



Maturing the concept of small-scale mining (SSM) in the Global North using concept evaluation criteria on the placer mining industry in Yukon, Canada[☆]

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ABSTRACT

An empirical study of the placer gold mining industry in Yukon, Canada reveals how small-scale mining relates to large-scale and artisanal-scale mining, historically in the Global North and in the contemporary global context. This work significantly matures the concept of small-scale mining (SSM), despite its conflation with neighbouring concept ASM. Archival and ethnographic data gathered from the industry, community, and government informants (2021 and 2022) was interpreted using Concept Evaluation Criteria, which looks at definitions, characteristics, boundaries, and preconditions and outcomes. Legislation in Yukon does not specifically separate SSM from large-scale mining (LSM) by definition, however, it does offer differentiated governance according to deposit type (i.e., Placer Mining Act). A characteristic of SSM is full legalization and formalization, however, formalization is only possible if accessible legal frameworks exist (precondition). Formalization is possible through proactive governance, and industry-community-government dynamism. Market-protective legal frameworks effectively preclude SSM from participating in stock markets but small-enterprises use independent capital, or can access alternative sources of capital to evolve into medium-scale enterprises. The Yukon's slower, smaller mining industries have endured despite the co-existence of large-scale operations and they play an active role in modern wealth distributions, economic diversification, and sustained rural economies resilient to boom-bust economies. The implications of the research are considered in the context of diversification of mining and sociological solutions to diversify responsible access to ore deposits.

1. Introduction

This research explores the concept of small-scale mining (SSM) in the Global North, focusing on a region in Yukon, Canada, where industry self-describes as 'small-scale mining'. The term "Global North"¹ denotes high-income nations, and "Global South" refers to low-medium income nations (Hickel et al., 2022). In the Global South, the smaller scales of mining are credited as diversifying rural livelihoods and economies by mitigating poverty (Fisher et al., 2009), sustaining rural populations, and deterring urban migration (Huntington and Marple-Cantrell, 2022). Additionally, they exhibit resistance to boom and bust commodity life cycles more effectively than large-scale mining (LSM) (Heemskerck, 2001; Quirke et al., 2019). Much less is known about the smaller scales

of mining in the Global North.

The literature about SSM in the Global North is limited to research of: 'modern small-scale mining' in medium income nations in Europe (Moore et al., 2021; Sidorenko et al., 2020; Sydd et al., 2022, 2023); technological innovations for mechanically separating fine gold from Yukon ores (Clarkson, 1994); how technology might be diffused in the Global South (Clarkson et al., 2017); the colonial and negative environmental impacts of the artisanal-scale mining (ASM) in the Klondike Gold Rush and subsequent large-scale placer mining on the First Nations People from 1896 to 1966 (Green, 2018). The authors are not aware of any peer-reviewed literature that specifically investigates contemporary, endogenous SSM or artisanal-scale mining (ASM) in high-income nations. This study seeks to comprehend why smaller scales of mining

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¹ The Global South encompasses low and medium income nations, sometimes referred to as 'developing' or 'Third World' (Dados and Connell, 2012), and are considered 'not-advanced' by the International Monetary Fund (IMF), and as 'recipient nations' by the Organization for Economic Cooperation and Development (OECD) (Hickel et al., 2022). In contrast, the Global North includes high-income nations, considered 'advanced' by the IMF and as 'donor nations' by OECD (Hickel et al., 2022). Global North includes Western and Northern Europe, USA, Canada, New Zealand, Australia, Japan, Israel, South Korea, Taiwan, Singapore, Hong Kong, and a subset of island nations (Hickel et al., 2022).

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are often overlooked in Global North contexts and whether they contribute positively to rural economies, akin to the impacts cited for the Global South.

ASM is broadly understood as poverty-driven mining that uses simple methodologies and tools for resource extraction, and is predominantly informal (World Bank, 2020). SSM is a closely related concept that denotes a more entrepreneurial-driven mining that is semi-mechanized. Less is understood about SSM, and it is often considered collectively with ASM (World Bank, 2009). SSM and ASM are crucial rural livelihoods for over 40 million people in the Global South (Hilson et al., 2019; World Bank, 2019). Because ASM is generally perceived as a poverty-driven activity predominant in low to medium-income nations, we make the assumption that poverty-driven mining may not be as prevalent in the Global North. We refrain from combining ASM and SSM to acknowledge developmental inequalities. Large-scale mining (LSM) is industrial mining using highly sophisticated technologies and methodologies, (Bernaudat, 2022; World Bank, 2020). LSM employees approximately 7 million people globally (Fritz et al., 2017).

To explore SSM in the Global North we identify a *concept location*, where the concept naturally occurs and can be studied using qualitative methodologies (Morse, 2017). Once the concept location is selected, the concept can be analysed using a Concept Evaluation Framework, which explores a concept's definition, characteristics, pre-conditions and outcomes, and boundaries (Morse, 2017). This paper considers the relationship between ASM, SSM, and LSM, because it is necessary in conceptual development to identify boundaries between related concepts. We argue that conceptualization of SSM is foundational to academic study, and may have different challenges and opportunities compared to the ASM and LSM concepts. Our methodology, employing the Concept Evaluation Framework, enables us to investigate formalization of SSM, the potential roles of SSM in rural development, and why the smaller scales of mining are largely missing from the Global North.

Our concept location is Yukon, Canada (Fig. 1), where the placer gold mining industry has persisted for over 100 years, famously known by the 18th/19th century Klondike Gold Rush which consisted of ASM (Canavesio and Pardieu, 2019; Telmer and Persaud, 2013). Yukon's modern placer gold mining industry has been referred to as ASM in grey literature (Veiga, 1997). More often though, grey literature refers to Yukon placer mining industry as 'small-scale mining' (SSM) (Bond and van Loon, 2018; CIRDI, 2018; Thompson, 2018). Because placer gold mining has included ASM of the Klondike Gold Rush (Canavesio and Pardieu, 2019), industrial large-scale placer mining (LSM) (Robinson, 2017), and contemporary SSM, Yukon is an ideal concept location to study the scales of mining and the boundaries between related concepts.

2. Scales of mining

Concept evaluation involves exploring boundaries between similar concepts, as noted by Morse (2017). To comprehensively understand SSM concept, our review necessitates delving into the current literature on artisanal and small-scale mining (ASM), small-scale mining (SSM), and large-scale mining (LSM). This paper builds upon Sidorenko et al.'s (2020) foundational work, highlighting the importance of separating ASM, SSM, and LSM.

Table 1 summarises the prevalent definitions of SSM, globally. Sidorenko et al. (2020) explained the need for a concept of modern SSM, using the European concept location of Bosnia and Herzegovina which is classified as a Global South nation (Hickel et al., 2022; Kertcher, 2023). The "modern SSM" concept was proposed to access complex, high-grade deposit types (particularly for critical metals) that are generally not amenable to LSM operations using sophisticated and bespoke technologies (Beylot et al., 2021; Moore et al., 2020; Sidorenko et al., 2020). The communities in Bosnia and Herzegovina were unfamiliar with SSM concept, but were familiar with LSM which supported generations of employment (Moore et al., 2021; Sidorenko et al., 2020; Sydd et al.,

2022).

Large-scale mining (LSM, Table 2) is industrial mining (Fritz et al., 2017), operating with large capital and sophisticated technologies to create 'economies of scale' and to access expansive low-grade and/or deep, complex deposits (Bernaudat, 2022; Sidorenko et al., 2020). LSM is more mechanical than human, producing 80% of the world's gold with a lean workforce (Bernaudat, 2022) and, in 2013, there were a recorded 7 million people employed by LSM, compared to over 40 million ASM workers (Fritz et al., 2017). This means that approximately 17.5% of those employed in the global mining industry have the lion's share of profit from the global gold mineral industries.

Sidorenko et al. (2020) highlight a historical tendency to use "ASM" as an umbrella term encompassing both "artisanal small-scale" and "small-scale mining", essentially treating them as interchangeable concepts. Recognizing the necessity for precision, they advocated for separating "SSM" from "ASM" for the European context (Sidorenko et al., 2020). This stance is challenged by Hilson and McQuilken (2014), who criticize early attempts to separate 'artisanal mining' and 'small-scale mining' in international policy documents as mundane and fruitless. They suggest focus should be placed on their role in development (2014, p. 106). The absence of an internationally agreed definition of ASM has attributed to its "dynamic characteristics, context-specific nature and lack of distinct boundaries between diverse types of artisanal and small-scale operations" (McQuilken and Hilson, 2016, p. 10).

SSM (Table 1) has been identified as separate from ASM in a few locations in the Global South, with evidence from South America and Sub-Saharan Africa (Cortés-McPherson, 2019; Seccatore et al., 2014a, 2014b). These literatures suggest boundaries between ASM and SSM relate to production rates (lower in ASM), labour intensity and poverty drivers (ASM), and semi-mechanization and entrepreneurial-driver (SSM) (Cortés-McPherson, 2019; Seccatore et al., 2014a, 2014b). An intermediate "Evolved ASM" (Table 1) is identified in sub-Saharan Africa, that has limited access to more advanced methodologies and technologies and financial barriers to formalization (Hilson and Maco-nachie, 2020a, p. 149). While ASM is often described as low-tech, labour intensive, poverty driven and predominantly informal mining that takes place in the Global South (Table 3), it operated in the Global North during the gold rushes of the 18th and 19th centuries, including the Klondike Gold Rush (Canavesio and Pardieu, 2019) and continues in contemporary Global North contexts (e.g. Veiga, Table 3).

While LSM is active globally (Table 2), ASM and SSM predominantly operate in the Global South (Table 3, Table 1), such that geographical disparity equates to a general wealth disparity associated with mining. We assert that industrial operators experience unique challenges and can leverage different opportunities in the Global North and Global South, which demonstrates that a simple single concept of artisanal and small-scale mining (ASM) is not ubiquitously applicable. Moreover, characterizing both Yukon's historic and modern placer gold mining industry as 'artisanal' might be a misnomer, as it currently fails to encompass the poverty-driven and informal aspects that characterize ASM studied in the Global South (Table 3). We assert that it is important to differentiate ASM from SSM due to potential conceptual variations and development contexts. Emphasizing the importance of clarity in terminology, our stance aims to contribute to a more nuanced understanding of ASM and SSM in the broader course of development.

None of the modern (European) SSM, ASM and LSM concepts in the literature adequately represent placer mining in Yukon but modern mining practitioners and related stakeholders in Yukon self-describe as operating within SSM, such that analysis of their perspectives may provide conceptual clarity. According to the available definitions of the scales of mining, legalization and formalization are characteristics of ASM, SSM, and LSM, which represent an important boundary. Legalization and formalization are related but separate. Legalization of an industry refers to the regulatory framework that exists (McQuilken and Hilson, 2016). The formalization of an industry goes beyond regulatory frameworks, and refers to the ability of the practitioners to successfully

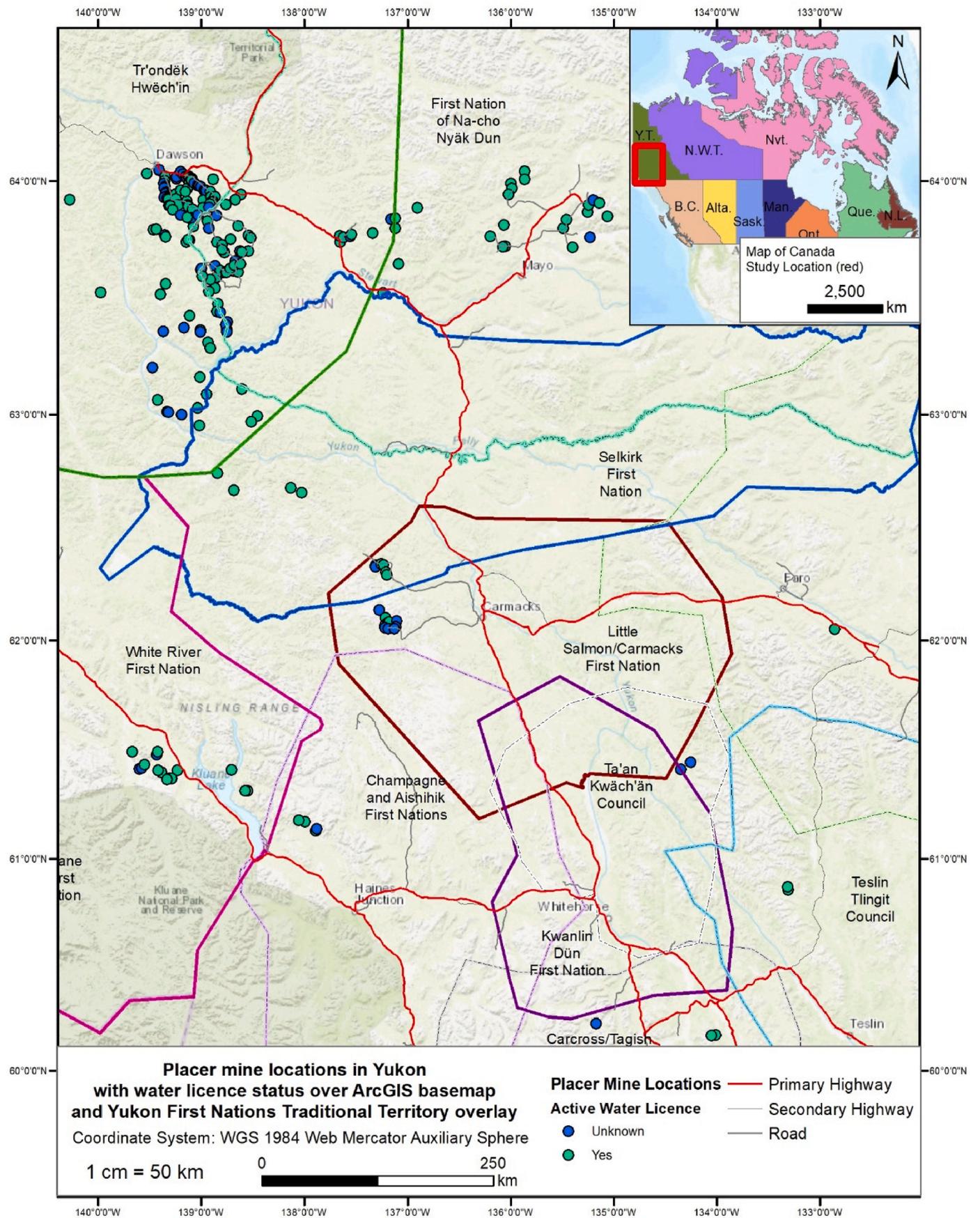


Fig. 1. Map of Traditional Territories and placer mine locations with active water licences (Bond and van Loon, 2018). An active water licence does not necessarily mean the mine is operational and a single miner can have multiple water licences.

Table 1
Existing definitions SSM.

Scale	Definition or description	Context	Source
SSM	From an artisanal origin, the miners diversified their labour force, mechanized their operations, and began to accumulate capital. More so, they also penetrated the political arena.	South America	(Cortés-McPherson, 2019, pp. 382–383)
SSM	Small-Scale Mining (SSM) is a mining activity producing less than 100,000 t/a ROM [t per day in the Run-of-Mine production] for profit. Artisanal Mining is a subset of the previous, where operation does not follow the conventional ecological and engineering principles of mining and uses rudimentary or basic simple techniques to extract minerals.	South America	(Seccatore et al., 2014b, p. 663)
Evolved ASM	A small number of individuals who have managed to overcome crippling financial barriers to secure titles to mine using more advanced technology.	Sub-Saharan Africa	(Hilson and Maconachie, 2020a, p. 149)
SSM	Modern SSM is extraction from ore or mineral deposits using low-impact, potentially short-term, small-footprint, regulated mining operations and technologies that are usually not labour-intensive.	Europe	(Sidorenko et al., 2020, p. 4)

Table 2
Example definitions of Large-Scale Mining (LSM).

Scale	Definition	Context	Source
LSM	LSM is extraction from ore or mineral deposits by companies with substantial labour forces that are employed across large sites, working a deposit using (technologically) optimized approaches to develop economies of scale.	Global	(Sidorenko et al., 2020, p. 4)
LSM	[Large-scale gold mining] is the domain of large mining companies. It is present on all continents and while it produces 80% of the world’s gold output, it is largely mechanized activity with a lean workforce structure. It can access deep, complex and/or lower-grade deposits, which are unreachable or unfeasible to its ASGM counterparts. In recent years, LSM has had to comply with a number of due diligence criteria in order to sell its gold to international markets (e.g., Dodd Frank, EU Conflict Minerals regulation)	Global	Bernaumat (2022)

operate while meeting government mandates. Formalization also refers to the extent in which those regulatory frameworks are successfully activated, implemented and enforced by the government (McQuilken and Hilson, 2016). ASM is described as predominantly informal with varying degrees of legality, LSM is described as formal and legal, and SSM is described as formalized in the European context with varying degrees of formality and legality in others.

The scales of mining have a relation to scales of enterprise, which relate to formalization and legalization (Echavarria, 2017; Sidorenko et al., 2020). For example, Colombia is described to have LSM and ASM

Table 3
Definitions of the ASM.

Scale	Definition	Context	Source
ASM	The term artisanal miner is preferred to be used as a simple way to encompass all small, medium, large, informal, legal, and illegal miners who use rudimentary processes to extract gold from secondary and primary ore bodies. ... there are thousands of “artisanal” miners [in Canada and the USA], applying their own mining and processing concepts to extract gold from placers ... [Or are] geochemical explorers who [se] primary intention [is] staking claims to sell to mining companies ... [Or] the weekend planner.	Global; North America	(Veiga, 1997, p. 4)
ASM	“Formal or informal mining operations with predominantly simplified forms of exploration, extraction, processing, and transportation. ASM is normally low capital intensive and uses high labour-intensive technology. “ASM” can include men and women working on an individual basis as well as those working in family groups, in partnership, or as members of cooperatives or other types of legal associations and enterprises involving hundreds or even thousands of miners. For example, it is common for work groups of 4–10 individuals, sometimes in family units, to share tasks at one single point of mineral extraction (e.g., excavating one tunnel). At the organisational level, groups of 30–300 miners are common, extracting jointly one mineral deposit (e.g., working in different tunnels), and sometimes sharing processing facilities.”	Global, Global South Emphasis	OECD (2016)
ASM	Artisanal mining (ASM) is extraction from ore or mineral deposits by formal or informal mining operations with low investment and the use of technologies that are highly labour intensive. The scale of mining can either be small (relating to self-employed status of mine workers) or large (relating to the size of the collective and/or deposit).	Global South	(Sidorenko et al., 2020, p. 4)
ASM	A collective term embracing both small-scale and artisanal mining. It covers formal or informal mining, which is characterized by low capital intensity and high labour intensity and relatively simple methods for exploration, extraction and processing. ASGM can involve men and women working on an individual basis as well as those working in family groups, in partnerships or as members of co-operatives or other types of association. This does not include activities which are criminal, such as trespassing or armed incursions into active mining areas to steal mined or processed materials, or organized schemes involving employees to steal refined or processed material.’	Global South Emphasis	(World Gold Council, 2022, p. 11)

operations, but is criticized for having policy and governmental frameworks that give preferential treatment to LSM (Rodríguez-Novoa and Holley, 2023). There has been an attempt to mitigate this in Columbia by promoting and protecting small and medium enterprises (SME) in rural spaces, including mining (Echavarría, 2017). Kemp and Owen (2019, p. 1) explain that LSM is the main beneficiary of structural adjustment and neoliberal economic reforms, arguing that poor governance exacerbates underlying problems for ASM. If large-enterprise have reduced formalization barriers compared to smaller enterprises, in mineral production, it is important to understand enterprise size in context.

In Canada, enterprise size is categorized by number of employees and by revenue (Table 4). There is a lack of research focusing on formal mining activity that is operated by micro, small, and medium enterprises, particularly social and environmental (Aryee et al., 2003; Hilson, 2001; Sidorenko et al., 2020). The biases in research focus, and spheres of influence associated with revenue generation explain interchangeability of the terms of ASM and SSM, whereby the smaller industries are rendered largely invisible by comparison to LSM (Sidorenko et al., 2020, p. 4). The focus on LSM builds narratives of the mining industry, such as discourses on environmental and social sustainability (de Villiers et al., 2014; Fonseca et al., 2014; Sidorenko et al., 2020).

3. Methodology and concept evaluation criteria

This research centres on placer gold mining in Yukon, Canada. The case study was conducted on the Traditional Territories of the Tr'ondëk Hwëch'in, Na-Cho Nyak Dun, White River, and Selkirk Nations, proximal to the municipalities of Dawson City, Whitehorse, Mayo, and Pelly River (Fig. 1). The fieldwork (July–October 2021, June–July 2022) was conducted using ethnographic and archival methodologies. This research was approved by the University of Exeter Ethics Committee (ECORN003518 2.1). A research licence by the Yukon Government was granted for 2021 and 2022. A data sharing agreement was signed with the Tr'ondëk Hwëch'in First Nation Government in 2023.

Archival research took place at the Yukon Archives, the Energy, Mines and Resources (EMR) library in Whitehorse, the Dawson City Museum, and the following Parks Canada interpretive programs: Dredge No. 4 (guided tour); Bear Creek Compound (guided tour); Red Serge, Red Tape: From Tr'ondëk to Klondike (guided tour), and; the Adventurous Life of Robert Service. Numerous placards and information sites implemented by Parks Canada were also visited. Participatory, interview and observation data were collected during visits to 20 placer mines, and the 2021 Klondike Placer Miners Association Annual Meeting.

There were 32 semi-structured interviews conducted both in person and virtually (Table 5). The primary focus group for semi-structured interviews comprised livelihood stakeholders to understand the industry using a bottom-up approach. Within this focus group, the term *floating pool of professionals* is used to describe consultants with skills specific to the placer industry, who are well known and trusted throughout the community.

The government/policy stakeholders comprised the second largest focus group, who develop and enforce the regulatory environment within which the miners work. This group consists of those with governance power such as the Yukon Territory Government from the Ministry of Energy, Mines and Resources, the Water Board, and First

Table 4
Enterprise types in Canada defined on employees and revenue (Government of Canada, 2015).

Enterprise Type	Employees	Revenue
Micro	1–4	<\$30,000
Small	5–99	\$30,000 to \$5 million
Medium	100–499	\$5 million and \$25 million
Large	500+	>25 million

Nations Governments with active placer mining on their Territories (Fig. 1). The governance/policy group also have individuals who do not have governing decision power including the Yukon Geological Survey, Parks Canada, Yukon Social and Economic Board, and Dawson Land Use Planning representatives. There are two tribunals in Yukon consisting of representatives from Territorial, Federal, and First Nations Governments, which are the Water Board (governing), and the Yukon Social and Economic Board (YESAB, non-governing, advising).

Measures were taken to increase anonymity of interviewee participation, as shown in the footnotes. Because Territorial Government agencies are small, they are not individually identified to protect the privacy of the interviewees, and are instead divided into governing and non-governing. First Nations Governments who work within natural resources are also small teams, and will be acknowledged as separate First Nations Governments, but not specified by the Nation to protect privacy of the interviewees, unless specifically agreed upon by the Nation. The Water Board and YESAB Tribunals will not be identified, and will be called 'Tribunals'. Additional anonymized stakeholder groups comprised 2 supplier businesses and one university researcher (Table 5).

Concepts are foundational to theory and play a critical role in research across multiple fields, being considered “the building blocks of law” (Ginsburg and Stephanopoulos, 2017, p. 147) and central to the ability of scholars to “intellectually frame issues and formulate theories” (Berenskoetter, 2016, p. 1). The Concept Evaluation Criteria Framework was developed in the field of nursing to subjectively isolate concepts that are used commonly by the ‘layperson’ without being well-understood (Morse et al., 1996). Methodologies for conceptual development in nursing are necessarily people- and community-focused, such that transfer into the sphere of mining can centre the experience-based knowledge of individual mining practitioners and other participants in the mining value chain.

Concept Evaluation Criteria classifies concepts as *immature*, *emerging*, and *mature* (Morse et al., 1996) (Fig. 2). Observation and archival research used to support the interview data and provide context specific to the concept location were analysed the same way. The first author's ten-year experience as an exploration geologist gives constructivist insight into LSM boundaries. The case study data were used to examine the SSM concept, based on four criteria: (1) definitions; (2) characteristics; (3) preconditions and outcomes; and (4) boundaries (Fig. 2). Measures to ensure that there was no unintentional bias were anonymity and an Excel-based analysis of representation of stakeholder populations.

The first author conducted interviews, transcribed and anonymized the data. Each pieces of text were then deductively coded using keywords, often resulting in multiple codes (Table 6). The data were then organized into broad themes reflecting the key words. The data was extracted from interview transcripts and organized in a spreadsheets under themes, which included scales of mining, governance/policy, technology/methodology, culture, economics, history, environment, and geology. Another spreadsheet was developed to organize these themes into Concept Evaluation Criteria data used to develop the concept (Fig. 2, Table 6). Definitions were identified in data organized under ‘scale’. Characteristics were recognized in data organized in the societal/cultural, governance/policy, technology/methodology, and economics themes. Boundaries were recognized with data organized under scale, as well as the same spreadsheets used for characteristics that focused on ASM and LSM. Pre-conditions and outcomes were identified under the policy/governance, society/culture, planetary (environment, geology). To enhance robustness and validity of data, co-authors independently reviewed the Concept Evaluation Criteria spreadsheet summarizing the data used in this paper, ensuring comprehensive and reliable interpretation of findings.

Table 5

Summary of respondents to semi-structured interviews, by stakeholder group and diversity characteristics. 2 of 21 direct livelihood interviewees are also associated with the Klondike Placer Miners Association

Total Interview Count	Overarching Stakeholder Group	Interview Count	Detailed Stakeholder Group	Yukon Citizen	Indigenous Person	Woman identifying
9	Government and/or policy employees	2	First Nations Governments	1	1	0
		3	Yukon Territorial Government	3	0	1
		1	Canadian Federal Government	1	0	0
		2	Tribunals	2	0	1
		1	Municipal Governments	1	0	0
21	Direct Livelihood	18	Miners (owners, operators, and workers)	10	1	2
		3	Floating pool of professionals	2	1	1
2	Suppliers	1	Equipment suppliers	0	0	0
		1	Provisions and supplies	1	0	0
		1	University	1	0	0

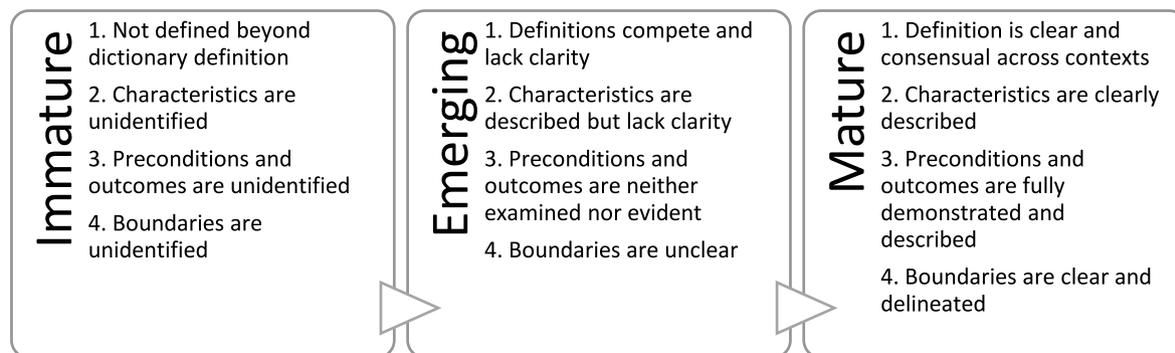


Fig. 2. Concept evaluation criteria (1–4) provide a framework that differentiates immature, emerging, and mature concepts (modified from Morse et al., 1996).

Table 6

Example of inductive coding using thematic analysis, and deductive coding using Concept Evaluation Criteria.

Interviewee	Quote	Code	Theme	Evaluation Criteria Code
Placer miner owner and operator, Dawson City, 2021 (Interview M2168)	Yeah, in my mind, everything that happens in the entire Yukon of placer mining is small scale. Like all of our production doesn't equal one large hard rock mine combined. And so I think that if that's the sense that you mean about small scale, then yeah, that's where we fit.	Small-Scale; Production; Hard-Rock Mine; Placer Mine	Scale, Economics, Geology	Definition, Characteristics, Boundaries
Placer miner owner and operator, Mine Site, 2022 (Interview M2252)	If a big corporation came in here, they wouldn't make it ... because they got too much overhead, too many people. And I'll tell you what, they'll just tear the ground apart, and it'll just end up worthless. As a little miner, I got to dial in ... it's so tight ... if a large corporation came in with 100 people, they would tear the ground apart, and they wouldn't make any money.	Big corporation; Overhead; too many people; Tear the ground apart; Worthless; Little miner; Large corporation; Wouldn't make money	Scale, Economics, Culture, Environment	Characteristics; Boundaries
Placer miner owner and operator, Mine Site, 2021 (Interview M2168)	"There's like a big market for gold. I don't have to go try to sell ... muffins to people. I would not do very well in a consumer based job. I'm not really a salesman, or people person. One on one I'm fine, but I wouldn't want to be dealing with customers. Yeah, the lack of customers, I like that out here.	Big market; I'm not really a salesman; Customers; Wouldn't want to deal with customers	Economics, Culture	Characteristics, Pre-condition
Supplier, Dawson City, 2022 (Interview S2248)	Interviewee: "Well, hard rock and placer are totally different. Totally, totally different. And with placer mining now, you have reclamation. Look at [placer miner, name retracted], he built the lake just off the highway that we get to enjoy. There's always one or two bad apples out there, but I think there's a lot of reputable mining outfits." Interviewer: "Like they're really in the community?" Interviewee: "Well, sure. He lives here. [Name retracted, placer miner's spouse] is First Nations, Tr'ondek Hwëch'in, his wife."	Hard Rock; Placer mining; Reclamation, First Nations; He Lives Here	Scale, Geology, Culture, Technology/ Methodology	Definition, Characteristics, Boundaries, Outcomes
Supplier, virtual interview, 2022 (Interview S2281)	"... but the grade [in placer mining] is much different and the processes involved are much simpler than it is for a hard rock operation."	Placer Mining; Grade; Processes are much simpler; Hard-rock	Technology/ methodology, Geology, Scale	Characteristics, Boundaries, Pre-conditions

4. Case-study results

4.1. Criteria one: definitions

A definition is the label of a concept, enabling reference, communication, identification, and recognition (Morse et al., 1996). In this section, we look at how the scales of mining are defined in the concept location of Yukon, Canada.

Legal literature do not use the scales of mining as definitions. A separate set of definitions are used to govern mining in the Yukon and provide important contextual information.

- The Placer Mining Act describes placer mining as inclusive of ‘every mode and method of working whatever whereby earth, soil, gravel, or cement may be removed, washed, or refined or otherwise dealt with, for the purpose of obtaining gold or other precious minerals or stones, but does not include the working of rock on the site’ (Yukon Government, 2003a, p. 2).
- The Quartz Mining Act defines quartz mining as “any land in which any vein, lode, or rock in place is mined for gold or other minerals, precious or base” (Yukon Government, 2003b, p. 7). It equates to hard-rock mining.

Placer deposits are secondary deposit types, termed alluvial in other places. Archival research demonstrates that the term SSM in Yukon is often used interchangeably with placer mining, but that the two are not synonymous. The Yukon Geological Survey (YGS) uses the term “small-scale” to describe operations within the territory (Bond and van Loon, 2018). International development organizations also use the term “small-scale” in reference to Yukon’s placer mining industry, and have developed knowledge exchange programs with other nations to facilitate mercury-free processing programs (Bond and van Loon, 2019; CIRDI, 2018). Media such as newspapers, magazines, and reality television programs also use the term “small-scale” to describe Yukon’s placer operations (Fuller, 2016; Gignac, 2020; Newsome, 2017; Thompson, 2018).

Quartz-deposits are primary deposit types, and are sometimes called hard-rock deposits. The media also use the term quartz -mining interchangeably with “large-scale mining” in Yukon (Hiyatel, 2018; Thompson, 2018) but the two terms are not synonymous, and many places around the world have non-LSM hard-rock mining.

The general association between deposit type and scale also emerge in the interview data when ‘definitions’ are probed. When the interviewee respondents were asked to define placer mining they would describe placer mining as ‘small-scale’ and quartz-mining as ‘large-scale’.^{2,3,4} When asked about definitions of ‘artisanal mining’, many miners were familiar with it, but defined it as mining that happens predominantly in the Global South or with the Klondike Gold Rush hand-miners.^{5,6} When asked if anyone practiced contemporary hand-mining today, the answers varied. As one stakeholder stated: “I think ... you can extrapolate that they’re all hand mining. They just use excavators”.⁷ Additionally, both interview data⁸ and archival research showed that ‘hand mining’ during the 18th and 19th centuries was technologically simple, labour intensive, and in part poverty driven (Gould, 2001; MacBride Museum of Yukon History, n.d.). This is further supported by Telmer and Persaud who liken contemporary ASM and the

hand mining of the Klondike Gold Rush (2013).

4.2. Criteria two: characteristics

A concept maintains consistent characteristics, which may manifest differently in various contexts (Morse et al., 1996). A non-exhaustive list of characteristics can be collected from literature definitions (Table 1; Table 2; Table 3). These characteristics include societal/cultural aspects (e.g., workforce and drivers), economic factors (e.g., capital expenditures and entrepreneurialism levels), technological complexity and mechanization (e.g., basic to advanced, labour intensive to fully mechanized), and governance aspects (e.g., degrees of legality and formality).

4.2.1. Societal/cultural characteristics of Yukon’s SSM industry

Archive and interview results show a variety of cultural characteristics of Yukon’s placer mining industry, particularly the family-run aspect and multi-generational characteristics.^{9,10,11,12,13} When one interviewee was asked how placer mining would be best described, they responded with: “We’re family-ran operations. You know, your kids grew up there, and your family is there. And it’s just, it’s not run like a hard-rock mine. It’s not corporate... So, it’s kind of like farmers, right? You have to do everything.”¹⁴ There is a strong pattern of association between placer mining and other rural livelihoods in Yukon.^{15,16} In Yukon, this relationship includes agriculture and ranching, outdoor sporting (e.g. guided expeditions), trapping, construction, aggregate, fishing, LSM, and forestry. Interviewees associate placer mining independent lifestyles, and human-nature connection, and a lack of corporate culture.¹⁷

4.2.2. The legality and formality of Yukon’s SSM industry

SSM is currently only observed in Yukon’s placer mining industry, not the quartz-mining industry, which are governed by separate mining acts. In this section, we explore how Yukon’s placer mining industry is completely legalized and formalized using the legal literature and archives, and interview data.

Legislation in the concept location is a joint process between Yukon’s First Nations and Territorial Governments, and governance frameworks involve multiple stakeholders. There are 14 unique First Nations in Yukon (Council of Yukon First Nations, 1990; Nadasdy, 2012), and 11 are self-governing; each with separate governance models and executive and legislative powers over their territory (Council of Yukon First Nations, 1990; Nadasdy, 2012; Yukon Government, 2021a). There are two tribunals of First Nations, Territorial, and Federal Government representatives: the Water Board and the Yukon Social and Economic Assessment Board (YESAB) (YESAB, 2021; Yukon Water Board, 2020).

The Placer Mining Act governs mining in 4 distinct classes of placer mining, which have different legally-binding communication channels (Yukon Government, 2023a), under the Yukon Economic and Social Assessment Act, and the Water Act. Class 1 mining requires miners to give notification to First Nations Governments and/or groups and the Territorial Government (Yukon Government, 2020). Classes 2–4 require an application to the Yukon Economic and Social Assessment Board, and Classes 3–4 require an application to the Water Board (Yukon Government, 2023a).

⁹ Government Official (Territory - non-governing), virtual call, 2021 (Interview G21108).

¹⁰ Floating professional, Whitehorse, 2021 (Interview P2162).

¹¹ Placer miner owner and operator, Dawson City, 2022 (Interview M2248).

¹² Placer miner owner and operator, Dawson City, 2022 (Interview M2255).

¹³ Floating professional, Whitehorse, 2021 (Interview P2157).

¹⁴ Placer miner owner and operator, Dawson City, 2021 (Interview M2170).

¹⁵ Placer miner owner and operator, Dawson City, 2022 (Interview M2255).

¹⁶ Placer miner owner and operator, Dawson City, 2022 (Interview M2248).

¹⁷ Floating professional, virtual interview, 2022 (Interview P2171).

² Placer miner owner and operator, Dawson City, 2021 (Interview M2168).

³ Government Official (First Nation Government A), Yukon, 2022 (Interview G2191).

⁴ Placer miner owner and operator, Dawson City, 2021 (Interview M2150).

⁵ Placer miner owner and goldsmith, Dawson City, 2022 (Interview M2234).

⁶ Placer miner owner and operator, Dawson City, 2021 (Interview M2170).

⁷ Floating professional, Whitehorse, 2021 (Interview P2157).

⁸ Placer miner owner and goldsmith, Dawson City, 2022 (Interview M2234).

Current mining legislation was first enacted in 1906 (Yukon Government, 2003a). The Placer Mining Act is under public scrutiny, especially regarding the low royalties for both Territorial and First Nation Governments and open-staking practices (e.g., Gignac, 2020). Following devolution of Yukon from Canada in 1990, the Final Umbrella Agreement was signed in 1993 (Council of Yukon First Nations, 1990; Yukon Government, 1993). The Final Umbrella Agreement is not a legally binding, but it provides a framework for Yukon First Nations and Territorial Governments to negotiate and conclude Yukon First Nation Final Agreements (Council of Yukon First Nations, n.d., p. 4). The Final Umbrella Agreement requires amendment of the Placer and Quartz Mining Acts (see section 12.3.5 Yukon Government, 1993) and rewriting is underway by the First Nations and Territorial Governments (Yukon Government, 2021b). Renewing both of the mining Acts is necessary as part of the Final Umbrella Agreement (Council of Yukon First Nations, 1990).¹⁸

The Tr'ondëk Hwëch'in Government's Mining Mandate outlines mining activities active within their territory on Crown Land, but not Settlement Land. This document specifies that the Tr'ondëk Hwëch'in Government supports responsible mining, meaning mining that does not compromise the environment, culture, communities, or the exercise of their aboriginal rights (Tr'ondëk Hwëch'in Government, 2011, p. 2). Like all Governments, the Tr'ondëk Hwëch'in Government expects to share in the economic opportunities and wealth that come from mining projects within their territory that are undertaken by a company with publicly traded shares; that have potential to affect Tr'ondëk Hwëch'in Rights and interests, and that have gross annual expenditures and revenues of over \$2,000,000 (Tr'ondëk Hwëch'in Government, 2011, p. 3).

Through interview data, we gain insight into the Yukon placer miners' and governments' attitudes about the dynamic formalization process enabling miners to operate legally within the existing regulatory frameworks, and the governments to change, activate, implement, and enforce the laws. As one miner interviewee said, "give us regulations, but make them enforceable, so that the inspectors aren't ... turning a blind eye ... make it so the miner can monitor things for [themselves]."¹⁹ The dynamism is demonstrated by recently introduced environmental stewardship policies, i.e. the sediment load and fish habitat reclamation policies (Yukon Placer Secretariat, 2010), and wetland policies (Yukon Government, 2023b). Following concerns about sediment load in streams, the placer miners learned how to check their pond turbidity using the Imhoff cone, an intermediate technology for onsite measurements²⁰, as well as develop workable solutions for water use,²¹ and fish habitat.²²

Yukon's placer miners and governments dynamic formalization approach is tempered by concerns that the industry may be stifled by excessive technocratic regulations.²³ Miners often draw parallels with the experience of New Zealand's placer mining industry, which suffered due to stringent environmental regulations that proved unattainable for their 'alluvial' miners. This situation prompted miners and related tradespeople to ship their equipment and migrate to Yukon to continue

their work.^{24,25,26,27,28,29,30} Although the migration of miners from New Zealand to Yukon in the 1990s is documented in interview data, there are no statistics available to investigate this quantitatively. The fear is that combining the Placer and Quartz Mining Acts will force small enterprises (Table 4) out of the industry.^{31,32,33} This underscores the need for enforceable regulation with structural support tailored to the specific contexts and scales of mining operations.

The Klondike Placer Miners Association (see KPMA, 2022) is a mining community stakeholder group that has adopted a role in guiding formalization of the placer mining industry. At the time of this research, the KPMA is operated by one paid employee and a board of volunteers who are active placer miners. The KPMA is funded by community sponsorship, through local businesses, Yukon Government, Victoria Gold (an LSM company), and membership fees (KPMA, 2022). The KPMA offers members access to training programs that they design reflecting the needs of the industry, as well as standards such as Health and Safety protocols. As an interviewee stated prior to publication of the Wetland Policy in 2023 (Yukon Government, 2023b):

[We] offer carrots over sticks and try and get people to improve and help them to do that as best as they can. The government has done a really bad job at providing guidance and support to the industry to improve or even to set a standard. There are no reclamation guidelines. There are no wetland policies. There are no wetland guidelines. And yet we're having restrictions put in without even knowing what has been good or bad up till now ...

So it's very, very difficult to expect a miner who's alone all summer, doing what they believe is the right thing, and then just shut them down for no reason. They have to know what they're doing wrong and how they can do it right. It's really frustrating. But ... they are trying to do a good job. It's not that the government is out to get us; they're not. They've done a bad job at this, but it doesn't mean that they're doing a bad job [in general]. It's just, it's a hole, and unfortunately, we're [the KPMA] filling it. It shouldn't be up to us to fill it, but it is, and so we're doing it.³⁴

The Yukon Geological Survey (YGS) aids in the formalization process as well by: 1) developing scientific studies and providing scientific input; 2) documenting the industry in biannual reports (e.g., Bond and van Loon, 2018), and; 3) understanding environmental concerns, such as those involving wetland classification (e.g., Bond, 2018). Both the KPMA and YGS work involves significant fieldwork, becoming trusted experts who serve as an anchoring point for industry questions and concerns.

4.2.3. Economic metrics

This section delves into placer mining's moderate economic profile, and explores the interplay between production, revenue, and enterprise (Table 4) while addressing the constraints on accessing capital in

¹⁸ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

¹⁹ Placer miner owner and operator, telephone interview, 2021 (Interview M21103).

²⁰ Placer miner owner and operator, telephone interview, 2021 (Interview M21103).

²¹ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

²² Placer miner owner and operator, Dawson City, 2021 (Interview M2170).

²³ Floating professional, Whitehorse, 2021 (Interview P2157).

²⁴ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

²⁵ Government Official (Tribunal B), virtual interview, 2022 (Interview G2269).

²⁶ Supplier, virtual interview, 2022 (Interview S2281).

²⁷ Placer miner owner and operator, Dawson City, 2022 (Interview M2255).

²⁸ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

²⁹ Government Official (First Nation Government C), email exchange (email G2149).

³⁰ Government Official (First Nation Government C), email exchange (email G2149).

³¹ Placer miner owner and operator, Dawson City, 2021 (Interview M2150).

³² Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

³³ Hard rock prospector and placer hobbyist; Whitehorse, 2022 (Interview M2293).

³⁴ Floating professional, Whitehorse, 2021 (Interview P2157).

modern placer mining. Interview data highlighted the contrast in capital access between placer and quartz mining, primarily due to the National-Instrument 43–101 (NI-43-101).³⁵ The NI-43-101 regulates the disclosure of technical and scientific information by Canadian mineral company's, enabling them to raise funds on stock exchanges for projects within and beyond Canadian borders (British Columbia Securities Commission, 2023; Canadian Securities Administrators, 2011). This regulation emerged in the 1990s as a response to fraudulent mineral projects that had adversely affected stock markets (Hiyatel, 2009; Parianos et al., 2021).

However, the NI-43-101 is generally unsuitable for placer mining as it demands technical resource estimates, necessitating extensive and costly drill programs and involvement of 'Qualified People' (QPs). Disclosure regulations are also incongruent with geological nature of placer deposits, given the complexities in resource calculation in the unconsolidated deposit types with a significant nugget affect.³⁶ An interviewee noted, "In placer mining ... to achieve the most basic classification of the ore deposit ... it is more expensive than mining the damn thing."³⁷ The placer mining industry predominantly operates with independent capital,^{38,39} and extensive drilling programs to prove resources are beyond economic and technical thresholds, which limits access to the regulatory frameworks for investment and thereby to the stock market. Some interviewees who have been in Yukon since the 1960s and 1970s reported that before the NI-43-101, there were multiple small quartz mining operations throughout the territory that were independently funded.⁴⁰

In 2015, the industry consisted of 108 active mines (Kishchuk, 2018). The industry's total expenditure was \$60.5 million, allocated to labour (29%), fuel and equipment (19%), equipment maintenance and camp supplies (18%), regulatory (13%), and accounting (2%) (Kishchuk, 2018). Of the 17 miners interviewed, all began using personal finances or on a family-owned mine, and 15 remain financially independent. They stress the contrast between mining with their own funds and external market funds, expressing "we're not on the stock market ... It's not other people's money; it's our money. It's a big difference."⁴¹

Initial and operating capitals for placer mining are significantly smaller than quartz-mining operations with stock market access. For instance, Victoria Gold, a NI-43-101 compliant quartz-mining company in Yukon, reported a 2021 revenue of C\$ 284,366,680; the initial capital expenditure was C\$1389 million; and the operating expenditure was C\$1603 million (JDS Energy and Mining Inc, 2019).

Production is an economic metric revealing the placer mining industry resilience over time (Bond and van Loon, 2021). In the Yukon, the 2017 collective gold production from approximately 108 mines amounted to 72,464 crude ounces (of which includes 57,971 fine ounces) (Bond and van Loon, 2018, p. 5). Individual placer mines exhibit varying production rates, ranging from modest rates like 5 yd³/h,⁴² to more substantial rates, such as 100 yd³/h (Bond and van Loon, 2018, p. 97) to approximately 200 yd³/h.⁴³ One of the largest placer operators interviewed reported a production of approximately 8000 ounces per year (roughly 10% of industry production),^{44,45} Some miners are known to slow production if the price of gold is high, and miners often

seek low-grade material first, essentially saving their high grade material, to prolong their livelihood longer. As an interviewee described:

"Some ... operations, who have known claims and a relatively stable pay streak throughout the claims, can work that for three decades more. If they go at the pace that they're going. And if gold goes up, they usually work less, because they don't want to mine themselves out. They love doing this work. They love the land. They love being out in the field, so they want to keep doing it" (Floating Professional, Whitehorse, 2022 (Interview P2157))

While the mines are seasonal, and individual mine licences are relatively short (ten years), the average tenure of ground is 25 years (Kishchuk, 2018), and the cumulative life of placer mine can extend beyond a century. For example, Miller Creek Mining, a placer mine, produced approximately 108,000 ounces over 130 years, from 1887 to 2017 (Bond and van Loon, 2018, p. 145). This cumulative life of mine is 10 times longer than the estimated life of mine for the quartz-mining operation Victoria Gold, which is expected to produce 200,000 ounces annually over a 13-year span (Victoria Gold Corp, 2019). The annual production at Victoria Gold is, however, significantly larger than the cumulative production of 108 placer mines but the distribution of wealth by small enterprise (Table 4) mining plays a significant role in Yukon's economic diversification. Placer mining is an important rural livelihood in Yukon, where 49.1% of employment is public sector (Yukon Bureau of Statistics, 2022).

The certainty of any statement about the revenue of the 108 placer mines (perhaps barring profits from reality television franchises and operations partnered with quartz-mining companies) relative to revenue of Victoria Gold's Eagle Gold Mine is speculative: the placer mines are private companies, organized as either incorporated and unincorporated partnerships, or sole proprietorship (Kishchuk, 2018), and therefore public financial disclosure is neither required (Yong et al., 2021) nor available. Although revenue data from individual placer mines are not available, interview data from the Klondike Placer Miners Association indicate that the vast majority of placer miners are small enterprise and medium-enterprises, or SMEs (Table 4).⁴⁶

4.2.4. Technological sophistication and mine life cycle

The mine life cycle comprises five stages: exploration, development, operations, reclamation, and closure. In placer mining, the cycle is rapid and short lived, averaging 5–8 years, as per KPMA interview data.⁴⁷ Typically, mine owners are engaged in every stage, but the industry increasingly relies on the *floating pool of professionals* for technical and bureaucratic aspects.⁴⁸ In addition, the KPMA and the non-governing government bodies like the YGS provide expertise when necessary.

The data shows that Yukon's placer miners have a deep knowledge of their technologies⁴⁹ and the mine life cycle.⁵⁰ Due to the remote locations, miners must have technological skills to operate machinery, maintain, repair, and sometimes build equipment.⁵¹ Intermediate technologies, also called appropriate technologies, are accessible to owners to purchase, construct, maintain, repair and operate (Schumacher, 1973, 2010). While larger placer operations employ specialized staff like heavy equipment operators, smaller operation miners take on multiple roles.

The industry leans towards mechanization, but specific hand-methods remain crucial throughout the mine life cycle. Legal requirements, such as in-person lease and claims staking and trail cutting with hand tools, necessitate hand-methods (Yukon Government, 2023a).

³⁵ Floating professional, Whitehorse, 2021 (Interview P2162).

³⁶ Government Official (Territory, non-governing), virtual interview, 2021 (Interview G22118).

³⁷ Floating professional, Whitehorse, 2021 (Interview P2162).

³⁸ Placer miner owner and operator, Mine Site, 2022 (Interview M2252).

³⁹ Supplier, virtual interview, 2022 (Interview S2281).

⁴⁰ Placer miner owner and operator, Mine Site, 2022 (Interview M2275).

⁴¹ Placer miner owner and operator, Mine Site, 2022 (Interview M2252).

⁴² Placer miner owner and operator, Mine Site, 2022 (Interview M2275).

⁴³ Supplier, virtual interview, 2022 (Interview S2281).

⁴⁴ Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

⁴⁵ Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

⁴⁶ KPMA Representative, virtual exchange, (Interview KPMA01).

⁴⁷ Floating professional, Whitehorse, 2021 (Interview P2157).

⁴⁸ Floating professional, Whitehorse, 2021 (Interview P2157).

⁴⁹ Floating professional, Whitehorse, 2021 (Interview P2162).

⁵⁰ Floating professional, Whitehorse, 2021 (Interview P2157).

⁵¹ Placer miner owner and operator, Dawson City, 2022 (Interview M2255).

Hand-methods also play a significant role in gold-processing since small machines like long-toms, sluices, and rocker boxes rely on manual design, construction, and labour. Panning is a continuous practice in the mine-life cycle, ensuring consistent grade assessment and aiding decision making in mine development.⁵²

4.3. Criteria three: boundaries

The boundaries between neighbouring concepts are crucial as characteristics can change over time (Morse et al., 1996). Understanding the dynamic boundaries between mining concepts, as seen in Yukon's placer gold industry, is vital. Yukon's placer mining industry history involves both ASM and LSM operations. Additionally, Yukon's quartz mining features large-capital LSM mining, aiding boundary delineation. While SSM is currently the industry term, considering medium-scale mining (MSM) for larger placer operations may be more accurate. Mining scales are flexible, with blurred boundaries affected by factors like governance, economics, and stressors. Key factors affecting scale shifts include access to capital, land, resources, technology and engagement with formalization process.

In interviews, quartz and placer mining boundaries are discussed,^{53,54} An interview from the quartz-mining industry pointed out the significant scale difference. They stated how placer mining begins small with individual mining claims and can progressively scale up. Nonetheless, even the largest placer projects pale in scale compared to quartz-mines.⁵⁵ Some interviewees noted variations within the placer mining industry, with scales ranging from small-scale to very large operations.⁵⁶

While every miner considers the industry small-scale, some government officials disagree. Government officials who dispute the characterization of placer mining as small-scale rely on quantifiable measures to make their arguments, such as number of employees, footprint, production, and collective impacts.^{57,58} Some interviewees argued that labeling certain operations in the gold fields⁵⁹ as small-scale as misleading, as it depends on factors such as equipment and material volumes.^{60,61} They emphasized that certain operations genuinely qualify as small-scale. Another respondent was surprised by the notion of placer mining as small-scale, highlighting that while some individual operations might be small, others span hundreds of hectares.⁶² Moreover, the collective footprint of placer mining is likely significant (e.g., Fig. 1). Examples cited include Indian River,^{63,64,65} Reality-Television Mines, and those in the gold fields proximal to Dawson City.⁶⁶

⁵² Floating professional, Whitehorse, 2021 (Interview P2157).

⁵³ Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

⁵⁴ Placer miner owner and operator, Dawson City, 2022 (Interview M2255).

⁵⁵ Researcher, virtual interview, 2023 (Interview Rch23.77).

⁵⁶ Government Official (First Nation Government C), email correspondence (email G2149).

⁵⁷ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

⁵⁸ Government Official (TRIBUNAL B), virtual interview, 2022 (Interview G2269).

⁵⁹ A geographical term referring to the placer mines proximal to Dawson City (Fig. 1).

⁶⁰ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

⁶¹ Supplier, virtual interview, 2022 (Interview S2281).

⁶² Government Official (First Nation Government C), email correspondence (email G2149).

⁶³ Government Official (First Nation Government C), email correspondence (email G2149).

⁶⁴ Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

⁶⁵ Hard rock prospector and placer hobbyist; Whitehorse, 2022 (Interview M2293).

⁶⁶ Observation Notes (2021, 2022).

Big business growth (Table 4) is generally not the desired outcome of placer miners, who articulate distaste for corporate culture associated with large enterprise,^{67,68} and describe a characteristic disconnect from stock markets.⁶⁹ Another miner compared the nature of SSM and LSM, saying "Well, if a big corporation came in here, they wouldn't make it ... because they got too much overhead, too many people ... As a little miner, I got to dial in ... it's so tight ... if a large corporation came in with 100 people, they would tear the ground apart, and they wouldn't make any money."⁷⁰ Access to capital is a prominent boundary condition, recognized by respondents. An interviewee stated: "Large scale mining is corporate backed, right? That's Wall Street It's completely different".⁷¹ The effective capital-capping by the NI-43-101 reinforces the role of small enterprises (Table 4) in placer mining.

However, well-established and experienced (largely MSM rather than SSM) placer miners can gain access to third party finance when buying equipment from certain suppliers, not available to more inexperienced 'starting placer miners'.⁷² There are other notable exceptions where placer mining operations do have capital that is perhaps comparable to LSM, including placer mine operations that are associated with Reality Television Companies, placer miner operations who have partnerships with quartz-mining companies who do have access to the public market, and mines owned by private investors who hire local placer miners to operate.

According to Forbes Magazine, the *Gold Rush* franchise is the highest-rated series for Discovery Incorporated (Berk, 2022). Economics change when reality television companies are involved, as equipment is often sponsored and salaries are given to at least some of the miners. In partnerships between quartz-operations and placer operations, the former develop NI-43-101s and can spend the raised capital on their placer claims. There are three examples of quartz-mine exploration companies who also have placer claims,^{73,74,75} one of which owns the largest amount of placer claims in the Territory, and hire placer miners to operate them (e.g., *Metallic Minerals Corporation, 2024*). Private companies also sometimes hire local placer miners to manage their company mines, so the miners are no longer working with their own independent capital.⁷⁶

Technologies are a defining boundary in the scales of mining. Historically, 'hand miners' of the 18th and 19th century employed simple, manual methods (Gould, 2001). Interviewee results also recount early methodologies and technologies employed by miners' parents and grandparents, which primarily relied on manual labour in the 1940s, 50s, and 60s.⁷⁷ In contrast, large-scale placer mining introduced sophisticated technologies that were financially and operationally inaccessible to the independent hand miners (Johnson, 2012). In contrast, SSM employs intermediate technologies and methodologies, and rely on semi to mostly mechanized processes.^{78,79,80,81,82} These technologies

⁶⁷ Floating professional, virtual interview, 2022 (Interview P2171).

⁶⁸ Placer miner owner and operator, Dawson City, 2021 (Interview M2245).

⁶⁹ Placer mine worker, Dawson City, 2021 (Interview W2180).

⁷⁰ Placer miner owner and operator, Mine Site, 2022 (Interview M2252).

⁷¹ Placer mine worker, Dawson City, 2021 (Interview W2180).

⁷² Supplier, virtual interview, 2022 (Interview S2281).

⁷³ Floating professional, Whitehorse, 2021 (Interview P2157).

⁷⁴ Government Official (Territory, non-governing), virtual interview, 2021 (Interview G22118).

⁷⁵ Placer mine worker, Dawson City, 2021 (Interview W2180).

⁷⁶ Placer miner owner and operator, telephone interview, 2021 (Interview M21103).

⁷⁷ Placer miner owner and operator, telephone interview, 2021 (Interview M21103).

⁷⁸ Placer miner owner and operator, Dawson City, 2022 (Interview M2245).

⁷⁹ Placer miner owner and operator, Dawson City, 2022 (Interview M2245).

⁸⁰ Placer miner owner and operator, Mine Site, 2022 (Interview M2269).

⁸¹ Placer miner owner and operator, Mine Site, 2022 (Interview M2275).

⁸² Observation notes (2021, 2022).

are more accessible, as miners can acquire, operate, and maintain equipment or share with neighbours. Intermediate technologies also assist miners in self-regulation, as exemplified with the Imhoff cone explained in legality/formality subsection of 4.2. Technological sophistication distinguishes mining scales; if it exceeds miners' capabilities, it may shift towards medium-scale mining (MSM). For instance, if a company secures financing for a CAD\$1.5 million wash plant, it leans towards MSM. SSM technologies and methodologies differ significantly from LSM, which demand qualified people, geochemical labs, and NI-43-101 compliant plans.

Yukon's SSM industry is fully formalized, distinguishing it from predominantly informal ASM (Fritz et al., 2017). The Territorial and First Nations Governments work proactively with the placer mining industry (through the KPMA and YGS) to enhance formalization with industry-wide standards and stewardship. These initiatives, informed by miners' experiences, cover areas such as health and safety, sexual harassment protocols, and environmental stewardship. These standards and new ideas are communicated through tools such as the Placer Miners App for mobile phones.⁸³ The formalization boundary between ASM and SSM benefits from access to *floating pool of professionals* and expertise from the YGS. In contrast, LSM companies maintain permanent teams of accredited experts (e.g., lawyers, accountants, ESG professionals, and environmental scientists) to ensure legal compliance and technological optimization to adhere to highly complex geological models, design detailed community relations strategies, and to adhere to NI-43-101 standards.

4.4. Criteria four: preconditions and outcomes (consequences)

The criteria for concept evaluation (Fig. 2) indicate that concepts should share similar preconditions and outcomes (Morse et al., 1996). Preconditions to SSM in Yukon encompass suitable geology, enabling governance and policy structures, market presence, and existing infrastructure. In Yukon, the jurisdiction developmental trajectory from ASM, to LSM, to SSM (Fig. 3), demonstrates appropriate geology (for ASM to operate), and contributed to infrastructure, governance and policy frameworks (via LSM). Outcomes encompass cultural clashes, influence and change, mining-centric rural livelihoods, and environmental impacts.

4.4.1. Preconditions

Economic deposits are rare. Geology serves as the foundation for all mining aspects, encompassing scale, environmental reactions and social response (Caven and Johnson, 2022; Levson, 1991; Wall et al., 2017). Yukon hosts five broad categories of placer deposits (LeBarge, 1997), characterized by their non-consolidated nature, which simplifies technical compared to hard-rock deposits, as the ore does not have to be crushed and chemically processed.⁸⁴ This geological uniqueness is a precondition for SSM in Yukon.

For Yukon's placer gold, millions of years of geological activity have done much of the gold processing already, concentrating the gold at the boundary between what is known as "White Gravel" and bedrock. This straight forward geological model is well-known in the placer mining industry, with miners primarily focusing on assessing grade appropriateness and depth to bedrock. Experienced miners report developing an innate sense for locating gold. As one miner stated, "You start to get the knowledge and understanding where the gold is; where it most likely would be. When you're young and starting, a lot of it is guessing ... As you [gain] experienced, you realize, oh, no, it'll be over here, and not over there. How do I explain it ... gold is where you find it."⁸⁵ Despite

the simple geological model, successful extraction and processing solutions are not immediately apparent, necessitating a learning curve involving various entrepreneurial and technical skills for profitable mine operation.

The presence of ASM demonstrated accessible geological potential, which later became less accessible as the high-grade, shallow ore was harvested. The Klondike Gold Rush resembles contemporary ASM in the Global South, using simple technologies and methods (Canavesio and Pardieu, 2019; Telmer and Persaud, 2013) during a period of acute poverty (McClymer, 1986; Sager et al., 2016). The ASM-dominated Klondike Gold Rush was brief (1896–1900) (Green, 2018) and was followed by corporate large-scale dredge mining. The Canadian Federal Government granted large tracts of land to large companies with external private investors as early as 1897 (Government of Yukon, 2021), leading to conflict between ASM and LSM, with hand miners protesting against the takeover by large companies collected data from Dredge No. 5 placard.⁸⁶ As an interviewee explained "[the Federal Government] [w]ould award these large tracts to the [large-scale] dredges [when there] were still ... independent miners mining those areas. There was a lot of corruption."⁸⁷

Pre-existing legal and physical infrastructure is another precondition, and in Yukon it was largely built through LSM. LSM played a critical role in establishing legal and physical infrastructure for modern placer mining through the development of the Placer Mining Act in 1906, and significant physical and technological advancements not only to mining, but also planning, construction, transportation, power, and water resource development in northern environments (Johnson, 2012). The Alaska Highway, built during World War 2, also provided transportation routes for equipment and the miners who migrated to Dawson City in search of work (The Klondike Viking, 2016).⁸⁸

A third precondition for SSM is an accessible market. The end of the gold standard in 1974 led to a surge in gold prices, prompting the emergence of independent placer gold mines in Yukon (Holmes, 2021). Gold's high value streamlines transportation logistics, and the presence of trusted gold buyers has nurtured a well-established gold market, integral to Yukon's placer mining community. Miners also acknowledge the market accessibility in enabling their professions.⁸⁹ While placer gold is the current target commodity for SSM in Yukon, there are also placer deposits of tungsten, copper, and tin that have been mined in the past (Bundtzen et al., 1999), and may be of future interest.

4.4.2. Outcomes

The ASM of the Klondike Gold Rush and subsequent dredge companies brought about colonialism and cultural clashes between incoming miners and Indigenous peoples, who have inhabited the region for millennia (Green, 2018).^{90,91} The clashes persist today, in part due to differing land-use perspectives. Land-use disagreements are highlighted in media, with headlines such as "Yukon wetlands pushed to tipping point by placer mining, First Nations and conservationists" (Gignac, 2020). When a First Nation Government interviewee was asked about their community's perception of placer mining, they stated that "The perception of placer mining in our community ... is probably bad.

⁸⁶ Parks Canada. "Dredge N^o 4 National Historic Site". Site visit and tour. Summer 2021.

⁸⁷ Floating professional, Whitehorse, 2021 (Interview P2162).

⁸⁸ Placer miner owner and operator (retired), Dawson City, 2021 (Interview M2164).

⁸⁹ Placer miner owner and operator, Mine Site, 2021 (Interview M2168).

⁹⁰ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

⁹¹ Parks Canada. "Red Surge, Red Tape: From Tr'ondëk to Klondike". Site visit and tour. Summer 2021.

⁸³ Floating professional, Whitehorse, 2021 (Interview P2157).

⁸⁴ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

⁸⁵ Placer miner owner and operator, Mine Site, 2022 (Interview M2252).



Fig. 3. Development trajectory indicating that accessible deposit type, shown by ASM, and infrastructure and legal frameworks, in this case developed by LSM, are preconditions to the SSM of Yukon. (A) Shows rudimentary, self-built manual ASM mines (Cantwell, 1898); (B) shows Dredge No. 4, a large sophisticated machine used by LSM in mechanized and optimized bulk operation placer mining. It is now a museum owned and operated by Parks Canada (image from 2021 fieldwork); (C) modern semi-mechanized mine using heavy equipment. The image includes family pets (image from 2021 fieldwork).

It's because of our cultural beliefs; [they] really clash. We're more land caretakers.⁹² These land-use disagreements are understandable as one Yukon Policy/Governance interviewee states:

I don't think [First Nations perspectives] are explicitly anti mining. I think [conflict is] rooted in the lack of planning and acknowledgement of land use and how it affects their rights under their Final [Umbrella] Agreements. If you look at the Final Agreements, they have rights to water and wildlife, and a variety of other things for traditional uses, and those rights are protected under binding agreement with the Federal Government, and the Yukon Government.

As placer mining has evolved, in some cases, gotten really big ... From that perspective, maybe ... their rights been impacted, or affected. And because these approvals happen on a claim by claim basis, they're just little decisions made over "yes, you can work these claims". It advances from there. And so, on the aggregate, as soon as you have a whole valley that's now Placer mining, it's like, "Oh, wait a minute. Our rights. We can't go there to hunt anymore."⁹³

Although the First Nations in Yukon suffered immensely as a result of the ASM of the Klondike Gold Rush and proceeding LSM, "the Tr'ondëk Hwëch'in and other Indigenous groups were not passive victims in this process" (Green, 2018, p. 369). 130 years of coexistence between placer mining and Indigenous cultures have also led to collaborations and co-alescences (UNESCO, 2004). Some placer mines are owned and operated by Indigenous families, and placer mines offer employment opportunities although statistics are not available,⁹⁴⁻⁹⁸ although there are no statistics available to investigate Indigenous involvement. Additionally, First Nations territories have developed corporations, such as the Chief Isaac Group of Companies of the Tr'ondëk Hwëch'in, that have been involved in the placer industry (KPMA, 2022).

It is important to recognize the intersections of placer miners and First Nations communities. One interviewee stated that to consider First Nations and placer mining communities as two distinct groups is harmful, and that the "the concept of miners versus First Nations, when

miners are often First Nations, or miners are embedded in the community in such a way that to consider them as different is hurtful".^{99,100} This research suggests that First Nations Governance positively impacted environmental outcomes of the placer mining industry, steadily pushing for improved environmental standards such as reclamation and recognizing the presence of small enterprise mining within their Traditional Territory (Tr'ondëk Hwëch'in Government, 2011). The cultural outcomes of this coexistence are highly nuanced and complex, with neither First Nations nor placer mining communities being completely separate, nor homogenous.

Placer mining is a vital source of rural livelihoods and has endured various global crises, the World Wars, the 1930s depression in North America, and through the COVID-19 pandemic (Bond and van Loon, 2021). In 2015, approximately 650 worked in the industry, with around 64% being Yukon residents (Kishchuk, 2018). Small enterprise (Table 4) play a significant role in, transforming and enriching communities (Ribeiro-Duthie et al., 2017, p. 2).

The industry has led to the development of other sectors, including gold-mining related tourism industries,¹⁰¹ gold and jewellery shops,¹⁰² and media as exemplified by the television series *Gold Rush* (CBC, 2018). This television show, filmed in the Klondike Region near Dawson City, is Discovery TV's top-rated reality television program (Klondike Visitors Association, n.d.). Interviewees have mixed attitudes towards the television program due to its negative impact on industry reputation and the positive economic diversification.¹⁰³ Placer mining is also important for supplier industries and other local businesses (KPMA, 2022).

The environmental consequences of placer mining vary depending on scale and era. One interviewee separated the placer mining industry into 4 types: 1) ASM of the Klondike Gold Rush; 2) large-scale dredge mining without reclamation; 3) modern placer mining without reclamation; and 4) modern placer mining with reclamation.¹⁰⁴ Today, large piles of cobble and boulder characterize the landscape around Dawson City, a result of large-scale dredge mining. In 1966, the largest corporation in Yukon abandoned their operations without reclamation because it was no longer profitable (Gilbert, 1989).

Yukon's gold processing is gravity driven and chemical free (Clackett

⁹² Government Official (First Nation Government B), Yukon, 2022 (Interview G2270).

⁹³ Government Official (Tribunal A), virtual interview, 2022 (Interview G2259).

⁹⁴ Floating professional, Whitehorse, 2021 (Interview P2157).

⁹⁵ Government Official (First Nation Government B), Yukon, 2022 (Interview G2270).

⁹⁶ Supplier, Dawson City, 2022 (Interview S2248).

⁹⁷ Supplier, Dawson City, 2022 (Interview S2248).

⁹⁸ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

⁹⁹ Floating professional, Whitehorse, 2021 (Interview P2157).

¹⁰⁰ Government official (Municipality - governing), field site, 2021 (Interview G2147).

¹⁰¹ Placer miner owner and operator, Dawson City, 2021 (Interview M2150).

¹⁰² Placer miner owner and goldsmith, Dawson City, 2022 (Interview M2234).

¹⁰³ Placer mine worker, Dawson City, 2021 (Interview W2180).

¹⁰⁴ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

et al., 2021), however there are other environmental impacts of great concern. The environmental impacts of Yukon's placer mining are terraforming, permafrost destruction, sediment loading, and habitat destruction (wetlands are of particular concern currently).^{105–114} There is no reclamation-specific policy in placer mining, and reclamation is indirectly governed through Water Licences, with violations punishable by Law (Government of Canada, 1999; Hong, 2017; Standish and Leader, 1986; Wright et al., 2022). There is also no monetary security (a bond) in place to ensure reclamation in placer, though there is in quartz-mining.¹¹⁵ Proactive reclamation efforts are gaining momentum but the landscape bears visible alterations and damages from over a century of placer mining.

5. Discussion

With this research, we matured the concept of SSM, investigating definitions, characteristics, boundaries, and preconditions and outcomes in Yukon, Canada, in a self-described small-scale gold mining industry (Fig. 4). In this section, we distil the SSM concept, by using the 4 criteria to discuss: (1) why definitions alone are insufficient; (2) the dynamics of certain characteristics; (3) boundaries explaining why context matters; and (4) how preconditions and outcomes can inform development trajectories.

Interrogating the definitions provided by interviewees revealed conflicting understandings of how scales of mining are locally understood. Yukon's placer mining industry is described as SSM by interviewees, as well as in grey literature, although the term 'small-scale mining' is not present in legal documents. The data from this study adds to the literature by clarifying the SSM definition as predominantly legal and formal extraction of minerals from primary, secondary, or anthropogenic deposits by SMEs, employing intermediate technologies and methodologies (Fig. 4).

Diverging from existing literature (Table 1), our definition includes a geological precondition, as well as clearer and concrete characteristics that apply across contexts while excluding ambiguous criteria. Operation by SMEs is characteristic of SSM, implying that while capital accumulation is feasible, it is also capped (Fig. 4). Sidorenko et al. (2020, p. 4) explain that SSM could be operated by any enterprise size. While this may be true in terms of the action of harvesting a small ore

deposit, the wealth distribution of a large enterprise operating multiple small mines might not necessarily make SSM economically, socially, and/or environmentally viable. For instance, a large enterprise mining multiple small ore deposits globally will have a significant footprint, and a different wealth distribution than a SME mine that is locally owned. Small deposit mining by large enterprise using sophisticated technologies may be better described as surgical mining (e.g., Gleeson, 2023) to not confuse with SSM.

Another vital component of the SSM definition is intermediate technologies, referring to technologies that miners can build or purchase, maintain, operate, develop and repair themselves (Schumacher, 1973, 2010). This differs slightly than existing definitions that use terms such as 'mechanized', 'more advanced', and 'usually not labour intensive' (Table 1). The nuance of this term provides flexibility as the choice of technologies can evolve over time. The term 'predominantly legal and formal' is used to acknowledge government-industry-community relationship enabling dynamic formalization, recognizing the spectrum of legality and formality described by McQuilken and Hilson (2016). For example, while ASM is predominantly informal, SSM is predominantly formal. The contextual nature of legality and formality means that government frameworks in one jurisdiction may hinder SSM formalization.

The definition omits static measurements related to the mine operation. For example, life of mine was excluded to account for the cumulative production time observed in Yukon, which we refer to as 'slow mining', while acknowledging the potential for more rapid life of mine described by Sidorenko et al.'s (2020) (Table 1). Additionally, static descriptions including production, depth, and footprint are omitted as they hinder change, adaptability and development. We argue against the effectiveness of incorporating measurable quantities into legal definitions, such as depth limits that define SSM in Sierra Leone (Republic of Sierra Leone, 2018, p. 8), or aerial limits in Ghana (Ghana Minerals Commission, 2015). Planetary (with the exception of deposit type) and societal aspects are not included because there is too much variance depending on other factors. The deliberate exclusions emphasizes the need for a flexible definition that accommodates diverse natural (e.g., geological or environmental), technological, governmental, and societal dynamics.

In summary, existing definitions of SSM (Table 1), do not adequately encapsulate Yukon's placer mining industry. Merely examining the definitions (criteria 1, Fig. 4) in isolation has limited academic and policy utility, because they lack the nuanced insights provided by the other three criteria (e.g., Table 1-Table 3). For example, definitions do not consistently include economic, societal or planetary aspects. Despite these limitations, definitions are essential as they facilitate communication of complex concepts (Morse et al., 1996).

The characteristics were the most recognizable Concept Criteria in the data analysis, based on interviews. Characteristics were often simultaneously recognized with other criteria throughout the process of deductive coding (e.g., Table 6). The thematic analysis allowed for recognition of characteristics, including those in themes of societal/cultural, governance, economic, and technological, and do not discount possible broader or intersecting themes. From these themes, it was found that SSM is characterized by dynamic formalization, operations by SMEs, and intermediate technologies (Fig. 4).

Concepts are described to be relevant in all contexts, with their characteristics being stronger or weaker illustrating conceptual variance (Morse et al., 1996). By investigating concepts using the Concept Evaluation Criteria, it becomes clear why the fundamental characteristics of concepts remain consistent but their relational nature means they develop differently in individual contexts. For example, some SSM concept characteristics are intermediate technologies (e.g. Imhoff cone, aiding with regulatory compliance) and methodologies used throughout the mine life cycle, a desire to be legalized and formalized, and small industrial enterprise (Fig. 4). Yukon miners are often involved throughout the entire mine life cycle, but SSM industries in other

¹⁰⁵ Government official (Territory – Governing), virtual call, 2021 (Interview G21115).

¹⁰⁶ Government Official (Tribunal B), virtual interview, 2022 (Interview G2269).

¹⁰⁷ Government Official (First Nation Government B), Yukon, 2022 (Interview G2270).

¹⁰⁸ Floating professional, Whitehorse, 2021 (Interview P2162).

¹⁰⁹ Placer miner owner and operator, Dawson City, 2021 (Interview M2245).

¹¹⁰ Floating professional, Whitehorse, 2021 (Interview P2157).

¹¹¹ Floating professional, Whitehorse, 2021 (Interview P2162).

¹¹² Placer miner owner and operator, Mine Site, 2022 (Interview M2269).

¹¹³ Placer miner owner and operator, Mine Site, 2022 (Interview M2266).

¹¹⁴ Government Official (Municipal Government), Government of Yukon, 2021 (Interview G2147).

¹¹⁵ Government Official (First Nation Government B), Yukon, 2022 (Interview G2270).

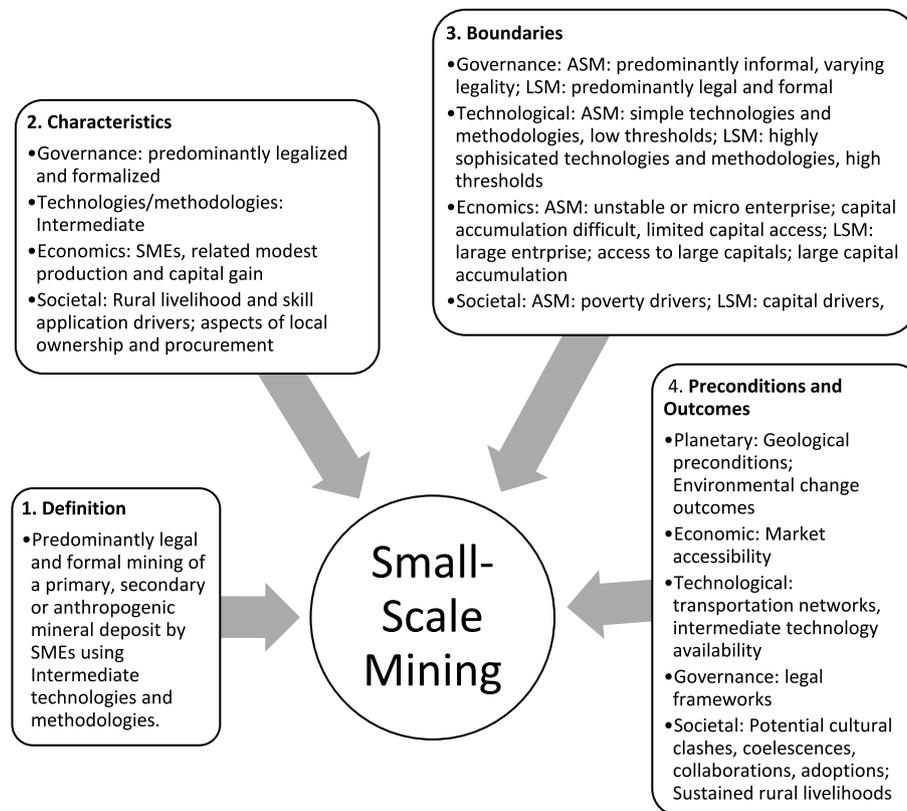


Fig. 4. Summary of the four criteria of the SSM Concept.

contexts may have a diversified labour force, as described by Cortés-McPherson (2019). Enterprise brackets (Table 4) are contextual, and what is considered a micro and small enterprise in Canada is different to a micro or small enterprise in another nation. Legality and formality are contextual in that governmental frameworks that exist in one jurisdiction might make it almost impossible for the SSM to formalize, despite a desire to formalize amongst stakeholders. The characteristics should remain consistent regardless of context, but the characteristics in themselves have highly different meaning depending on environment and micro political context.

Formalization of SSM in Yukon is possible because of an industry-community-government dynamic. Placer mining in Yukon benefits from community-assisted formalization that embodies community empowerment, giving individuals and communities power to address issues they deem important (Yue et al., 2023). In Yukon, the key stakeholders that enable formalization include the mining practitioners and the Klondike Placer Miners Association, the First Nations and Yukon Governments and related tribunals, the Floating Pool of Professionals, and the Yukon Geological Survey. This dynamic could look different in other jurisdictions to include educational institutions (universities), and NGOs (e.g., Women in Mining groups), who could support community empowerment.

Yukon's dynamic formalization model would prove challenging to replicate in other jurisdictions because Yukon's industry is relatively small. It employs around 650 people directly (Kishchuk, 2018), in contrast to approximately one million individuals in Ghana's ASM and SSM industry, for example (McQuilken and Hilson, 2016). Yukon's Territorial Government in the high-income Nation of Canada is well funded, receiving federal transfer payments from the Canadian Government. Furthermore, self-governing First Nations add strength to Yukon's governance model, as Indigenous self-governance enhances local governance and environmental outcomes (e.g., Benzeev et al., 2023). The Yukon Government simply has more resources than most other regions with ASM and SSM industries.

Management of natural resources by deposit type differentiates quartz-mining from placer mining: the former has complex geology and environmental considerations, requiring large-enterprise; the latter is dominated by relatively accessible geology, less complex environmental considerations (e.g., chemical free), and is amenable to small or medium enterprise (Table 4). Yukon's governance by deposit type considers materiality, often overlooked in mining governance frameworks (Akong, 2020). The Quartz Mining Act and Placer Mining Act have developed independently, with the former consisting of large enterprise, and the latter sheltering the SMEs. There is concern that a merger of the Quartz and Placer Acts would unintentionally exclude small enterprise (Table 4) due to unattainable regulatory measures or regulatory code compliance aimed at promoting and protecting capital markets. These concerns align with bias in mining policy favouring LSM over ASM in other locations (Kemp and Owen, 2019). This has been exemplified in Zimbabwe and Columbia, where requirements such as environmental impact assessments are only viable for larger enterprise, leading to technocratic suffocation of the smaller mines (Echavarría, 2017; Spiegel, 2017). However, there is potential for legal frameworks to allow for scale-specific environmental stewardship, as is being explored by active Governments in Yukon (Yukon Government, 2021a). As outlined, the Tr'ondëk Hwëch'in Government already does differentiate enterprise types in their Mining Mandate, expecting a share from mines with a gross annual revenue and expenditures of over \$2,000,000 (Tr'ondëk Hwëch'in Government, 2011).

Intermediate technologies are important SSM characteristics (Fig. 4). Technologies are intermediate relative to the knowledge and skill within a population (Schumacher, 1973, 2010), emphasizing the need for context specific considerations, like enterprise. Schumacher advocated for further research and development of intermediate technologies opposed to sophisticated technologies, to support small enterprise and sustainability (Schumacher, 1973, 2010). The placer mining industry research and development seems to parallel formalization networks; such that the industry-community-government dynamic that enables

formalization also enables community research and development. The floating pool of professionals know how to adapt or invent technologies and methodologies specific to the industry, sometimes with direct government funding, and the miners entrust them to enact these changes. The network of stakeholders, and accessibility of a floating pool of professionals differs between mining regions, which impacts formalization and knowledge flows. Misalignment of formalization with government and industry dynamics or deposit type could risk failure of one sector.

Although less clear, there are societal/cultural characteristics recognized in SSM, such that the workforce is driven by the desire to have a rural livelihood and to use their skills, and the businesses have aspects of local procurement and ownership (Fig. 4). The strong association between placer mining and other rural livelihoods such as agriculture in Yukon mirrors a global pattern that tie ASM and SSM to rural livelihoods (Fritz et al., 2017; Hilson, 2016; Huntington and Marple-Cantrell, 2022; Ofosu et al., 2020).

Boundaries (criteria 3) were more difficult to recognize, but Yukon's coexisting SSM and LSM industries, and historical ASM helped clarify this criteria. Boundaries, recognized from when a characteristic emerges or disappears (Morse et al., 1996), are contextual and include pathways, degrees of, and access to legalization and formality, capital, and innovation. Bounding between scales of mining is not necessarily limited to absolute definition of formalization and legalization; it also reflects the desire for formalization and legalization (Fig. 4). Occasionally, SSM evolves from ASM (Hilson and Maconachie, 2020b). SSM practitioners may aspire for formalization and legalization, but challenges arise when governments' capacity issues or legal frameworks make formalization unattainable (Hilson and Maconachie, 2020b; Spiegel, 2017). For instance, many government frameworks are more accessible to LSM (Kemp and Owen, 2019). LSM access to specialized resources, such as lawyers and accountants, facilitates operations within existing governing systems. Policy regarding SSM in the Global North is seemingly absent, and the existing policies governing mining, which may be described as neoliberal (Kemp and Owen, 2019), are more amenable to LSM for similar reasons to those outlined in the Global South, meaning the mining industry is now dominantly operations by large-scale enterprise.

Whilst SME status acts as a characteristic, it also serves as a boundary (Fig. 4). The boundary between SSM and LSM is evident in large-enterprise mining activity (Table 4). LSM is capital driven, with shareholders and a board who hold economic leverage over material direction. SMEs in formal mining have decreased since the 1990s (Sidorenko et al., 2020), which may have affected rural economies. Our research suggests that this may be partly due to regulatory frameworks such as the NI-43-101 limiting small-capital projects. This may also be a similar pattern with the Joint Ore Reserves Committee (JORC) code, a regulatory instrument regulating mining in Australia and Asia (see JORC, 2012). Regulatory frameworks that homogenise the upstream mineral supply chain to LSM, can hinder capital access beyond NI-43-101 and the JORC code. SMEs dominate at the smaller scales of mining, which is considered to be important for the development of rural economies in the Global South, but have diminished in the Global North (Sidorenko et al., 2020). In contrast to SSM, ASM is poverty driven (Hilson, 2009), leading to challenges in revenue accumulation, and making tax and royalty contributions less feasible (Laing et al., 2023; Mestanza-Ramón et al., 2022; Pedersen et al., 2021). Some grey literature suggests that poverty-driven ASM may exist in the USA, such as by the war Veterans who mine gold in California (Tucker, 2012).

The confusion over whether operations should be considered individually as SSM, or collectively as LSM can be resolved using the share of prosperity from the mines. By SSM, the profits of approximately 72,464 crude oz. of gold production are shared across approximately 108 active placer operations (Bond and van Loon, 2018; Kishchuk, 2018), while just one company receives the profits of an average 2190,000 oz. gold production by a LSM quartz-mining operation (see JDS Energy and

Mining Inc, 2019, pg 22-1). Company size, as in number of employees as a function to mine area, does not necessarily dictate the scale of mine, since multiple artisanal miners can mine one large deposit and a large-scale mining company can also mine a modest size deposit (Sidorenko et al., 2020). The disparity between employment and gold production by placer-mining and quartz-mining in Yukon follows the pattern of global disparities between SSM and LSM. Moreover the impediments to distribution of wealth by the market-protective NI-43-101 are echoed by the JORC code that is too technical and costly for micro and small enterprises. Placer miners rely on personal finances, sometimes earned with a combination of placer mining and another rural livelihood, to continue their operation, as opposed to money raised on the market.

SSM is not poverty driven, but rural-livelihood and lifestyle driven. Miners may adjust production rates to maximize resource lifespan during high gold prices, thus sustaining their livelihoods for decades. This is in contrast to operations like Victoria Gold's Eagle Mine, which has a 13-year mine life and more rapidly undermines the natural resource base of gold than slow mining by small enterprises. Placer miners who desire to scale up, might drive SSM towards and across a border into medium-scale mining (MSM). For example, there are some experienced placer miners who secure third loans to advance technologically. Reality television and partnerships with quartz-mining companies can facilitate MSM. Reality television companies are large enterprises, and provide miners with equipment, thus changing the economics. Quartz-mining exploration companies raise money on public markets as NI-43-101 compliant hard-rock projects and can use capital flow to purchase and explore placer claims.

Preconditions and outcomes in Yukon, like boundaries, can be understood through coexisting SSM and LSM, and historical ASM (Fig. 3). It was difficult to analyse whether a thematic code was a precondition/outcome or a characteristic, and the preconditions and outcomes that were recognized are not apparent from definitions (Table 1, Table 2, and Table 3). The characteristic of legality/formality is an example of this difficulty. Pre-existing legal frameworks must exist for the industry to be legal. However, the SSM industry in other contexts may still exist despite the lack of legal frameworks, regardless of a desire of miners to formalize. This is a chicken-or-egg type of problem, such that SSM is best characterized as the *desire* to be formalized/legalized, which is only possible if the pre-condition of an accessible legal framework is present.

Preconditions (Criteria 4) of SSM include accessible geology, legal and physical infrastructure, and market (Fig. 4). The presence of ASM miners during the Yukon's Klondike Gold Rush demonstrates that the ore deposit was easily accessible, allowing miners to use simple, low-entry technologies. The Klondike Gold Rush also led to significant social and environmental upheaval (Green, 2018). The preconditions and outcomes were similar to those observed for modern ASM (Table 3). Infrastructure in Yukon was partially established by LSM, including transportation networks and equipment. The Federal Government also developed the Placer Mining Act in response to LSM, providing a legal framework for modern SSM Parks Canada, n.d. a (Bear Creek).¹¹⁶ Yukon's placer mining industry transitioned from ASM, to LSM, to SSM (Fig. 3), indicating fluidity and diachrony in the scales of mining as a function of policy and access to capital infrastructure.

The outcome of a relatively small environmental impact, as proposed by Sidorenko et al. (2020), is worth exploring. SME operations with intermediate technologies and localized decision making, in contrast to large-enterprise operations with sophisticated technologies, may exhibit lower environmental impact (Schumacher, 1973, 2010). This outcome is partially observed in Yukon, where the environmental outcome of SSM is linked to placer geology, featuring free gold in unconsolidated deposits. In Yukon, environmentally compliant extraction using

¹¹⁶ Parks Canada. "Bear Creek Compound". Site visit and tour, Summer 2021.

intermediate technologies without chemicals means that small-scale miners feel safe to source drinking water and engage in recreational activities in their tailings pond; practices uncommon in LSM due to severe pollution. However, mercury as an intermediate technology is highly problematic in ASM and SSM industries in other jurisdictions (Veiga and Fadina, 2020), where the geology is less conducive to environmentally benign processing methods. The combined impact of multiple SSMs may thus have significant environmental impact globally and investigation is needed to fully understand and validate this potential planetary outcome of cumulative SSM activities that might be of long duration, of possible low grade ore, and reliant on chemical separation for minerals like gold in sulphides.

Although the manageable effects of SSM may be more aligned with progressive thought on resource extraction, where the impacts of mining can be decoupled from the impacts of consumption (Oberle et al., 2020), insights into improving environmental outcomes may have limited transferability to other geological and formalization contexts. However, learning about slow mining of unconsolidated deposits, including technology development, professional support, or formalization, could be valuable for re-mining and remediation of tailings in other contexts. Our research on Yukon's placer mining industry suggests that SSM's viability with high-value minerals is enhanced in slow, SME operations, when governments can legalize and formalize the industry, and where the industry can operate without chemicals due to its material nature.

Yukon's SSM development trajectory has the outcome of livelihood and rural development (criteria 4). A sustainable livelihood is one that is resilient to shocks and stresses, and is able to maintain capabilities and assets while not undermining the base natural resource (Chambers and Conway, 1991). The smaller scales does simply reflect market gold prices, but more reflective of localized socioeconomics; exhibiting greater resilience to global boom and bust life cycles (Heemskerk, 2001) than LSM and mining for other commodities that are tied by application to industrial/manufacturing industries. Yukon's SSM industry supports this, showing low correlation between of gold price and production (see graph on page 5 of Bond and van Loon, 2018). Inclusion of SSM in mining industries promotes upstream diversification and builds a substantial value chain, contributing to local and beyond local procurement (e.g. specialist equipment) and wealth distribution. Yukon's SSM establishes local ownership, surpassing local procurement. The Yukon SSM industry yields robust social and environmental outcomes through stakeholder convergence in governance, mine ownership, workforce and community, fostering close community relations. Mine owners' involvement throughout the mine life cycle necessitating living on the mine integrates them and their mine into the local community. Various pre-conditions and outcomes shaped by legal frameworks and geological deposit types prompt inquiry into whether social and governance constructs adequately address the physical/geological nature of ores or if they are excessively guided by economic considerations, to the neglect of both nature and society.

6. Conclusion

The concept of SSM is illuminated by four concept criteria: definitions, characteristics, preconditions and outcomes, and boundaries. Exploring the complete conceptual framework is favoured over the sole reliance on definition, which lacks depth for effective policy and research development. SSM in the concept location of Yukon is characterized by SMEs, intermediate technologies, and the desire for full formalization and legalization. Boundaries of capital differentiate ASM, SSM, and LSM, where ASM is associated with poverty, SSM is associated with livelihood, and LSM is associated with capital accumulation goals. Preconditions encompass accessible geological deposit, market, and necessary infrastructure. Outcomes are multifaceted, potentially driving sustainable rural development with varying environmental and societal impacts. Preconditions and outcomes can be understood as underpinning development trajectories, shaped by a myriad of possibilities. The

Yukon's SSM development trajectory was from ASM, to LSM, and finally to SSM.

SSM in Yukon is demonstrated by intermediate technologies, where miners and a floating pool of professionals enact community-driven research and development, and where the miners are able to build and/or purchase, maintain, operate, and repair equipment largely independently. The access of miners to wide-ranging and applicable expertise, and alternative modes of financing are particular to Yukon. While SSM in Yukon can offer valuable insights applicable to the other ASM and SSM industries worldwide, the insights must be translated and contextualised with respect to the unique realities of each location (McFarlane, 2006). The SSM concept should be tested in other jurisdictions to identify further characteristics, clarify boundaries, and identify variances in development trajectories. We should approach SSM framing cautiously, as new perspectives could inadvertently trigger or perpetuate community conflicts.

This case study shows that just like LSM, SSM exists in the Global North, as well as the Global South, but is less represented in high-income Nations. Yukon's SSM embodies the essence of slow mining, thriving as SMEs in the Canadian mining sector, which is predominantly mining by large enterprise. Yukon's SSM supports rural livelihoods, and the multi-governance model and deposit-style governance may pave the way for a comprehensive perspective on livelihoods and equitable wealth distribution in rural places. Specifically, Yukon's placer mining industry offers valuable insights into the complexities of SSM legalization and formalization, addressing environmental degradation, promoting sustainable innovation, and fostering rural development. It is imperative that the industry continually build strong relationships with First Nations through collaboration, engagement, and development of mutually-beneficial partnerships (MAC, 2024). These are critical issues with far-reaching effects on global regions, given increasing global demand for mineral resources and the need for a diverse range of mining solutions along with careful examination of production and consumption patterns.

CRedit authorship contribution statement

C. Johnson: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. **K.R. Moore:** Conceptualization, Supervision, Writing – review & editing. **D. Johnson:** Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

My data is available upon request. The small community where the interviews are sourced makes anonymity difficult. Public disclosure of anonymized, randomized interview data is being considered.

References

- Akong, C., 2020. Reframing matter: towards a material-discursive framework for Africa's minerals. *Extr. Ind. Soc.* 7, 461–469. <https://doi.org/10.1016/j.exis.2019.02.007>.
- Aryee, B.N.A., Ntiberi, B.K., Atorkui, E., 2003. Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact. *J. Clean. Prod., Environ. Manag.* 11, 131–140. [https://doi.org/10.1016/S0959-6526\(02\)00043-4](https://doi.org/10.1016/S0959-6526(02)00043-4).
- Benzeev, R., Zhang, S., Rauber, M.A., Vance, E.A., Newton, P., 2023. Formalizing tenure of Indigenous lands improved forest outcomes in the Atlantic Forest of Brazil. *PNAS Nexus* 2, pgac287. <https://doi.org/10.1093/pnasnexus/pgac287>.

- Berenskoetter, F. (Ed.), 2016. *Concepts in World Politics*, first ed. SAGE Publications Ltd, SOAS, University of London. London, UK.
- Berk, N., 2022. 'Hoffman family gold' aims to mine more gems for Discovery. *Forbes*.
- Bernaudeau, L., 2022. The planet gold programme and the large-scale gold mining sector. PlanetGOLD Programme Large-Scale Gold Min. Sect. <https://www.planetgold.org/planetgold-programme-and-large-scale-gold-mining-sector> 11.7.22.
- Beylot, A., Muller, S., Segura-Salazar, J., Brito-Parada, P., Paneri, A., Yan, X., Lai, F., Roethe, R., Thomas, G., Goettmann, F., Braun, M., Moradi, S., Fitzpatrick, R., Moore, K., Bodin, J., 2021. Switch on-switch off small-scale mining: environmental performance in a life cycle perspective. *J. Clean. Prod.* 312, 127647 <https://doi.org/10.1016/j.jclepro.2021.127647>.
- Bond, J., van Loon, S., 2021. Yukon Placer Mining 2020 Development and Exploration Overview.
- Bond, J.D., 2018. Analyses of regional wetland distribution using predictive ecosystem mapping data sets for west-central Yukon and east-central Alaska. In: MacFarlane, K. E. (Ed.), *Yukon Exploration and Geology*. Yukon Geological Survey, Whitehorse, Yukon, pp. 1–18.
- Bond, J.D., van Loon, S., 2019. Yukon placer mining 2018 development overview. In: *Yukon Exploration and Geology Overview 2018*. Yukon Geological Survey, Whitehorse, 17–4.
- Bond, J.D., van Loon, S., 2018. Yukon Placer Mining Industry 2015 to 2017 (Annual Report No. YPMI2015-17). Yukon Geological Survey, Whitehorse, Yukon.
- British Columbia Securities Commission, 2023. Mining. <https://www.bsc.bc.ca/industry/issuer-regulation/guidance-by-sector/mining>, 4.25.23.
- Bundtzen, T.K., Morison, S., Nokleberg, W.J., 1999. Heavy Mineral Placer Deposits of Alaska and Yukon Territory. Canada - Abstract 2.
- Canadian Securities Administrators, 2011. NI 43-101 Standards of Disclosure for Mineral Projects, Form 43-101F1 Technical Report and Related Consequential Amendments.
- Canavesio, R., Pardiou, V., 2019. Rushing for gemstones and gold: reflecting on experiences from the United States, Canada, New Zealand, Australia and Madagascar, 1848-present. *Extr. Ind. Soc.* 6, 1055–1065. <https://doi.org/10.1016/j.exis.2019.08.005>.
- Cantwell, G.G., 1898. *Miners Working in Underground Gold Mine by Candlelight*. Yukon Territory, approximately 1898. - Meed (William E.) Photographs of the Yukon Territory, 1898-1907 - University of Washington Digital Collections.
- Caven, S., Johnson, C., 2022. Mining and sustainable development – a project-level approach to identify opportunities for collaboration and innovation. In: *Routledge Handbook of the Extractive Industries and Sustainable Development*. Routledge, London, pp. 561–653. <https://doi.org/10.4324/9781003001317-33>.
- CBC, 2018. Reality shows settle into Yukon community, "warts and all." *CBC News*.
- Chambers, R., Conway, G.R., 1991. *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century (IDS Discussion Paper 296)*.
- CIRDI, 2018. CIRDI Hosts Yukon ASM Fellowship | CIRDI - Canadian International Resource and Development Institute. <https://cirdi.ca/cirdi-hosts-yukon-asm-fellowship/>, 10.27.21.
- Clackett, S.P., Porter, T.J., Lehnerr, I., 2021. The tree-ring mercury record of Klondike gold mining at Bear Creek, central Yukon Environ. Pollut. 268 <https://doi.org/10.1016/j.envpol.2020.115777>.
- Clarkson, G., Clarkson, R., Hitch, M., 2017. Reducing mercury usage in artisanal gold mines using grinding and sieving. *Miner. Process. Extr. Metall. (IMM Trans. Sect. C)* 126, 167–171. <https://doi.org/10.1080/03719553.2016.1200765>.
- Clarkson, R., 1994. Use of radiotracers to evaluate gold recovery efficiency. *Can. Min. Metall. Bull.* 87 (979), 21–37.
- Cortés-McPherson, D., 2019. Expansion of small-scale gold mining in Madre de Dios: 'capital interests' and the emergence of a new elite of entrepreneurs in the Peruvian Amazon. *Extr. Ind. Soc.* 6, 382–389. <https://doi.org/10.1016/j.exis.2019.01.002>.
- Council of Yukon First Nations, 1990. Umbrella final agreement. <https://cyfn.ca/agreements/umbrella-final-agreement/>. (Accessed 11 February 2021).
- Council of Yukon First Nations. An understanding of the umbrella final agreement. n.d. <https://cyfn.ca/wp-content/uploads/2013/08/ufa-understanding.pdf>. (Accessed 5 April 2023).
- Dados, N., Connell, R., 2012. The Global South. *Contexts* 11, 12–13. <https://doi.org/10.1177/1536504212436479>.
- de Villiers, C., Low, M., Samkin, G., 2014. The institutionalisation of mining company sustainability disclosures. *J. Clean. Prod., Special Volume: The sustainability agenda of the minerals and energy supply and demand network: an integrative analysis of ecological, ethical, economic, and technological dimensions* 84 51–58. <https://doi.org/10.1016/j.jclepro.2014.01.089>.
- Echavarría, C., 2017. 'What Is Legal?' Formalising Artisanal and Small-Scale Mining in Colombia.
- Fisher, E., Mwaipopo, R., Mutagwaba, W., Nyange, D., Yaron, G., 2009. "The ladder that sends us to wealth": artisanal mining and poverty reduction in Tanzania. *Resour. Policy, Small-Scale Mining, Poverty and Development in Sub-Saharan Africa* 34, 32–38. <https://doi.org/10.1016/j.resourpol.2008.05.003>.
- Fonseca, A., McAllister, M.L., Fitzpatrick, P., 2014. Sustainability reporting among mining corporations: a constructive critique of the GRI approach. *J. Clean. Prod., Special Volume: The sustainability agenda of the minerals and energy supply and demand network: an integrative analysis of ecological, ethical, economic, and technological dimensions* 84 70–83. <https://doi.org/10.1016/j.jclepro.2012.11.050>.
- Fritz, W.M., McQuilken, J., Collins, N., Weldegiorgis, F., 2017. Global Trends in Artisanal and Small-Scale Mining (ASM): A Review of Key Numbers and Issues 91.
- Fuller, C., 2016. Yukon Gold Raises Profile of Small-Scale Miners. *Star Phoenix*.
- Ghana Minerals Commission, 2015. *Artisanal and Small-Scale Mining (ASM) Framework*. Gignac, J., 2020. Yukon First Nation calls on territory to abolish "colonial" claim staking process for mines. *The Narwhal*.
- Gilbert, G.W., 1989. *A brief history of placer mining in the Yukon (Y002-000-EE-A 1)*. Indian and Northern Affairs Canada, Whitehorse, Yukon.
- Ginsburg, T., Stephanopoulos, N., 2017. *The Concepts of Law*. Univ. Chic. Law Rev., Essay, pp. 147–175.
- Gleeson, D., 2023. Novamera plots path forward for surgical mining technologies. *Int. Min.*
- Gould, J.A., 2001. *Frozen gold: a treatise on early Klondike mining technology*. Methods and History, first ed. Pictorial Histories Publishing, Missoula, Mont. Whitehorse.
- Government of Canada, 1999. *Handbook of reclamation techniques in the Yukon*. Minister of Indian Affairs and Northern Development. Whitehorse, Yukon.
- Government of Canada, I, 2015. *SME Operating Performance [WWW Document]*. URL <https://ised-isde.canada.ca/site/sme-research-statistics/en/research-reports/sme-operating-performance/sme-operating-performance>, 2.16.23.
- Government of Yukon, 2021. *Sights and sites of the Yukon: central Yukon - tailing piles*. <https://sightsandsites.ca/central/site/tailing-piles>. (Accessed 11 February 2021).
- Green, H., 2018. The Tr'ondëk Hwëch'in and the Great Upheaval: Mining, Colonialism, and Environmental Change in the Klondike. University of Alberta, Edmonton, Alberta, pp. 1890–1940. Thesis in partial requirements for degree of Doctor of Philosophy in History, University of Alberta.
- Heemskerck, M., 2001. Do international commodity prices drive natural resource booms? An empirical analysis of small-scale gold mining in Suriname. *Ecol. Econ.* 39, 295–308. [https://doi.org/10.1016/S0921-8009\(01\)00223-3](https://doi.org/10.1016/S0921-8009(01)00223-3).
- Hickel, J., Dorninger, C., Wieland, H., Suwandi, I., 2022. Imperialist appropriation in the world economy: drain from the global South through unequal exchange, 1990–2015. *Global Environ. Change* 73, 102467. <https://doi.org/10.1016/j.gloenvcha.2022.102467>.
- Hilson, G., 2016. Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: a critical overview. *Extr. Ind. Soc.* 3, 547–563. <https://doi.org/10.1016/j.exis.2016.02.003>.
- Hilson, G., 2009. Small-scale mining, poverty and economic development in sub-Saharan Africa: an overview. *Resour. Policy, Small-Scale Mining, Poverty and Development in Sub-Saharan Africa* 34, 1–5. <https://doi.org/10.1016/j.resourpol.2008.12.001>.
- Hilson, G., 2001. Putting theory into practice: how has the gold mining industry interpreted the concept of sustainable development? *Miner. Resour. Eng.* 10, 397–413. <https://doi.org/10.1142/S0950609801000725>.
- Hilson, G., Maconachie, R., 2020a. For the environment: an assessment of recent military intervention in informal gold mining communities in Ghana. *Land Use Pol.* 96, 104706 <https://doi.org/10.1016/j.landusepol.2020.104706>.
- Hilson, G., Maconachie, R., 2020b. Entrepreneurship and innovation in Africa's artisanal and small-scale mining sector: developments and trajectories. *J. Rural Stud.* 78, 149–162. <https://doi.org/10.1016/j.jrurstud.2020.06.004>.
- Hilson, G., McQuilken, J., 2014. Four decades of support for artisanal and small-scale mining in sub-Saharan Africa: a critical review. *Extr. Ind. Soc.* 1, 104–118. <https://doi.org/10.1016/j.exis.2014.01.002>.
- Hilson, G., McQuilken, J., Perks, R., 2019. *Delve | 2019 State of the Artisanal and Small Scale Mining Sector*.
- Hiyatel, A., 2018. Yukon Weighs Large Scale Mining at Casino Proposal. *Can. Min. J.* Hiyatel, A., 2009. NI 43-101 to Get an Overhaul. *North, Min.*
- Holmes, F., 2021. The gold standard ended 50 Years ago. *Federal Debt Has Only Exploded Since*. *Forbes*. URL <https://www.forbes.com/sites/greatspeculations/2021/01/25/the-gold-standard-ended-50-years-ago-federal-debt-has-only-exploded-since/>, 10.23.22.
- Hong, J., 2017. Ex-Yukon Gold Star Fined \$145,000 for Not Cleaning up Placer Operation - Yukon News. *Yukon News*.
- Huntington, H., Marple-Cantrell, K., 2022. The importance of artisanal and small-scale mining for rural economies: livelihood diversification, dependence, and heterogeneity in rural Guinea. *J. Rural Stud.* 94, 177–191. <https://doi.org/10.1016/j.jrurstud.2022.06.004>.
- JDS Energy and Mining Inc, 2019. *Technical Report for the Eagle Gold Mine, Yukon Territory, Canada*.
- Johnson, K., 2012. *Gold dredging in the Klondike and number 4*. In: Presented at the Annual General Conference for the Canadian Society of Civil Engineers, Edmonton, Alberta, p. 10.
- JORC, 2012. *Australasian code for reporting of exploration results*. Mineral Resources and Ore Reserves.
- Kemp, D., Owen, J.R., 2019. Characterising the interface between large and small-scale mining. *Extr. Ind. Soc.* 6, 1091–1100. <https://doi.org/10.1016/j.exis.2019.07.002>.
- Kertcher, C., 2023. The Global South contestation narratives and the transformation of military humanitarian interventions in the early 1990s. *Cogent Soc. Sci.* 9, 2251251 <https://doi.org/10.1080/23311886.2023.2251251>.
- Kishchuk, P., 2018. *Yukon Placer Mining Economic Profile*. Vector Research, Whitehorse, Yukon.
- Klondike Visitors Association, n.d. *Discovery Gold Rush - Filmed in Dawson City Yukon*. Dawson City Yukon. URL <https://dawsoncity.ca/discovery-gold-rush/> (accessed 4 February 2023).
- KPMA, 2022. *ABOUT US [WWW document]*. Klondike Placer Min. Assoc. KPMA. <https://www.kpma.ca/about-us/>, 10.25.22.
- Laing, T., Edwards, R., Yusuf, S., Sparman, C., 2023. Assessing the economics and finances of Artisanal and small-scale gold mining in Guyana. *J. Rural Stud.* 97, 438–448. <https://doi.org/10.1016/j.jrurstud.2022.11.009>.
- LeBarge, B., 1997. *Yukon Quaternary Geology Volume 1. Overview of Yukon placer geology, gold production and prospects*. In: Indian and Northern Affairs Canada. Exploration and Northern Services Division., Whitehorse, Yukon, Canada (No. ISBN 0-662-24415-X).
- Levson, V., 1991. *Influences of geology on alluvial gold mining central British Columbia, Canada, in: institution of mining and metallurgy (great Britain). Alluvial Mining*.

- Published for the Institution of Mining and Metallurgy by Elsevier Applied Science, London ; New York, pp. 245–268.
- MacBride Museum of Yukon History, n.d. Gold Rush Exhibit.
- McClymer, J.F., 1986. Late nineteenth-century American working-class living standards. *J. Interdiscip. Hist.* 17, 379. <https://doi.org/10.2307/204771>.
- McFarlane, C., 2006. Crossing Borders: Development, Learning and the North: South Divide. *Third World Quarterly* 27, 1413–1437.
- McQuilken, J., Hilson, G., 2016. Artisanal and small-scale gold mining in Ghana. Evidence to inform an Action Dialogue (Country Report: Ghana No. ISBN: 978-1-78431-330-2). IIED.
- Mestanza-Ramón, C., Ordoñez-Alcivar, R., Arguello-Guadalupe, C., Carrera-Silva, K., D'Orío, G., Straface, S., 2022. History, socioeconomic problems and environmental impacts of gold mining in the Andean region of Ecuador. *Int. J. Environ. Res. Publ. Health* 19, 1190. <https://doi.org/10.3390/ijerph19031190>.
- Moore, K.R., Moradi, S., Doyle, K., Sydd, O., Amaral, V., Bodin, J., Brito-Parada, P.R., Dudley, F., Fitzpatrick, R., Foster, P., Goettmann, F., Roberts, D., Roethe, R., Sairinen, R., Sambrook, T., Segura-Salazar, J., Thomas, G., 2021. Sustainability of switch on-switch off (SOSO) mining: human resource development tailored to technological solutions. *Resour. Pol.* 73, 102167 <https://doi.org/10.1016/j.resourpol.2021.102167>.
- Moore, K.R., Whyte, N., Roberts, D., Allwood, J., Leal-Ayala, D.R., Bertrand, G., Bloodworth, A.J., 2020. The re-direction of small deposit mining: technological solutions for raw materials supply security in a whole systems context. *Resour. Conserv. Recycl.* X 7, 100040. <https://doi.org/10.1016/j.rcrx.2020.100040>.
- Morse, J.M., 2017. Analyzing and Conceptualizing the Theoretical Foundations of Nursing. Springer Publishing Company, New York, NY. <https://doi.org/10.1891/9780826161024>.
- Morse, J.M., Mitcham, C., Hupcey, J.E., Cerdas, M., 1996. Criteria for concept evaluation. *J. Adv. Nurs.* 24, 385–390. <https://doi.org/10.1046/j.1365-2648.1996.18022.x>.
- Nadasdy, P., 2012. Boundaries among kin: sovereignty, the modern treaty process, and the rise of ethno-territorial nationalism among Yukon first nations. *Comp. Stud. Soc. Hist.* 54, 499–532. <https://doi.org/10.1017/S0010417512000217>.
- Newsome, B., 2017. Todd Hoffman Struck Gold; in the Ground and on Discovery Channel. *Syd. Morning Her.*
- Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., Clement, J., 2020. Global Resources Outlook 2019: Natural Resources for the Future We Want. UN. <https://doi.org/10.18356/689a1a17-en>.
- OECD, 2016. OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, third ed. OECD. <https://doi.org/10.1787/9789264252479-en>.
- Ofof, G., Dittmann, A., Sarpong, D., Botchie, D., 2020. Socio-economic and environmental implications of Artisanal and Small-scale Mining (ASM) on agriculture and livelihoods. *Environ. Sci. Pol.* 106, 210–220. <https://doi.org/10.1016/j.envsci.2020.02.005>.
- Parianos, J., Lipton, I., Nimmo, M., 2021. Aspects of estimation and reporting of mineral resources of seabed polymetallic nodules: a contemporaneous case study. *Minerals* 11, 200. <https://doi.org/10.3390/min11020200>.
- Metallic Minerals Corporation, 2024. Alluvial Royalties: Ausralia Creek Royalty [WWW Document]. Metallic Minerals Corp. URL <https://mmsilver.com/projects/klondike-gold-district/australia-creek-royalty/> (accessed 3.30.24).
- Pedersen, A.F., Nielsen, J.Ø., Mempel, F., Bager, S.L., Jønsson, J.B., Corbera, E., 2021. The ambiguity of transparency in the artisanal and small-scale mining sector of Tanzania. *Extr. Ind. Soc.* 8, 101004 <https://doi.org/10.1016/j.exis.2021.101004>.
- Quirke, H., Galopin, P.-Y., Lanagan, W., 2019. Project staging to manage uncertainty: 'Smaller and staged' invariably trumps 'bigger and faster'. In: *A World of Commodity Price Volatility*, pp. 28–29.
- Republic of Sierra Leone, 2018. Artisanal Mining Policy for Sierra Leone.
- Ribeiro-Duthie, A.C., Domingos, L.M.B., Oliveira, M.F., Araujo, P.C., Alamin, R.C.J., Silva, R.S.V., Ribeiro-Duthie, J.M., Castilhos, Z.C., 2017. Sustainable development opportunities within corporate social responsibility practices from LSM to ASM in the gold mining industry. *Miner. Econ.* 30, 141–152. <https://doi.org/10.1007/s13563-017-0107-x>.
- Robinson, S., 2017. The home front: the Yukon's economy during the first world war. *North. Rev.* 31–49.
- Rodríguez-Novoa, F., Holley, E., 2023. Coexistence between large-scale mining (LSM) and artisanal and small-scale mining (ASM) in Perú and Colombia. *Resour. Pol.* 80, 103162 <https://doi.org/10.1016/j.resourpol.2022.103162>.
- Sager, E.W., History, D. of Victoria, of U., 2016. 7.3 poverty, 1867–1945. In: *Canadian History: Post-Confederation*.
- Schumacher, E.F., 2010. Small Is Beautiful: Economics as if People Mattered. Harper Perennial, New York [New] ed./foreword by Bill McKibben.
- Schumacher, E.F., 1973. Small Is Beautiful: a Study of Economics as if People Mattered, Vintage Classics. Vintage Books, London.
- Seccatore, J., Marin, T., De Tomi, G., Veiga, M., 2014a. A practical approach for the management of resources and reserves in Small-Scale Mining. *J. Clean. Prod., Special Volume: The sustainability agenda of the minerals and energy supply and demand network: an integrative analysis of ecological, ethical, economic, and technological dimensions* 84 803–808. <https://doi.org/10.1016/j.jclepro.2013.09.031>.
- Seccatore, J., Veiga, M., Origliasso, C., Marin, T., De Tomi, G., 2014b. An estimation of the artisanal small-scale production of gold in the world. *Sci. Total Environ.* 496, 662–667. <https://doi.org/10.1016/j.scitotenv.2014.05.003>.
- Sidorenko, O., Sairinen, R., Moore, K., 2020. Rethinking the concept of small-scale mining for technologically advanced raw materials production. *Resour. Pol.* 68, 101712 <https://doi.org/10.1016/j.resourpol.2020.101712>.
- Spiegel, S.J., 2017. EIAs, power and political ecology: situating resource struggles and the techno-politics of small-scale mining. *Geoforum* 87, 95–107. <https://doi.org/10.1016/j.geoforum.2017.10.010>.
- Standish, J., Leader, J., 1986. Materials handling and reclamation of Yukon placer mines : an overview. <https://doi.org/10.14288/1.0042116>.
- Sydd, O., Sairinen, R., Orenius, O., Tiainen, H., 2023. Local perceptions of small-scale metal mining development in post-conflict transition countries: the case of Bosnia and Herzegovina. *Extr. Ind. Soc.* 13, 101225 <https://doi.org/10.1016/j.exis.2023.101225>.
- Sydd, O., Sairinen, R., Orenius, O., Tiainen, H., 2022. Social impacts of modern small-scale mining: case studies from Serbia and Bosnia & Herzegovina. *Soc. Nat. Resour.* 1–20. <https://doi.org/10.1080/08941920.2022.2079157>.
- Telmer, K., Persaud, A., 2013. Historical and modern government responses to artisanal and small scale gold mining. In: Artisanal Gold Council. Presented at the Rocky Mountain Mineral Law Foundation (RMLLF) and the International Bar Association, Special Institute on International Mining and Oil & Gas Law, Development, and Investment, Cartagena, Colombia.
- The Klondike Viking, 2016. Canada Council for the Arts.
- Thompson, J., 2018. Gold seekers are flooding into the Yukon and wreaking havoc on its rivers. *The Narwhal*.
- Tr'ondëk Hwëch' in Government, 2011. Tr'ondëk Hwëch' in Mining Mandate.
- Tucker, A., 2012. There's a new breed of forty-niners rushing to the pacific. *Smithson. Mag.*
- UNESCO, 2004. Tr'ondëk-Klondike [WWW Document]. UNESCO World Herit. Cent. URL <https://whc.unesco.org/en/tentativelists/6255/>, 10.24.22.
- Veiga, M.M., 1997. Introducing New Technologies for Abatement of Global Mercury Pollution in Latin America. CETEM/CNPq, Rio de Janeiro, RJ, Brazil.
- Veiga, M.M., Fadiná, O., 2020. A review of the failed attempts to curb mercury use at artisanal gold mines and a proposed solution. *Extr. Ind. Soc.* 7, 1135–1146. <https://doi.org/10.1016/j.exis.2020.06.023>.
- Victoria Gold Corp, 2019. The Eagle gold mine [WWW document]. Vic. Gold Corp. <http://vgcx.com/production/eagle-gold-mine/overview/>. (Accessed 10 October 2022).
- Wall, F., Rollat, A., Pell, R.S., 2017. Responsible sourcing of critical metals. *Elements* 13, 313–318. <https://doi.org/10.2138/gselements.13.5.313>.
- World Bank, 2020. The State of Artisanal and Small-Scale Mining Sector.
- World Bank, 2019. Shining a Light on a Hidden Sector. World Bank. <https://www.worldbank.org/en/news/feature/2019/06/19/shining-a-light-on-a-hidden-sector>, 1.30.23.
- World Bank, 2009. Mining together A guide for action large-scale mining meets artisanal mining: a guide for action. Communities and Small-scale Mining (CASM), The World Bank/International Finance Corporation Oil, Gas and Mining Sustainable Community Development Fund (CommDev).
- World Gold Council, 2022. Lessons Learned on Managing the Interface between Large-Scale and Artisanal and Small-Scale Gold Mining.
- Wright, N., Greenacre, D., Smith, A., 2022. Klondike placer miners' association wetland classification handbook. https://www.kpma.ca/wp-content/uploads/2022/05/KPMA_Wetland-Classification-Guide-screen-version-April-2022.pdf, 1.24.23.
- YESAB, 2021. Faq - YESAB. <https://www.yesab.ca/faq/>. (Accessed 11 February 2021).
- Yong, J., Winters, J., Law, T.H., Vis, J., Clark, K., 2021. Establishing a Business in Canada (Federal).
- Yue, X., Li, Y., Zhou, L., 2023. The impact of empowerment practice on the rural collective economy: empirical evidence from rural communities in China. *Land* 12, 908. <https://doi.org/10.3390/land12040908>.
- Yukon Bureau of Statistics, 2022. Yukon Monthly Statistical Review January 2022.
- Yukon Government, 2023a. Determine the class of your placer mining operation. <https://yukon.ca/en/doing-business/licensing/determine-class-your-placer-mining-operation>, 10.19.22.
- Yukon Government, 2023b. A policy for the stewardship of Yukon's wetlands. <https://yukon.ca/en/policy-stewardship-yukons-wetlands>, 1.24.23.
- Yukon Government, 2021a. Government of Yukon collaborating with Yukon First Nations to develop new mining legislation. <https://yukon.ca/en/news/government-yukon-collaborating-yukon-first-nations-develop-new-mining-legislation>, 10.17.22.
- Yukon Government, 2021b. Yukon mineral development strategy: what we heard. http://yukon.ca/sites/yukon.ca/files/ymds-what-we-heard-report_1.pdf, 10.19.22.
- Yukon Government, 2020. What's new with Class 1 Notification? <https://yukon.ca/sites/yukon.ca/files/emr/emr-forms/emr-whats-new-with-class1-notification.pdf>, 1.24.23.
- Yukon Government, 2003a. Placer Mining Act, S.Y. 2003; c.13. CanLII.
- Yukon Government, 2003b. Quartz Mining Act, SY 2003, C. 14.
- Yukon Government, 1993. Umbrella Final Agreement.
- Yukon Placer Secretariat, 2010. Guidebook of mitigation measures for placer mining in the Yukon. Whitehorse, Yukon.
- Yukon Water Board, 2020. Yukon water board. <https://www.yukonwaterboard.ca/>. (Accessed 11 February 2021).
- MAC, 2024. Mining Association of Canada: Indigenous Affairs. [WWW Document]. URL <https://mining.ca/our-focus/indigenous-affairs/> (accessed 4.1.24).