Environmental Research of the
Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Project number: 3715 32 3100

Report number: FB000275/ANH,5,2,ENG

OekoRess II: Country Case Study I

Canada: Copper and Gold Mining (Mount Polley)

by

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On behalf of the German Environment Agency

Completion date February 2017

Abstract

The project "Further development of policy options for an ecological raw materials policy" (OekoRess II) builds on the results of two preceding research projects, UmSoRess and OekoRess I. It links experiences gained in the analysis of environmental and social standards with the assessment of environmental risks in the mineral resources sector. The project team conducts 10 case studies to evaluate and refine the method to assess site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. The focus is on improving the indicator for environmental sector governance, by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the questions whether existing governance indices and indicators are able to adequately reflect the capacity of governments, companies and civil society to manage potential environmental hazards and avoid or reduce environmental impacts of mining.

This case study analyses the environmental hazard potentials and the environmental impacts of the Mount Polley copper and gold mine in Canada. In 2014, the tailings storage facility at the mine site breached, leading to large-scale contamination of nearby waterbodies. The case study provides insights into how such hazards are managed in a highly industrialized country. The site-related environmental hazard potentials, identified by the OekoRess methodology, pointed quite well to the actual environmental impacts. The indicator "mining waste management" shows a high environmental hazard potential, which adequately reflects the risk of such an event.

While the site-related OekoRess methodology correctly indicated the high environmental hazard potential regarding the mining waste management at the mine, this risk is not reflected in existing governance indicators. Canada scores high on almost all governance indicators. The incident at Mount Polley shows that environmental disasters can occur even in the most developed governance systems. However, Canada's high scores reflect the capacity of Canadian authorities, companies and civil society to manage and reduce the damages of an environmental disaster well.

Kurzbeschreibung

Das Vorhaben „Weiterentwicklung von Handlungsoptionen einer ökologischen Rohstoffpolitik" (ÖkoRess II), welches auf den Ergebnissen zweier vorangegangener Forschungsprojekte (UmSoRess und ÖkoRess I) aufbaut, verbindet Erfahrungen aus der Analyse von Umwelt- und Sozialstandards mit der Bewertung von Umweltrisiken im Rohstoffsektor. Das Projektteam führt 10 Fallstudien durch, um die im Rahmen des ÖkoRess-I-Projekts entwickelte Methode zur Bewertung standortspezifischer Umweltgefährdungspotenziale im Bergbau zu evaluieren und weiterzuentwickeln. Der Fokus liegt auf der Verbesserung des Indikators für Umwelt-Governance, indem die bewerteten Umweltgefährdungspotenziale, die tatsächlichen Umweltauswirkungen und die Governance-Analyse mit vorhandenen Governance-Indikatoren verglichen werden. Ziel ist es, die Frage zu beantworten, ob die Governance-Indikatoren in der Lage sind widerzuspiegeln, inwiefern relevante Akteure (Regierungen, Unternehmen und Zivilgesellschaft) potentielle Umweltgefährdungen bewältigen und Umweltauswirkungen des Bergbaus vermeiden oder reduzieren können.

Diese Fallstudie analysiert die Umweltgefährdungspotenziale und die Umweltauswirkungen der Kupfer- und Goldmine Mount Polley in Kanada. Im Jahr 2014 brach das Rückhaltebecken des Bergwerks, was zu einer großflächigen Verschmutzung der Gewässer in der Umgebung führte. Die Fallstudie gibt einen Einblick in den Umgang eines hochindustrialisierten Landes mit solchen Gefahren. Die mit der ÖkoRess-Methodik identifizierten standort- und umweltbezogenen Gefährdungspotenziale wiesen sehr gut auf die tatsächlichen Umweltauswirkungen hin. Der Indikator „mining waste management" zeigte ein hohes Umweltgefährdungspotenzial, welches das Risiko eines Rückhaltebeckenbruchs angemessen widerspiegelt.

Während die standortbezogene ÖkoRess-Methodik die hohen Umweltgefährdungspotenziale in Bezug auf „mining waste management“ im Bergwerk korrekt angab, spiegelt sich dieses Risiko in den bestehenden Governance-Indikatoren nicht wider. Kanada schneidet bei fast allen Governance-Indikatoren sehr gut ab. Der Vorfall in Mount Polley zeigt, dass Umweltkatastrophen auch in den am weitesten entwickelten Governance-Systemen auftreten können. Die hohen Werte Kanadas spiegeln jedoch die Fähigkeit der kanadischen Behörden, Unternehmen und der Zivilgesellschaft wider, die Schäden einer Umweltkatastrophe gut zu bewältigen und zu reduzieren.

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List of Abbreviations

APEGBC	Association of Professional Engineers and Geoscientists of British Columbia
AMD	Acid Mine Drainage
AZE	Alliance for Zero Extinction
C $	Canadian Dollar
CBA	Cost-benefit analysis
DPSIR	Driving Forces, Pressures, States, Impacts and Responses (Framework for describing interactions between society and environment)
EA	Environmental assessment
ECDA	Economic and Community Development Agreements
EDI	Environmental Democracy Index
EGS	Ecosystem Goods and Services
EPI	Environmental Performance Index
FNHA	First Nations Health Authority
GDP	Gross domestic product
GPI	Global Peace Index
GRRS	Government resource revenue sharing
HDI	Human Development Index
ICMM	International Council on Mining & Metals
MAC	Mining association of Canada
MOE	Ministry of Environment
MPMC	Mount Polley Mining Corporation
NNTC	Nkala'pamux Nation Tribal Council
PEEIAR	Post-Event Environmental Impact Assessment Report
TSF	Tailings storage facility
TSM	Towards Sustainable Mining
TSX-TSX-V	Leading stock exchange for the mineral exploration sector
US $	United States Dollar
WGI	Worldwide Governance Indicators
WSI	Water Stress Index

1 Focus of the study and relevance

The following case study is the first of ten case studies that are being prepared as part of the project "Further development of policy options for an ecological raw materials policy" (OekoRess II) commissioned by the German Federal Environment Agency. The case studies build on the results of two research projects, the UmSoRess[1] project and the OekoRess I[2] project. In UmSoRess, the impacts of raw material production on the environment, society and the economy were analyzed in 13 case studies.[3] The goal of the case studies was to gain a better understanding of the connections between the environmental and social impacts of mining in the context of various countries with different problems and governance contexts. In OekoRess I, a method to evaluate the ecological availability of raw materials and the site-related environmental hazard potentials posed by mining operations was developed with the aim to further developing the criticality concept.

As part of the follow-up project OekoRess II, 10 additional case studies will be conducted combining the analytical approaches of UmSoRess and OekoRess I in order to evaluate and further develop the method to assess the site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. This effort will particularly focus on improving the indicator for environmental sector governance used in the methodology, by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the questions if existing governance indices and indicators are able to adequately reflect the capability of governments, companies and civil society to manage environmental hazard potentials and avoid or reduce environmental impacts of mining. The results of the 10 case studies will be compared and a set of governance indicators will be identified that can be used to improve the raw-material-related assessment approach developed as part of the OekoRess I project.

In this case study the Mount Polley copper and gold mine in Canada is analysed. This case is of particular interest due to Canada's globally leading role in the mining sector and the country's positive reputation in addressing the environmental and social challenges of mining. In 2014, the tailings storage facility of the Mount Polley mine breached, releasing large amounts of mining waste into nearby waterbodies. The case study provides insights on how this accident was handled in a highly developed industrialised country.

The case study is structured in four parts: First, the structure of the mining sector of Canada and its contribution to the national economy is analysed (chapter 2). Second, a brief overview of the Mount Polley mine site is given. The geographic and geologic context is analysed followed by an overview of the applied mining and processing methods (chapter 3). Third, the environmental hazard potentials posed by the mining operation are discussed using the site-related OekoRess methodology and selected environmental impacts and reactions to these are described using the DPSIR framework that was also used in the UmSoRess case studies (chapter 4).[4] Fourth, the governance of Canada's mining sector is analysed (chapter 5) and last, the findings of the assessment of the environmental hazard potentials and environmental impacts and the governance analysis are compared with existing governance indicators and indices and first conclusions for the methodology development are drawn (chapter 6).

[1] Approaches to reducing negative environmental and social impacts in the production of metal raw materials. For more information see https://www.umweltbundesamt.de/umweltfragen-umsoress

[2] Discussion of ecological limits of raw materials production and development of a method to evaluate the ecological availability of raw materials with the aim of further developing the criticality concept. For more information see https://www.umweltbundesamt.de/umweltfragen-oekoress

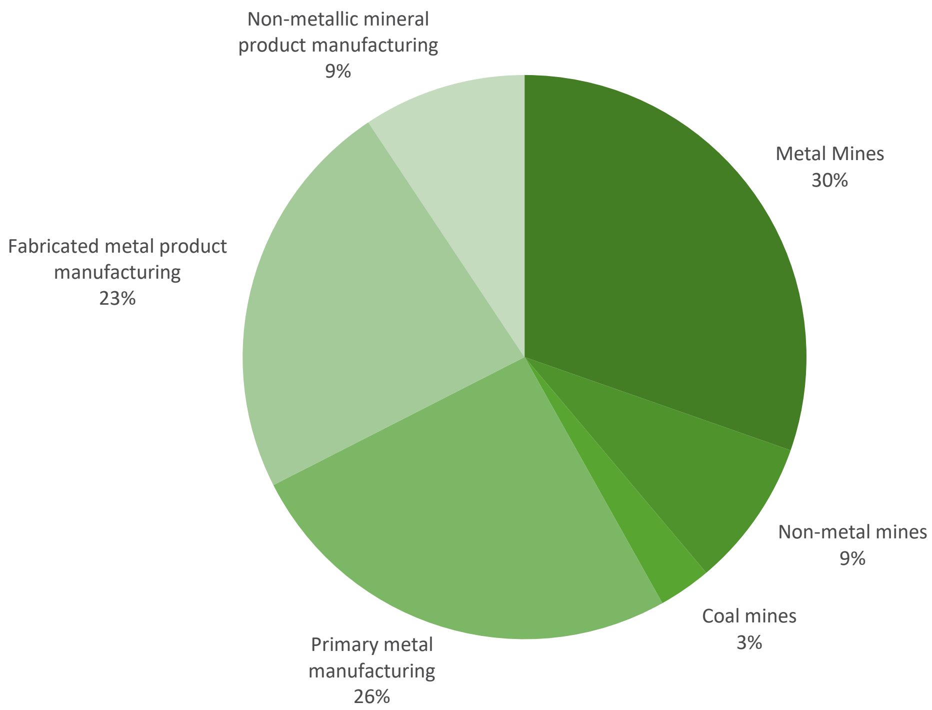
[3] The case studies and fact sheets on the standards and approaches analysed can be accessed here: https://www.umweltbundesamt.de/umweltfragen-umsoress

[4] The DPSIR framework comprehensively accounts and visualizes the causal connection between environmental issues, their origin, their impacts and the responses taken. The model consists of driving forces, pressures, state, impacts and responses. For further information, see e.g. Kristensen (2004).

2 Structure and macroeconomic relevance of Canada's mining sector

In 2014, Canada's mining industry contributed C $57 billion (3.5 % of total GDP) to the national gross domestic product of which C $24 billion were mineral extraction and C $33 billion mineral processing and manufacturing. Figure 2-1 shows the share of the sub-sectors to the mining industry's GDP contribution. Metal mines account for almost one third and primary metal manufacturing for more than a quarter of the mining sector's GDP contribution. 18.2 % of Canadian goods exports can be attributed to the selling of various minerals, such as aluminium, copper, gold, iron and steel, iron ore, nickel, silver, uranium, zinc, and diamonds. The mining industry paid a total of C $6.6 billion in royalties, corporate income taxes and personal income taxes to provincial and territorial governments (Marshall 2015).

Figure 2-1: Sub sector contribution to the GDP of mining and mineral manufacturing



Source: Own graphic, based on data from Marshall (2015).

Mining is one of the most important economic sectors in Canada and is a major job creator. Approximately 380,000 people (2 % of 19.12 million labour force) (CIA 2013) are employed in mining or mineral processing industries. Additionally 68,000 workers (0.35 % of labour force) are employed by mining supplier companies (Marshall 2014). The country has the second largest mining supply sector, with 3,215 companies listed (KPMG n.d.). The wages in the mining sector are the highest among all industries in Canada (Marshall 2015).

Richly endowed with natural resources, Canada ranks among the top five countries in the global production of 11 major minerals and metals (Table 2-1):

Table 2-1: Canada Mineral Production in 2014

Mineral [*= critical according to EC 2014]	Production 2014		
	Volume [t]	% of ∑ World	Rank
Potash (K2O equivalent)	11,345,000	29.0	1
Uranium (metal content) (2013)	8,729	15.6	2
Niobium* (Nb2O5-Content)mine production)	5,600	6.4	2
Cobalt* (mine production)	6,574	5.1	3
Aluminium (primary metal)	2,858,238	5.4	3
Tungsten* (mine production)	2,689	3.2	3
Platinum*	11	7.4	4
Nickel (mine production)	234,951	11.4	4
Titanium minerals	2,500,000	20.7	1
Diamonds (precious) (2011)	(carats)12,082,000	9.6	5
Gold (mine production)	152	5.0	5

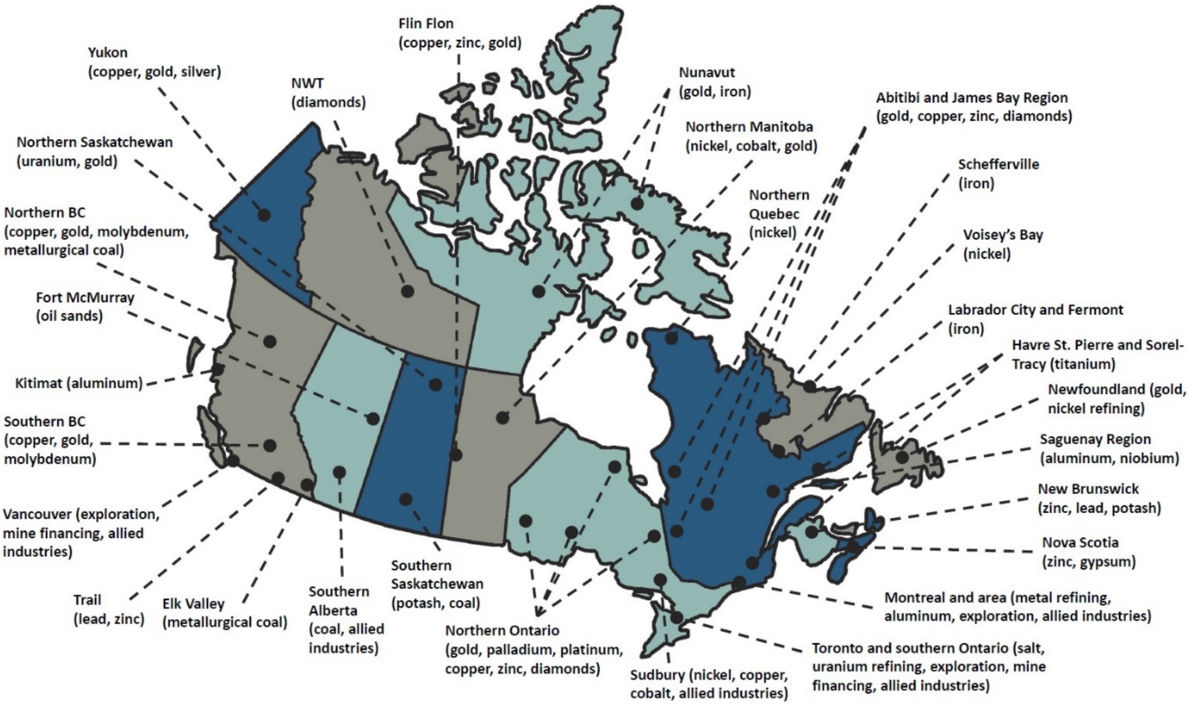
Sources of information: Marshall (2015) and BGS (2016). Selected critical minerals (according to EC 2014) are marked with *.

The country produces several critical raw materials as defined by the EU e.g. cobalt, platinum, niobium and tungsten (European Commission 2014) (Table 2-1). Canada plays a leading role particularly in the mining of potash, which accounts for almost one third of world production. Also more than one fifth of the world's titanium was mined in Canada in 2014.

Furthermore, Canada has several advanced rare earth projects, including an advanced heavy rare earth project. Most of those projects are currently inactive due to low prices but are viewed to be competitive once prices rebound.

Other materials from the EU critical raw materials list being produced in Canada include magnetite (by German company Baymag), germanium, indium, and gallium (by Teck Resources, Trail Operations). A phosphate rock mine is in development in Quebec (co-owned by the Quebec government and by a Norwegian fertilizer company, which will process the raw material), a graphite mine is being developed in Quebec, and a Fluorspar mine is under construction in Newfoundland/Labrador. In addition, lithium, which has seen a surge (together with cobalt) due to rising demand in battery manufacturing for electric vehicles, is also being explored and several projects are being developed in Canada. Chromite, also part of the critical raw materials list, has recently been discovered in Canada in what is now known to possibly be the world's largest Chromite deposit, located in north-western Ontario's so-called Ring of Fire. Some of the more advanced projects for strategic metals that are being developed in Canada include fluorspar, heavy rare earth elements, lithium and cobalt.

Figure 2-2: Mining clusters in Canada



Source: MAC (2018).

In 2014, Canada had a total number of 1,209 active mines of which 77 mined metals and 1,132 non-metallic minerals (Marshall 2015).

Moreover, it is one of the largest resource producing countries, as well as the world's most important financing centre for exploration projects. Canada hosts the world's leading stock exchange for the mineral exploration sector, the TSX/TSX-V. With its 160+ year history the TSX stock exchange has a current total market capitalization of approx. C $2.3 trillion (as at January 2016) and raised a total of C $267 billion in equity capital in the last five years.

With respect to the mining sector, the Canadian stock exchange is the number one in listed mining companies globally with a total of 1,318 listed companies. It is also the number one in mining equity raised globally, with a total of C $6.8 billion in 2015 (34 %). The TSX/TSX-V managed 53 % of all global mining equity financings in 2015 (TMX 2016). Below is an illustration of the diversity of issuers at the TSX/TSX-V with regard to listed junior and senior mining companies. The Toronto Stock Exchange and the TSX Venture Exchange handled 48 % of global mining equity transactions in 2013, making it the global centre of mining finance (TMX 2016).

Furthermore, Canada has a number of global centres with expertise on mining. Vancouver is the world's leading cluster of exploration companies, many major aluminium and iron ore firms are located in Montreal, Edmonton is a global centre for expertise on oil sands while Saskatoon offers expertise on potash and uranium. More than 800 Canadian exploration companies are exploring in over 100 countries worldwide (Marshall 2015).

With regard to gold and copper, which are the focus of this case study, Canada contributes only to a lesser extent to the global production. Canada accounts for less than 0.4 % of the global copper production and ranks as eighth of the copper-producing countries. Gold plays a more significant role. In 2015, the country had a 5 % share in the global gold production, ranking fifth (USGS 2016).

3 Overview of Mt Polley mining operation and geology

The Canadian Mount Polley copper and gold mine is located in NW British Columbia, 400 km northeast of Vancouver. The nearest non-first nations community from Mount Polley is located 7 km NE. The closest town is Williams Lake, 56 km SW from the deposit (Figure 4-2 a).

3.1 Geography

The mine is located on the eastern end of the so-called Fraser Plateau and is characterized by moderate relief and a rolling topography. The Interior Plateau of British Columbia is bordered by the Coast Mountains in the West and by the Rocky Mountains in the East. The highest elevations at the Mount Polley Intrusive Complex reach up to 1,266 m at the peak and go down to approximately 920 m.

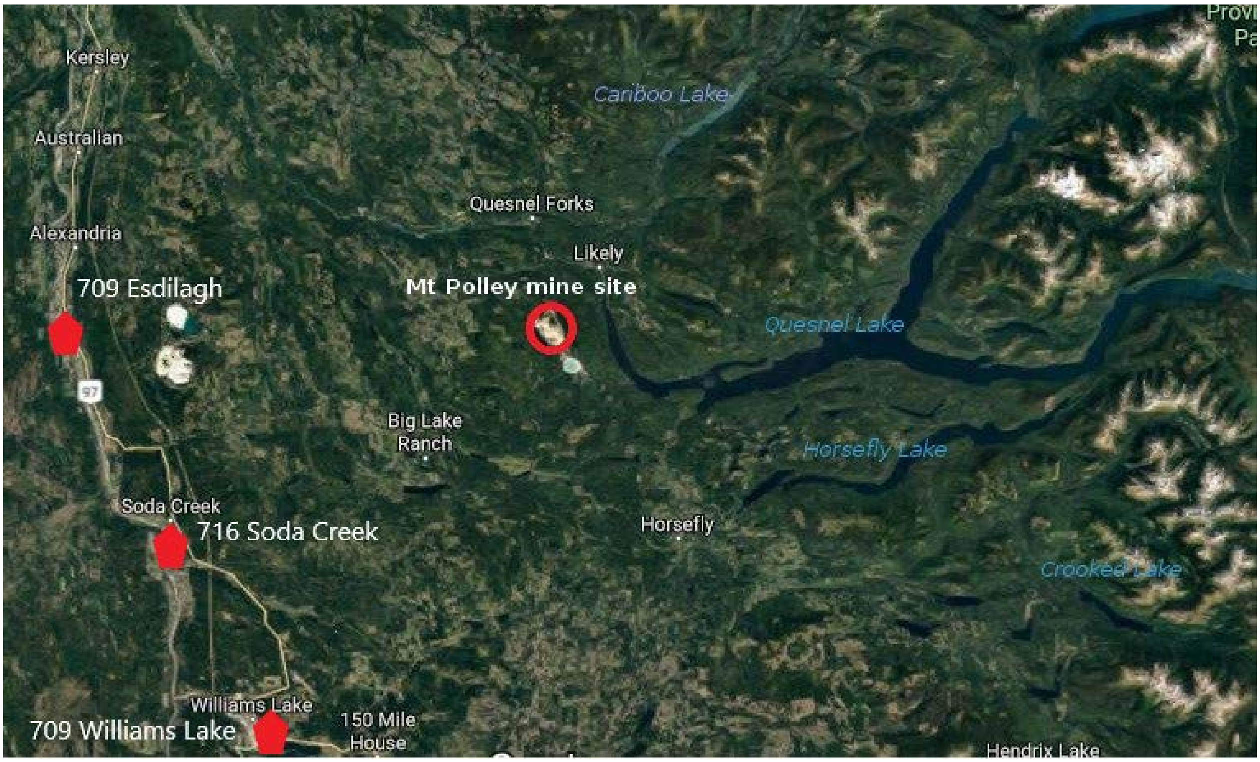
Commercial logging has cut down large areas of forest. The prevalent forest cover is typically red cedar, Douglas fir and sub-alpine fir, with fewer black cottonwood, trembling aspen and paper birches. The dominating wildlife consists of moose, black and grizzly bears, ruffled grouse, golden eagle, and American robin (Hashmi 2015).

The average monthly temperature at Mount Polley ranges between -6.0 °C in January and 15.3 °C in July and August. The annual precipitation is 670 mm on average. The precipitation is high during summers mostly due to storms and the lowest in February. Winds are coming mainly from NNE and SSW (BCMEM 2015)

Mount Polley is located at the intersection of two sub-watersheds within the Quesnel Lake watershed: the Polley Lake in the east and the Bootjack Lake in the west. The tailings impoundment is right next to the Hazeltine creek (Figure 3-1 and Figure 4-2).

The closest First Nation communities are Esdilagh in the West and Soda Creek and Williams Lake south of the Mine. Mount Polley is located within the northern part of the Secwepemc te Qelmucw traditional territory and is within the traditional territories of T'exelc Williams Lake Indian Band and the Xat'sull Soda Creek First Nations (Figure 3-1). The First Nation communities use the surrounding water bodies in particular Quesnel Lake and Cariboo River for fishery (FNHA 2014).

Figure 3-1: Overview map showing first nation communities and water bodies in the area.



Source of underlying map: Landsat/Copernicus (2019), first nation communities depicted as red pentagons (based on information from Indigenous and Northern Affairs Canada (2016), location of mine marked with a red circle.

3.2 Geological context and ore deposit formation

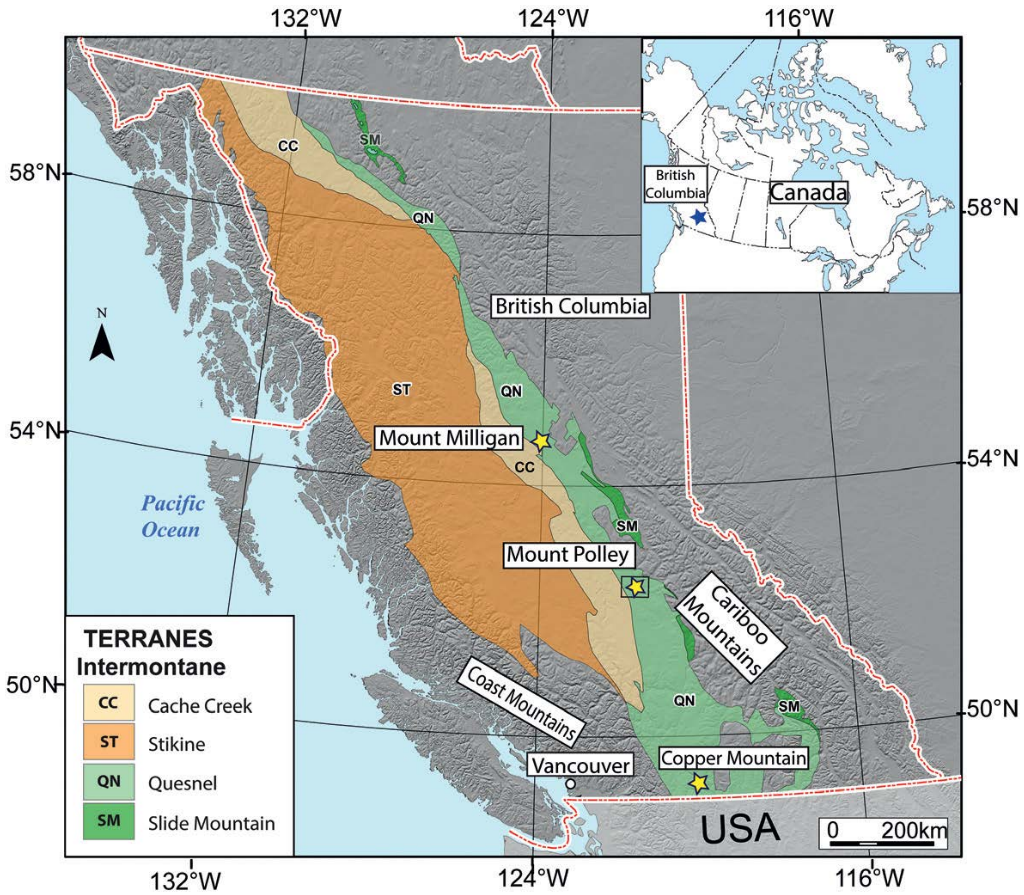
The region around Mount Polley is characterized by NW trending structures. Figure 3-2 shows the Intramontane (cf. Stikine in Figure 3-2) of the Canadian cordillera that is bordered to the east by the accreted Quesnel terrane (Hashmi et al. 2015). The latter is situated in the core of a Middle Jurassic NW trending upright syncline and comprises Triassic to Jurassic volcanic, sedimentary and mafic to ultramafic intrusive rocks that formed in a west-facing arc. Latest stage of the Quesnellian island arc magmatism was in late Triassic to early Jurassic. The syncline formed after the eastward obduction of the Quesnel – jointly with its eastern marginal basin onto the continental margin during Early Jurassic. This phase of tectonic activity was followed by continued crustal shortening in the Middle Jurassic. The process resulted in regional metamorphism and southwest-verging back-folding. The oldest formation in the region with Permian to Triassic marine sediments and volcanic rocks is the Cache Creek terrane that crops out between the two units Intermontane and Quesnel (Figure 3-2).

Mount Polley is situated within the Quesnel terrane at the westward boundary of this Middle Jurassic fold more specifically, the Triassic mafic volcanic, volcanoclastic and sedimentary rocks of the Nicola Group (Brown 2016; Hashmi et al. 2015). The latter crops out to the east and west of Mount Polley on the limbs of the syncline. Mount Polley itself constitutes an Intrusive Complex that intruded into the Nicola Group rocks with a seize of 5.5 by 4 km during the latest stage of Quesnellian island arc magmatism (Hashmi et al. 2015). The Mount Polley Intrusive Complex comprises multi-phase intrusions with syenites, diorites, monzodiorites and magmatic-hydrothermal breccia (Fraser et al. 1993). The Intrusive Complex hosts the Mount Polley copper-gold porphyry deposit with alkalic, marginally silica-undersaturated mineralization, and magmatic-hydrothermal breccias. The hydrothermal alterations associated with the porphyric deposit are also rich in magnetite. Economically viable Cu-Au(-Ag) mineralization in this setting is vein/fracture controlled and mainly found in the breccias, or in mineralized stockwork veins in adjacent wall rock intrusions. Mount Polley belongs to the alkaline class of porphyry copper deposits. The multiphase intrusion is typical for such an alkali porphyry copper deposit, leading to a number of ore zones and, thus, to the repeated discovery of new minable ore bodies during the lifespan of the Mount Polley mine. The most important ore zones are divided in two groups, the Springer-Cariboo and the Northeast-Boundary areas. Beside the different location, they also vary in size as well as styles of mineralization and average ore grades. Most of the other mineralized zones have been mined already but can still contain some ore.

The estimated resources add up to 247 million tons of ore with an average grade of 0.266 % copper 0.293g/t gold and 0.563g/t silver (BCMEM 2015). Next to the Mount Polley deposit, other porphyry copper deposits are hosted by the Nicola Group, such as the Highland Valley, Copper Mountain and New Afton mines.

Tectonic activity with dextral transpressional / transtensional movements affected the region during the Paleocene to Eocene resulting in NW trending faults that form the borders of the recent lenticular block form of the Mount Polley Intrusive Complex and pass through the close by Polley Lake and Bootjack Lake. Due to the well-defined borders and abundance of magnetite, the porphyric body was discovered early during magnetic aerial surveys in 1963 despite the nearly complete coverage of till, caused by several quaternary glaciation periods (Hashmi 2015).

Figure 3-2: Geological setting of the Mount Polley region



Source: Hashmi et al. (2015).

3.3 Mining and Processing

The mine is operated by the Mount Polley Mining Corporation which is a subsidiary wholly owned by Imperial Metals. These days, the property consists of seven mining leases and 45 mineral claims, totalling up to almost 200 km^2 (Brown et al. 2016). At the peak of production the mine processed 20,000 t/d ore and employed roughly 400 people. The operation produces a copper-gold concentrate, which is processed in the mill on site. Mining waste is stored as slurry in the tailings storage facility measuring almost 300 hectares enclosed by a 4 km long earthen dam structure (BCMEM 2015). The dam breached in 2014 resulting in a large spill, which will be further described in later chapters.

Production at Mount Polley started in 1997 when three ore bodies were mined. Up until October 2001, approximately 27.5 million tons of ore were milled before suspending the production due to a sustained period of low metal prices. The discovery of a new high-grade zone along with rising metal prices resulted in resumption of production in 2005. From March 2005 until August 4, 2014 - the day of the tailing storage facility (TSF) breach - the mine operated continuously. During the operations, the mine expanded to five open pits and the same number of mine rock waste dumps (Knight Piésold 2011). In 2015, the mine restarted operations after the dam burst.

Mount Polley is a conventional shovel, truck and open pit mine with an underground mine being under development. The mined ore is processed through crushing, grinding and flotation. The copper and gold concentrates are shipped through the port of Vancouver for smelting overseas or transported by rail to North American smelters, which is typical for many Canadian mines. The operation can process between 17,800 and 22,000 t of ore per day depending on its hardness. The current life of mine plan is 11 years.

The main access to the mine is the Likeley Highway, supply and concentrate trucks use this road. The mine employees live in nearby communities that are connected to the highway such as Beaver Valley, Big Lake, Morehead Lake, Hydraulic, Little Lake and Likely. The highway has no seasonal restrictions, making it possible to transport the ore concentrate all year. The power for the mining operation is supplied onsite via an electrical substation. It is fed by the British Columbia hydro grid from the Soda creek substation tab. The 70 km long line from Soda Creek to Mount Polley was built by the mining company (BCMEM2015).

Mining activities are standard hard rock drilling and blasting techniques followed by milling operations. The ore is transported by trucks to the on-site mill where it is first processed in a gyratory crusher; reducing the ores‘ diameter of 200 mm; oversized material is broken by a hydraulic rock breaker. The crushed ore is then transported via conveyor belt to a number of mill circuits where the ore is further prepared by grinding. Appropriately sized material is then separated by mineral. The fine fractions are pumped to a number of selective flotation circuits where valuable minerals are separated from the waste rock. The rougher concentrate is dewatered and shipped to market. Tailings from the mill are transported as slurry through pipelines to the tailings storage facility.

The tailings storage facility is located 4 km south of the mill and fill height varies between 17 and 45 m. The embankment is 4.2 km long and separated into three sections - the main, perimeter and south-embankment. The process water is collected in facility and reused in the milling process. The tailings storage facility is designed in the centreline construction method making staged expansion possible. Using the centreline construction method, earth and rock filled embankments are constructed that include a low permeability core zone. The latter, passes on into a basin liner that forms a seepage barrier within the impoundment (Brown 2016).

Analysts calculating the cash flow of the mine conclude that at metals pricing Cu US $3.00 US/lb, Au US $1,200 US/oz and Ag US $15 US/oz the mine will provide a cash flow of US $502 million dollars. However, the Mount Polley’s economic value is very sensitive to metals pricing, resulting in much lesser cash flow values if prices get lower. If the current life of mine plan is carried out, the mine will generate over 350 jobs over a period of 11 years, as well as added economic benefits in the local and provincial area. The mine has operated for 14 years now, therefore skilled and experienced workers in the sector are available (Brown 2016).

4 Overview of environmental hazard potentials and environmental impacts

4.1 Environmental hazard potentials

As part of the OekoRess I research project an evaluation scheme for assessing the environmental hazard potentials (EHPs) of the extraction of primary abiotic raw materials was developed. This evaluation scheme is based on indicators, which are assigned to three levels of consideration. These levels are geology, technology and site surroundings. The level "Geology" comprises five indicators, which include environmental factors inherent to the geology on site. These key influencing factors are "precondition for acid mine drainage (AMD)", "paragenesis with heavy metals", "paragenesis with radioactive components", "deposit size" and "specific ore grade". The second level is "Technology" and includes the indicators "mine type", "use of auxiliary substances", "mine waste management" and "remediation measures". The third level "Site (surroundings)" comprises the indicators "natural accident hazard due to floods, earthquakes, storms, landslides", "Water Stress Index (WSI) and desert areas", and "protected areas and Alliance for Zero Extinction (AZE) sites". Furthermore, the indicator "conflict potential with local population" focusses on the social context. The latter indicator is further developed by analysing ten case studies of which the present case study is one.

The environmental hazard potential for each indicator can be rated as low (green), medium (yellow) or high (red) (for detailed information on the method see Dehoust et al. 2017b). Table 4 1 shows the evaluation of the EHPs of the Mount Polley mine, which are described in detail below.

The assessment of the EHPs of the Mount Polley mine is followed by an analysis of the actual situation and impacts of the mining activities on the environment as well as the responses from the mine site operator, the responsible authorities as well as the local communities, using the DPSIR framework (Chapter 4.2).

Table 4-1: Site-related OekoRess assessment

Level of consideration	Indicator	Environmental hazard potential		
		low	medium	high
Geology	Preconditions for acid mine drainage (AMD)	X		
	Paragenesis with heavy metals			X
	Paragenesis with radioactive components		X	
	Deposit size	X		
	Specific ore grade			X
Technology	Mine type		X	
	Use of auxiliary substances			X
	Mining waste management			X

Level of consideration	Indicator	Environmental hazard potential		
Site (surroundings)	Remediation measures	X		
	Natural accident hazard due to floods, earthquakes, storms, landslides	X		
	Water Stress Index (WSI) and desert areas	X		
	Protected areas and AZE sites	X		
	Conflict potential with local population	X		

4.1.1 Geology

Preconditions for acid mine drainage (AMD)

Deposits of the Mount Polley type are relatively low in sulphur; pyrite is not a major component of copper mineralization and usually restricted to small and narrow zones. Calcite accumulated in veins serves as buffer zones for the pH of fluids which limits potential sulphide decomposition and metal dispersion due to weathering and oxidation, resulting in an overall low potential for acid mine drainage (Brown 2016) *(low environmental hazard potential)*.

Paragenesis with heavy metals

Copper itself is defined as a heavy metal. Additionally the tailings contain elevated levels of arsenic, lead, cadmium and selenium and therefore show a clear contamination with heavy metals (Environment and Climate Change Canada 2013) *(high environmental hazard potential)*.

Paragenesis with radioactive components

There is no data on radioactivity, but no indication on elevated levels of uranium, thorium or other radioactive elements either. Due to the lack of data, the indicator is rated as moderate in accordance with the measurement instructions *(medium environmental hazard potential)*.

Deposit size

The total copper content of the remaining deposit (based on proven and probable reserves) is estimated to be approx. 200 kt (Imperial Metals 2017). At an annual production of approximately 8.5 kt (approximately 2017 levels), a total of ca. 170 kt has been mined since the opening in 1997 (Imperial Metals 2019). Consequently, the deposit can be categorized as small. The larger a deposit is, the more surface is disturbed which in turn increases the potential of negative environmental impacts *(low environmental hazard potential)*.

Specific ore grade

The ore contains 0.266% copper, 0.293g/t gold and 0.563g/t silver (cf. Section 3.3) on average and is categorized as low grade ore in comparison to other renown mine sites. Mining and processing of low-grade ore leads to the production of more waste material. Accordingly, the metal to waste ratio at the Mount Polley mine is rather low *(high environmental hazard potential)*.

4.1.2 Technology

Mine type

The ore is mined in five open pit mines with an underground component under development. Underground mines do not disturb the land as much as open pit mines. However, Mount Polley is mainly a hard rock open pit operation. Hard rock open pit mining disturbs the surface to a much larger extent than underground mining. In contrast to open pit mining in alluvial or unconsolidated sediment, the disturbance only extents to the size of the ore body. Hence, the indicator is evaluated with a medium EHP *(medium environmental hazard potential)*.

Use of auxiliary substances

The ore is crushed and grinded in a number of processes and afterwards treated with flotation reagents to separate the metals from the gangue minerals. The use of chemical agents in processing poses a high EHP *(high environmental hazard potential)*.

Mining waste management

A tailings storage facility with a structural height of 15 m above ground level is regarded as medium to large in accordance with the World Register of Dams. As the processed slurry is stored in a tailings storage facility with a structural height between 17 and 45 m, it falls into the category of medium to large tailings dam structures. This results in a high-risk classification for the indicator mining waste management in the OekoRess methodology *(high environmental hazard potential)*.

Remediation measures

The mine closure plan foresees that all waste dumps will be recontoured with low slopes. Stockpiles and infrastructure areas will be capped with soil, making revegetation easier (Brown et al. 2016). The presence of a mine closure plan results in a low evaluation result for the indicator 'remediation measures' *(low environmental hazard potential)*.

4.1.3 Site (surroundings)

Natural accident hazard due to floods, earthquake, storms, landslides

The total natural disaster risk is assessed by analyzing four individual sub-indicators. All sub-indicators (earthquakes, floods, tropical storms, landslides) show a low environmental hazard potential. The evaluation is carried out in accordance with the measurement instructions, which suggest to use georeferenced data from publicly available risk maps. The results are taken directly from the given risk assessment. The indicator total is derived by the highest hazard potential of the sub-indicators. Hence, the overall potential for natural disasters is relatively low. The region shows no risks for earthquakes, landslides, tropical storms or floods *(low environmental hazard potential)*.

Water Stress Index (WSI) and desert areas

The WSI by Pfister et al. (2009) provides characterization factors on the relative water availability at watershed level. The indicator combines this information with an evaluation whether the site is located in a desert area. Mining operations often need large amounts of water for the operation. Depending on the hydrological situation, a competition for water between the different users can occur. The evaluation was carried out in accordance with the procedure described in the measurement instructions (Dehoust et al. 2017a). The water stress index in the region is low and the mine is not located in a desert area. Therefore, other sectors do not compete for water resources with the mine *(low environmental hazard potential)*.

Protected areas and AZE (Alliance for zero extinction) sites

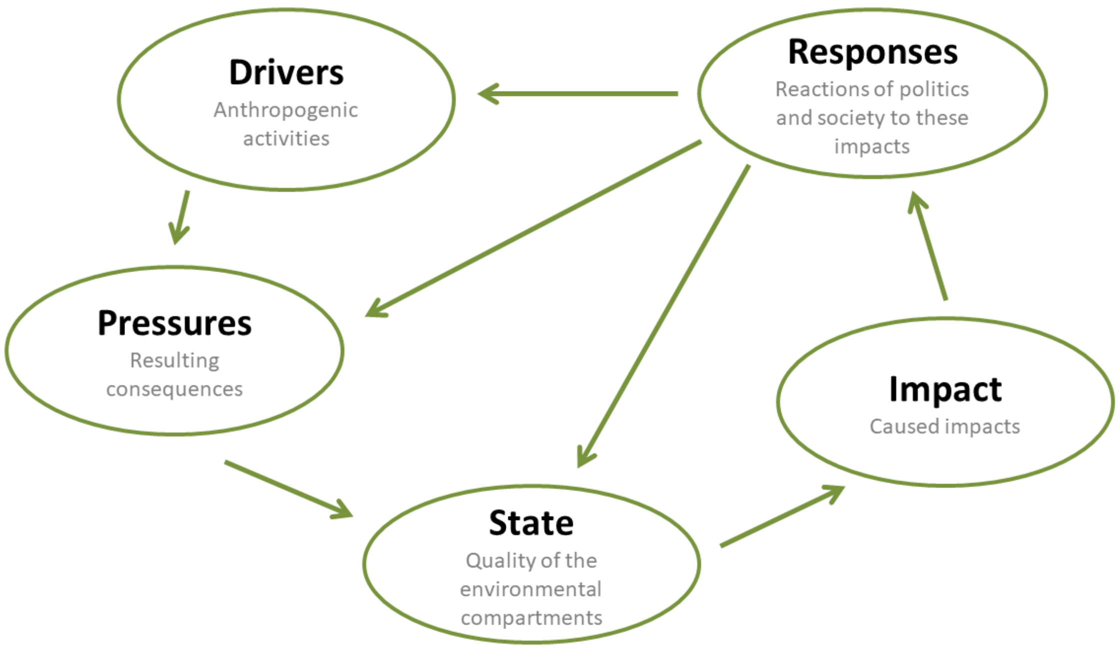
Georeferenced data for designated protected areas are used to assess hazards posed by mining extraction. The metric to evaluate EHPs corresponds to the method first described in the draft standard of the Initiative for Responsible Mining Assurance (IRMA 2014). The mine is not located within a protected area as defined by the UNESCO or close to vulnerable habitats defined by the Alliance for Zero Extinction, resulting in a *low environmental hazard potential*.

Conflict potential with local population

The governance indicators 'Voice and Accountability' and 'Control of Corruption' both range at almost 100 % resulting in a low EHP (World Bank 2016). Therefore, the EHP due to low governance is rather low *(low environmental hazard potential)*.

4.2 Environmental impacts

Figure 4-1: DPSIR framework



Source: Own preparation based on Kristensen (2004).

The DPSIR framework is a systemic analytical approach to better understand the interaction of humans and their environment in order to derive adequate policy measures. It comprehensively accounts for and visualizes the causal connections between human activities, the resulting consequences for the environment and the responses of humans. The model consists of driving forces, pressures, state, impacts and responses.[5]

The focus of this chapter is on the tailings dam burst, and its impacts on the environment and health as well as on the responses taken in terms of investigations, remediation and the return to operation. The dam breach incident had a major impact on the environment in the area. In consequence, a number of extensive investigations were undertaken and reports on the subject published. Therefore, the data available on the accident and its impacts is much better than the data on the rest of Mount Polleys operations.

[5] For further information on the DPSIR framework and its elements see Kristensen (2004).

4.2.1 Pressure

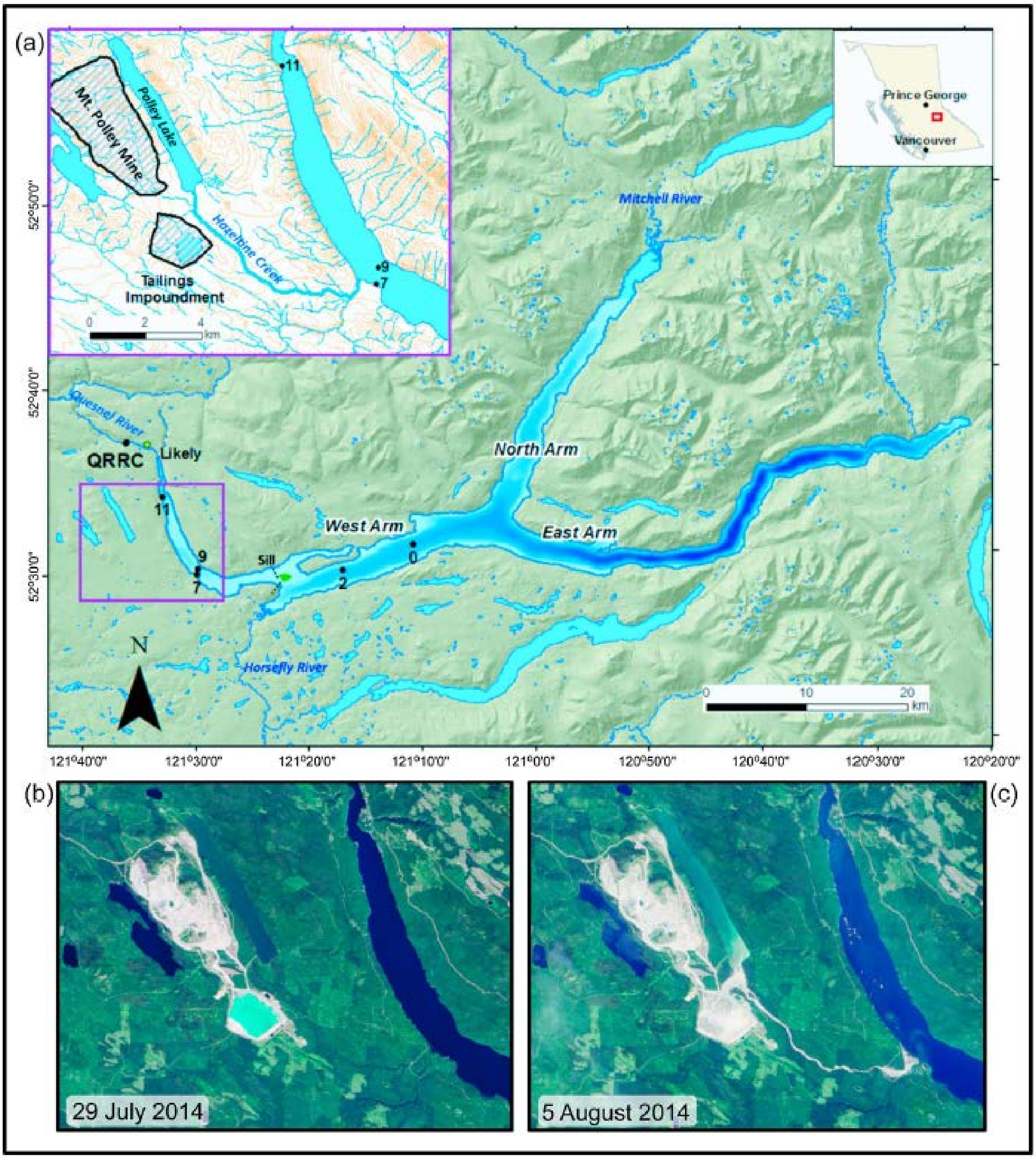
Pressures → State → Impact → Responses

Tailings dam failure in 2014

Mount Polley gained international attention due to a tailings dam failure in 2014. On August 4^{th} the tailings storage facility at the mine breached and released water and tailings to the environment. Although nobody was harmed or killed and no personal property damage occurred, the incident has had a significant impact on downstream areas and is considered an environmental disaster (see chapter on impacts). Up to 25 million m^3 of tailings slurry were released during the breach (Nikl et al. 2016). The structure and architecture of the dam were designed 20 years ago and unknowingly constructed on a pocket of clay material 10 m under the dam (Independent Expert Engineering Investigation and Review Panel 2015).

Approximately at midnight on August 4^{th} a part of the tailings storage facility caved in about five metres resulting in a small stream flowing over the dam. Due to the late hour of the incident, the monitoring measures were weak and no employees were on site to start countermeasures. Therefore, the overflowing stream quickly became much stronger and finally the dam breached, releasing all the content of the pond within four days. The tailings and wastewater streamed down to Polley Lake, which rose one meter (see images of the tailings dam failure before and after the incident in Figure 4-2). The overflow went down southeast and gathered debris in the Hazeltine Creek and travelled seven kilometres into the Quesnel Lake, which is a pristine deep-water lake.

Figure 4-2: Overview on mine location (a) and satellite images of the tailings dam failure before (b) and after (c) the incident



Source: Petticrew et al. (2015).

4.2.2 State and Impacts

Pressures | State | Impact | Responses

Geochemistry

The released tailings led to changes in the state of the environment. With regard to soil and sediment toxicity, reports show that "there are some metals that exceed guidelines and/or standards", for example copper and vanadium (Golder Associates 2016: 69). However, the geochemistry investigations also points out that tailings, which were released during the breach, are "not acid-generating and have low leaching potential" (ibid.). Groundwater investigations from accumulation sites show metal concentrations below groundwater standards.

Erosion and deposition of tailings and eroded materials

The main physical impact of the event was the erosion and deposition of tailings and eroded materials (Nikl et al. 2016). The 25 million m^3 of solid and liquid waste like construction material, tailings and water entered Polley Lake and Hazeltine Creek, which flows into Quesnel Lake and then into Quesnel River. As the physical energy of the debris flow exceeded the normal flow by far, the breach event resulted in the erosion and displacement of an estimated 0.6 to 1.7 million m^3 of glaciolacustrine, fluvial and upper soil horizon materials, and vegetation and forest soils (ibid.). It also led to the widening of Haseltine Creek channel from 2 m to over 25 m (Byrne et al. 2015), the loss of riparian vegetation and the deposition of tailings in both of the two lakes. However, the majority of the dam outwash is estimated having accumulated in the West Basin of Quesnel Lake with a probable deposit thickness in the order of 10 m over an estimated area of 1.81 km^2 (Nikl et al. 2016).

Aquatic impacts/impacts on water quality and fish

The inflow resulting from the dam breach raised the Quesnel Lake by 7.7 cm, which is equivalent to 21 million m^3 (Petticrew et al. 2015). The dense bottom layer (hypolimnion) of the west basin was directly disturbed by the spill (ibid.). The temperature increased on average between 5 to 6-7.5 °C, the turbidity became much stronger and the conductivity increased by 40 % due to the metal content in the tailings (ibid.). Due to the water movement, the contaminated water spread east and westwards affecting the main basin of the lake. Consequently, a thick layer of material was deposited on the ground of the lake permanently.

Among dam failures, the Mount Polley disaster was unique in that that the tailings contained an unusual wide range of contaminants (arsenic, copper, gold, manganese, nickel, lead, vanadium) (Hudson-Edwards et al. n.d.). Copper concentrations rose directly after the breaching event, however, the concentrations returned to below environmental benchmarks by 2015 (Nikl et al. 2016) and the potential for metal release in subaqueous environments is rather low (SRK 2015; Nikl et al. 2016). Surface waters show a “decreasing trend in concentrations of total metals” and were tested to be “not toxic to various aquatic test species” in 2015 (SRK 2015). Nevertheless, measurements of tissue concentrations of benthic invertebrates indicate “higher concentrations of metals, including selenium” and, in deeper areas of copper. However, the Government of British Columbia (2014b) released a statement that they are “confident any fish caught for human consumption beyond the immediate sediment deposit zone are safe to eat” (Government of British Columbia 2016b).

Furthermore, the contamination poses risks due to an accumulation of the sediments which leads to a loss of physical habitats that affects the fish stocks. These fish stocks are of particular importance for First Nation fisheries. Particularly the Quesnel Lake is an important rearing area for Sockeye Salmon (Oncorhynchus nerka) and a habitat for Rainbow Trout (O. mykiss) and numerous other forage and bottom fish species (Golder Associates 2016). Studies show that benthic invertebrates in deeper areas of the lakes are affected in growth, survival and behaviour for these physical reasons and “biomass measurements indicate lower populations in Polley Lake and the deeper areas of the West Arm of Quesnel Lake” (ibid.). However, the benthic invertebrate biomass did not change in the littoral areas (ibid.).

Health impacts

After the dam breach, the First Nations Health Authority (FNHA) commissioned a health impact assessment (HIA, Shandro et al. 2016). An official human health risk assessment commissioned by the state of British Columbia is expected to be published in January 2017 and was therefore not available as data basis for this case study (Gov. of British Columbia 2017).

The HIA of the FNHA was a systematic assessment of the health impacts and the risks associated with the dam breach event (FNHA 2017). The assessment found that for the First Nation communities, “emotional stress is a key health impact and appears to be shared among all communities” (FNHA

2017). The emotional stress is, according to the study, directly linked to the severity of the event itself, to further risks and impacts, and to the uncertainty and a lack of trust in the information provided by the government and the mining company. The assessment also highlights the direct impacts of the dam breach to traditional territories of three First Nations - Xat'sull, T'exelcemc and Lhatko Dene First Nation. The communities for example lost access to sacred territories as well as to food and medicine sources.

Furthermore, the breach led to a decrease in individual fishing practices, which play a central role in First Nations' health. It led to a change in diet composition, physical activity and cultural practices. It also led to reduced incomes and employment opportunities, because it resulted in negative impacts on First Nation communities' commercial fisheries.

In conclusion, even though the report does not highlight any direct impacts of the dam breach on the clinical health of people like deaths or injuries, "the strong links between First Nations, the land and resources, culture and associated health outcomes" resulted in indirect health problems (FNHA 2017).

4.2.3 Responses

Investigations and remediation

Immediately after the dam breach, the Ministry of Environment (MOE) of British Columbia started water sampling in the area, which resulted in a drinking water ban that was lifted on August 13 (Government of British Columbia 2016a). Until 2016, the MOE took over 365 water samples and monitored the impacts on fish. Furthermore, the Mount Polley Mining Cooperation took more than 4,500 water samples (ibid.).

The Government of British Columbia oversees all environmental remediation work of the Mount Polley Mining Corporation (MPMC). Together, the Government of British Columbia and the company have published technical, environmental and assessment reports that described pre-event infrastructure issues, post-event impacts to the receiving environments, and the pathways for re-permitting.

Following the spill, MPMC was ordered to submit environmental impact assessments and clean-up action plans. In December, MPMC started to repair the breach in the tailings storage facility dam, which was completed in April 2015.

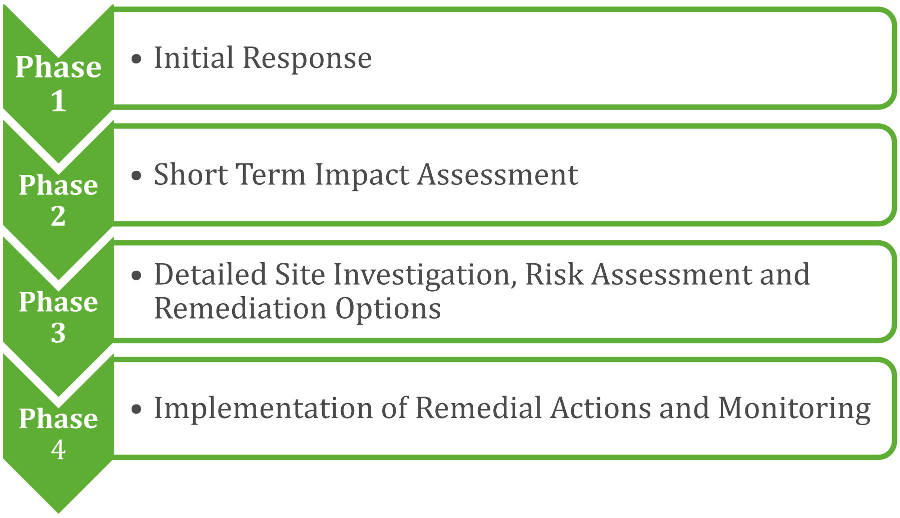
MPMC'S rehabilitation and remediation strategy is divided into four phases: (see Figure 4-3). Phase 1, the initial response phase, was completed in summer 2015. Amongst other control-oriented restorations, the protection of the Hazeltine Creek channel against erosion and the control of the water quality in Quesnel Lake were part of phase 1. In phase 2, MPMC initiated several studies to assess the impacts of the spill on the ecosystems and began to develop strategies for remediation. The first edition of a Post-Event Environmental Impact Assessment Report (PEEIAR, MPMC 2015b) was released in 2015. It sums up the findings of the initiated studies and covers the first six to eight months after the spill. It was updated with a second edition of the PEEIAR (Golder Associates 2016), which was based on the ongoing post monitoring with a focus on the studies and results of the following months until end of December 2015. It marked the completion of phase 2 and gave direction for the detailed side investigation and risk assessment as well as the human health and ecological risk assessment. These will be used to develop remediation options in phase 3. Results of phase 3 will also be taken into consideration in MPMC's Comprehensive Environmental Monitoring Plan, which is required under Environmental Management Act Permit 11678.

More than 20 community meetings took place during the process in order to keep residents informed. In addition, MPMC regularly publishes so called "community updates" in order to inform about the ongoing rehabilitation work and to respond to local concerns (Imperial Metals 2017) The MOE is planning to monitor fish health and Interior Health, a publicly funded healthcare provider, is mandated to monitor the results from a human health risk perspective (Interior Health 2016).

Until June 2016, Imperial Metals (the parent company of MPMC) payed at least US $ 67 million on remediation measures (Brown 2016).

After the breach event, an independent expert engineering panel instructed by the Government of British Columbia, through the Ministry of Energy and Mine and together with the Williams Lake Indian Band and the Soda Creek Indian, started investigations regarding the root cause of breach. Their findings were published in a "Report on Mount Polley Tailings Storage Facility Breach" (Independent Expert Engineering Investigation and Review Panel 2015) in which the panel concluded that "that the dominant contribution to the failure resides in the design", which did not take into account the complexity of the sub-glacial and pre-glacial geological environment. No evidence was found that human interventions such as overtopping or piping led to the tailings dam failure. The reason for the accident was a clay layer at the base of the dam.

Figure 4-3: Rehabilitation and Remediation Strategy



Source: Own graphic based on information in Golder Associates (2016)

Return to operations

In January 2015, MPMC applied to return to restricted operations and depositing the tailings in the Springer pit (MPMC 2015a). In March 2015, a revised application with comments from the main stakeholders was accepted and allowed the company to restart production for one year with a limited throughput of 4 million tonnes of ore, which is half the amount of full operation. In June 2016, MPMC was allowed to return to full operation. The approval followed a technical review process with the Cariboo Mine Development Review Committee after a public comment period (Government of British Columbia 2016b).

Reactions of the Association of Professional Engineers and Geoscientists of British Columbia and the Mining Association of Canada

The independent expert engineering panel on the Mount Polley Tailings Storage Facility Breach recommended in its report that the mining company should move from best applicable practices in tailings management to the best available technology in case of tailings management at Mount Polley mine site. This includes improvements in corporate design, responsibilities, and the adoption of Independent Tailings Review Boards (Independent Expert Engineering Investigation and Review Panel 2015).

Following the dam breach event, the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) tightened their guidelines on dam safety and the construction of tailing ponds. The association furthermore updated their guidelines "APEGBC Professional Practice Guidelines: Site Characterization for Dam Foundations in British Columbia" (APEGB 2016) and the "Professional Practice Guidelines for Legislated Dam Safety Reviews in British Columbia". Imperial Metals is a member of the Mining association of Canada (MAC) and therefore has to apply their Towards Sustainable Mining (TSM) Framework, which is considered to be one of the leading initiatives for responsible mining. The association also began a review process of their tailings management program and guidelines following the dam breach in order to "demonstrate the Canadian mining industry's commitment to dam safety" (Jamasmie 2015). MAC improved their protocols to prevent future incidents and to restore credibility in the initiative. The International Council on Mining & Metals (ICMM) reviewed its tailings management guidelines in 2016 (ICMM 2016).

5 Governance

5.1 Sector governance, regulation and effectiveness of national institutions

Due to its federal system, the governance of the mining sector in Canada is complex. The provinces and territories have jurisdiction over mining affairs and their own Mining Acts, environmental regulations and industry related incentive or economic development programmes. In addition, the federal natural resources ministry (Natural Resources Canada) plays an important role in the governance of the mining sector. Other than that, matters specifically falling under federal jurisdiction, which are relevant for mining include aboriginal rights, nuclear energy (including uranium mining), international affairs, trade and commerce, environmental protection and conservation (shared with the provinces), railways and integrated management of ocean-related activities (Abdel-Barr and MacMillan 2016).

Ownership rights and rights to explore

The regulation of ownership rights and the right to explore is equally complex. Regulations are in place; but they differ from province to province and territory to territory. In general, private land ownership in Canada does not extend automatically to ownership of subsurface minerals. Provinces or territories are usually the owners[6] of nearly all the subsurface minerals, but miners and mining companies can obtain the right to explore and exploit subsurface resources. The requirements to obtain such rights vary from jurisdiction to jurisdiction. In some provinces and territories, licenses that permit the inspection of the surface (prospector's license or equivalent) must be obtained from the appropriate provincial or territorial government authority prior to exploration or development activities. This is the case in the Northwest Territories, Nunavut, British Columbia, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia. In the Yukon, Alberta, Saskatchewan, Prince Edward Island, Newfoundland and Labrador no prospector's license is necessary.

Across Canada, several mineral tenure systems apply to obtain a mineral title and gain the right to start extraction, depending again on the federal, provincial or territorial legislation. In some parts of Canada, it is permitted to physically claim a stake to gain the exclusive rights to explore and extract, without prior consultation (so called historical 'free-entry' system) (Hart and Hoogeveen 2012). In other parts, an online computer system replaces the physical claim staking. After the recording of a claim, an assessment report and costs estimations must be issued regularly. In general, miners or mining companies have to replace mining claims with mining leases, which are more permanent and safer (Abdel-Barr and MacMillan 2016).

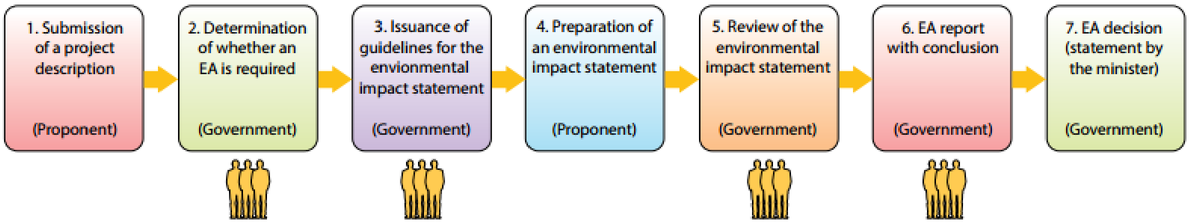
Most of the time, the owner of the land is compelled to provide access for the purpose of exploration or extraction. In case disputes between the holder of the claim and the land owner arise, most provincial and territorial legislation provides some kind of dispute resolution mechanism (Abdel-Barr and MacMillan 2016). Mining is prohibited in National Parks. In National Wildlife Areas and Migratory Bird Sanctuaries a special permission for mining is required (Hart and Hoogeveen 2012).

Environmental impacts and mining closure

With regard to environmental impacts and mine closure, regulation is less complex: In most provincial or territorial jurisdictions, miners or mining companies have to conduct an environmental assessment (EA) in the early planning phase of a major mining project. An EA follows several steps and needs to involve the public (see Figure 5-1 for an overview of the process). In addition, the Canadian Environmental Assessment Act (renewed in 2012) requires reporting to the federal government on potential environmental impacts related to federal matters such as Aboriginal peoples, fisheries, migratory birds, and cross-border impacts (Hart and Hoogeveen 2012).

[6] With exception to the Nunavut territory in which the federal government owns most mineral rights (Abdel-Barr and MacMillan 2016).

Figure 5-1: Key steps of a generic EA process and public participation



Source: Government of Canada (2016a).

Once a mine is operating, miners/mining companies are obliged to file a mine closure and rehabilitation plan (Hart and Hoogeveen 2012). However, only in some jurisdictions, a mine closure and rehabilitation plan must be developed before mining operations start (Abdel-Barr and MacMillan 2016). Further, miners or mining companies have to provide financial assurances to guarantee rehabilitation in cases of bankruptcies or mine site abandonment (Hart and Hoogeveen 2012).

Mining profits and revenue sharing

Mining profits are distributed according to the provincial, territorial and/or federal jurisdiction. Mineral taxes/royalties vary between approximately 5 to 17 per cent and are based on net revenue, net profits and/or production output. In some jurisdictions, mineral taxes/royalties are applied on a sliding scale: if the output value increases, the tax/royalty rate increases as well (Hart and Hoogeveen 2012; Abdel-Barr and MacMillan 2016). Additionally, miners or mining companies have to pay provincial corporate income taxes and federal income tax (Hart and Hoogeveen 2012).

Some provincial and all territorial jurisdictions have government resource revenue sharing (GRRS) arrangements with Indigenous communities. GRRS means, the federal or provincial/territorial government shares public revenues generated from natural resource extraction or use with indigenous communities through formal agreements (PDAC 2014). GRRS can be either project-specific agreements, which are negotiated individually for each mining project between the government and the indigenous community or integrated agreements, which are included in broader land claim treaties[7]. British Columbia has a project-specific GRRS agreement[8]; Newfoundland and Labrador, Northern Quebec, the Yukon, the Northwest Territories and Nunavut have integrated GRRS agreements; Nova Scotia, New Brunswick, Prince Edward Island, Ontario, Southern Quebec and Manitoba have no formal GRRS agreements and Saskatchewan and Alberta are opposed to GRRS (Coates 2015).

Aboriginal rights

In the Canadian case, the governance of the mining sector cannot be considered without taking into account Aboriginal people. There are over 1.4 million people who identify themselves as aboriginal and they represent 4.3 per cent of the Canadian population (Statistics Canada 2016). The Aboriginal population is made up of First Nations, Inuit and Métis. With regard to mining and indigenous rights, Canada provides strong legislations and frameworks; however, as already highlighted above in the

[7] The British Crown and later the Canadian government entered into various treaties with Aboriginal people "to define, among other things, the respective rights of Aboriginal people and governments to use and enjoy lands that Aboriginal people traditionally occupied" (Government of Canada 2010). There are historic treaties (concluded prior to 1975) and modern treaties (concluded after 1975), which are also called comprehensive land claims. In addition, there exist specific claims (also post-1975) which take effect when obligations of a historic treaty are not fulfilled. Further, the Inherent Right Policy recognizes the right of self-government for Aboriginal people which allows them to "constitute governments in their own right and, as a result, the Parties to the agreement form groundbreaking government-to-government relationships that transform how they relate to and collaborate with one another" (Government of Canada 2016b).

[8] These project-specific agreements are called Economic and Community Development Agreements (ECDA). Twenty ECDA became into being between 2010 and 2015 (Government of British Colombia 2017).

cases of ownership, the right to explore and revenue sharing, the regulations leave ambiguity and lack clear procedures which is a particular challenge in case of Aboriginal people's rights.

Mines and undeveloped deposits often lie in or close to the traditional lands of indigenous peoples. When a mine is being considered or developed in such an area, negotiations with indigenous communities are an important part of the process to ensure that their values, traditions and concerns for the land are respected. Decisions around resource use within the traditional territories of these First Nations must, by law, be preceded by meaningful consultation.

Section 35 of the 1982 Constitution Act stipulates the rights of Aboriginal peoples in Canada. Although the section leaves ambiguity[9], emblematic Supreme Court cases interpreted these rights and established the so-called duty to consult. In 2011, the federal government published guidelines on how to manage the consultation process in the federal context (Government of Canada 2011). The guidelines stipulate that the federal government and its agencies state should rely on existing consultation mechanisms, such as environmental assessment processes (Government of Canada 2011).

The provinces and territories have their own legal approaches on if and how Aboriginal peoples should be consulted – in some jurisdictions there are no or only community-specific policies, in others only draft or interim guidelines (Bains and Ishkanian 2016). According to a Supreme Court decision, governments can delegate the consultation process to the proponent of the mining project (Bains and Ishkanian 2016). Yet, most jurisdictions do not have clear procedures on how the delegation of consultation should work (Bains and Ishkanian 2016).

Already in its 1996 Mining and Metals Policy, the federal government encourages the "collaboration between the industry and Aboriginal communities related to local mineral development" (Government of Canada 1996). Yet, there is no legal framework for such collaboration. In practice, mining companies often negotiate individual agreements with affected indigenous groups in order to establish formal relationships and gain community support (Abdel-Barr and MacMillan 2016; Hart and Hoogeveen 2012). These agreements can be made at any stage of the life-cycle of a mining project and have different names, such as impact and benefit agreement, participation agreements, cooperation agreements, memorandum of understanding or socio-economic agreement (Government of Canada 2016a). Company-community agreements often include provisions on economic and business opportunities, employment and training options, financial provisions, social and cultural community support, environmental issues (Government of Canada 2016a). As of 2015, there were 384 active agreements between the industry and indigenous communities across Canada (Government of Canada 2015a).

This regulatory patchwork leaves many uncertainties for indigenous communities as well as the project proponents, which increases the potential for conflicts (Bains and Ishkanian 2016).

Mt Polley: A governance failure?

The question of what the dam breach at the Mt Polley Mine tells us about the sector governance in Canada is not easy to answer. Opinions differ if the dam breach also points to governance problems or gaps. The Mount Polley Mining Company constructed the dam in compliance with all official requirements. The root causes of the breach were identified by the office of the Chief Inspector of Mines for the Province of British Columbia, resulting from investigations carried out from August 2014 through November of 2015 as organizational in nature, which started with faulty foundation studies, the misplaced faith in these studies and overconfidence in the reliance on professional judgement, a narrow planning perspective in mine management, and a failure to adequately understand and act on risk (Ministry of Energy and Mines 2015). Norbert Morgenstern, who was head of independent expert engineering panel summarised in an interview with the newspaper The Globe and Mail (Hunter and

[9] The Section states that "The existing aboriginal and treaty rights of the aboriginal peoples of Canada are hereby recognized and affirmed". However, it does not define what the existing aboriginal rights are.

Hume 2015) that "the failure at Mount Polley can be traced to the original design, and government inspections could not have detected the fault. However, the panel is recommending a tougher regulatory environment, stricter design requirements and the use of independent review boards to oversee tailings facilities and improve safety." The opposition leader John Horgan highlights that the report suggests a failure in governance, as the design of the dam was amended 13 times and when doing this, the government had the opportunity to revisit the design in order to prevent an accident (Hunter and Hume 2015). In conclusion, the dam breach seems to have had multiple and interlinked causes that were primarily organizational in nature, but the chain of failure might have been stopped if additional review mechanisms would have been in place. If the missing review mechanisms or the failure of the government to detect the faulty design can be called a governance failure or gap, is disputed and a final answer based on the available data is not possible.

5.2 Social context of mining and conflicts

As of 2015, there were 96 operating metal mining projects in Canada in which gold and/or copper were extracted (Government of Canada 2015b). Conflicts around gold and copper mining projects are not as prevalent as for example around the extraction of oil sands. However, there have been conflicts around gold and/or copper mining, most of them closely linked to indigenous matters. Three cases, which received public attention over the past years, two of them located in British Columbia and one in Quebec will be briefly outlined in the following sub-chapter. The first case illustrates issues around consultation processes and the second and third case issues around compensation mechanisms. In addition, conflicts around the Mount Polley project will be reviewed.

In British Columbia, conflict arose around the proposed The Prosperity mine project and The New Prosperity mine project, both proposed by the Canadian mining company Taseko Mines. In 2006, Taseko Mines proposed The Prosperity mine, a large open-pit gold-copper mine located in the Fish Lake watershed. Part of the planned mining project was to drain the nearby Fish Lake to fill it with waste rock and use Little Fish Lake as tailing pond (Taseko Mines 2017; British Columbia EAO 2014). The Environmental Assessment Office of British Columbia conducted an EA and concluded in January 2010 that the project would not have any significant adverse effects except the loss of Fish Lake and Little Fish Lake. Therefore, the government of British Columbia authorised the project (British Columbia EAO 2014). However, in July 2010, a federal EA came to a different conclusions and found that the project would have several significant adverse effects, e.g. on fish, grizzly bears, on navigation, on the current land and resource use practices by First Nations and their cultural heritage (West Coast Environmental Law 2010). On these grounds, the federal government rejected The Prosperity mine project. Subsequently, Taseko Mines proposed The New Prosperity mine project. In October 2013, a new federal EA still found various significant adverse effects and in February 2014 the federal Ministry of Environment and the Governor in Council did not authorise the amended project (British Columbia EAO 2014). In reaction, Taseko Mines commenced two Judicial Reviews and filed a civil claim in the B.C . Supreme Court to challenge the federal government's decisions (Taseko Mines 2017). In June 2016, the government of British Columbia granted a new lease on life to Taseko Mines and gave the company a new chance to obtain an environmental certificate (Hume 2016). This case highlights the issues arising from the complex governance structures in Canada and the apparent differences between the EAs on the federal and provincial governments, the lack of consultation between the two, and – at the time of conducting the EAs[10], a lack of a harmonised EA process (Gage 2010). It also shows that EAs are meaningful instruments of consultation, both for social and environmental issues, and raising concerns of indigenous populations.

The second case in British Columbia is the Highland Valley Copper Mine. Since 1962, the large open-pit copper mine is operating in the traditional territory of several Nlaka'pamux First Nations (The Globe

[10] In 2012 Canada's federal environmental assessment law was re-written which changed the number and scope of assessments in order to improve Canada's environmental assessment processes.

and Mail 2013). Only about 40 years later, the company and the provincial government started engaging with the local First Nations. After several years of negotiations, the Nkala'pamux Nation Tribal Council (NNTC), representing five First Nations, and the provincial government decided a GRRS agreement and provisions for future community involvement in decisions linked to the Highland Valley Copper Mine and other businesses on their territory. The GRRS agreement stipulates 37.5 per cent of the mineral tax revenue originating from the mine to be shared amongst the NNTC First Nations (Burgmann 2014). Further, the provincial government invested 550,000 Canadian dollars in an 18-months pilot phase in which a technical working group and a shared decision-making board were set up (British Columbia 2014). In 2016, the last Nlaka'pamux First Nation, which is not affiliated with the NNTC, reached a GRRS agreement with the province and a separate agreement with Teck, the operating mining company (British Columbia 2016). The GRRS agreement comprises an initial payment of 557,000 Canadian dollars, annual payments based on the mineral tax generated by the mine and the establishment of a collaborative consultation process between the First Nation, the provincial government and the company (British Columbia 2016). The community-company agreement established cooperation arrangements on employment, business opportunities and environmental and cultural heritage issues (British Columbia 2016). In total, 15 First Nations negotiated agreements related to the Highland Valley Copper Mine (British Columbia 2016). These individually negotiated agreements are one way of establishing relationships with First Nations and are part of a long-term reconciliation and compensation process (Burgmann 2013). This second case highlights again, that there are mechanisms for the engagement of indigenous people in place, however, as clear procedures and guidelines are missing, the outcomes of the agreements differ from case to case.

The third case is the Innu First Nation's longstanding lawsuit against the Iron Ore Company of Canada's development initiatives in Quebec and Labrador of which Rio Tinto is the major shareholder. The mine is operating since the late 1940s and is a major producer of iron ore (Iron Ore Company of Canada 2013). In this case, no individual agreements with the province or the company could be reached (Pay the Rent 2017). As a reaction, the Innu First Nation engaged in litigation against Rio Tinto, suing the company for historical damages since the beginning of mining operations and wanting the operations to stop (Pay the Rent 2017). They demanded 900 million Canadian dollars in compensation. So far, Iron Ore Company of Canada/Rio Tinto received four setbacks at different judicial authorities, but the case is still pending (CNW 2016; van der Linde 2016). This case shows that challenges exist regarding the process of reaching GRRS, which can result in inaction or stalemate. However, it also shows that there are other judicial mechanisms in place to address existing conflicts.

Mount Polley is regulated by the Province under the Environmental Management Act, the Water Act and other legislation implemented by the British Columbian Ministries of Energy and Mines, Environment and Forests, as well as the Ministry of Lands and Natural Resource Operations. The main Federal regulation affecting the mine is the Fisheries Act. It aims at protecting fish habitat and includes an annex regulating the deposition of mining waste into fish-bearing waters (BCMEM 2015). For the Mount Polley case, research in national, regional and local newspapers[11] showed that there was very little or no reporting on the Mount Polley mine prior to the tailing facility breach. The Williams Lake Indian Band and the Soda Creek Indian Band (Xatsull First Nation) are two First Nations that are in the immediate surroundings of the Mount Polley mine. In 2011 and 2012, prior to the breach, the two First Nations signed participation agreements with Imperial Metals (Imperial Metals 2016). In 2013, both First Nations entered into a GRRS agreement with the provincial government, related to the expansion of the mine (Government of British Columbia 2013). After the breach, these two First Nations signed a letter of understanding with the provincial government to cooperate to address the impacts of the failed tailings facility, including the establishment of several cooperation committees and financial

[11] The online versions of the following newspapers were searched: The Globe and Mail and National Post (national newspapers), Vancouver Sun (regional newspaper) and The Williams Lake Tribune and the Quesnel Observer (local newspapers).

compensation (Government of British Columbia 2014a). The Mount Polley mine reopened in June 2016, after having spent over 70 million Canadian dollars for remediation and restoration (Bailey 2016). However, some Aboriginal social movements opposed the reopening of the Mount Polley mine. They engaged in protests and launched the #imperialnomore campaign (Imperial No More 2016; Eagland 2016). Nevertheless, the case of the Mount Polley mine seems to be an example for working conflict prevention measures, even after a mining accident.

As the section on governance and the described cases show, there are several ways for conflict management or compensation to address mining-related grievances. These mechanisms evolved over time and vary across federal, provincial and territorial legislation, creating a complex system of regulatory instruments. This complex system is working for the most part and highlights Canada's overall strong governance and effective institutions. However, it also shows that challenges and issues arise where regulation is unclear or leaves space for interpretation. It also underlines the important and active role First Nations take in arguing for their rights, negotiating agreements and suing companies.

6 Conclusion and comparison of the analysis with existing governance indices

In this final chapter, the findings of chapter 4 (potential for environmental hazards and environmental impacts) and chapter 5 (governance analysis) are analysed to answer the research questions:

- Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?
- Are existing governance indices and indicators able to adequately reflect the governance capability to cope with the challenges arising around the environmental hazard potentials and environmental impacts of mining? In other words, are the identified governance gaps reflected in existing governance indices and indicators?

In order to answer the second question, a number of indices and indicators (see Table 6-1) were chosen based on a screening of a wide range of existing governance, environmental governance, and peace and conflict indices.

The results of this case study will be compared with the results of nine additional case studies that are conducted as part of this project as well as the case studies conducted in UmSoRess and OekoRess I. By comparing the findings of the case studies, a set of governance indicators will be identified that can be used to improve the assessment approach to analyse the potential for environmental hazards of the OekoRess I project.

Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?

Within the site-related OekoRess methodology, a tailings storage facility with a structural height of 15 m above ground level is regarded as medium to large and is categorized as having a high environmental hazard potential for the indicator "mining waste management". As the processed slurry in Mount Polley was stored in a tailings storage facility with a structural height between 17 and 45 m, it fell into the category of medium to large tailings dam structures. Regardless of the actual tailings dam breach, the risk for such an event was estimated as high and adequately reflected the potential for environmental hazards. However, the methodology does not include site-specific geologic characteristics, such as the probability of clay lenses in the underground, which was, as it was undetected, the cause of the accident. Including such information would be very complex and lies beyond what an indicator-based methodology can achieve.

Main findings of the governance analysis

The case of the Mount Polley mine breach shows that standards and regulations to prevent such accidents are in place in Canada. However, they could be improved by stricter regulation regarding dam design and an independent review mechanism. The question if the accident points towards a governance gap is disputed and could not be answered. In general, the governance analysis underlines Canada's overall strong sector governance. Nevertheless, it also shows that in some cases its federal system leaves unclear areas and space for interpretation that lead to conflicts, which are mostly solved by the existing conflict management mechanisms.

Do existing governance indicators reflect Canada's governance gaps and challenges?

Canada's overall strong sector governance is well reflected in key governance and development indices: Canada's Human Development Index (HDI) is very high showing Canada's high level in key dimensions of human development (UNDP 2014). Furthermore, the set of displayed Worldwide Governance Indicators (WGI) all rank Canada very high (90th percentile) (World Bank 2016). The WGI indicators "Rule of Law", "Government Effectiveness", and "Regulatory Quality" reflect Canada's overall strong sector governance. This is also reflected in Canada's high scores in the Environmental Performance

Index (EPI) which displays Canada's performance regarding the protection of human health and protection of ecosystems: Canada ranks 25 out of 178, scoring 85.06 out of 100 (Yale University n.d.). However, these indicators do not reflect the very specific challenges in Canada, for example the existence of review mechanisms for dam safety. Furthermore, these indicators and indices measure only the national level and thus seem to not reflect the challenges arising from Canada's federal system.

The same is true for the Investment Attractiveness Index surveyed yearly by the Fraser Institute. The index is an overall investment attractiveness index, which is based on a country's geologic attractiveness and a measurement of the effects of government policy on attitudes towards exploration investment (Fraser Institute 2016). Canada has the most attractive policy environment of all countries assessed, and is the second most attractive country in the world for mining investment, thus also reflecting Canada's overall strong governance in the mining sector. In contrast to the other indices and indicators, the Fraser Investment Attractiveness Index provides also data for the subnational level. While the subnational data also reflects the overall strong sector governance, it also shows significant differences between provinces. This fact seems to reflect the challenges created by Canada's federal system. Looking at the underlying interviews provided by the Fraser Institute, these clearly point out uncertainties concerning disputed land claims and uncertainty over the protection of certain areas for British Columbia (Fraser Institute 2016). However, the Fraser Investment Attractiveness Index provides only subnational data for Canada, the United States of America, Argentina and Australia.

The Global Peace Index (GPI) displays a country's level of peacefulness according to a ranking in three domains: ongoing and internal conflicts, levels of harmony or discord within a nation and a country's militarisation. Canada's state of peace is rated very high (on a scale from very high to very low) which seem to reflect the country's peacefulness well (IEP 2016). However, the index accounts for the whole country, and is not able to reflect subnational differences and regional or sector-specific conflicts. Even with a focus only on the domain of ongoing domestic and international conflicts which could reflect mining-related conflicts, the indicators taken into account for this domain of the index are that diverse and numerous, that no sector-specific or regional conclusion can be drawn.

An index which might reflect the sometimes missing procedures and gaps within Canada's overall governance is the Environmental Democracy Index (EDI), where Canada only ranks 35 out of 70 (fair scoring; WRI 2019b). The EDI indicates the "degree to which countries have enacted legally binding rules that provide for environmental information collection and disclosure, public participation across a range of environmental decisions, and fair, affordable, and independent avenues for seeking justice and challenging decisions that impact the environment" (WRI 2019a). Within EDI, Canada scored well on the Justice pillar, and fair on the Transparency and Participation pillars (WRI 2019c)). The fair scoring arises from a lack of legal requirements for timely information disclosure during environmental emergencies and very limited national legal protections to ensure public rights to participate in environmental decision-making (WRI 2019c). Furthermore, the public has certainly a broad legal standing to bring environmental claims and can obtain a range of remedies when environmental rights are violated, but there are very limited mechanisms to remove financial or gender-based barriers to justice (WRI 2019c)). However, even though the EDI assessment is limited to national-level laws, regulations, and practices and explicitly does not assess laws and regulations at a sub-national level, it is unclear if the "very limited national legal protections to ensure public rights to participate in environmental decision making" does indeed reflect the governance challenges arising from Canada's federal system. Furthermore, the EDI is only available for 70 countries and can therefore not be used for a global assessment methodology.

Conclusion

Canada's overall strong sector governance is well reflected in key governance and development indices like the HDI, the Worldwide Governance Indicators or the EPI. However, the existing indices and indicators show a very limited ability to reflect the very specific and nuanced governance challenges of

Canada. Two indices seem to be able to capture some of the more specific challenges, but have other limitations and problems. The significant differences between provinces in Investment Attractiveness Index of the Fraser Institute seem to reflect the challenges created by Canada's federal system. However, subnational data is only available for four countries. The EDI might be able to reflect these challenges as well, but the available information provided did not offer conclusive evidence to this end and will have to be tested as part of the following nine case studies.

Furthermore, the case study shows that even in one of the best ranked governance contexts globally, a comparatively small mine with only little economic value can cause significant environmental impacts, owing to e.g. failures in design of tailing breaches or failures in the monitoring of accidents. Yet, due to Canada's strong governance in the sector, incidents like this can be managed – in comparison to other countries – relatively well. Nevertheless, the environmental impacts were significant. However, the event led to stricter regulations and better practice in the future. In case of Mount Polley, Government regulations on dam safety were tightened and became stricter. The TSM-Framework and ICMM guidelines were reviewed and APEGBC tightened their guidelines on tailings storage facilities.

Table 6-1: Governance indicators Canada

Index/Indicator	Canada	Year	Index/Indicator measures…	Applicability
Human Development Index (HDI)	0.913 (very high human development, rank 9)	2014	Average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions	Reflects well the overall very high development and standard of living in Canada.
Environmental Performance Index (EPI)	Rank 25 of 178, Score 85.06 (out of 100)	2016	Measures the performance of countries on high priority environmental issues in two areas: protection of human health and protection of ecosystems.	Reflects well the overall strong governance in the environmental sector. Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Fraser Investment Attractiveness Index	Most attractive policy environment (rank 1), second most attractive region in the world for mining investment (rank 2)	2016	The overall investment attractiveness which is based on a country's geologic attractiveness and a measurement of the effects of government policy on attitudes towards exploration investment	Reflects well the overall strong governance in the mining sector. The significant differences between provinces seem to reflect the challenges created by Canada's federal system. Sub-national data is only available for Canada, the United States of America, Argentina and Australia and therefore it cannot be used for a global assessment methodology.
Environmental Democracy Index (EDI)	Rank 35 of 70, Score 1.48 (fair)	2015	The degree to which countries have enacted legally binding rules that provide for environmental information collection and disclosure, public participation across a range of environmental decisions, and fair, affordable, and	Might be able to reflect the very specific and nuanced governance challenges of Canada, but the available information provided did not provide conclusive evidence to this end and will have to be tested as part of the following 9 case studies.

Index/Indicator	Canada	Year	Index/Indicator measures…	Applicability
			independent avenues for seeking justice and challenging decisions that impact the environment.	Data is only available for 70 countries and therefore cannot be used for a global assessment methodology.
Voice and Accountability (WGI)	1.44 (estimate between -2.5 and 2.5); 96.1 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Voice and Accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	Reflects well the overall strong governance. Does not reflect the specific challenges in terms of varying legislations across federal states and provinces and participation. The available information did not explain why the WGI and the EDI indicate different outcomes for Canada in terms of participation. However, the EDI has a particular focus on environmental issues, which the WGI does not.
Political Stability and Absence of Violence (WGI)	1.2 (estimate between -2.5 and 2.5) 93.8 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Reflects well the overall strong governance. Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Government Effectiveness (WGI)	1.77 (estimate between -2.5 and 2.5) 95.2 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Reflects well the overall strong governance. Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Regulatory Quality (WGI)	1.71 (estimate between -2.5 and 2.5)	2015	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit	Reflects well the overall strong governance.

Index/Indicator	Canada	Year	Index/Indicator measures…	Applicability
	94.2 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)		and promote private sector development.	Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Rule of Law (WGI)	1.84 (estimate between -2.5 and 2.5) 95.2 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	Reflects well the overall strong governance. Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Control of Corruption (WGI)	1.85 (estimate between -2.5 and 2.5); 93.8 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	Reflects well the overall strong governance. Very limited ability to reflect the very specific and nuanced governance challenges of Canada
Global Peace Index (GPI)	1.388 (very high, scale of 1-5, overall rank 8)	2016	Countries' level of peacefulness.	Reflects the situation in Canada well.

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