.03.19).*

As *Interviewee 22* argues of the REDI format, eliminating the public voice raises the risk that public opinion may be lost through one-on-one conversation. With public voice comes accountability on the part of the meeting host to listen to and react to public comments, as well as greater transparency about the types of information communicated to community members. In the public hearings run by the MVRB, attendees' information requests are recorded in writing and a deadline for their response agreed, ensuring accountability. When questions or issues are raised in individual settings, this imperative disappears, and the onus is on the community member rather than the facilitator to be scrupulous about recording and pursuing responses the questions or issues that were raised.

Meanwhile, the fracking regulation meetings in Tulita, Norman Wells, and Fort Good Hope demonstrated that open meetings are important for communities to state publicly the ethics and standards of consultation they expect to receive in a space that receives public coverage. Like the Berger Inquiry, such spaces allow voices from different communities to be heard, and for commonalities and networks between and within settlements to be established. Therefore, I argue that if the GNWT wishes to pursue the ethics of reconciliation in an authentic manner (including for example, honouring UNDRIP commitments of free, prior and informed consent), then it must keep community spaces of debate open and allow people to feel, express and direct their emotions between themselves and at government.

7.4 Conclusion

In this chapter I have focussed on the normative assumptions that facilitators deploy in their efforts to increase public support for resource development at a public engagement event in the NWT. I have shown the importance of how geoscience information is used for public engagement and outlined how it is leveraged by government facilitators seeking to smooth a pathway for resource development. Structured to accommodate an 'ignorant' audience imagined through public deficit models, the REDI tradeshow uses science to try and create 'rational' responses to resource extraction amongst participants. Critical in enabling this are the materials and objects that facilitators use to support their narratives and create points of conversation between themselves and attendees of the REDI tradeshows. Materials are also chosen to try and generate new or interrupt old emotional relations to matters of concern.

I have shown that REDI works within webs of institutional history and mistrust, and that facilitators at REDI have done poorly to recognise and respond to this in their engagement practices, exhibiting limited institutional reflexivity. I have suggested that government facilitators' shutting down of public debate in order to control narratives may work to undermine attempts at reconciliation between Indigenous people and settler-colonial governments. This approach is undemocratic and removes spaces that are integral to allowing different experiences and memories to be heard and honoured and raises questions about what the ethics of consultation and engagement are. Dismantling spaces in which shared goals, energies and intentions can be articulated within communities and with government may reduce the capacity for communities to establish and speak with a common voice and thus increase the challenge of finding consensus when development projects do arrive in communities for consultation. Given the depth of often negative historical relations between the resource development industry and Indigenous peoples in northern Canada, it is questionable as to whether REDI's superficial approach of public 'education' will help build receptivity towards the resource development industry in the long-term. Rather, after Daigle (2019, p. 710), I suggest that REDI serves to function as "part of a larger architecture of performative acts" which seek to level relations between settler-government and Indigenous community, yet continue to leverage affective politics to reinforce hegemonic forms of land-based dispossession. This chapter supplements the critique levelled by Todd (2016) and Davis and Todd (2017) that STS fails to acknowledge the historical experiences and contemporary expressions of dispossession amongst Indigenous groups via Western methods of engagement and scientific communication. The chapter showcases the imperative to take account of the relational histories and positionalities of different parties to the subject matter and to each other. The Euro-Centric starting point and resource-development intentions behind what was communicated at REDI highlights that greater attention needs to be paid by scholars to the experiences of those marginalised groups who are recipients of this kind of engagement programme. It demonstrates that, just because engagement is carried out, does not mean that democratic, reconciliatory or decolonial outcomes may be had.

Within this chapter I have also added to existing STS literatures, in particular Sarah Davies' work (Davies, 2014, 2019; Davies *et al.*, 2019) by discussing how facilitators seek to elicit emotional responses imbued with political intentionality in public engagement spaces. This, I argue, increases the critical leverage of this branch of STS, and opens its application to decolonial studies wherein efforts at reconciliation in public engagement spaces can be considered through a critical lens of colonial affect. I suggest that this approach to evaluating the mechanisms and success of public engagement should also be applied to circumstances where public consultation is in progress, particularly in the Canadian context under Section 35 commitments where application to e.g. natural resource extraction carry deeper, existential meaning to some Indigenous people and communities.

I have also developed Jason Chilvers' work by discussing who facilitators are, the materials they rely upon to conduct their work, and what their intentionality within public engagement spaces is. What I note is that although facilitators represent the mandate of their organisation, they also carry their own experiences, politics and emotional relations with resource development which serves to frame matters of concern and utilise scientific materials in ways that delivers a particular (potentially biased) narrative of resource development. Therefore, this chapter highlights that facilitators are not neutral mediators of information, but rather explores an example of how facilitators' politics plays out in their communication of science and government policy and the possible implications thereof. Noting and understanding the positionality of facilitators is crucial in spaces where much is at stake politically and where public-scientific or public-institutional relations are fragile. Academics and practitioners alike should therefore consider this space as a key interface across which science and technology can adopt new meanings or applications and raises ethical situations for different social groups.

8. Conclusion

8.1 Change at the geological frontier

As I conclude this thesis, we have journeyed through the NWT as it continues the turbulent course of change underway over the last 150 years. The NWT is at a societal, environmental and economic crossroads. Mineral development ambitions intersect with new politics of Indigenous recognition and reconciliation, plus environmental motivations for conservation and climate change adaptation. The NWT political agenda aims to draw liminal areas, both surficial and subterranean, into the core of economic productivity - thereby enabling attempts to exploit the opportunities newly afforded by infrastructure development. Fuelled by the imagination of a 'northern industrial powerhouse' and Arctic security ambitions, the coordinated expansion and symbiosis between geological knowledge and infrastructure access mean that once-remote Arctic areas are being drawn closer to humans' zone of influence. These ambitions represent a political perpetuation of the status quo in terms of financial and economic planning and reliance upon the mineral development industry in the face of substantive changes in the NWT, placing the industry's sustainability and viability at risk.

This conclusion is structured to carry forward the key findings of this thesis to understand their implications on life and economy more broadly in the NWT, and to consider further academic contributions that can be made through additional research in the region or in geographic disciplines. The first half of the conclusion discusses how understanding caveats and restrictions of geoscience knowledge production opens opportunities to evaluate the possibility of alternative economies and futures. I discuss how affect and emotions have been used to rationalise geological futures in the NWT and their distinct relation to settler-colonialism. In the second half, I examine how changes in Indigenous land rights and governance stand to intersect with the SGPC discussed in Chapter 6. In this section, I also discuss what the implications are of different institutional and organisational sites of knowledge production about the region, and how this impacts how different economic and environmental values are evaluated against one another in the SGP and NWT more widely.

8.2 Putting the inevitability of geofutures at risk

Through ethnographic methodologies, this thesis has shed light on how contemporary cartographic practices in geology contribute to Canadian Arctic ambitions, specifically the development and sustenance of a mining economy. Geological mapping seeks to know, bound and enrol geology into capitalist economies, thus remaining a foundational component of how, where and why frontier expansion occurs. Geological mapping defines whose (traditional) territories come into contact with industry desires for mineral discovery and extraction, and in turn sets up (unequal) socio-economic dynamics between citizens and land as mediated by government institutions. As I traced the evolution and migration of geological knowledge from geologists into communities, the significance of *who* is producing geological knowledge about *where* came to the fore. Geological knowledge expansion is not a tidy and ordered progression from one area into the next, nor is it objectively generated in terms of its interpretation or choice of location. This means that there is a great unevenness in the quality, type and places where geoscience mapping occurs and the resultant opportunities it affords for mineral development. As a result, this thesis has helped give texture to a frontier land commonly thought of as part of 'the North' and has shown that it is not a homogenous zone of (geological) knowledge but an assemblage of geological spaces that are politically defined and made as a result of historical and contemporary settler-colonial relationships.

Notably, this thesis has enabled geoscience objects (i.e. regional geology maps and mineral potential maps) to be unravelled and the implications of their diverse constitution understood and critiqued. It has thus been possible to identify the conditionalities of geological storytelling and recognise that the interpretation of geological landscape is less objective than subjective. In addition, the production of geoscience in a frontier area results in a patchwork quilt of map work characterised by diverse qualities and coverages of geodata. Therefore, despite what geological maps might seem to tell us - that we have finished storying the subterranean because it has all been 'coloured in' and assigned a geological unit - uncertainties around our knowledge of what geology lies where remain in parts of the NWT. Acknowledging these contingencies and caveats within map work is critical when evaluating the claims made by the GNWT that the mineral extraction industry should and can be relied upon as the major driver of the NWT's future economy, and that future mines can contribute the same value in GDP, royalties and taxes as the existing diamond mines do.

The analysis of geological mapping practices in this thesis has allowed me to pinpoint what doesn't quite 'make sense' in the stories that are told by policy makers and politicians about their ambitions for resource futures in the NWT. By untangling the normative statements accompanying resource development proposals that are propped up using scientific objects (such as maps) and circulated at public engagement events, my work has argued that mineral resource futures are perhaps not as clear-cut as those in government would like their citizens to imagine and invest in with their money and votes. Effectively, what this thesis therefore does is help create space for other narratives around e.g. land use, economic futures and infrastructure requirements to emerge, become rational and develop in contrast or in parallel to established resource economy imaginaries.

Creating such opportunities is of vital importance as the NWT moves into a new geopolitical and environmental era, defined by politics of Indigenous self-governance, recognition and reconciliation alongside Arctic climate change. The NWT remains vulnerable to the boom and bust cycles of the global commodity market, yet remains precariously non-resilient to them due to its overwhelming dependence on a single commodity (diamonds) for over 20% of its GDP (Couturier, 2017). Added to this, the NWT is experiencing a time where the profits of the existing economy have been shown to be inequitable in their reach of who benefits. For example, the status quo of resource dependency in the NWT has created a 'tale of two territories', generating significant income wealth for some whilst leaving others behind (Alternatives North, 2020). Similarly, despite the high-value jobs mining offers, the average wage of Northerners remains insufficient to adequately meet the high living costs of northern communities, creating a crisis of housing and affordable, healthy food provisioning (ibid.). Additionally, a quarter of children in the NWT live in poverty despite the mining industry being a high earner for some families and generating the largest tax revenues by sector for the GNWT (ibid.). From a human development perspective, it is therefore imperative that the opportunity opened-up by calling mining promises into question can be translated into socially just change whereby economic development and alternative industries do not remain concentrated around major centres such as Yellowknife and Inuvik. The arguable need for a new, resource independent northern identity, economy and future should be examined and better publicly discussed.

Such discussions have begun with various NGOs, citizen action groups and local businesspeople seeking alternative ways of making a living in the north. For example, tourism, agriculture, forestry and higher education have received a significant amount of attention and have been posited as potential diversifiers of local and regional economies.

Tourism now contributes about $2bn annually to the NWT economy, representing a doubling in value since 2012 and demonstrated that with concerted effort, new industries can be made in the North (GNWT-ITI, 2021). The recognition of the precarity of a resource dependent economy exists both within government and amongst civilians, yet a shift to something different or supplementary to mining has been pedestrian at best. Many challenges sit in the path of economic diversification, primarily climate, remoteness, technology and energy infrastructures, and education. Agriculture has so far been small-scale, however community greenhouses in Inuvik and Yellowknife have shown that growing food commercially for local communities is possible, albeit seasonal (Co-op Yellowknife, 2021; Inuvik Community Greenhouse, 2021). The NWT's plans for a university have been approved by the GNWT with a new polytechnic planned to launch in May 2025. However, the scope of classes and educational interests has been criticised by some including the Mayor of Yellowknife, Rebecca Alty, for being unambitious and not encouraging non-domestic students to bring 'new money' to the NWT (Williams, 2020). Hopes had been placed on extra-territorial money being introduced to the NWT to boost the local economy through additional spending on recreation and living costs by students and academic staff.

Some, such as a senior geologist I spoke to from the NTGS, suggested that industries that harness the unique climate and weather should be pursued such as seed banks, data storage facilities or ultra-cold car safety testing (*Interviewee 10, 30.10.18*). The difficulties the NWT has with bringing these ideas to life hinge on its isolation: internet connectivity and reliability is patchy at best and is monopolised by Northwestel making it the most expensive in Canada (Canadian Radio-television and Telecommunications Commission, 2019)[34]; and the energy

[34]Commitments by Northwestel made in December 2020 promise high bandwidth unlimited internet connectivity by satellite to remote communities currently suffering from poor or unaffordable internet (McBride, 2020), increasing the opportunity of non-Yellowknife centred business emerging.

profile across the NWT demonstrates a reliance on diesel which is both highly costly and dirty in terms of carbon emissions. This is particularly an issue for communities not connected to one of the two hydro-based grids in the region (i.e. the majority of the NWT's communities) (Canada Energy Regulator, 2021). However, even where communities are connected to hydroelectricity, diesel generators stand in backup for some of the frequent power outages that occur. With the challenges of providing low-carbon and low-cost energy, communities other than Yellowknife, Hay River or Inuvik where one may want to site a seed bank or data bank (in order to spread industry more evenly through the territory) would struggle to provide reliable, sustainable energy to enable such industry to grow and be sustained.

Thus, although there *are* options for diversifying the NWT economy, many of these are stymied not only by environmental and climatic constraints but also by infrastructural issues around energy supply and internet connectivity. The NWT is also constricted by complex bureaucratic regimes that strangle grassroots attempts by independent business owners to get projects off the ground (*Interviewee 30, local business owner and member of the Yellowknife Chamber of Commerce, 10.04.19*). Interviewee 30 posited that, because the NWT is essentially a rentier state dependent on finances from external sources (i.e. Federal transfers and mining royalties), "when most of the money comes from a source that isn't the people you serve, you're not incentivised to be efficient and do the things they want". Despite the GNWT's intense and unsustainable focus on the resource development industry as the main economic driver in the Territory's future, there is significant motivation and many examples of grass-roots projects amongst citizens and non-governmental organisations such as businesses and charities to realise alternative ways of living and economic production in the NWT that moves away from a reliance upon mining. There are fascinating and worthwhile avenues for scholars to research and contribute towards finding new pathways into the future for the NWT. In part, scholars like me have been contributing towards sustaining the resource-dependent economy of the NWT since we have been working within the status quo of the geographies the mining industry provides rather than pushing beyond them and asking what else is possible. Therefore, in the future, scholars should find responsibility in contributing to sustainable change in the NWT through more innovative research projects that look into alternative economies and ways of living (e.g. as done with the Dechinta Bush University (Ballantyne, 2014)). Alternative economies would help improve the resilience of the NWT to boom and bust cycles, as well as contribute to diversifying the skills that the current economy relies upon and the places where economic production happens in the NWT. In turn, this would broaden the scope of people who have the opportunity to contribute to and benefit from diversification.

Much of the reliance upon mining comes from the belief that future mines can deliver the same economic value that existing mines do. Geoscience objects such as the mineral potential map analysed in Chapter 6 provide a source of speculation about the capacity of the SGP to produce mineral reserves upon which the NWT could continue to base its economy as promised by the GNWT. In that chapter, I contrasted the work done by economic geologists producing the SGP mineral potential map for the GNWT and the work that is done by economic and exploration geologists in corporate settings that are regulated under the national NI 43-101 laws. These laws are intended to ensure that realistic depictions and descriptions of mineral properties' capacities to become productive mines are provided. Essentially, they seek to bound and force mining companies to give substance to claims to mineral futures.

As shown in Chapter 6, the complexity of geological volumes lends itself to speculation as to what exists below-ground and thus to an extent geology requires extrapolation and inference. However, Canadian NI 43-101 regulations seek to deal with and mitigate misleading or inaccurate speculation amongst resource developers in order to protect investors and maintain good and even geological practice and trust throughout the industry. Here I have added to the work of resource geographers such as Kama and Kuchler (2019) by highlighting that it is possible for frameworks of knowledge control to exist that seek to place knowledge resources on an equally comparable plane. I showed how in Canada speculative *language* around mineral potential is regulated and tightly related to the weight of geological evidence that can be provided about a property. Expectations are therefore placed on the methods used to evaluate different geological types, helping to ensure that consistent and reliable quality information across geologies is attained for resource accounting, allowing investors to make better-informed comparisons between different companies' mineral properties. Added to this, international frameworks created by the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) set mineral reporting standards (covering 13 countries plus the European Union) that enable inter-jurisdictional reporting consistency and allow for better evaluation of international reserves (CRIRSCO, 2021).

Geopolitically, this production of consistent, more trustworthy data has enabled the UN-Economic Commission for Europe to begin looking at international supply chains for the supply, processing and recycling of raw materials that are required by the global economy. Through this, it seeks to prepare infrastructure, funding and knowledge sharing capacities to accommodate new commodity sources being developed and others running out. This is to say that the mineral potential map produced for the SGP was not done within the international standards of mineral reporting that are typically used to make major public spending decisions as is being done with the SGP Corridor. Indeed, this is mainly because it was not the *minerals* being reported on (although the information was presented in such a way for readers of the map to infer this) but the types of *geological knowledge* that had been collected about places.

As such, I would argue that a closer examination and untangling of the differences between speculation, extrapolation and inference is necessary, particularly in regions where it is known geodata is scarce. Speculation implies a (political) intent to imagine a reality without firm evidence, whilst extrapolation and inference imply reaching a conclusion from existing evidence elsewhere. For example, a combination of extrapolation and speculation are used in the mineral potential map of the SGP, where extrapolation of the mineral hosting patterns in different geologies are applied to similar known geologies in the SGP. However, these are overlain by speculative metrics of mineral potential that are not grounded directly in geological evidence. Were the SGP mineral potential map a purely extrapolative exercise, the biases of land tenure explicated in Chapter 6 would be avoided since these are not grounded in geological materiality but in socio-institutional behaviours. I would like to make clear that in other situations where mineral resource assessments have been conducted in the NWT, speculation of the kind used in the SGP has not played a role and rather extrapolation and inference from existing or collected geodata has been relied upon for mineral potential evaluations according to peer-reviewed, international best practices (c.f. Wright *et al.*, 2013, evaluating the mineral resource potential of the Thaidene Nene national park).

My intention therefore is not to dismiss all mineral resource assessments as speculative or lacking in evidence, but rather to place a direct critique on the stand-in metrics used by economic geologists upon the request of government agencies when geodata is unavailable and highlight that methods for controlling and managing speculative tendencies exist. Applying these best practice methods to the SGP analysis would improve the validity and trustworthiness of any claims made by the GNWT based on the evaluation of mineral potential there. Lastly, I would add that in many instances, extrapolation is necessary in order to make vital decisions about public lands. It would be unreasonable to expect that no decisions should be made around land use simply because limited geological evidence exists for them. At the same time, questions about value also come into play – an absence of geoscience knowledge is not equal to absence of all knowledge about a place, be it ecological, traditional or other knowledge, which in itself conveys a certain value of the land and its societal meaning and importance.

An issue associated with speculation, extrapolation and inference is how geoscience objects like mineral potential maps work for the audience they are targeted at. The mineral potential map is showcased in many GNWT-ITI publicity communications, yet its intended purpose of helping to define a road route is omitted and it becomes a stand-alone product that appears to showcase the minerals that can be found in the SGP. Several geologists spoke about their hesitancy in producing the mineral potential map because of the subsequent challenges that would accompany communicating the conditionalities associated with it. Singer and Menzie (2010), working at the interface between economic geology and land use decision making, make clear the significance of audience in producing resource accounts, and I argue this end-user perspective has also been missing in resource geography literatures. The life of speculative objects within decision-making institutions warrants discussion and greater understanding so that geologists can better craft and communicate the drawbacks or limitations of their work so that decision makers are better informed of their works' conditionalities. How can geoscience objects become immutable mobiles (Latour, 1986), where the conditionalities of their production are stabilised and retain meaning between social spaces? Currently, there are fears amongst geologists at the GNWT that mineral potential maps might take on "a life of their own" (*Interviewee 41, government geologist, 31.05.19*). The nature of conditionality around geological knowledge prompts questions about how to make cartographic representations of resource accounts *true* to the geologies they depict. How can scientific objects remain connected to place so that an "economy of expectations" is not generated based on faulty or misleading interpretations of available geodata (Weszkalnys, 2011, p. 349)? This is a question that geologists themselves are grappling with and would perhaps hinge on applying industry-style best practice to government/political settings.

Lastly, flowing from the above critique that resource futures are perhaps not as inevitable as governments would like us to believe, is the emotional and affective register within which this optimism or scepticism takes place and unfolds. I showed in Chapter 7 how the public engagement event REDI was used to influence how people feel and respond to the mineral extraction industry. In my example, a combination of carefully selected geoscientific materials and a public engagement format worked together to 1) reduce the space for critique of government-endorsed information, resulting in a flattened and neutralised political space in which information was being communicated; and 2) represented an attempt at control by settler-colonial institutions of publics' and communities' emotional relations, responses and experiences of the mining industry in the Territory.

The perspective I have delivered about the significance of affect in engagement spaces that targets Indigenous publics builds on STS work, particularly that of Sarah Davies and colleagues (Davies, 2014, 2019; Davies *et al.*, 2019). While Davies and her colleagues examine the productive promise of affect in public engagement spaces for the co-production of knowledge and the generation of emotions like curiosity, wonder and love through science communication, my work has taken a more cynical view of how affect might be used in public engagement. The engagement contexts within which Davies writes do not contain stark power imbalances and the politics of affective construction go largely unchallenged. The REDI public engagement format however demonstrates what can unfold when affective methods of science communication are taken into communities where histories of negative relations with affective control and subjugation by governing institutions exist. In particular, questions emerge from my insights at REDI as to what type of knowledge is worth sharing or learning in these forums? For example, there have been instances where Indigenous people have been paid to collect rock samples whilst out hunting or trapping, yet this was not advertised at REDI. There was little room at the engagement initiative to speak about the roles that traditional knowledge or land-based practices could have within the mineral development complex.

An attention to the affective in such potentially politically charged situations enables new discussions about how meaningful the politics of reconciliation in Canada is, and in particular draws into view the sites where subtle attempts at colonial control retain a foothold. Viewed from start to finish, this thesis allows colonial affect to emerge as a two-sided coin. Professor Ann Cvetkovich, in conversation with Driftpile Cree author Dr Billy-Ray Belcourt (*public webinar, 11.02.2021*) explicated this dynamic: Cvetkovich considered how settler-colonisers feel emotions and generate atmospheres as they engage in and enact colonial performances in Canada, whilst Belcourt discussed how colonial structures create affective impositions on Indigenous lives. This thesis is bookended by considerations of affect in the making, expansion and control of territory. Cvetkovich and Belcourt's insights led me to reflect on how colonial affect is not just the (generated) response of Indigenous bodies to regimes of settler-governance but is also a key ingredient and tool that enables certain kinds of material relations between settlers and their non-traditional territories to emerge and be rationalised.

Relatedly, another contribution to the academic literature that flows from this thesis is the improved understanding of how bodily practices and relations between geological materials and geoscientists enables the making of resources and facilitates their circulation in global resource economies. In Chapter 5, I demonstrated the reliance of geoscientists upon affective relations between themselves and geological materials to produce cartographic renderings of geological expressions. The significance of action and movement in the field for geological mapping and data collection was demonstrated by the importance placed on walking as a method for enabling bodily relations with geological materials to be produced, enabling geoscientists to harness their bodies as a scientific instrument. By paying attention to the feelings and relations between geologist and geological space in northern Canada that enable mapping, I have emphasised the significance of affect as a territorialising mechanism. Affect, for geologists, is a vital tool that enables their work to take place. It facilitates their understanding of geological history and mediates their movement through spaces they read as 'significant' to the storying of an area and of importance to the mineral complex.

As Simpson (2018) argues, emotions of desire propelled the colonial machine through Canada to extract natural resources. I have not examined how affect motivates expansionist ambitions, as Simpson has, but rather how affect and emotions function as tools of territorial opening and expansion on a more quotidian level. Affect lies within the settler-colonial toolkit as a day-to-day enabler of imagination, policies and practices for land use management and territorial expansion. It is therefore pertinent that the everyday violence of such practices is held in view when discussing resource development in Canada and the NWT to help understand the subtleties and resistances of colonial rule to contemporary politics of reconciliation and Indigenous self-determination. It is thus also important that the role of colonial affects in the delineation and promotion of resource development futures is considered when assessing the opportunities for alternative economies. Frequently, in informal conversations at e.g. the Yellowknife Geoscience Forum or at the Terra-X investors luncheon in Yellowknife, rationality was used as an emotive guide to engender support for mineral development projects in opposition to alternative economies that were seen as 'airy fairy' or 'unrealistic'. However, the antiquated rationality of the status quo is no longer good enough in a society and environment that is starkly different to that of 20 or 30 years ago, where the uncertainties of climate change place at existential risk the relations and dependencies humans have on the natural environment in the Arctic. Where the everydayness of affect is identified (whether in the production or application of science), the more opportunities exist for the disruption of motivations and mechanisms of the modes of capitalist territorial dispossession emerge. I propose therefore that political geography needs to make greater use of cultural geography perspectives as well as works leaning on queer Indigenous studies (such as Rifkin, 2012; Belcourt, 2019a, 2019b, 2020) that deploy quotidian affects to understand how regimes of exploitation and control continue to enable territorial expansion and resistance to emerge and be sustained, particularly in resource development contexts.

8.3 Land, geoscientific absence and industry-led territorialisation

Meanwhile, as the juggernaut of resource development pushes on with limited space and provisioning being made for alternative futures by the GNWT (aside from tourism), political relations to land are being redefined as a result of the continuing negotiations of land claims between Indigenous governments (such as the Akaitcho First Nations) Ottawa and the GNWT. Through this, relations and balances of power in the mineral development sector stand to change too. The Akaitcho First Nations, who are negotiating the extent and governance of their traditional territories in the SGP, are in a position where they have the opportunity to determine the future of their land, who has access to it and on what terms. This thesis has shown that it really matters *who* is in the driving seat of the settler-colonial industrial complex's expansion. It matters because it affects the trust communities have in mineral development proposals and because it impacts who stands to benefit from extractive regimes and to what degree. The NWT's political-economic future is at stake while land negotiations in the SGP are ongoing because this geological area is being relied upon by the GNWT to be the current and future engine of the NWT's economy. How land claim negotiations play out in the coming decade in the SGP will be pivotal for how the NWT develops and who stands to benefit from it.

Seen from this perspective, the mining industry in the Slave is beholden to Indigenous governments' decision making and negotiating power with Ottawa and the GNWT. One of the exciting things that will emerge in the NWT in the coming decade is what the Akaitcho land claim agreement will result in for industry, and the benefits that the Akaitcho First Nations are able to negotiate and put in place for their communities. These changes waiting in the pipeline are not to be underestimated, particularly in a geological area brimming with opportunity. For example, Bennett (2018) showed how for the Inuvialuit Settlement Region in the north of the NWT, an Inuit-driven campaign for the Inuvik-Tuktoyaktuk all-season road has created an infrastructure route on Canada's Arctic coast of national and international geopolitical importance. It is highly likely that with Akaitcho First Nations input and buy-in, the Slave Geological Province Corridor (SGPC) has the potential to do the same.

Despite this opportunity for the redressing of historical power inequities related to the access and control of land, this thesis has shown that in a jurisdiction where the extractive economy is king, the spatially politicised production of geoscience knowledge still strongly affects power in the resource economy. Although the Akaitcho First Nations stand in a tactical position to guide the future of the SGP, historical and contemporary relations to land and the withdrawal of lands under negotiation from exploration and geoscience production places them at a disadvantage. In Chapter 6 I signalled the significance of geoscience absence in resource accounting. There, I explained how evaluations of mineral potential in the SGP were more like knowledge evaluations rather than data evaluations. Where limited data existed and where lands had been withdrawn from exploration, the relative mineral potential evaluation of land was low since these lands are considered high-risk for investors due to our lack of information about them.

As a result, I present a perhaps controversial proposal that all land should have equal access to resource evaluation because *where* knowledge is produced impacts *who* benefits from it. Particularly in political landscapes like the NWT where increasingly greater control and self-determination about land use futures sits at the tables of Indigenous governments, they should have equal opportunity to consider the full value of that land (i.e. including extractive resources), should they desire to use it as a means to fulfil economic self-determination goals. At least, the GNWT should offer financial support to Indigenous governments after their land claims are completed to have a comprehensive evaluation of mineral potential done for their land. The work needed to 'make up' for lost geoscience inputs is great, meaning that perhaps we should consider Akaitcho lands not as an immediate source of new minerals but rather as a gateway to the SGP. This therefore opens discussion for how geological mapping patterns affect the opportunities for control and benefit from the resource industry and the types of engagement and involvement it can bring forth. Being a gatekeeper to physically accessing the SGP brings different socio-economic opportunities than does being a rights-holder to highly prospective mineral tracts. It was beyond the scope of this thesis to explore this dynamic, however the practical implications of the geographical relation of Indigenous property to mineral prospects should be considered in future research and policy decisions for the NWT.

Related to discussions of *what areas* have knowledge coverage is the question of *who* holds that knowledge and the resultant tools for control and influence over land use decision making. This matters in contexts like the NWT where Crown lands have a free-entry mining system where geological knowledge becomes distributed amongst private companies. Private mining companies, backed by international investors, have an arsenal of geoscience knowledge production tools to imagine and make possible resource futures in Canada and the NWT. As argued in Chapter 5, Indigenous people make limited contributions to geoscience knowledge in the NWT and are also underrepresented in the geosciences industry in Canada as a whole. The implication of this is that a divide is created in who has knowledge assets to decide what happens to land and who benefits financially from holding and producing information about land with potential for minerals. However, the capacity of Indigenous communities to produce scientifically circulatable knowledge about their traditional territories is small, albeit growing, with for example the Tlicho Government's Tlicho Research and Training Institute prioritising producing original research around cultural heritage, language and lands. Yet the Tlicho Government does not dedicate capacity to geoscience knowledge production per se. This has two impacts – 1) the type of data produced about land by the Tlicho government is skewed away from geoscience production;

and 2) the balance of geoscience knowledge production away from Indigenous people results in the means of production of the dominant economic and political force in the NWT is not held amongst those whose traditional territory the NWT is.

As Howitt (2012) describes for remote Aboriginal communities in Australia, the dislocation between primary knowledge production about lands and those who live and depend on it contributes to driving a wedge of inequality between settler and Indigenous groups. Without control over or a stake in knowledge production and the subsequent opportunities this offers for developing their traditional lands, Indigenous communities primarily remain the dependents of mining corporations via Impact Benefit Agreements and employment, rather than becoming generators of their own wealth. I make this conclusion about geoscience knowledge production with Coulthard and Simpson's (2016, p. 252) statement in mind which argues that settler encouragements of Indigenous engagement with capitalist modes of production is "a call on Indigenous peoples to forcefully align their interests and identities in ways that contribute to our own dispossession and erasure".

This therefore raises questions which have not been answered in this thesis about how the balance between traditional knowledge and western scientific (specifically geological) knowledge are able to work when placed beside one another in settings like environmental impact assessments. It also raises questions about the compatibility of comparison between different knowledges for different aspects of the land – for example using Western science to evaluate the "value" or "losses" of ecological protection versus geological development or balancing traditional hunting versus resource extraction opportunities. When conducting interviews with ungulate biologists at the GNWT as well as non-government caribou researchers, I was told that the level of certainty with which they had to present information about caribou migration patterns and population decline were much more stringent than the data that geologists had to produce about the value of an area. Meanwhile, in conversations with geologists who worked on mineral resource assessments of the Nahanni National Park to establish park boundaries, they felt that the certainty demanded of geologists was greater than that of ecologists. Whether or not either of these perceptions are true, and what effect either has on environmental impact assessments (EIAs) should be researched further. However, the primacy of geosciences knowledge/imperative towards resource development in EIAs has been shown since not a single proposed resource development project has been rejected outright by the Mackenzie Valley Review Board (MVRB) in the NWT[35]. Contra this, extensive protected areas have been established in regions of high potential for minerals like uranium in the Thelon Basin/Thaidene Nene National Park area. It suggests therefore that there is a possible difference in evaluation outcomes depending on who is doing the evaluating (Parks Canada, Federal - versus the MVRB, Territorial), for what reasons and with what potential political outcomes (e.g. whether a project has local Indigenous support/whether it fulfils Federal conservation ambitions). Thus, since all sciences about the natural environment contain inherent uncertainties, the way uncertainty is dealt with and evaluated in EIAs and the implicit or explicit value systems at work in these regulatory processes needs exploring. This is important for power dynamics because different members of the community hold different types of knowledge which are, arguably, not equally valorised within a system of evaluation.

Related to this, the GNWT's encouragement of mineral exploration and associated geoscience production promotes industry as a primary producer and holder of knowledge about Arctic territory. The dominance of industry as a knowledge-producer in the Arctic

[35] Although some have been withdrawn by the companies in face of extreme community opposition.

echoes historical relations between private companies, Arctic environments, trade and territory. The involvement of corporations in territorialisation was demonstrated by the North West Company's and Hudson Bay Company's historical trading in eastern, central and northern Canada from the late 1600s to mid-1800s and associated mapping programmes (Simpson, 2019). The Company laid the infrastructural foundations on which the Government of Canada was able to assert colonial control over this territory once it was handed control by the British government in 1867. The Hudson Bay Company had both funding and capacity to establish trade networks between settler and Indigenous communities and began supporting infrastructure development through their mapping efforts, mirroring what the GNWT would like to achieve in the SGP today.

The GNWT and Federal Government will be dependent upon industry investment and support to enable their territorial assertions over Arctic lands and waters to be realised. The role of the private sector is crucial in the SGP because royalties from mining activities will provide taxes to pay back the road, ensure that the road is peopled with workers from mines and stimulate police presence. Infrastructure from the road would support platforms for people and industry-associated infrastructure which, in coastal areas such as Gray's Bay which the SGP Corridor would connect to, will also support the presence of coastguards for greater policing of Arctic waters as fishing, tourism and industry marine transport expand (*Interviewee 60, Arctic security professor, 23.07.19*).

A reliance upon corporations and industry for enabling territorial expansion limits the accountability of those leading the territorialisation process to an area's inhabitants: it is not possible to "vote out" a company in the same way it is a government. Meanwhile, the reliance on private companies to enable expansion into new territories means that territorialisation becomes an organisationally distributed practice between companies and government. What resource development processes in the NWT have shown is the huge governance capacity that engagement, consultation and monitoring takes up amongst Indigenous communities who must respond to and work with companies applying to use their traditional territories. The absorption of capacity into engagement and oversight means that there are fewer financial and human resources available to address other pertinent issues in communities such as healthcare, education and housing (Sacco, 2020).

What the scope of my PhD has not enabled me to discuss, but remains crucial, is an evaluation of the significance and implications of privately produced and held geological knowledge on sovereignty, state-making and territorialisation today. A gap exists in critical cartographies as to what role industry plays in rendering space knowable, boundable and extractable, since most emphasis has until now been placed on counter-mapping and critique of government-led colonial mapping projects. If the SGPC goes ahead, academics must prepare to critique the implications of an inevitable tsunami of mineral claims sparked by its opening-up. There will be impacts on for example, caribou conservation, traditional land uses, Indigenous land claims and rights, Arctic habitat disruption, labour profiles at exploration camps/mines, the GNWT's royalty regimes etc. There is a worrying lack of consideration or discussion both in public and academic circles of the implications of the SGPC on the socio-environmental and economic politics and futures of the NWT. As far as I am aware, I am the only researcher who has conducted any social science research into this proposed project, yet there needs to be others measuring and critiquing the environmental and social justice of this proposed project.

However, it is possible to learn lessons and heed warnings from similar proposals for resource development corridors in e.g. East Africa. There, scholars and think-tanks have been evaluating the promise of development corridors planned by governments and development banks for their capacity to deliver on, e.g. the Sustainable Development Goals (SDGs) and provide equal industrial growth between regions and countries (Weng *et al.*, 2013; Baxter *et al.*, 2017; Gannon *et al.*, 2020). In particular, researchers argue that biodiversity, environmental and land access trade-offs will be made within the East African context in response to corridor development (Gannon *et al.*, 2020). A study by Gannon *et al.,* (2020) uses a methodology which enables objectives or value statements (in their case certain SDGs) to be evaluated against evidence from corridor development proposals as to the likely achievement or failure of those objectives. Such a method could be used for the NWT also, given that the 19th Government of the NWT (2019-2023) has set a clear mandate for what it wants to achieve in its term ranging from settling land claims, improving resilience to climate change, increasing employment in small communities, lessening poverty divides in the Territories and increasing resource exploration and development (Government of the Northwest Territories, 2021). Such methods would enable a more incisive critique about the capacity for the SGPC to 'work' for northerners along set lines of priority and provide suggestions for improvement.

Lastly, in an informal discussion with a base metals producer with interests in the SGP, I was told that what is of interest to industry is not just what could be *found* in the Province as a result of opening-up through infrastructure, but also what financial resources could be *saved*. His perspective was that the main prohibitive factor for mining the SGP was cost, and therefore an expansion of geological knowledge about potential is not enough to encourage mining interests there. Rather, he asked what money his company would save by having year-round access to trucking supplies and mined materials in and out, and savings on accommodation for workers at mines that were no longer only fly-in fly-out. The possible cost saving benefits of the SGP all-season road were not evaluated by the GNWT, which seems a curious omission given that the mineral potential map is an otherwise completely social evaluation of potential, and that local mining lobby groups have produced reports stating that distance from urban centres and markets remains the biggest hurdle to remote mine development (Association of Consulting Engineering Companies - Canada *et al.*, 2015). Such an analysis should be taken up by an economic geographer or geologist as it would be critical for evaluating the likelihood of the Corridor actually resulting in the development of new mines, thus contributing to any cost benefit analysis that would take place during an EIA.

8.4 Concluding remarks

To finish this thesis, I circle back to the idea of change in the NWT, and the fact that Territorial resilience to change and socially-just influence of it demands multiple epistemological inputs and a diversification of who holds knowledge about the primary economic driver. First, the rationality of future lifeways in the North needs to be given clearer and more focussed attention in order to enable a diversified economy to emerge. Likely, the NWT will retain dependence upon resource extraction but wider recognition that the industry is not a panacea to the Territory's social issues and economic provisioning is needed. Relatedly, policy makers, business leaders and politicians need to work to ensure that a broader spectrum of people can contribute to and benefit from industry and economy in the North. Diversification is one way to achieve this. I propose that for future research in the NWT, the significance of affective experiences and patterns should be better understood to enable and make possible different futures emerging in the region. Such an approach provides the opportunity to better include or ground futures in Indigenous perspectives and those whose ideas have otherwise been marginalised in the resource economy.

I want to prompt further consideration about who is making and controlling Arctic territory through science and infrastructure. In particular, I would suggest placing a lens on the contemporary dependence on industry to sustain territorial ambitions and juxtapose this with what contributions traditional land holders are able to make to Canadian ambitions for retaining and exerting control over a changing Arctic geopolitical landscape. Interrelatedly, serious thought needs to be given to what and how the SGPC can deliver on the NWT's priorities today and in the future, particularly when faced uncertainties born from climate change. Associated with this will be the need to think about who has what knowledge about the NWT, how those knowledges are differentially integrated and evaluated in planning systems, and lastly how those knowledges remain relevant to an NWT in change.

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