Nb41: A Speculative Ethnography of the Element Niobium

Andrés Salas

A Thesis
In the Department of

Fine Arts

Presented in Partial Fulfillment of the Requirements
For the Degree of

Doctor of Philosophy

at Concordia University
Montréal, Québec, Canada

August 2025

CONCORDIA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

This is to certify that the thesis prepared
By: Andrés Salas
Entitled: *Nb41*: A Speculative Ethnography of the Element Niobium
and submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

complies with the regulations of the University and meets the accepted standars with respect to originality and quality.

Signed by the final examining committee:

---------- Chair
Dr.

---------- External Examiner
Dr.

---------- Examiner
Dr.

---------- Examiner
Dr.

---------- Thesis Supervisor
Dr.

Approved by

Dr. Jesse Arsenault

August 5, 2025

Dr. Annie Gérin

Abstract For PhD

Nb41: A Speculative Ethnography of the Element Niobium

Andrés Salas, Ph.D.

Concordia University, 2025

Nb41 is a speculative ethnography of niobium (Nb), a strategic mineral central to contemporary technologies, scientific research, cultural imaginaries, and Indigenous cosmologies and struggles. Structured through a written dissertation and an art installation comprising an experimental documentary film (45 minutes) and a series of ceramics, the project critically explores how niobium's multiple materialities—geological, industrial, cultural, and spiritual—construct and modulate human understandings of the world. Grounded in fieldwork at sites such as the former St. Lawrence Niobium Mine in Oka, Mount Saint-Hilaire, the Omacha Natural Reserve in Vichada, and the TRIUMF particle accelerator in Vancouver, the research interweaves personal narrative, archival excavation, and theoretical inquiry.

The thesis moves through diverse institutional and archival spaces, drawing from materials at the National Film Board of Canada, Quebec National Archives, Canadian Museum of Nature, National Library of Colombia, and the Cooper Hewitt Smithsonian Design Museum. A residency at the Banff Centre for Arts and Creativity allowed for a direct material engagement with niobium in ceramics, an innovative practice rarely explored in contemporary art, foregrounding an ecosophical approach to matter.

The theoretical framework brings into dialogue Alfred North Whitehead's philosophy of relationality; Gilles Deleuze and Félix Guattari's concepts of machinic phylum and Deleuze's "power of the false"; Brian Massumi's notion of semblance; Erin Manning's articulation of research-creation as a practice of sensing and worlding through the minor gesture; Henri Bergson's theories of creative evolution and cinematic perception; Walter Benjamin's critique of technological modernity; Ruth Wilson Gilmore's theory of racial capitalism; critical theories of logistics and extraction; and Davi Kopenawa's Indigenous cosmology and relational thought. Through these frameworks, niobium emerges not merely as a technological input but as an active participant in the narration and construction of human and more-than-human worlds.

Ultimately, the thesis proposes an expanded, speculative engagement with matter. By materially re-appropriating niobium and re-reading its histories, it challenges extractive paradigms and reframes art-making as a transformative practice situated within ecological, technological, and cosmopolitical concerns.

Acknowledgements

The niobium encounter has been a transformative experience—one that has carried me across distant territories, guided by a mineral whose paths exceeded what I could have imagined. It has been a journey marked by wonder: imagining a time when these distant places were once part of the same landmass; and also by mourning, the loss of dear friends and family who are no longer here. It has been a journey of endurance through moments of sickness and uncertainty, and of deep gratitude for the unwavering support of family and friends at each step of the road.

If there is one thing I have truly learned during this research, it is that life is collaborative. Though I believed I understood this, niobium has shown me, through practice, that our worlds emerge only in relation. That knowledge happens at the encounter.

This work would not have been possible without the support of my family and close friends. To my mother, all my love, gratitude, and admiration. To Pia for her patience, support, and love.

To my supervisor, Dr. Erin Manning, words cannot express the depth of my gratitude. Thank you for your trust, for your friendship, for so much inspiration and motivation. Thank you for showing me that iguanas also live in the Boreal forest.

I am also deeply thankful for the financial and institutional support that made this research possible: the Social Sciences and Humanities Research Council (SSHRC), the Canada Council for the Arts, and the Banff Centre for Arts and Creativity.

Table of Contents

List of Images VI
Introduction 1
Chapter 1 6
The initial encounter 6
Niobium in Oka, Quebec 10
The New 13
The Uncertain Future of Niobium Mining in Oka 16
From Columbium to Niobium a history in film 20
NFB archives vault: Columbium a space-age metal (1964) 22
The Quebec National Archives: Columbium (1967) 27
Thinking the movable through the unmovable 28
Chapter 2 34
From columbium to America 37
Porcelain as technology 41
The continents Set 46
Chapter 3 54
Speculating at the quarry 57
Niobium at The Canadian Museum of Nature 60
The curtain rises and it is me 67
A flowsheet of cracks 71
Niobium in the tropics 74
Chapter 4 79
One Continent 82
From Minastyc to Seis Lagos 86
One niobium 92
The Bojonawi Natural Reserve 94
The Tepuis, the Savannah, the River 101
Chapter 5 111
The Q-Slope Problem 121
Niobium at TRIUMF 126
The Film's Montage and the encounter with clay 135
Conclusions 139
Bibliography 149

List of Images

Image 1.1 Saint Lawrence Niobium mine. (Salas, A., 2020). 10
Image 1.2 Columbium – Jet Engine Metal (National Film Board of Canada). 13
Image 1.3 Saint Lawrence Niobium mine. (Salas, A., 2020). 20
Image 1.4 Documenting the film Columbium: A Space-Age Metal at the NFB (Salas, A., 2024). 24
Image 1.5 National Film Board of Canada, Montreal vault. (Salas, A., 2024). 26
Image 1.6 Still image from the film “Colombium”. 29
Image 1.7 Still image from the film “Colombium”. 32
Image 2.1 Iconologia, Cesare Ripa, 1764. 36
Image 2.2 America, from Iconologia (1764) 39
Image 2.3 Europa, from the set “Four Continents” by Johann Friedrich Eberlein, 1760. (Salas, A., 2024) 41
Image 2.4 Asia, from the set “Four Continents” by Johann Friedrich Eberlein, 1760. (Salas, A., 2024) 44
Image 2.5 Africa, from the set “Four Continents” by Johann Friedrich Eberlein, 1760. (Salas, A., 2024) 48
Image 2.6 America, from the set “Four Continents” by Johann Friedrich Eberlein, 1760. (Salas, A., 2024) 52
Image 3.1 Canadian Museum of Nature collection. (Salas, A., 2024). 56
Image 3.2 Mount Saint-Hilaire quarry. (Salas, A., 2024). 59
Image 3.3 Saint Lawrence niobium mine at Kanehsatà:ke. (Salas, A., 2024). 65
Image 3.4 Still image from the film “Colombium”. 69
Image 3.5 Linear Accelerator Cold Box at TRIUMF. (Salas, A., 2024). 74
Image 3.6 Minastyc mining site. Vichada, Colombia. (Salas, A., 2024). 77
Image 4.1 Niobium bulk SRF cavities produced at Jefferson Lab, in Virginia, USA. (Salas, A., 2024) 81
Image 4.2 View from Mount Campana at the Bojonawi Reserve. (Salas, A., 2024). 102
Image 4.3 Tepui in the Bojonawi reserve. (Salas, A., 2024). 103
Image 4.4 Minastyc testing site. Vichada, Colombia. (Salas, A., 2024). 104
Image 4.5 Fires in the Savannah next to Mount Carabayo. Vichada, Colombia. (Salas, A., 2024). 105
Image 4.6 Rock Island in the Orinoco River. (Salas, A., 2024). 106
Image 4.7 Ruben looking at Mount Carabayo, Sikuani territory. (Salas, A., 2024). 107
Image 4.8 View of a tepui in Venezuela from the Orinoco River. (Salas, A., 2024). 108
Image 4.9 Pictograms at Mount Carabayo, Sikuani territory. (Salas, A., 2024). 109
Image 5.1 Cyclotron Control Room. TRIUMF. (Salas, A., 2024). 114
Image 5.2 SRF Niobium Cavity at TRIUMF. (Salas, A., 2024). 117
Image 5.3 TRIUMF. (Salas, A., 2024). 123
Image 5.4 TRIUMF. (Salas, A., 2024). 127
Image 5.5 Test tiles with niobium-based glaze at Banff. (Salas, A., 2024). 131
Image 5.6 Ceramic with niobium glaze. (Salas, A., 2025). 138
Figure 6.1 Rodinia (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025). 145

Figure 6.2 Universalis Cosmographia (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025). 146
Figure 6.3 Pangaea Proxima (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025) 147
Figure 6.4 *Nb41* - Film with ceramics. (Salas, A., 2025) 148

Introduction

Nb41 is an ecosophical research-creation project and speculative cartography tracing the complex entanglements surrounding the mineral niobium (Nb). It emerges from extensive doctoral fieldwork conducted across a range of geographies and infrastructures: from the boreal forests of the Canadian Shield and the rainforests along the Orinoco River in Colombia's Guiana Shield, to particle physics laboratories such as TRIUMF, Canada's national accelerator centre, and the now-closed St. Lawrence niobium mine in Kanehsatà:ke, unceded Mohawk territory. This broad geographic and disciplinary range highlights niobium's distinctive qualities: its cosmic origins in the aftermath of the Big Bang; its geological presence in critical biomes; its embeddedness in histories of colonial extraction; and its pivotal role in superconducting technologies essential to particle accelerators, quantum computing, and artificial intelligence.

Central to *Nb41* is the understanding that human histories and technological futures are deeply intertwined with the stories and materialities of elements such as niobium. Rather than treating minerals as inert resources, this project conceives of them as active participants in human and more-than-human world-making. These narratives unfold across multiple registers, from ancient pictograms painted on the Precambrian rocks of the Guiana Shield, to the finely tuned superconducting radio-frequency (SRF) cavities and magnets used in high-energy physics. The project materializes as both this written thesis and a video installation, comprising an experimental documentary (45 minutes) and a series of ceramic sculptures glazed with niobium oxide—an unconventional application of the mineral developed through tactile and speculative experimentation.

Drawing on archival research, site-specific documentation, and material engagement, *Nb41* follows niobium across landscapes, technologies, and institutions: from geological outcrops and scientific laboratories to archival films from the National Film Board of Canada, mineral collections at the Canadian Museum of Nature, and allegorical porcelain figures from the Cooper Hewitt Smithsonian Design Museum. Through these heterogeneous encounters, niobium emerges as a mediator, a narrative agent through which histories, epistemologies, and economies intersect and evolve. Each field encounter, whether scientific, geological, spiritual, or artistic, challenges

conventional narratives and prompts a reimagining of how knowledge is produced, circulated, owned, and embodied. The project thus foregrounds the material and affective dimensions of knowledge production while questioning dominant frameworks that separate science from art, and matter from meaning.

A pivotal moment in the development of *Nb41* occurred during a residency at the Banff Centre for Arts and Creativity, where the research practice shifted toward tactile experimentation. Rather than relying solely on moving images, the project began to work directly with niobium as a ceramic glaze. Allowing the material to guide the process, the resulting sculptures reflect niobium's inherent unpredictability. As mineralogist Paula C. Piilonen notes, niobium is an "oddball" element—one that frequently defies scientific classification: "Niobium doesn't fit neatly into typical mineralogical categories. It behaves unpredictably, forming unusual compounds and appearing in geological contexts where you wouldn't normally expect it." This embrace of material uncertainty became central to the project, decentering human authority, prioritizing material agency, and opening space for new relations between science, narrative, and artistic practice.

Ultimately, *Nb41* asks speculative and methodological questions at the heart of this thesis: What does it mean to let a mineral speak, and how might listening to materials transform our understanding of the relations that co-construct the world? How are emerging technologies reshaping our emotional and affective landscapes? What forms of knowledge arise when scientific inquiry and artistic exploration become porous? And how might tactile engagements with minerals shift our understanding of technological development, the more-than-human world, and the very conditions of knowing?

The fieldwork conducted through this research was shaped by thinkers who critically examine the relationships between humans and the world—relationships mediated by the materials we live with, alter, and are altered by. Rather than rejecting technology, their work allows for a rethinking of it: a reconsideration of the material processes that sustain it, the ecological and social relations it transforms, and the role it plays in shaping planetary habitability. This perspective foregrounds collective responsibility in the production of the world and opens the possibility of reimagining technology not as extraction, but as relation. In this

spirit, and following Whitehead's *Philosophy of Nature* (1920), niobium is conceived as a nexus of actual occasions: an ongoing, processual, evolving entity formed by interrelated events, always in the process of becoming. From this perspective, niobium is not merely a passive element in scientific progress, but an active participant in worldmaking. The abandoned Saint Lawrence niobium mine in Oka, Quebec, for instance, is explored not as a static ruin, but as a site of relation. Drawing from Brian Massumi's theory of semblance (2011), Walter Benjamin's aesthetics of relation (2003), and Deleuze and Guattari's concept of the machinic phylum (1980), the mine is positioned not as a relic of past extraction, but as a field of affective intensities where relations become visible through encounter. Through this lens, sites, materials, and images become agents of worlding, activating memory, sensation, and thought-feeling. Niobium begins to operate less as a material resource and more as an intercessor, drawing disparate elements into relation across time and space.

Building on this approach to relational materiality, the project examines the entanglement of matter, representation, and colonial imaginaries. Ruth Wilson Gilmore's theory of racial capitalism (2022) and Harney and Moten's critique of logistical representation (2021) frame an analysis of how materials such as eighteenth-century Meissen porcelain participated in visual regimes that spatialized power. The allegorical figures of the continents—particularly that of America—reveal how storytelling technologies such as maps, ceramics, and ornamentation have long operated as instruments of domination and classification. In this context, porcelain emerges not merely as decorative art, but as a medium of logistical control: a substance born of extraction and refinement, used to racialize bodies, inscribe fantasies of conquest, and materialize imperial worldviews. Materials such as porcelain and niobium are thus not neutral carriers of meaning, but are saturated with ideological and geopolitical intensities, shaping how the world is represented, ordered, and imagined. From porcelain figurines to contemporary AI infrastructures, these material-discursive systems persist as technologies that organize visibility, hierarchy, and endurance.

Grounded in site visits to Mount Saint-Hilaire and the Canadian Museum of Nature, the research further mobilizes Whitehead's process philosophy (1978) and Massumi's notion of non-sensuous similarity (2011) to explore niobium not as a stable object, but as a becoming, an evental field that gathers, folds, and reshapes relations across time and scale. Niobium's

geological “weird personality” becomes a conceptual anchor for thinking with matter rather than about it. The element acts as a speculative agent that does not merely inhabit the world but co-creates its perceptibility, worlding through affective resonance, mineralogical excess, and unpredictable movements across geological and geopolitical formations. In this expanded view, niobium appears not only as an extractable substance but as a cosmopolitical presence embedded in landscapes, soils, and ancestral knowledge systems.

Fieldwork along the Orinoco River, encounters with the *tepuis*[1], and reflections on Indigenous worldviews bring the research into dialogue with Davi Kopenawa’s relational cosmology (2013) and Glissant’s poetics of opacity (1990). Here, niobium ceases to be an object of abstraction and becomes a participant in more-than-human relations—stories carved into stone, felt through climate, or encoded in the scarred topographies of extractive frontiers. Niobium is reimagined as a mineral mediator between territories, temporalities, and ontologies, challenging the linearity of Western science and inviting other modes of sensing, narrating, and coexisting with matter. In resonance with Erin Manning’s notion of speculative pragmatism (2016), the work foregrounds a methodology rooted in thinking-feeling with materials. Through montage, ceramics, and embodied encounters with scientific infrastructures, niobium ceased to function as a passive element and instead became an expressive participant in the unfolding of the project.

Alongside field encounters and material experimentation, this research engages extensively with archival materials and interviews, treating both as living sites of relation. Film archives from the National Film Board of Canada and mineral collections at the Canadian Museum of Nature offered not only historical traces, but affective atmospheres. These archival spaces, like the mines and laboratories, structure what is visible and sayable about minerals, technologies, and futures. Similarly, interviews with scientists, conservators, and Indigenous thinkers opened dialogical spaces where disciplinary knowledge could encounter intuitive speculation. Rather than reinforcing disciplinary boundaries, the interviews contributed to a more porous and affective understanding of niobium, shaped by the gestures, metaphors, and material

[1] A tepui is a table-top mountain or mesa found primarily in the Guiana Highlands of South America, especially in southern Venezuela, northern Brazil, Colombia, and Guyana. The word *tepui* comes from the Pemon language (spoken by Indigenous peoples in the Gran Sabana region of Venezuela), and it means "house of the gods."

imaginaries that emerged in each exchange. In this way, both archives and interviews become integral to the speculative ethnography of niobium, crystallizing the sedimented logics and emergent possibilities through which materials participate in worldmaking.

Chapter 1

The initial encounter

The first time I visited the now closed Saint Lawrence niobium (Nb) mine, in Oka Quebec[2], I was not sure what I was looking for. I just had the urge to move from thinking and theorizing about niobium, to go out and attempt to encounter it. I knew the site was important for my research, (beyond the apparent connections) but I did not yet know how. I convinced my friend Diego to come with me. I knew we had to drive for about one hour, and that just before Oka, we would find a cheese factory, where we would park. Then we would have to walk for about ten minutes to the entrance of a small road I marked on a hand-drawn map. Our objective was to visit two big water ponds that looked to be surrounded by a dense forest on the satellite images. After a short walk we encountered a small dirt road with a prohibited entrance sign, and a small chain as the only obstacle to access the site, a blockage more symbolic than real. We jumped the chain without effort and started to walk up the dirt path, very fast and quiet, afraid of being seen or heard. It did not take us long before we found a metal fence, and through the bushes we saw one of the pounds we were looking for. We then found an old barrier gate covered in graffiti, and through it, we walked toward the water. It was a cloudy fall morning, I had my camera with me and started taking images of everything I saw around. We walked around for a while and one of our first questions was to think how deep the quarry could be; the water was clear but the pond was pitch black. Some little fish could be seen swimming and looking back at us, as curious about us as we were of them. At the point when we found the second pond, we were not afraid of being caught anymore. At first, the whole site appeared abandoned; the broken fences, still water, and the absence of workers gave it the semblance of a forgotten place, where the only sounds that we could hear were the rustling of trees. I was very excited, it was the first time I was face to face with niobium, an encounter that represented a small victory in my quest to

[2] This small village, located one hour drive to the west from Montreal, is well known for its cheese, its lake and beach—an integral part of life for Montrealers during the summer—and for the Oka crisis. Its original name is Kanehsatà:ke, name given by the Kanien'kehà:ka (Mohawk), original custodians of this territory. In 1717, seven-year-old King Louis XV of France granted The Seminary of St-Sulpice mission in Montreal, this territory. Rather than holding it in trust, the Sulpicians retained the ownership rights of the land and decided to sell it to white settlers. The Mohawk people repeatedly contested these claims over the following two centuries, leading to one of the most enduring and contested land disputes in Canadian history.

do this research. Standing in front of the ponds, looking at the water, it was inevitable to think about how something so complex as superconductivity, particle accelerators, and the study of the universe, were possible in part by the mineral I was standing on. My mind also started to wonder about the indigenous history of this place, the multiple struggles and fights related to this land, and the present legal status of the mine. I shot some video and recorded some soundscapes. We wandered around for about two hours before we started to feel rain falling and decided to pack up and leave.

Back at home, looking at the images we gathered, my first thoughts after the excitement of having found and visited the site successfully were about recognition. Other abandoned extraction sites that I have visited in the past, as part of other research-creation projects, felt very similar and activated parallel thoughts in my mind. They were not abandoned nor empty, although it seems time stopped for them, the case often is that there is always something else to extract revenues from, there are more studies to conduct, rights and permits to be processed, government plans to be developed. The Oka mine is not merely a ruin; it is an accumulation of semblances, a multilayer array of affects, materials, relations, and histories. As Brian Massumi suggests, "a semblance is a form of inclusion of what exceeds the artifact's actuality" (Massumi, 2011, p. 58). A semblance is not an illusion, it is a whole relational universe, one that in my case, has been activated by an encounter; an infinite of possibilities. The mine appeared abandoned, but this perception is only visible through what is beneath, what cannot be seen, by the forces working—in the present— "on the other side." The apparent stillness of the mine is fueled by the economic speculation and strategic interests to re-open it, by new commercial products, by new scientific and industrial developments that require superconducting technologies, by the very active radon contamination of the old tailings, by the tensions between the Mohawk community of Kanehsatà:ke and a history of dispossession, displacement, and extermination.

This first visit was about reaffirming my commitment with my initial intentions and about testing how feasible the project was. Back then, I had the feeling that I was being naïve about being able to go deep into the different environments and settings where I was tracking the mineral. Perhaps, I romanticized the connections and findings I was making, hoping to make it all the way to CERN and to learn about how they use Nb at the LHC, or to have full access to the

active Niobec mine in Saguenay, Quebec, while working with the Innu community, inhabitants of the land where this mine operates today. As my naivety allowed me to be excited, about having trespassed a site I thought was extremely difficult to access, I also understood that I really did not know what I wanted from visiting the mine, and that I was far away from understanding what kind of relation I had with Nb until that moment. All I knew was that the mineral that was extracted from this now closed mine, allowed scientists to study the birth of the universe and that such production of knowledge was closely linked to the multiplicity of stories of the mineral.

What is needed for something to appear? To emerge? To become? In the background of the experience of life, what is amiss, allows what is perceived, to be "visible." Like in a photographic negative, the image that is revealed through chemical processes becomes positive, identifiable, readable, and a copy of a relatable reality, thanks to its "opposite". What is not perceived is the stand, the background where everything that can be captured by the senses, lies on. The mine site (anywhere in the world) appears as a place to think about the logistics of capitalism; forces working endlessly towards the creation of economic value through the stock market, the invention of techno-scientific-commercial objects, the production of knowledge, the clearing of forests, the health of local communities, and the indigenous human, cultural, and spiritual genocide that keeps repeating itself. "Logistics emerges as much as the science of loss prevention as the science of moving property through the emptiness, of making the world as it travels by filling it" (Harney, Moten, 2021, p. 17). Logistics operates on the colonial concept of emptiness, on the fear of the unknown, and the control allowed by what has been cleared.

"Emptiness is the lack of something. It is not something that you define by what it is, it is something that you define by what it is not" (Ouellet, 2022); lack of, not mere absence. According to astrophysics, before the expansion of the universe, there was no such thing as empty space. Every single part of what we call now outer space was tightly packed. As the universe evolved, empty spaces started to appear, to then be filled by different celestial bodies, created as the universe was expanding. In outer space, emptiness means a lack of density, the lack of dust, gas, light, etc., which is equal to a lack of gravity, meaning the impossibility to create new planets, stars, or suns, the impossibility for novelty. For the colonial mind, emptiness is translated as absence of production of value, a missing opportunity to find new resources,

invent new products, or the opportunity to dominate, expropriate, displace, trade, or enslave human and more-than-human beings. Developed after the technology of the slave ship[3], our existence under a capitalistic environment, is framed by how much value can be extracted from every aspect of our lives, from the moment we are born. Actions framed within this paradigm, "aim at getting something that we feel we want of, or at creating something that does not yet exist… only if the present reality is not the one we are seeking, we speak of the absence of this sought-for reality wherever we find the presence of another. We thus express what we have as a function of what we want." (Bergson, 1941, p. 298)

For Walter Benjamin, semblance (*Schein*) exists in different degrees, and its aesthetic and political power depends on its ability to make relationships noticeable. Some semblances can be considered more intense or revealing than others, depending on their capacity to make relations visible to the senses. The intensity of semblance, its beauty, is linked to its potentiality to generate a perceptual move, an experience through which an event opens the door to deeper comprehension. This experience is not simply cognitive but affective, a thought-feeling that allows one to grasp a universe of relations through the singularity of an encounter. My encounter with the abandoned mine site marks the beginning of a system of relations through which I have come to think of niobium as an event, one that has pushed me to move through the world in a different way, allowing me to question the ways in which I frame reality. If for Benjamin semblance has degrees of intensity and makes underlying relations visible, for Brian Massumi semblance is an activation of potentiality. In this sense, semblance is a process that amplifies reality, allowing the perception of what might be apparently invisible. The abandoned mine site does not only signify an industrial past, it exceeds its material ruins, generating a field of affect that has attracted me into its network of relations. Furthermore, my obsession with semi-abandoned industrial environments pulls me back to teenage memories, of leaving the coffee farm where I grew up to move to a working-class industrial neighbourhood in the city. Warehouses, old factories, and workshops became a new environment where during the day I would go to school and at night we would explore what the empty lots had to offer. These spaces

[3] The slave ship was not only a vessel for transporting enslaved people but also a key site in the emergence of modern capitalism, logistics, and extractive economies. As theorized by Marcus Rediker in *The Slave Ship: A Human History* (2007) and Christina Sharpe in *In the Wake: On Blackness and Being* (2016), the ship functioned as both a literal and metaphorical structure for the systematic commodification of human life. The ship, as an early apparatus of global logistics, laid the groundwork for modern capitalist supply chains.

were both home and playground, *zones of excess,* where fabulation was activated. In the same way the mine does not feel inert to me. Niobium becomes an activator, an intercessor, something that exceeds its role in modern industries, moving between different worlds, beings, and temporalities, activating, and transforming deeply my existence. Research-creation and thought-feeling then come together, away from academic discussions, to generate a field of fabulation where concepts are finally transformed in experiences, and experiences shape a creative process that guides the work.

Image 1.1 Saint Lawrence Niobium mine. (Salas, A., 2020).

Niobium in Oka, Quebec

The story of Oka's niobium mine is one of geological origins, technological advancement, and cycles of resource extraction on unceded Indigenous land. It is deeply intertwined with Canada's modern mining industry and the global race for strategic materials. Though officially classified as "inactive," the mine remains full of potential, not just for renewed extraction, but for

rethinking how we understand technological development, knowledge production, and environmental challenges. It offers an opportunity to reconsider how imaginaries of the future are inherently connected to material processes, both organic and inorganic, that co-construct the world. As Brian Massumi suggests, "you have to be willing to see the world in a semblance. That could be mystical. But again, it could be a question of technique" (Massumi, 2011, p. 85).

Located in Deux-Montagnes, Quebec, the St. Lawrence Columbium[4] mine, also known as the Oka complex, was discovered in 1954 and began operations in 1961. During its operational years, it was one of the world's most productive niobium mines, extracting niobium-rich ore from a 117 to 120-million-year-old carbonatite complex. However, after nearly two decades of production, the mine ceased operations in 1977. Despite its closure, the legacy of the mine continues to impact local communities. Environmental concerns, including radioactive waste management, underground water contamination, and the risk of radon exposure leading to lung cancer[5], have made niobium mining in Oka a point of contention. The Mohawk community of Kanehsatà:ke has repeatedly opposed efforts to reopen the mine; their resistance is part of a broader struggle against extractive industries that have long disregarded Indigenous sovereignty and environmental sustainability.

Niobium's history in Canada dates back to the 1950s when it was initially known as *columbium* and referred to as the "jet engine metal." By the 1960s, scientists discovered that niobium alloys exhibited exceptional superconducting properties, leading to its adoption in advanced technologies. For the past six decades, niobium-titanium (Nb-Ti) alloys have become the industry standard for superconducting applications. Though niobium's primary industrial use has been in strengthening steel alloys for the automotive industry, its superconducting properties have made it a crucial material for a new generation of technologies. Niobium-based materials are used in MRI medical equipment, spacecraft alloys, and superconducting radio-frequency (SRF) cavities and magnets for particle accelerators. At the European Organization for Nuclear Research (CERN) Large Hadron Collider (LHC), over 500 tons of Nb-Ti wire have been used in

[4] For decades Columbium and Niobium were thought to be different elements. Later studies showed they were the same. The name niobium was standardized in 1950 by the International Union of Pure and Applied Chemistry (IUPAC).

[5] *Bureau d'audiences publiques sur l'environnement* (2002). *Rapport d'enquête et d'audience publique – Projet de mine souterraine de niobium à Oka*. Québec: Gouvernement du Québec.

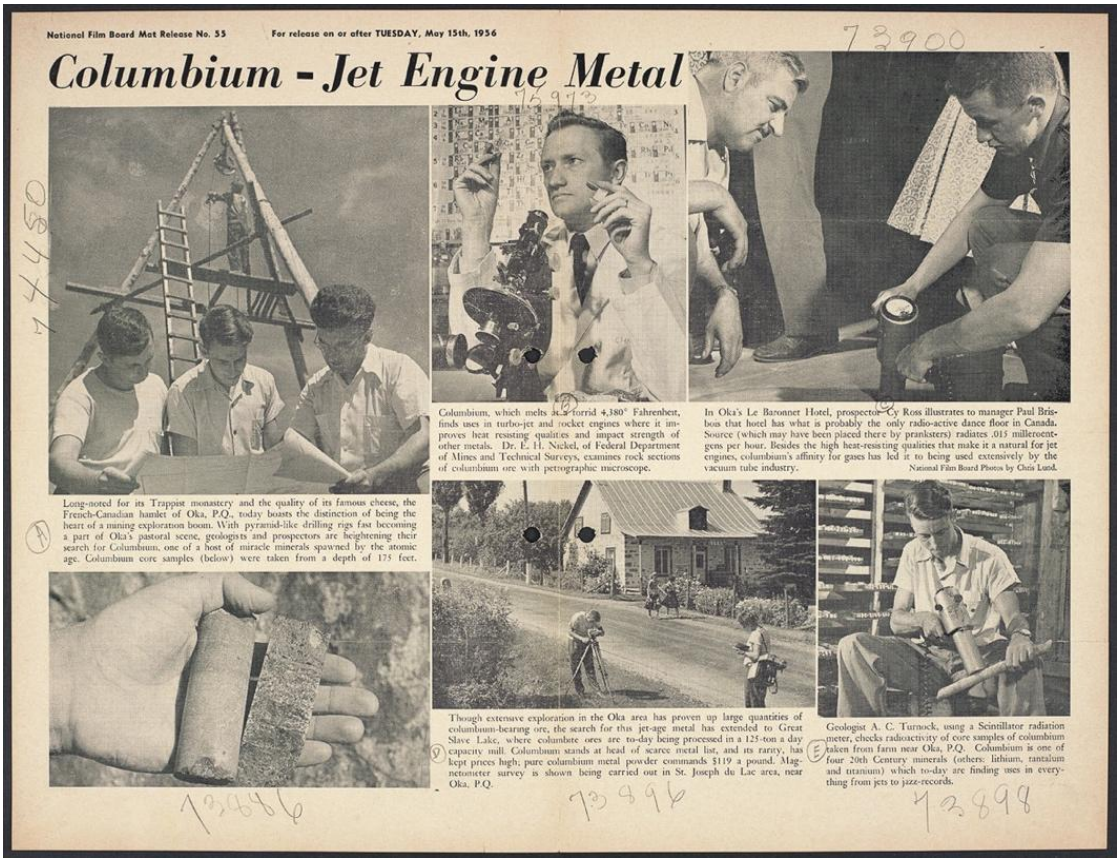
magnets, superconducting wire filaments, and SRF bulk niobium cavities, illustrating its indispensable role in high-energy physics. Today, the global niobium supply is concentrated in just a few locations. Approximately 90% of the world's niobium comes from Araxá, Minas Gerais, Brazil—named after the now-extinct Indigenous Araxás people. The remaining 10% is extracted from Niobec, a niobium mine located within Mashteuiatsh, an Innu territory in Saint-Honoré, Quebec.

The story of niobium is not just about technological innovation, it is also about the geopolitics of extraction. The mining industry continues to transfer materials from resource-rich regions to industrial and technological power centres, reinforcing historical patterns of exploitation and control. These extractive economies are deeply linked to histories of colonialism and capitalism, perpetuating cycles of dispossession and environmental destruction. Regions abundant in critical minerals are often sites of heightened violence against environmental defenders, particularly Indigenous land protectors. While niobium fuels scientific progress, its extraction remains fraught with social and ecological consequences that are overlooked, when the need for a stable and solid economy is at play. From the Jet Engine Metal to the main superconductor material, to now an essential element in quantum computing and AI technologies, niobium has become critical for next-generation digital advancements.

Recent developments have propelled niobium-based chips into the heart of technological progress, yet, even as its technological value climbs, (just as the interest to open new extraction sites[6]) the underlying social and environmental challenges of its extraction persist, calling into question the logic of our relentless pursuit of innovation. This push to develop new mines across Malawi, Australia, Canada, Tanzania, China, Spain, Norway, and Greenland reveals an inherent geopolitical anxiety; each country racing to secure niobium reserves out of fear of economic vulnerability, and to claim national respect in global markets. Yet, Brazil's Araxá mine alone holds sufficient niobium reserves to supply current global demand for at least another 200 years. The world doesn't necessarily need more niobium mines for practical purposes; rather, nations

[6] Several new niobium mining projects are under development worldwide; Malawi, Australia, Canada, Tanzania, China, Spain, and Norway are among the countries currently advancing significant extraction projects for niobium (Nb). Additionally, Greenland, an autonomous territory within the Kingdom of Denmark, has emerged as a geopolitically critical area due to its abundant reserves of niobium and other rare earth minerals, essential for advancing artificial intelligence (AI) and quantum computing technologies.

seek their own mines simply to affirm control, competitiveness, and economic sovereignty—even if it comes at the cost of unnecessary environmental and social harm.


National Film Board Mat Release No. 55 For release on or after TUESDAY, May 15th, 1956

Columbium - Jet Engine Metal

Long-noted for its Trappist monastery and the quality of its famous cheese, the French-Canadian hamlet of Oka, P.Q., today boasts the distinction of being the heart of a mining exploration boom. With pyramid-like drilling rigs fast becoming a part of Oka's pastoral scene, geologists and prospectors are heightening their search for Columbium, one of a host of miracle minerals spawned by the atomic age. Columbium core samples (below) were taken from a depth of 175 feet.

Columbium, which melts at a torrid 4,380° Fahrenheit, finds uses in turbo-jet and rocket engines where it improves heat resisting qualities and impact strength of other metals. Dr. E. H. Nickel, of Federal Department of Mines and Technical Surveys, examines rock sections of columbium ore with petrographic microscope.

In Oka's Le Baronnet Hotel, prospector Cy Ross illustrates to manager Paul Brisbois that hotel has what is probably the only radio-active dance floor in Canada. Source (which may have been placed there by pranksters) radiates .015 milleroentgens per hour. Besides the high heat-resisting qualities that make it a natural for jet engines, columbium's affinity for gases has led it to being used extensively by the vacuum tube industry.

National Film Board Photos by Chris Lund.

Though extensive exploration in the Oka area has proven up large quantities of columbium-bearing ore, the search for this jet-age metal has extended to Great Slave Lake, where columbite ores are to-day being processed in a 125-ton a day capacity mill. Columbium stands at head of scarce metal list, and its rarity, has kept prices high; pure columbium metal powder commands $119 a pound. Magnetometer survey is shown being carried out in St. Joseph du Lac area, near Oka, P.Q.

Geologist A. C. Turnock, using a Scintillator radiation meter, checks radioactivity of core samples of columbium taken from farm near Oka, P.Q. Columbium is one of four 20th Century minerals (others: lithium, tantalum and titanium) which to-day are finding uses in everything from jets to jizz-records.

Image 1.2 Columbium – Jet Engine Metal (National Film Board of Canada).

The New

It is possible to talk about a language of music and of sculpture, about a
language of justice that has nothing directly to do
with those in which German or English legal judgments are couched,
about a language of technology that is not the specialized language of technicians.

—Walter Benjamin —*On the Language as Such and On the Language of Man.*

The emergence of the "new," a recurrent event in the history of colonialism, has nourished the imaginary of modernity and the techno-scientific laboratory, where objects are defined by measuring the “events” they supposedly produce. This process is repeated indefinitely, granting the power to name, confer qualities, and assign values to entities, all while disregarding the consequences inherent in creating meanings and establishing facts. The creation of value—described by Benjamin as emerging at the intersection of commodity and allegory, where value “outshines meaning; its luster is more difficult to dispel. It is, moreover, the very newest” (Benjamin, 1999, p. 347)—renders opaque the faculty of semblance. Thus, the possibility of meaning becomes invisible, and the desire for commodities erects a wall, obstructing the perception of relationships. Value creation becomes the mechanism through which semblance is transformed into commodity; objectified, its inherent ability to traverse time and space, and to build relational worlds, is reduced to a “simple location,” (what Whitehead considers the main mistake of modernity and scientific thought: the thought that an object exists independently at one fixed point in space time, completely detached from relationships) where the “new” supposedly exists. Value as distance hides meaning, preventing us from genuinely experiencing semblance.

The semblance of the new in a capitalistic frame is progress. Progress exists in repetition and recurrence, (like the process of extracting ore from the earth, which has not changed for centuries), where the new is no longer true emergence but rather an analogy, a similarity, a homogeneous, empty copy. Brian Massumi notes, “It feels different to see a semblance—this produces another level of affect—even in something so banal as a decorative motif, there is the slightly uncanny sense of feeling sight see the invisible” (Massumi, 2011, p. 44). Semblance activates time and space; it is a vehicle that allows understanding beyond the evident, reaching into relationships. “The perception of any object also involves the thinking-feeling of a semblance; an object is a semblance to the extent that we feel-think things like its backedness, volume, and weight” (Massumi, 2011, p. 44). What escapes explicit thought-feeling is completed by perception, by the senses, activating the potentialities that the object evokes in us. Potentiality is shaped by culture, personal history, etc., by the frame one gives to contemplation and individual experience. To perceive likeness, therefore, is to perceive semblance.

Why do we need more Nb mines?

To truly understand scientific knowledge and move beyond this cycle, it helps to revisit how the first people related to nature. “The ancient’s intercourse with the cosmos had been different: the ecstasy trance. For it is in this experience alone that we gain certain knowledge of what is nearest to us and what is remotest to us”. (Benjamin, 1996, p. 486). It is through this process, through the experience of nature, that the concept of semblance in Benjamin detached itself from resembling. Dancing a storm, writes Brian Massumi, was possible because of a likeness perceived between the human body and a cloud, one that is different from what today we call a resemblance. “For non-sensuous similarity is what establishes the ties between the written world and the spoken world, and between them and what is “meant” —meaning what is sensible” (Massumi, 2011, p. 105). The possibility for establishing a relationship with nature where not an imitation, but a deep communicational relationship is developed, is given through the non-sensuous similarity, the capacity of thinking-feeling not from one sense, but in the collectivity of senses and of corporeality. Furthermore, “in no one mode. All and only in their relation.” (Massumi, 2011, p. 110).

Away from the creation of scientific factishes through *newning*, through the opening of an infinite number of mines, ("new" mines emerge less as genuine innovations than as hollow repetitions, mere analogies that reaffirm historical patterns of resource competition, exploitation, and ecological damage) the emergence of a close relationship with nature allows the becoming of scientific knowledge. The affect attunement with nature is what allows the emergence of feeling part of, of belonging to, and it is what dissipates distantism; is the place where meaning emerges, and where not connection but mutual worlding, happens.

What becomes in repetition?

Following John Lee Clark[7], Erin Manning defines distantism as the presupposition that there exists a distance between the world and us, distance as “the value we put on all that is

[7] John Lee Clark is a DeafBlind poet, essayist, and activist known for his contributions to DeafBlind culture and pro-tactile theory.

already in place," (Manning, 2022, p. 101) objectively identifiable on a map. The distance comes from the utility assigned to each part of a catalogued nature, it is a process of value creation, one that outlines those things in nature that capitalism calls resources. Separating it, creating individualities, what composes the forest becomes a techno-scientific object, indispensable for the invention of weapons and tools in industrial laboratories. Value creation is distance creation; value creation is the rupture of relations; it distorts Darwinian evolution into narratives of competition and survival, where individuality and self-preservation have written the dominant story of life. Forgotten is the idea of mutual aid and collective struggle as they are not part of the reality of value creation. "There is an immense amount of warfare and extermination going on amidst various species; there is, at the same time, as much, or perhaps even more of mutual support, mutual aid, and mutual defence… Sociability is as much a law of nature as mutual struggle." (Kropotkin, 1902, p 11) It becomes impossible not to think about what constitutes the art of life for Whitehead, (first to be alive, secondly to be alive in a satisfactory way, and thirdly to acquire an increase in satisfaction) for whom the idea of "the survival of the fittest must be understood to be a fallacy." (Whitehead, 1954, p4)

The Uncertain Future of Niobium Mining in Oka

Extraction has been central to human survival and technological progress, but it has also been a tool of domination and environmental degradation. The challenge is not to reject mining entirely but to rethink extractive systems in ways that acknowledge the interconnectedness of human and more-than-human worlds, while questioning profoundly the processes of knowledge creation and its finality. Moving away from cycles of overconsumption and exploitation requires envisioning sustainable and equitable futures. Technological objects are not only manufactured in laboratories; they are also symbolically and politically constructed. Every act of mining transforms landscapes, economies, and ways of life, with effects that extend far beyond the sites where raw materials are extracted. Niobium's history—from its geological formation to its applications in advanced physics—illustrates how scientific knowledge and popular imaginaries of the future are shaped by material histories. Niobium's stories—of its name, its diverse applications, and its extraction—are just a few among many that trace its becoming into the human world. Continuously re-territorialized and re-signified, niobium is an active agent in the

construction and shaping of scientific knowledge, of popular imaginaries of the future, of the lives and environments where human and more-than-human beings exist.

¿Acaso tu cuerpo existe aparte de la tierra?
Hurgamos el desierto en busca del uranio
Olvidamos que los elementos están interconectados
Dejamos atrás el radio, gas radioactivo
Las hijas del radón suspendidas en el aire
—Juan Guillermo Sánchez, Uranio

Although the St. Lawrence niobium mine in Oka, Quebec, has been inactive since 1977, its future remains uncertain. Currently, the mining site lies abandoned, featuring two open pits and underground workings filled with water. However, the growing global demand for niobium continues to open the door to potentially reactivating mining activities at this site. Originally renowned for its agricultural significance, notably dairy farming and Oka cheese production, the discovery of niobium-rich minerals in the mid-20th century marked a significant economic transition from agriculture to mining in the region. The mine property was initially developed and operated by the St. Lawrence Columbium and Metals Corporation between 1961 and 1977. Subsequently, in the 1990s, Niocan Inc. acquired mining rights to the land, comprising 49 claims covering approximately 2,281 acres. Niocan's objective was to become a significant producer of ferroniobium, also holding substantial mining rights in the Hudson Bay territory, covering an additional 24,944 acres. For more than a decade, Niocan actively pursued the redevelopment of the Oka site but faced opposition constantly from local residents and the Mohawk community of Kanehsatà:ke[8].

Opposition has been rooted primarily in environmental and health concerns; the only recognized effect to radon exposure is lung cancer. Reports from the *Bureau d'audiences publiques sur l'environnement* (BAPE), a government body of Quebec, documented significant radon emissions from uranium- and thorium-bearing carbonatite rocks at the site. Radon,

[8] The community of Oka, Quebec, has actively opposed niobium mining projects on multiple occasions over recent decades, primarily through public consultations and organized campaigns. The most notable instances of opposition occurred in 1997, 2000, 2002, 2007, and 2016.

recognized as a carcinogen by the International Agency for Research on Cancer (IARC), was found at high concentrations in local residences, sometimes exceeding ten times the recommended Canadian public health guideline of 800 Bq/m³ (BAPE, 2002, p. 73). At this level prolonged radon exposure poses a substantial lung cancer risk, approximately 1 in 100, increasing dramatically to around 1 in 10 among smokers (BAPE, 2002, p. 74). Despite the relatively short duration of residence for most inhabitants at the time, limiting immediate epidemiological evidence of increased cancer cases, health experts recommended immediate intervention rather than awaiting the manifestation of cancer cases due to the severe potential risks (BAPE, 2002, p. 75).

Additional environmental concerns have included potential water contamination, particularly the risk of releasing metals and radioactive substances into local water bodies. Concerns extend to groundwater contamination due to infiltration from the abandoned underground workings and open pits now filled with water, which could potentially spread contaminants to nearby aquifers (BAPE, 2002, p. 24). The removal and management of old radioactive mine tailings to arrange new mining activities further worsens fears regarding environmental and public health risks, as disturbing these tailings could reintroduce pollutants into local ecosystems. The impacts on local flora and fauna due to habitat destruction, noise, and pollution from renewed mining operations have also raised significant concerns. Potential degradation of the landscape, disruption of agricultural productivity, and threats to biodiversity further amplify community resistance (BAPE, 2002, pp. 25-26).

A 2005 BAPE report emphasizes that the mine's revival would require careful management of radioactive waste, particularly the existing tailings from previous mining activities. These radioactive residues could pose serious contamination risks to both surface water and groundwater if disturbed during new mining operations (BAPE, 2005, p. 68). Water contamination is highlighted as a primary concern. The abandoned pits and underground workings currently filled with water create a potential pathway for pollutants to reach local groundwater aquifers. Reactivation of mining activities would require rigorous water management and treatment protocols to prevent contamination of local water sources, which serve residential and agricultural purposes (BAPE, 2005, p. 70). The report also identifies the

potential impacts on local ecosystems, particularly regarding habitat disruption and loss of biodiversity. Renewed mining operations could disturb local flora and fauna, threatening species that are sensitive to noise, dust, and habitat fragmentation. Measures would need to be implemented to safeguard sensitive ecological zones, emphasizing biodiversity conservation and ecological restoration post-mining (BAPE, 2005, p. 72). Additionally, increased industrial activities would likely result in higher noise levels and dust emissions, affecting nearby residential communities. Strong strategies for controlling dust dispersion and minimizing noise pollution would be necessary to mitigate these adverse effects on the local environment and community well-being (BAPE, 2005, p. 74).

In 2021 Niocan Inc. changed its name to Nio Strategic Metals Inc. As of March 2025, the company holds the mining lease and is actively conducting research activities at the site. A company's press release from December 2024 reports that the company raised approximately CAD $329,000 through a private placement, destined to determine the presence, quality, and scale of niobium at the Oka property. Furthermore, in February 2025, the company informed through their website that they received financial support of up to CAD $400,000 from Éléments08, a Quebec based strategic metals innovation company. Éléments08 — or *Centre d'excellence sur les métaux stratégiques* — was funded by the Quebec government as part of the Quebec Plan for the Development of Critical and Strategic Minerals 2020–2025, which granted the company $7.5 million on May 11, 2018 (Gouvernement du Québec, 2018). The primary objective of *Éléments08* is to promote responsible and sustainable mining practices for strategic minerals, ensuring that extraction methods respect environmental standards.

Image 1.3 Saint Lawrence Niobium mine. (Salas, A., 2020).

From Columbium to Niobium a history in film

The Niobium Oka mine is one of the doors to enter a diverse history of extraction, contested land, and actively changing material narratives in the modern world. A glimpse of its history is archived in three films: a 3-minute, 16mm silent institutional documentary from 1964, that portrays the mine and has not yet been digitized—named: *Columbium: A space-age metal*—archived at the National Film Board (NFB) vault in Montreal; a 1965 experimental film shot at the same site, likely screened exclusively at Expo 67, that imagines niobium as a female figure, titled: *Columbium*; and a 1977 documentary film—*Niobec Inc.*— about the Niobec mine in Saguenay, (one of the only global producers of Nb today) both films are preserved in the Quebec Film Office archives.

The first thing I asked myself was, what has been left out in these films? What is the *semblatic* capacity of these archives? At the core of Whitehead's philosophy is the vision of reality as a dynamic network of processes rather than static substances. Actual occasions are the

fundamental units of reality, and they do not exist through external relations but through internal processes of *prehension*—the feeling of other actualities. While actual occasions are interdependent through their inheritance of the past, they are also mutually external when contemporary, meaning they do not directly prehend one another but exist in parallel processes of becoming. In the process of worlding through an event, of experiencing the *semblatic capacities* of an event, Whitehead's negative prehension concept is indispensable to understand the "stand" that allows something to appear. Prehension in Whitehead's thought is the process through which it is possible to feel an experience, it is the possibility for an event, a being, human or more than human, to live an experience; to world through and with the other. The negative part of this prehension is what is found in the background of the experience, what is cut, put aside, what allows for the contrast that makes something "visible;" "what must be actively excluded in order for the event to have consistency." (Manning, 2020, p 17) Consistency can be possible only by cutting.

While watching the archival films, Bergson's concept of the cinematographic mechanism of thought came to my mind; his critique of how the intellect, shaped by evolution, fragments time and movement into fixed, measurable units. Bergson argues that this is a consequence of how intelligence has evolved; for him the intellect did not develop to grasp the continuous flow of reality, but to act upon matter—to survive. The process is to extract from the events a general movement, and, just as in a film projector, put together snapshots, to make sense of it; to return movement to the event, in a way that can be comprehensible for the mind. "We take snapshots, as it were, of the passing reality, and, as these are characteristic of the reality, we have only to string them on a becoming, abstract, uniform and indivisible, situated at the back of the apparatus of knowledge, in order to imitate what there is that is characteristic in this becoming itself. Perception, intellection, language so proceed in general." (Bergson, 1944, p. 332). How is it possible to think beyond the human condition and outside of this particular way of framing reality? Again, the answer might lie in what is "actively excluded", what is in between photograms. Knowledge in this framework is not about accessing truth, but a tool for action. Whitehead's response to this idea is not to reject the intellect but to situate it within experience. For him intellect becomes just one way of feeling the world, which can either close down or open up possibilities, he also makes clear his intention to rehabilitate the philosophical lineage of

Bergson, not to dismiss his critique of reason, but to defend them from accusations of anti-intellectualism: “One of my preoccupations has been to rescue their type of thought from the charge of anti-intellectualism” (Whitehead, 1978, p. xi). The cinematographic mechanism that Bergson identifies can be seen not just as a flaw of perception, but as an evolutionary affordance that capitalism would later formalize and exploit.

Bergson does not directly mention industrial capitalism, but his reflections allow us to trace how the mechanism he describes was reinforced and weaponized by capitalist modernity. The Industrial Revolution, the rise of photography, and later cinema itself, introduced new technologies that did not just try to encapsulate time, they standardized and mechanized it, synchronizing bodies, machines, and labour into repeatable and profit-oriented sequences. Under capitalism, the world becomes a measurable, segmentable, and productive place. The cinematographic way of knowing sustains a techno-capitalist rationality that extracts value by standardizing movement, abstracting time, and breaking the world into frames—frames that can be analyzed, reproduced, optimized, and sold. Knowledge in the capitalistic paradigm is cinematographical; we think of the becoming of anything in nature, we write about it, we perceive and imagine it, through a cinematograph apparatus. “It consists in supposing that we can think the un-stable by means of the stable, the moving by means of the immobile.” (Bergson, 1944, p. 297) We think of continuity through language, and in this way, we organize the spaces we encounter, whether we decide to believe they are empty or not, in order to frame them through our understanding. In this way, the following films reflect this logic, they present the mining site at Oka as land full of niobium, full of the opportunity to develop advanced technology, to build a very specific vision of the future, only achievable through extraction.

NFB archives vault: Columbium a space-age metal (1964)

When I first contacted the NFB to request access to this film, I didn’t expect to hear that it hadn’t yet been digitized. They told me it was part of a batch of film rolls waiting to be scanned, and that if I really needed it, and could pay for the service, they could accelerate a process that usually takes months. They were just as excited as I was to hear that someone was interested in

such a specific and somewhat forgotten piece. I arranged the details to visit their vault in the neighbourhood of Ville Saint-Laurent, an industrial part of Montreal, where I met a technician who had the 16mm reel ready for viewing in a projection room. I took public transportation to get there, first the metro, then the bus, a trip that took about an hour and a half. I was thrilled to leave the inner city. I always enjoy experiencing the demographic shift that happens when heading to neighbourhoods beyond the reach of the metro, where the city begins to dissolve into an endless suburb, a blend of immigrant communities and working-class Quebecers. This trip was no different. The refined architecture of the Outremont metro station, near my apartment in Mile End, gave way to a melting pot of languages and faces on the bus that would take me to the vault. As I looked at the other passengers and thought about Quebec's official policies of interculturalism, I felt quiet a thrill about the fact that I had to travel to a specific location just to watch a film. I was elated by the idea that I would be seeing a film no one had watched in years, that these images existed nowhere as digital files, that they had never been online. I felt privileged, but it also scared me. Looking out the bus window, I suddenly panicked when I realized that—just like during my first visit to the actual mine site— I wasn't really sure what I was looking for.

I had around two hours to work with the film. I was always accompanied by a technician, who was responsible for manipulating the film and operating the machine. I watched it four times, in repetition. I wanted to play with it, to pause it, rewind, repeat, move frame by frame. I had a whole plan to extract as much as I could from it, but they did not allow it. This was a sixty-year-old film, very delicate, and with each pass through the projector, it wore down a little more. I felt careless. I was used to working with digital files, and these images were not digital, they were fragile, material, finite. The archived film was resisting extraction, it demanded another mode of attention, one that could acknowledge the cost of repetition. Then, I stopped, and it hit me. The digital is also material, I reminded myself. It may offer the illusion of infinite repetition, but what wears down is not the file itself, not the frame, not the screen, it's the world. It's the water used in server farms, the forests cleared for rare earth mining, the energy pulled from the grid, the climate altered by the infrastructures that sustain digital life. The damage is displaced, dislocated, visible only if the frame through which it is watched is changed.

Image 1.4 Documenting the film Columbium: A Space-Age Metal at the NFB (Salas, A., 2024).

"Time is running, and I can only watch the film a couple of times," I said to myself. Being here feels like entering a mine site, a space where one searches for something specific, something valuable, I think to myself. I decided just to write, to watch and write anything that comes to my mind. The film provides a comprehensive view of the mine's operations. The process of extracting niobium from ore has remained largely unchanged over the decades. Whether through open-pit or underground operations, the method follows the same principle: extract the ore, crush it, mill it, wash it, and repeat. Like any other modern industrial process, everything in this paradigm is similar, is repeated infinite times; in the same way that we teach artificial intelligences to exist within a human world. It is through repetition that colonialism has developed and refined its tools; extraction has not fundamentally modified its ways and methods. But what exactly is being repeated? Repetition allows discovery, invention, and mastery, it is the foundation of learning, colonizing, and controlling. So, where do we draw the line between our impulse to produce knowledge, and reproducing systems of domination? The problem is not repetition itself, but its limits. At what moment does extraction cease to serve knowledge production, and instead become a mechanism for economic value alone?

I questioned each stage in the process of extracting Nb. What do these historical images say about our present? That capitalistic progress still operates on the same logic; disrupt, extract,

transform, mass produce, sell—repeat. This raises a fundamental question about technology: must extraction always be the condition for technological development? Walter Benjamin challenges this assumption arguing that humanity's mastery of nature consists in its capacity to enter a new, non-exploitative relationship with it. Instead of conceiving technology as a means and objective to extract, control, and manipulate nature, it is possible to envision a potentiality in technology, one that could amplify our experience in the universe. "The mastery of nature, so the imperialist teach, is the purpose of all technology…Technology is not the mastery of nature but of the relation between nature and man." (Benjamin, 1928, p. 146) When the creation of knowledge is reduced to value creation, it guarantees the repetition of a system of domination, one where the promise of progress is presented as moving forward. I left the vault filled with joy as I felt that pieces were coming together. At home I started to reflect on the nature of archives as living entities, repositories of history that must be constantly revisited, reinterpreted, and understood in new ways. Before leaving the vault I set up a date for a new visit. I decided that I didn't want to ask for a digitized version of the film, that I wanted to shoot the film while it played on the film inspection machine, that I wanted to shoot myself watching the film.

After a couple of weeks, I came back to the archives armed with my camera and a sound recording device. I met the technician at the entrance of the vault and explained to them my shooting plan. We would start in the room where they kept all the film rolls, and then move to the projection room. The idea was to shoot a sequence where they would enter the storeroom, retrieve the film roll, and bring it to the projector. Entering the vault where all the films are archived and preserved was special, I felt like going deep down into a mine; but little did I know that my fieldwork would take me to almost-the-same-vault multiple times, always looking for an encounter with niobium. "We forget that a chair isn't just a chair. In addition to being one, it looks like one. The "likeness" of an object to itself, its immediate doubleness, gives every perception a hint of deja vu. (Massumi, 2011, p. 44)

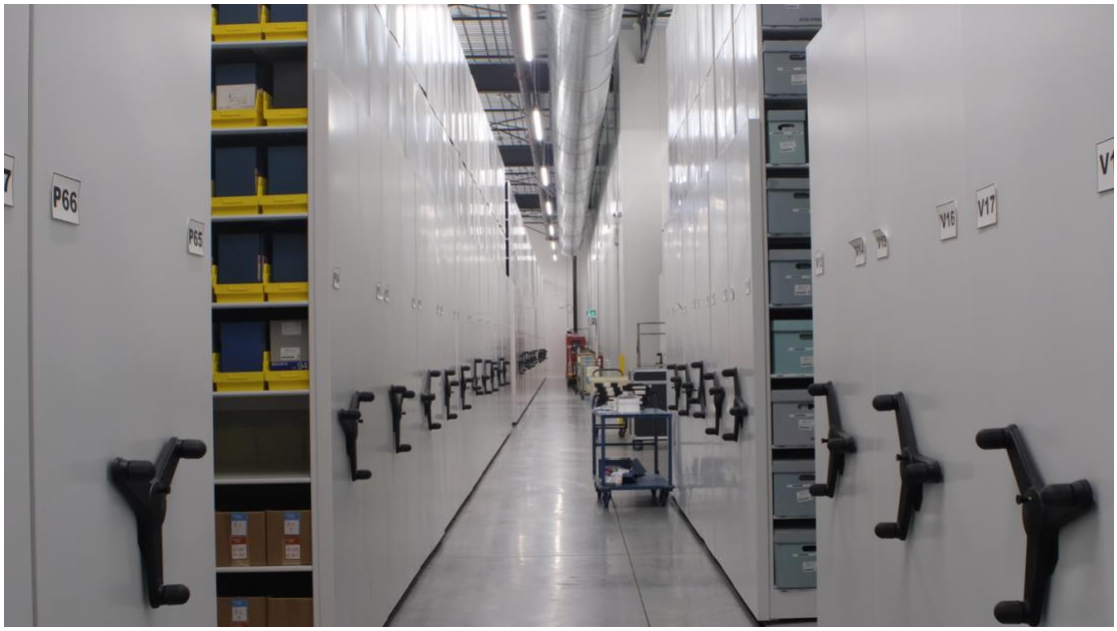


Image 1.5 National Film Board of Canada, Montreal vault. (Salas, A., 2024).

All I could think was that I was really lucky to be at that point in my fieldwork, after having navigated a bit of back and forth due to administrative paperwork and the series of permits needed to shoot inside the vault. I was also lucky that I did not have to pay for the use of the images in my artistic work. The preservation team at the NFB was very supportive, especially because, as they shared, not many students or researchers come to work with their archives. Which is surprising, considering how many treasures remain to be discovered, re-watched, and reinterpreted in that collection. And perhaps that is the work: to return to what already exists, not to classify or confirm, but to perceive anew. Archives are like old friends; after a long absence, re-encountering them can shift our understanding of lifelong relationships— and, sometimes, of ourselves. As Bergson writes at the end of *Creative Evolution*, "A theory of life that is not accompanied by a criticism of knowledge is obliged to accept, as they stand, the concepts which the understanding puts at its disposal... A theory of knowledge which does not replace the intellect in the general evolution of life will teach us neither how the frames of knowledge have been constructed nor how we can enlarge or go beyond them." (Bergson, 1941, p. XXIV) What I'm searching for in these images, in these spaces, is not just information or history, but a way of enlarging the frame, of encountering, and perhaps unlearning the mechanisms through which I have been taught to see.

The Quebec National Archives: Columbium (1967)

> *Such is the contrivance of the cinematograph. And such is also that of our knowledge. Instead of attaching ourselves to the inner becoming of things, we place ourselves outside them in order to recompose their becoming artificially. (Bergson, 1941, p.332)*

I uncovered two films at the Quebec National Archives. The first was *Colombium* (1967), an artistic piece produced for Expo 67. In this film, niobium (formerly known as columbium) is symbolized by a female figure who leaps from a forest into a high-tech industrial facility. The second film was *Niobec Inc.* (1977), which features footage of the active niobium mine in Chicoutimi. As part of my fieldwork plan, I intended to visit this mine site. Although I tried multiple strategies to gain access, in the end it was impossible. It seems the only research projects the company is interested in supporting are those directly related to mining, geology PhD students are the lucky ones. Finding this archival footage became the only way I could engage with the site. Although the film is sixteen minutes long (five times longer than the NFB one), there is not much difference between the two, both depict the process of extracting niobium, from blowing up rock with dynamite, to packing the ore into metal barrels. Since my work also engages with audiovisual creation, I had hoped to use this footage in a video installation/film, the creative component of my research-creation doctoral thesis. In the end, neither the use of the footage nor a visit to the mine proved possible. The archival team at the Quebec archives was extremely helpful throughout the process. The problem was with the rights: half belong to the Quebec government, while the other half remain with the film's director or production company. Although we made efforts to trace the company and the director, we kept ending up in the same grey zone. This unresolved "grey zone" speaks to a broader tension within the archive: while materials are preserved, access is often regulated by fragmented ownership, limiting not only who can see, but who can re-engage, reinterpret, or reimagine these historical images—especially when they concern extractive industries and contested territories. On the other hand, the rights to *Colombium* (1967) were fully held by the Quebec archives, who generously granted me permission to use the film as part of my thesis, including its integration into any audiovisual artistic production. This contrast highlights how uneven and unpredictable access to archival

material can be, depending not on the content or cultural value of the work, but on the legal and bureaucratic infrastructure surrounding it.

Thinking the movable through the unmovable

Form is only a snapshot view of a transition (Bergson, 1941, p. 328)

Visiting the archives, just as visiting the mine, is about asking what makes these events possible, what allows them to exist. What is the semblance of these events? What constitutes their negative prehension, what has been cut out, pushed aside, so that something else can appear? And most importantly, what becomes possible through my encounter with them, what is activated in the relation? Whether in the case of the archive or the abandoned site, one could say that the capitalist apparatus operates through the idea of emptiness, through the false logic of obsolescence, through fraud and concealment. The archive in the vault mediates this relation, it dictates what is real and what is imaginary, it operates in between the documentary and the fiction in order to establish a truth; it mediates to justify and re-signify the clear. Bergson states that "Plato was the first to set up the theory that to know the real consists in finding its Idea, that is to say, in forcing it into a pre-existing frame." (Bergson, 1941, p.55) The archive in one hand allows one to find a place for niobium, answering the question: "In what drawer, ready to open, shall we put it? (Bergson, 1941, p.55) but on the other hand, it opens the door to think how to resist the will to shrink nature to the measure of our ideas. In his *Cinema* seminars, Deleuze proposes that "only what is true has form**,"** while **"**the false has no form, but it has power**."** The power to destabilize fixed truths and introduce indiscernibility between image and referent, between what is real and what is imaginary, allowing movement within static representations. **"**The power of the false is the indiscernibility between the real and the imaginary," he says, adding, "we could just as easily say that a crystalline formation is the coalescence of an actual image and its virtual image. This is the principle of indiscernibility between the real and the imaginary**.**" (*Deleuze, Cinema 3*, Lecture 1).

Image 1.6 Still image from the film "Colombium".

The film *Columbium* starts with some general shots from the Oka mine. It shows big trucks going up and down in an open pit mine. The movement of the trucks is synchronized by a classical violin melody and contrary to the NFB film, this one was shot in vibrant colours. Children's voices narrate: "columbium, also known as niobium, is a metal extracted in the region of Oka, Quebec…" What follows is a personification of niobium as a woman. The children describe their properties, uses, and promises, framing niobium through a language of technological utopia and space conquest. If the false has no form, it is because it resists closure, it is because it refuses the logic of representation. In this sense, *Colombium* does not simply teach us about niobium; it stages the mineral as a product of worldmaking and a producer of worlds, of colonial vision. It's precisely in this stable image of niobium that I locate the urgency to rethink form itself. What does it mean for a metal to take on a human shape? What does it mean for a material to be framed in a time-image, and narrated by the voices of children? Niobium jumps from the forest to an industrial facility, the violins are replaced by synthesisers and niobium's make up goes from brown tones to metallic ones. An open pit, a forest, and then a power facility with big generators, industrial cables, and no sign of trees, are the sequence of environments where Nb exists in the film. A close-up of the mineral's face then takes us to an airplane lifting

off, perhaps toward the future, accompanied by the children's voices, which continue to narrate the importance of niobium for society, marketing it as *the metal of the future* and a key element in the conquest of space. Each image and voice overlay the next one in a way that, as Deleuze suggests, "forms a series of modifications where each one is the representation of the next. I see something real in each, I see a reality in one, and the unreal of the next. In other words, I can only see it as a series." Seeing this movement in a series, where representation and modification blur, is not about retrieving an original or a truth. It is, instead, noticing an expression of the power of the false, which Deleuze calls a temporal force, "aspects or accents of time," revealed most clearly in crystals of time. These crystals, he writes, are formations "where the real and the imaginary are indiscernible… a bit of time in its pure state, in the form of a series of powers." Again, if the false has no form, it is because it can't be closed, because it can't be reduced to a fixed meaning, because it operates through movement, through variation. To what it points to, is not representational, but relational.

The encounter with this film has drastically changed the direction of my work. That's precisely the function of all this; entering the mine and the archives I thought I was looking for something, but now I feel like niobium has been guiding me, exercising an attraction force, mediating my relationship with what it means to encounter the material not as a fixed resource, but as part of an unfolding assemblage of images, affects, and speculative relations. The crystalline formation that makes this relation visible is composed by the mine and the films, different forms offering different angles on the event of niobium. This formation is the context that has allowed me to in-discern who or what Nb is, it gave me the chance to consider other possibilities. There is no line between the real person and the mirror image, between the real and the imaginary. This indiscernibility is the impulse that permits the continual appearance of a series, each more charged than the last, each carrying its own power: temporal, affective, and speculative. As Deleuze says, "what we see in the crystal are aspects or accents of time"—not fixed identities or static objects of truth, but temporal intensities, reflections, memory, becoming. The films and the mine, as crystals of time, are formations in which "we find a bit of time in its pure state, in the form of a series of powers." Niobium, through these encounters, becomes part of a temporal formation that is not about representation or stability, but about becoming and emergence.

It is precisely through the power of the false that I can challenge the frames through which initially I was looking at these archives. My embodied encounter with the films, with the mine, the repetition of watching, the impossibility of full access, the fragmentary, static, and ideological images, these become tools not of clarification or confusion, but of activation. Through this process, a new crystal of time begins to take shape: a structure in which the actual and the virtual, the real and the imagined, fold into one another, revealing the indiscernibility of my own past and future. These are not static documents but crystalline configurations where falsity (in the sense that these films are only one of many versions of what Nb is) becomes a force of fabulation, of counter-memory, of world-making, of art-making. Capitalism, by contrast, dismembers relation. It prevents us from encountering these events and activating them through our own past, into the life of the present. In doing so, it blocks the conditions through which collective, potential futures might emerge. It is almost as if capitalism does not merely extract material and knowledge, it steals the possibility of relation itself, and with it, the possibility of the future. For relation is the only way to world, and duration is the time in which worlding unfolds.

> *The form of the object is the way a whole set of active, embodied potentials appears in present experience (Massumi, 2011, p. 42)*

Niobium is not a fixed form. It is a static object only when thought through the extractive logics of capitalism—counted, priced, mined, traded. But when thought-felt as an event, niobium becomes movement: it becomes relational, affective, emergent. All I have been looking for is an encounter. That is what I was looking for. Not the recovery of a truth lost in the archive, nor a complete image of the mine as it once was, but an opening, a moment of contact that resists finality. The archive and the mine are not simply repositories of memory or ruins of industry; they are events with potentiality. They persist not through their material continuity, but through their capacity to be met, to be felt, to be activated. This activation is not about mastery, it is about relation. In *Creative Evolution*, Bergson critiques radical finalism for imposing fixed ends upon life, assuming that all becoming unfolds toward a destined goal. Such a framework denies the creative force of life, the continual invention of forms that emerge through encounters with the unforeseeable. “Radical finalism,” he writes, “proceeds as if the future were given in advance,

and the time necessary for the realization of the plan served merely to unfold a roll already prepared" (*Creative Evolution*, Ch. II). But the mine and the archive do not unroll a completed film, they flicker, resist, shimmer. Their truth is not behind them, waiting to be retrieved, nor ahead of them, waiting to be fulfilled. It arises in relation, in the fragile space of encounter where the past is reactivated into a living present. Against radical finalism, what I seek is not the end of a sequence, but the possibility of continuing, to live not in explanation, but in worlding, where the form is the encounter.

Image 1.7 Still image from the film "Colombium".

Through a panoply of processes—fieldwork, illness, grief, friendship, mentorship, and creative shifts—I have come to realize that niobium is not a subject I chose to study, but an event I've been living through. Each encounter, whether in the archive, the mine, the lab, the editing room, or across the countless trips between Canada and Colombia, has become a moment in the emergence of what I now understand as my own event niobium. This mineral has passed through my life like a thread, shaping and being shaped by my experiences. It was there in the exciting times— visiting laboratories and facilities, interviewing scientists and physicists—but also in the difficult ones: while I was ill and doubting the project, in the loss of my beloved friends Andrés and Tatiana, and in the quiet joy of exploring clay through ceramics, letting niobium speak again through fire and form. Each of these moments has not been simply a step-in research, but part of

a processual unfolding, a relational event, what Whitehead might call a “concrescence,” and Deleuze would describe as a series of powers, intensities that compose a becoming. The truth of niobium has not revealed itself as a fixed form or substance, but as a crystal of time, refracting memory, perception, and possibility. Through the power of the false, I let myself be led away from fixed representations, into other ways of worlding: letting ceramics and storytelling bend the mineral into new meanings. Even this thesis is not just about niobium, it is part of niobium’s becoming, a space where the mineral continues to exist differently, to shape how it lives in my world, and how I live in relation to it.

Niobium is not just the material that binds them, it is the thread that holds the possibility of another kind of worlding. And so, this chapter closes not with conclusions, but with a threshold. What remains is the question: What becomes possible through this encounter? And how might it reshape how we see, think, and feel what we call niobium?

Chapter 2

"In other words, frameworks—or "paradigms"— are not structures that emerge with spontaneous accuracy in the context of knowledge production. Rather, they are politically and socially as well as empirically contingent and contested explanations for how things work that, once widely adopted, are difficult to disinherit."

Ruth Wilson Gilmore — *Abolition Geography*

Although there is ongoing debate regarding the accuracy of Amerigo Vespucci's accounts and whether he personally undertook all the voyages attributed to him, his published letters contributed significantly to the European understanding of the newly encountered lands as a separate continent from Asia (Vespucci, 1503). In 1507, the German cartographer Martin Waldseemüller published a world map in which he named the continent "America," using the Latinized version of Vespucci's first name, *Americus*. Accompanied by the text *Cosmographiae Introductio*, Waldseemüller's map credited Vespucci with recognizing the lands as a "New World". While Vespucci did not name the continent himself, the map's wide circulation helped cement the term. Over time, "America" became a term embedded in the logic of the colonial project, used to refer to the entire continent.

The naming of minerals often reflects the places where they were first identified. In the case of niobium, it was first encountered by a Western scientist in 1801. While analyzing a mysterious ore specimen from Sir Hans Sloane's collection at the British Museum in London, chemist Charles Hatchett identified an unknown element. The sample in question had been found near New London, Connecticut, along the Connecticut River, in an area known as Seldon Cove—ancestral land of the Western Niantic, Mohegan, and Pequot peoples. Hoping to honor the place where it was found, Hatchett chose to name this new element "columbium," after "Columbia"—a poetic term for America widely in circulation at the time. (Britannica, 2024; Niobium Canada, 2023) Over the following decades, scientists realized that columbium was closely associated with another element, tantalum (Ta); the two are often found together in nature, bound within the same ores, and can only be separated through chemical processes often conducted at mining sites. In

1950, the name “niobium” was officially adopted by the International Union of Pure and Applied Chemistry (IUPAC) to acknowledge this chemical kinship—drawing from Niobe, the daughter of Tantalus in Greek mythology (Tantalum-Niobium International Study Center, 2021). Until relatively recently, both names—columbium and niobium—were used interchangeably, particularly in North America.

Yet this transition was far more than a straightforward reclassification. The initial choice of “columbium” implicitly tied the element to the story of a “New World,” a vision immersed in colonial imaginations of territory and resources. By invoking “Columbia,” Hatchett’s classification symbolically claimed the land and its minerals as part of an emerging American identity—effacing the complex and Indigenous histories and identities bound to that same geography. This logic would repeat itself through times, (just as the process of mining ore, which has changed little over the centuries) naming and claiming land and resources remains a central gesture of colonialism, from continents and minerals to the so-called Gulf of America. In shifting from “columbium” to “niobium,” we see how scientific naming is never neutral. It carries the weight of cultural, historical, and political agendas, from the demarcation of colonial frontiers to the desire to anchor what are supposed to be the components of earth, within a Eurocentric classical tradition.

This historical trajectory—from the colonial naming of continents to the scientific naming of elements—illustrates how systems of representation and classification are deeply intertwined with power and ownership. Names shape how we understand and relate to the world, reflecting broader cultural and political dynamics, whether in art, science, technology, or colonial modernity. The practice of naming embodies the colonial framework of imposing a persona onto an unfamiliar land, transforming it into something comprehensible, compact, claimable, ready to own and be told as a story.

If niobium was embodied by a young female persona in the Oka mine film, then America, too, has its own allegorical representation—one that dates to the early days of European colonial expansion. The attributes of the allegories were standardized by Cesare Ripa in his book *Iconologia del Cavaliere* from 1593. In its initial edition, Ripa described allegorical figures personifying virtues, vices, the arts, sciences, continents, and human passions, among other

abstract concepts. Later editions, including the 1764 version now held by the National Library of Colombia, were accompanied by illustrations that visually interpreted Ripa's original descriptions. *Iconologia* played a foundational role in shaping the visual language of the time: it made the invisible—ideas, concepts, moral values—visible through personification. Ripa's system became the principal reference for European artists, and his allegories of the continents—whether geographically or culturally accurate—formed the basis for much of the imagery representing Europe, Asia, Africa, and America from the 16th century well into the 18th century.

Image 2.1 Iconologia, Cesare Ripa, 1764.

For Ruth Wilson Gilmore race and space are mutually constituted (Gilmore, 2022, p.84), one supports the other, and their relationship and co-existence is what allows to racialize bodies, groupings, activities, and places. In this sense, these allegorical figures, first imagined as textual descriptions and later rendered in engraving, did not remain confined to the pages of *Iconologia*. As Europe expanded its colonial ambitions, these personifications began to circulate through other media—murals, tapestries, paintings, and most strikingly, porcelain. The possibility of reproducing these images allowed the reproduction of a specific way to relate to the so-called continents, whose female representation was not accidental. Technologies developed in the arts allowed the production and reproduction of a way to see, understand, and relate to the world—to perceive the other. Maps and allegorical representations came together to determine race as a socio-spatial location, where places of abundance considered underdeveloped continued to supply

natural resources and physical labour to sustain a global commerce that started more than 500 years ago.

Territories defined and represented through race, described as virgin lands, waiting to be activated and put into production, were normalized as sources of raw materials for the developed world. These territories became part, or rather, completed structures conceived and designed to control and dominate. The set of porcelain figures representing the four continents helped fix the ideology that drew the maps, that still today, sustain global capitalist modern commerce; "such a map is the product of rounds and rounds of globalization, five centuries' movement of people, commodities, and people as commodities, along with ideologies and political forms" (Gilmore, 2022, p.85). Race does not exist without space; capitalism exists in space and is constituted by racism. "Capitalism requires inequality and racism enshrines it" (Gilmore, 2020). This relationship allows the production of profit and the constitution of nations, empires, and states. The abstraction that produces the universalisation of commerce-maps-assemblages, where design and geography merge, represents the imposition of a kind of relation whose only aim is to preserve a colonial order while preventing the development of other kinds of relations.

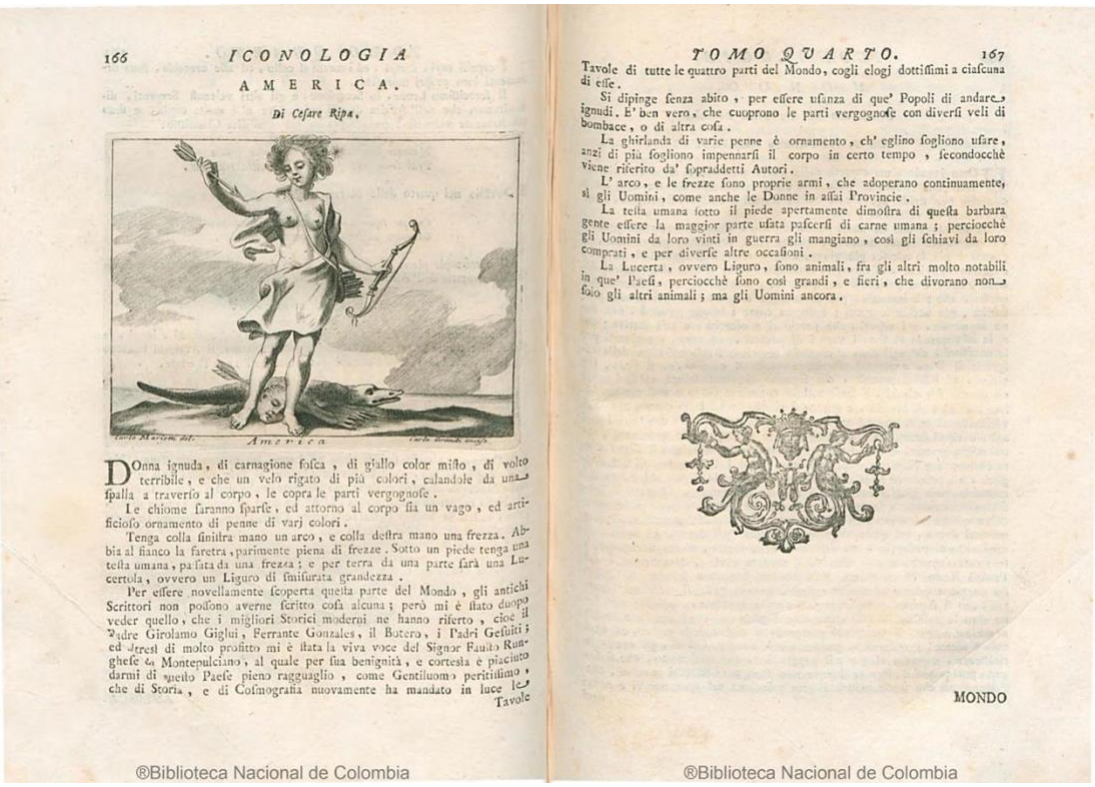
From columbium to America

As I moved through the thought of niobium's name, I started to feel that my encounters, as different from each other as they could seem, were always looking at the origin of Nb. Either at the mine, the archive, or the library, my interest was always oriented towards the becoming of the mineral: materially, ideologically, symbolically, and temporally. The research into its name brought me to discover Ripa's book, and then to be fascinated by one of the first porcelain sets of the continents made by Meissen, once the main porcelain manufacturer in Europe, around 1760. I became obsessed with these figures and decided that it was crucial for my research to go to New York City and visit the Cooper Hewitt Smithsonian Design Museum, where the set was stored and conserved. I filled out an online form requesting a visit to their archives, since the pieces were not actually exhibited nor available to the general public at the time. I was surprised by how fast they answered me; besides asking a few technical questions, the process seemed fairly easy. We set up an online meeting with a couple of members of the conservation team, and the person

from communications with whom I was first in touch. While preparing the meeting, the question hit me again: What is it really that I am looking for here? I prepared a short and precise explanation about my research; I wanted to make clear that I was an artist-researcher, that I was working on a research-creation project that required filming at their vault and interviewing, off camera, one of their experts. At that point in the research, I always struggled to explain what my work was about. Regardless of how many times I had practised my pitch, I often felt that I was missing something, that the project was missing a connection, that maybe it was clear in my mind, but I was still looking for the right words to express it; it did not feel completely right. This is part of my first email explaining the material approach of the project:

"*My intention in visiting the Smithsonian comes from a strong interest in comprehending the stories behind the materials we used in the construction of the human world, the strings that compose the global entanglement of modern societies. Human stories are modulated by materials like niobium, and these in turn are modulated by human stories. In the case of the allegorical representations of the American continent, what were the materials used to tell such story? What does it mean that porcelain was the technique used to express this idea by the artists? What are the roots of such iconography?*

At the first online meeting, the two conservators that I had the chance to talk to—Sarah Barack and Jessica Walthew— expressed that my initial approach was interesting, and that the idea of preserving these kinds of pieces was to give the opportunity to researchers, artists, and scholars to look at them closely, and to critically think about them in a context outside of traditionally dominant frames. (I deeply hope that this intention has not been affected by the recent order by the Trump administration, "Restoring Truth and Sanity to American History," which intends to "eliminate improper, divisive, or anti-American ideology" from museums.) As Jessica pointed out, we often tend to divorce technologies from representations, and one of the things that sparked interest in my proposal was precisely the way I was trying to reconnect iconography to its material history, to examine these allegorical forms not just as symbols, but as outcomes of specific technological processes, extractive economies, and systems of power. Moreover, to think of the porcelain set as a fundamental piece that activates the maps used for commerce and exploration. The material approach of my work was closely related to the history of porcelain as a technology of representation, a fundamental piece in the logistics of colonialism.



166 ICONOLOGIA

AMERICA.

Di Cesare Ripa.

DOnna ignuda, di carnagione fosca, di giallo color misto, di volto terribile, e che un velo rigato di più colori, calandole da una spalla a traverso al corpo, le copra le parti vergognose.

Le chiome saranno sparse, ed attorno al corpo sia un vago, ed artificioso ornamento di penne di varj colori.

Tenga colla sinistra mano un arco, e colla destra mano una frezza. Abbia al fianco la faretra, parimente piena di frezze. Sotto un piede tenga una testa umana, passata da una frezza; e per terra da una parte sarà una Lucertola, ovvero un Liguro di smisurata grandezza.

Per essere novellamente scoperta questa parte del Mondo, gli antichi Scrittori non possono averne scritto cosa alcuna; però mi è stato duopo veder quello, che i migliori Storici moderni ne hanno riferto, cioè il Padre Girolamo Giglj, Ferrante Gonzales, il Botero, i Padri Gesuiti; ed altresì di molto profitto mi è stata la viva voce del Signor Fausto Runghese da Montepulciano, al quale per sua benignità, e cortesia è piaciuto darmi di questo Paese pieno ragguaglio, come Gentiluomo peritissimo, che di Storia, e di Cosmografia nuovamente ha mandato in luce le Tavole

TOMO QUARTO. 167

Tavole di tutte le quattro parti del Mondo, cogli elogj dottissimi a ciascuna di esse.

Si dipinge senza abito, per essere usanza di que' Popoli di andare ignudi. E' ben vero, che cuoprono le parti vergognose con diversi veli di bombace, o di altra cosa.

La ghirlanda di varie penne è ornamento, ch' eglino sogliono usare, anzi di più sogliono impennarsi il corpo in certo tempo, secondocchè viene riferito da' sopraddetti Autori.

L' arco, e le frezze sono proprie armi, che adoperano continuamente gli Uomini, come anche le Donne in assai Provincie.

La testa umana sotto il piede apertamente dimostra di questa barbara gente essere la maggior parte usata pascersi di carne umana; perciocchè gli Uomini da loro vinti in guerra gli mangiano, così gli schiavi da loro comperati, e per diverse altre occasioni.

La Lucerta, ovvero Liguro, sono animali, fra gli altri molto notabili in que' Paesi, perciocchè sono così grandi, e fieri, che divorano non solo gli altri animali; ma gli Uomini ancora.

MONDO

Image 2.2 America, from Iconologia (1764)

The first meeting with the Smithsonian team ended with a list of bibliography they suggested to me, and the possibility of organizing a visit not before the next four months. Suddenly, I was immersed into a subject that had never crossed my mind when I first started this project. Furthermore, this was the first time in my life that I thought about porcelain, beyond the memories of my mom's little animal figurines at home and a strange lamp lodged in my memory. With elephant toes for legs, a multiplicity of animals, human figures wearing turbans, and a dense mix of trees and plants all over it, the lamp was entirely ceramic. A funny orange hat sat on the bulb, with adornments hanging all around. I remember how I used to play around that lamp, as tall as I was when I was around eight, imagining wars and expeditions in this imaginary ceramic jungle. I realized that might have been my first encounter, however imagined, with the Far East.

What is it really that I am looking for here? At first, it seemed as if I was following a line of material inquiry, porcelain as a mechanism of representation, as a system of control, as a product of global commerce, as technology. But something shifted. I kept returning to the figurines of the continents, to the image of America sculpted in white, and I began to feel that this project wasn't just about niobium, or porcelain, or ceramics, it was about how these materials

have been used to tell stories about the world, to build and preserve certain orders, and to situate people within a particular frame. Why do we need to represent? Why do I need to be represented? Why must I continue to fit into the mold of an organized world? During a conversation at an arts residency about this project, at the Banff Centre for the Arts, I was confronted with the idea of making my own figurine, "to show who I am". But what if I don't believe in this system of identification, in this globalized taxonomy of difference? America is an invention, a way of naming and containing the unknown for European systems of understanding, a racial capitalism map. The cosmovision I come from is different. It was different. And lost or not, it was not this. This was the first time in the process of this research that I realized I might be looking for myself through the many becomings of niobium.

This project is a gathering of stories: stories of how niobium came into the human world, and how we've used it—sometimes without knowing—to write stories about the universe and ourselves, across distant times and geographies. "The violence of abstraction produces all kinds of fetishes: states, races, normative views of how people fit into and make places in the world" (Gilmore, 2022, p.100), If I'm trying to represent anything, it's not myself, but rather the systems—subtle or overt—through which domination and control have shaped the way we tell a singular, universal story of the world. I try to do that through this text, through the film I'm working to complete, through every trip back and forth between Colombia and Canada, through all the conceptual and speculative maps, through all the circling around concepts and ideas, and maybe, too, I could do it through ceramics and niobium itself.

Image 2.3 Europa, from the set "Four Continents" by Johann Friedrich Eberlein, 1760. (Salas, A., 2024).

Porcelain as technology

"What is it? It is 'made of a certain juice which coalesces underground and is brought from the East', wrote an Italian astrologer in the mid-sixteenth century. Another writer asserted that 'eggshells and the shells of umbilical fish are pounded into dust which is then mingled with water and shaped into vases. These are then hidden underground. A hundred years later they are dug up, being considered finished, are put up for sale."

—Edmund de Waal*, The White Road, 2019*

As I read through the articles and books recommended by the museum's conservation team, a mix of excitement and anxiety took over, I had the feeling I had found a key piece in my research. And maybe, if things went well, I'd be granted access to the vault where the 4 continents set was stored. From our first online meeting, it became clear that my approach interested the team. But the visit wasn't fully approved; we would need to meet again, and I would need to clarify how this object, an 18th-century porcelain representation of the American continent, fit into my evolving niobium research plan. In the meantime, I began reading. What started as a detour soon revealed itself as a parallel path: the history of porcelain, its techniques, technologies, materials, and symbolism, offered a mirror to the themes I had been exploring all along.

It took around 800 years for Europeans to produce porcelain locally. Before this breakthrough, the European elite had to import vast quantities of expensive porcelain from China and Japan for over two centuries. How crazy is that? The recipe to make porcelain was a secret, and the obsession to crack the code sparked a technological arms race among European courts, an intense desire to replicate what they could not yet understand, whose similarity with today's AI global dynamics is not coincidence. "Porcelain is the *Arcanum*," writes Edmund de Waal in *The White Road*. "It is a mystery. For 500 years no one in the West knew how porcelain is made." Porcelain had long been made and traded across Asia. "It has been made for 1,000 years, traded for 1,000 years," de Waal continues, "and has been in Europe for 800 of these." The opacity surrounding its fabrication only intensified its value: it was seen as a symbol of power, of sophistication, but also of technological advancement; of colonial power.

"There is in China a very fine clay with which they make vases which are as transparent as glass; water is seen through them. These vases are made of clay,'" de Waal recounts. "It is light when most things are heavy. It rings clear when you tap it. You can see the sunlight shine through. It is in the category of materials that turn objects into something else. It is alchemy." But porcelain is not just magic, it is geology. It is a process of extraction, refinement, repetition. "Porcelain is made of two kinds of mineral," de Waal explains. "The first element is petunse or what is known as porcelain stone... The second element is kaolin or porcelain clay; China clay... Together petunse and kaolin fuse at great heat to create a form of glass that is vitrified." In other words, porcelain is mining turned into form. As I began to grasp the alchemical language that surrounded this material, it started to be clear that this was not so different from my own work on niobium, or the history of particle physics: a story of materials made to perform, to transform, to represent. These materials are not neutral; they are charged with the histories of the technologies that shaped them, the worldviews that demanded their transformation, and the humans and more-than-humans that participated in one way or another in their becoming into the capital world markets. From the mine to the laboratories, to the stock markets; extraction allows knowledge production, and this in turn is transformed into profit. The process objective is to minimize financial loss while moving materials all over the planet with one aim: profit as the result of building and preserving a system of representation and identification. If logistics is "the science of lost means advanced with every act of loss prevention" (Harney, 2021, p.15), porcelain's global circulation, relied on complex logistical infrastructures, shipping routes, production

secrecy, inventories, designed to preserve not only the object itself but the ideological and economic systems it upheld. Logistics is about preserving the system by preventing escape—of objects, meanings, or people. “America, its human inhabitants, then gradually its animals, vegetation, water, land and climate, have been radically redefined by the history that followed their European “discovery”” (Stengers, 2011, p. 58), and the appropriation and later production of the porcelain technology by Europeans took part on this process.

Accounts by explorers like Cortés, Vespucci, and Columbus laid the ideological foundations for today’s vision of the Americas. These stories found material form in the allegorical depictions of the continents, crafted by artists and artisans, who found in mastering porcelain making a precise and luminous medium through which to reproduce and disseminate identity, a logistical operation to distribute the idea of race. Hard paste porcelain, in this sense, became not just a canvas, but a soft technology of control. One of porcelain’s most telling characteristics in 18th-century Europe was its tendency to appear in sets. Tea services, dinnerware, figurine ensembles. As de Waal suggests, “sets are a way of controlling the world.” They signal, for the elite powers, not only refinement, but also legibility: everything in its place, every object harmonized to serve a larger symbolic unity. In the case of the Meissen set representing the Four Continents, the allegorical organization of the world was made literal, each figure fit into a closed loop of global hierarchy, balance, and control. These were not neutral decorations; they were tools that encoded a worldview premised on European centrality and dominion. Producing porcelain in sets reflects the Enlightenment-era impulse to rationalize, measure, and order. Just as the scientific world sought to classify nature, porcelain sets were crafted to classify culture, aligning geographies, aesthetics, and nature into stable, repeatable systems, with the ability to comprehend, contain, and master the unknown. To have the whole world on your table was to possess a microcosm of global order allowed by the assemblage—in Deleuzian-Guattarian terms—formed by the allegory and the map, the tool and the weapon, whose relation was mediated by the science of logistics. And just as with today’s technological developments, “the kind of person who would have owned a set of porcelain sculptural figures was also probably engaged in some of the same sort of questions about prestige and power and trade and availability of resources that these speak to” (Walthew, 2024).

“I am choked by porcelain as prescription, porcelain as control…because every single one of these hundreds of thousands of porcelain bowls, perfect and balanced and harmonious, has cost so much. This amount of control costs more than I can comprehend… this white frightens me” (de Waal, 2019). Porcelain consumed hills, entire forests, it has flooded millions of lungs and keeps piling literally as tons of tailings everywhere in the world, and this has repeated infinite times over more than 2,000 years. When cobalt turned white bowls into blue-and-white stories, those stories travelled. They moved through courts and cabinets, through inventories and diplomatic exchanges, through war loot and collector dreams. “Cobalt allows the world to be turned into stories,” de Waal reminds us. But those stories are not innocent. They are structured, repeated, glazed and set. They consolidate a vision of the world. They create templates of difference.

Image 2.4 Asia, from the set “Four Continents” by Johann Friedrich Eberlein, 1760. (Salas, A., 2024).

Like rare earth elements today, porcelain was once a frontier material, wrapped in secrecy, tied to state ambition, existing in closed markets, and controlled through elite knowledge systems. Its history reminds us that materials are never neutral. They come loaded with hierarchies, routes of extraction, layers of meaning, and asymmetries of power. And when those materials become the substrate of representation, of how we imagine the planet, divide it, name it, own it, they do more than tell stories. They enforce them. And what has all that cost been for? For control, for producing a very specific vision of the world that is racialized, hierarchized, that

works under certain kinds of relations. “Racism functions as a limiting force that pushes disproportionate costs of participating in an increasingly monetized and profit-driven world onto those who, due to the frictions of political distance, cannot reach the variable levers of power that might relieve them of those costs.” (Gilmore, 2022, p.100). Distance, geographic, political, epistemic, is the method, it prevents the emergence of parallel forms of relations, relations that, more than not being recognized by the control powers, are suppressed.

Porcelain is more than decorative; it’s a vital technology. A technological material with significant contributions to science and medicine. Its vitrified nature made porcelain containers essential for sanitization in early scientific research, and its use extends to aeronautics, space exploration, and electronics. Far from obsolete, ceramics remain integral to advanced technologies today. Much like today’s global pursuit of critical technologies, computer chips, superconductors, rare earth minerals, historical porcelain production illustrates a persistent global pattern: powerful nations relentlessly seeking technological dominance through resource extraction and mastery. This drive is not merely about controlling resources but also about cultural dominance and the ability to dictate global narratives. In this regard, porcelain, niobium, and rare earth elements become interconnected symbols of global trade and cultural control. Porcelain technology, therefore, offers critical insights into how technological advancement intertwines with cultural hegemony, environmental exploitation, geopolitical power struggles, and the preservation of the tale of races, reflecting a history of extraction and knowledge production that remains highly relevant today. The global trade and technological competitiveness that shape our culture today, echo how decorative arts once served as essential tools within the logistics of representation that advanced the European colonial project. Although porcelain may have belonged to the world of decorative arts, the systems that enabled its production—resource extraction, secrecy, competition, and state-sponsored innovation—are the same ones driving today’s global logistics race. What has changed is not the structure, but the scale. Interplays between porcelain, technology, and colonialism reveal how materials and resources were and are not only tools of scientific and artistic advancement, but also central to the logistics of representation and control.

The continents Set

The popularity of the continents theme during the age of empires and global colonization reflects the colonial mindset of the time. For royalty, such representations symbolized dominion, bringing the entire world to their table, a way of making distant lands and their subjects both visible and symbolically controllable. Beyond revealing the social, cultural, racial, and political hierarchies of the time, and speaking of resource extraction and colonialism, the set also reflects the vibrant global trade that enabled porcelain production. This trade involved the mining of kaolin, the sourcing of glazes, and rare minerals for colours, as well as the technologies required to build kilns and achieve precise firing temperatures. This is a story of materials and knowledge transfer, of art as a tool to standardize the unknown, to locate and define the other. Of representation as a logistics for ownership. The maker of the set, Meissen, is significant because it was the first European manufactory to produce hard-paste porcelain starting around 1709. Trade along the Silk Road had for centuries facilitated the exchange of refined goods between East and West, and with this discovery, Europe inserted itself into a longstanding material and technological lineage. The creation of a European porcelain recipe didn't just spur new artistic production, it activated a new phase in global trade, now involving the extraction and shipment of porcelain ingredients. By 1760, when this set of the Four Continents was produced with kaolin extracted from the new mines in Saxony, Meissen held a tight monopoly over the technology. From this point on, monarchs across Europe rivalled to replicate Meissen's success, seeing porcelain as a symbol of imperial sophistication and control. These early Meissen pieces became the archetype—technologically, iconographically, and symbolically—from which others drew, this shared vision that transcended geographic borders, cemented the basis of a common European aesthetic that would become well-established by the early 19th century.

This set was donated to the Smithsonian Institution by James Hazen Hyde, a businessman and philanthropist, with a deep fascination for the theme of the representation of the continents. It is now held within the Product Design and Decorative Arts department at The Cooper Hewitt, Smithsonian Design Museum. This department holds a collection of more than 40,000 pieces, of which ceramics is one of the largest sections. The four continents was a recurring theme in decorative arts from the mid 18th century, serving as a way to visualize the world through allegorical figures. These representations often merged the image of a young woman with the

resources, symbols, and attributes that their makers associated with each continent. Hyde's collection spans over 400 works across various museum departments. Most of those pieces are porcelain, but the collection includes wood carvings, pastels, and drawings in ink. Although the set is attributed to Johann Joachim Kändler, a master sculptor of Meissen's early production, the identities of the painters, molders, and designers involved in its creation remain speculative. Women played a significant role in the manufacture of porcelain, particularly in painting intricate designs. Even today, creating a porcelain set like this would require a coordinated effort from a team of artists, artisans, and technicians. During an interview at the Smithsonian, conservator Jessica Walthew details that "separate people worked with the clay body, casting, modeling, painting… Very few had the full recipe." The figures are made in multiple molds, glazed and fired multiple times, until around 25 to 50 different parts need to be put back together. The monopoly of technology was also maintained like this, dividing labour so that no single worker knew the complete process.

I spent around four hours at the Cooper Hewitt, Smithsonian Design Museum's vault, a large concrete bunker with multiple security door access, containing all their archives. Jessica Walthew, the conservator that accompanied me during my visit, walked me through a series of passages and halls, leading to where the ceramic set was stored. For a second, I felt as if I was back in the National Film Board archives; the room temperature, the colours and the textures of the walls, the moving shelves, it all gave me a feeling of déjà vu. I thought to myself, "everything in this kind of controlled environment becomes an archive." Jessica brought up a movable staircase while I set up my camera and lights. When I was ready, she climbed the ladder and brought down, one by one, each of the porcelains composing the Meissen set. Thinking about that moment now, I feel that part of my interest in this project started to be fueled by the rushes of adrenaline and dopamine that I was getting through each of these encounters. Carefully placed on a wheeled chariot, we brought the four pieces to their laboratory, where we could do an interview and examine the set closely. They were incredibly beautiful, so much so that, to me, they didn't even seem to belong to 1760. Somehow, they felt very present, modern: the vibrant colours, the cohesive aesthetics that held them together, every animal, flower and plant, every object, garment, and ornament. So much beauty and so much control: control over the commerce of materials, over the technology to produce them, over the artists' techniques, and over continents, treated as colonies.

The cost of this control was ecological and human. Forests fueled kilns whose fumes choked workers; cobalt miners inhaled toxic dust to paint the vision of a European world. Yet the final product—a harmonious Four Continents set—erased this violence, just as it erased the labour of unnamed hands. Porcelain being "delicate brushwork" and "vitrified purity" were excuses, transforming extraction into elegance, and racialized hierarchies into decorative order. The refined aesthetic of porcelain concealed the systemic violence embedded in its production: ecological destruction, human suffering, and the consolidation of imperial power. Each continent figure in the Meissen set appears regal, adorned, and composed. "They are all very queeny," (Walthew, 2024) as one might observe. But why? Is this the vision of the world they sought to construct? Was this an idealized projection of a civilized empire? Or was it merely the ornamental tale of a colonial world, carefully arranged for the European table? Behind the elegance of the set the reality of the colonial project was one of extraction and domination. The queens of porcelain stood atop animals and emblems not to honour them, but to assert control over the wild, the unknown, and the subjugated. Reality was different. "It is not simply the individual, but rather the individual capable of self-improvement, who must and can enter into the economic contract" (Harney, 2021, p. 33), into the frame required by dominant cosmovision.

Image 2.5 Africa, from the set "Four Continents" by Johann Friedrich Eberlein, 1760. (Salas, A., 2024).

They all seemed very improved to me, especially given the historical moment of their production in 1760. That year, the transatlantic slave trade and the displacement of Indigenous peoples in the Americas were central to the European global system of extraction and exploitation. Portuguese colonizers had consolidated control over Minas Gerais in the colony of Brazil, after nearly a century of violent resource extraction of gold, diamonds, and human lives. Brazil would go on to become the largest single destination of enslaved Africans in the Atlantic world and is today the world's leading producer of niobium. In North America, the dispossession of Indigenous land following the Seven Years' War (1756–1763) set the stage for the violent incursions into Mohawk and Haudenosaunee territory, conflicts whose effects continue to this day. The only place where an African or an Indian could resemble anything like these figures, was in the imagination of the European elite. The logic of the colonial discovery implies the possibility for improvement, this gives the right to own. Or the right to talk freely about appending countries and territories for the sake of resource extraction and nationalism.

As I look at each one of these figures, I see the abandoned niobium mine in Kanehsatà:ke; I see the history of displacement and the human, cultural, and spiritual genocide suffered by the Mohawks, traditional inhabitants of this territory. I see the massacre of the Araxá people in Minas Gerais by Portuguese explorers, and the forced trade of millions of people, enslaved and extracted from their homes in Africa. The vibrant colors of the set, every detail in the depiction of animals and flora, the ornaments and jewelry, the resources that compose each of the personas represented, each perfect body, each face full of well-being, is part of an ensemble that moves through time. It is not static; it keeps being replicated, produced, and sustained by capitalism, a cosmovision fundamentally built on racism. "Art isn't an 'illusion.' That is not what 'semblance' means. Art is about constructing artifacts—crafted facts of experience" (Massumi, 2011, p. 58). These porcelain pieces reflect a mindset obsessed with possessing the world in one's hands. How different is this from our phones today? What is the ghostly force of Marx's "commodity fetishism," if not a semblance of life lived through consumer artifacts? asks Brian Massumi: "The aura of the life banal. The art of cool. Lifestyle marketing" (Massumi, 2011, p. 56).

While China closely guarded its kaolin reserves, European empires scoured their colonies for alternatives, expanding extractive frontiers in search of the raw materials needed to tell their stories of power in porcelain. In North America, young, intrepid, and adventurous explorers—

free spirits full of qualities that have fed the imaginary of countless generations in the "civilized" world—would find in Cherokee lands a weird white clay that would pave the road for what is now known as the Trail of Tears.

> *"It is 20 December 1767. In pelting rain, high in the mountains of the Cherokee Nation, an Englishman is making safe five tons of white earth, packing it into casks, battening, preparing a train of pack animals."*
>
> —Edmund de Waal*, The White Road*

The story of the Cherokee clay, like that of kaolin from Jingdezhen in China, was not only about material acquisition but about the systems of dispossession and broken agreements that enabled imperial technologies to flourish. The fascination with white clay, and the porcelain it enabled, was one strand in the broader tapestry of colonial desire: to own the land, its people, and its meanings. Between 1838 and 1839 over 60,000 Indigenous people, including the Cherokee, were forcibly displaced from their ancestral territories to lands west of the Mississippi. The Trail of Tears was the violent enforcement of a logic that had long been embedded in the aesthetics of empire: that land, bodies, and materials could be reorganized, extracted, or destroyed in the name of order, civilization, and progress. "Logistics emerges as much as the science of loss prevention as the science of moving property through the emptiness, of making the world as it travels by filling it" (Harney, 2021, p. 17). Always the construction of sets, the eternal possibility of improvement that grants the right to own, to modify and transform in a singular universal vision. An empty land is only good for becoming productive. Complex systems where cultural, economic, environmental, and spiritual networks produce each other and become together, conforming infinite truths, are reduced to spaces for productivity, to fields to test techniques for domination. In the process of producing this vision of the world, distance is fundamental to render nature as close as possible to one's own image. One needs to be different, and nature must be *the other* to construct the world. A world that is white; it is whiteness what supports the blackness of the Africa figurine, it is whiteness that allows for the diversity of bright colours that poisoned thousands of European children working at porcelain factories, it is whiteness the means and the results. The set, as both material and metaphor, is a technology of representation, yes—but also a technology of erasure.

The world represented by the continents set is one that has been made possible through the development of logistics— a science whose ultimate objective is to guarantee that a specific vision of reality, in which relations between beings and lands are dictated by the parameters of capital, is implemented without pause or disruption in every single space-time corner of the planet. Logistics ensures that extractive visions of the world remain uninterrupted: that minerals flow from periphery to centre, that bodies move or are immobilized according to economic value, and that representations circulate to reinforce order. Logistics is the bloodstream of capitalism. Today, algorithms deliver rare earth elements from extraction sites all over the world, to university and national laboratories, industrial facilities, tech warehouses, and military compounds. It is both a tool for optimization and a weapon of preservation.

"After I had Ate, drank, smoked, and began to be familiar with these strange Copper Coloured gentry, I thought a fair opportunity to request leave to travel through their Nation in search of anything that curiosity might lead me to; and in particular to speculate on their Ayoree white earth. This they granted, after a long hesitation, and several debates, among thoughtfulness some more seemed to consent with some Reluctance: saying that they had been Troubled with some young Men long before, who made great holes in their Land, took away their fine white Clay, and gave 'em only Promises for it."

—William Griffiths, July 16th, 1765

The Cherokee, the Aniyvwiyaʔi, the Principal people, lived in what are now the states of North Carolina, Tennessee, South Carolina, Georgia and Alabama, lands traversed by what is known today as the Georgia-Carolinas kaolin belt. From these lands, the Cherokee developed a deep pottery tradition, crafting vessels marked by intricate designs and rich cultural symbolism, using locally sourced clay—Unaker, *unagi*, white. In the 1760s, English scientists and ceramicists, including figures from the Wedgwood company, learned of a pure white clay found in Cherokee territories in what is now North Carolina and Georgia. This clay, often referred to as "Cherokee clay" or "Ahyoree white earth," was identified by William Griffiths and others as a promising ingredient for porcelain production, comparable to Chinese kaoilin. The Cherokee, aware of the value of their land and wary from past experiences, were reluctant to allow outsiders to extract the clay. A few decades later, thousands of Cherokees would die walking east, as part of the Trail of Tears, and their land would be later mined for gold and industrial porcelain manufacturing, an industry that is well-known world-wide until today. Archeological evidence

found in the southeastern United States, that dates back over 3,000 years, confirms the Cherokee pottery tradition's longevity. These traditions persist today, with modern artisans preserving techniques while contending with the long history of dispossession and resource extraction from their ancestral lands.

Image 2.6 America, from the set "Four Continents" by Johann Friedrich Eberlein, 1760. (Salas, A., 2024).

As I was leaving the Museum's vault, my mind started to go in circles. Much like the Meissen figures— crafted through the logistics of extraction, dispossession, and slavery— served 18th-century Europeans to be informed and to construct a vision of what the world supposedly looked like in distant lands, our modern devices— cell phones, computers, algorithms— continue this legacy of material storytelling. These objects, made with coltan (a black metallic ore from which the elements niobium and tantalum are obtained) extracted primarily from African and South American territories, "inform" global citizens about the world dynamics through screens, images, maps, and networks. The new does not really exist; rather, it is a continuous and repetitive redefinition of nature as a commodity, where the answers we obtain are determined by the questions we have decided to ask. In this process, matter is continuously reinvented, re-imagined, trapped in a permanent becoming, stressed to be in a perpetual state of "new", where the kinds of relation that *world* our lives are dictated by the laws of capital. This "cult of factishes" as Bruno Latour calls it, "is the celebration of the event that brings a new being or a

new method of measurement into existence, and to culture" (Stengers, 2010, p.33), then the question for the emergence, for the invention, for the discovery, cannot be only a concern of science. The problem, as Isabelle Stengers describes it: "is ecological— scientific and political."

In his thesis of history, Benjamin defines his idea of "homogeneous empty time", (a moment/time without semblance). It is the time of progress, of the invention of the new, of newness, the time of historiography, of a succession of known events, only veiled as different through similarity, through mimicry, through repetition. It is a time of no meaning, a linear causal cascade of episodes. "Logistics extends, expands, accumulates the space and time of a capitalism driven across the earth by the algorithmic zero-one/one-two beat" (Harney, 2021, p. 57). In doing so, it composes the only space-time where it is possible to inhabit the world*,* allowing only entering it as individual*,* as a logistical being; it dictates the relations needed to exist in the globalized world. "If the plantation is the first bank of America" (Harney, 2021, p. 85), the modern plantations are data centres. We know this, and we have said it multiple times, "we must change aspects of both the forces and the relations of knowledge production in order to produce new and useful knowledges" (Gilmore, p. 421).

Chapter 3

Astrophysics and nuclear physics explain that niobium, like most heavy elements, formed billions of years ago in the intense heat and pressure of stars and supernova explosions, distributing it across the universe, including our solar system. This ancient cosmic origin laid the foundation for niobium's presence on Earth. The known geological history of niobium on the planet can be traced back as far as 1.3 billion years in a place called Rodinia, one of many supercontinents that once assembled most of Earth's continental blocks or cratons, into a single landmass. The name Rodinia was coined by geologist Mark McMenamin and his wife Dianna McMenamin in their 1990 book *The Emergence of Animals: The Cambrian Breakthrough.* Derived from the Russian word *Rodina*, meaning homeland or motherland, the name evokes the idea of a mother continent, a singular land mass from which later continental distributions emerged after Rodinia's eventual breakup. Life in Rodinia was microscopic. Continents were surrounded by a single, vast ocean, and the atmosphere, still low in oxygen, was slowly transforming. The ozone layer was not yet fully developed, limiting life, primarily single-cell organisms, to the oceans. Rodinia predates later supercontinents such as Gondwana and Pangaea, where plant and animal life eventually left the seas to populate land. Rodinia's mineralogy is different from that of other supercontinents. The concentrations of niobium (Nb), yttrium (Y), and zirconium (Zr), in igneous rocks formed during the Rodinian assembly are statistically higher than during the formation of other supercontinents. Meanwhile, many other materials were comparatively less abundant. The formation and eventual breakup of Rodinia, around 750 million years ago, played a key role in the distribution of Nb-rich minerals across the Earth's geological shields over vast timescales. Today, Rodinia's Precambrian igneous rocks, among the oldest on the planet, are found within geological shields such as the Guiana and Canadian shields, which also host the world's primary active niobium mines, in Brazil and Quebec. It is also striking to speculate that these geological shields not only preserved a rich mineral diversity but also seem to provide a foundation for diverse biomes such as the Amazon Forest, the Arctic Tundra, and the Boreal Forest. Equally fascinating is the thought that, at one time, these ancient geological cratons were joined together, forming part of the same ancient continent.

Today, we mine niobium from deposits in Earth's crust, where it was concentrated through vast geological processes and ancient stellar and cosmic events. At the Oka site, for instance, niobium is extracted from pyrochlore rocks, the same mineral also mined at the currently active Niobec Inc. mine, in Saint-Honoré, also in Quebec. Pyrochlore, a niobium-rich mineral commonly found in carbonatite and alkaline igneous rocks, remains one of the primary global sources of niobium. In addition to pyrochlore, other niobium-bearing minerals are found at the Oka site, including niocalite, a rare calcium-niobium silicate. Niocalite is significant to geologists because its presence often indicates the potential for niobium-rich deposits. Another mineral, Latrappite, a titanium-niobium oxide, was first identified near Mount-Laurier, Quebec. Its presence not only indicates niobium potential but also suggests the presence of titanium-rich deposits. Elsewhere, niobokupletskite and wöhlerite, both rare niobium-rich silicates, have been found at Mount Saint Hilaire, located about 40 km east of Montreal in Quebec, a unique site renowned for its mineralogical diversity. This mountain is famous worldwide for its mineralogical diversity, standing as one of the most extraordinary sites for mineral collectors and geologists alike.

Both the Oka Nb mine and Mount Saint Hilaire are situated within the Canadian Shield, one of the world’s cratons that hosts some of the oldest rocks on the planet. They are geologically connected through the Monteregian Hills Intrusive Suite, a series of igneous intrusions that crystallized millions of years ago from deep magmatic activity. Mount Saint-Hilaire holds significant cultural and historical importance for Indigenous peoples, particularly the Abenaki Nation. In the Abenaki language, the mountain is known as Wigwômadenizibo, meaning "small house-shaped mountain.” Today, the mountain is situated within the traditional territory of the Waban-Aki Nation, known as Ndakina. This region encompasses a vast area that has been inhabited and stewarded by the Abenaki people for many generations.

Image 3.1 Canadian Museum of Nature collection. (Salas, A., 2024).

Mount Saint-Hilaire hosts two very different environments. On one side, it is home to the Gault Reserve owned by McGill University, dedicated to the preservation of biodiversity and the study of ecological systems. On the other side, the mountain hosts a quarry that extracts filling rock. It has been in operation since the late 1950s, primarily extracting gravel and crushed stone for construction purposes. Over its more than 50 years of operation, the quarry has become renowned for yielding over 440 distinct mineral species, representing about 7% of all known minerals on Earth. This remarkable mineral diversity has attracted geologists and collectors worldwide, making the intrusion one of the most significant mineralogical sites globally. Places like Wigwômadenizibo are invaluable for studying Earth's formation, offering insights into the origins of geological shields and the processes that move and distribute minerals like niobium. These processes are deeply tied to the planet's magmatic, tectonic, and mineralogical evolution. In 1978, the Saint-Hilaire region was declared a UNESCO Biosphere reserve, which includes the mountain and 12 municipalities. The quarry is also a haven for mineral hunters, including members of the Montreal Mineralogy Club, who are periodically granted access to search for unique mineral specimens within its rocks.

Speculating at the quarry

The first time I visited the quarry, I did not have permission. It was a Sunday, a sunny summer afternoon. I had tried to contact their office for several weeks, but they told me they were not granting any access to anyone. It was the middle of the pandemic, and reaching any site was very restricted, almost impossible. I convinced my friend Jade to drive me there with her car, following the same tactics I had used when visiting the Oka mine. Using satellite images from Google Maps, I hand-drew a map, locating an entry point through the back of the quarry. Everything went smoothly. We made it without trouble to the point I had marked on the map. We parked and began walking slowly. According to the plan, we would first have to cross a small dense forest before entering the extraction site. I thought to myself: always the cracks, it is through the cracks, it is within the cracks, it is between the cracks.

The small forest turned out to be a sugar bush. We walked carefully between the trees, under the network of tubes that drained maple sap from the tree trunks to the sugar shack. After a few minutes, we reached a dirt road and soon we were in the quarry. If caught by security, we had a plan: we would say we were simply lost, wandering through the forest and disoriented. We started to walk, looking for the place where they extract gravel. Before long, we were in front of the quarry. This is how much we have taken from the mountain, was my first thought. I walked toward the pit, weaving through giant trucks and excavation machinery. Everything was still, inert, warm. Once again, I managed to be close to the minerals, close to the elements I had been chasing, waiting for the right moment to approach, to touch, to smell. But as I kept pushing forward, convinced that the research was being conducted by me, and unconsciously trying to channel and frame my process through different texts and authors, I began to sense that niobium's ways and niobium's time were dictating something else. Its own modes of relation were already at work; subtle, slow, dry, salty, and folding me into them. In retrospect, I was no longer outside the event. I had become part of it. By then, I was already within niobium's nexus, in Whitehead's terms, part of a constellation of actual occasions, of events interrelated through prehension and unfolding together. More than a substance defined by chemical or physical properties, Nb dictates its own conditions of perceptibility, of both sensation and thought, through relation. Walking beneath the maple sap tubing behind the quarry; drafting long emails negotiating access to archives; conducting interviews with scientists across fields and disciplines,

each of these became part of the element's relational field, its living nexus. Niobium was not an object I studied. It was a processual field that included me. Not a passive element waiting to be discovered or extracted, but an active participant in the making of worlds, a mineral presence capable of shaping the conditions through which thought, matter, and relation co-emerge. To follow niobium is to become folded into its becoming. To study it is to be studied by it. The questions I asked, the archives I visited, the landscapes I entered, the labs I negotiated access to—all of it became part of its story as much as mine. Niobium is a nexus, not only in physical terms but in experiential and epistemological ones. It gathers. It holds. It reshapes. It stimulates speculation.

Surrounded by rocks of all sizes at the quarry, it was hard not to start thinking about the Earth before plants and animals, about stepping on some of the oldest rocks on the planet, about what thoughts, feelings, and perceptions might have belonged to the oceanic inhabitants of a singular-continent-planet. Could those ancient organisms have imagined the future? If they could, what might they have described?

In 1 billion years these rocks won't be part of the same land mass. They will move around the planet and will form many different worlds. They will host an infinite number of environments, with life forms so strange that, through the consciousness of a microscopic life form, trying to imagine them now is impossible. Oxygen is just appearing, and as its amount in the atmosphere increases, life will most likely thrive, inventing new ways to produce it, expanding the diversity of beings, intelligences and of perceptions on the planet. With the ozone layer slowly growing, wrapping itself around the planet, life will move onto the land, creating a complex web of interconnected ways to exist, perceive, and world together. To feel alive was the first feeling we felt. As life grows, new feelings will also emerge, new ones will evolve and change alongside the shifting environments, as beings acquire a wide range of senses to inhabit the planet. The Earth will revolve, mixing the basic ingredients of what the universe is made of, in as many ways as imagination and creativity will allow. One day there will be sounds. And later signs called words—words to describe the impossibility of being apart from another, words to name many things in the universe, words to describe the disappearance of life from the world. Words will appear and vanish, just as different forms of life will emerge and fade, and maybe, on other planets, this will happen too. One day, words will cease to exist, life will slowly return to the oceans, temperatures

will rise once again, and separate continents will come back together. And one day, life itself will vanish from this planet. The only permanence in this universe is the endless cycle of leaving.

Microscopic Life Form - 1 billion years A.D

Image 3.2 Mount Saint-Hilaire quarry. (Salas, A., 2024).

My second visit to the quarry was very different. This time, I contacted the Montreal Mineralogy Club, and they invited me to join them during one of their organized mineral hunting visits. Unlike my first entrance—covert, through the forest—this time I entered through the main gate, wearing steel-toed boots, a construction safety helmet, and carrying my camera gear. The landscape was the same, but the choreography had shifted. I spent around three hours with the group, watching as members scattered across the quarry floor, their movements purposeful yet instinctive, like ants drawn to sugar. Armed with drills, hammers, and chisels, they worked with quiet intensity, pausing often, kneeling down, tapping stone with practiced ears. They would locate a promising formation and then, with a kind of surgical precision, split open large rocks, peeling them apart to reveal the mineral forms hidden inside. For the first time in this research, I felt part of a group that, in its own way, was doing something similar to what I was doing, looking for an encounter.

Niobium at The Canadian Museum of Nature

After many decades of scientific studies, the geological processes through which Mount Saint Hilaire was formed remain speculative. What geologists do know is that minerals found here contain over forty different chemical elements. Among the most predominant are lithium (Li), beryllium (Be), zirconium (Zr), and niobium (Nb). The Canadian Museum of Nature has studied in detail the geology of this rare geological intrusion and, in 2020, acquired the Haineault Mont Saint-Hilaire Collection, comprising more than 8000 mineral specimens. According to the museum, "the collection includes display specimens, rarities and numerous type specimens." The collection was acquired by Gilles Haineault and his wife Liliane between 1980 and 2007, and today it has a special place at the museum in Ottawa, where teams of geologists have been studying Saint Hilaire since the 1970s. Today, "scientists are still discovering and describing new mineral species from the site with the help of advancing scientific tools", explains Dr. Paula Piilonen, research scientist and museum mineralogist, with a deep fascination for niobium.

After contacting the Museum and having an initial interview to clarify the nature of my research and what my aim to visit their facilities was, I asked myself again: what am I looking for here? Although I was moving far outside my usual fields, I wanted to test some of my theories. The initial questions I drafted for Dr. Piilonen were meant to better understand the processes through which niobium is formed and distributed across the Earth's crust—and to explore possible connections between geological shields around the planet and biomes like the Amazon and the Boreal Forest. Looking back, that initial framing now feels reductive. All I wanted was to guide niobium toward my own speculations, a gesture that now strikes me as naïve. I came to the museum seeking facts. Once again, I found becomings. As I continue to search for a material called niobium, I keep encountering something else: not an object, but a material-conceptual entity that unfolds through multiple registers of relation, time, and speculation.

For Whitehead, "the actual world is a process, and the process is the becoming of actual entities" (Whitehead, 1978, p. 22). From this perspective, as a material entity, niobium does not exist as a static substance but as an unfolding process of becoming, from its stellar formation to its crystallization in alkaline rocks, from its industrial alloying to its speculative role in scientific research, and now, through this research-creation, in artistic inquiry. Each of these settings

represents a different phase in Nb's passage through time and space, through history and matter, meaning that it is prehended differently in each context. In Whitehead's cosmology, "actual entities" are the basics of reality. Each has "atomic unity", they are indivisible occasions of experience, and each can only be understood as process. Prehension is the mode by which actual entities relate to and selectively incorporate aspects of the world into their own becoming: it is the act of grasping. "The analysis of an actual entity into prehensions is that mode of analysis which exhibits the most concrete elements in the nature of actual entities" (Whitehead, 1978, p. 19). At this stage of the research, although I was consciously attempting to distance myself from traditional academic epistemologies, I began to notice how I was still, unconsciously, trying to direct niobium—sequestering it into pre-established frameworks, sites, and lines of inquiry that reflected my own tendencies. "It is presupposed that no entity can be conceived in complete abstraction from the system of the universe" (Whitehead, 1978, p. 3). This realization pushed me to question, on one hand, my methods of research, and on the other, to revisit the artistic dimension of the study. Is Art merely a form of representation? Is thought a way of directing? The opportunity then became one of reorientation, of beginning to feel art-making as relation. In that unfolding, the work becomes a practice of becoming with the element, rather than defining it from outside.

My early attempts to collect an assemble of niobium's histories, its becomings into the human world, now seem like an effort to think the mineral, rather than with it. That gesture risks repeating a relational mode not aligned with the creative study I am trying to undertake. What I am aware of now, are encounters; not representations, not the replication of similarities, or recipes for thinking nature, but what Brian Massumi calls a non-sensuous similarity, the capacity of thinking-feeling not from one sense, but in the collectivity of senses. "In no one mode. All and only in their relation." (Massumi, 2011, p. 110). As I follow niobium and let the mineral guide me through its own prehensions, I ask myself: what drew me to it? Why does it continue to open doors for me? Massumi speaks of amodality as the perception that appears *between the senses*, in the cracks. This is where affective attunement with nature becomes possible: not as domination, but as a way of becoming-with, feeling part of, sensing from within. I feel that it is through these "cracks", that it becomes possible to "fit" oneself into nature; like a puzzle, as naïve as that may sound, where pieces come together not through resemblance, but through a mode of relation that

exceeds sensuous similarity, in a relation of impossible-full-integration. What happens between the modes of perception—this amodal awareness, this non-conscious, non-sensuous similarity—is the terrain of emergence. What emerged in my mind as I was walking in the quarry, was the thought-feeling that I was already part of niobium's nexus of actual occasions. That this relational field had not been formed through resemblance, but through what Massumi calls the relation of non-relation—a field effect arising from tension, difference, and proximity without assimilation. As I continue walking through niobium's world, my puzzle and niobium's keep changing, expanding, and finding new pieces to grasp, fit, and prehend together.

Emergence, rather than imitation, is what constitutes our becoming in the world. So what are the attunements, movements, and relations that unfold between niobium and those who encounter it? Between scientists and samples, miners and rocks, local communities and extraction sites, stock markets and strategic reserves—and me? Like many raised in Western schools, I was taught to relate to minerals as immobile, inert, inanimate—a static backdrop to human action. But I also witnessed, growing up on my grandfather's coffee farm in the Colombian mountains, how rocks hold and sustain, how they mark and demarcate, how they organize life in ways rarely acknowledged. Contrary to being silent, they ground memory, effort, experience, and direction. It is through amodal experience, through the non-sensuous similarities it makes possible, that another kind of relation begins to emerge. One that does not reproduce inherited categories, but opens a space where self-worlding happens in the folds, where matter, feeling, and relation co-compose, together.

During our interview, Dr Piilonen spoke of niobium as a kind of an outsider in the mineral world, what she called an "oddball", and it is precisely this unique nature that attracted her to study this mineral extensively. In her descriptions, niobium doesn't behave the way closely related elements do. It refuses expected substitutions. It declines to partner with tantalum, its sibling, in alkaline systems. It forms rare and complex minerals like niobokupletskite and latrappite under specific, often unrepeatable conditions. This oddness is not merely technical—it is expressive. It speaks of a mineral that resists classification not because it lacks structure, but because its mode of relation exceeds classification itself—a relation of non-relation. Dr. Piilonen explained that Mount Saint Hilaire, particularly in its final stages of formation, exhibits unusually high concentrations of niobium. What intrigued her as a mineralogist was not only where

niobium ends up, but how it moves, transforms, and partners with particular minerals during the closing phases of magmatic activity. “I want to understand how that happens,” she said, “and then what particular minerals niobium will actually go to in these systems.” As a mineralogist, her goal is to study minerals from a chemical and structural point of view, but also to use minerals and elements to understand how intrusions like Mount Saint Hilaire formed. She described a particular fascination with the late magmatic phase, a moment when most of the magma has cooled, but a small volume of residual fluid remains. This fluid is not entirely liquid nor fully solidified, “kind of not a magma, but not water,” she said. “It’s between that where kind of all the interesting things happen,” she noted, “and that’s where the niobium will go.” In this unstable and chemically rich zone, elements like niobium begin to behave unpredictably, forming rare minerals that only emerge under these singular conditions.

The world’s niobium-rich regions are not randomly distributed; they align closely with the Earth’s most ancient geological foundations, continental shields, or cratons. These deeply rooted landmasses, like the Canadian Shield, the Guiana Shield, and others across South America, Russia, Asia, Australia, Africa, and Scandinavia, form the planetary backbone of niobium’s emergence. With something like the Canadian Shield,” Dr. Piilonen explained, “what happens is you create an environment… a deep keel under the continent… and underneath the keel you get these melt-sanitized fluids.” These carbon-rich, high-pressure fluids, carbon dioxide, methane, and other “weird” molecular assemblages, circulate through the lower crust and preferentially collect incompatible elements like niobium, titanium, and zirconium. “It’s just fantasy at this point,” she added. “Nobody actually knows what’s going on down there.” And yet, it is precisely within this zone of uncertainty, of speculation, where the deep mantle meets crustal fractures, and where ancient elements begin to migrate, that something strange begins to take form. “It’s not a coincidence,” she said, “that we find things like Mount Saint Hilaire, or any of the ones in South America, or in the lava complexes in Norway or Russia, they’re always related to these deep cratons, they’re always related to deep, deep, deep fracturing into the lower mantle.” These fractures are not simply geological weaknesses; they are zones of transformation, sites where ancient matter, pressure, and time collide to generate conditions for mineral novelty. The presence of niobium is not reducible to location, abundance, or chemistry; it is an expression of a geological event, a meeting of conditions that exists not on the surface but deep in a folded terrain of time, force, and speculation.

Niobium is not simply found, it is carried, drawn upward through complex interactions between the deep mantle and crust, between high temperatures and pressure. “Those fluids preferentially pick up elements like niobium, titanium, zirconium,” she explained. These same zones also give rise to diamonds, lifted to the surface by kimberlite flows—those “bizarre rocks,” as she called them, that form in extreme, fleeting encounters between heat, depth, and time. “The interaction of that deep mantle with these weird metastatic zones,” she said, “creates the magmas that we get places like Saint Hilaire from.” In her telling, niobium moves through these spaces—ascending from deep, ancient zones, drawn up by supercritical fluids, magma pulses, and the same violent geological surges that stitch the deep earth to the surface. The earth keeps becoming, it keeps emerging, the process has never ended. Mining, then, is not extraction from a static reservoir, but a capture of movement, a way of intercepting the mineral in its upward trajectory. This vertical motion, this slow emergence, is part of a planetary process of geological recycling. “You would never find these rocks three billion years ago,” she said, “because you didn’t have enough crust to create that environment… you have subduction, you have seawater coming in, mixing, and it gets pooled underneath.” The Earth, over billions of years, has been folding, sinking, heating, pushing, thus creating new sites of chemical possibility. Niobium’s existence at the surface is the result of countless interactions across tectonic time. It is through these deep, fractured, memory-bearing formations, through the possibilities of old crust, that niobium becomes mineable, becomes visible, becomes a tool in the construction of different human worlds.

Image 3.3 Saint Lawrence niobium mine at Kanehsatà:ke. (Salas, A., 2024).

When it comes to locating a viable niobium deposit, Dr. Piilonen explained, the key question is not just where niobium is, but how and where it concentrates. “In alkaline rocks, if you want enough of it, you’re going to have to go after a carbonatite type, because that’s where the bulk of it is,” she said. While niobium appears in many minerals, some even abundant, they often lack the density to make mining economically viable. Carbonatites, in contrast, concentrate niobium in forms that are easier to extract. “You just take them, crush them, and pull out the heavy minerals,” she explained. Most are oxides, and “they’re easy.” Perovskite, a niobium-bearing mineral in the class of oxides, is a good example: chemically cooperative, abundant enough, and already industrially mined. What determines whether a site is mineable depends on the mineral phase the niobium ends up in. Even though places like Oka and Saint Hilaire are part of the same magmatic system, their niobium is different.

One of the most perplexing aspects of niobium’s behaviour, Dr. Piilonen explained, is its chemical loneliness in certain geological systems. Niobium and tantalum are periodic neighbors, chemical siblings, often found together in granitic environments. But in alkaline systems like those of Saint Hilaire or Oka, tantalum simply doesn’t appear. “Something happens in a granite, you get both,” she said, “but in a syenite, you only get niobium.” Even when niobium forms abundant minerals, tantalum is absent. “It’s like it gets rejected,” she added, describing a pattern

she's seen repeatedly in detailed chemical analyses. To understand this behaviour, it may help to imagine niobium as a guest at a formal dinner who never sits where expected, wears strange but beautiful clothes, speaks in an accent no one can quite place, and somehow alters the mood of the entire room just by being there. Niobium doesn't disrupt the table. It reorganizes it. It makes new arrangements necessary. It insists on being noticed, not through noise, but through structural tension, through a chemistry that doesn't quite fit, through affinities that never fully resolve. This is what makes it so fascinating to scientists, and perhaps, also, so attractive.

Beyond its selective affinities, niobium's electronic structure presents another layer of complexity, one that makes it both fascinating and difficult to work with. As Dr. Piilonen explained, niobium exists most stably in a 5+ oxidation state, a high charge that many mineral lattices struggle to accommodate. "Nature doesn't like to be unbalanced," she said. "As soon as you start putting a 5+ cation in and substituting for something else, weird things have to happen just to charge-balance." The result is a cascade of mineral distortions, unexpected substitutions, and unstable crystalline forms. Niobium refuses simplicity. It enters structures only by disrupting them. Its presence alters the behaviour of other elements, warping established patterns. As Piilonen put it, "The bonding's weird. The substitutions are weird." This weirdness, far from being incidental, seems to be niobium's mode of expression. Its chemical excess becomes a kind of material resistance, a refusal to settle cleanly into known forms. Niobium causes distortions. It is not just found in unusual places—it makes those places behave unusually. It bends structure, warps geometry, and resists symmetry. Its superconductivity and its mineral "weirdness" are not separate—they are two faces of the same material temperament.

Niobium is an oddball—It bends crystal structures to its needs. It forms under conditions where magma hovers between liquid and solid, where deep crustal pressures and mantle interactions create strange, volatile chemistries. Its superconductivity and its mineral "weirdness" are not separate—they are two faces of the same material character. Though niobium shapes particle accelerators, MRI machines, and superconducting futures, it remains largely unheard of, operating below the threshold of public recognition. It is an infrastructural ghost, embedded in systems that forget the elements and processes that sustain and allow them, that are charged with complex geopolitical logistics, where borders are determined by economic and national interests. On the other hand, Niobium does not recognize borders. It emerges wherever the planet becomes

strange enough to hold it. Its world is not the map, but the mantle. It moves across borders not only as mineral, but as commodity, as diplomatic leverage, as strategic absence, surfing the whole history of the universe. Its distribution echoes the fractures of the Earth, and the fractures of geopolitics.

The curtain rises and it is me

As part of my fieldwork, I had the opportunity to attend the 10th International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity, hosted at Jefferson Lab in Virginia, USA. The event gathered an army of researchers from leading laboratories around the world, all working on the development of new technologies for the next generation of particle accelerators; mostly national facilities. It was there, in the gaps of presentations and coffee breaks, that someone mentioned a book I had never heard of: *Extractive Metallurgy of Niobium*, by Gupta and Krishnamurthy. Curious, I looked it up, and to my surprise, found that its final chapter was written in the first person, as if niobium itself were speaking. I was amazed. After hundreds of pages of technical specifications, metallurgical processes, and industrial data, here was niobium finally allowed to speak its own history. Or so it seemed. In this closing gesture, niobium thanks the authors for recounting its story, at least, as it is known in the Western scientific and industrial imaginary. Its voice, however, remains confined to a specific script: a narrative of birth, discovery, naming, and classification. Its history begins with where it was "born," who "discovered" it, and what names it was given—Columbium, Niobium. It traces its lineage through human encounters: its first identification, its confusion with tantalum, its insertion into the periodic table, its commercial uses, and strategic importance. Even in this imaginative exercise, niobium is only allowed to exist through what it is to others. It defines itself not through its own material behavior or affective presence, but through similarities and differences with other elements, based on physical and chemical properties, extractive methods, and technological applications. It is grouped, ranked, positioned—first as a curiosity, then as an asset. Its geopolitical condition is narrated: niobium explains that the United States is entirely dependent on foreign sources for supply; that Brazil holds the monopoly, now contested by China. This ensemble of histories and dependencies becomes niobium's identity. In this script, to speak is not to become, it is to be cast into a prewritten theatrical role.

The emergence of niobium is a history of nationalism, of colonial logistics, of industrial utility, of technological developments, of purity, of Western science. Anchored in the geography of the periodic table, its history is the same of the other elements that surround it, all separated by the same borders that constitute national identities, following the rules and norms that define nature as the other. The *other* is then defined through the attributes, properties, and characteristics assigned to it, depending on what is needed to sustain a global order of control. The cycle is the same and is repeated infinitely; the markets require new products to supply new needs for consumers; science produces the knowledge needed to produce new products; the most profitable needs are the ones to be developed. The maintenance of the cycle ensures the preservation of a cosmovision that divides and differentiates, using categories designed to fabricate an illusion of belonging, through competition, through hierarchy.

Defining the *other* by chemical and physical properties follows the logic of control, where the senses are partitioned to enable categorization—an operation central to the machinery of modern colonial power. The geography of the periodic table is one of the logistics of modern capitalism; it is the map of geopolitical displacement and extraction, of environmental degradation, of artificial intelligence, and space colonization, a grid of certified differences arranged not only by mass and valence, but by value, access, and control. The national map is only a distraction for the senses, in a world controlled by infrastructures of domination constructed through standardization, purification, and marketability. The map of control is a system to ensure the flow of matter, of bodies, of capital, and the universal itself. It ensures predictability over the energetic, cognitive, and planetary resources needed to preserve a very specific world order. Human-drawn stabilize the map and regulate the channel through which these flows circulate, often at the cost of environmental devastation. The movement of merchandise through the oceans of the planet is not real movement, but choreography. The purity of the elements we dictate to compose the entire universe is a human invention; rare earth elements or strategic metals are only defined by the systems that determine what is usable, visible, or profitable. Their rarity is determined by how expensive it is to transform them, they are strategic because of a competitiveness that mirrors destruction and violence. The periodic table transforms materials into metrics, and metrics into capital. Its geography is the embodiment of a nature without relations, where each element is abstracted from its becoming, its

environment, and stories. In this technological schema, matter is made mute, rendered docile for the purposes of use, storage, and accumulation.

Image 3.4 Still image from the film “Colombium”.

Niobium is considered a critical element not for what it is, but for what it makes possible: stronger pipelines, faster trains, cleaner fission, and quieter superconducting coils. It is classified as a strategic mineral—not a rare earth, and not geologically scarce—but rendered critical by the infrastructures, monopolies, and predictive regimes it enables. When they call it a metal of the future, it is because niobium operates inside systems of prediction, optimization, and acceleration. A particle accelerator is an image engineered for the senses, a machine that few can fully understand, a vacuum for public funding, and a key instrument in the geopolitics of calculated futures, where scientific imagination is embedded in militarized research and global patent regimes. A particle accelerator is a machine designed to propel charged particles, typically protons or electrons, to extremely high speeds using electromagnetic fields. These particles are then made to collide with targets or with each other, allowing scientists to study fundamental forces, create new materials, or simulate the conditions of the early universe. It transforms invisible processes into detectable traces, particles into patterns, forces into data. A particle

accelerator is a current of capital and ambition. It exists through immense flows of public and private investment. It not only accelerates particles; it accelerates funding, alliances, and institutional prestige.

It is a machine that sculpts popular imaginaries of a future tailored to obey and preserve existing hierarchies and elite speculation. Niobium is central not simply because of the superconducting cavities, magnets, or filaments it enables, but because its engineered purity, miraged as neutrality, allows current to flow without resistance, collisions to occur without responsibility, and logistics to be optimized at maximum speed. Like the allegorical personification of America crafted by Meissen, niobium's persona is that of a soft, quiet, reactive body, structured to function under conditions of extremity. It is docile, compliant, and ultimately, ready to be sacrificed for a future it did not choose.

What kind of being thrives in cold, vacuum, silence?

Niobium's superconductivity is achieved only under extreme conditions: 9.3 K, –263.85 °C. At this threshold, colder than any natural environment on Earth, colder even than outer space, resistance vanishes. No heat. No friction. A perfect, silent medium—and only niobium is capable of this. It is here, in the deepest artificial cold, that niobium reveals its full capacities, but only in a state of engineered purity. Yet niobium, as it exists in nature, is never alone. It is always entangled, geologically, chemically, politically, with others: tantalum, titanium, iron, phosphate, state, war, art, speculation, particle physics, artificial intelligence. Purity, then, is not natural; it is technological. It must be produced, enforced, and maintained through the violent logics of extraction, mapping, and standardization. Purity is pure speculation. It operates at the level of the senses, fabricated through prehensions aimed at stabilizing markets, whether through bodies, materials, or data. Isolated, niobium as a pure element becomes a technological fiction, a machine of abstraction calibrated for specific functions, embedded in a system, an assemblage designed to convert nature into infrastructure, matter into strategy, relation into logistics. As a technological commodity, its purity is a precondition for its usefulness, the metal's value increases as it is stripped of its entanglements (tantalum, oxygen, hydrogen, nitrogen); it performs well under pressure— pressure is its natural environment, its culture—but not without tension, not without the violence inscribed in the flowsheet that maps its path towards

the elimination of impurity. Its incorporation into the assemblage of particle physics entails a negative prehension; to be cleansed from its geological past is the requirement to enter industrial subjectivity. Yet, chemical purification is another story in its machinic becoming; niobium is never just itself, but always a compound, the tension here is between usefulness and loss. When superconducting niobium becomes a silent medium, capable of carrying force without friction. A mineral whose usefulness increases the closer it gets to absolute zero. It is a relational element, it co-exists, it is always-with, as part of mineral assemblages shaped by geological deep time that sustain continents and oceans, and part of machine assemblies intended to replicate the past, and to predict speculative futures.

A flowsheet of cracks

Every mine follows the same flowsheet and is guided by similar objectives: profit while preserving a geopolitical order. What is the real need then? A flowsheet is a visual representation of movement, of transformation, a speculative diagram of control and prediction—but also of desire. They are machines of prediction on paper, promises of future products from a present material, political artifacts that map what humans are willing to do to reach a mineral's essence. They calculate risk, list compromises, alleviating uncomfortable decisions by ensuring the fulfilment of what is wished. Disguised as engineering, they are tool and weapon, belonging to an assemblage of desire. "Weapons and tools are subject to the same laws, which define, precisely, their common sphere" (Deleuze, Guattari, 1987, p. 397). In the ecology of extractivism, they come together to preserve an order. "The question is whether the assemblages of war and work, considered in themselves, do not fundamentally mobilize passions of different orders" (Deleuze, Guattari, 1987, p. 399).

Mining and crushing; grinding; flotation; leaching and purification; dewatering; drying and packaging. This standard process is followed by both CBMM in Brazil and Niobec in Quebec. The ore is mined, then crushed; through a process of flotation, which requires vast amounts of water, niobium is separated from the ore. A magnetic separation further eliminates remaining impurities. Then the mineral is dried and then packed. Every diagram of inclusion implies one of exclusion. The flowsheet, like any other industrial diagram, is a map of prehensions; it stages a smooth flow of matter through a production line, but it also tells a second

story, one made of omissions. Its negative prehensions are many: it excludes labour, violence, opacity, and resistance. It does not register niobium's entanglement with tantalum, with rainforest soil, with patent law. It purifies the process by removing the relational, by subtracting what cannot be made to circulate. But the excluded is not gone. It returns as instability, as waste, as radon, as resistance from local communities, as art that can contest. The flowsheet is not merely a technical schematic, it is a diagram of desire. It outlines what is wished for: clarity, control, and compliance. It projects a technological mineral future without uncertainty. Each step is an expression of what must be achieved, and also of what must be denied. The desire to separate, to purify, to accelerate, is not neutral. It is geopolitical. It is epistemological. It is metaphysical. For Deleuze and Guattari, desire is not born of lack; it is a productive force, shaping machines, fantasies, and extractions alike. "Desire is a machine, and the object of desire is another machine connected to it." (Deleuze & Guattari, 1983, p. 5). The flowsheet is not a map of resources; it is a machine of desire, where niobium is positioned not as an object of lack, but as a node in a network of productive wishes: for clarity, utility, speed, intelligence, control.

One thing that strikes me constantly is the fact that only the CBMM mine in Araxá could supply the world demand of niobium for decades to come. But we want more. We want more mines, and every nation-economy needs its own mine, and its own particle accelerator, and its own nuclear fission facility. Scarcity is not geological, it is strategic. What does it mean to have a mineral that is globally strategic but logistically fragile? When a single mine can supply the world, but nations insist on securing their own, we begin to see how material precarity is manufactured. Scarcity is no longer a matter of geology—it is a matter of infrastructure, of narrative, of desire. Monopoly and vulnerability are geological fictions, not based on material absence but on political orchestration. Either through mining or programming, everything starts on paper—on the flowsheet, on the engineered diagram where the excavation machine and the optimization algorithm are already inscribed. The flowsheet is the scene of instruction: it tells machines what to dig, and tells code what to simulate. It is where desire becomes executable. The flowsheet enables both the hole in the ground and the line of code. It renders the earth legible as profit, and reconfigures matter into function and data. The diagram, made of objects-actions, flows in the direction of arrows, it splits, it loops, it circles. It optimizes. Everything is calibrated to move toward the final objective. But the diagram does not account for what happens in between: between flotation and leaching, between grinding and drying. Between the objects and

the arrows, something else pulses. This is where thought-feeling happens. Where the amodal lingers. Where what cannot be diagrammed becomes possible, here it is possible to deviate from the course, to take another turn, to refuse the directive logic of extraction. This is not innovation. Innovation is repetition with variation. It is the name we give to the continual refining of control. It optimizes but does not create. It sustains the system that extracts, classifies, and accelerates. Innovation is the mask of stasis. It is the flowsheet repeating itself—faster, cleaner, more violently, promising novelty but only delivering recurrence. Creativity, by contrast, is not the production of the new; it is the event of something. Whitehead names this the creative advance of nature. "Creativity is the universal of universals characterizing the ultimate matter of fact. It is that ultimate principle by which the many, which are the universe disjunctively, become the one actual occasion, which is the universe conjunctively." (Whitehead, 1978, p. 21) It is not programmed. It is not modeled. It happens where relation is allowed to unfold, where exclusion fails, where prehensions include what was meant to be left out. In the cracks, prehension is released from instruction. Here, something can be felt that wasn't accounted for. Something can be taken in without being reduced. Here, prehension regains its force: not to finalize or classify, but to relate, to become-with. Creativity is not engineered; it erupts in the cracks of the system. Benjamin's "homogeneous empty time" is the time of modernity: the clock, the flowchart, the flowsheet. But the creative happens in concrescence, in the moment when something is felt and brought into being. "'Concrescence' is the name for the process in which the universe of many things acquires an individual unity in a determinate relegation of each item of the 'many' to its subordination in the constitution of the novel 'one.'" (Whitehead, 1978, p. 211) This time is not linear—it is thick, recursive, partial, alive.

Through the flowsheet, niobium ceases to behave as a mineral; it becomes a human invention, no longer what the earth made, but a machine forged under desired conditions. It becomes possible after movement, after erosion, after separation, after decay. Perhaps this is why its superconductivity can become unstable, at a given point, in the extreme conditions towards which it is pushed by desire. It rebels. It performs well under pressure, but not without tension, and that also has a limit. The Q-slope problem embodies this limit. It is a drop in the performativity of the material when the tension is higher, when it is expected it would perform better, but then, niobium decays. But what if this is not merely a technical flaw? What if it is a symptom of a material-machine that, while oscillating between states, is haunted by its geological

past and its instrumental demand? A machine that decays into something else, into difference, into refusal. In this state of decay, the element draws a line for desire, articulating a limit to optimization. Niobium superconductive cavities and magnets for particle accelerators are mass-produced, designed to be identical, interchangeable. But in their failure, they become distinct. Each decay is different. Each crack, each slope, and each limit point is singular. In failing, niobium gains visibility. It stops functioning as planned, and in doing so, it emerges as a presence. Not as resource, but as witness. As event. In this moment of decay, the flowsheet is disrupted, the map is interrupted, optimization finds its limits, and niobium asserts itself, not by design, but by expression.

Image 3.5 Linear Accelerator Cold Box at TRIUMF. (Salas, A., 2024).

Niobium in the tropics

Lateritic enrichment is a geological process that unfolds in the tropics, where time, heat, rain, and biology combine in long erosive cycles. Under these conditions, soluble elements like sodium, calcium, potassium, and silica are slowly leached out from rocks. What remains are the insoluble, often metal-rich residues: iron, aluminum, titanium, and niobium. These processes create laterite soils, red, ochre, and heavy. Not productive in the mono-cropping agricultural sense, but full of hidden metals. When a mineral resists dissolution, it doesn't vanish; it

concentrates, slowly accumulating in the upper layers of the weathered crust. These are not ores in the traditional sense, but supergene enrichments, residual deposits built not by formation, but by persistence; niobium is released from pyrochlore, its original “host”, then is reincorporated into secondary oxides through weathering processes. This is how niobium is found in places like Araxá, in Brazil, or across the Guiana Shield, which spans Colombia, Venezuela, northern Brazil, and into Guyana. It is not born in these soils, but it has moved, through weathering, through time, through residue. Lateritic deposits are economically significant in regions where niobium and other critical and rare earth minerals become concentrated not through depth, but through erosion. This is distinct from deposits in colder regions, like the Canadian Shield, where sites like Niobec, the old Oka mine, or Mount Saint Hilaire are found. There, niobium is part of deeper magmatic processes, locked in carbonatites or syenites, to be cracked open through underground blasting and flotation. Those niobiums are mined from origin; the tropical ones are mined from weather. Lateritic deposits matter, economically, geopolitically, and geopoetically. They shape the surface crusts of countries like Brazil, Gabon, the DRC, Venezuela, and Colombia, nations marked not only by mineral abundance and extractive asymmetries, but also by ecological depth and political vulnerability. These are not just mining states; they are homes to some of the world’s most vital biomes: the Amazon rainforest, the Congo Basin, the Guiana Shield, and the African savannas. In Gabon, niobium emerges from the reworking of ancient ferric soils. In the Democratic Republic of Congo, niobium is chemically entangled with tantalum in coltan, a well-known critical mineral essential to global electronics, GPS systems, surveillance infrastructures, smart weapons, and military logistical computing. Its extraction is tightly bound to environmental devastation and ongoing human rights abuses, revealing how so-called “criticality” is often a mask for systemic violence.

These minerals do not just come from the Earth. They come from conflict, erasure, and engineered abandonment. The often absence of the state in these territories, and the poverty that comes with it, is a strategy. The state is always present, not through care, but through mapping, satellites, stock markets, mineral studies, and logistical operations. Abandonment is not neglect; it is an extractive function. Just another line in the flowsheet of extractivism.

Recent studies from the Morro dos Seis Lagos deposit in the Brazilian Amazon forest, have shown that niobium does not simply persist in laterites as a passive remnant of weathering.

Instead, it is released, moved, and recaptured; it migrates following the chemistry of the land, and enters new structural relationships. A process that started around 60 million years ago and continues to the present. In this tropical setting, the primary niobium-host mineral, pyrochlore, is broken down by prolonged weathering. But the niobium does not disappear. It becomes mobile, and is reincorporated into secondary oxides, particularly goethite (Fe), rutile and brookite (Ti), and to a lesser extent, Ce and Mn oxides (Bory et al., 2023). This is not surface adsorption; it is atomic substitution. "The exceptional Nb concentration in the lateritic weathering profile results from Nb release during pyrochlore alteration and subsequent fixation by newly formed Fe-Ti oxides." (Bory et al., 2023, p. 14) This finding is significant because niobium has historically been considered insoluble under surface weathering conditions. However, recent spectroscopic studies of similar lateritic systems have provided a deeper understanding of this mechanism. *Bollaert et al. (2023)* used XANES and EXAFS spectroscopy to confirm that niobium is not merely adsorbed onto the surface of secondary minerals, but is structurally incorporated through atomic substitution into the crystalline frameworks of Fe- and Ti-oxides. These findings reveal that the lateritic profile is not just a passive residue of leaching but a reactive zone of mineral recomposition, where niobium is transformed—not lost, not entirely new, but structurally rewritten by weather, time, and mineral affinity.

In this frame, niobium is not simply what remains after other elements dissolve; it is a participant in lateritic becoming, a mineral re-sedimented by weathering, a foundation of the soil of these biomes. Its presence is not given. It is made again, structurally, chemically, and geohistorically. Just as niobium does not recognize national borders, extraction does not obey the flags that supposedly govern it. It's the geology that matters. It is the cratons, the ancient continental cores, that guide the flow of mineral desire: through the Amazon, the Boreal Shield, the Congo Basin, the Arctic. These are the real maps of power. The politics follow the rocks. Geopolitical action today reveals this subterranean logic. Where minerals cluster, so does surveillance, speculation, and militarization. The Amazon is being remapped not for its forests, but for its subsoil; Roraima, Vichada, and the Guiana Shield are now part of mineral supply forecasts. In the Congo, coltan has left a trail of death and displacement. In the Canadian Arctic and the unceded lands of the Boreal Forest, niobium, lithium, and rare earth exploration accelerates, often under the banner of green transition or technological necessity. Without mentioning the interest of the US in buying Greenland or adding Canada to its control.

Image 3.6 Minastyc mining site. Vichada, Colombia. (Salas, A., 2024).

But these territories are not empty. They are inhabited, defended, and named. In Roraima, the Macuxi, Wapichana, and Yanomami peoples actively resist both illegal and state-sanctioned mining. The Yanomami territory, in particular, has faced significant challenges due to illegal gold mining activities, leading to environmental degradation and health crises within the community. In Colombia, Indigenous communities such as the Barí, Curripaco, Sikuani, and Puinave stand against extractivism in the Orinoco watershed. These groups have raised concerns over the environmental impacts of mining activities on their ancestral lands, particularly in regions like the Orinoco, Atabapo, Guainía, and Negro rivers. Across unceded Indigenous lands in Canada, including those of the Algonquin, Atikamekw, Innu, and Dene nations, resource extraction continues to be challenged by deep-rooted territorial knowledge and cultural refusal. These communities have engaged in negotiations and initiatives to assert their rights and protect their lands from unsustainable resource development. In the Arctic, the Gwich'in, Inuit, and Sahtu Dene peoples push back against extractive incursions justified by global criticality. They have raised concerns over oil and gas drilling projects in sensitive ecological zones, emphasizing the need to protect their traditional territories and ways of life. These peoples do not just contest mining, they contest the very logic that treats geology as destiny and territory as supply. They remind us that what lies beneath is not inert, not neutral, and not disconnected from what lives above. Niobium moves across borders because the Earth itself does. It travels through cratons,

through soils, through time. It ties together places that are often linked only through the environmental and humanitarian challenges they share. The Congo, the Amazon, the Arctic and the Andes, are not only places to be mined and stripped of resources, they are worlds that, often imagined as geographically distant, contest the ways in which we understand how relations are constructed and lived. What extraction names as a “deposit,” others name as relation, universe, story, resistance.

Chapter 4

"What the white people call 'minerals' are the fragments of the sky, moon, sun, and stars, which fell down in the beginning of time. This is why our long-ago elders have always called the shiny metal mareaxi and xitikarixi, which are also our names for what the white people call the stars."

Davi Kopenawa – *The Falling Sky*

Looking at the stars is looking into the past, it is accessing the echo of the first explosion, the first event, what Western scientists call the beginning of everything. The story of the Big Bang reinforces the technical procedures through which particle physicists attempt to explain the nature of matter, of everything visible and tangible, of all that can be accessed through the senses. This origin story supports the technical practices that aim to replicate the first moments following the explosion that is said, marked the birth of the universe. For this, particle physicists have developed a complex infrastructure, technological machines known as particle accelerators, which, by accelerating hadrons— subatomic particles— seek to make them collide, violently and precisely. According to particle physics theory, it is thought that by studying these events, it is possible to increasingly understand the smallest, the least visible, the most fundamental. In this way, it is expected that by dividing, we will, more and more, understand the nature of matter. Invisible particles whose existential evidence is marked by long lists of data, immense quantities of information whose size and scale are directly proportional to the development of new technologies linked to superconductivity.

"How can we approach the question of what distinguishes 'science' from 'technique'?" (Stengers, Cosmopolitics I, 2010, p. 341). For Stengers, a scientific technique operates within a tightly defined environment: an experimental situation where devices are constructed to answer very specific questions. These are not neutral instruments, but machines designed to satisfy the demands of paradigms, machines built to fulfill the requirements of what counts as a legitimate problem. In this way, the invention of a new device for the detection of a particle is not only a technical gesture but a political one. It opens space for a new term, a new protocol, even a new

career path for a technician, allowing the apparatus of knowledge production to keep moving forward.

Technique, then, is never outside of politics; it is embedded in and conditioned by the assemblage that activates it. “It is through the intermediary of assemblages that the phylum selects, qualifies, and even invents the technical elements” (Deleuze, Guattari, 1987, p. 397). The technical element does not exist in isolation. It is drawn from a continuous flow of matter, what Deleuze and Guattari call the machinic phylum, and shaped by the assemblages that deploy it. In the context of particle physics, this means that superconducting cavities, magnets, and detectors are not simply devices; they are material crystallizations of epistemic and institutional logics. In this regime, the application of technique to nature becomes a form of objectification. Nature is configured as that which can be measured, simulated, divided. It becomes the object of a mode of relation that Brian Massumi calls “interacto-centrism, technoscientifically enhanced” (Massumi, 2011, p. 75). This refers to a highly functionalized interaction between vision and touch, seeing becomes grasping, and grasping becomes extraction. The collider does not just show the particle; it captures it, renders it intelligible through the constraints of the system that made it visible in the first place, and allows for its violent partition.

Particle physics, then, is not merely about observation. It is about constructing conditions under which a particular version of the cosmos becomes thinkable. “The tool does not define work; just the opposite. The tool presupposes work… But the principle behind all technology is to demonstrate that the technical element remains abstract, entirely undetermined, as long as one does not relate it to the assemblage it presupposes” (Deleuze, Guattari, 1987, p. 397). What matters, in other words, is not the tool or machine in isolation, but the assemblage, the relational constellation of forces, bodies, affects, and materials, into which it enters. The same technical object can become a weapon or a vessel, a slave ship, a scientific instrument or an artistic surface, depending on how it is composed and activated. Walter Benjamin offers a crucial distinction, not between technique and technology as such, but between two orientations of technique. When technique is used to aestheticize domination, as in fascism, it becomes instrumental, serving power and control. But when it opens space for new forms of collective perception, it becomes non-instrumental: a medium for emancipation. The dynamic between instrumentality and transformation is not abstract; it is materially embedded in the elements and devices that compose

the collider itself, and in the machinic phylum from which it emerges. Alexis Pauline Gumbs extends this critique with devastating clarity. Reflecting on Audre Lorde's cosmology, she writes: "Elmina and all those other fortresses became early particle accelerators, structures of compression where colonists and their local collaborators crowded millions of kidnapped Africans into dungeons so tightly that their skin cells and excrement still make the stones of Elmina smooth." These fortresses, like modern colliders, were built for compression, collision, and separation. Gumbs continues: "Western scientific progress requires as many collisions as possible. Transatlantic particle accelerators shattered bloodlines, shattered social contracts, shattered consciousness…" (Gumbs, 2022) In this light, the particle accelerator is not only a scientific device but part of a longer colonial infrastructure, built not to uncover the origins of the universe in neutral terms, but to violently reconfigure which lives, which knowledges, and which futures are possible.

Image 4.1 Niobium bulk SRF cavities produced at Jefferson Lab, in Virginia, USA. (Salas, A., 2024).

One Continent

The idea that our continents were once part of the same landmass, billions of years ago, has been a guiding force throughout this research. To think that the Canadian Shield and the Guiana Shield were once connected, not only fuels the speculative core of my work, but also energizes the theoretical frameworks I've engaged. This sense of deep geological unity has given me the conviction, perhaps even the stubbornness, to pursue access to elusive sites: prestigious, bureaucratic cultural institutions, highly secured national laboratories, and abandoned or emerging mining territories. It's a drive that moves beyond logistics into something like cosmopolitical alignment. Visiting the Guiana Shield became fundamental to this process. My first impulse was to reach Roraima[9], in northern Brazil, a territory where the Ingarikó people among others have struggled for centuries to defend the northern Amazon Forest, their cosmology, and ultimately, their lives. Roraima is not only geologically significant, believed by mineralogists to contain large undeveloped niobium deposits, but it is also the Brazilian state with the highest proportion of Indigenous peoples relative to its population. Communities like the Ingarikó, Yanomami, Macuxi, and Wapichana inhabit lands that sit atop these ancient geological formations, making the region a contested zone of extractive projection and ancestral stewardship. In 2016, these communities' resistance confronted the ambitions of then-president Jair Bolsonaro, who vowed to expand Brazil's niobium dominance. Despite the fact that CBMM's mine in Araxá already supplies over 90% of the global niobium market, Bolsonaro's rhetoric positioned Roraima as a future mineral frontier, drawing on nationalist myths and techno-scientific promises. But for the people who live there, the land is not a deposit, it is a sacred geography, a relational world, a place of life and story. It was this tension between mineral dreamscapes and cosmopolitical resistance that initially drew me toward this region.

I contacted Professor Márcia Falcão from the University of Roraima, whose work with Indigenous communities in the Serra Raposa do Sol territory has been extensive. This sacred

[9] The word "Roraima" comes from the Pemon language. Its etymology gives it three possible meanings: "Green Peak", "Mother of the Winds" and "Cashew Mountain".

region, home to Mount Roraima, one of the largest and most venerated inselbergs or *tepuis*[10] on the Guiana Shield, is composed of some of the oldest rocks on Earth. I imagined tracing these mineral lines across borders, connecting these highlands with the niobium-rich outcrops of Oka, Chicoutimi, and Saint-Hilaire, a trip through geological times to imagine a planet where all these places were one. But something I haven't yet mentioned in this written dissertation, is that for much of my doctoral studies I was dealing with long COVID. The illness had a profound impact on the original scope of this research. Everything was ready for the trip to Roraima, but my health, although it had improved significantly by then, kept shifting from one state to another. My heart rate would spike without warning in the middle of the night. My stomach turned inexplicably. My head would spin, and some mornings even walking to the bathroom felt like running a marathon. The symptoms came and went in waves: one day I felt "okay," the next I felt crushed under an invisible weight. I had planned to travel from Bogotá to Leticia, the capital of Colombia's Amazonas department, then by boat down the Amazon River to Manaus, and finally by plane to Roraima. It was the cheapest and most geographically meaningful route, a trip shaped by water and ancient landscapes. The alternative, flying via São Paulo, was prohibitively expensive and disjointed. In the end, the journey was cancelled, my health was not stable enough to embark on a trip like this. But the desire to visit the Guiana Shield only intensified. As with every step, every site, and every interview that are part of this creative study, the question transformed from *how* I was going to get there to *why* it had become so essential. My longing to touch the rocks of this ancient shield, where niobium still rests in the stone, where ancient human stories resist, turned into an obsession. Looking at the map of the Guiana shield from my family's house in Bogotá, I suddenly saw it. The Guiana shield is right here, in southeastern Colombia, in the Vichada region, the east side of the Andes. This is where the mountain chain turns into a near-infinite savannah. The thought was quick, I could easily take a flight to Vichada's capital Puerto Carreño. From there, I could easily travel by boat on the Orinoco River. I just needed to find the right institutional contacts, and make sure that it was safe to spend time there.

[10] A tepui is a table-top mountain or mesa found primarily in the Guiana Highlands of South America, especially in southern Venezuela, northern Brazil, Colombia, and Guyana. The word *tepui* comes from the Pemon language (spoken by Indigenous peoples in the Gran Sabana region of Venezuela), and it means "house of the gods."

In the past, I have worked extensively with Afro-Colombian communities in the Chocó department, on the far western coast of the country where the dense tropical rainforest meets the Pacific Ocean. This region is marked by strategic state abandonment, and a long history of both legal and illegal extraction, particularly of gold, platinum[11], and other minerals. It is also a territory shaped by overlapping forms of violence: from narco-trafficking routes, to guerrillas and paramilitary presence, to infrastructural private and state-led "development" projects that often displace communities and fragment ecosystems. Communities have continuously resisted the imposition of new ports[12], roads, and mining concessions that threaten to fracture a forest that is not only ecologically irreplaceable, but spiritually and historically continuous[13]. Despite these pressures, Chocó is home to a vibrant culture with deep, living roots in Africa, where languages, rhythms, recipes, and cosmologies converge into a universe centred on the Pacific Ocean as its vital élan. In Nuquí, Chocó, I collaborated with the *Colectivo de Comunicaciones en Puja de Nuquí* on community-based audiovisual education projects. I offered technical and creative support for local video productions and led workshops with adolescents in scriptwriting, audio and video recording, and editing. These processes culminated in short films created entirely by the youth, stories grounded in their territories, languages, and perspectives. My friend Carolina, a member of this collective, has done environmental and community-based work throughout Colombia. I reached out to her for advice on how to get to Vichada, and more importantly, who I could contact and who might host me. Like Chocó, Vichada is a region known for its natural beauty, though of a very different kind: expansive plains, the Orinoco River that borders it, and the tepuis that rise from its ancient landscapes. But it is also a territory historically lacking a strong state presence, with control shifting between armed groups over time. Eventually, Carolina connected me with the Omacha Foundation, which manages the Bojonawi Natural Reserve along the Orinoco River, not far from the site where Alexander Von Humboldt first spoke about climate change. The directors of Omacha were very supportive and generously allowed me to use their research station—a place used frequently by biologists and anthropologists—as a base for my fieldwork. As I prepared for the journey to Vichada, I revisited some of my earlier research on

[11] Platinum extraction in Chocó began in the 18th century and peaked in the early 20th century, before declining due to market shifts and environmental exhaustion.
[12] The proposed Tribugá port has faced strong resistance due to its threat to mangroves, marine biodiversity, and community autonomy.
[13] The Chocó Forest is one of the most biodiverse and rain-soaked regions on Earth, forming part of the Chocó-Darién corridor, critical for both terrestrial and marine life.

the mining of strategic and rare minerals in the region, an area whose geological richness continues to attract both scientific interest and speculative extraction. From official documents at the Colombian Ministry of Mines and Energy, I knew of the existence of niobium deposits along the country's Guiana shield.[14] During that research I came across an article from August 27, 2023 about a new niobium and tantalum mine project being developed by a Canadian company based in Montreal. The article was titled *La historia no contada de la primera mina de tierras raras en Vichada*[15]. It told the story of Minastyc, a project promoted by the Canadian company Auxico Resources, which claims to have found significant reserves of niobium, tantalum, and other rare earths in eastern Colombia. According to the journalist, the promises were bold: a new strategic mining frontier, capable of supplying the global tech industry. But something in the article didn't sit right. No environmental license had been granted[16]. The land appeared to overlap with areas zoned both as natural reserves and as ancestral Indigenous territories, primarily inhabited by Sikuani, Piaroa, and Curripaco peoples, nations with long-standing ties to the Orinoco basin. The communities had not been properly consulted. There were even allegations of "mineral seeding", a practice where minerals are introduced into the soil to simulate a rich deposit. Of course, this information contrasted the official communications from Auxico on their website as of January 2024. The whole operation smelled like speculation disguised as progress.

This speculative approach to resource extraction isn't new. As Thomas Cramer, a geoscientist at the National University of Colombia, who has done extensive work in Colombia's Guiana Shield, notes, understanding the abundance of such minerals requires years of scientific studies, especially in geological formations that are over 1.3 billion years old. Despite this, Auxico's projections were based on limited data, raising questions about the viability and ethics of their claims. Meanwhile, the reality on the ground tells a different story. Coltan has been, for some time now, exploited by armed groups, to finance their activities. In March 2025, Colombian authorities seized over 19 tons of illegally extracted coltan in Vichada, valued at approximately $7 million. This wasn't an isolated incident. In 2024, military operations uncovered shipments

[14] The Guiana Shield covers approximately 10% of Colombia's national territory, spanning the departments of Guainía, Vaupés, and parts of Amazonas. Though relatively small in percentage, it represents a vast and ecologically rich area of about 110,000–120,000 km²—roughly the size of Iceland, Bulgaria, or the Canadian province of Nova Scotia.
[15] The untold history of the first Rare Earth Minerals mine in Vichada (https://www.elespectador.com/investigacion/la-historia-no-contada-de-la-primera-mina-de-tierras-raras-en-vichada-colombia/)
[16] The company Auxico Resources Canada obtained the environmental permit to explore the Minastyc property, in April 2023. In June 2023, the company was granted a two-year environmental license for small scale open pit mining.

totaling over 100 tons, intended for illegal export to China, according to the Colombian Army. And these are only numbers about the official seizures. These findings underscore a stark contrast: while companies like Auxico speculate on untapped reserves, illicit mining and trafficking of these minerals are already causing environmental degradation and fueling conflict in the region. The juxtaposition is striking. On one hand, there's a narrative of potential and promise, crafted to attract investment and position Colombia as a key player in the rare earth market. On the other, there's the tangible impact of unregulated extraction: deforestation, pollution, and the empowerment of illegal armed groups. This dichotomy highlights the dangers of speculative ventures that keep prioritizing profit over people and the environment. As I prepared for my journey into the Guiana Shield, these stories lingered in my mind. They reminded me that beneath the surface of research and exploration lies a complex web of interests, narratives, and consequences. That what appears to be local is, in fact, embedded in logistical operations tied to global systems of power. These dynamics are not unlike the search for gold by European colonizers during the conquest of the so-called "New World." The land I was about to traverse was not merely a site of geological, ecological, and cultural significance; it was a deeply contested space, shaped by ancient processes, Indigenous histories, colonial legacies, extractive logistics, and ongoing resistance.

From Minastyc to Seis Lagos

The Minastyc Project, operated by Auxico Resources Canada Inc., has been the subject of increasing attention and scrutiny due to its strategic positioning at the intersection of global clean energy demands and fragile Amazonian ecologies. Located near Puerto Carreño in the Vichada Department of Colombia, the project lies on the west bank of the Orinoco River, in a zone bordering both Indigenous territories and conservation areas. The project is located adjacent to the Indigenous reserves of Guacamayas and Maipure, home to the Amorúa people, and near the Bojonawi Nature Reserve, a site of high ecological value with over 1,500 documented species, an interdisciplinary research facility, where biology, anthropology, and art, among other disciplines, intersect. Findings from Auxico's official NI 43-101 Technical Report of February 2025, and *the Plan de Gestión Social* (PGS) for the mining title LFH-14431X, downloaded from the company's

official website[17], and prepared by geologist J. Ricardo Sierra, describe the Minastyc Project as an area of 188.74 hectares, located within the Amazon Craton[18], with a surface geology dominated by ferruginous lateritic deposits and saprolitized Parguaza granite. The region's alluvial and colluvial sediments concentrate various heavy minerals, including iron (Fe), titanium (Ti), and tin (Sn), with minor and inconsistent indications of niobium (Nb), tantalum (Ta), and rare earth elements (REEs). Despite early-stage field sampling campaigns (361 pits identified, 687 channel samples, and 72 bulk samples between 2019 and 2024), no drilling, geometallurgical processing, or reserve estimation has been conducted. Field XRF analysis suggested the presence of niobium and cobalt, but these results were not corroborated by laboratory assays. As such, the 2025 report characterizes the project as being in an early exploration phase, with limited and speculative potential for critical minerals like Nb or REEs. Contrasting with the cautious tone of this official report, public-facing materials and investor briefings released in 2022 and 2023 by Auxico Resources, portray the project in significantly more optimistic terms. These sources claim exceptionally high concentrations of critical minerals, including:

> Niobium (Nb): 25.44% ; Tantalum (Ta): 25.08% ; Tin (Sn): 62.13% ; Titanium (Ti): 42.85% ; Neodymium (Nd): 9.49% ; Cerium (Ce): 31.09%

These values appear to derive from selective sampling and pan-concentration techniques, analyzed by the Coalia Research Institute in Quebec[19]. However, such sampling methods do not conform to NI 43-101 standards, and the 2025 report does not validate these results. The promotional framing of Minastyc as Colombia's "first rare earths project" thus seems premature and potentially misleading. A comparison between the NI 43-101 reports from December 2023 and February 2025 reveals continuity in geological interpretation, sampling strategy, and cautious resource evaluation: Both reports confirm 361 pits, 27 stratigraphically logged by Onix Geoscience, and 72 bulk samples. The December 2023 version includes XRF field detection of elements like Nb and Co, but these are explicitly noted as unconfirmed in lab assays by 2025. Tin (Sn), iron (Fe), and titanium (Ti) levels are consistent across both reports, with maximum values

[17] As of May 31st, 2025, the Auxico Resources website (www.auxicoresources.com) appears to be offline. Checking the Internet Archive, the website was last online in April 2025.
[18] The Guiana shield is part of the Amazonian craton, which is the larger geological unit, where the Araxá mine is found.
[19] Coalia, a Quebec-based research centre, received $3.7 million under Canada's Critical Minerals R&D program to pilot extraction technologies. While not focused solely on niobium, its work supports Quebec's broader strategic mineral goals.

around 0.36% Sn, 27% Fe, and 1.57% Ti. The 2025 report reaffirms the need for systematic bulk sampling (25 tonnes) from Area 50 and Area TA, granulometric separation, and geometallurgical analysis.

The 2025 version of the technical report reinforces the absence of economically significant critical mineral values at the Minastyc site, in sharp contrast to the bold claims made in corporate promotional materials. While early surface samples and XRF data had suggested the possibility of critical mineral potential, further laboratory analysis and conservative geological modelling have led to a more restrained and technically grounded interpretation. This raises a broader question: what does a confirmed niobium deposit look like in tropical lateritic contexts? One of the most rigorously studied examples is Seis Lagos, in the Brazilian Amazon, where the presence of economically significant niobium concentrations has been geochemically and mineralogically confirmed. Located within the Brazilian Amazon, *Morro de Seis Lagos*, situated further west of the state of Roraima, in the municipality of São Gabriel da Cachoeira, Amazonas, presents a case of lateritic weathering acting on pyrochlore-bearing carbonatites. Recent research by Bory et al. (2023) demonstrates how tropical weathering leads to niobium release and subsequent fixation in newly formed iron and titanium oxides, processes supported by advanced spectroscopic analyses such as XANES and EXAFS. Although Minastyc and Seis Lagos both occur in tropical lateritic settings, environments known to favour niobium enrichment in weathered profiles, the contrast between them is profound. At Seis Lagos, the niobium is materially confirmed and scientifically analyzed; at Minastyc, it remains a speculative construct, shaped more by investor narratives than by verified geochemical data. In the Colombian context, Bonilla-Pérez et al. (2013*)* studied the Granito de Parguaza[20], a Mesoproterozoic rapakivi-type granite that extends across Vichada and Guainía, part of the western Guiana Shield. Their findings noted geochemical enrichment in incompatible elements, including Nb and REEs, and highlighted petrological similarities with other rare-metal granites. However, the mineralization is dispersed, not concentrated, and no claim was made about economic exploitation or lateritic enrichment.

[20] The *Granito de Parguaza* forms part of the Precambrian basement of the western Guiana Shield and underlies many of the region's tepuis. Its resistance to weathering contributes to the formation of these flat-topped mountains, which rise from lateritic plains. The granite is geochemically enriched in elements like niobium and rare earths, though its mineralization is dispersed.

Further south, a field report by Ingeominas and the Universidad Nacional de Colombia (2011) documents Nb-Ta mineral presence in alluvial deposits within the Indigenous communities of Matraca and Caranacoa, inhabited by Curripaco and Puínave peoples, in the department of Guainía. The report confirms the occurrence of coltan (columbite-tantalite) through mineralogical and granulometric analysis, but clearly emphasizes the non-commercial nature of these findings and warns of the social and environmental risks of speculative narratives. It stresses the vulnerability of Indigenous communities when mineral "potential" is exaggerated in the absence of regulatory safeguards or validated deposits. The resource potential is framed not as a large-scale extractive opportunity, but as a model for low-impact, potentially surface-level artisanal recovery. Even then, the environmental fragility of these soils and their embeddedness in biodiverse ecosystems pose critical risks.

In the Brazilian Amazon, niobium is no longer hiding. It is a solid, quantified resource buried in the depths of Morro dos Seis Lagos. In 2020, Brazilian media[21] revisited the long-contested issue of mineral exploitation in this region, which lies within the officially demarcated Yanomami Indigenous Territory. Seis Lagos is globally recognized as containing one of the richest untapped niobium reserves on the planet, alongside other critical minerals. The geological structure is a rare carbonatite ring complex, and surveys conducted since the 1980s by Brazil's *Companhia de Pesquisas de Recursos Minerais* (CPRM) have confirmed the presence of high-grade niobium, titanium, and rare earth elements. Yet the mine remains unexploited, not for lack of interest or mineral wealth, but due to sustained Indigenous resistance and the legal protections that recognize this territory as sacred and sovereign. The area was officially demarcated as part of *Território Indígena Yanomami* in 1992, following a long and violent period of land invasion, mercury pollution, and violent encounters during the Amazon's gold rush era. Since then, multiple attempts by both public and private entities to access Seis Lagos have failed, due to judicial rulings upholding Indigenous territorial integrity. The 2020 reporting emphasized a renewed push by elements within Brazil's military and mineral policy establishment to reinterpret the constitutional limits on mining in Indigenous lands under the pretext of strategic sovereignty. However, Yanomami leaders, supported by organizations such as *Hutukara Associação Yanomami*, reiterated that Seis Lagos is a sacred site. The region is part of the living body of the

[21] https://news.mongabay.com/2020/07/niobium-mining-in-brazilian-amazon-would-cause-significant-forest-loss-study/

earth, filled with xapiri (spiritual entities) and powerful forces that regulate health, fertility, and climate. As Davi Kopenawa describes in The Falling Sky, these spirits are not metaphors but active agents that sustain the world, through the forest's vitality. "The xapiri are the images of the yarori ancestors who turned into animals in the beginning of time. This is their real name. You call them 'spirits,' but they are images" (Kopenawa, 2013, p.55).

Everything has an image, its own spirit. The xapiri are these images. "Every being of the forest has an utupë image. These are the images the shamans call and bring down. These are the images that become xapiri" (Kopenawa, 2013, p. 60). This cosmological dimension gives Seis Lagos and the entire Amazon its sacred character. Its geography is saturated with meaning, and its minerals are not inert substances but embodiments of relations. Coltan, composed of niobium and tantalum, is one such relational mineral, forming not in isolation but through molecular alliances shaped by deep geological time. Niobium's industrial desirability too lies in its capacity to form alloys: with steel, with tin, with titanium, with copper. It rarely acts alone. Just as in the forest it coexists with other elements in black sands, in metallurgy it lends strength, flexibility, or superconductivity when combined with others. In this world of relations, names and landscapes are not blank slates or inert resources. They are storied, inhabited, and remembered. "The white people tell that a Portuguese man said that he discovered Brazil long ago. They really think that he was the first to see our land… Our words have been present on this land since the beginning of time, as are the mountains where the xapiri live… This land was never empty in the past and it is no more empty today" (Kopenanawa, 2013, p.184). The Yanomami resistance is not merely strategic or political, it is ontological. It expresses an entirely different relationship to matter, time, and existence, that regulates health, fertility, and climate. Extracting minerals from the forest is not only an act of physical disturbance; it is an act of cosmic aggression. The niobium in the earth is thus not just materially rich, it is ontologically full. Its protection resists not just extraction, but the entire grammar of resource conversion that underlies global energy and infrastructure policy. It marks a horizon where resistance becomes cosmopolitical: a refusal to allow niobium to become a commodity, because it is already a being. The speculative thirst for niobium at Minastyc dissolves in the face of Seis Lagos's grounded refusal. Here, niobium is not a number in a table, nor a promise of superconductivity, it is the embodiment of a world that insists on being otherwise. This unsettles the very premise of the energy transition when it depends on mineral intensification. The economic promise of a low-carbon economy is not a

break from extractivism, but another path towards the same cosmological debt, and perhaps a shorter and faster one.

Minastyc and Seis Lagos are both fueled by the speculative fire of this global energetic shift. The surge in demand for minerals used in clean technologies is propelling a new cycle of extraction in the Amazon. While these minerals are meant to support the decarbonization goals of countries in the Global North, their extraction reproduces colonial patterns of environmental degradation and dispossession in the Global South. Minastyc emerges as a case of speculative extractivism: here, niobium has not yet taken geological form, but already animates corporate fantasies, investor decks, and regulatory anticipation. The mineral is desired, evoked, conjured into being, its potential more consequential than its presence. The project exemplifies the paradoxes of green capitalism, where the promise of a cleaner future justifies extractive operations in places where neither the science, the social, nor the ecological conditions are stable. Portrayed as a high-potential rare earth venture, Minastyc remains unsubstantiated by peer-reviewed data or formal geological validation. At the same time, it raises urgent questions about environmental justice, Indigenous sovereignty, and the geopolitics of planetary transition. While its official framing speaks of modest impacts and unconfirmed potential, Indigenous testimony and independent investigations urge caution, transparency, and participation.

While Minastyc speculates on a mineral it does not possess, Seis Lagos contains the mineral but resists its extraction. Between them lies the full arc of niobium's entanglement in planetary politics: from desired absence to endangered presence. But this arc is not smooth nor transparent, it bends through shadows. In the forests between Vichada and the Brazilian border, another form of extractivism unfolds: clandestine, violent, and undocumented. Here, niobium and tantalum are not only speculated or defended, they are trafficked. Extracted illegally by armed groups, moved through informal corridors, and shipped covertly to Asian and European markets, these minerals are folded into the circuitry of global infrastructure without ever passing through formal registers. Official statistics barely graze the surface of this trade. Its geography is one of secrecy; its temporality, one of urgency and disappearance. To speak of niobium only in terms of promise or protection is to overlook the hidden flows that fuel modernity from below. In this layer, niobium is not a figure of the future or a guardian of Indigenous cosmology, it is

contraband, ghostly, and lethal. The mineral that flickers in Vichada and is defended in Amazonas is also being moved in silence through untraceable routes that turn forests into corridors of disappearance. This is the other niobium story, the one lived by environmental activists across Colombia and South America, where killings of land and water defenders remain among the highest in the world. It is a story told not in corporate reports or geochemical surveys, but in threats, displacement, and silencing. In regions like this, where state presence is sporadic and armed actors shape the rules of extraction, speaking about the forest, protecting the river, or questioning the path of a boat loaded with minerals can be fatal.

These materials, unlike the imagined one in Minastyc, or the defended one in Seis Lagos, or any other metal resting quietly beneath a riverbed in the jungle, are soaked in fear. They move not only through economic circuits, but through corridors of violence. The logistics behind technological machines, pure materials, access routes, extraction techniques, experimental labs, or development facilities, have long been rooted in the mass-killings of Indigenous peoples, the deforestation of ancient forests, the drying of rivers, and the heating of the planet. What we call progress is not a sequence but an accumulation. Perhaps it is not an evolution at all, but a complementation. The brutal methods of the colonizers have not disappeared; they have simply been updated, now accompanied by data sets and predictive algorithms that make the violence more efficient, more profitable, more abstract. Extraction today wears the face of innovation, but its ground remains soaked in blood and hydrocarbons.

One niobium

Of course, substance and quality, as well as simple location are the most natural ideas for the human mind. It is the way in which we think of things, and without these ways of thinking we could not get our ideas straight for daily use. The only question is: How concretely are we thinking when we consider nature under these conceptions? (Whitehead, 1926, p.52)

But beyond the debates about one site or another, beyond fluctuating measurements and shifting concentration reports, beyond both the speculative projections of foreign investors and the extractive violence of illegal armed groups, a deeper reality persists. Can we even analyze niobium in the geological shields around the world by breaking it down into zones, coordinates, mining sites, or isolated deposits? There is no single niobium. It's on the move—it's on a dispositional continuum. There is no such a thing as site-specific. The very word conjures up the notion of "simple location" that Whitehead identified as the basic error of modernity. (Massumi, 2011, p.50) In reality, no material is ever fully divorced from its relations, from its environment, from the historical, ecological, and cosmological networks that give it meaning and force. To say that "a bit of matter has simple location means that, in expressing its spatiotemporal relations, it is adequate to state that it is where it is, in a definite finite region of space, and throughout a definite finite duration of time, apart from any essential reference of the relations of that bit of matter to other regions of space and to other durations of time" (Whitehead, 1926, p.58). But niobium refuses such enclosure. Its presence cannot be meaningfully captured without accounting for the field it activates and emerges through: economic pressure, colonial history, geological time, Indigenous cosmology, and global circuitry. In Kopenawa's words: "They call their thought 'science.' But it is a thought that walks without ancestors" (Kopenawa, 2013, p. 374). Whitehead echoes this when he writes, "It looks, therefore, as though memory, as well as induction, would fail to find any justification within nature itself… there is nothing in the present fact which inherently refers either to the past or to the future" (Whitehead, 1926, p. 51). The disjunction between Western extraction logics and relational cosmologies is not merely philosophical, it plays out across maps, policies, and terrains, it dictates who has the right to live, where, and under which conditions.

States, Departments, villages, mountains, rivers. Everything is fractured, the territory is divided not only by geology, but by fantasy, policy, and conflict. Speculation lies everywhere, and what passes for certainty often dissolves upon closer inspection. The only real coherence I've encountered comes not from mining reports or investor briefings, but from Indigenous knowledge systems, environmental defenders, and local community leaders who insist that the forest is one, that the rivers are one, that the territory cannot be segmented without consequence. The mine here, the seizure there, the map that shows something that doesn't exist, the map that is

full of it, it all produces a kind of epistemic disorientation. Meanwhile, extraction and distraction continue, quietly, chaotically, violently, efficiently, like colonialism. What, then, are the distractions at work? One is the tale of the allegorical set of the world's continents, a fantasy where a universal order of colours, textures, shapes, scales, codes, and symbols still governs how the world is narrated by the powers that control mass media, itself powered by minerals extracted from the forest. The story remains the same: progress, development, destiny. These aesthetic and epistemic regimes, once sculpted in porcelain, now embedded in policy and design, continue to tell the same story. That the world is becoming better. That technology will save us. That there is order. We know this; but do we care?

As Falcão (2016, p. 36) notes, numerous researchers, including Pardo-de-Santayana & Macía (2015), Lauriola (2011), Pereira & Diegues (2010), Silveira (2010), Sobrevila (2008), Schwartzman & Zimmerman (2005), and Fearnside (2003), emphasize that Indigenous lands are a crucial limiting factor against deforestation and biodiversity loss in the Amazon. For Indigenous peoples, there is a cosmological relationship with the land that fundamentally sustains environmental services and forest continuity. They do not "break the land," as Falcão writes. The territory is not an extractive environment but a living body with which reciprocal relations are maintained. This challenges dominant environmental governance frameworks. It affirms that true forest protection cannot rely solely on external conservation laws or carbon metrics, it must be rooted in supporting the epistemologies, spiritualities, and ways of life that have safeguarded the Amazon for millennia, now endangered by dominant paradigms of development, infrastructure, and *technological modernization*.

The Bojonawi Natural Reserve

The first night I arrived in Puerto Carreño, I met with one of the Sikuani capitanes[22], teacher at one of the ethno-educational schools[23] in town. It was late, the air was thick with heat, and I was still adjusting to the feeling of being in a place I had imagined for so long. We spoke

[22] In Sikuani communities, the *capitán* is the elected leader who represents the community, mediates conflicts, and coordinates relations with external actors. The role blends traditional authority with colonial administrative structures.
[23] An ethno-educational school is a state-recognized institution in Colombia that incorporates Indigenous languages, cultural practices, and knowledge systems into its curriculum. These schools are designed to support the educational autonomy of Indigenous communities while aligning with national education standards.

about the rivers, about the animals, about the mining rumours. He was cautious, but generous. He said: *"El territorio siente."* The territory feels. That phrase stayed with me. It unsettled the language I had brought with me, language of analysis, of mapping, of fieldwork. It reminded me that the territory is not a backdrop to extraction, but a living, sensing body, one that is under threat, but also resisting in ways that don't always appear in reports or headlines. We talked about minerals, about niobium and its role in emerging technologies. By that time, I had already visited Jefferson Lab in Virginia, a particle physics research centre where advancements in superconductivity are driving the development of improved niobium-based technologies for particle accelerators. I showed him photos of SRF niobium bulk cavities, we talked about how the minerals along the Guiana Shield make possible these machines and this science. That night, as we chatted under the dim yellow light at my hotel in Puerto Carreño, the conversation turned to recent events: news of the army seizing several tons of illegally extracted black sands[24], the growing presence of artisanal mining along the rivers, and the steady flow of minerals trafficked across the border from Venezuela, right on the other side of the impressive Orinoco River. My companion spoke calmly but with a weight behind his words. He knew the routes. He knew who was doing what, and where. He knew that the difference between legal and illegal, permitted and prohibited, was often blurred by power, by distance, by money. He knew about the new mine some Canadians wanted to start not far from where we were, and he knew about the complications around the samples they took, and the permits to be granted. On a table not far from ours sat a group of around six men, tall, white, blonde. They stood out in the dusty, quiet evening. At first, I couldn't place the language they were speaking. It wasn't English, or French, or German. After a moment, it clicked: Russian. I must have shown a flicker of surprise, because the capitán noticed immediately. Without looking over, he said: *"They say they're tourists. Coming to fish."* It was a sentence dense with implication, and with years of repetition. In this place, borders are porous, and stories have layers. The rivers carry more than water, they carry contradictions, rumours, logistics. Later, I would better understand that sometimes, groups of men of different nationalities would come to fish in the river and negotiate black sands. Sitting there, I realized that my research, my interest in niobium, in the Guiana Shield, in particle physics and planetary timescales, was entering a different territory. This was not just about minerals or

[24] In Vichada, the term *arenas negras* ("black sands") is commonly used to describe alluvial sediments rich in heavy minerals such as niobium and tantalum (often in the form of coltan).

machines, or the future of superconducting technologies, or trying to understand what exactly niobium does in a particle accelerator. It was about narratives, about who gets to tell them, and at what cost. In that moment, niobium ceased to be merely a superconducting element or a geological curiosity; it became a node in a broader story, one that cuts across militarized borders, Indigenous territories, extractive fantasies, and clandestine economies that silently fuel the production cycles sustaining global markets. The machinic phylum of tool and weapon felt closer, material, present, and enacted. The Guiana Shield was no longer just a geological formation to be mapped and analyzed, but a contested terrain where mineral, myth, tool, and weapon collapse into one another. What I was witnessing wasn't just a research site, it was the daily choreography of a territory accessible only by river or air, where cell signals vanish, where the state's absence is strategic, and where colonialism remains alive, operational, and well-rehearsed. That night, I slept lulled by the hum of an old AC unit in my small room. The excitement of finally being there kept me awake, but so did the unease of knowing I was in a territory where things can change quickly. At the same time, I wanted to trust the people from the Bojonawi Reserve and focus only on making the most of the two weeks ahead.

I had with me rapé and coca leaves, medicine from my last journey to the Sierra Nevada de Santa Marta[25], where I had also gone in search of niobium. Although I couldn't reach the Indigenous territory I had intended to visit then, the trip was marked by a significant encounter with Teyrungūmū Torres Zalabata, the first Arhuaco physicist, a graduate of the National University of Colombia who visited CERN in 2021 as part of his master's studies. These medicines weren't just remnants of a past trip, they were part of the continuity I was trying to trace. They were what sustained me. Ever since the long COVID episodes began, this medicine had been one of the few ways to push through the fatigue, the disorientation, the sudden drain of energy that would come without warning. It grounded me. It helped me keep going. The next morning, I headed to the port with enough time. I called a mototaxista, one specifically recommended by the people from the reserve. There, I met Rubén, the person who was coming to

[25] The Sierra Nevada de Santa Marta, located in northern Colombia, is the world's highest coastal mountain range and holds immense cultural and ecological significance. While not a major niobium mining region, the area has geological affinities with the Guiana Shield and has been subject to speculative interest in strategic minerals, including niobium. For the Indigenous Arhuaco, Kogi, Wiwa, and Kankuamo peoples, the Sierra is a sacred territory, and mineral extraction is viewed as a threat to the spiritual and ecological balance of the planet.

pick me up and who would be my companion for the next two weeks. At 6:00 a.m., it was already hot and humid. The port was busy, fish being sold alongside manioc[26] and plantain. This is the head of the Amazon: dense forest near the river, surrounded by prairies that dry out in the summer and flood in the rainy season, making the cultivation of fresh fruits and vegetables difficult. The encounter was quick. We said hi, shook hands, loaded my bags and provisions into the boat, supplies Rubén had already gathered in town, and left heading south. It was the first time I had ever been on the Orinoco[27].

The reserve is located south of Puerto Carreño, about 20 minutes away by motorboat. When we arrived, Millis, Rubén's wife, and their two daughters welcomed us. It was the middle of the dry season, so the river level was low, making some of the sites I wanted to visit more accessible. During the rainy season, the prairies flood with the river's current, and the only way to travel inland is by small canoe. For the time I would be staying at the research station, we would be moving around by motorcycle. On the first day, Rubén and I sat down to set a realistic schedule for the fieldwork I intended to carry out. He was quiet and reserved, offering short, cautious answers. After our planning session, we walked around the station so I could get oriented. He explained how to manage water use, which is scarce during the dry season, and briefed me on the limited electricity: power came from solar-charged batteries and was available only between 6 p.m. and 8 p.m., the only window to charge equipment. He also gave me safety guidelines, particularly on how to respond in case of encounters with wild animals. We had lunch, and afterward, I went to my room: a wooden structure raised on stilts, with open doorways and windows without glass panes. My bed was covered by a mosquito net. I lay down to test it out and immediately crashed, exhausted from the previous night, the heat, and the anxiety of the trip.

[26] Manioc, also known as cassava (*Manihot esculenta*), is a starchy tuber native to South America and a staple food across the Amazon basin. It is traditionally processed to remove naturally occurring cyanogenic compounds and is used to prepare various local dishes, including flatbreads, porridges, and fermented beverages.

[27] The Orinoco River is one of South America's major waterways, stretching over 2,100 kilometres. It originates near the Sierra Parima close to the Colombian-Venezuelan border and flows in a giant arc through the Guiana Shield before emptying into the Atlantic Ocean. Over millions of years, its course has shifted dramatically; today it gathers waters from the eastern Andes and the Guiana Highlands, acting as a vital ecological and cultural artery across the Orinoco-Amazon basin.

My first night beside the Orinoco was calm and restful. The forest was loud, its nocturnal sounds mixing with the wind and the low, constant hum of the river. I tested all my batteries, prepared the camera gear and sound recorder for the next morning, and went to bed early. Everyone at the station goes to bed around 8 p.m. Rubén and Millis slept on the boat, afraid that the motor might be stolen during the night. The research station itself is built atop a massive rock that overlooks the Orinoco. That night, I walked to the edge of the rock and sat there for a while. I looked up and watched the sky, it was a warm summer night. A clear atmosphere revealed the Milky Way in full view, stretching like a corridor above me. I thought about niobium, about how scientists dedicate entire careers trying to understand the origin of matter, and about how strange and beautiful it felt to have finally arrived at this place. I like to imagine that the equator grants access to a wider celestial panorama, not a fuller cosmos perhaps, but one that stretches across two hemispheres at once. “We are the centre of the terrestrial layer. The back of this sky that fell in the beginning of time is now the forest where we live and the ground that we walk on. This is why we call the forest *wãro patarima mosi*, the old sky, and the shamans also call it *hutukara*, which is the name of this ancient celestial layer.”*(Kopenawa, 2013, p. 130)*

At Bojonawi, the days began early. We would leave by motorcycle around 4:30 a.m., setting out to visit a list of tepuis I had compiled based on geological information. Each of these flat-topped mountains were located in a different community bordering the reserve, some even within its boundaries. We’d return by 11 a.m., rest during the midday heat, and then head out again around 2 p.m., once the sun had softened. By 5:30, we’d be back, just as the light began to dissolve behind the trees. Supper was served around 7:30 p.m.. By 8 p.m., lights out and sleep.

“If some of these pages are rescued from oblivion, those who live on the banks of the Orinoco or Atabapo may see cities enriched by commerce and fertile fields cultivated by free men on the very spot where during my travels I saw impenetrable jungle and flooded lands.”

Alexandre Von Humboldt

In these regions, artisanal mining exists, it’s called barequeo. Black sands are panned, sorted, sold. It's a gesture of subsistence, of knowledge passed through generations by the Sikuani, Puinave, Curripaco, Piaroa, Tucano, and Yeral, among others. But the moment the minerals are renamed through global media, they begin to attract another kind of gravity. In the

Congo, coltan speculation fueled brutal wars, displacement, and child labour, entangling geology with global supply chains of smartphones and conflict minerals. Here in the Colombian Amazon, the ways to extract are evolving, they depend on the amount of money available for the excavation equipment. In Puerto Carreño, I spoke with someone involved in the commerce of black sands. He explained that most of the material doesn't originate there, it comes from deeper inside the territory. Puerto Carreño functions less as a hub of extraction and more as a point of transit. The real commerce happens further in, within Indigenous lands where the Guiana Shield stretches in all directions. Extraction is mostly manual—pick and shovel work—because excavation equipment is prohibitively expensive. Those who do have machinery are armed groups who can extract in larger volumes, they own the tools to extract, and the weapons to protect them.

Across the border, in Venezuela, rare earth mining is legal and environmental controls are more lax. There, extraction is mechanized, and the prices are better, no need for permits or documentation of mineral titles. "You see Russians, Chinese, and Iranians there," he told me. "They're extracting, buying, exporting. Over there, because there's no regulation, it's more visible. Here, it's more underground." Black sands are ubiquitous along the shield. "There's something everywhere," he said. "Tantalum, niobium, tin, gold, you name it." These minerals are embedded in all Indigenous territories, in different concentrations and combinations. The material is extracted, washed, dried, and packed into 25 kg bags, where all the minerals remain mixed. "The buyers know what they're really after," he added. "They're the ones who separate it. And when you're extracting, you already know who your buyer is." Official export routes pass through Bogotá and exit via the port of Cartagena, but that's only one stream. "A lot leaves through Venezuela," he said. "That's where you go if you want to sell. But what goes out from here, when it's extracted for export, moves legally, at least on paper. Everything else is contraband." The territories are immense. Vichada alone is the size of Hungary; Guainía is nearly as large as Portugal. Both contain many exit points, legal and illegal, and what leaves the forest often does so invisibly, carried in silence through rivers and informal trails. Deeper into Guainía, near the national parks, even more material is extracted, away from oversight. "In Venezuela, they say it's the subversives who control the mines. But honestly, it's safer that way. Without their control, you get robbed, even killed. They protect the territory, not because they're good, but because it's business. Extraction and protection collapse into the same gesture. Where

minerals don't just move through supply chains, but through networks of risk, silence, and coercion. In this story niobium is not imagined, like in Minastyc, or defended, like at Seis Lagos, but it moves quietly, soaked in fear, under the cover of forest canopies and armed protection. A story with no headlines. A story of bags, international buyers, and borders. As the Sikuani Capitan said; tourists come to fish in the river.

The name "niobium" now feels shallow. Like colonial maps that reduced vast, living territories into grids and lines, abstract shapes imposed over ecologies, histories, and relations, the name condenses a dense reality into a symbol of extraction. It dictates concentrations, thresholds, temperatures, velocities, resistances, alloys, formulae, profits, losses. It signals cancer, deforestation, legal and illegal markets. The name becomes a map itself. It erases relation in favour of measure. When niobium becomes Nb41, the drawn word, it is encoded into the periodic table, an ontological apparatus of classification that detaches matter from its geography, from its stories, from its violence. The mineral becomes data, stripped of context, turned into value. This epistemic operation, this flattening, is precisely what Kopenawa critiques when he speaks of naming as an act of relation rather than reference. For him, names are not signs, they are connections. Not labels, but positions within a living world. "My last name, Kopenawa, came to me much later, when I truly became an adult. This time it was a real Yanomami name. Yet it is not a child's name or a nickname that the others gave me. It is a name I acquired alone." (*Kopenawa, 2013*, p. 19) To name, in this cosmology, is to enter into relation. It is not about ownership or control, but about placement, about being situated within a network of meaning and responsibility. Black sands turned into Nb41 travel across laboratories and stock markets, from particle accelerator schematics to clandestine trade networks. It appears in investor decks and disappears from forest soils, all without contradiction. "Only the xapiri spirits were with me at that moment. They were the ones who wanted to name me. They gave me this name, Kopenawa, because of the rage inside me to face the white people." (*Kopenawa, 2013*, p. 19)

Niobium is a piece of sky, and the forest is the back of the fallen sky.

The Tepuis, the Savannah, the River

On the rocks, the heat is intense. The feeling of not being able to endure long under the sun is diminished by awe, curiosity, and fear. With every metre ascended, the landscape shifts in tone, the wind cools, mosquitoes disappear, soundscapes widen with the savannah, and the desire to keep climbing and visit another rock grows. Each rock, whether in the savannah, the jungle, or the river, seems to be a continuation of the one before; one might say they are all connected; that they form a single rocky formation that undulates, going underground and resurging again, like surfing the plains from southern Colombia to Guyana. Is this what they call the Guiana Shield?

I am always on it, whether in the savannah, the jungle, or the river, one always stands atop the shield. On it, people fish, cut wood, mine minerals, survive. In my first week, I visited several hills and encountered numerous species of animals, plants, and rocks. The tairos, the river dolphins, iguanas, guaicacaminos, savannah eagles, palometas, catfish, caimans, giant river otters, and morrocoys have accompanied me during my first days. It's incredible how initial fear transforms into a roadmap; vast, endless distances become familiar paths, where the sun is always the reference point in the open plains. "I am on the shield," I repeat to myself. I made it. Something that seemed so elusive has become real. Neither my health problems, nor the trip's logistics, nor the money to get here could stop me from stepping onto the oldest rocks on the planet. And now what? What will I do? I'm afraid to speak openly about niobium. This Colombia of 2024 has a false sense of security, or maybe I wear that sense like a cloak after living abroad for 18 years. Maybe the insecurity is still there, only my naiveté blinds me to it.

Image 4.2 View from Mount Campana at the Bojonawi Reserve. (Salas, A., 2024).

At the easternmost edge of Colombia's geography, along the great Orinoco River, where the Andes dissolve into savannah, and the ancient Precambrian rock rises as tepuis, a unique horizontal stratification unfolds. Just as mountains host distinct ecosystems at different altitudes, here, across the plains, the shifting geology of exposed rock gives rise to endemic ecosystems that emerge laterally, varying with the mineral composition beneath them. The rocks in the savannah look like sleeping beings, giants that after crossing the Andes decided to lie down and rest in the warm eastern plains. On their slopes are the only trees for miles. Sometimes, inside these geological castles, one finds ancient gardens, gardens atop rocks, between rocks, part of the rocks, carefully planted. Some pictograms are still distinguishable: ancient spirals and animal figures, mixed with anthropomorphic forms and complex symbols alluding to nature, nomadic life, and pilgrimage sites. These sleeping giants might be awake; perhaps they hear us. The rock is alive, full of lizards, inhabited by birds and eagle nests, vultures, tairos, foxes, and rabbits. The stone warms under the sun. Its skin is, let's say, scaly, composed of thousands of small stones. The first time I saw it, I thought of embedded shells, of fossils layered into a long geological blanket: small round stones that from a distance give the impression of a smooth, uniform surface. This skin attracts; it makes you want to touch it, caress it, lie on it, feel its warmth, embrace it, listen to it closely as if it were a giant seashell, a prehistoric one, slowly moving

across the plains, turning infinitely around the planet. Each rock has a different personality, behaves differently, like a herd of animals running through the plains. The surfaces are full of craters. From afar they look like eyes, and up close, each hole represents the possibility of a shrub taking root, a tiny ecosystem existing. Large holes become mini-forests, unique places where endemic species continue adapting and evolving with changes in climate and temperature. The wind blows strong and keeps the mosquitoes away, prevents the temperature from rising too much. Between the stone's smoothness and the wind's caress, one could fall asleep, hoping the sleep becomes millennial, with the possibility of disappearing from thought. The rocks in the jungle are more hidden. Sometimes their crests jut out, rising before plunging back into the green. Their solid walls contain lagoons full of caimans and water dogs, electric eels, guios, and countless endemic fish. Mosquitoes abound. Unlike the rocks in the savannah, the jungle surrounds them, the wind blows slowly, and one becomes easy prey.

Image 4.3 Tepui in the Bojonawi reserve. (Salas, A., 2024).

The organization of the drill holes for sample extraction contrasts with the rocks' curved shapes, their softness and fluidity, the way the rock merges with the jungle, savannah, and river. Entering the new mine site is strange, it carries an industrial planning spirit, yet it's also comical. There are signs for heavy vehicles, tool zones, loading and unloading, extraction, but no workers.

It’s a kind of extraction zone in waiting. Everything is new, clearly marked, like a small Lego model waiting to be used. Two people guard the area, which borders the Orinoco River on one side and a clear, clean creek on the other. Seeing it, I wonder how much longer this little well of life will last. Further ahead, I imagine how the river landscape will change with massive earth movers, with infrastructure for a small port to serve the mine. The wind’s whistle and the river’s slap against Precambrian rock will be replaced by engine noise, music, and human sounds. What will the river dolphins think? Just hearing the river bongos at 7 a.m. makes me think engine noise must be unbearable. This morning I wondered, can they sleep well? Sound travels far in the savannah, you can easily hear the wind’s whistle, monkeys’ howls, and suddenly, far off, the drone of a small plane. Then everything falls into deep silence, then the wind blows hard, bringing echoes of other distant realities. In the plains, sound travels fast, like summer fires.

Image 4.4 Minastyc testing site. Vichada, Colombia. (Salas, A., 2024).

The summer burns are brutal, they stretch across the horizon. I wonder if the whole savannah has always been like this, if climate change is felt here too. If the rains begin in April, how much damage can fires do in four months? “When fire is so powerful, it is no longer friendly. It becomes an unknown and dangerous being who seizes every tree around him to build his house. He even started to ascend the slopes of the Watoriki mountain, not far from our house, right where the evil beings of the forest grow their own sorcery plants” (Kopenawa, 2013, p.137). Scavenger birds feast on the carnage, armadillos, snakes, squirrels, and a whole host of mammals

and lizards make up the menu. The stone will be the fire's limit, it's the only barrier that exists in the savannah.

Image 4.5 Fires in the Savannah next to Mount Carabayo. Vichada, Colombia. (Salas, A., 2024).

Fishermen pull palometas without stopping. Here, next to the Bojonawi rock, no authority controls the number of fish taken. The river belongs to everyone, and the reserve's authorities cannot prohibit fishing. Today, they say the price is good—"eight thousand pesos (around 3 CAD dollars) per kilo," they tell me. Over the past three days, the number of fishermen has multiplied. From 8 a.m. to 6 p.m. they fish non-stop. The river otters appear and take what they can, the dolphins approach and the fishermen insult them, they say they are thieves. I came to fish, too. "Andrés is fishing," they say, and yes, I came to fish images, thoughts, ideas, conclusions, and understandings, to fish for problems, some might say. To research niobium, to ask questions—if anyone knows what that stone is for, if anyone knows what a particle accelerator is, or understands what superconductivity is. They say you see more of that in Venezuela, but the truth is, it's present throughout this territory. You see it in the Chinese, Russian, and Iranian buyers, they say, for whom neither Colombia nor Venezuela nor any Indigenous people exist. For them, only metals at low prices are real. They will produce military equipment, cellphones, computers, cameras, medical equipment. These rocks have witnessed it all: the stories of Indigenous peoples and early humans in the savannahs; the arrival of colonizers; the rubber boom; timber extraction; the invention of the Orinoco as a navigable frontier; the botanical expeditions disguised as

science; the quina tree and its use as a tool for the conquest; the cataloguing of nature; and the strategic invisibility of the state, always present, always absent, folded seamlessly into the logistical machinery of modern capitalism. This logistical absence, or better yet, technological absence, is a fundamental piece of modern technical development. Through technological absence, the rare elements and metals that, like oil once did, will drive the economies, cultures, and societies of the new century, can be extracted. Rare earths are propelling technological revolutions, as oil once did during the industrial age.

Image 4.6 Rock Island in the Orinoco River. (Salas, A., 2024).

Particle physicists say they search for the origin of matter or the nature of matter. They find endless reasons to emphasize the importance of discovering ever-smaller particles. They justify their immeasurable budgets with the mystique of the data they collect, which guarantees the transfer of new particles into the realm of scientific artifacts, expanding the hadron family. Rare earths will allow the expansion of these categories and support the technological and national need to develop new technologies aimed at dominating a technoscientific discourse. The fisherman fishes for palometas in a river of endless organic and inorganic species; the technoscientist fishes for particles in rivers of uncertainty, using devices built to collect data, expensive hooks made to feed the hunger for knowledge, always aiming to answer the ultimate scientific question: how did everything begin?

Image 4.7 Ruben looking at Mount Carabayo, Sikuani territory. (Salas, A., 2024).

The rocks sink into the jungle, emerge in the plains, reach the river's edge, submerge into it, lift their heads out of the water, submerge again, form lakes and lagoons, microclimates, beaches, and gardens. They don't recognize human borders. They serve as platforms for ecosystems where life and evolution continue their race to adapt and keep harnessing oxygen, carbon, and sunlight. They are alive, they breathe, walk, roar, and heat up. They have experienced the highest temperatures the planet has ever seen. I wonder what they make of today's sudden acceleration in heat. In their temporal scale, this must feel like a sharp and abrupt fever. Through their eyes we might see shifts in colour, the spread of fire, green turning quickly to yellow, then to flame, and finally to ash. It must be a stunning spectacle, visually, yet devastating in feeling.

Where are the niobium's cavities? Where is the nature of superconductivity? What allows these experiments to be carried out? The element's unique properties originate from unique places, special sites charged with a vital force born in the very instant of creation. The energy generated in that original moment echoes through deserts, plains, chants, and rivers, in

biodiversity, in the intrinsic capacity of species to adapt, evolve, and survive change. This force, which has travelled through time to the present, is what enables the development of this particle technology. This energy is what allows for the division, cataloguing, and extraction of increasingly small particles to understand the origin of matter. This echo is more than technology or techno-objects. It is the adaptive force of species. It is the grass regrowing after fire. It is the river's power to hold its course for centuries. The echo is possibility. It is the programming of the ecosystem. It is evolution. It is the ability to adapt, to continue living, to be reborn after fires, after floods, after extractive industries carve the land into geometrically perfect scars.

Image 4.8 View of a tepui in Venezuela from the Orinoco River. (Salas, A., 2024).

At the same time that I planned and carried out my travels in search of niobium, in laboratories, in archives, in geological formations, and in contested territories, I watched how the mineral's global story was evolving. New technologies emerged, especially in superconductivity, quantum computing, and energy storage, expanding niobium's industrial relevance. Reports surfaced about new mining projects in Africa, Australia, and Europe. Regulatory frameworks began to adapt, particularly in the U.S., Canada, and the EU, identifying niobium as strategic for national supply chains. What remained constant, however, was the deforestation of the Amazon, the killing of environmental defenders, Colombia being the country with the highest number of murders according to Global Witness, and the speculative acceleration of niobium's market value. The mineral was not just material; it was a promise, a bet, a node in the geopolitical

scramble for “green” futures. A future whose cost was visible in the clearing of forests and the silencing of those who dared to speak for them.

Image 4.9 Pictograms at Mount Carabayo, Sikuani territory. (Salas, A., 2024).

Just as niobium is sculpted into superconducting cavities, in the Orinoco region, stone is engraved to sustain cosmological knowledge. Along the river, monumental petroglyphs carved into exposed granite outcrops act as cosmographic inscriptions: serpents over 40 metres long, geometric figures, and animal forms that map spiritual geographies, mark seasonal rhythms, and anchor ancestral narratives. These are not remnants of a lost past, but active technologies of relation. They do not accelerate particles; they stabilize worlds. The minerals of the Guiana Shield have always been part of technological systems, not only through circuits and alloys, but through ceramics, pigments, engravings, and ritual forms. Niobium, like other elements, does not enter culture only through extraction and transformation into commodities. It already participates in Indigenous epistemologies, in relational mappings of territory, knowledge, and cosmos. This other niobium, already drawn, already named, already known, unsettles the notion that materials become meaningful only when folded into scientific infrastructures or economic circuits. In Guainía, black sands are not only extracted, they are shaped, understood, and storied. These minerals, rich in niobium, tantalum, and other rare elements, are not merely materials for export or speculation. They are also used to make ceramics, to explain the cosmos, to remember the origin of things. Among Curripaco artisans, ceramic practices are not separated from cosmology;

they are a continuation of it. The minerals are ground, mixed with clay, fired with care, and turned into vessels that hold more than form: they hold relation. This is another kind of extraction, one that does not erase, but connects. It is relational, embedded in a world where matter speaks and making is a mode of memory. Here, niobium does not disappear into formulas or alloys, it becomes part of a tactile language, one that sustains ancestral knowledge and ways of life. In this cosmology, the mineral is not a commodity, but a participant: a teacher, a remnant, a future. The forest is not a reserve of resources, but a constellation of stories. And the ceramic object, shaped from black sand and fire, is not a product, it is a cosmogram. It is a way of holding the world together.

"The things that white people work so hard to extract from the depths of the earth, minerals and oil, are not foods. These are evil and dangerous things, saturated with coughs and fevers, which Omama was the only one to know. But long ago he decided to hide them very deep under the forest's floor so they could not make us sick. To protect us, he did not want anyone to be able to touch them. This is why they must be left where he has always kept them buried. The forest is the flesh and skin of our earth, which is the back of the old sky Hutukara that fell in the beginning of time. The metal Omama hid in its soil is its skeleton, which the forest surrounds in humid coolness."

(Kopenawa, 2013, p.283)

Chapter 5

"Each step will be a renewal of how this event, this time, this problem, proposes this mode of inquiry, in this voice, in these materials, this way. At times, in retrospect, the process developed might seem like a method. But repeating it will never bring the process back. For techniques must be reinvented at every turn and thought must always leap."

— Erin Manning, *The Minor Gesture*

Whether at a party speaking to strangers, in a laboratory engaging with a scientist, or inside a gallery conversing with an artist or curator, introducing this research-creation project has always been a challenge. Over the past six years, my thought-feeling around it has shifted profoundly. The conditions that have allowed the artistic forms of my encounter with niobium to unfold have continually transformed, altering the very means through which I can channel what the encounters have been revealing to me. The first time I encountered research-creation was during my master's studies at the *Université du Québec à Montréal* (UQAM), where I collaborated with a group of five Colombian political refugees living in Quebec to do a database film about their exile experiences. That was, in fact, where the niobium story began for me. As I witnessed the rising popularity of interactivity, video mapping, and electronic arts in the mid-2010s, not only among certain artists but also among a broader public increasingly immersed in digital life, I began to ask myself about the material processes that made these digital experiences possible. After finishing my studies at UQAM I decided to move to Berlin, Germany, following the advice of my ex-roommate and very good friend Janna. I lived there for two years, a time during which I took many different jobs, including working as a server for a catering company. I would regularly work at the Berlin Congress Center, where I attended different conferences and events while serving wine and snacks. Ranging from launchings of new drugs by pharmaceutical companies, political conventions, and engineering meetings, one of these events was named "Applications of The Internet of Things (IoT)". For a few days I listened to a few presentations and read many brochures that transported me to my master's studies final year and brought back the question about the materiality of this data world. Listening to the new opportunities that IoT offered, my concerns about the practice of digital arts and the materiality of the digital were amplified, leading me to encounter niobium (Nb), the superconductor metal that is at the heart of this research-creation thesis.

This is one more story of the origin of Nb; it is my story, one about how this element became into my life, changing its direction, reshaping it, and offering me new ways to understand the world I move through. Human histories are modulated by materials like niobium, and these in turn are modulated by human stories. Beyond the materiality of the biophysical world within processes of artistic and scientific knowledge creation, there are both human and more-than-human narratives that participate actively in the construction of the world. These stories take many forms: they appear as pictograms and petroglyphs on Precambrian rocks, rich with minerals like niobium in certain geological shields across the planet, or as meticulously sculpted SRF cavities designed to accelerate particles close to the speed of light. As an active participant in the production of scientific knowledge, cultural imaginaries of the future, environmental policy, global geopolitical dynamics, and artistic creation, niobium is deeply interwoven with the ways humans understand and shape the universe. It enables new forms of knowledge, technology, and ways to inhabit the planet to emerge. In this ongoing process of worldmaking, each story of niobium unfolds a different universe of material, conceptual, and affective, relations.

I have to say that I have been able to follow the path that niobium has traced for me, in part because of my encounter with research-creation. When I first heard the term, I thought to myself, “Wait—but isn’t that what art-making is about anyway?” But I had a very long way to go. Over time, I began to understand it more deeply, to trust it. Research-creation became a space where I could enjoy theory and art practice equally, a space of unfolding rather than constraint. Gradually, this approach transformed the possibilities of my work, bringing new challenges as well. It offered an active framework in which I was no longer afraid to experiment, to dwell in uncertainty, or to let materials and ideas guide me. As Erin Manning writes, research-creation “generates new forms of experience; it tremulously stages an encounter for disparate practices, giving them a conduit for collective expression; it hesitantly acknowledges that normative modes of inquiry and containment often are incapable of assessing its value” (Manning, 2016, p. 27). I had this in mind, at least in theory, when I began what I sometimes call the niobium adventure. But as I mentioned in earlier chapters, the work only truly activated until I allowed myself to let go of familiar paths of making art. It was only when I stopped trying to produce artworks through

known methods, and instead opened myself, first unconsciously and then with growing awareness, to unexpected forms of creation and encounter, that the project began to take shape.

Activation happened at many levels. It occurred in moments of trespassing, crossing boundaries, both physical and institutional, with a strange feeling of having gained unique access, and the ethical weight that came with it. I could see what others perhaps could not. And I would ask myself: what am I doing with this? It happened when I found myself in distant environments, among people living in territories shaped by extraction, witnessing their generosity, the trust they placed in me, and their openness despite everything. It happened in conversations with scientists, where I could feel their passion and commitment. I still remember Philipp Kolb at TRIUMF— Canada's particle accelerator— telling me: "We're not just here to do science. I mean, yes, we are. That is our main focus. But outreach, and explaining our work to the community, and why it matters, is a fundamental part too." It activated when I physically touched niobium. When I watched films that weren't online, that existed only in archives and vaults, flickering in the dark as forgotten fragments of history. It activated when I explained the project and found resonance with people who, like the team at the Smithsonian Cooper Hewitt, are also working to rethink how knowledge is made and preserved, how stories are told, and how they might help us to think about the future. It activated again, during one of the final stages of my fieldwork, an arts residency at the Banff Centre for Arts and Creativity, when other artists began to connect with niobium. In that space, the aesthetics of my work, still loosely threaded through an emerging theoretical frame, helped amplify the affective field that niobium seemed to generate. All these moments allowed the material to speak and to guide the process. They were not isolated events, but encounters, vital, affective, generative. And although I did not recognize them as such at first, they gradually revealed themselves as a methodology in their own right.

Image 5.1 Cyclotron Control Room. TRIUMF. (Salas, A., 2024).

As Erin Manning writes, drawing from William James, “To reorient toward the radically empirical is to profoundly challenge the knower-known relation as it is customarily defined” (Manning, 2016, p. 30). This reorientation has been central to my process. The encounters I have described, whether with niobium itself, with archives, with scientists, artists, or communities, did not simply provide “data” or “content” for interpretation. They co-composed the work. They unsettled the conventional roles of researcher, artist, material, and subject. They blurred the lines between observation and participation, between knowing and being affected. What gradually emerged was a mode of working where the process was not about translating the world into representation, but allowing the world to insist in and through the work. This is where research-creation offered more than a method; it became a space of relation, a speculative practice, a field where thought and feeling could move together. A space where the material, not as passive matter, but as agentic and affective, could lead. Manning reads Whitehead’s The Function of Reason as a call for what she names a speculative pragmatism—speculative in the sense that the process remains open to the more-than, and pragmatic in that it is entirely invested in its “something doing” (Manning, 2016, p. 33). This dual orientation resonates deeply with the method that gradually revealed itself to me: a speculative ethnography attuned to the expressive force of materials, to the shaping of experience, and to the ongoing construction of the world. In this approach, niobium is not merely a case study or metaphor, but a participant, an expressive

mattering. The speculative opens a space for the unforeseen, the unmeasurable, the not-yet, the more-than, while the pragmatic insists on situated, embodied action, on the bodily encounter. This is not abstraction for its own sake. It is worlding with the materials and experiences at hand. The speculative ethnography I propose is, in this way, not a study about niobium, but a becoming with niobium, in acts of making, listening, responding, and moving.

In how many ways is it possible to encounter niobium? I have followed this element through minerals, archives, particle accelerators, ceramics, and cosmologies. And I am convinced that there are infinite possible ways to encounter this single element, each one a valid and unique aperture into the history of everything, our place within it, and the urgent challenges of imagining and materializing other worlds. In 1872, from his cell at the Fort du Taureu, Louis-Auguste Blanqui wrote in his book *L'Éternité par les astres*: "In addition to our whole life, to our birth and death, which we experience on a number of earths, we also live ten thousand different versions of it on other earths." (Blanqui, 2013, p. 125) Niobium, in this sense, becomes a portal: not just a strategic metal or an industrial component, but a variable in a universe of repetition and divergence. Each of its appearances, whether in a superconducting cavity or a pictogram carved into a Precambrian rock, whether at the Smithsonian or at a mine in Brazil, offers a way to think time, relation, and matter.

"The Universe as a whole is composed of Stellar Systems. In order to create them, nature has only one hundred simple bodies at its disposal. In despite of the prodigious wealth that she is able to draw from these resources and of the incalculable number of combinations that make its fecundity possible, the result is surely a number as finite as the elements themselves, and in order to fill the expanses, nature must repeat every one of her original combinations or types."

—Louis-Auguste Blanqui*, Eternity by the Stars*

As I read Blanqui, I cannot help but think of the infinite possibilities of encountering niobium. Not only in its physical manifestations, in the lab, the archive, the mine, but in the fleeting, fragile architectures of relation: the interviews that happened, the emails that were never answered, the logistical interests that opened and then disappeared. The hesitations, the broken channels, the late replies, the moments when I didn't know how to explain what I was doing. All of these, too, are encounters. Each one a version of a trajectory, one of the myriads of possible

worlds that niobium traces in its passage through mine. These thoughts come back not as regrets, but as forms, materialized in this very text, in a film that cuts across scales, domains, architectures, and geographies, and in a series of ceramic pieces glazed with experimental niobium mixtures. Each work is a crystallization of one possible thread, one bifurcation in the field of infinite encounters. Each one a speculative answer to the question: What does it mean to follow a material across universes? To encounter niobium in infinite ways, is only one way to encounter a relation with everything. In this sense, niobium as semblance, becomes what Massumi, drawing from Benjamin, calls a "little absolute": dispositionally expressing 'an infinitude of alternative potentialities, not a totality, but a singular expression of infinite potential. Each encounter becomes a portal into a relational world, irreducible yet open-ended, where the material is not a fixed object but a becoming, a speculative vector within a constellation of affect, memory, and worldmaking.

A contradiction seems to surface here. If everything in the universe is made from the same finite set of materials, and if these arrangements repeat across infinite time, then what is left to discover? The process becomes disturbingly predictable, its mystery flattened by recurrence. When I dwell on this, I return to Blanqui's cosmological treatise. I begin to hear Benjamin's voice echo through it. A suspicion begins to take form: that this notion of eternal return is not merely a cosmological fantasy, it is a historical condition. As Benjamin wrote, "hell is not what we suffer, but what we repeat." The repetition of worlds, of lives, of failures, of extractions, this too is part of the apparatus. Blanqui's vision reveals itself not only as a cosmology, but as a critique of capitalism disguised as astronomy. Massumi's notion of the relation of non-relation may help clarify what is at stake. To encounter niobium in infinite ways is to enter into singular connections, each irreducible, each becoming. This is not repetition. It is the pulse of difference. A universe composed of identical worlds, endlessly repeating the same arrangements from the same table of elements, is not infinite. It is closed. It is control. A world of non-relation, by contrast, is the condition for emergence, for unanticipated connection, for an infinite field of becoming. Perhaps this is where the suspicion takes root: that the repetition Blanqui envisions from his cell is not a vision of cosmic law, but of political order.

Image 5.2 SRF Niobium Cavity at TRIUMF. (Salas, A., 2024).

Niobium as SRF cavities

Although one of my earliest connections with niobium was its role in particle accelerators, encountering its form as a superconducting radio-frequency (SRF) cavity was one of the last journeys I undertook as part of my fieldwork. The first time I stood close to an actual niobium cavity was at Jefferson Lab, in Newport News, Virginia. I attended the 10th International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity, a gathering of the world's leading scientists dedicated to advancing superconducting technologies for particle acceleration. For four days, I immersed myself in presentations and technical discussions about surface treatments, deposition techniques, performance optimization, and theoretical limits. Thin films, developed specifically for SRF cavities, were at the centre of attention, and the standard for these investigations was niobium: in its pure bulk form, as well as in alloys and layered configurations. One of the highlights of the workshop was a guided tour through the cavity fabrication facilities. I remember the sensation of finally being face to face with bulk niobium cavities, freshly made, gleaming, and still in their raw state of preparation. I was deeply excited. But mine was a quiet excitement, inward and contained, as I stood among physicists and engineers for whom this encounter was routine, everyday. For three full days, I listened attentively, took pages of notes, and conducted a handful of interviews. The experience

was not just informative, it was affective. I was not there as a scientist, nor as an evaluator, but as someone moved by the speculative potential of this metal. I was tracing a line between matter and imagination, surface treatment and worldmaking.

From the very first day, I had to explain my presence there. I had prepared a pitch about my research, rehearsed it in my mind several times, and believed I had everything under control. I introduced myself as a PhD student working at the intersection of philosophy and artistic practice, with a deep fascination for the materials that enable technologies like particle accelerators. I explained that I was interested in how humans relate to these materials in different settings: in the lab, in the mine, in the machine. But things were not so simple. Explaining my presence there, to scientists accustomed to precise parameters and measurable outcomes, was not easy. I was prepared for this discomfort. I knew I might feel out of place, and I told myself that the only thing I needed to do was to focus on my research, to remain attentive, and to observe what emerged. Still, a few connections began to form, tentative at first, then slowly becoming more grounded as the days passed. I reminded myself that I had made it here, to one of the world's top laboratories where niobium is studied and shaped. That, like in other moments of trespassing into forbidden or restricted sites, I had reached a threshold. My task was to stay present, to make the most of this encounter, and to allow the material and the people around it to show me something I couldn't yet name. The scientific community around niobium is tightly connected and deeply collaborative. Many of its members have dedicated their entire careers to understanding this material more precisely, pushing the limits of its performance and exploring its potential across contexts. Niobium remains indispensable not only to the ongoing development of particle accelerators but also for magnetic resonance imaging (MRI) machines, superconducting magnets used in medical diagnostics and research, energy-efficient transportation systems including high-speed rail, advanced aerospace components, and, more recently, the development of quantum computing and artificial intelligence hardware. I learned a great deal about niobium during my time at Jefferson Lab, about thin films, about the material's physical limits, and about the complexity of working at this level of material science. I also learned how difficult it would be to connect on a deeper level with scientists working within this highly specialized domain of physics. While there was generosity and openness, I could feel the gap between my research-creation approach and the expectations of that institutional context.

Throughout this journey, I have been fortunate to work with Dr. Erin Manning, Dr. Brian Massumi, and Dr. Juan Sánchez, whose presence and mentorship have been invaluable. Their support, especially during moments of personal difficulty and health challenges, has been a source of inspiration and motivation. They welcomed the speculative directions I brought to this study, and continually encouraged me to trust in the path that was unfolding, even when it felt uncertain. In Virginia, I hoped to complete my PhD committee with a material physicist, ideally someone working directly with niobium. Although I made a few promising connections during the workshop, those relationships never fully developed. After leaving Jefferson Lab, the lines of communication that I had carefully tried to establish slowly faded. I wasn't able to follow up the research in the way I had hoped. Still, the experience was crucial. The interviews, the technical presentations, the moments of informal exchange, they all fed the development of this research. They helped me understand niobium not just as a speculative force, but as a precise, contested, and materially bounded element. These encounters shaped how I came to write about it, not as an ideal object, but as a field of tension between aspiration, application, and affect.

At Jefferson Lab, there's a consensus both quiet and persistent: niobium will not work forever. "Eventually we will stop using bulk niobium cavities," one physicist said. Niobium's use in superconducting cavities is effective, but unsustainable at the scale of future megaprojects. The field is approaching both physical and economic thresholds. Still, the conversation is not about abandoning niobium immediately. "Nb still has a future in the next 10 to 15 years," I was told. "We're trying to look beyond pure bulk Nb cavities, but machines are too expensive to risk changing materials just yet." Niobium is suspended at a temporal edge, its use extended by caution, inertia, and infrastructure. But something is certain: scientists are reaching the material's theoretical limit. Larger machines like the FCC (Future Circular Collider) make the urgency more apparent. "FCC will be 100 kilometres," one researcher noted. "The LHC (Large Hadron Collider) is 27 km and already needs around 35,000 Nb cavities. That's a gigantic machine." International collaboration becomes the only viable model for such undertakings. Speculative successors are already being studied: laser-plasma acceleration, Nb thin films, multilayer composites. But readiness remains elusive. Why niobium? The answers are practical. "We used copper before," one physicist explained, "but it would melt under accelerating conditions. Nb is malleable and resistant. The only other option was lead, but it's too soft, too toxic." In this

telling, niobium is less a discovery than a default. It was simply what didn't fail. Still, using it effectively took decades. "It's not just the material, it's how you prepare it. How you treat the surface. That's the real science here."

A German scientist working at DESY (Deutsches Elektronen-Synchrotron), the research centre in Hamburg that built the largest superconducting linear accelerator to date, noted that every step of cavity production was standardized: "One recipe. One protocol. Every sheet was scanned. Every cavity tested." In total, 832 cavities were built using that single production model. The journey of a niobium cavity is planetary. "You can buy niobium from Brazil, Japan, Austria, China, and Germany. For DESY, only three made the cut: China, Japan, and Austria. They produced ingots; we made sheets. Every sheet was scanned. Then sent to manufacturers. Then cavities returned for testing." It's a choreography of transnational precision, where every stage is calibrated, repeated, tracked. After the cavities were formed, they were sent back to Germany to be tested, then assembled in France, and then returned to Hamburg for installation. Each step reveals a different geography, a different logic of trust and expertise. The accelerator is not a single object, it's a moving infrastructure, a loop of transformations. Yet niobium's superconducting behaviour isn't linear. "Higher purity improves performance, yes, but slight impurities help too." One researcher compared it to cooking: "Like meat on a barbecue. No salt, it still cooks. But a little pepper enhances everything." The material needs to be fine-tuned, not purified into abstraction.

The scale is staggering. "There are around 25,000 accelerators worldwide," I was told. "Only 100 or 200 of them are used in scientific research. The rest are used in medical or industrial applications. Most use 70-year-old technology." And still, energy remains the problem. "Accelerating particles heats up the material. You want less heat, fewer losses, what we call a higher quality factor. That's where Nb helps." Yet each improvement has a cost. "You also need the helium cooling system. The cost of construction is only one part. The cost of operation matters just as much." Some machines recycle energy. Others are moving toward environmental optimization. "We do our best to build accelerators that are energy-conscious." But the more fundamental the experiment, the colder, faster, and more demanding the infrastructure becomes. Despite the complexity of the supply chain, there's a distance from origin. "Visiting a mine?"

someone repeated. “Could be interesting. Could be not. I don’t know that it would change my work.” The task, as they see it, is not to ask where niobium comes from, but how to make it work. “We’re materials scientists,” one said. “Not superconductivity scientists. Our job is to guarantee the standard.” Even niobium’s presence in their field is relatively minor. “Superconductivity is a small part of niobium’s use. Most of it goes to high-temperature alloys. Or horses. You know those nosebands? Horses are sensitive. And horses are money.” There’s a certain clarity in this instrumental view, a resistance to metaphors. Not to mention the real estate operations needed for a 100 km facility, across different countries. Nb is not special, it works, it does not matter where it comes from, as long as it can become standardized, and impossible to differentiate its origins, it is the right tool.

The Q-Slope Problem

One of the most resonant conversations during this phase of the research was with Antonio Bianchi, who at the time was working at CERN and investigating the so-called Q-slope problem, a progressive degradation of cavity performance as the accelerating field increases, a phenomenon especially present in niobium thin film cavities. He described it this way: “I have analyzed experimental data from different cavities with varying shapes, frequencies, cooling systems, and so on… It seems that there is a common pattern. The performance degradation can be described by the same formula. This is something that wasn’t known. But I believe there is something more, because recent research is mainly focused on avoiding defects and irregularities in the crystalline lattice of niobium films. However, it seems there is something more profound, essentially intrinsic to niobium itself when it is superconducting.” His hypothesis, that the cause of performance degradation might not lie in surface defects or lattice irregularities, but in something intrinsic to superconducting niobium itself, felt like an opening. It revealed a moment where high-level physics met a kind of epistemic hesitation, a speculative pause. The Q-slope was not yet fully explainable, even under conditions optimized by decades of research. The material, in a sense, pushed back. Bianchi also shared his surprise at seeing a philosopher and artist at a superconductivity conference. He admitted that many of his colleagues were equally surprised. But he later reflected that this discomfort had made him thoughtful, that perhaps the

presence of art and philosophy in such a setting pointed to something lacking in how scientific knowledge is typically framed or communicated. It was a quiet but meaningful affirmation of the need for more porous disciplinary boundaries. This encounter reinforced a feeling that had been growing throughout my fieldwork: that moments of methodological dissonance are often the most productive. The Q-slope, as both a material behaviour and a conceptual metaphor, invited me to reflect on how materials like niobium refuse full mastery. What if the resistance we encounter is not a problem to be solved, but a signal of the material's expressive threshold, a zone where matter begins to speak back, not in language, but in performance?

The limits of the materials we use to build machines and develop new technologies, based on the novel properties we extract from Earth's elements, define where we can go, how we can go there, and to what extent. These materials, by revealing themselves, by wearing down, by failing, keep western science in motion, always in pursuit of what it considers fundamental: the origin of everything, the nature of matter itself. The limits drawn by materials are also the limits of what we call progress. Each time a limit is reached a new idea is born, ideas that not only often reposition humanity within what we name the universe, but that also catalyze new products to be developed, new consumer needs to be manufactured, and new avenues for profit to emerge. This is the engine of capitalist futurity: an endless cycle of breakdown, innovation, and commodification. The limits of materials, of bodies, of environments, lead the history of the colonial human. These limits are the very strata upon which we continue to pile the sediment of progress, one layer over another, always reaching, never arriving. When niobium reaches its limit in superconductivity, when it begins to change its behaviour, it does so not due to impurities in its composition, but because of its own nature. Niobium's limitations are the same ones we encounter everywhere on Earth. Its degradation is not a defect, but a material response to the relentless push to discover how far we can go, technically, epistemologically, ontologically. This dynamic, of extraction, experimentation, exhaustion, reflects a deeper cosmological structure. As Walter Benjamin argued in his reading of Blanqui[28], even the stars can become mirrors for the

[28] Benjamin writes about Blanqui: Blanqui is the most remarkable representative of this class. No one else in the nineteenth century had a revolutionary authority comparable to his. … In fact, the cosmic vision of the world which Blanqui lays out, taking his data from the mechanistic natural science of bourgeois society, is an infernal vision. At the same time, it is a complement of the society to which Blanqui, in his old age, was forced to concede victory." (Letter of January 6, 1938, to Horkheimer). [D5a,6]

social order. Blanqui's vision of an infinite universe filled with endlessly repeating worlds, each reproducing the same failures, inventions, exhaustions, and revolutions, worlds made infinite times with the same elements to be found everywhere in the universe, is not a neutral cosmology but a phantasmagoria, a projection of capitalist modernity's own image of eternal return. For Benjamin, this was not progress but an infernal vision, a cosmos without rupture, without transformation, in which history is condemned to repetition.

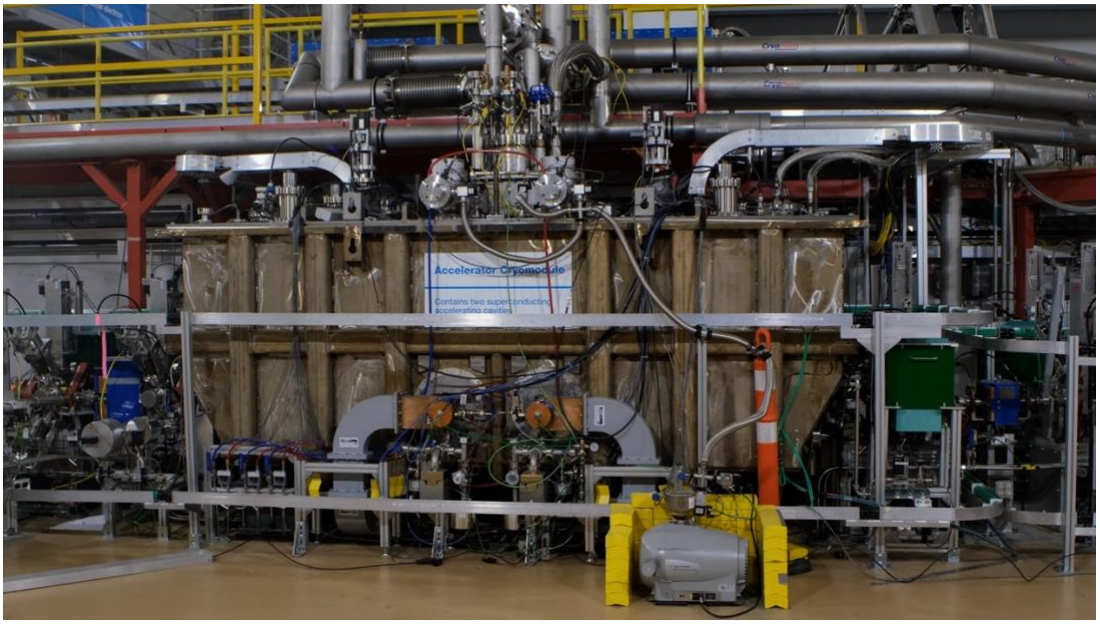


Image 5.3 TRIUMF. (Salas, A., 2024).

Niobium's material threshold, its failure to sustain superconductivity beyond a certain point, is not only a technical limit but also a philosophical one. It stages, in the most literal sense, the tension between what we can do and what we desire to do. Benjamin reads *L'Éternité par les astres* not as a scientific cosmology, but as the final phantasmagoria of the 19th century. Phantasmagoria, for Benjamin, refers to the illusionary display of commodities and images that mask the material and social relations behind them, the seductive illusion masking the logistics beneath capitalist progress, that exists in a homogenous empty time. Blanqui writes:

> That which I am writing at this moment, in a dungeon of the Fort du Taureau, I have written and shall write again forever, on a table, with a quill, under clothes and in entirely similar circumstances. And so it is for all of us. … What we have is ever-old newness and ever-new oldness. … The number of our body-doubles is infinite

> in time and in space. In all honesty, one could not demand more. These body-doubles are in flesh and bones, even in trousers and vest, in crinoline and chignon. They are not ghosts, they are a piece of eternity actualized.
>
> Yet, there is one shortcoming: there is no progress Alas! no, these are vulgar reissues, repetitions. So too are the copies of past worlds, so too are those of future worlds. Only the chapter of bifurcations remains open to hope. … There is neither revelation here, nor prophet, but a simple deduction drawn from spectral analysis and the cosmogony of Laplace. These two discoveries make us eternal[29]. …. On billions of earths, the future will witness the very same ignorance, the very same foolishness, and the very same cruelties of our old ages! … What we call progress is locked up on each earth and disappears with it. Always and everywhere, on the terrestrial camp, the same drama, the same set, on the same narrow stage, a noisy humanity, infatuated by its own greatness, thinking itself to be the universe and inhabiting its prison like an immensity, only to drown soon along with the globe that has borne the burden of its pride with the deepest scorn. The same monotony, the same immobility in the foreign stars. The universe repeats itself endlessly and struts on its legs. Unfazed, eternity plays the same performance in the infinite. (Blanqui, 2013, p. 146-147)

Under the spell of phantasmagoria, progress appears as glittering novelty, while in reality it reproduces the same structures of domination. Blanqui's cosmology, written during his final imprisonment, where he would die the following year, is for Benjamin a tragic document. Blanqui, once the uncompromising revolutionary of the barricades, here imagines a universe composed of finite elements endlessly recombined across infinite worlds, not to liberate history, but to doom it to eternal recurrence. Benjamin sees this not as science fiction, but as a metaphysical allegory of capitalism: a system that, having reduced matter to discrete and pure components, endlessly recomposes them into new products, people, and experiences. But because these compositions are drawn from a closed, finite table of elements, of resources, of forms, of

[29] In this passage, Blanqui emphasizes that his claim of eternal repetition is not a mystical prophecy but a conclusion based on scientific reasoning. Drawing on spectral analysis, which reveals that stars and planets are composed of the same elements, and Laplace's nebular hypothesis, which theorizes that the solar system formed from a rotating cloud of gas, Blanqui infers that the universe, being infinite and materially uniform, must produce identical worlds and events again and again. Thus, *"These two discoveries make us eternal"* encapsulates his radical thesis: eternal return as a consequence of material determinism, not divine revelation. (*Eternity by the Stars*, 2013, p. 148)

desires, they are condemned to repeat. Infinite here is a mirage; what is infinite is the repetition of the flowsheet. Infinite innovation without transformation is hell, novelty without change, creation without rupture. In this way, niobium's material threshold, its eventual failure in superconducting regimes, speaks not only to the elemental reality of physical constraints, but also to the symbolic exhaustion that creates the environment for control in the form of endless repetition. The breakdown of niobium at its limit reflects a broader exhaustion: not of possibility, but of meaning within a system that endlessly repackages the same under the name of the new; control. The limit of the material marks the end. It marks the beginning. It marks the repetition. It fails, so we begin again, chasing new alloys, new compounds, new thresholds. Each iteration is hailed as innovation, yet always unfolds within the same structural loop: failure followed by discovery, discovery followed by commodification, commodification followed by failure once more. In this cycle, the material does not simply wear out; it enacts the very logic of capitalist temporality, where history becomes circular and progress becomes repetition. As long as we remain within the finite table of extractable elements, following the flowsheet, bound to the promise of novelty through recombination and purity, we are not building futures, we are orbiting them. "Blaqui's cosmic speculation conveys this lesson: "that humanity will be prey to a mythic anguish so long as phantasmagoria occupies a place in it." (Benjamin, 2002, p. 15) The commodity-producing society "represents itself and thinks to understand itself whenever it abstracts from the fact that it produces precisely commodities." This self-image, which it calls culture, becomes a phantasmagoria, a magical projection in which, "as Wiesengrund defines it, the object becomes a magical object, insofar as the labor stored up in it comes to seem supernatural and sacred at the very moment when it can no longer be recognized as labor" (Benjamin, 2002, p. 669).

In this way, when understanding the processes through which Nb cavities perform, the question of material limits, how to eliminate impurities, avoid defects, and push performance, becomes central to the discipline of material physics. To think about the limits of the materials that allow us a deeper understanding of our place in the universe could help us not only to build better laboratories or develop more advanced AI technologies, but also to recognize the finite conditions of the planet itself. It is through the limitations we encounter in materials that we construct the world. And perhaps, by acknowledging these limitations, we might learn to design different futures, not ones aimed at preserving systems of control rooted in repetition and

overconsumption, but futures where material limits are not failures or breakdowns, but openings. Limits become invitations to reorient: not toward competition and extraction, but toward mutual aid, care, and the generation of other knowledges. In Davi Kopenawa's view, the challenge is not anti-knowledge, but a call to resist knowledge that forgets its grounding, or what Whitehead calls the "fallacy of misplaced concreteness": mistaking abstractions for the real. For Whitehead, reality is not made of static things, but of events and relations; every actual occasion is shaped by prehensions, relations that carry the past into the present. If thought does not carry its past, if it silences the voices that precede it, it cannot see the world. In this view, knowledge is not only epistemic, it is cosmopolitical. Thought without ancestry, without echo, without breath, becomes an extractive force. It counts trees, maps rivers, weighs ore, but it does not speak with them. It does not carry memory; it stores data. "They think their merchandise makes them strong. But it only makes them forget" (Kopenawa, 2011, p. 334). Forget not only the forest, but the capacity to listen to it, to be within it, to recognize one in it, to be with it, to be it.

Niobium at TRIUMF

TRIUMF, Canada's national particle accelerator centre, plays an important role in global high-energy physics research, including collaborations on the Large Hadron Collider (LHC) at CERN. As a hub of scientific innovation, TRIUMF shows how niobium is central to advancing particle physics, particularly through its research in superconducting technologies for radio frequency (SRF) cavities. My ethnographic research at TRIUMF included interviews with materials physicists who work with niobium daily, studying its properties to push the boundaries of superconductivity. I conducted two field visits to the facility and various Zoom calls with the scientists prior to my visits, which provided valuable insights into their work. As usual I requested authorization to capture video and soundscape recordings during my time there, and once again I was lucky I could do so.

My host there was Philipp Kolb, an SRF researcher scientist, with extensive experience working on superconductive niobium cavities. I had the opportunity to sit and talk with him about his work and his experiences with SRF cavities. I spent two full days at their facility in Vancouver, next to the campus of the University of British Columbia. For Kolb, as for all the

scientists I had the chance to talk to at Jefferson Lab, niobium is a tool. And yet, even in this utilitarian framing, flashes of wonder and metaphor persist, revealing the subterranean entanglements between scientific practice, material agency, and social imagination. He emphasized superconductivity as the driving principle behind TRIUMF's use of niobium. Unlike ordinary conductors such as copper, superconductors allow electrical current to flow with virtually no resistance, though this zero-loss condition is only truly achievable in direct current (DC). Still, niobium allows for a "factor of a thousand" improvement in energy efficiency compared to normal-conducting RF systems. This extraordinary gain is what enables modern accelerators to remain compact and economically viable. Without niobium, Kolb reflects, the scientific advances of the last decades would have required "a lot more effort and a lot more investment in real estate." In other words, niobium mediates not only energy, but space, time, and the very feasibility of large-scale experimentation. The SRF cavity is described by Kolb as a carefully tuned electromagnetic chamber, a kind of high-tech resonator that transfers energy from electromagnetic waves to charged particles. "A cavity is essentially a container for electromagnetic energy… with a specific geometry so that the transfer of energy into the particle is efficient."

Image 5.4 TRIUMF. (Salas, A., 2024).

One of the first metaphors I used to better understand what a particle accelerator is was to think of it as a giant cannon. Of course, the reality is far more complex, but the image helped: I pictured the niobium cavities as the barrel through which scientists would fire the particles they were studying, either to make them collide (as in circular accelerators like the LHC) or to strike a fixed target (as in linear accelerators). When I shared this metaphor with Kolb, he nodded and expanded on it, describing the setup as "a cannon firing subatomic bullets at fixed targets." It's a metaphor that, while crude, reveals something essential about the accelerator's structure: the containment of force, the engineering of directional energy, the transformation of a material vessel into an interface between motion and knowledge. This image, half metaphor, half diagram, invites a different kind of reflection. What kind of machine is this? What kind of world does it produce? In A Thousand Plateaus, Deleuze and Guattari describe the distinction between tools and weapons, and how materials enter into a machinic phylum, a lineage of transformation, invention, and affective force. Niobium, in this context, is not only a technical solution but a passage through which different regimes of force, knowledge, and imagination converge. A reality determined in itself by the means of measurement, where the weapon has become a scientific tool, or maybe the tool a weapon? "Weapons and tools are subject to the same laws, which define, precisely, their common sphere" (Deleuze, Guattari, 1987, p. 397). As part of the assemblage [nation/market/techno-laboratory], tool and weapon give us a sense of identity, a reason to feel different and the means to own and transform what can't be owned. Better tools and better weapons come from better economies, from the Global North, from better countries with better industries. They are complemented and find their reason to exist in the process of understanding and quantifying a nation's natural resources. They construct and keep moving nations, labs, wars, and economies.

If you throw a ball with your hand, you use mechanical energy from your arm to transfer that into the ball. In a particle accelerator scientists use electromagnetic waves to impulse whatever particles they work with, and that's where the RF cavities come into play. They are containers for the electromagnetic energy, with specific properties and geometry, so that the transfer of the energy into the particle is as efficient as possible. At TRIUMF they do linear collisions, meaning that their experiments aim to hit specific fixed targets. In the words of Kolb: "We have the source, where the particle beam is, that's often called the gun. If you want to go

with the canon analogy, it is one very, very precise, very delicate, with lots of knobs and settings to adjust everything, so you can guide your perfect beam wherever you want it." But as opposed to a gun, the barrel is the part that accelerates the beam. Niobium has the right characteristics in terms of machine ability, in terms of critical temperatures, in terms of critical fields." As scientists at Jefferson Lab and researchers at TRIUMF agree, the performance gains achievable with pure niobium have become increasingly marginal. As a result it is now crucial to explore realistic alternatives to keep pushing the limits of SRF technologies.

Despite its superconducting powers, niobium is not invincible. Kolb explains the phenomenon of quenching, where the superconducting state collapses abruptly if critical magnetic fields are exceeded, even when the temperature remains cryogenic. "Quenching is the total loss of superconductivity… Suddenly, we have normal conducting material there, and a lot of power gets dissipated." In a sense, like with the Q-Slope problem, quenching marks the threshold where scientific desire meets material refusal. It is an event of breakdown, not failure of design, but exposure to the limits of what matter will bear. This is distinct from the Q-slope problem. Whereas quenching is a catastrophic event, Q-slope refers to a gradual decline in the cavity's quality factor as the accelerating field increases. Quenching is binary, you cross a line and the system collapses, it is scientifically tractable. Q-slope is incremental, performance decays slowly, often unpredictably, scientifically enigmatic.

In the final part of our conversation, Kolb mentioned that niobium is now being used in quantum computing. Not in high-field accelerators, but in systems that rely on extremely low-field resonance. "They don't want high fields," he explained. "They want very low fields." It's a shift not only in application, but in imagination, niobium transitioning from the propulsion of particles to the stabilization of qubits. From acceleration to coherence. He paused for a moment, then added: "There could be a major shift in how society works if quantum computing becomes widespread." Throughout the interview, Kolb returned to a quiet philosophy of science. "Most scientists want to gather knowledge," he said, "but to do that, we have to come up with clever ideas. Solutions nobody's thought of before." In this account, invention is not linear. The breakthroughs are not always where they are expected. A detour in material behaviour leads to a new device. A failure in one system reveals the seed of another. And here, unexpectedly, we met

in agreement: on the importance of interdisciplinary dialogue. “Knowledge, just for knowledge’s sake, is not that useful,” he told me. “We need to explain why we want to do things. What’s the benefit for society?” For Kolb, the arts and humanities are not peripheral, they are essential to translating the stakes of science to those not already inside its walls. “Our outreach to the humanities, to the arts, can help transfer that knowledge, or at least give an understanding of what we are doing.” But even within this generosity, a gap remains. “It was a bit of a head-scratcher to me,” he admitted, smiling. “Approaching niobium as a metal from a humanities point of view, I didn’t quite know what to make of that.” I didn’t try to explain. Not fully. I think that moment of uncertainty is important to hold open. The idea that a material could be both a tool and a story, a protocol and a becoming, that it could form part of a machinic lineage, express a speculative logic, or open the door to new ways of artistic creation, is not something to be resolved. What happens when science is no longer the only field where niobium has something to say? What happens when its behaviour, its entanglements, its resistances, are taken as epistemic gestures? When are its limits used to open a different space for creation and dialogue?

At every step of this creative research, I was questioned about what the work was about. The entire process was marked by tension, by frictions, by repeated moments of not knowing what to make of it. And maybe that is precisely the point. Perhaps the question is not only what the work is about, but who gets to decide what knowledge matters, and how its meanings are distributed, valued, and elevated. As Isabelle Stengers writes: “The modern technical laboratory, if it is actively stripped of the rhetorical resources of modernity, communicates directly with a cultural-social-political question. How can those who are affected by what is being produced be ‘invited’ to participate in its production? How can they become concerned parties, multiplying questions, objections, and requirements?” (Cosmopolitics II, p. 346) Kopenawa reminds us that for those who inhabit the territories where the materials of modern society are extracted, those that allow for its entertainments, cultures, and countercultures, the understanding of those materials is radically different; there is no space in that cosmology to imagine that destruction could ever bring completeness. “Much later, once I had become an adult, I began to ask myself what these white people had come to do in our forest. I came to understand that they wanted to know it and plot its limits in order to take possession of it.” (The Falling Sky, p. 177) The meanings that circulate in laboratories and exhibition spaces are built on phantasmagorias, but in

the forest, meaning is woven into life and death. There is no concept of abstract knowledge that is worth the cost of planetary unraveling. The modern obsession with extracting meaning, like extracting ore, is itself a form of violence, unless it opens space for those who have long been silenced to become concerned and active parties, not after the fact, but from the beginning.

> *It is possible to talk about a language of music and of sculpture, about a language of justice that has nothing directly to do with those in which German or English legal judgments are couched, about a language of technology that is not the specialized language of technicians.*
>
> —Walter Benjamin, On the Language as Such and On the Language of Man.

Image 5.5 Test tiles with niobium-based glaze at Banff. (Salas, A., 2024).

From the Laboratory to the art studio

Following Glissant, Relation as a process, happens at the encounter of cultures, his philosophy opposes the idea of cultural singularity, what he calls a totalitarian root, in favour of a conception of Relation, "in which each and every identity is extended through a relationship with the Other" (Glissant, 1990, p. 23). This resonates with a Whiteheadian view, where each event is not self-contained but emerges as an extension, or prehension, of other events. Then, we exist, not only through a relationship, we are fundamentally extensions of one another, shaped by the presence, absence, and opacity of others. It is the possibility of the unknown, creativity: a force

to become something other than an ideal, away from a singular root. In this way, "the conception of culture (and not of cultures) is monolithic," and those who have access to it "are the pilots and the guardians of it" (Glissant, 1990, p. 147). As an ideal object, western culture has positioned itself as the enigma par excellence, where the question for the origin of the world, translated in the Big Bang, is the main motor of western scientific practices. The experimental thought is then at the foundation of our modern conception of reality, and is fundamental for the construction of a universal humanist model, where the aim for "pure" scientific practices is fed by the design and development of technical instruments. The question of the origin guarantees the need for new experiments, the development of new technical tools, the finding of smaller and smaller particles, the exploration of deeper space, and travelling to other planets. To discover in one way and to conquer in another, compose the sacred spirit of our modern cathedrals; laboratories where a whole network of scientists and technicians around the planet work together to develop new methods of analyzing data, and more accurate instruments to measure the invisible. Science and its methods and tools belong to a spirit of conquest where, by trial and error, experiments are developed until fulfilling "an unconscious desire to satisfy the mathematical formulae" (Whitehead, 1926, p. 104). Without a limit, new scientific questions feed the need for new equipment for exploring new frontiers, in an unending cycle of new technical devices for new scientific particles/places. Participation in this dynamic is limited though; it is reserved for those who control the means to fund research and knowledge production, the heirs and protectors of western thought. Meanwhile, developing countries, "dispossessed regions, countries in the throes of absolute poverty, are isolated from participation" (Glissant, 1990, p. 151), only count for science as the repositories of raw materials indispensable for the construction of technical tools. Their existence in the scientific equation is marked by the natural resources that they can provide for the construction of bigger and more modern laboratories. Like in the construction of cathedrals for the Spanish colonizers, the Global South provides the purest elements needed for the development and exercise of the only true faith. "Scientific objects are not only "technically" manufactured in laboratories but are also inextricably symbolically or politically construed." (Knorr Cetina, 1992, p. 115)

The products of science come from technical objects built from deterritorialized materials; in this sense, they are cultural products, not natural phenomena discovered through

experimentation, and every aspect involved in scientific research is shaped by culture. This is not to say that the raw elements used in the construction of laboratories or, for instance, particle accelerators, are not part of nature: “the abstractions of science are entities which are truly in nature, though they have no meaning in isolation from nature” (Whitehead, 1920, p. 127). Culture becomes a concept of matter when through the development of a technical object, an event such as the origin of the universe is translated into human time scales and located through Cartesian coordinates. In the process of “discovering” the properties of an element such as niobium, laboratory experiments use purified versions of what is found in nature. These purified forms enable the development of new scientific methods through which new material capabilities can be found, tested, and used. The possibility of enhancing the laboratory environment, conceived as a controlled atmosphere, depends on the malleability of these purified elements. It is therefore rare for a laboratory to work with raw elements as they are found in nature. The controlled conditions of the laboratory allow events to be reproduced piece by piece, rendering them intelligible from the scientist’s point of view; “the power of the laboratory (but of course its restrictions) resides precisely in its enculturation of natural objects” (Knorr Cetina, 1990, p. 118). In such a manner, laboratories as artificial environments are somehow a mirror of the natural environment; both composed of the same elements, hosting similar events, but operating under very different orders. The laboratory is a bridge where the natural world is aligned with a human order, where elements extracted from the earth serve as catalysts in the construction of western versions of natural life. The need for purified versions of natural objects can be only understood as a method to control what everything is and where it comes from. Furthermore, as modern cathedrals, laboratories are central points where people, resources, and technology from all around the world meet in order to preserve a faith.

At the encounter of cultures, the unknown is possible. It is through diversity that encounters of different worldviews can create new orders and question generalizations and absolute truths. But a plurality of cultures does not prevent the appearance of hierarchies. With a single culture at the top of the pyramid, the idealization of a worldview allows for the emergence of totalitarianism, where the idea of identity as root becomes the right and justification for declaring the order of nature. This “root identity is founded in a vision, a myth of the creation of the world; is sanctified by the hidden violence of a filiation that strictly follows this founding

episode" (Glissant, 1990, p. 157). An identity based on relations, for Glissant, is not linked to the creation of the world, but to an understanding of the history of the encounter of cultures on the planet; it is not anchored to a land as territory, from where it is possible to expand and grow as a nation state, but it "exults the thought of errantry and of totality." (Glissant, 1990, p. 157). Scientific practices not only dictate an order of nature where every phenomenon, entity, and organism in the environment is perfectly classified, explained, and understood, but also ensure the standardization of the human-environment relationship. The scientific methods go outside of the laboratory to become culturalized and socialized, they dictate the aesthetics of our relations in an attempt to replicate the controlled environments where purity is the rule. Landscapes, tomatoes, and cows are standardized; countries become plantations and extraction sites. The need for a new relational aesthetic where a different idea of sacred, closed to Indigenous knowledge, is a must; land and not territory, Earth without limits nor flags. In Glissant's view "thought of the Other is sterile without the other of Thought." (Glissant, 1990, p. 169). To think of the other, with the other and for the other, is the possibility to think of the world not as an environment composed of singularities, isolated, classified, and well-differentiated from one another, but as a multiplicity of truths. Moreover, thought of the other is the opportunity to accompany the other while being conscious of the changes that that relation produces in one. "Solitary and solidary;" to think of the other is the capacity to experience otherness, while allowing the relation to change oneself in the course of an exchange. The other of thought is the activation of the relation, or better, the materialization of the relation; it is comprehending how the extension of each and every entity constitutes the other, not in competition, but in solidarity. In this dynamic of imagining new ways to feel and think of relations, to become through the other does not mean a togetherness. Distancing is the guarantee for more relations to be formed, more connections to be made, and new ways of becoming to happen; the adventure of the voyage for the voyage, the encounter, not the conquest. This aesthetic of experiencing the other while knowing that one becomes through this relation, is the capacity of being one while becoming one in the relation with the other. "Together is a generic term covering the various special ways in which various sorts of entities are together." (Whitehead,1929, p. 21). We can say that togetherness is an aesthetic of the relation, it "presupposes the notions 'creativity,' 'many,' 'one,' 'identity,' and 'diversity.'" (Whitehead, 1929, p. 21). In togetherness we are born, exist, and die. The new is constantly happening, never ending, one is constantly becoming one. Each and every entity in

nature has inherent the capacity to become (to self-become, to become through and with others), the potential for a creative advance into novelty (which through a poetic relation with others, stimulates the appearance of something new), the possibility to be transformed through transforming. In taking part of this unending process, organisms transform and are transformed with and by the environment, this is their function; they modify it and adapt to it, participating actively in the production of reality. Reality, or nature in Whiteheadian terms, is a process; a process which is the becoming of entities, "a structure of evolving processes" (Whitehead, 1926, p. 70). The real misconception that "we have to get rid of is that nature is a mere aggregate of independent entities, each capable of isolation;" (Whitehead, 1920, p. 105).

A science practised from awareness, and not only from perception, might recognize that it is the mine, the museum, the forest, the river that are missing from the experiments conducted in a particle accelerator. It is the awareness of what it means to study proton collisions without accounting for their entanglement with ecosystems. The thousands of kilometres of pure niobium cables and superconducting radio frequency cavities that enable these experiments are not just buried underground in specialized facilities, they are also embedded in the histories of colonialism, in the disruption of environments, and in violence against bodies. Niobium's properties and characteristics may help us better understand the nature of matter, but they also invite us to imagine different relations, and different ways of producing knowledge. What could be constructed from the attributes of this element is not merely a set of technical objects, but a relationship: We⇹Niobium. A relationship in which each is an extension of the other, opening the possibility for a different mode of thought, a different kind of attunement. A thoughtfeeling.

The Film's Montage and the encounter with clay

As I stepped away from fieldwork, I began to ask myself where the line could be drawn between a written thesis and an artistic body. I turned first to the film, organizing the audiovisual material I had gathered over years of research. That process opened the door to theoretical writing. Footage, soundscapes, interviews, and field notes came together and began to resonate with a theoretical framework I had been slowly weaving, questions that once seemed distant now started to connect organically. One of the first decisions was to choose the voice of the film. I

decided to narrate it myself. As I began drafting the script, I found not only a voice and a tone, but also a cadence and an intention that would go on to guide the writing of this dissertation. I paused the montage to focus on the structure of the thesis. And as the form of the theoretical work became clearer, my excitement to return to the film also grew. Once again, the dissertation was guided by the audiovisual materials, the archives, and the encounters, and in turn, the writing began to shape the voice of the film. This movement between realms became a methodology I had not fully anticipated, but which ultimately provided the foundation upon which this research-creation has taken shape.

As both components of the project began to unfold in parallel, I applied to an arts residency at the Banff Centre for Arts and Creativity. My goal was to finish the script, define the structure of the video, complete the montage, and record the voice-over, all in five weeks. It was ambitious, but I felt ready. I had a pre-edit, a well-organized archive of footage, and a partial draft of this dissertation as a foundation for the narration. Still, as with every step in this creative process, doubts crept in. I wondered whether I had been clear enough in the application, whether the project might be considered too risky on an institutional level, or simply too expansive for such a short time frame. I submitted my proposal, not knowing what to expect. A few weeks later, I received a letter of acceptance. The excitement of this opportunity pushed me to move forward with a rough cut of the film and to sketch out the initial structure of the written thesis. I arrived at Banff ready to dive into the final edit, and into the writing.

Arriving in the town of Banff, the landscape welcomes you. At first sight of the towering Rocky Mountains, you begin to understand why people speak of mountain fever as part of the Banff residency experience. Their presence is not merely scenic; it's visceral, immediate. Something in your rhythm shifts. Over time, you begin to slip into a kind of dreamlike state, one that, as I would later experience, leaves behind a quiet, soft melancholy. A gentle nostalgia that borders on sadness, one of the subtle but lasting effects of the residency after it ends. The residency was led by artists Shary Boyle and Howie Tsui, who worked closely with a group of 15 artists over several weeks. It was a remarkable gathering of painters, sculptors, illustrators, filmmakers, ceramicists, printmakers, musicians, and writers, each bringing distinct worldviews,

techniques, questions, and motivations. I was deeply moved and inspired by each presentation and felt incredibly fortunate to be part of this vibrant, generous community of practice.

One presentation struck me in particular: artist France Goneau, an expert in ceramics, who shared her concern about the waste produced in ceramic work. She arrived at Banff with the idea of developing a paste made from residual materials, a kind of adhesive that could "glue" together fragments of broken ceramics to create new works. Her sensitivity to material afterlives, her aesthetics, and her experimental approach resonated immediately with me. This encounter marked the beginning of a new and unexpected chapter in my research, one that would radically shift the direction of my residency. In our early conversations, a new idea emerged: niobium could be used to develop a ceramic glaze. The excitement was immediate and contagious. As I worked on the film, this parallel exploration into niobium as a glaze expanded the conceptual field of both the written thesis and the film itself. My artistic practice, rooted in moving images, has often extended beyond the flatness of the screen, through materials like mirrors and semi-transparent fabrics, and through installations that embed projections within spatial compositions. I think of these not as traditional films, but as filmic worlds not meant for festivals. Before Banff, I didn't yet know what formal shape *Nb41* would take, or how it might expand beyond the screen. That uncertainty vanished in my conversations with France. A new material path opened, literally, and with it, a deeper way to think through the resonances between science, art, and matter.

The team at Banff was incredible. Their support, availability, and the quality of the studios and resources provided made this residency an unforgettable experience. The group of artists was generous, open, and deeply inspiring, a constant source of motivation. The guidance of Shary Boyle and Howie Tsui was also essential, creating space for critical and honest conversations about what it means to make art in a world so profoundly challenged. And so, when I wasn't in the editing room, immersed in footage of mines, archives, forests, rocks, and rivers, I was in the ceramic studios, working alongside France, developing the first prototypes of what would later become a series of niobium worlds. These ceramic pieces, born from our experiments with niobium glazes, now accompany the 45-minute film, extending its language into three-dimensional form. Working with niobium outside the lab, no longer alloyed, machined,

or purified, but kneaded into clay, dissolved into glaze, and fired in a kiln, revealed something unexpected. This wasn't the niobium of superconducting cavities or quantum architectures; it was niobium as process, as event. In this form, it did not accelerate particles, it decelerated thought. The material became errant, speculative, unstable. In Manning's terms, it became a minor gesture: not a fixed act, but a force immanent to the event, altering what a material body can do. Niobium as glaze was no longer a tool of control, but a collaborator in a process of emergence, its sheen revealing cracks, its surface recording intensities of heat and oxidation. These ceramic niobium worlds did not assert their use; they invited presence. They did not explain, but co-composed. They offered a way of thinking with the material, not about it, of creating together. They became, in Manning's sense, gestures that "exceeds the bounds of the event, touching on the ineffable quality of the more-than," proposing not what niobium is, but what it can become when allowed to exceed its function.

Image 5.6 Ceramic with niobium glaze. (Salas, A., 2025).

Conclusions

This research-creation project has been a journey across geographies, epistemologies, and materials. From the niobium-rich soils of Vichada to the vaults of national museums, from particle accelerators to ceramic studios, this work has followed the tangled trajectories of a mineral that is both elemental and geopolitical. Niobium, as traced in this speculative ethnography, is not simply a resource but a narrative device, a relay between worlds: scientific and spiritual, human and more-than-human, past and future.

What began as a study of niobium's role in particle physics evolved into a broader inquiry into how materials shape and are shaped by the stories we tell. This project has challenged boundaries, between art and science, technique and technology, territory and map—and has refused singular perspectives in favor of relational, speculative worldings. The archives I encountered—film, mineral, ceramic, colonial—all shared a logistical sameness, a repetition that erased the singularity of the places and beings they purported to represent. Against this flattening logic, I sought to attune to the affective traces, the "negative prehensions," in Whitehead's terms, that linger in and around the materials.

The wide variety of sites I visited were not merely locations of extraction or knowledge, but events of encounter. Each offered different relations with niobium, and each asked different questions of me. In returning to ceramics, experimental filmmaking, and creative writing, I found a method of slowing down, of refusing the aerial view and embracing other speeds: walking, touching, waiting. These movements allowed me to resist the temporalities of logistics and capital, and instead inhabit what I now call *elemental affects*, forms of knowing that emerge through contact, through story, through sensation. This emerging methodology has allowed me to accept the encounter with matter in a way I had not previously considered. An openness to relate to niobium in dialogue, rather than through one-directional inquiry, enabled me to be guided by the material itself. To study a mineral is also to be studied by it. This is where research-creation, in its fullest sense, begins to articulate its potential: not as illustration, but as co-composition with the world.

This shift allowed the encounter to unfold into a series of experiences—embodied, speculative, affective—that gave rise to new stories about niobium: stories that challenge dominant narratives about scientific progress, resource extraction, and material control. These stories, told through cracks in glazes, archival resonances, personal diary, and speculative montage, revisit material histories to reframe niobium not as a passive object of knowledge and profit, but as an active participant in the shaping of a multiplicity of worlds. This practice of *elemental affects*, a mode of sensing and knowing through contact, story, and sensation, is now giving way to a new line of inquiry.

Building directly from *Nb41*, a new direction begins to emerge, one that gestures toward materials such as neodymium, yttrium, and dysprosium. These elements, crucial to the architectures of quantum computing, superconducting systems, and artificial intelligence, are not only technological substrates but also potential agents of emotional, epistemic, and expressive resonance. While *Nb41* interrogates niobium's place within extractive and epistemological systems, it also opens a space for response and reciprocity, an invitation to explore what materials ask of us, and what we become in contact with them. This shift, from analysis to co-presence, from logistics to resonance, marks not an end, but a threshold. It proposes a mode of research-creation where art and science do not simply illustrate one another, but inhabit a shared field of uncertainty, vibration, and worldmaking.

This emerging approach focuses on the emotional, ontological, and relational dimensions of matter itself. It invites a reorientation: from material as resource to material as relation; from extraction to expression; from certainty to resonance. Within this expanded framework, materials at the core of contemporary technologies may no longer be understood solely in terms of utility, but as affective participants in the shaping of knowledge and experience. What begins to take form, then, is a bridge—one that connects scientific research and artistic creation through an affective relationality with elemental matter. These foundational materials of energy transition and AI point not only toward technical futures, but toward a deeper entanglement of emotion, perception, and ontology.

The possibility opened by *Nb41* is precisely this: to approach materials not as fixed components of progress, but as speculative and affective vectors, agents through which we might

begin to imagine and materialize other kinds of worlds. It also opens the possibility of a science and art creation articulated through the affects generated by the very elements at the core of both realms—elements that shape not only technologies and experiments, but also gestures, forms, and emotions. In this shared affective space, *Nb41* proposes a method for thinking through materials, where knowledge is not extracted or translated, but co-created. It offers a foundation for more open, reciprocal conversations about how knowledge is produced, for whom, and with what materials—conversations in which science and art no longer speak from separate disciplines, but from within a common field of resonance.

Through layered fieldwork, archival engagement, and philosophical inquiry, niobium emerges here not as a singular object but as a multiplicity of forces—technological, historical, environmental, and affective. The mine, like the archive, becomes a crystal of time: a site where past, present, and possible futures intersect, not as linear narratives but as overlapping powers of the false. Rather than treating the site as a static ruin, I approached it as a relational formation, where past and future remain in negotiation. This field encounter initiated a key methodological commitment of the thesis: to remain attuned to the ways materials world us, even in the absence of spectacle or clarity.

The mine resists closure. But this resistance is not only symbolic, it is physical, legal, and geopolitical. The mine continues to emit radon, affecting the health of nearby communities, while laws regulating its future remain unstable, rewritten in response to shifting economic priorities. Speculation—economic, geological, political—surrounds niobium like a magnetic field, whether in Vichada or Quebec. Its fate is tethered to stock markets, governmental agendas, and corporate dreams of extraction yet to come. Thinking niobium, then, requires moving beyond the coordinates of space and time imposed by capitalist logics. It requires challenging the boundaries that frame a site as merely dormant or extractable, and instead recognizing place as layered with contested sovereignties, entangled temporalities, and fragile relations.

The places I encountered throughout this research—mines, labs, reserves, archives—revealed themselves not as inert backdrops, but as possibilities: as generative thresholds where other narratives, speeds, and ways of sensing the world become possible. As I moved by foot through these environments, at a speed often dismissed by maps and budgets, I encountered

places not as abstractions, but as living assemblages. Walking altered the temporality of the research. It allowed me to feel the weight of terrain, the resonance of histories, the presence of those who inhabit and remember the land. To walk is to refuse the aerial view, to decenter the fantasy of resource mastery, and to recompose value: not as extraction, but as relation. By foot, geology becomes uneven, porous, and storied. By foot, borders blur. I encountered not only rocks and ruins, but pathways, paths shaped by others, visible and invisible, human and more-than-human. These pathways did not close the world; they opened it. They invited fabulation, speculation, and the possibility of co-becoming. I moved in time as much as in place.

It is in this gesture, of walking, sensing, filming, glazing, that *Nb41* takes form. Across thesis and installation, it proposes that to engage with matter is not to define it, but to walk with it. To allow the mineral to deform the method. To let the speculative be grounded in contact, and to recognize knowledge in territory. *Nb41*, as articulated in both this written thesis and the accompanying art installation, gives form to these encounters. It assembles them into a method for sensing the world through its materials, not as fixed resources, but as expressive and unfinished beings. It proposes that to follow niobium is to follow the unresolved, and in doing so, to imagine other possible worlds.

The porcelain allegories examined in this research are not merely artifacts of the past, they are representational machines that continue to resonate in contemporary infrastructures of control. As soft technologies of empire, they helped organize the world visually and materially, encoding colonial hierarchies and extractive logics into aesthetic form. But these objects also form part of a machinic phylum, a lineage of representation and regulation that stretches from allegory to algorithm, from porcelain to AI. In this sense, they are maps, tools for shaping perception, for distributing value, for determining which worlds are visible and which remain erased. Yet to look closely, to dwell in the details and materials of these forms, is also to open them. This attention allows for the speculative possibility of drawing other maps, maps that do not serve extraction or classification, but relation and opacity. When art and science meet through this lens, when the unclear is not dismissed but held as a space of potential, the aesthetics of control can be reconfigured. This is the bridge *Nb41* gestures toward: not a synthesis of disciplines, but an encounter where the material, the symbolic, and the geopolitical are understood as inseparable. In following these materials—niobium, porcelain—not as inert

resources but as expressive agents, the work calls for a shift from representation to relation, from clarity to entanglement, from control to co-composition.

This shift from classification to opacity, from measurement to story, is central to this thesis. The speculative ceramic niobium glazes and the experimental film become embodiments of this approach, not as conclusions in the traditional sense, but as openings, as ways of encountering a relation with everything. This creative study, then, does not aim to define niobium, but to show how following it across disciplines and terrains reveals a plurality of worlds. The element becomes a portal: into history, extraction, creativity, and the ethical tensions of knowledge production. Through this journey, the thesis ultimately insists that worldmaking is not the product of mastery, but of relation.

This commitment to relation is made tangible in the final gesture of the project: a series of three ceramic spheres that accompany the 45-minute film *Nb41*. Each sphere, glazed with experimental mixtures of niobium oxide, offers a material meditation on deep time, impermanence, and our place within the planet's lifespan. Together, they form maps, not of territories, but of the paths traced in the becoming of this project. The first evokes *Rodinia*, an ancient supercontinent that predates the human species, a time when niobium concentrations were especially high across the Earth. The second responds to Waldseemüller's 1507 world map, *Universalis Cosmographia*, the first world map to include and name "America," and a key moment in the cartographic construction of empire. The third looks ahead to *Pangaea Proxima*, a speculative future supercontinent when the continents may converge once again, an image that invites us to think beyond extraction, beyond mastery, and toward new planetary imaginaries. These three spheres are not representations, but material relations, maps of my relation with niobium.

The path niobium has traced for me has profoundly transformed my artistic practice, my academic methodology, and the way I move through the world. What began as an effort to study this element through established methods, those shaped by university classrooms, long theoretical discussions, and disciplinary expectations, was gradually deviated by political forces and environmental tensions emanating from the mineral itself. I had to unlearn familiar ways of knowing, and open myself to uncertainty. To follow a mineral is to enter unknown territories, not

only geographical, but conceptual, affective, and relational. In allowing myself to be reshaped by this encounter, I stepped into a new realm of research-creation, one that does not seek to master matter, but to move with it. In the end, *Nb41* is not a thesis about niobium—it is a thesis with niobium.

Figure 6.1 Rodinia (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025).

Rodinia is a supercontinent that geologists believe existed over a billion years ago. It is thought to be unique for its unusually high concentrations of niobium during that stage of the planet's formation.

Figure 6.2 Universalis Cosmographia (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025).

The Waldseemüller map (Universalis Cosmographia), published in 1507, is the first known map to use the name "America." It marks a turning point in European worldmaking, where new continental imaginaries became tied to extraction, possession, and naming.

Figure 6.3 Pangaea Proxima (ceramic sphere with niobium glaze, 31 cm diameter). (Salas, A., 2025).

Pangaea Proxima imagines a future supercontinent, where Earth's tectonic plates have once again converged. It gestures toward a planetary future beyond the Anthropocene, shaped by deep time and speculative geologies.

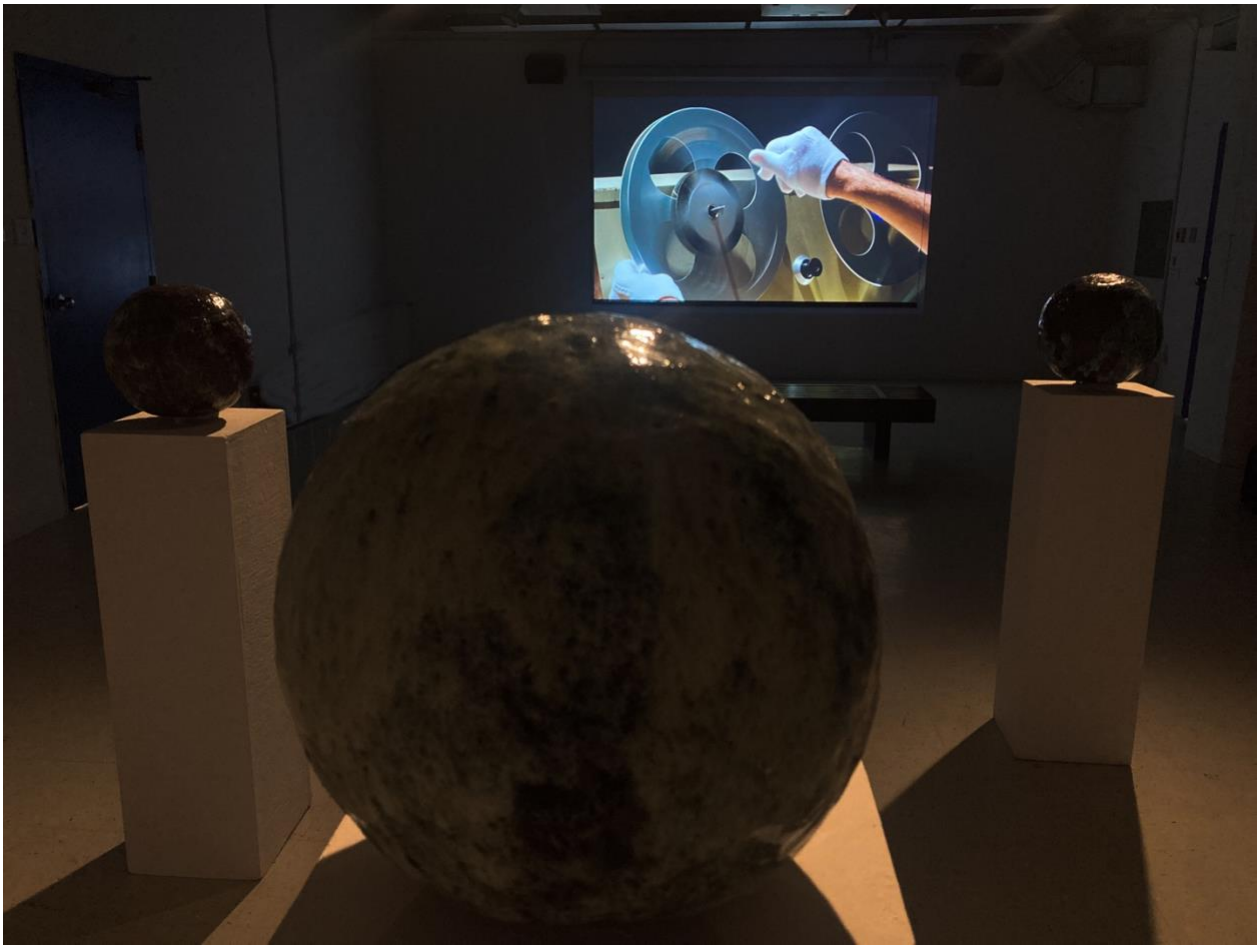


Figure 6.4 *Nb41* - Film with ceramics. (Salas, A., 2025).

Bibliography

Adorno, T. W. (1939). Fragmente über Wagner. *Zeitschrift für Sozialforschung*, 8(1–2), 1–49.

AP News. (2024, March 29). Scientists release plans for an even bigger atom smasher to address the mysteries of physics. https://apnews.com/article/2eb0b838b11940b3ab70d0a872ca4fdd

Bateson, G. (2000). *Steps to an ecology of mind*. University of Chicago Press.

Bateson, G. (2002). *Mind and nature: A necessary unity*. Hampton Press.

Bateson, N. (2021). Aphanipoiesis. *Journal of the International Society for the Systems Sciences, Proceedings of the 64th Annual Meeting of the ISSS*, 1(1). (Under review)

Benjamin, W. (1968). *Illuminations* (H. Arendt, Ed., H. Zohn, Trans.). Schocken Books. (Includes "Theses on the Philosophy of History.")

Benjamin, W. (1999). *The arcades project* (H. Eiland & K. McLaughlin, Trans.). Belknap Press.

Benjamin, W. (2003). On the concept of history (H. Zohn, Trans.). In H. Eiland & M. W. Jennings (Eds.), *Walter Benjamin: Selected writings, Volume 4: 1938–1940* (pp. 389–400). Harvard University Press.

Bergson, H. (2005). *Creative evolution* (A. Mitchell, Trans.). Cosimo Classics. (Original work published 1907)

Bonilla-Pérez, G., Ospina-Torres, R., & Guzmán-Álvarez, R. (2013). Petrografía, geoquímica y geocronología del Granito de Parguaza en Colombia. *Boletín de Geología*, 35(2), 35–55.

Bory, A., Guédron, S., Benedetti, M. F., Baratin, L. M., Amorim, R. S. S., & Deschamps, Y. (2023). High-grade niobium deposit in laterites developed on Seis Lagos carbonatite (Amazonian Craton, Brazil). *Chemical Geology*, 631, 121569. https://doi.org/10.1016/j.chemgeo.2023.121569
Britannica. (2024). Columbium. https://www.britannica.com

Business Insider. (2024, February 12). Scientists are building tunnels under South Dakota for a $3 billion experiment that could solve some of the universe's grandest mysteries. https://www.businessinsider.com/ghost-particles-neutrinos-fermilab-dune-tunnels-south-dakota-2024-2

Bureau d'audiences publiques sur l'environnement (BAPE). (1998). *Document technique – Projet de mine de niobium à Oka* [PDF]. https://archives.bape.gouv.qc.ca/sections/archives/oka/docdeposes/documdeposes/DB17.pdf

Bureau d'audiences publiques sur l'environnement (BAPE). (2002). *Mémoire du Conseil de bande de Kanehsatà:ke – Consultation publique sur le projet de mine de niobium à Oka* [PDF]. https://voute.bape.gouv.qc.ca/dl/?id=00000057223

Bureau d'audiences publiques sur l'environnement (BAPE). (2005). *Commentaires et recommandations de l'Assemblée des Premières Nations Québec-Labrador (APNQL) sur le projet de Niobium à Oka* [PDF]. https://voute.bape.gouv.qc.ca/dl/?id=00000057660

Bureau d'audiences publiques sur l'environnement (BAPE). (2014). *Niobium project in Oka: Public consultation report* [PDF]. Canadian Coalition for Nuclear Responsibility. https://www.ccnr.org/CCNR_BAPE_2014.pdf

CERN Courier. (2023, July 12). Portable particle accelerator analyzes rock art in situ. https://cerncourier.com/a/portable-particle-accelerator-analyzes-rock-art-in-situ/

Crown-Indigenous Relations and Northern Affairs Canada. (2024). *Negotiations in progress*. Government of Canada. https://www.rcaanc-cirnac.gc.ca/eng/1100100030285/1529354158736

Deleuze, G. (1994). *Difference and repetition* (P. Patton, Trans.). Columbia University Press. (Original work published 1968)

Deleuze, G. (2001). *Cinema 2: The time-image* (H. Tomlinson & R. Galeta, Trans.). University of Minnesota Press. (Original work published 1985)

Deleuze, G. (2003). *Cinema 1: The movement-image* (H. Tomlinson & B. Habberjam, Trans.). University of Minnesota Press. (Original work published 1983)

Deleuze, G. (1983–1984). Seminar on Cinema, Truth, and Time – The Falsifier (Lecture 01, November 8, 1983). Trans. B. D. Goehring; transcription by F. Fafa & N. Ouis; edited by C. J. Stivale.

Deleuze, G., & Guattari, F. (1980). *Capitalisme et schizophrénie 2: Mille plateaux*. Les Éditions de Minuit.

Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia* (B. Massumi, Trans.). University of Minnesota Press.

DOE Office of Science. (2023). *Electron-Ion Collider (EIC)*. U.S. Department of Energy. https://science.osti.gov/np/Facilities/EIC

European Spallation Source. (2024). *About ESS*. https://europeanspallationsource.se/

Falcão, M. T. (2016). *Ambiente e conhecimento tradicional da etnia Ingarikó na terra indígena Raposa Serra do Sol – Roraima: Abordagem etnocientífica no estudo do uso da terra* (Master's thesis, Universidade Federal do Pará), p. 36.

Fournier, C. (Director). (1965). *Colombium* [Film]. Office du film du Québec. BANQ archive (Cote: E6, S7, SS2, DFC07576).

Gilmore, R. W. (2022). Fatal couplings of power and difference: Notes on racism and geography. In R. W. Gilmore & B. Bhandar (Eds.), *Abolition geography: Essays towards liberation*. Verso Books.

Gilmore, R. W. (2022). Racial capitalism. In R. W. Gilmore & B. Bhandar (Eds.), *Abolition geography: Essays towards liberation*. Verso Books.

Ginter, P. (2013). *LHC: Large Hadron Collider*. Edition Lammerhuber.

Glissant, É. (1990). *Poétique de la Relation*. Gallimard.

Gómez-Barris, M. (2017). *The extractive zone: Social ecologies and decolonial perspectives*. Duke University Press.

Gouvernement du Québec – Ministère des Ressources naturelles et des Forêts. (2020). *Plan québécois pour la valorisation des minéraux critiques et stratégiques 2020–2025* [PDF]. https://cdn-contenu.quebec.ca/cdn-contenu/ressources-naturelles/Documents/PL_critical_strategic_minerals.pdf

Guattari, F. (2008). *Les trois écologies*. Éditions Galilée.

Gumbs, A. P. (2022). *Survival is a promise*. Oakland, CA: AK Press.

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Duke University Press.

Harney, S., & Moten, F. (2021). *All incomplete*. Minor Compositions.

ILC Newsline. (2024). *International Linear Collider Project Updates*. https://newsline.linearcollider.org/

Indigenous Watchdog. (2024, November 13). Gwich'in brace for fight on oil and gas drilling in wildlife refuge after Trump victory. https://www.indigenouswatchdog.org/update/gwichin-brace-for-fight-on-oil-and-gas-drilling-in-wildlife-refuge-after-trump-victory/

Ingeominas & Universidad Nacional de Colombia. (2011). *Caracterización de depósitos aluviales con manifestaciones de Tantalio y Niobio (Coltán) en las comunidades indígenas de Matraca y Caranacoa en el Departamento del Guainía*. Contrato Interadministrativo No. 021 de 2010.

International Union of Pure and Applied Chemistry (IUPAC). (n.d.). *Element naming conventions*. https://iupac.org

James, W. (1976). *Essays in radical empiricism*. Harvard University Press.

Kändler, J. J. (ca. 1760). *Porcelain set of the continents*. Meissen Manufactory. Held at Cooper Hewitt, Smithsonian Design Museum.
KEK High Energy Accelerator Research Organization. (2024). *SuperKEKB and Belle II*. https://www.kek.jp/en/

Knorr Cetina, K. (1992). The couch, the cathedral, and the laboratory: On the relationship between experiment and laboratory in science. In A. Pickering (Ed.), *Science as practice and culture* (pp. 113–138). University of Chicago Press.

Kopenawa, D., & Albert, B. (2013). *The falling sky: Words of a Yanomami shaman*. Harvard University Press.

Manning, E. (2009). *Relationscapes: Movement, art, philosophy*. MIT Press.

Manning, E. (2016). *The minor gesture*. Durham, NC: Duke University Press.

Manning, E. (2020). *For a pragmatics of the useless*. Duke University Press.

Manning, E. (2023). *Out of the clear*. Minor Compositions.

Massumi, B. (2011). *Semblance and event: Activist philosophy and the occurrent arts*. MIT Press.

Massumi, B. (2015). *The power at the end of the economy*. Duke University Press.

Massumi, B. (2017). *The principle of unrest: Activist philosophy in the expanded field*. Open Humanities Press.

National Film Board of Canada. (1964). *Produced in Quebec* [Film; 16mm, silent, 3 min]. National Film Board of Canada. https://collection.nfb.ca/film/produced-in-quebec-216602

Nature Reviews Physics. (2023). China's CEPC Higgs factory: Promise, progress, and perspective. https://www.nature.com/articles/s42254-023-00672-7

Niobium Canada. (2023). *History of niobium in North America*. https://www.niobium.ca

Niobium Strategic Metals. (n.d.). Nio annonce un soutien financier pour son projet de niobium à Oka [Press release]. https://niometauxstrategiques.com/nio-annonce-un-soutien-financier-pour-son-projet-de-niobium-a-oka/

Piilonen, P. (2024, July 15). Personal interview at the Canadian Museum of Nature, Ottawa.

Raby, R. (Director). (1977). *Niobec Inc.* [Film]. Les Productions LEM inc. BANQ archive (Cote: E72, S77, DFC2002-153).

Reuters. (2024, January 18). Gold miners bring fresh wave of suffering to Brazil's Yanomami. *Reuters Investigates*. https://www.reuters.com/investigates/special-report/brazil-environment-

yanomami/

Ripa, C. (1764). *Iconologia*. Various editions.

Sánchez, J. G. (2023). *Uranio*. México y Japón: Cactus del Viento.

Stengers, I. (1995). *L'invention des sciences modernes*. Flammarion.

Stengers, I. (2011). *Cosmopolitics II* (R. Bononno, Trans.). University of Minnesota Press.

Stengers, I. (2011). *Thinking with Whitehead: A free and wild creation of concepts*. Harvard University Press.

Tantalum-Niobium International Study Center. (2021). *Annual bulletin*. TIC.

Teyrungumu. (2025, March 13). Personal interview.

Vespucci, A. (1503). *Lettera a Soderini*. Early accounts of the New World.

Viveiros de Castro, E. (2015). *The relative native: Essays on indigenous conceptual worlds*. Hau Books.

Waldseemüller, M. (1507). *World map*. First map to use the name "America".

Walthew, J. (2024). Interview with Jessica Walthew, conservator at the Cooper Hewitt Smithsonian Design Museum. Personal communication.

Whitehead, A. N. (1920). *The concept of nature*. Cambridge University Press.

Whitehead, A. N. (1926). *Science and the modern world*. The Free Press.

Whitehead, A. N. (1978). *Process and reality: An essay in cosmology* (D. R. Griffin & D. W. Sherburne, Eds.). The Free Press. (Original work published 1929)

Wynter, S. (2006). On how we mistook the map for the territory. In L. Gordon & J. Gordon (Eds.), *Not only the master's tools: African American studies in theory and practice* (pp. 107–169). Routledge.

Wynter, S. (2008). The re-enchantment of humanism: An interview with Sylvia Wynter. *Small Axe*, 8, 119–207.