One Stone, Three Processes:
A Material Culture Study on Queenston Limestone

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Named after the Queenston Quarry, Queenston Limestone is Canada's highest calibre of building stone for its durable building properties and aesthetics.[1,2] The stone has been quarried in the St. David's and Niagara region for over two hundred years.[3] They were used in significant buildings and infrastructure in Canada such as the Ontario Parliament Building and the Grand Trunk Railway, earning their reputation as the "Corner Stone of Upper Canada".[4] Using Queenston Limestone as the vehicle, this thesis challenges the idea of materials as inert objects by revealing materials' relationships with the built environment. Three themes are investigated to establish materials as active participants in the built environment. First, materials are positioned as part of *assemblages*, which are interrelated with other environmental elements. Second, the thesis emphasises *material agency*, which is materials' power to influence and affect their surroundings. Third, materials' involvement with *human work* shows how humans transform material while the materials shape human experiences.

One Stone, Three Processes: A Material Culture Study on Queenston Limestone interacts with Queenston Limestone through three processes: documenting and drawing the extraction site, learning and experimenting with traditional crafting techniques, and designing with discarded limestone. **Part One, Landscape as Culture**, involves a study of the Queenston Quarry through a series of drawings, diagrams and photographs, documenting the geological forces and human activities that influenced the development of the landscape over time. **Part Two, Crafting Discards**, includes three material experiments that study how traditional dry-stone stacking transforms Queenston Limestone and how Queenston Limestone enables the craft's training environment. **Part Three, Translating Materials**, explores the designers' role in working with materials by resonating with the complex material landscape of Queenston Quarry and foregrounding the intricate processes of stone craft. Through these three parts, this thesis explores the value of building materials, and reflects on the designers' methods in studying and designing with materials.

1. For the purpose of the thesis, I choose to capiltalise Queenston Limestone to show respect to the material. I also adress Queenston Limestone with the pronouns *they* instead of *it* to emphasise the animacy of the material. This is an intentional grammatical choice.

2.Stone," Queenston Limestone, Queenston Quarry Reclamation Company Ltd., The Cellars of Niagara-on-the-Lake, Queenston Limestone. Accessed March 29, 2022. http://www.queenstonlimestone.com.

3. "Stone," Queenston Limestone.

4.Frank Racioppo, "The Queenston Quarry," (lecture, The Niagara-on-the-Lake Museum – Niagara Historical Society, Niagara-on-the-Lake, ON, March 24, 2021), https://www.youtube.com/watch?v=JgKppfk3L04 .

Acknowledgements

This thesis is a milestone in my academic journey and an essential part of my self-discovery process. Research could be a very lonely journey, and I would not have been able to complete this without the encouragement and support of the people around me.

I want to dedicate this thesis to my supervisor, Jane Hutton. Working under your guidance for the past two years has been a privilege. Your unwavering support, love and care for your students helped me through the most difficult time of my life. Thank you for always challenging me to dive deeper into topics and think critically about concepts. I deeply admire your depth of thought, area of expertise and work ethic.

I would also like to thank my committee member John McMinn; your work has inspired me since my undergraduate years and motivated me to pursue my research topic. Your feedback brings fresh perspectives that greatly enhanced my work. Thank you to my thesis review panel, Robert Jan van Pelt, Tracey Eve Winton and Kellie Chin. Your questions and comments brought together the fragmented pieces of this thesis to its final form.

To the school of Willowbank, thank you for selecting me for the MITACS partnership. This partnership introduced me to Queenston Limestone, a material that prompted the beginning of this thesis, and now holds special meaning in my heart. Without the funding, teaching, and learning opportunities, this project would not be possible. I owe so much of my knowledge of the stone craft to Willowbank. Alison, Marcin, Craig and Joey, thank you for reviewing my work at its early stages. Your insights helped me lay the foundation for my thesis.

To Frank Racioppo and the Queenston Reclamation Company Ltd., thank you for allowing me to visit the quarry site, providing technical data to assist with my thesis, and eventually pointing me to Robert Watson for guidance. Thank you, Bob, for generously lending me your research manuscripts and sharing your wisdom in the geology of the Niagara region. Your work had a direct impact on how I approached studying the quarry.

To my friends and family:

Natalie, thank you for staying alongside me, balancing our times between the Galt. Publication and our thesis work. You were the best teammate I could ask for. Your creativity, attention to detail and work ethic constantly inspire me. To my entire Galt. Publication issue 4 team, thank you for your talent and hard work dedicated to the publication. The time we spent together was precious break times that soothed me throughout my years in Masters.

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To Allan, you are the best brother I can ever ask for. Thank you for being empathetic and sharing the burden with me during difficult times. I am so proud of you for everything you do and for the wonderful person you have grown to be.

Land Acknowledgement

This thesis begins with the land. It is inspired by Queenston Limestone, a material extracted from Queenston Quarry at Queenston, Ontario.

This material carries memories of the land. They were once buried under the forested landscape of the Niagara Escarpment. Before the arrival of European colonisers, the Indigenous Peoples protected the Carolinian forestlands of the Niagara Escarpment with their traditional wisdom through land practices. Queenston Limestone was extracted from beneath as the trees were violently torn from the earth's surface. Like the land's protectors, Queenston Limestone carries memories that outlast human life. I acknowledge the violent history of genocide towards Indigenous Peoples on this land, and promise to advocate for Indigenous rights and decolonisation. The Quarry and the town of Queenston are situated in the traditional territory of the Neutral, the Missisaugas of the Credit, the Haudenosaunee and the Anishinaabe Peoples under Treaty 3 with the Missisaugas of the Credit, including lands between Lake Ontario and Lake Erie.

While writing this thesis, I started as a guest in Tkaronto (Toronto) on many nations' traditional lands, including the Missisaugas of the Credit, the Anishinaabe, the Chippewa, and the Haudenosaunee, and the Wendat Peoples under Treaty 13 with the Missisaugas of the Credit. I then attended school in person at the University of Waterloo School of Architecture in the community of Galt, Ontario. The school is located in Block 1 of the Haldimand Tract – land promised to the Six Nations under the Haldimand Treaty of 1784. These treaty lands extend for 10 km on either side of the Grand River, from its source at Dundalk until its end at Lake Erie, on the traditional territory of the Neutral, the Anishinaabe, and the Haudenosaunee Peoples. I recognise that our use of this land and its resources is made possible through Indigenous people's ongoing stewardship and protection efforts.

Table of Contents

Part III Translating Materials

Epilogue

List of Figures

Introduction

The Beginning

I grew up with a Chinese upbringing that introduced me to a traditional phrase "万物皆有灵", which translates to "every physical aspect of our world is a spiritual being". Matter such as plants, rocks, and water are unique life forms that relate to all other beings. This philosophy originated from historical texts, Taoism beliefs and Buddhist literature throughout Chinese history. Although deeply touched by this perspective, I find it challenging to navigate this viewpoint as part of a non-white North American settler culture, especially when I begin to study materials in architecture. In the building industry, materials are viewed as fixed commodities, and their value is often measured through consumption.[1] While globalisation has accelerated material consumption to an unprecedented rate, the relationships between materials and other beings are neglected.[2] This thesis challenges the idea of materials being inert objects and presents materials as active agents in the built environment. I am interested in how materials are formed and shaped through human and non-human processes, and, how they reciprocally influence our surroundings.

At the beginning of my graduate studies, I collaborated with Willowbank, a heritage conservation school in Queenston, through the MITACS research program. During the summer studio I facilitated for Willowbank, one of the projects the students and I took on was creating a dry-stone stacked seating area. This experience introduced me to Queenston Limestone, a material significant to the local landscape. The stones I worked with were discarded from the Queenston Quarry, only five kilometres from the school. I learned that the stone was the highest calibre of limestone in Canada, and was widely used in the region for significant buildings.[3] The discarded stones at Willowbank are reserved for students to learn the dry-stone stack craft. As I investigated the material more, I discovered more historical connections between the material and the region's development. This marked the beginning of this thesis, where I wanted to study Queenston Limestone to investigate the materials' relationship with its built environment.

1. Jane Hutton, *Reciprocal Landscapes: Stories of Material Movements* (Oxford: Routledge, 2020), 5.

2. Vaclav Smil, preface to *Making the Modern World: Materials and Dematerialization* (Chichester: Wiley, 2014), ix-x.

3. "Stone," Queenston Limestone, Queenston Quarry Reclamation Company Ltd., The Cellars of Niagara-on-the-Lake, Queenston Limestone. Accessed March 29, 2022. http://www.queenstonlimestone.com.

Thesis Framing

Material culture studies is a field that examines the relationship between people and matter, centred around archaeology and anthropology, providing human-centric analysis of the meaning of "things".[4] At the beginning of the twenty-first century, experts from other disciplines such as cultural geography, technology studies and political theory, begin to engage in the discourse of material studies. Opening the dialogue across disciplines encourages studying material relationships to extend to other beings, introducing a "more-than-human world" for material culture studies.[5] Composed of complex material relationships, landscapes and the built environment can be examined through material culture studies to go beyond the fixed boundaries of the site. One Stone, Three Processes: A Material Culture Study on Queenston Limestone stems from a desire to understand materials through their relationship with the "more-than-human world". Through an extensive literature review on material culture studies, I summarised three themes that guide this exploration of Queenston Limestone's material relationships. They were initially developed as independent themes, each paired with a different location to explore aspects of the material. Later in the thesis, it became evident that these themes are interrelated.

Assemblages – The premise of this thesis is based on interpreting landscapes and social environments as assemblages. Gilles Deleuze defines an interrelated network of diverse matters as an assemblage.[6,7] It is the space of events where vital human and non-human players come together, forming an interrelated network.[8] Landscapes, composed of vibrant materials, are assemblages that transform in relation to time and space. In the book, Reciprocal Landscapes: Stories of Material Movements, Jane Hutton shows the interconnective nature between materials and their landscapes by tracing material trajectories.[9] Guano used as fertiliser to enrich the soil in Central Park, New York City, tells the story of slavery, a wounded ecosystem and depleted terrain in Chincha Islands, Peru.[10] By pairing the materials' extraction sites to their urban designed sites, Hutton reveals that the growth of one urban landscape is often at the cost of a landscape elsewhere.[11] This shows that landscapes must not be examined as isolated entities, but as embedded with relationships that extend beyond their current site boundaries. In this thesis, Queenston Limestone is viewed as a player in assemblages such as its extraction site, in the craft environment, and at the design site. As Queenston Limestone travels through assemblages, it becomes the thread that connects these networks for dialectical thinking.

Material Agency – The concept of material agency emphasises how materials hold power to impact the elements they interact with. This relates to the positioning of this thesis, where I identify materials as active participants in the built environment. Bennett also identifies

4. Dan Hicks and Mary C. Beudry, "Introduction: Material Culture studies: a reactionary view," in *The Oxford Handbook of Material Culture Studies, ed. Dan Hicks and Mary C. Beaudry* (Oxford: Oxford University Press, 2010), 2.

5. Dan Hicks and Mary C. Beudry, "Introduction: Material Culture studies: a reactionary view", 3.

6. Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham: Duke University Press, 2010), 1.

7. Claire Colebrook, "A Guide to Key Deleuzean Terms," in *Understanding Deleuze* (Oxford: Routledge, 2002), 10.

8. Bennett, *Vibrant Matter*, 20.

9. Jane Hutton, *Reciprocal Landscapes*, 11.

10. Jane Hutton, *Reciprocal Landscapes*, 26-56.

11. Jane Hutton, *Reciprocal Landscapes*, 218.

materials as vital players that produce effects in the world, and describes materials' ability to interact and affect other beings as "thing-power".[12] The interconnected nature of assemblages implies that a change in a player will influence the results of an entire network. Thus, as vital players in the built environments, materials' transformations are directly related to how the environment is shaped. In this thesis, I describe materials as having the agency to emphasise the animacy of materials. Human and non-human forces shape the material, while the materials become actants that affect their surroundings' social, cultural and material landscape. For the remainder of the thesis, I refer to Queenston Limestone as they instead of it to emphasise this concept. I also choose to capitalise on Queenston Limestone for the same reason. This thesis studies the environmental forces that shaped Queenston Limestone's properties, and investigates how Queenston Limestone influences its surrounding landscape.

Human Work – It is impossible to omit the importance of human work while discussing the value of materials, specifically building materials. Hannah Arendt defines work as the fabrication of things that creates objects with durability, and believes that work is central to human identity and the human condition.[13] When humans put in the time, labour and creativity to create, the created objects resist decay and outlast the human experience. In this process, materials become an avenue for self-expression of human identity, establishing permanence in the world. Through the process of work, humans transform the built environment. At the same time, the human experience is shaped by the material. The relationship between materials and human work is reciprocal: material properties inform the work; the work shapes the material, and the quality of work gives materials permanence.[14,15] This thesis analyses how Queenston Limestone is extracted, shaped, and designed, to investigate how the material influences human activities such as quarrying, stone crafting and design. And how, simultaneously, humans transform the material and give them new meaning during each process.

12. Bennett, *Vibrant Matter*, 20.

13. Hannah Arendt, "Work" in *The Human Condition* (Chicago: University of Chicago Press, 1958), 137

14. Richard Sennett, The Craftsman (New Haven, CT: Yale University Press, 2008), 7-8.

15. Arendt, "Work" in *The Human Condition*, 143.

Thesis Orientation

This thesis comprises three parts, which interact with Queenston Limestone at three different locations to explore these themes. The three locations, are assemblages where sets of relationships related to Queenston Limestone occur. The three locations I identified and investigated are as such; the Queenston Quarry, where Queenston Limestone is formed; the crafting environment involved with refining and shaping Queenston Limestone, and designing with Queenston Limestone. [Fig. 0.0] Each part explores how Queenston Limestone interacts with different bodies and forces at each site. By revealing these connections, I see how the transformation of Queenston Limestone at one site relates to another. I hope to understand the material's value through these relationships.

Part One: Landscape as Culture includes an in-depth study of the Queenston Quarry landscape through site visits, drawings and archival research. From various site visits, I translate information extracted from quarry visits into drawings that depict the fundamental geology of the quarry. This investigates the non-human forces that shaped the geological properties of Queenston Limestone. Detailed drawings of quarry faces also show marks of previous extraction and production processes, and evidence of human work performed on the material. A historical timeline is drawn from local archives and mining reports, showing the shift in landscape from a forested landscape to agricultural land, followed by the quarry and mixed-use residential development. Paired with Queenston Limestone's rise and fall in demand over time, these historical connections exhibit how the material influenced the region's social, economic and landscape development.

Part Two: Crafting Discards re-connects me with the material through handcraft and reuse. I conducted three material experiments using discarded Queenston Limestone pieces and the traditional method of dry-stone stacking. This section takes knowledge from literature, workshops and hands-on practices to learn the foundations of the craft. Both the act of handcrafting and reuse become practices that shows the value of human work and the material agency of Queenston Limestone. Each experiment utilises different techniques to capture an aspect of Queenston Limestone. The improvisation and makers' marks left during crafting pay tribute to the human work invested in the quarry. This gives the material an additional layer of meaning in a social and cultural context that resists the uniformity and soulless process of machine production.

Part Three: Translating Materials is a design exercise of an outdoor stone crafts classroom for Willlowbank's Laura Secord Campus. This design exercise focuses on understanding Queenston Limestone and the proposed site as assemblages to explore the implications of designing with the material. Also situated in Queenston, the proposed design is envisioned to be constructed with discarded stones from the Quarry, utilising techniques learned from part two of the thesis. It includes a crafting area and an

exhibition area. Part two of the thesis provides a reference for how to design for the process of dry-stone stacking. Inspired by the Queenston Quarry face, the featured wall that leads to the exhibition area introduces visitors to discover the afterlives of Queenston Limestone in art forms. The final design proposal synthesises findings from previous exercises to design a space grounded in Queenston Limestone's materiality while considering how the design interacts with different active bodies in the chosen site.

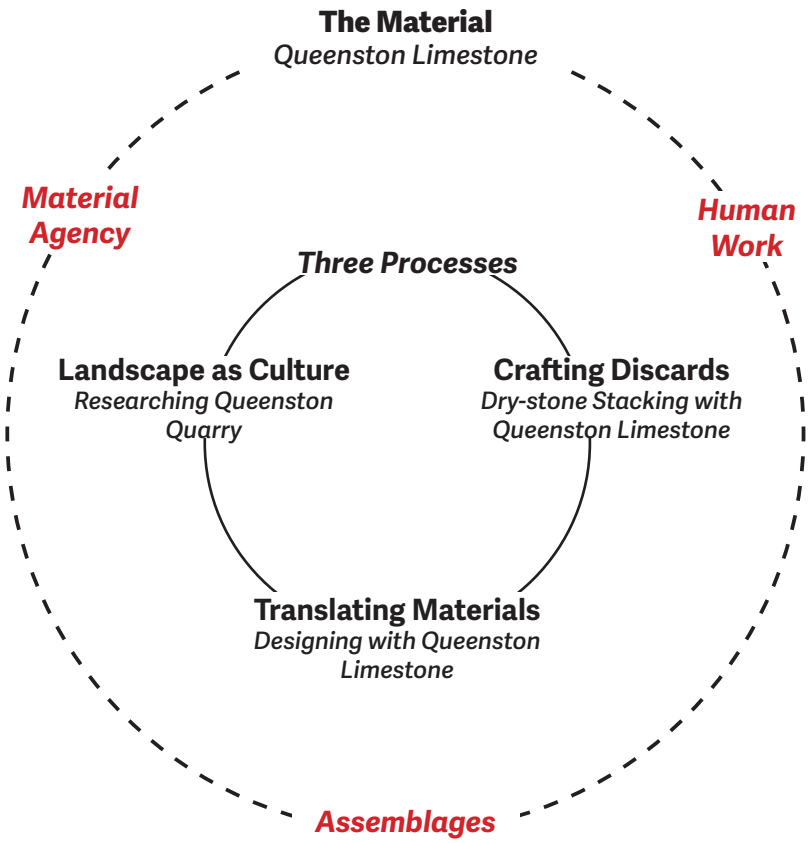


Fig. 0.0 Thesis Concept Diagram, by author.

Thesis Orientation

Landscape as Culture

Introduction

Queenston Limestone is recognised as the highest calibre limestone in Canada, earning a reputation as the "Corner Stone of Upper Canada" for their durability and pleasing aesthetics.[1] The stone has been used locally in the St. David's and Queenston area for over two hundred years.[2] Situated in Queenston, Ontario, at the brow of the Niagara Escarpment, the Queenston Quarry is the only place to obtain Queenston Limestone. [Fig. 1.0]

Robert Smithson's site and non-site theory explains how materials, displaced from their production site, are means for dialectical thinking.[3,4] They are part of an assemblage, embedded with relationships from previous sites. Thus, the transformation of one material not only influences the assemblage itself, but is also related to transformations elsewhere.[5] This section of the thesis tries to understand Queenston Limestone as a fragment of the quarry assemblage to examine the geological and human transformations of the material.[6] The active role of the material is revealed by studying the interaction of Queenston Limestone with other landscape elements.

Using the extraction site as the starting point, this part of the thesis investigates the value of Queenston Limestone through an in-depth analysis of Queenston Quarry. It looks at the material before they become market resources, focusing on the human and non-human forces interacting with Queenston Limestone within the network. First, I examine the geological processes that form the material properties of Queenston Limestone, then investigate the material's relationship with the technological advancements in quarrying methods. Lastly, I look at how the extraction of Queenston Limestone altered the landscape and drove the development of Queenston's local economy.

Fig. 1.1 Exposed rock surfaces at Queenston Quarry, image by author.

1. "Stone," Queenston Limestone, Queenston Quarry Reclamation Company Ltd., The Cellars of Niagara-on-the-Lake, Queenston Limestone. Accessed March 29, 2022. http://www.queenstonlimestone.com.

2. "Stone," Queenston Limestone.

3. Robert Smithson, "A Provisional Theory of Non-Sites (1968)," *In Robert Smithson: The Collected Writings*, ed. Jack Flam (Berkley: University of California Press, 1996), 364.

4. Jane Hutton, Reciprocal Landscapes: Stories of Material Movements (Oxford: Routledge, 2020), 3.

5. Hutton, *Reciprocal Landscapes*, 3.

6. Hutton, *Reciprocal Landscapes*, 5. This section of the thesis takes a similar perspective to how Jane Hutton investigates materials in her book. Jane Hutton uses three approaches - "materials-in-motion", "material exchange" and "material culture" - to examine the connections formed in global material circulation. This thesis looks at materials at a local scale.

Methods

This section uses three methods to analyse the quarry. I started with field visits and documenting the quarry, bringing back information I resonated with for analysis, performing additional archival research, and synthesising them into completed drawings. These three methods provide feedback to one another. Photographs and archival research on quarrying methods inform the content of the drawing, where my personal experience on-site determine the format and medium.

Field Work - Field work in architecture is a process of reflection and action to a site that traverses time, space, and perspectives boundaries.[7] When I walk through the quarry, I begin to understand the vastness of the quarry. Getting up close and personal when touching the stone surfaces, I understand the contrasting texture between polished stone pieces and the raw quarry face. Site documentation practices such as photographs, sketches and field diaries note down aspects of the site that resonated with me. When I draw interdiciplinary knoweldge to analyse the landscape, I see the social, industrial and economic factors that influence the site. The site is no longer static, and field work becomes a method of interpreting a site as a network that is in constant transformation.[8]

Archival research - To me, field work is an intimate way to understand the site through my senses and feelings in the present, and archival research is a method that draws historical connections to the site's evolution. My research includes photos from the Niagara-on-the-Lake Public Library, lectures at the Niagara-on-the-Lake Museum, mining reports of Ontario, and documents from the Public Archives of Canada. I collected the information to create a visual timeline of the quarry's development. The timeline is represented as a series of thumbnail images, several of which also serve as footnotes for the details of the large drawings to provide additional explanation. When the timeline is compared to the rise and fall of Queenston Limestone, I see the links between the material and the ever-evolving landscape.

Drawing - I synthesise and visualise my findings from field work and archival research through drawing. Drawing the site assembles snippets of information to discover new relationships.[9] The format, medium and technique I choose reflect how I interpret my findings. Elevation drawings best represent contrasting formations. The drawings are done in large formats to emphasise the scale of the quarry, while still capturing the relationship between different quarrying methods. I use earth-tone graphite to depict the grounded nature of the quarry, and blue-grey graphite to emphasise the colouring. Various techniques are used to highlight the difference in quarrying methods. Sharp, vertical streaks are drawn with the side of a graphite stick to show the dense vertical strikes of the channeling method on the quarry face, and a soft, finger rub of graphite colour was applied to show the Knox method and its resulting smooth quarry surface.

7. Chris Speed, "Field/ Work and Site – Introduction," in *Architecture and Field/ Work*, ed. Suzanne Ewing, Jérémie Michael McGowan, Chris Speed and Victoria Clare Bernie (Oxford: Routledge, 2011), 61,63.

8. Speed, "Field/ Work and Site – Introduction,"61-62.

9. Claudia Mitchell et al., "Drawing as Research Method" in *Picturing Research: Drawing as Visual Methodology*, ed. Linda Theron et al. (Rotterdam: Sense Publishers, 2011), 19.

Quarry Geology

The investigation into Queenston Limestone begins with looking into the geological processes that shaped the stone's unique material properties. The landscape from which this precious stone is extracted, the Queenston Quarry at Niagara Escarpment, has over 450 million years of history.[10] [Fig. 1.1] Sitting at the brow of the Niagara Escarpment, the quarry was part of the migration from the bottom of the Silurian Sea south of the paleo-equator to its current location.[11] [Fig. 1.2] This geological shift brought along the identifying feature of Queenston Limestone – the presence of crinoid fossils. Crinoids were marine life from 430 million years ago, which once thrived in the Silurian Sea's warm, tropical marine environments.[12] The remains of Crinoid fossils are one of the most identifying features of Queenston Limestone today. They are evidence of the millions of years of geological transformation embedded within the stone. As the marine environment evolved over millions of years of chemical reactions involving pressure and heat, the remains of these marine lives combined with accumulated calcium carbonate to form Queenston Limestone.[13] These natural processes gave Queenston Limestone its unique blue-grey colouration and exceptional durability.

10. "Niagara Escarpment Conservation," What We Do, Bruce Trail Conservancy, updated February 15, 2023, https://brucetrail.org/what-we-do.

11. Frank Racioppo, "The Queenston Quarry," (lecture, The Niagara-on-the-Lake Museum – Niagara Historical Society, Niagara-on-the-Lake, ON, March 24, 2021), https://www.youtube.com/watch?v=JgKppfk3L04 .

12. Robert Watson, "Geology of Niagara Building Stones" (unpublished manuscript, last modified September 23, 2016), Microsoft Word file. Robert Watson is a local geologist in the Niagara Region. Formally a faculty member of Willowbank, he generously lent me this unpublished textbook along with the research he complied over the years to assist with my thesis.

13. Racioppo, "The Queenston Quarry."

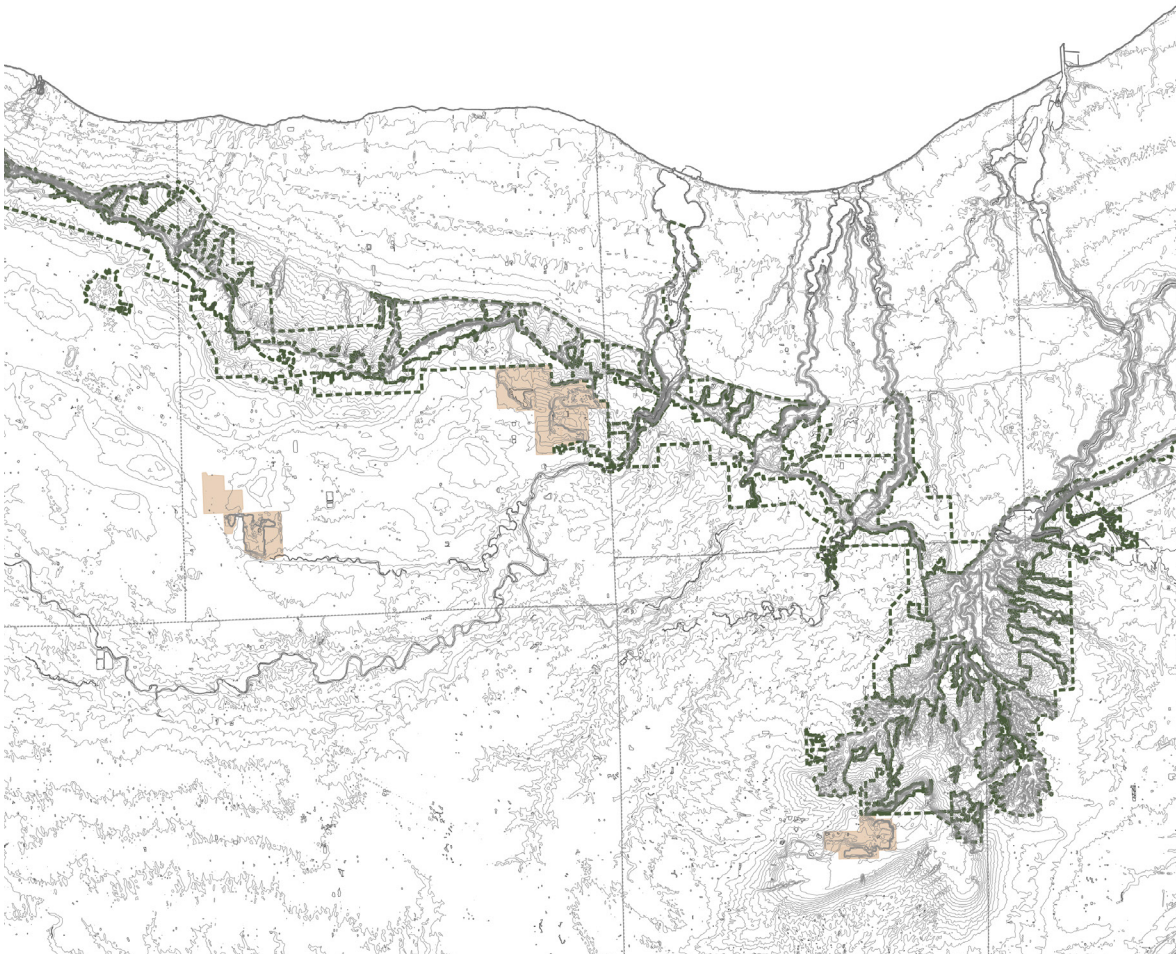
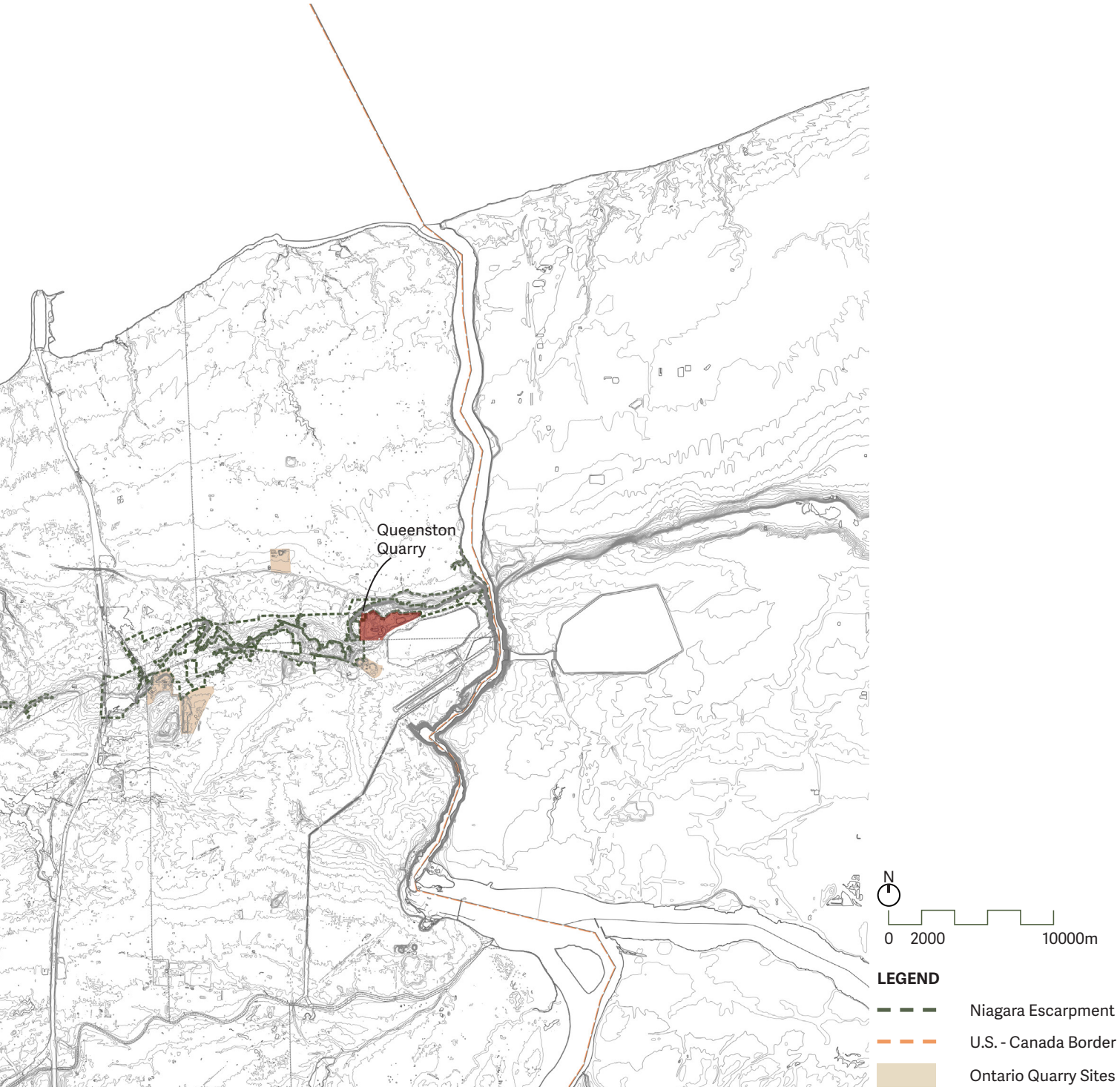


Fig. 1.2 Mapping the Niagara Escarpment, image by author.

Quarry Geology



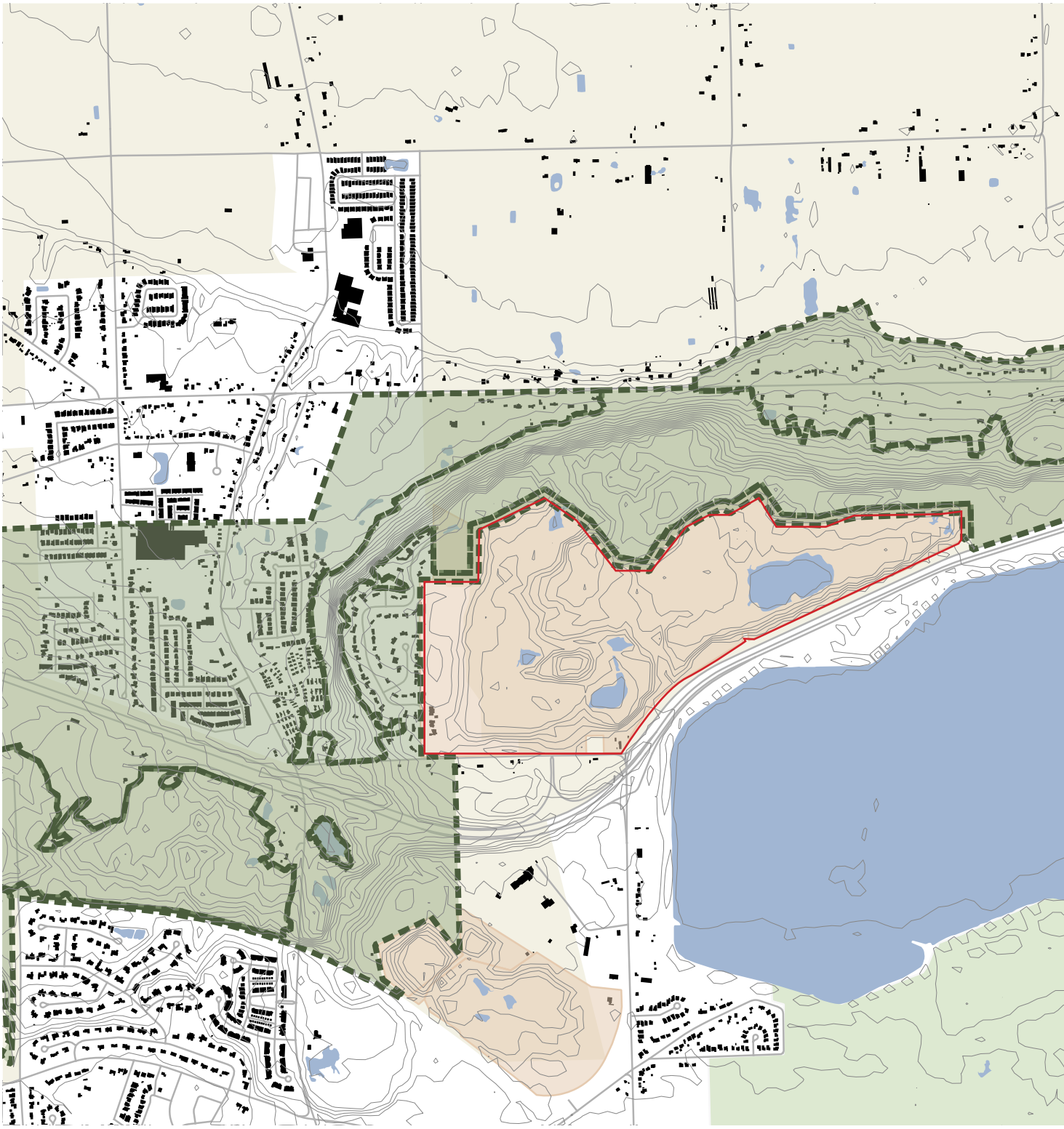
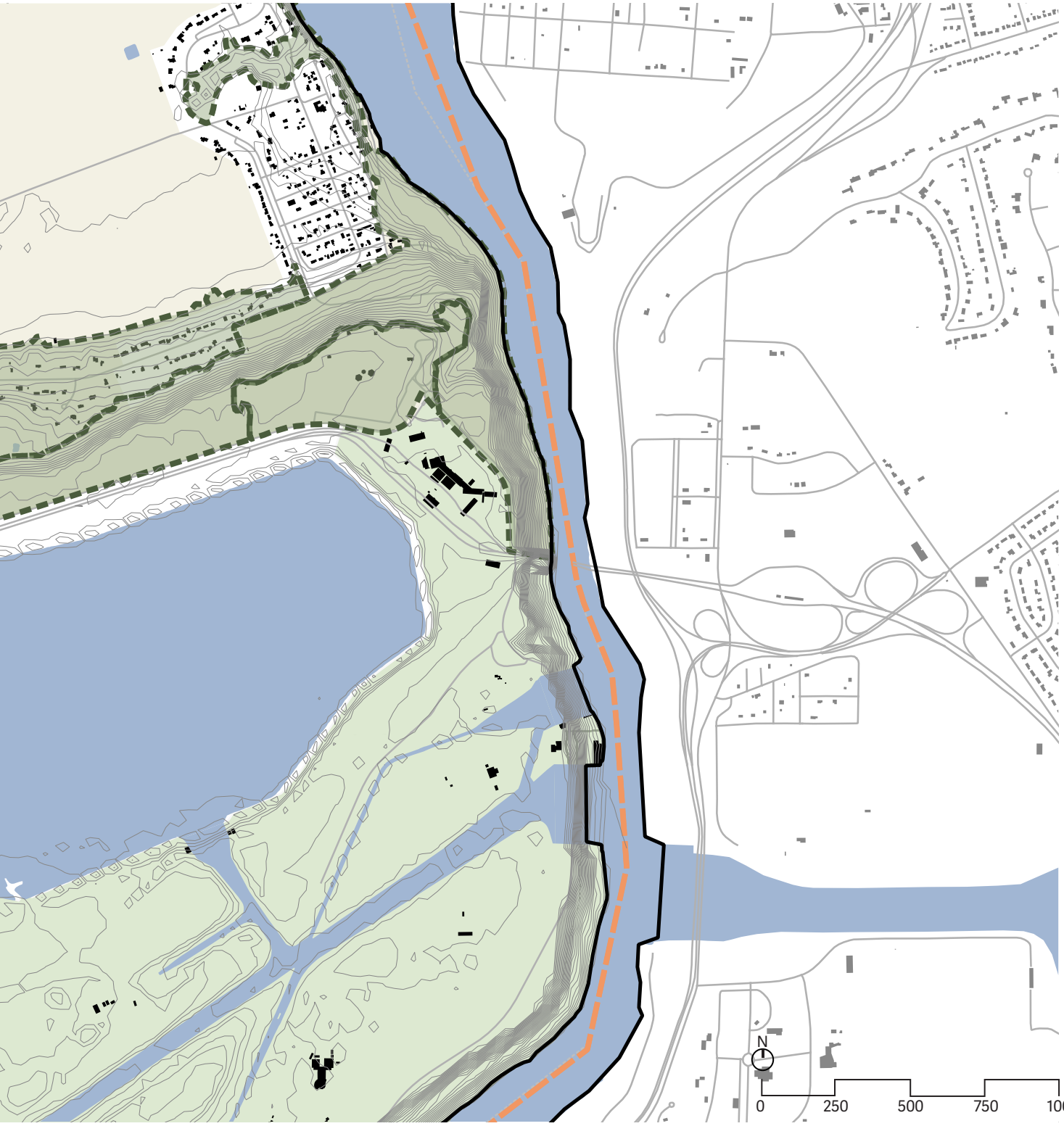


Fig. 1.3 Context Mapping of Queenston Quarry, image by author.



LEGEND

- Niagara Escarpment
- Queenston Quarry
- U.S. - Canada Border
- Water Body
- Buildings
- Aggregate Sites
- Unique Agricultural Land
- Rural Area

The Niagara Escarpment is part of a geological formation named the Guelph-Lockport dolomite, which extends from Niagara Falls through Hamilton, north through Georgetown and Orangeville to the Bruce Peninsula.[14] The dolomite is divided into three formations - the Lockport (the lowest part of the dolomite that forms the Queenston Quarry), Amabel and Guelph. The Lockport formation is divided into three members: the Gasport, the Goat Island, and the Eramosa Member.[15] [Fig. 1.3] These compose the majority of the Queenston Quarry. The depths of the different formations are not uniform around the quarry and vary significantly from east to west. According to the 1960 report, The Limestone Industries of Ontario, the quarry is approximately thirty-eight feet deep, thirty-three of which is the Gasport member, and the remaining three feet consists of the Goat Island Member.[16]

The Goat Island member is easily distinguishable from the Gasport member. The change in lithography is shown through a colour gradient on the Quarry surface. Lithology is the physical characteristic of a rock unit visible on an exposed rock surface.[17] The Gasport member is light-grey, whereas the Goat Island has a dark- to medium-brown colour, and is aphanitic (fine-grained).[18] The Gasport member has a steelish grey-blue colour, which is the signature colouring of Queenston Limestone. Some gradients transform into a light brown-pink as the extraction moves closer to the Goat Island member. The bottom sections of the Gasport member in the quarry are building-stone ledges, of around ten to sixteen feet thick, where dimensional building stones are extracted.[19] Once removed, the stone ages towards a warm-grey patina over a decade of exposure.[20]

Below the Lockport sits the Decew dolomite, visible on the west side of the Quarry. It is a bedding approximately one meter deep and was used for lime extraction to produce natural cement.[21] Where the Decew dolomite has eroded, the Gasport formation directly sits on the Rochester Shale, which is visible on the East side of the Quarry.[22] [Fig. 1.4] However, the different layers of the formation have eroded over time. Most of the quarry faces are now buried under clay. The current owner of the quarry is in the process of uncovering these surfaces and the Quarry faces on the North and East side have sections where the Gasport member is now visible. [Fig. 1.5]

14. D.F. Hewitt, *The Limestone Industries of Ontario,* (Toronto: Ontario Department of Mines, 1960), 88. http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/IMR014//IMR014.pdf

15. Hewitt, *The Limestone Industries of Ontario*, 88-90.

16. Hewitt, *The Limestone Industries of Ontario*, 91.

17. "Lithology," Terminology, SEPM Strata, Society for Sedimentary Geology, last modified November 11, 2021, http://www.sepmstrata.org/Terminology.aspx?id=lithology.

18. D.F. Hewitt, *The Niagara Escarpment*, (Toronto: Ontario Department of Mines, 1971), 29-30. https://www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/IMR035/IMR035.pdf.

19. D.F. Hewitt, *Building Stones of Ontario Part II*, (Toronto: Ontario Department of Mines, 1964), 4-5. http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/IMR015//IMR015.pdf.

20. "Stone," Queenston Limestone.

21. Linda Fritz, "History Unveiled: The Quarrymen of Queenston," Niagara Now, November 16, 2019, News, https://niagaranow.com/news.phtml/3002-history-unveiled-the-quarrymen-of-queenston/

22. Hewitt, The Niagara Escarpment, 33.

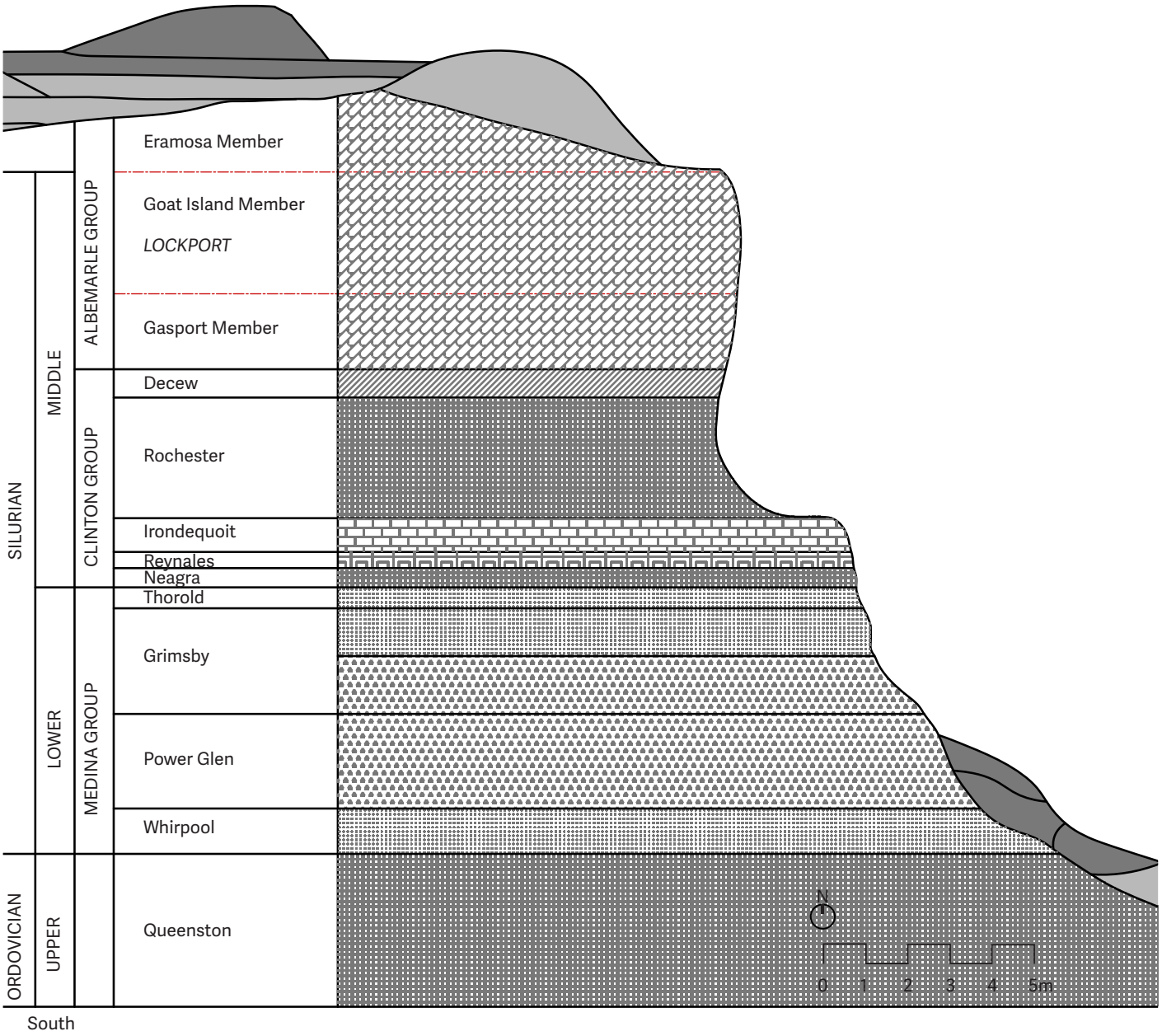
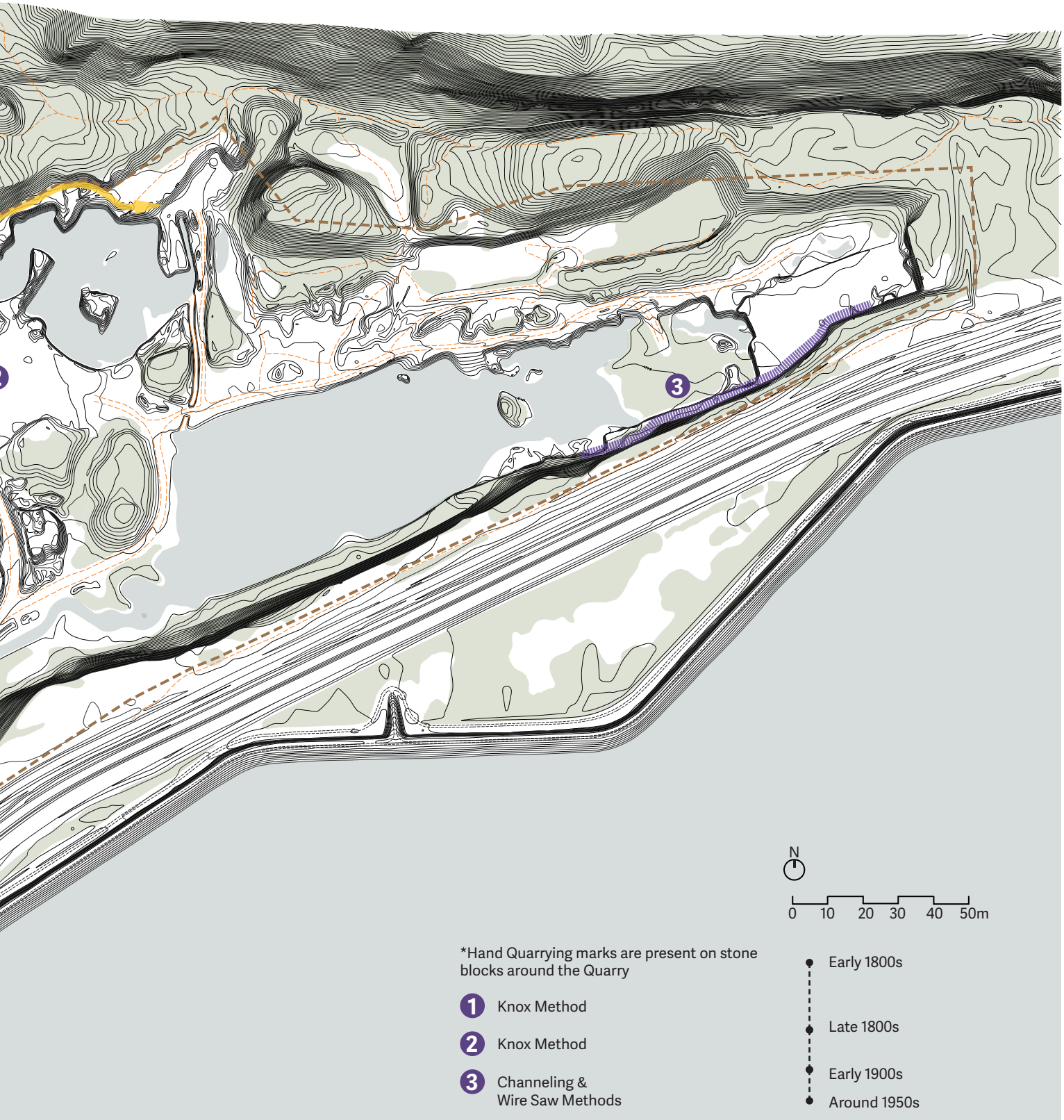


Fig. 1.4 *Geological Section across the Niagara Escarpment near St. Catherine's*, adapted from Niagara Rocks, Building Stone, History and Wine, re-drawn by author. Middleton, Gerard V., Nick Eyles, Nina Chapple and Robert Watson. *Niagara Rocks, Building Stone, History and Wine*. American Geophysical Union and Geological Association of Canada, Field Trip A3: Guidebook, May 23, 2009, 12.

Fig. 1.5 Perspective Section Facing West Side of Queenston Quarry, 22"x 90", at 1:500 scale, graphite and pencil drawing by author. This geological section shows the depth of quarrying activities once present on the landscape. The volume of geological formation removed from site is revealed, along with the different formation layers beneath the Queenston Quarry. It also shows the gasport member exposed on the west side of the quarry.

Fig. 1.6 Plan Axonometric Drawing of Queenston Quarry, Image by author.


3
N
0 10 20 30 40 50m
*Hand Quarrying marks are present on stone blocks around the Quarry
1 Knox Method
2 Knox Method
3 Channeling & Wire Saw Methods
Early 1800s
Late 1800s
Early 1900s
Around 1950s
Extraction Order & Direction
Exposed Surfaces
Paths
Quarry Boundary
Tree Covering
Water Body

Extracting Stones

Queenston Limestone's distinctive material properties result from the natural landscape processes, while its extraction by human activities renders it suitable for use as a building material. This section details the different quarrying methods throughout the history of Queenston Quarry, to understand the ***human work*** involved in the materials' extraction process.

As previously mentioned, the building-stone ledges of the Gasport member are inconsistent around the quarry. The beds within the building-stone ledge of the Queenston quarry are around two to seven feet thick, determining the maximum thickness of mill blocks removed from the bed.[23] Thus, the building stone ledge is what governs the quarrying practices of Queenston Quarry. In geologic terminology, a bed is a three-dimensional rock body distinguishable from layers above and below. Bedding planes, or bedding partings, separate the beds from each other with defined surfaces.[24] [Fig. 1.6] The bedding planes of the Gasport Member are also relatively closely spaced, which allows for a wide variety of quarrying methods. The spacing of vertical joints within beds determines the actual size of the mill blocks.[25] After being stripped off the overlying rocks, the beds are examined for vertical joints ranging from ten to fifty feet apart on a case-by-case basis.[26] Depending on the quarrying method employed, blocks are then removed from the bed. The report from the Ontario Department of Mines, Building Stones of Ontario, Part 1, by D.F Hewitt, describes each technique in full detail. The quarrying methods detailed in this section are primarily based on this report.

Different quarrying methods leave unique markings on the exposed rock surfaces, indicating what was once present. Queenston Limestone's extraction started from the north side of the quarry to the southeast side.[27] The markings on quarry surfaces changed accordingly, and are physical evidence of how the methods have evolved. The markings of stone blocks extracted with specific methods retain these marks – some are removed during processing, yet many remain visible. It is important to dive deeper into Queenston Limestone's extraction and refinement process to understand the amount of *human work* involved.

23. Hewitt, *Building Stones of Ontario Part II*, 4.

24. Charles V. Campbell, "Lamina, Laminaset, Bed and Beset," Sedimentology 8, no. 1 (February 1967): 8. https://doi.org/10.1111/j.1365-3091.1967.tb01301.x.

25. Hewitt, *Building Stones of Ontario Part II*, 4-5.

26. D.F. Hewitt, *Building Stones of Ontario Part I*, (Toronto: Ontario Department of Mines, 1964), 31. http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/IMR015//IMR014.pdf.

27. Watson, "Geology of Niagara Building Stones."

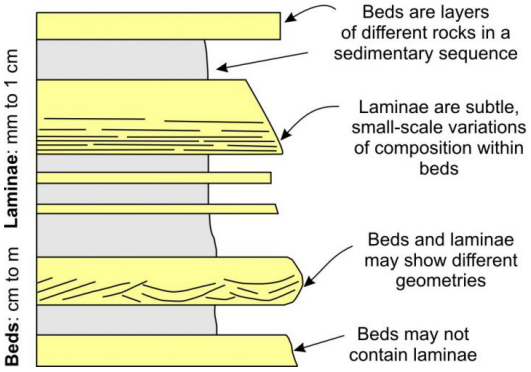


Fig. 1.7 Sketch illustrating geology beds and laminae, graphic by Samuele Papeschi/GW, https://geologyistheway.com/sedimentary/bedding-and-lamination/

Hand Quarrying

The hand quarrying method used at the Queenston Quarry is similar to that used at other small building-stone quarries across Ontario. In the early 1800s, before the quarry was transformed from farmland, it was the only method to extract stone from the quarry. As one of the earliest quarrying methods known, it was used for extracting various materials such as sandstone, granite, and limestone.[28] [Fig. 1.7]

28. Hewitt, *Building Stones of Ontario Part I*, 32.

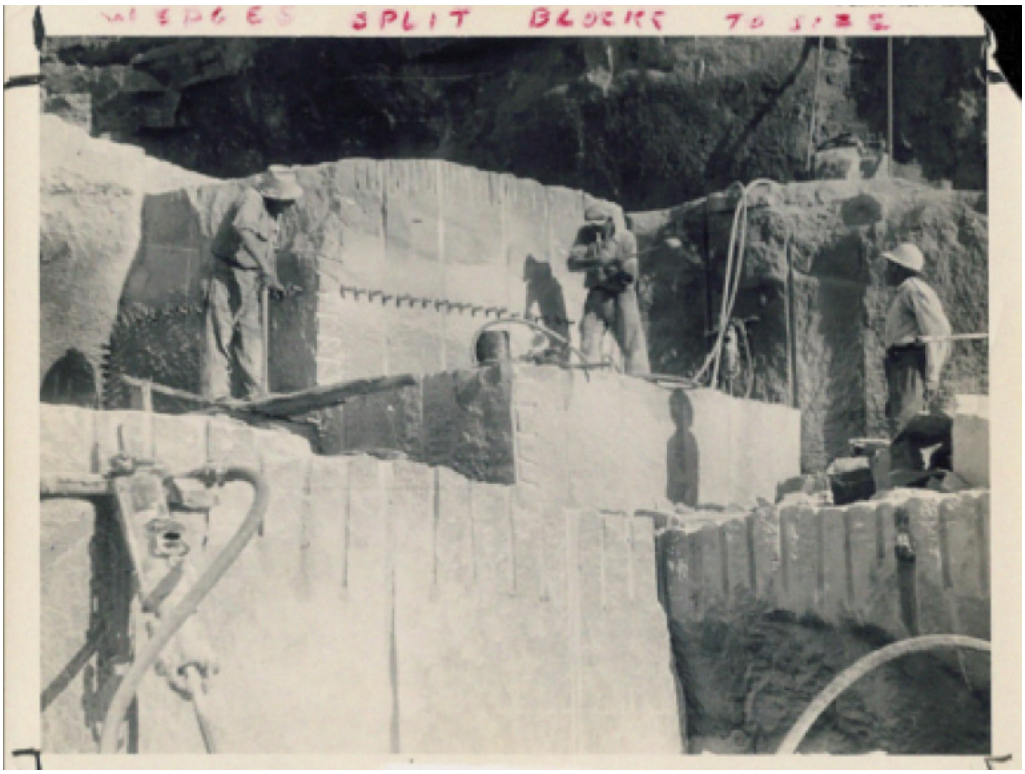


Fig. 1.8 Photograph showing workers hand-quarrying at Queenston Quarry, red text above reads "wedges split blocks to size", Kathy Thomas, retrieved from https://niagaranow.com/news.phtml/3002-history-unveiled-the-quarrymen-of-queenston/.

The drawing on the following page illustrates the process of this ancient technique.

29. Hewitt, *Building Stones of Ontario Part I*, 32.

30. Hewitt, *Building Stones of Ontario Part I*, 32.

31. Dave Butler, "The Split Stones of Holbrook Hill," *Piscataquog Land Conservancy,* July 9, 2020, https://plcnh.org/split-stones-of-holbrook-hill-2020/ .

32. Dave Butler, "The Split Stones of Holbrook Hill."

33. Hewitt, *Building Stones of Ontario Part I*, 32.

34. Watson, "Geology of Niagara Building Stones."

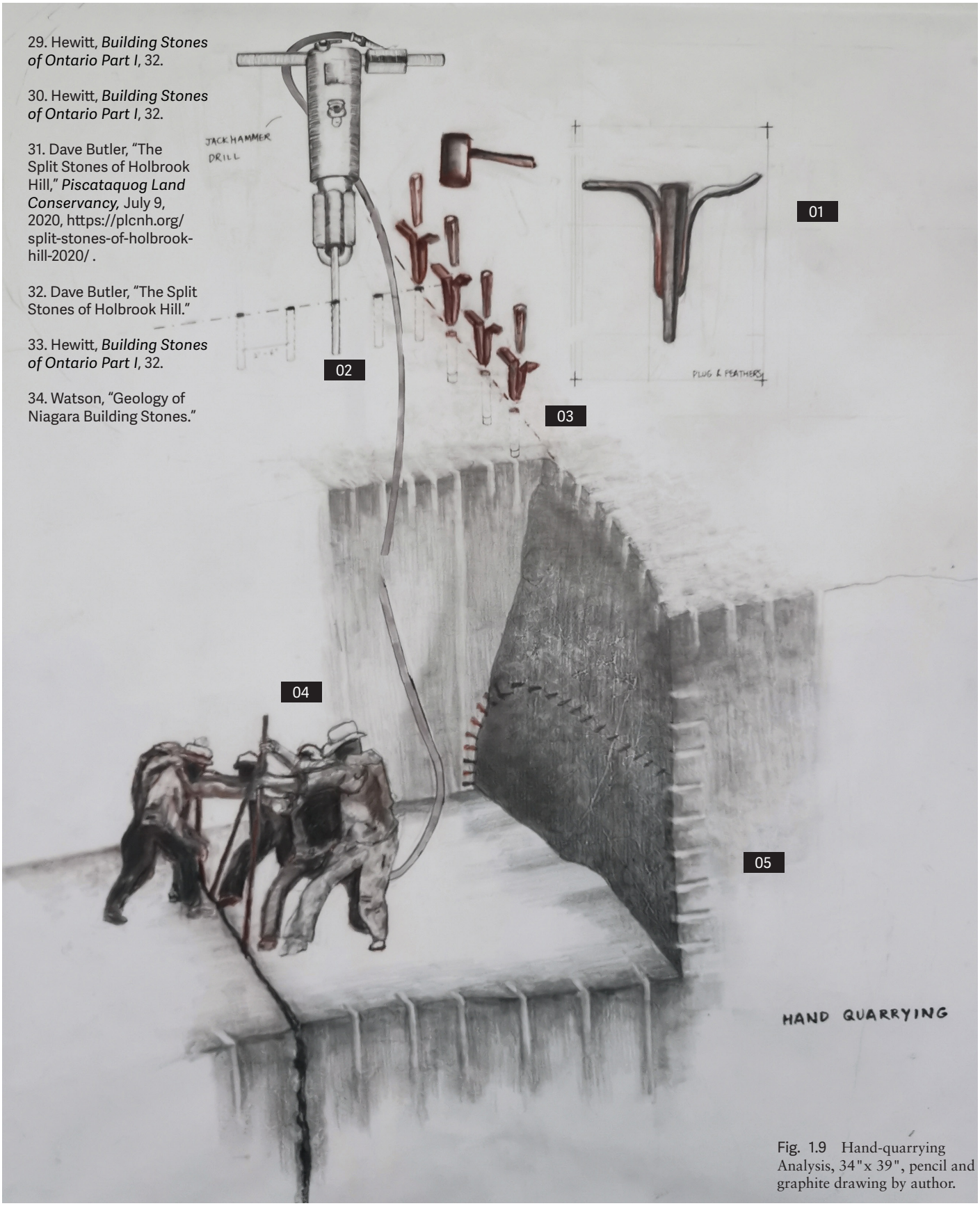


Fig. 1.9 Hand-quarrying Analysis, 34"x 39", pencil and graphite drawing by author.

Fig. 1.10 Photograph showing plugs and feathers in various sizes, Reiner Flassig, Wikimedia Commons.

01: The technique used for hand-quarrying is called plug and feather. The name of this technique takes after the tools used – a metal wedge, which is the plug, and two shims, called the feathers.[29]

Fig. 1.11 Photograph showing worker using Jackhammer drill in a quarry, Halvard, Wikimedia Commons.

02: A series of short vertical holes are pre-drilled six to twelve inches apart, usually four to five feet parallel from the quarry face using hand-held hammer drills.[30,31] The number of holes drilled indicates the length of the block. Sometimes horizontal holes are drilled to lift the block. Where the bed thickness is up to seven feet thick, the holes are filled with black powder and blasted lightly to break a large block off the quarry face.[32]

Fig. 1.12 A block of marble prepared with wedges for splitting, Reiner Flassig, Wikimedia Commons.

03: For larger blocks already broken off the quarry face, or parts of the quarry with thinner beds, the feathers (shims) are inserted into pre-drilled holes perpendicular to each other. Occasionally, when working with smaller blocks, cape chisels and plug drills are used to create the holes. Plugs (wedges) are then driven into the shims using a heavy sledgehammer. The feathers expand as the plugs are driven in. Eventually, the drilled points will form a break line along the plug and feather.[33]

Fig. 1.13 *Workers of the Queenston Quarry Compay*, workers splitting mill blocks with crow bars, Niagara-on-the-Lake Public Library, Collection of Alan Clifford, NOTLPL00227-03 to NOTLPL00227-11.

04: Using crowbars, stone blocks are split off simultaneously at multiple points of the break line. This step is unnecessary when blocks are smaller, as the break line created from the plug and feather is enough to split off the block.

Fig. 1.14 Stockpile - Queenston Limestone, A. H. Tiplin, Niagara Falls Public Library Heritage Foundation Collection, D11766.

05: The plug and feather technique leaves short vertical marks on the quarry's face. On stone blocks where plug drills are used, the tool's unique shape leaves grooves that are wider on the top of the stone face and narrower at the bottom. Instead of chiselling out the markings, many stone masons who used these building stones intentionally kept the markings as an ode to the quarry workers.[34]

The Knox Method

The Knox method was first developed in the late 1800s.[35] It was used at the Quarry during the nineteenth century. This method combines drilling and blasting based on the Knox Blast theory.[36] [Fig. 1.14] For this method, the desired block must be "bounded by a free quarry face and two joints at either end, or by one joint and an open end where the adjacent block has been removed." The vertical joints for Queenston Quarry limestone beds range from ten to fifty feet apart; these joints determine the length of the blocks removed.[37]

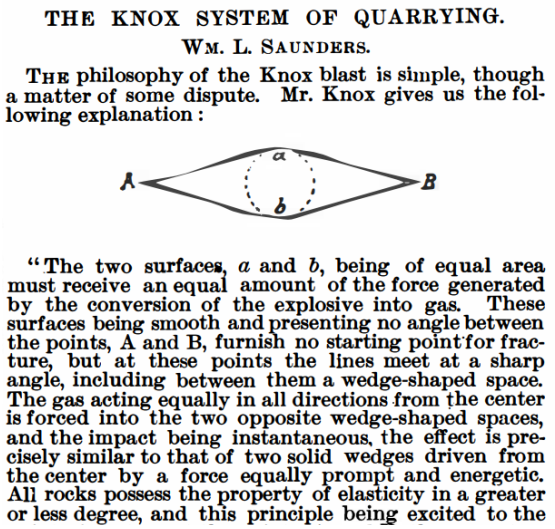
Once a block is determined, steam-powered drills drill holes parallel to the front quarry face and perpendicular to the break line. Each hole is around one and a half inches in diameter. This is called a "back-wall" cut, usually ten to twelve feet from the face. The drill holes are widened out using a Knox bit and lightly filled with tamping – a pack of clay and sand that helps concentrate forces of explosions - and black powder to be detonated with an instantaneous cap. This leaves an air pocket between the charge (explosive) and the tamping in each hole. These pockets are fundamental to the success of the Knox method, as they orient the force of the explosion to be exerted in a broader surface area. Each bed is charged when horizontal bedding planes in the block are quarried. The Knox method leaves groove marks approximately twelve feet apart on the quarry face and extracted quarry block. [Fig. 1.15] After the quarry block is removed, plug and feathers are used to split mill blocks that range from four to twenty tons in weight.[38]

35. Wm. L. Saunders, "The Knox System of Quarrying," *Scientific American Supplement*, no. 836 (January 9, 1892): 13356, https://doi:10.1038/scientificamerican01091892-13356supp.

36. Hewitt, *Building Stones of Ontario Part I*, 35.

37. Hewitt, *The Limestone Industries of Ontario*, 93.

38. Hewitt, *Building Stones of Ontario Part I*, 35.



THE KNOX SYSTEM OF QUARRYING.

WM. L. SAUNDERS.

THE philosophy of the Knox blast is simple, though a matter of some dispute. Mr. Knox gives us the following explanation:

"The two surfaces, *a* and *b*, being of equal area must receive an equal amount of the force generated by the conversion of the explosive into gas. These surfaces being smooth and presenting no angle between the points, A and B, furnish no starting point for fracture, but at these points the lines meet at a sharp angle, including between them a wedge-shaped space. The gas acting equally in all directions from the center is forced into the two opposite wedge-shaped spaces, and the impact being instantaneous, the effect is precisely similar to that of two solid wedges driven from the center by a force equally prompt and energetic. All rocks possess the property of elasticity in a greater or less degree, and this principle being excited to the

Fig. 1.15 Journal clipping showing the Know blast theory, Saunders, Wm. L. "The Knox System of Quarrying." *Scientific American Supplement, no. 836* (January 9, 1892): 13355-6. doi:10.1038/scientificamerican01091892-13356supp

Fig. 1.16 Elevation showing Knox Quarrying Method, 30"x 43", 1:25 scale, graphite and pencil drawing by author.

Channeling Method

In the early 1900s, channeling machines became increasingly available to the North American mining industry.[39] The channeling method is a combination of drilling and broaching. It uses compressed air to drill a series of closely spaced vertical holes to define the edges of desired stone blocks.[40] Broaching requires a sharp-toothed tool to remove material continuously and consistently, which helps remove the remaining material between the drilled holes.[41] Using quarrying bars as broaching tools, two to four drills are mounted and clamped onto each quarry bar to drill at the required angle. Drills then slide along the bar to drill parallel holes on all four sides of the stone block to split the stone. [Fig. 1.16] Similar to other methods, where the stone block is too thick, horizontal holes are required to lift the stone blocks.[42] Long, closely spaced vertical drill marks are visible along the quarry surface and on all four sides of the stone blocks. [Fig. 1.17]

39. Cathy Miglorie, "A Patent Success," *Rutland Herald Online,* updated October 27, 2018, https://www.rutlandherald.com/a-patent-success/article_21edcef6-c7ec-5d1f-b032-da6944ee0381.html.

40. Hewitt, *Building Stones of Ontario Part I*, 36-37.

41. Oliver Bowles, "Quarry Operations," in *The Technology of Slate* (Washington, DC: Government Printing Office, 1922), 31-32.

42. Hewitt, *Building Stones of Ontario Part I*, 36-37.

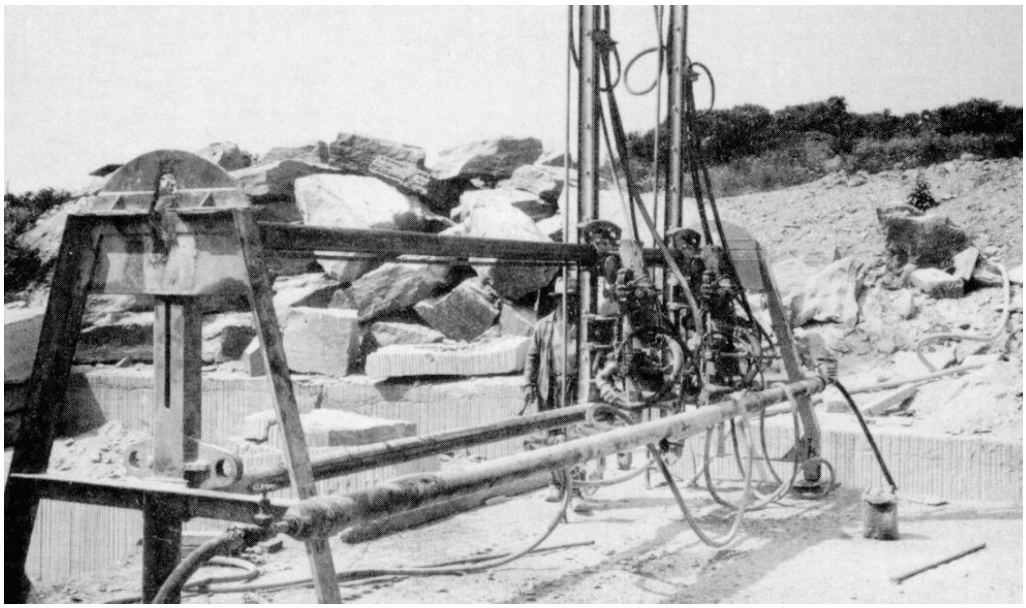


Fig. 1.17 Example of quarry bar with two drills set up at Peninsula Limeston quarry, Thorold, Ontario, D.F Hewitt, Building Stones of Ontario, Part 1, Introduction, 34.

Fig. 1.18 Elevation showing Chanelling and Wire-saw Method, 30"x 43", 1:25 scale, graphite and pencil drawing by author.

Wire Saw Method

The first wire saw machine was used in the United States in the 1950s.[43] This method uses a pulley system with a tension carriage to maintain tension on a three-strand steel wire that is one to two thousand feet long. Two guide standards are mounted at either end of the cut, thirty to a hundred feet apart, with an upper and lower guide pulley. The wire then travels over the guide pulleys to the cutting face, located between the lower guide pulleys, with sand or carborundum used as abrasives to cut. Where the pulley system cannot be employed at the ends of the desired block, drilling positions the pulley standards. [Fig. 1.18] Once a large block is quarried off the quarry face, the wire saw cuts the stone into blocks.[44] This method can be identified on clean and smooth surfaces of quarry faces, with cut marks at the edges where stone blocks are extracted.

43. Stefan Janusz Konstanty, "The Mechanics of Sawing Granite with Diamond Wire," *The International Journal of Advanced Manufacturing Technology*, no. 116 (July 10, 2021): 2591, https://doi.org/10.1007/s00170-021-07577-3

44. Hewitt, *Building Stones of Ontario Part I*, 37.

Fig. 1.19 Mill blocks of marble cut by wire saw at Tatlock quarry of Omega Marble Tile and Terrazzo Limited., D.F Hewitt, Building Stones of Ontario, Part 1, Introduction, 38.

Limestone Production

Once large stone blocks were extracted from the quarry and cut on-site, they were lifted by bars and forklift trucks onto derricks to the stone-cutting plant at the quarry. [Fig. 1.19 & Fig. 1.20] There were four electric derricks and two steam derricks that handled the quarried blocks in the quarry. One of them was used for stockpiling, while others were in production. A Mack truck with a semi-trailer twenty-ton float is used to haul mill blocks to the mill building. Railway flatcars are also used for the same purpose.[45]

45. Hewitt, *Building Stones of Ontario Part I*, 38.

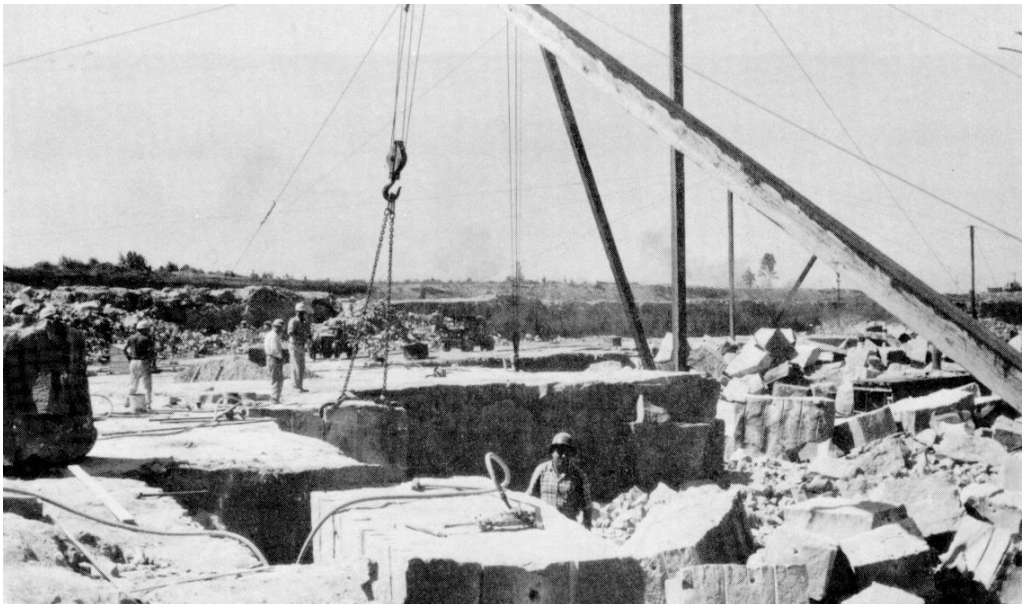


Fig. 1.20 Handling mill blocks of limestone at Queenston Quarries, Image by D.F Hewitt, Building Stones of Ontario, Part 1, Introduction, 9.

Fig. 1.21 Queenston Quarries, showing derricks transporting limestone to Queenston quarry stone yard, Gonder, Niagara-on-the-Lake Public Library Local History Collection, Francis J. Petrie Collection, D417697.

Within the stone yard, two travelling cranes service the mill. Diamond-toothed gang saws and gang saws that use silica sand as abrasives are used to cut large stone blocks into long slabs and dimensional stones.[46] [Fig. 1.21 & Fig. 1.22] The stone from the dressing plants is polished primarily and smooth on all sides, the most common form of Queenston Limestone in the building market.

The extraction of Queenston Limestone requires intense human labour and technical skills. At the same time, the evolution of extraction methods mirrors the technological advancements of the mining industry at the time. Each method leaves unique markings on the quarry face and stone blocks, evidence of this landscape's industrial past.

46. Hewitt, *The Limestone Industries of Ontario*, 94.

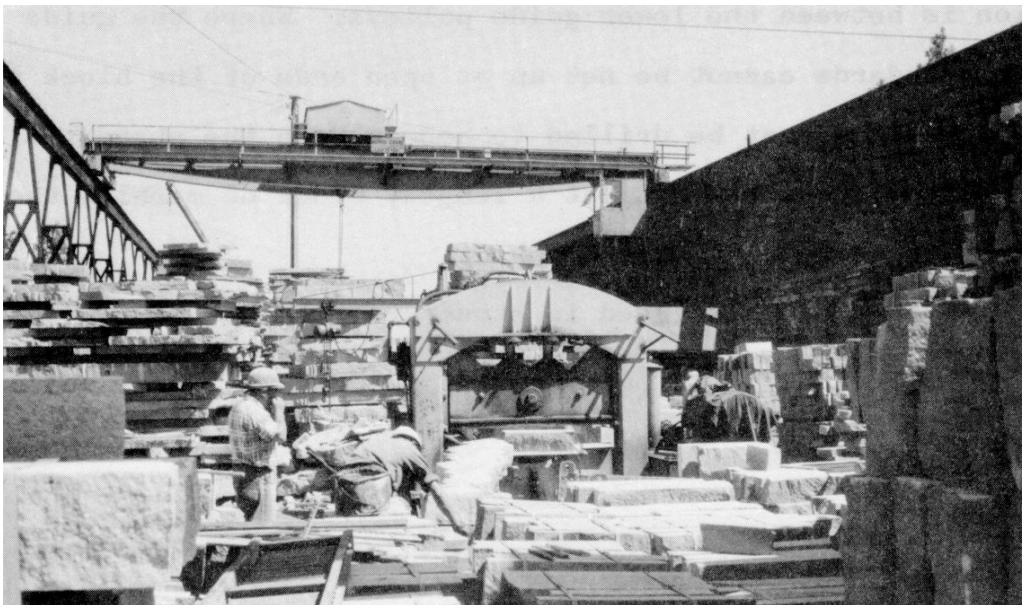


Fig. 1.22 Stone dressing yard at Queenston Quarries showing guillotine and overhead crane, D.F Hewitt, Building Stones of Ontario, Part 1, Introduction, 38.

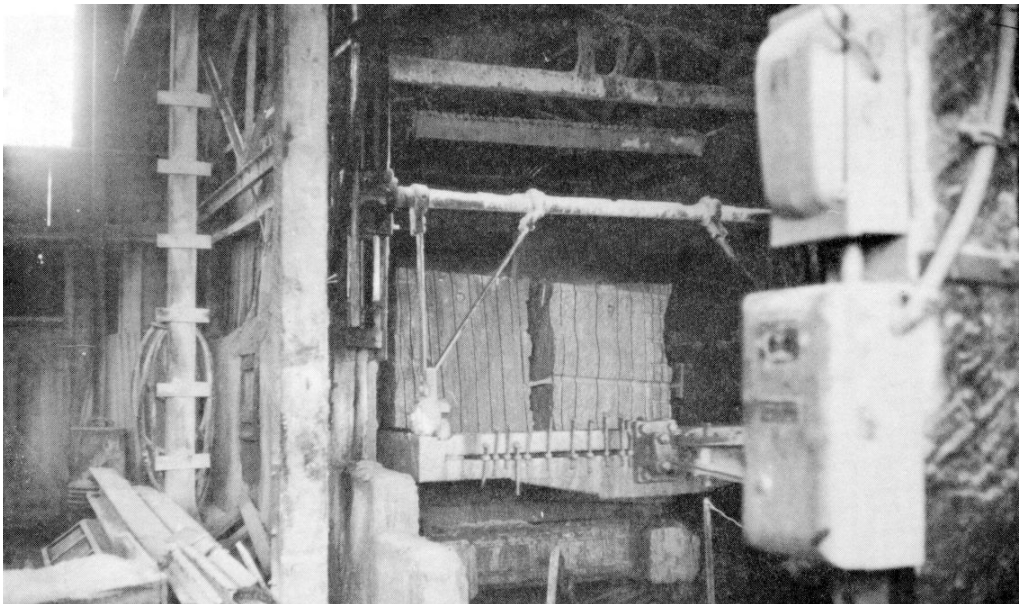


Fig. 1.23 Gang-sawing mill blocks of Queenston limestone at Queenston Quarries, D.F Hewitt, Building Stones of Ontario, Part 1, Introduction, 9.

Altering Landscape

After studying the human and non-human processes that form Queenston Limestone, the beginnings of Queenston Limestone's influence on the Queenston Quarry Landscape started to show. This section takes a deeper look at the development of Queenston Limestone's extraction economy in parallel to the evolution of the quarry landscape, from farmlands to the quarry, to understand the active role of Queenston Limestone as part of the quarry assemblage.

Indigenous Land Practices and Farmland Beginnings

Before quarrying, Queenston Quarry was covered by the Carolinian forest landscape inhabited by the Neutral, the Missisaugas of the Credit, the Haudenosaunee and the Anishinaabe peoples.[47] Linda Fritz, a journalist from Niagara Now reported that nomadic hunters and gathers discovered evidence of a Neutral settlement near the Queenston Quarry land due to its proximity to drinking water.[48] Indigenous Peoples preserved and protected the land through various land practices such as controlled burning to manage vegetation.[49] The Prescribed Burns Program, operated by Niagara Parks since 2008, uses this Indigenous technique to encourage the regeneration of native plant species.[50,51] Indigenous Peoples also pioneered agricultural practices of the region through crop rotation, growing the "Three Sisters" crops (Corn, Squash and Beans) and Tobacco plants.[52] Once European settlers arrived, colonists combined European and Indigenous farming techniques to establish farmsteads.[53] There was also a brief period following the Treaty of Niagara when the Queenston Quarry was designated for military use by the British Crown.[54] From 1801 to the 1840s, the land was assigned to the Secord Family from 1801 to the 1840s for use as farmland.[55][Fig. 1.23] After the Secord family's ownership ended, the quarry land's use for farming also ended.

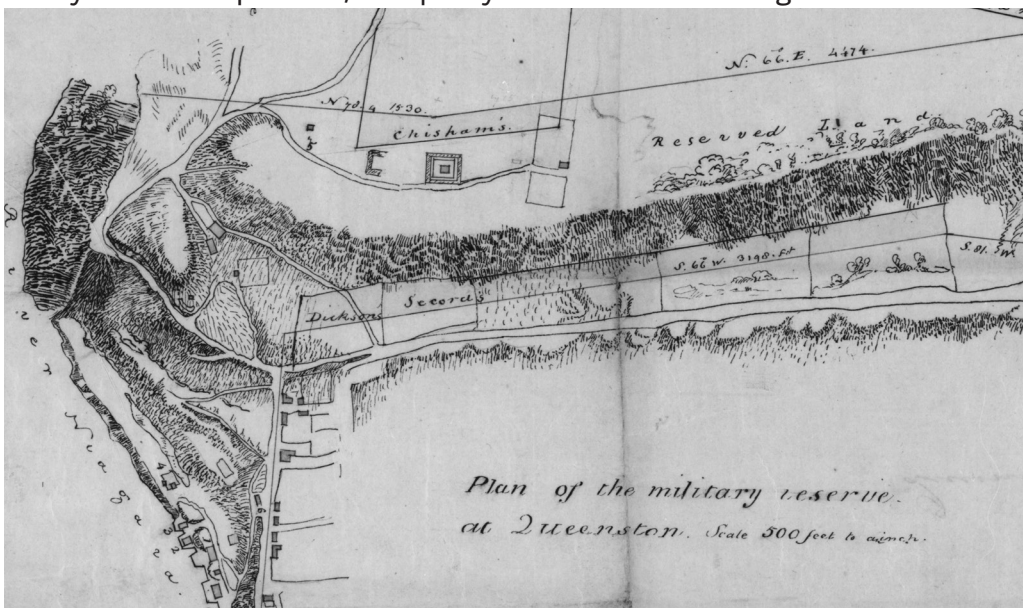


Fig. 1.24 Plan of the Military Reserve at Queenston, showing a lot belonging to the Secord Family, Library and Archives Canada, National Map Collection: NMC - 4349.

47. Native Land Digital, Accessed March 29, 2023. https://native-land.ca.

48. Linda Fritz, "History Unveiled."

49. Robin Wall Kimmerer and Frank Kanawha Lake, "Maintaining The Mosaic: The Role of Indigenous Burning in Land Management," Journal of Forestry 99, no. 11 (November 2001): 36-41.

50. Nick Kuemmling, "Prescribed Burns Program Underway to Restore and Manage Natural Areas," Niagara Parks, March 22, 2023. https://www.niagaraparks.com/media-room/news/prescribed-burns-program-underway-to-restore-and-manage-natural-areas/.

51. Racioppo, "The Queenston Quarry."

52. Andrew Coppolino, "Three Sisters Garden Food Shares Deep Roots with Indigenous Community," CBC News. August 14, 2021, https://www.cbc.ca/news/canada/kitchener-waterloo/andrew-coppolino-three-sisters-garden-steckle-heritage-farm-in-kitchener-1.6140113.

53. Racioppo, "The Queenston Quarry."

54. J.G. Kelly, Queenston Plan of the Military Reserve, Total Content Called 175 Acres, Lithography, February 1851, 1:9000 scale, 26x38cm (Library and Archives Canada, National Maps Collection: NMC-4351), georeferenced and modified by Map, Data and GIS Library, Brock University.

55. Linda Fritz, "History Unveiled."

The Stone Industry and Local Railways

Although stone was extracted while the Queenston Quarry was part of the Secord Family farm, it was not until ownership was transferred into the hands of John Brown (1840s-1861), a stone mason, that this land established a reputation for limestone extraction.[56] As the Secord Farm was subdivided into separate lots, the Queenston Quarry comprised several quarries. Brown was part of the railway bed construction of the horse-drawn railway from Chippawa to Queenston and provided stone from the quarry for buildings in Fort Niagara and eventually for one of the Welland Canals.[57] [Fig. 1.24] This marked the beginning of Queenston Limestone's significance within the local construction industry, an area described by Lake Erie and Ontario Railway members as having "inexhaustible quarries of lime and building stone".[58]

56. "Our History," Queenston Limestone, Queenston Quarry Reclamation Company Ltd., The Cellars of Niagara-on-the-Lake, Queenston Limestone. Accessed March 29, 2022. http://www.queenstonlimestone.com/our-history/

57. Hewitt, *Building Stones of Ontario Part II*, 2.

58. Racioppo, "The Queenston Quarry."

Fig. 1.25 Queenston Chippawa Railway, built 1835-1844 for industrial use alongside Queenston Quarry Stoneyard, Gonder, Niagara-on-the-Lake Public Library, Francis J. Petrie Collection, D417698.

In 1861, William Hendershot purchased Queenston Quarry, with many companies operating under royalty agreements, including the Great Western Railway Company, later amalgamated with the Grand Trunk Railway in 1882.[59][Fig. 1.25] Grand Trunk Railway's construction prompted the opening of many quarries in the area, which also relied on the railway to transport their dimensional stone. [Fig. 1.26]

Queenston Quarry Limited owned the land for the next thirty years, acquired the smaller quarries nearby, and eventually became the principal building-stone quarry in Ontario.[60] This was when quarrying activity was at its prime at the Queenston Quarry. Countless monumental buildings, including the Welland Canals, court houses in the Niagara Region, the Grand Trunk Railway, the Great Western Railway Bridges, and the Brock Monument, to name a few, were constructed using dimensional stone extracted from the Queenston Quarry.[61] In 1925, Queenston Quarry Limited was bought by the Canada Crushed Stone Company. This larger business also expanded production to extract crushed stone and aggregates from the quarry.[62] The Usher Mines and Kilns company also extracted lime from the Decew formation of the quarry to produce cement. [Fig. 1.27] By this time, Queenston Limestone had significantly contributed to building Canadian railways. In return, the construction of these railways allowed the material to be transported across Canada, gaining recognition as one of the most important building materials at the time.

59. Linda Fritz, "History Unveiled."

60. Hewitt, *Building Stones of Ontario Part I*, 36-37.

61. Hewitt, *The Limestone Industries of Ontario*, 91.

62. "Buildings," Queenston Limestone, Queenston Quarry Reclamation Company Ltd., The Cellars of Niagara-on-the-Lake, Queenston Limestone. Accessed March 29, 2022. http://www.queenstonlimestone.com/our-buildings/.

Fig. 1.26 Artist's Sketch of Queenston Quarry, 1876, Niagara Falls Public Library, Niagara Falls heritage Foundation Collection, D11776.

Fig. 1.27 *Usher Cement Plant in Queenston, 1905,* Niagara-on-the-Lake Public Library, Alan Clifford Collection, NOTLPL00206.

Fig. 1.28 Aerial photo of the quarry landscape, 1934, showing evidence of quarrying activies along the Niagara Escarpment, Canada.Department of Energy, Mines and Resources. Niagara Air Photo Index. Scale 1:9,000. Roll 4. Photo A4701-80 to A4701-80. Ottawa, Ontario, 1934.

Fig. 1.29 Aerial photo of the quarry landscape, 2021, Google Earth.

Queenston Quarry Now

As new materials such as cement and concrete replaced limestone for construction in Upper Canada, large-scale quarry operations at Queenston Quarry began to decline and were eventually halted in the 1970s.[63] The Queenston Quarry Reclamation Company now owns the quarry, and is planning a redevelopment project including a mix of residential, commercial, recreational and agricultural uses on this land.[64] Early stages of the development are in progress as this thesis is being written. Site work for the construction project has commenced, and exposing covered rock surfaces to show the geological formation of the quarry and evidence of extraction has been the first step.

From a forested landscape protected by Indigenous people turned colonised farmstead land, to a limestone quarry turned mixed-use residential development, the landscape progression of the quarry co-evolved with the material. The durability and pleasing aesthetics of Queenston Limestone motivated the start of quarrying activities at the Queenston Quarry. The popularity and significance of Queenston Limestone stimulated the economic growth of the region, as the construction of one of the first railways in Canada was intimately linked to the material. Once other materials replaced Queenston Limestone, the quarrying activities eventually ended. However, the effects of Queenston Limestone did not stop there. The remaining void of the quarry with beautiful, exposed faces became a living documentation of the landscape's rich historical connections with the region, motivating the development of a mix-used residential project to revitalise the site. Because of the material, the Queenston Quarry Landscape was significantly altered throughout history. [Fig. 1.28 & 1.29]

63. Hewitt, *The Limestone Industries of Ontario*, 91.

64. Ontario Municipal Board, *Queenston Quarry Redevelopment* (Niagara-on-the-Lake) OMB Decision, January 27, 2012. https://niagararegion.ca/living/icp/policy-plan/pdf/pl110340-jan-27-2012.pdf.

Fig. 1.30 Photograph of Queenston Quarry, by author.

Conclusion

The relationships between Queenston Limestone and the original landscape are revealed through the documentation processes of field work, archival research, and drawing of the quarry. The crystallised faces, beautifully aged patina, and durability result from millions of years of geological formation. The crinoid fossils and unique blue-grey colouring are qualities of the Niagara Escarpment gifted to this unique stone, making the material aesthetically desirable. Concerted amounts of human work have been invested in the extraction process, with the labour and skill involved in quarrying and dressing the stones contributing to the material's versatility. Different quarrying methods employed at the quarry result in unique markings on the quarry faces and extracted stones, documenting the landscape and technological progressions in the area. The inherent beauty, durability and work required give Queenston Limestone its economic value. Queenston Limestone encapsulates these complex relationships existing in the quarry through its transformation. At the same time, the material becomes the driving force to influence the local economy and landscape, a historical progression from farmland to the quarry, leading to the construction of railways and recent residential development. This relationship between the Queenston Quarry and the material captures Queenston Limestone's material agency within an assemblage.

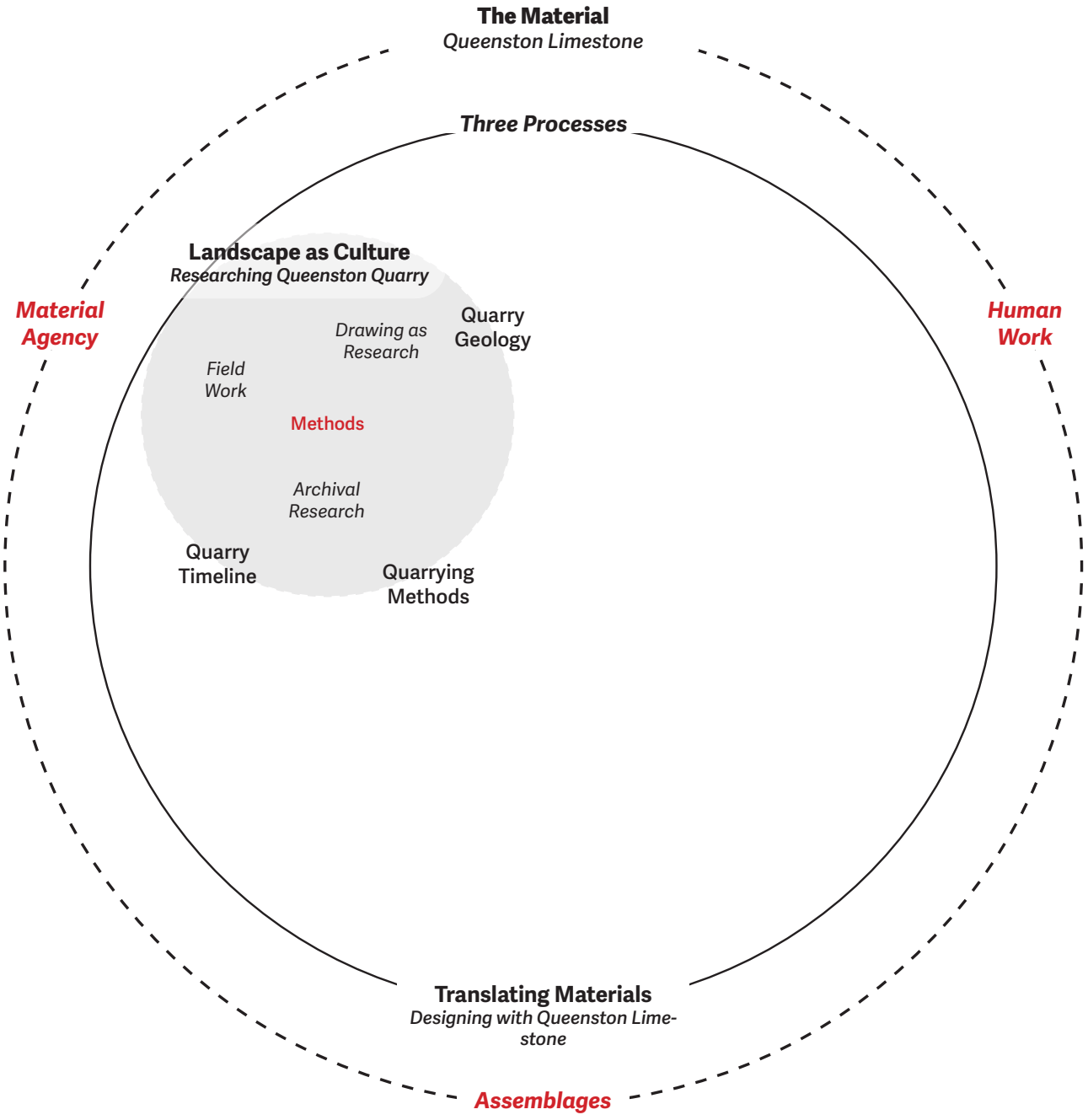


Fig. 1.31 Thesis Diagram Part I, by author.

Crafting Discards

Introduction

In part one, I concluded that the value of Queenston Limestone comes from its embodiment of relationships of the quarry, the human work invested in the extraction of the material and the material's influence on its environment. First, the geological properties given by the land make it a desirable building material. Millions of years of substance compression offer Queenston Limestone top-tier durability. The chemical reactions created the unique colouring of the material. At the same time, the crinoid fossils present in the Limestone are evidence of the geological shift of the landscape from the Silurian Sea. Second, an intense amount of human work is involved in the extraction process, adding value to the stone. Adolf Loos explains the value of human work in materials using granite as an example,

> "For granite demands much work to wrest it from the mountains, much work to bring it to the designated location, work to give it the correct form and to endow it with a pleasing appearance by cutting and polishing. Our hearts beat with reverential awe at the sight of the polished granite wall. Awe for the material? No, awe for the human work."[1]
>
> - Adolf Loos, *Building Materials*

Splitting stones with plug and feathers, operating extraction machinery, transporting, cutting and polishing stones are all work in Queenston Quarry. In the essay, Loos also talks about human work from three aspects – human labour, technical skills and artistry.[2] All of which are fundamental to craft practices. The cutting and shaping of stone are processes that require craft. Part two of this thesis includes three hands-on material experiments, each highlighting a unique property of Queenston Limestone. These three experiments investigate how Queenston limestone is transformed through craft, how the stone's material properties shape craft, and the interactions between the maker and the material. Willowbank generously lent me a pile of Queenston Limestone stored in the school courtyard and introduced me to the stone craft of dry-stone stacking to assist with the experiments.

1. Adolf Loos, "Building Materials," in *Speaking into the Void: Collected Essays by Adolf Loos, 1870-1900,* trans. Jane O. Newman and John H. Smith (Cambridge, MA: MIT Press, 1982).

2. Adolf Loos, "Building Materials."

The Human Work and Craft

There are two major ways of shaping and building with limestone after they are extracted from quarries, each suitable for a different construction method. The first method is contemporary, wherein machinery processes extracted blocks into dimensional blocks in stone yards. The sizes are pre-determined, and surfaces are polished for standardised construction. Stones blocks are then combined with mortar for uniform stacking in courses. The second method employs the ancient handcrafting technique, where stones are broken and shaped using hand tools into smaller pieces for ease of transport, then either dry-stacked or combined with mortar to create a structure. Stones processed with hand tools come in irregular shapes and conditions, creating a more "unfinished" look resembling its natural state. It provides flexibility and room for creativity in building, since stone masons can shape and adjust individual stones according to their size and shape. I am interested in the hand-crafting method for Queenston Limestone, as I primarily work with discarded, irregular stones extracted from the quarry.

Richard Sennet defines craft as the basic human desire to do things well.[3] This resonates with Arendt's concept that the quality of work gives materials permanence in the world.[4] In her book, The Human Condition, she stated:

> "Labor, to be sure, also produces for the end of consumption, but since this end, the thing to be consumed, lacks the worldly permanence of a piece of work, the end of the process is not determined by the end product but rather by the exhaustion of labor power, while the products themselves, on the other hand, immediately become means again, means of subsistence and reproduction of labor power. In the process of making, on the contrary, the end is beyond doubt: it has come when an entirely new thing with enough durability to remain in the world as an independent entity has been added to the human artifice."[5]
>
> - Hannah Arendt, *The Human Condition*

Intentional making and creativity in craft are where humans establish permanence by creating objects that resist decay and outlast the human experience.[6] In a world where machines replace human labour, and assembly lines replace skilled craftspeople; traditional handcraft is increasingly valued as a heritage for its authenticity. Products of industrial labour are intended for consumption, while carefully crafted objects are intended for durable use with a lasting impact. Thus, Craft is now more of an idea than a practice, a resistance against industrial labour, a practice of "making without thinking".[7] This thesis defines craft as the intentional making and shaping of stone experiments by hand. The deliberate decisions made according to materials, the experience of the maker's body, mind and material and the creativity involved in shaping materials make hand-crafting valuable.

3. Richard Sennett, *The Craftsman* (New Haven, CT: Yale University Press, 2008), 9.

4. Hannah Arendt, "Work" in *The Human Condition* (Chicago: University of Chicago Press, 1958), 137.

5. Arendt, "Work" in *The Human Condition*, 143.

6. Glenn Adamson, introduction to *Thinking Through Craft* (Oxford: Berg, 2007), 2-7.

7. Sennett, *The Craftsman*, 144.

The three experiments in this section explore the following concepts related to craft:

Material Consciousness – In The Craftsman, Sennett names three ways of interacting with materials while crafting: altering, marking or identifying with ourselves. He calls these processes "becoming aroused consciously by materials".[8] This section focuses on the first two interactions with materials. Altering is about shaping materials into more durable forms to prevent decay. Marking establishes the presence of the maker through the process of making.[9] For example, the plug and feather marks in Queenston Limestone are makers' marks that speak to the Quarry's extraction process. In the three material experiments, I alter stone pieces by breaking, shaping, and stacking to create sculptures that speak to different aspects of Queenston Limestone. Traces such as chisel marks are also preserved as makers' marks from the process of stone craft. The crafting technique is guided by an aspect of Queenston Limestone that I identified from the previous chapter. The theme of material consciousness is within the same realm of material agency, where embedded relationships within materials inform crafting decisions.

Body and Rhythm – Handcrafting is an interaction between the hand and the material and a bodily experience that engages the makers' minds and senses. It is an intimate experience with materials' appearance, sound, touch and smell. And through this intimate experience, the maker forms a personal connection with the material, while negotiating with the relationships embedded within the material.[10] The maker's mind processes these materials' properties and makes decisions based on the feedback. Once a decision is made, the body coordinates to act. Through repetition, the maker develops a rhythm for this practice. It is important to note that the rhythm of craft is an intentional practice that requires concentration.[11] This distinguishes craft from industrial labour. Adam Smith, an economist and philosopher in the eighteenth century who specialised in political economy, delved into the theory of productive labour in his book, Wealth of Nations. In the book, he described industrial labour as a mindless process.[12] Take breaking stones as an example; by reading the stone's grain direction, the maker decides the best chisel placement for splitting the stone. The body then coordinates to act. Through repetitive practice, the maker learns the ideal angle for chisel placement and the force needed to slam down the hammer to break the stones accurately. Over time, it becomes an instinctive act with prehension.[13]

Improvisation and Creativity – Once the maker develops a rhythm, improvisation and creativity become the next craft advancement. Richard Sennet describes it as a "user's craft" that "draws on the metamorphoses of type-form over time".[14] This means improvisation is a skill-based, adaptive response to a transforming material. Sennett differentiates "improvisation"

8. Sennett, *The Craftsman*, 119-25.

9. Steffan Appelgren, "Creating with Traces of Life: Waste, Reuse and Design," *Journal of Cultural Heritage Management and Sustainable Development* 10, no. 1 (January 2020), 67-68. https://doi.org/10.1108/JCHMSD-09-2019-0115

10. Sennett, *The Craftsman*, 171-7.

11. Adam Smith, "Wages and Profit" in T*he Wealth of Nations*, Volume I (London: J.M Dent & Sons Ltd., 1937), 90.

12. Sennett, *The Craftsman*, 174-2.

13. Sennett, *The Craftsman*, 144.

14. Sennett, *The Craftsman*, 235-2.

from “spontaneity”. Improvisation follows the basic rules of the craft, and selects elements to be varied within the guidelines. Spontaneity, on the other hand, is a mindless occurrence.[15] The construction of stacked stone walls follows fundamental rules to support the structure, and the craftsperson must master the skill of stacking before experimenting with different sizing, shapes and colouring of the stone. When working with irregularly shaped or previously used materials, improvisation becomes crucial. Unlike working with uniformed stone blocks, the maker shapes the stones individually to fit the envisioned final built form. Previous markings on used stones are typically viewed as “imperfections” in standardised construction. However, by improvising the orientation of stone faces and remixing the textures or colouring of stone, the “imperfections” can preserve and highlight the history of the materials.

15. Charles McRaven, *Stonework: Techniques and Projects* (Vermont: Storey Books, 1997), 59.

Learning

Dry-stone stacking is an ancient technique that creates stone structures without any adhesives. Charles McRaven, a renowned stone mason and blacksmith from the United States, first teaches his apprentices how to lay drystone walls during training.[16] Learning this method allows me to understand the fundamentals of stone construction: how gravity and friction work with stones to create a stable structure.[17] It also has the advantage of using simple and accessible tools. I focus on how limestone and handcraft complement one another in the process of building without incorporating other materials

Since it is my first time working with stones, I learned the method of dry-stone stacking through three different avenues:

Workshops and Practice - In summer 2021, I coordinated a summer design-build studio focusing on material reuse for Willowbank, a heritage preservation crafts school in Canada. During this time, two Willowbank students demonstrated the basics of dry-stone stacking, which included tips and tricks for keeping a wall stable and levelled. I worked with a team of four students to build a free-standing drystone wall as part of our studio project. [Fig. 2.27] Before creating the three experiments, I also practised creating small segments of dry-stone stack walls. Otto Salomon explained the benefits of hands-on practices in The Teacher's Handbook of Slöjd. *Slöjd* is an educational take on craft training, focusing on the maker's experience rather than craft's production output.[18] Making objects cultivates the sense of form more than reading drawings and instructional text. It also teaches one to respect the material and appreciate bodily labour, and at the same time, exercises observation.[19] Handcrafting, after all, is an exercise of thinking through making. Thus, workshops and practices are vital to my learning of dry-stone stacking.

Fig. 2.1 Dry-stone stacked wall practice at Willobank workshop, image by author.

16. Brenda Flynn, *The Complete Guide to Building with Rocks & Stone: Stonework Projects and Techniques Explained Simply* (Florida: Atlantic Publishing Group, Inc., 2011), 135.

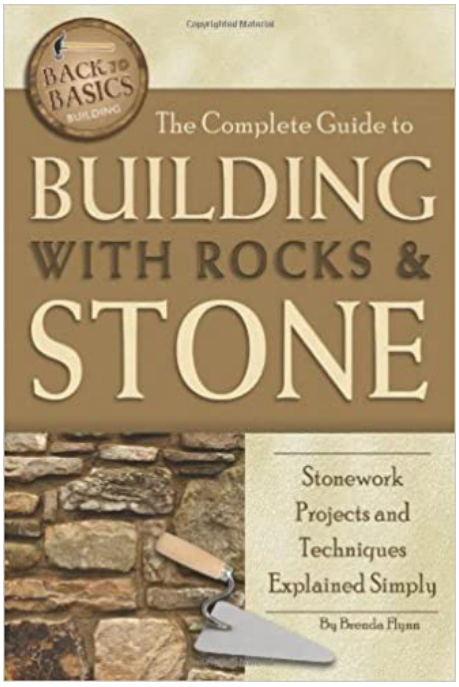
17. Otto Salomon, introduction to *The Teacher's Handbook of Slöjd* (Boston: Silver, Burdett & Co., 1891), 6.

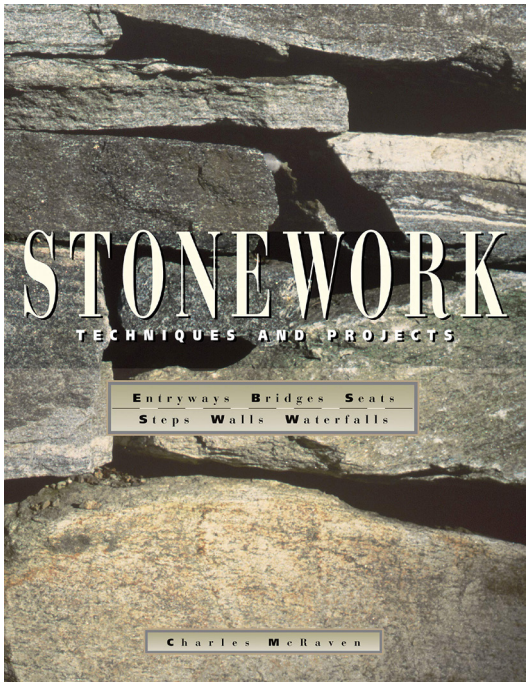
18. Glenn Adamson, "Section 1: How-to," in *The Craft Reader*, ed. Glenn Adamson, Oxford: Berg, 2007, 11.

19. Salomon, introduction to *The Teacher's Handbook of Slöjd*, 6-8.

"How-to" Texts **-** In addition to the workshops, I referenced two books extensively when creating the three experiments - "The Complete Guide to Building with Rocks and Stone – Stonework Projects and Techniques Explained Simply" by Brenda Flynn, and "Stonework Techniques and Projects" by Charles McRaven. [Fig. 2.2 & 2.3] Both books are "how-to" texts, a type of literature particular to craft. Glenn Adamson describes this genre of writing as "instructional writing that attempts to convey in words that can only be done by hand – to describe the specifics of process and material that constitutes craft".[20] These "how-to" texts offered me a holistic view of dry-stone stacking, filling in the missing pieces not taught during the workshops. From how to m Both books offered a detailed explanation of each step of stone construction on how to move, select, shape, and stack stones.

20. Glenn Adamson, "Section 1: How-to: Section Introduction," in *The Craft Reader*, ed. Glenn Adamson, Oxford: Berg, 2007, 9.





Left:

Fig. 2.2 Cover of The Complete Guide to Building with Rocks &Stone - Stonework Projects and Techniques Explained Simply, Brenda Flynn.

Right:

Fig. 2.3 Cover of Stonework Techniques and Projects, Charles McRaven.

Willowbank Observations **-** There were many stone structures designed and built by students at Willowbank. If the workshops and literature research were about the fundamentals of dry-stone stacking, observing these structures on-site allowed me to study the artistry of the craft. This is particularly important to my experiments, as creative solutions are often required for irregular, reused stones. The structures included retaining walls, column mock-ups and a stone pavilion, all constructed using dry-stone stacking. These examples, at different scales, gave me a glimpse into the creative details stone masons put in to enhance and elevate simple structures.

Preparation

Willowbank generously lent me the materials used in my experiments. A pile of Queenston Limestone was stored at Willowbank's lower campus courtyard. [Fig. 2.4] These pieces of stone came in various sizes, shapes and colours. They were off-cuts and discarded pieces taken from the Queenston Quarry that students previously used for dry-stone stacking practices. Drill marks from stone extraction, and break lines marked by chisels from shaping the stones all told stories of the human work invested in each piece.

Reusing stone is an ancient and common practice in the history of architecture. "Spolia" refers to building stones being repurposed for new construction.[21] It was common in late western antiquity, where stone fragments of past monuments were used in built structures centuries later. There are several interpretations of spolia – a symbol of historic preservation, the revival of antiquity, and appreciation of the material's beauty and utility.[22] Crafting with reused Queenston Limestone pays tribute to this practice, connecting the material to a significant part of the heritage of the stone craft. I constructed three artefacts to reveal the relationships these pieces of stone were entangled with, from the quarry to craft.

Preparing the stones was crucial to setting the intention of each experiment and organising the building process, and stone selection was the first step. Ideally, stones chosen for dry-stone stacking are levelled on the top and bottom sides. This allows the stone to lie flat and provide maximum support. One of the biggest restrictions I encountered during selection was the weight of the stone, as I could not move large pieces due to safety concerns and the transportation methods I used. Thus, I was limited to selecting smaller, movable fragments of stones. Out of the stone pile, I selected around seventy pieces of stone. Most stones were offcuts from the quarry and reused stones, so only half of the pieces chosen were levelled. The pieces selected also varied in thickness and colouring. Lastly, ones with "special markings" that show previous work performed on the stone were collected.

Cataloguing Stones

The criteria used when selecting stones were crucial to stone construction. Using these criteria, I created a catalogue documenting each piece of stone's size, thickness, colour and unique markings. These three categories informed each material experiment, each capturing an essence of limestone. [Fig. 2.5] Like getting to know new friends, this process allowed me to observe, respect, and appreciate each piece of stone. Number sixteen had three distinct drill marks, so I know that they were quarried using the knox method. Number twenty was a beautiful slab of stone with Queenston Limestone's signature blue-grey colouring. These material experiments were not just about creating coherent structures; it was also about retaining the individuality of each piece of stone when building. Cataloguing allowed me to become familiar with the characteristics of each stone I had to help with the building process.

21. Lex Bosman, review of *Reuse Value: Spolia and Appropriation in Art and Architecture from Constantine to Sherrie Levine*, ed. Richard Brilliant and Dale Kinney, Reviews in History, no.1313, September 6, 2012. https://reviews.history.ac.uk/review/1313.

22. Bosman, review of *Reuse Value*.

Fig. 2.4 The pile of Queenston Limestone available for selection, image by author.

#	Thickness	Colour*	Special Properties
01	2-1/2″	LBG	Crinoids visible Top and bottome faces both levelled and smooth
02	5-1/4″- 6″	LBG	Clean-cut on all sides except 1 Not levelled on one face Stone grain visible on side faces
03	3″- 4″	DBG	Crinoids Visible Smooth on one side; not levelled Stone grain visible on side faces
04	5″	PBG top LBG other	Smooth on 3 sides; levelled Stone grain visible on side faces Saw marks on a side face; wedge on one edge
05	4″	PBG top LBG other	Smooth on 1 sides; levelled Stone grain visible on side faces
06	4″	PBG top/ bottom DBG other	Smooth on 3 sides; levelled Change in lithography on side faces
07	4″	PBG	Smooth top and bottom faces; levelled Stone grain visible on side faces.

LBG: Light Blue-grey
DBG: Light Blue-grey
PBG: Pink Brown-grey

Fig. 2.5 Excerpt from the Queenston Limestone Catalogue, by author.

Fig. 2.6 Catalogue of Selected Queenston Limestone, image by author.

Tools

An advantage of dry-stone stacking is its accessibility. I only needed a simple set of hand tools: a pair of work gloves to protect the hands, a level to measure the flatness of each layer of stone, two hammers for breaking larger stones, a stone chisel for shaping each piece and a rubber mallet for tightening the spaces between interlocking stones.[23] [Fig. 2.6]

23. McRaven, *Stonework*, 38.

Fig. 2.7 Tool set used for the three material experiments, image by author.

Experiment Guidelines

Once all the preparation is in place, I set some guidelines to frame the three experiments. In terms of crafting, the three experiments abide by the following rules:

1) The original condition of each piece of stone is preserved to the best of my ability, giving them more possibility for future reuse;

2) Each piece is disassembled after construction to create the next experiment, showing how the same pieces of stone have the potential of fulfilling multiple creative visions through reuse;

3) The experiments must be self-supporting structures, demonstrating the principles of dry-stone stacking;

4) All three experiments are simple, cubic forms that bring the stones together while not overpowering the individual characteristics of the stones.

Each experiment showcases one aspect of Queenston Limestone, making the intentions clear for each piece. Experiment 01 demonstrates the basics of dry-stone stacking, showing how gravity works with the weight of Queenston Limestone to create standing structures. Experiment 02 highlights the geological formation of Queenston Limestone through its unique colouring and crystallisation. Experiment 03 exhibits the distinctive markings left on different pieces of stone.

Experiment 01: Weight of Stone

The first experiment focuses on understanding the weight of the stone. Weight is the most fundamental characteristic of stone, and much of the stone craft is influenced by this factor. Like brick structures, stone pieces are stacked in rows, with each course overlapping the gaps of the previous layer.[24] However, dry-stone stacking requires the stones to be thick to thin as it goes up in rows to provide stability, because more weight must be at the bottom to support the top. [Fig. 2.7] Each piece of stone must also push against its neighbour tightly so neither can move.

24. Flynn, *The Complete Guide to Building with Rocks & Stone*, 135.

Fig. 2.8 Dry-stone stacked wall at Willowbank in elevation and section view showing hearting, image by author.

Following the basic principles of dry-stone stacked walls and columns, each side of the structure must slope inwards. Sloping is achieved by stacking the larger ends facing outwards and the smaller ends inwards.[25] This process, called battering, prevents external forces from pushing over the structure.[26] This creates four sides of stone sections that are narrower on top and wider at the bottom, trapezoidal in shape.[27] After establishing the four sides, a gap is left at the centre, which requires additional support. I use the method I learned in Willowbank called hearting to provide additional support. This method utilises smaller rock pieces I had in hand to fill the interior gap.

25. McRaven, *Stonework*, 63-64.

26. McRaven, *Stonework*, 59.

27. Brenda Flynn, *The Complete Guide to Building with Rocks & Stone,* 137. I learned this method from a Willowbank workshop, and the book identified the name of the method.

Right:
Fig. 2.9 Experiment 01: The Weight of Stone, Image by author.

Experiment 01: Weight Of Stone

A few of the seventy-two pieces of Queenston Limestone are disproportionally larger than the remaining ones. Breaking stones into manageable chunks to work with while keeping the integrity of the material is critical for reuse. Referencing the size of other stone pieces, I broke the pieces of stone following the grain into similar sizes using two hammers. Placing the sharp side of one hammer on the surface of the stone, I first gently tapped the flat side of the hammer while moving the sharp side along the desired break line with the other hammer. When the break line started to form, I repeated the process with a larger force until the stone broke. Not all stone pieces broke according to plan, but I kept all the pieces and rock chips for other uses. [Fig. 2.9 & 2.10]

Fig. 2.10 Breaking stones, image by author

Within the formula of stacking stones from thick to thin, I observed from the Willowbank projects that I could stack a row of thicker stones across two sides of the structure after a few typical rows. [Fig. 2.11] These stones are called tie-stones. Using tie-stones is an alternative method to bridge the gap at the centre and provides additional support to the project. They prevent the bottom rows from moving and act as a new platform for the coming rows.[28] This method utilises the weight of the stone to provide a variation in the repetitive pattern of standard dry-stone stacking.

28. Brenda Flynn, *The Complete Guide to Building with Rocks & Stone*, 135.

Fig. 2.11 Stacking stones in progress, image by author.

Fig. 2.12 Sample Dry-stone stacked wall atWillowbank, showing variation in stacking pattern, image by author.

Experiment 02: Formation of Stone

The second experiment focuses on the geological formation of Queenston Limestone. As we learned from part one of this thesis, the colouring on the Queenston Quarry face changes due to its shift in lithography. Between the Decew member and Goat Island member, the Gasport formation gradients from a dark blue-grey to a brown-grey pink.[29] [Fig. 2.12] According to the catalogue, I first selected the stones at two ends of the colour spectrum, with the brown-grey pieces being the thinnest and the blue-grey pieces being the thickest. The brown-grey stones also had a rougher texture compared to the blue-grey stones. I then picked out stones with a gradient of medium thickness. This allowed me to create a structure resembling the quarry face's colouring while following the form of dry-stone stacking. I also incorporated pieces of Limestone with crinoids, which can be observed up close from the experiment. Lastly, I noticed that without going through natural weathering, freshly broken stone surface creates a unique glare compared to the aged pieces of stone, showing the crystallisation of the Gasport formation. I combined a few of these surfaces to contrast against the aged patina on other stones. Over time, these pieces would blend in with the rest of the pieces, documenting the natural ageing process of Queenston Limestone.

29. D.F. Hewitt, *The Niagara Escarpment,* (Toronto: Ontario Department of Mines, 1971), 29-30. https://www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/IMR035/IMR035.pdf.

Fig. 2.13 Queenston Quarry, showing the change in lithology at the exposed surface, image by author.

Right:

Fig. 2.14 Experiment 02: The Formation of Stone, image by author.

Experiment 02: Formation Of Stone

Because I prioritised the stone's colour during selection, a few pieces were not levelled or required additional support to fit tightly with the rest. This was when the stone chips from breaking the rocks became useful. [Fig. 2.15] A trick I learned from Willowbank was to use the rock chips as shims to fill the gaps between stones, so the structure stays stable. [Fig. 2.16 & 2.17] I also mixed double or triple-thickness stones within the same colour range in this experiment. These stones are stacked on the corners of the experiment, fitted with two or three courses of thinner stones to give depth to the project. Mixing different types, colours, textures and sizes of stone is common for stone masons.[30] [Fig. 2.14] A project loses its dimension when there is a slight variation in colour and texture. It is through contrast and comparison that each stone becomes unique.

30. McRaven, *Stonework*, 43-45.

Fig. 2.15 Dry-stone stacked pavilion at Willowbank, showing a mix of colour and texture in stone walls, image by author.

Fig. 2.16 Rock chips from breaking stones, image by author

Fig. 2.17 & Fig. 2.18 Using rock ships as shims to support stones, image by author.

Experiment 03: Marks and Remnants of Stone

The last material experiment centres around the marks and remnants of Queenston Limestone. Thus, I prioritised selecting the pieces of stones with markings from previous processes. Some pieces were clean-cut stone slabs, some had plug and feather holes, and others had different types of saw marks present on the surface.

Stacking these stones was difficult. Many came in sizes and shapes that were hard to fit with other pieces. However, breaking the stones with hammers would inevitably destroy parts of the markings. Thus, a more controlled method was needed to shape these pieces. Instead of two hammers, I lightly hit the stone chisel with a hammer along the desired break line. After a few passes, I repeated this process on the flip side of the stone, applying more force each time. I soon realised that the angle of the stone chisel and the force I applied when striking the chisel affected how the stone broke.

Fig. 2.19 Shaping stones with a stone chisel, image by author.

In most cases, I worked near the edge of the stone to preserve most of its form. Initially, I was holding the chisel perpendicular to the stone surface. This resulted in the stone chipping off, creating a more difficult ridge to remove. [Fig. 2.18] After reading through McRaven's text, I learned to lean the chisel edge into the mass of the stone with heavier hits, which cracked the stone deeper.[31] Sometimes the stone would break towards the edge regardless of how careful I was; thus, this process took multiple tries. Referencing the shape of the stones with quarry extraction marks, sometimes shaping means a clean cut, a nick, or a chip. Each decision is situational, according to the properties of each stone.

31. McRaven, *Stonework,* 51-52.

Right:

Fig. 2.20 Experiment 03: The Marks and Remnants of Stone, image by author.

Fig. 2.21 Close-up of Queenston Limestone with saw marks, image by author.

All the surfaces with evidence of previous human work were stacked facing outwards. I kept the marks from the process of shaping the stones as documentation of the human work I performed on the stones. [Fig. 2.20] A mix of techniques, new and old, from the quarry to handcraft, was shown through this experiment.

Conclusion

Each of the three experiments highlighted an essential aspect of Queenston Limestone. Experiment 01 demonstrated the techniques of dry-stone stacking, which was informed by the weight of the stone. Experiment 02 referred to the material's origin by remixing the stone's colours to resemble the Queenston Quarry's lithography. Experiment 03 was an ode to the human work shaping Queenston Limestone, highlighting new and pre-existing markings on the stone pieces. However, crafting these artefacts was just as significant as the artefacts themselves. Interacting with Queenston Limestone through hands-on practices was a method of further understanding the material. The previous chapter taught me the embedded relationships each material property and marking represent. I could also convey these relationships through the artefacts with creative decisions. The use of irregular stones also enabled craft practice through the development of improvisation. This also shows Queenston Limestone's material agency since the material informed the decisions throughout the crafting process, and provided a training ground for the craft. Through craft, I learn how to appreciate, respect and convey the individuality of Queenston Limestone through my own maker's mark. As I form this personal connection with Queenston Limestone, I become part of the material's assemblage.

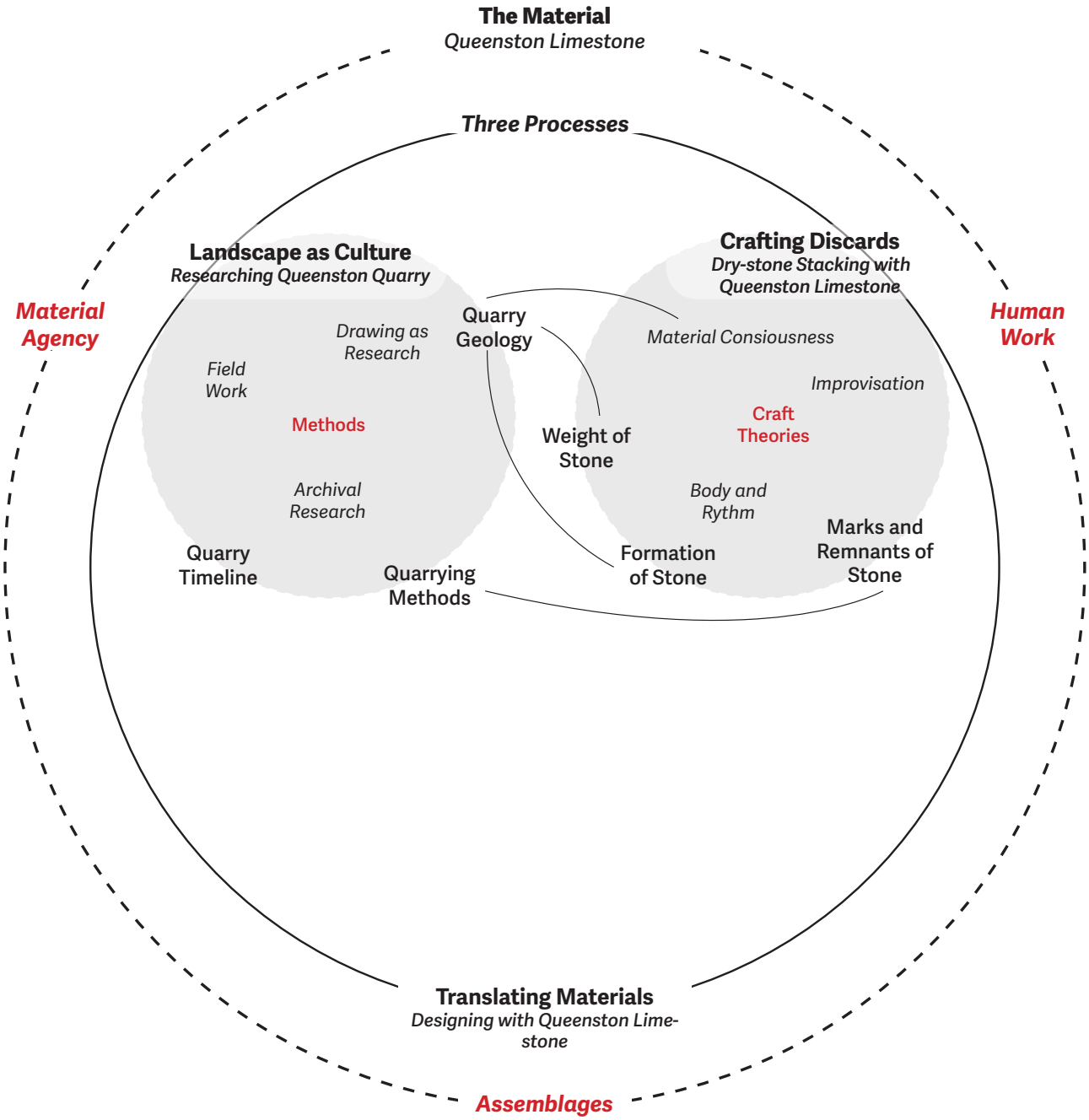


Fig. 2.22 Thesis Diagram Part II, by author

Conclusion

Translating Materials

Introduction

Parts one and two of this thesis investigate the forces and beings shaping Queenston Limestone and the human work involved with transforming materials. As a designer, I am naturally interested in the implications of introducing Queenston Limestone into part of a new assemblage when designing with the material. Designing with Queenston Limestone brings questions: How do I preserve the embedded relationships that Queenston Limestone brings to the new site? What new relationships are introduced to the material through the design process? How do the material and design affect the other forces and beings in the new assemblage?

Part three of this thesis explores these questions through a design exercise for the Willowbank Laura Secord Campus in Queenston. At the time of this thesis's development, Willowbank was going through redevelopment for its lower campus. I was fortunate to be part of the MITACS research program partnered with Willowbank to develop schemes for the lower campus re-planning. During the master planning process, one of the program ideas for the lower campus was to include an outdoor teaching space for the craft. Recognising the community this space is serving, the materials available, and my research, I saw the outdoor crafts workshop as an opportunity to understand better the responsibilities of designing with Queenston Limestone. Gathering my learnings from parts one and two, I proceeded with a schematic design exercise to create an outdoor dry-stone stacking workspace for Willowbank.

Design Objective

At this point of the thesis, design is the last step of interacting with Queenston Limestone to understand the material in relation to the region. As I learned from the previous two chapters, designing with materials is a complex process, due to the complex relationships materials carry with them. Each design decision had implications for the material and the new site. Thus, I drew themes and concepts from readings that relate material culture to architectural design to guide my design:

Materiality – The concept of materiality in architecture is often shallowly reduced to selecting appropriate materials for the design. But what is deemed appropriate? James Corner defines materiality as "the quality of being material and is best understood through the tactile and bodily perception of things, senses distinct from any form of secondary or objective deduction."[1] This definition encapsulates the sensorial experience between humans and materials but neglects materials' associated relationships with non-human forces. As materials move further away from their original landscape and are processed through human activities, their original sets of relationships become more tangential. The transformation of Queenston Limestone through craft in part three is an example of this, where human work is not always capable of capturing the entirety of the material's network. Instead, I had to pick and choose the relationships I highlighted in each piece of work. The struggle of materiality in architecture is a tug-of-war between making materials expressive and the materials' resistance.[2] Thus, to best portray materiality, the designer must cooperate with the materials, creating a design that stems from understanding the embodied relationships of the materials. Reusing materials is a method of retaining these relationships, since materials already carry signs of use and decay that show previous connections.[3] This also presents an opportunity for designers to create new connections between the material and the new environment, forming a new interpretation of materiality.

Communal Making – In the previous chapter, I discussed the importance of hands-on practices to craft training. This section further investigates the social implications of designing for a crafting environment. In The Craftsman, Sennett talks about how the traditional school setting is insufficient for the hands-on nature of craft practices. The ideal environment for craft training is what he describes as a "democratic workshop", where authority exists to transfer knowledge from the master to the student. In contrast, students still have autonomy over creating original projects.[4] One way to build a democratic workshop is through communal making. Wang Shu, the Pritzker Prize-winning architect's projects are manually constructed through collaboration with local craftspeople. The craftspeople and their supervisors developed many methods used at the site. The craftspeople had to improvise when Wang Shu's drawings became too hard to fulfil, and many of the results exceeded his expectations.[5]

1 James Corner, "Drawing and Making in the Landscape Medium" in *The Landscape Imagination: Collected Essays of James Corner 1990-2010,* ed. James Corner and Alison Bick Hirsch (New York: Princeton Architectural Press, 2014), 168.

2. Richard Sennett, *The Craftsman* (New Haven, CT: Yale University Press, 2008), 229-2.

3. Wang Shu, "Excerpts from 'One Day'. Stage One of the China Academy of Art Campus", in *Wang Shu: Amateur Architecture Studio*, ed. Michael Juul Holm, Kjeld Kjeldsen and Mette Marie Kallehauge, (Baden: Lars Müller Publishers, 2017), 90.

4. Sennett, *The Craftsman*, 53-80.

5. Ole Bouman, "For Love, or Other Reasons", *Wang Shu: Amateur Architecture Studio*, 208.

This is how Wang Shu's students and the construction team learned traditional construction methods to assist with the process.[6] The architect creates a framework to fulfil an overall creative vision while leaving room for craftspeople to execute the building process to showcase their creativity. The design must also be adaptive, catering to the unpredictable nature of communal making. In the end, the design becomes a creation of a collaborative process with craftsmanship at its core rather than an individualistic endeavour.[7] This forms a resistance to the soulless nature of standardised production, where authorship to the design is shared, and the gap between labourer and output diminishes.

Contextual design – Similar to Materiality, contextual design is an ambiguous architectural term. Generally, it implies continuity in a design's relationships to a place, reflected through the design form. Contextual design is not about imitation but responding to the elements of the site where the design is located.[8] The designer's role is to identify and select the elements the design responds to, ranging from the material background, traditional crafting techniques, local history and culture.

These three themes are general, abstract concepts that provide a basic design guideline. To understand the methods of implementing these concepts, I studied the works by Wang Shu, who is recognised for his deep understanding of materiality, communal making and contextual design. The following case study analyses how he achieves the three themes through his work.

In 2008, thirty villages in the City of Ningbo were demolished to make room for a new Central Business District, which included the Ningbo History Museum designed by Amateur Architecture Studio. The project reused tiles and bricks salvaged from the demolished houses to continue traditional Chinese building practices. The leading architect, Wang Shu, stated that construction materials from China have always been recycled as an economical construction method. "It is not our tradition to throw away things."[9] The traditional construction technique, *wa pan*, was used during construction to handle the various shapes and textures of salvaged materials. [Fig. 3.1] This technique was unique to the region. It is used to rebuild houses with salvaged materials after typhoons quickly.[10] The studio allowed the local craftspeople to improvise the composition of these materials according to their craft.[11] Wang Shu's students were also part of the construction process, as they learned the technique of wa pan in previous projects. The worn textures and marks, various sizes and shapes of materials, and the irregular patterns assembled through local craft in combination with the building's mountain form - which was inspired by traditional landscape paintings celebrated in the area - created a building deeply rooted in the local culture, telling heritage stories at different scales.[12,13]

6. Wang Shu, 造房子, (Changsha: Hunan Fine Arts Publishing House, 2016), 49.

7. Wang Shu, "Excerpts from 'One Day'. Stage One of the China Academy of Art Campus", 92.

8. Antoine Picon, "Matter, Materials, Materiality", introduction to *The Materiality of Architecture*, (Minneapolis: University of Minnesota Press, 2020). https://manifold.umn.edu/read/the-materiality-of-architecture/section/7042a5bc-b871-4ab4-9f8d-9315df2e6857#intro

9. Wang Shu, "Excerpts from 'One Day'. Stage One of the China Academy of Art Campus", 92.

10. Wang Shu, et.al., *Wang Shu: Amateur Architecture Studio*, ed. Michael Juul Holm, Kjeld Kjeldsen and Mette Marie Kallehauge, (Baden: Lars Müller Publishers, 2017), 21-25.

11. Ole Bouman, "For Love, or Other Reasons", 208.

12. Wang Shu, et.al., *Wang Shu: Amateur Architecture Studio,* ed. Michael Juul Holm, Kjeld Kjeldsen and Mette Marie Kallehauge, (Baden: Lars Müller Publishers, 2017), 21-25.

13. Allison Iris Arlotta, "Locating Heritage Value in Building Material Reuse", *Journal of Cultural Heritage Management and Sustainable Development* 10, no. 1 (November 28, 2019): 11. https://doi.org/10.1108/JCHMSD-06-2019-0076.

To summarise, the Ningbo History Museum utilised the materiality of tiles by reusing materials with traditional crafts. It enables craft training through the improvisational nature of communal making. This was where the architect provided the framework of the overall design, and collaborated with craftspeople, to cultivate the imperfections of reused materials as beauty. The final designed form drew inspiration from traditional local culture, and responded to its context through its use of local materials and crafting techniques.

Fig. 3.1 Reused tiles at the Ningbo Mueseum, image by author.

The Site

Like any other design project, this proposal began with the site. I applied my architectural background to analyse the proposed site through contextual research and technical drawings in this section to determine the spatial organisation of the design.

Willowbank is one of the most important institutions in Queenston. Its main campus sits on top of a hill on the north side of Queenston, isolated from the rest of the town. [Fig. 3.2] Thus, the town's general impression of the school is grand but unapproachable. The lower campus, formerly the Laura Secord Memorial School, is at the centre of Queenston. However, the craft teachings at the lower campus remain indoors. As a result, the local community is unfamiliar with the school's missions.

Fig. 3.2 Satellite view of Queenston, Google Earth, annotated by author.

The site for this proposal was located at the lower campus of Willowbank, formerly known as the Laura Secord Memorial School. The lower campus consists of two buildings - The main building was established in 1923, and is now a heritage building protected under the heritage act, and a modernist addition was constructed in 1945 to accommodate the growing student population during that time.[14]

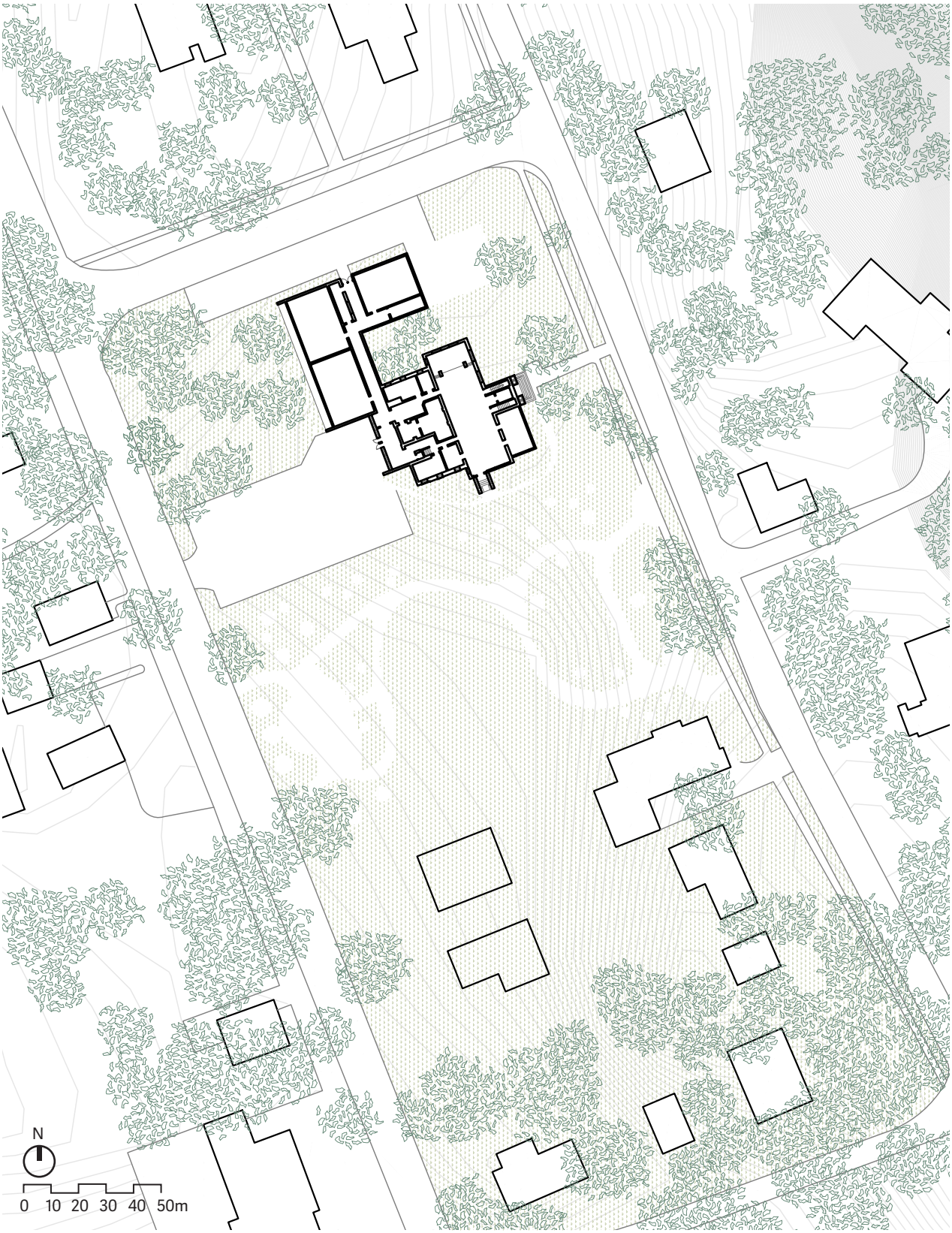
There is a courtyard space between the heritage building and the 1934 modernist addition. The courtyard was underutilised and overgrown with vegetation. During the summer studio, the students and I repurposed the place by introducing seating furniture constructed with reused materials so that the site could serve as a gathering space for students and faculty. The proposed design centres around this courtyard, facing outwards to Princess Street, one of Queenston's major roads. [Fig. 3.3]

14. Jean Huggins, "Open Two-Room Addition to Laura Secord School in Queenston Village", *The St. Catherines Standard*, March 16, 1953.

Right:

Fig. 3.3 Site context plan for Laura Secord Memorial School, image by author.

The Site



The Design

First Iteration

The first iteration of this design included a sunken outdoor workspace surrounded by retaining walls built with reused Queenston Limestone. The design aims to immerse students and visitors into a space that resembles the quarry, while showcasing the art of dry-stone stacking. The space was organised like an ambient theatre with tiers of seating, all facing inwards to encourage open communication and teaching. [Fig. 3.4 & 3.5] However, the idea was scrapped for several reasons. First, large amounts of turf and soil needed to be removed for this iteration, disrupting the terrain. This also meant that the design was difficult to disassemble, which diminished the purpose of using discarded limestone. Second, craft training benefits from a workshop setting, whereas the design favoured a traditional teaching method where the teacher was at the centre of education. As previously mentioned, hands-on practices and collaborative learning are crucial to craft training. While the seating around the perimeter made a great gathering and lecture space, flexibility in space was required for open craft practices. Lastly, the staircase seating design was inaccessible. Although this design was not selected, the final design took inspiration and lessons I learned from this process. I kept design elements such as a featured retaining wall to showcase the craft of dry-stone stacking, ensured that the new design was accessible, and mapped out the steps of dry-stone stacking to design for the process.

Left:

Fig. 3.4 Plan of the first design iteration, image by author.

Right:

Fig. 3.5 Perspective drawing of the first design iteration, image by author.

Fig. 3.6 The courtyard space of Laura Secord Memorial School, image by author.

Final Design

To design a space that enables craft training through communal making, I drew from my personal experience with dry-stone stacking. I was able to break down each step involved in thea craft from the process, and illustrated each step of dry-stone stacking to better understand the spatial needs of the process in the following diagram:

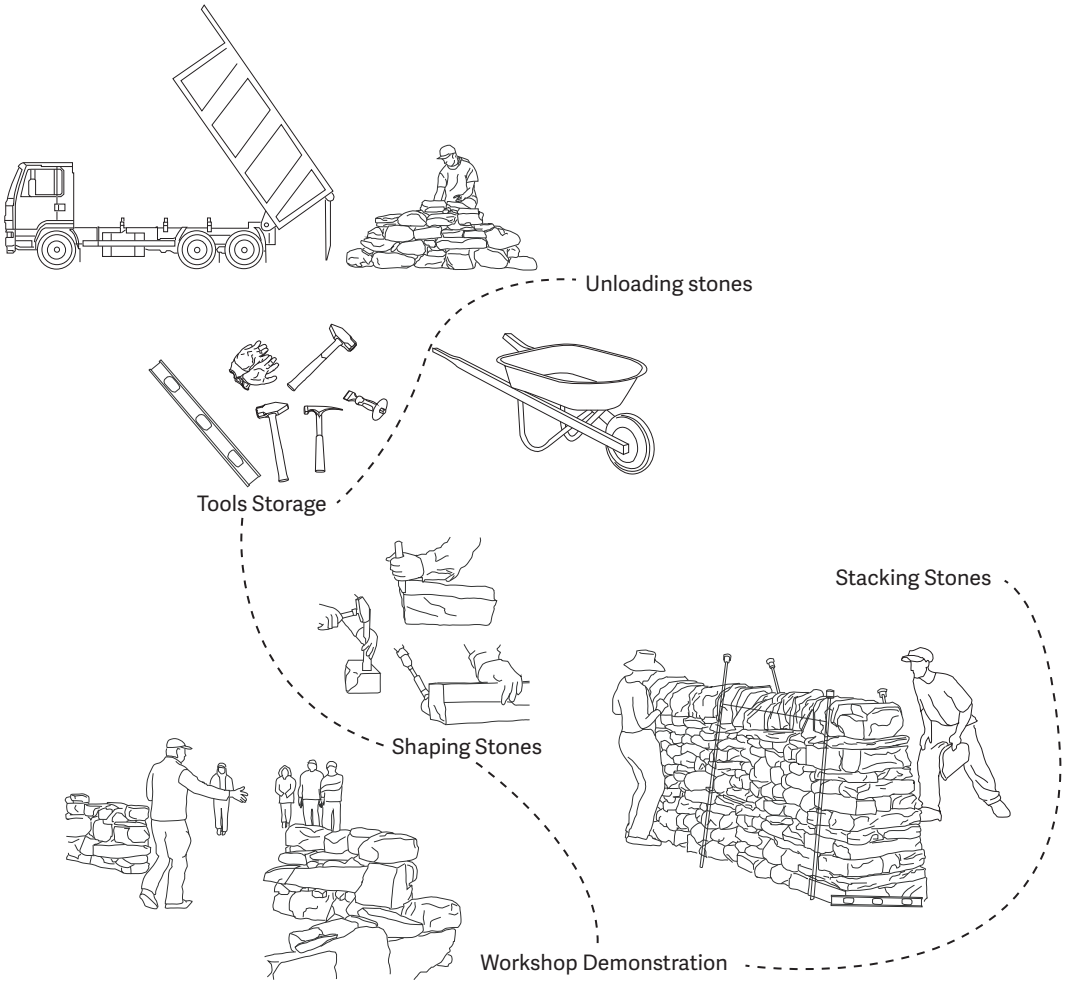


Fig. 3.7 Illustrating the dry-stone stacking process, by author.

In summary, the crafting process required a sheltered region for where stone storage and crafting activities take place, and an area with open visual access from the main street for the exhibition zone.

To begin with, the sheltered structure was a pitched-roof, wood beam and post pavilion that responded with the stone pavilion on Willowbank's main campus. Around the perimeter of this pavilion are dry-stone stacked walls that frame the crafting space. Both the wood structure and stone walls utilised reused materials. During the summer studio, I visited Willowbank's reused material bank. The material bank consisted of wood posts and beams in reusable conditions that can be applied to this project. [Fig. 3.8 & 3.9] A basket of slate tiles was left over from constructing the stone pavilion on the main campus, which could be used as the roofing material. [Fig. 3.10] For this project, materials with unique markings that show signs of the previous crafting process were favoured during the selection process.

Fig. 3.8 & Fig. 3.9
Reusable wood posts at Willowbank, image by author.

Fig. 3.10 Slate tiles for roofing material, image by author.

Reusing Materials

In the previous chapter, I discussed the long-standing tradition of "spolia", which uncovers the heritage value of reusing stone. Reusing stones enables the skill of improvisation in the stone craft. However, the heavy resource consumption in architectural projects gave the act of reuse another layer of value in terms of environmental impact. With the increasing awareness of environmental effects and the climate crisis in the industry, the circular economy is introduced to replace the "take-use-dispose" linear model rooted in current practices. The circular economy is a regenerative system that aims to eliminate waste to keep materials and products in use.[15] Reuse is a method used in implementing the circular economy. It is the act of putting objects back into use, either for their original purpose or a different purpose without major prior reprocessing to change their physical characteristics, so that they do not enter the waste stream.[16] [Fig. 3.11]

Aside from its environmental benefits, the act of reuse also holds heritage value. Material heritage is increasingly recognised as a renewable process based on associative values.[17] The process expands the scope of determining material value beyond the building itself to include material flow, use and exchanges of materials, while looking at the past, present and future sites along with the people involved in the process.[18] This aligns with the philosophy of viewing materials as part of assemblages. Traces that show the past context in materials and social meanings generated through the deconstruction and reuse process are all part of the heritage evolution of the site.[19] However, most current buildings are not designed to be deconstructed, so current practices still fixate on design for deconstruction with new materials instead of focusing on the existing material stock.[20] Thus, it is essential to study deconstruction, component reuse and design for disassembly as a whole rather than in isolation, to complete the closed-loop system of reuse in buildings.

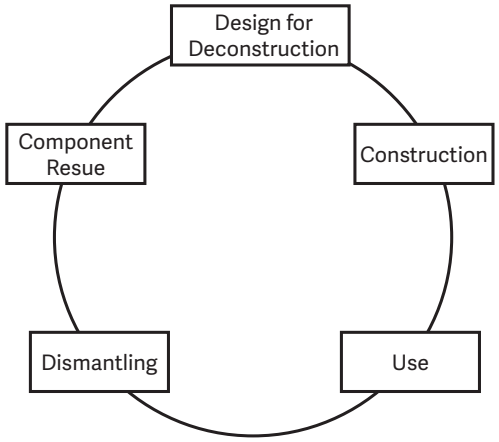


Fig. 3.11 *The loop of design for deconstruction*, adapted from Building with Reclaimed Components and Materials: A Design Handbook for Reuse and Recycling, Bill Addis, redrawn by author.

15. "What Is a Circular Economy?", Circular Economy, Ellen MacArthur Foundation. Accessed November 19, 2020. https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy.

16. Bill Addis, The Basic Concepts of Reclamation, Reuse and Recycling", in *Building with Reclaimed Components and Materials: A Design Handbook for Reuse and Recycling* (Oxford: Routledge, 2020), 12-15.

17. Allison Iris Arlotta, "Locating Heritage Value in Building Material Reuse", 7-9.

18. Jane Hutton, introduction to *Reciprocal Landscapes: Stories of Material Movements* (Oxford: Routledge, 2020), 5. The method of studying material heritage through reuse is similar to how Jane Hutton follow material relationships from the materials' production site to the designed landscape.

19. Allison Iris Arlotta, "Locating Heritage Value in Building Material Reuse", 10-11.

20. Susan Ross, "A Bibliography on Demolition Waste and Deconstruction", Discard Studies, updated November 6, 2017, https://discardstudies.com/2017/11/27/a-bibliography-on-demolition-waste-and-deconstruction/.

With design for disassembly in mind, bolts and nails are preferred over adhesive joining methods for wood joints of the pavilion. The pavilion also uses a helical pile foundation system, providing stability to the structure while minimising disruption to the soil. The reuse of material, design for disassembly, choice of foundation and surface treatment for the pavilion are all out of environmental considerations.

Under the pavilion shelter, an unloading zone is designed as a paved surface connecting to the parking space near the courtyard, for ease of transporting stone for storage on site. As we learned from part two of the thesis, the following steps to dry-stone stacking consist of sorting, cataloguing, selecting and shaping stones. Pavement tiles are selected over concrete to reduce the impact on soil. At the same time, the flat surface makes the sorting and shaping of stones an easier task. Within this zone, a small woodshed stores the essential tools used for dry-stone stacking. The design of the outdoor workspace draws insights from my experience with dry-stone stacking, and the workshop model for The Stone Trust. The Stone Trust is a non-profit organisation that provides educational training programs for dry stone wall construction.[24] I studied how the trust set up its craft training spaces to learn the basics of designing a collaborative learning environment. The Stone Trust operates out of a repurposed barn building, and the supporting wood columns guide the direction of workstations. The crafting area gives ample open space that encourages cross-learning among the craftspeople. [Fig. 3.12]

Fig. 3.12 Training walls in the indoor training barn at the Stone Trust Centre, Dummerston, VT, image by Stone Trust staff.

Terms

Deconstruction[21]
A process of carefully taking apart components of a building at the end of its life to recover materials and components or systems for potential reuse or recycling. Usually aims to extract resources for higher value future use.

Component Reuse[22]
Reuse of individual components extracted from the dismantling of one project in a new building.

Design for Disassembly[23]
Design for deconstruction describes a building designed to be readily taken apart at the end of its life so that the components can have a second use

21. Eleanor M. Gibeau and Bradley Guy, *Deconstruction Institute: A Guide to Deconstruction*, January 2003, http://www.deconstructioninstitute.com/files/learn_center/45762865_guidebook.pdf, (site discontinued).

22. Mark Gorgolewski, *Resource Salvation: The Architecture of Reuse,* (Hoboken, NJ: Wiley, 2018), 59-60.

23. Gorgolewski, Resource Salvation, Definitions.

24. About The Stone Trust," About, The Stone Trust, last modified February 3, 2019, https://thestonetrust.org/about-the-stone-trust/.

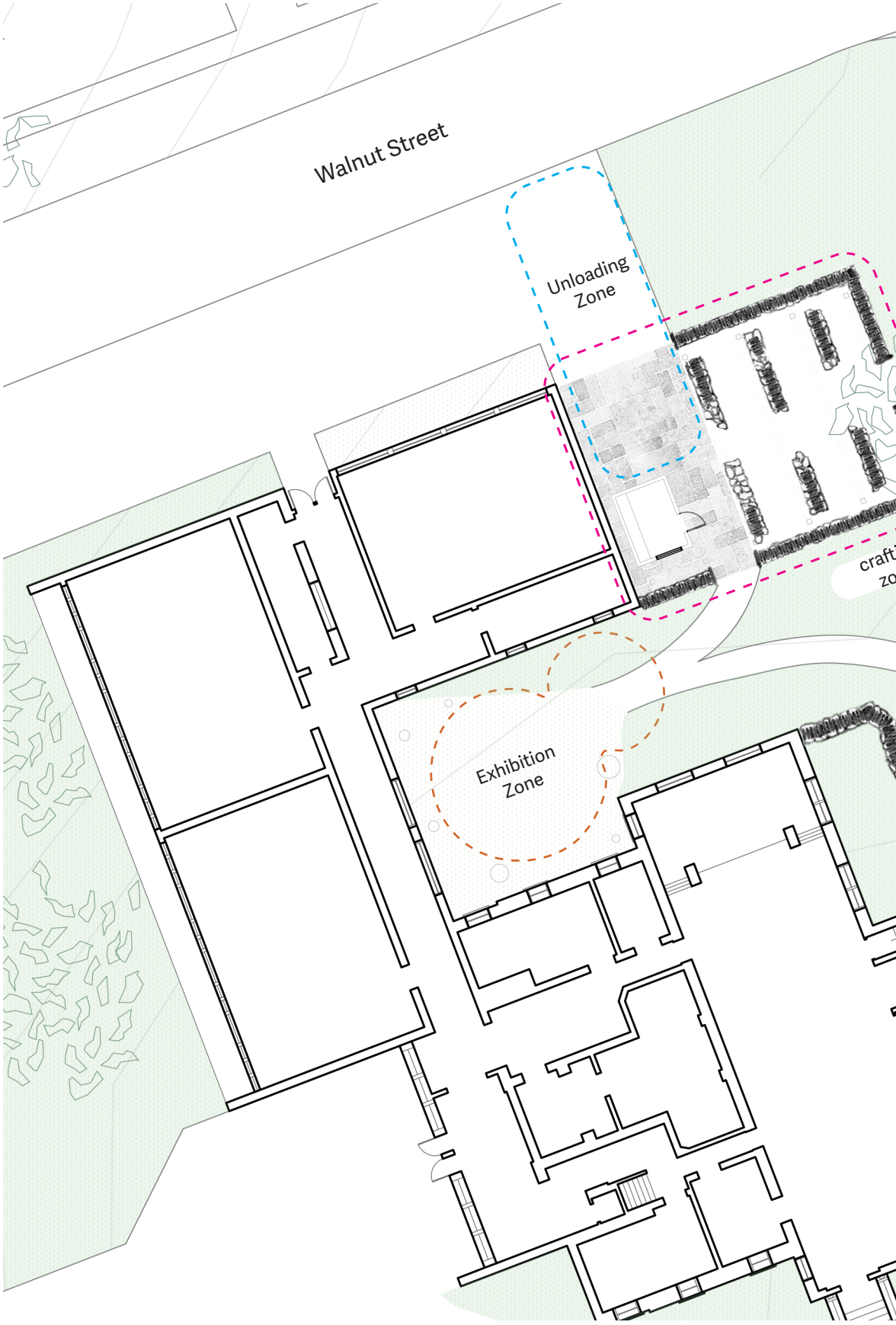


Fig. 3.13 Site plan of the outdoor workspace design at Willowbank, drawing by author.

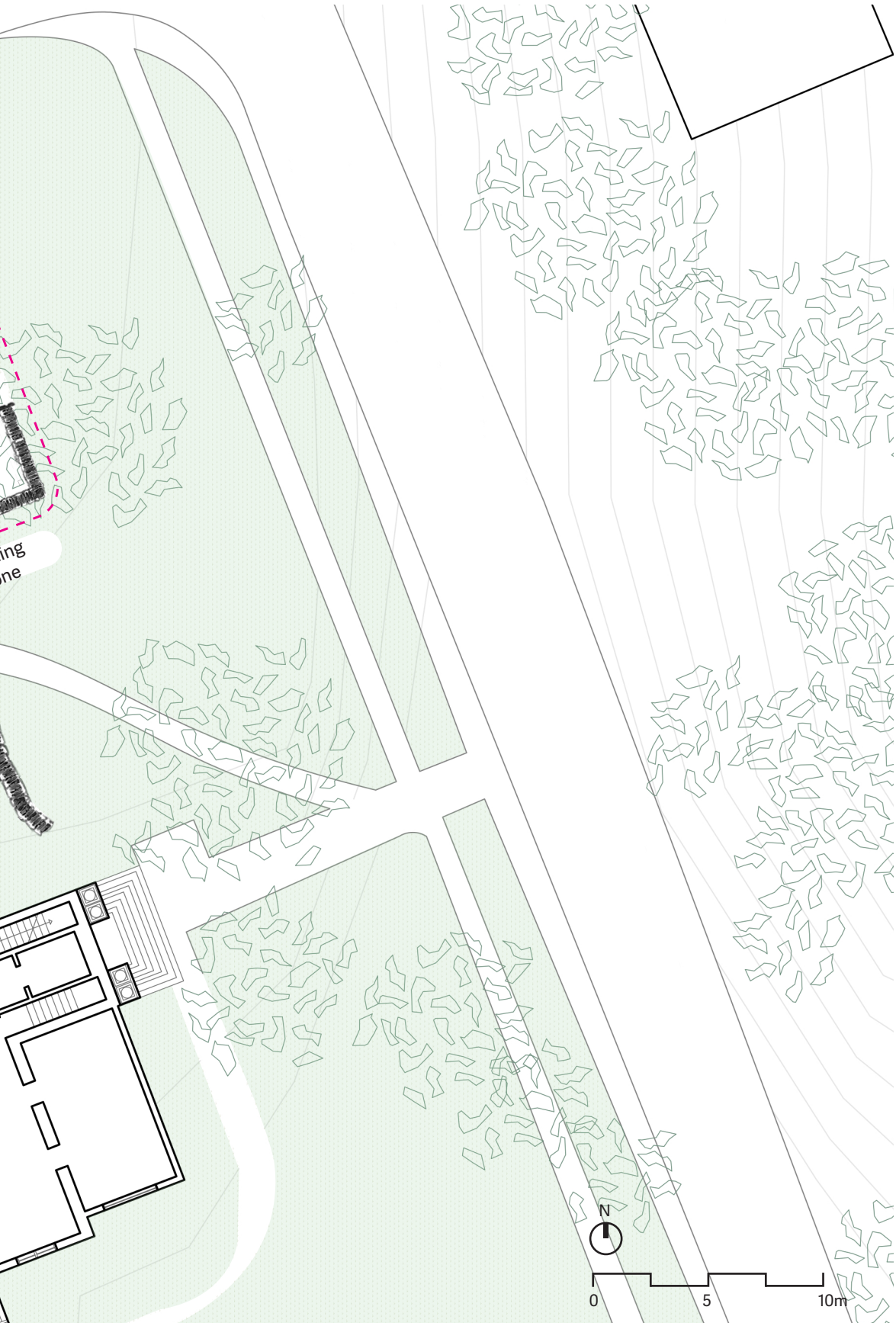

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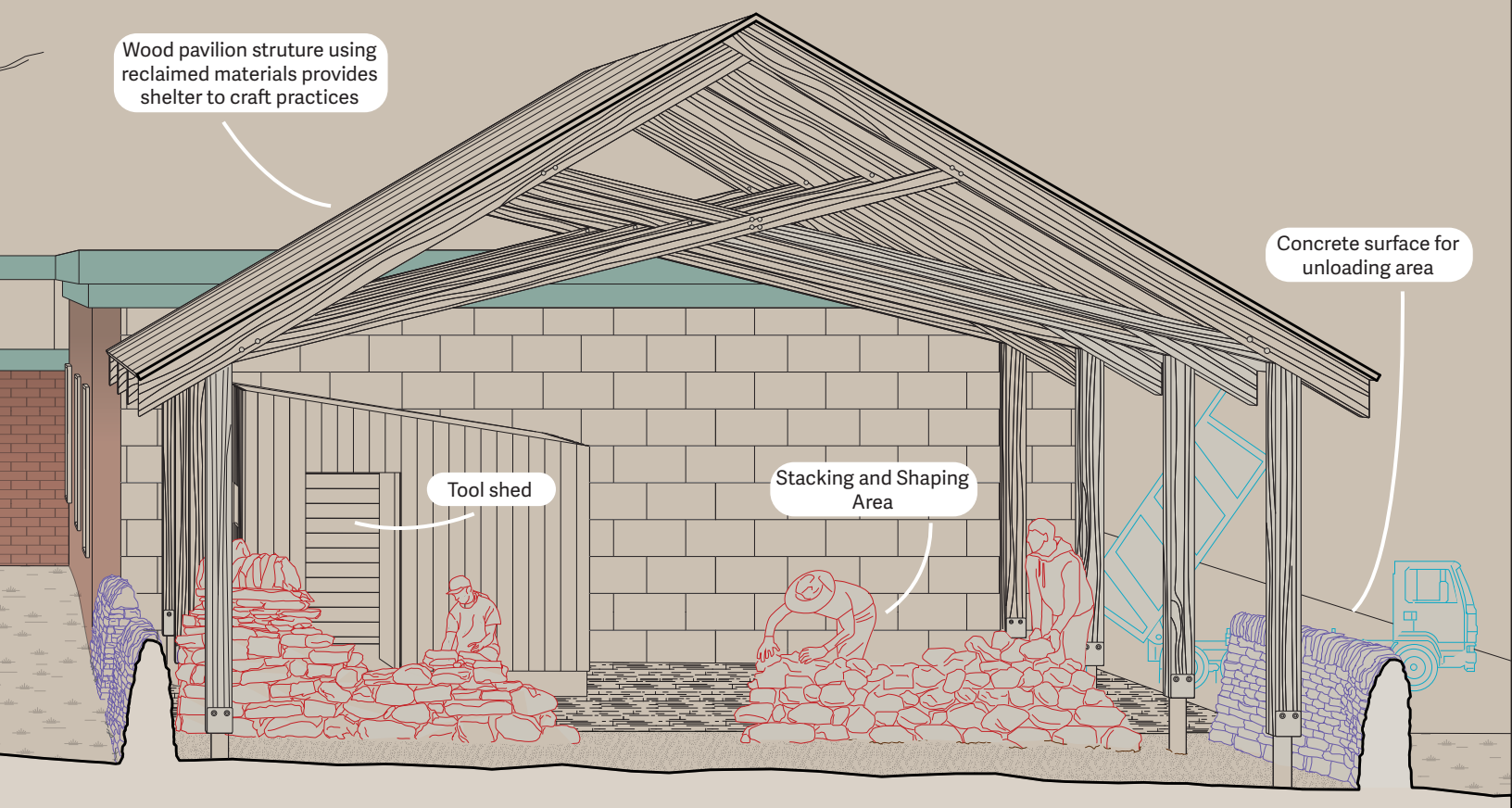
Fig. 3.14 Section perspective of the outdoor workspace design at Willowbank, drawing by author.

The Design


Wood pavilion struture using reclaimed materials provides shelter to craft practices
Tool shed
Stacking and Shaping Area
Concrete surface for unloading area

From my experience, the dry-stone stacking process is not linear while building larger projects such as a stone wall. Tasks such as shaping, sorting and selecting stones occur simultaneously. Thus, a flexible working environment is needed. I incorporated these organisation methods into my design, as the columns establish an order that prevents interference in activities, while the open space promotes a collaborative crafting environment. Turf is removed from the area where the stone walls are stacked to provide convenience to the crafting activities. The first two courses of dry-stack stone walls are usually placed in a shallow dug-out trench to provide additional support. The stone walls around the crafting area serve as an educational reference to the makers as they perform the craft themselves. This move is also drawn from my crafting experience, where I can learn creative ways of stone stacking by studying the examples at Willowbank. The reference walls are only one meter high to allow visual access to the activities in the pavilion for visitors approaching from all sides. This gives the local community a glimpse into Willowbank's activities, demystifying the school's missions.

The third part of the design proposal is an exhibition area for stone artefacts created by students. A stone wall extends from the entrance of the heritage building, leading into the courtyard, indicating the entrance to the exhibition space as visitors approach the space. If the perimeter stone walls of the outdoor structure demonstrate the technique of dry-stone stacking, this stone wall section is a creative expression of stone craft. The process used for constructing this stone wall is similar to how Wang Shu treated the reuse of tiles in his design, where the architect indicates the overall form and placement of the wall, and lets the craftspeople freely improvise the construction. Like how Wang Shu told the craftspeople to draw inspiration from the clouds and the sky when patterning the tiles, Queenston Quarry's rock surfaces inspired this process.[25] This wall is no longer just an aesthetic feature of the site, but also introduces the origins of the material through craft and design. It responds to the local material background of Queenston, while showcasing the creativity in a craft that Willowbank's training provides.

25. Ole Bouman, "For Love, or Other Reasons", 208.

Conclusion

This section of the thesis explores the designer's role when designing with materials through three themes: materiality, the act of communal making and contextual design. In terms of materiality, the use of Queenston Limestone responds to the material background of Queenston, as many of the local buildings are also constructed using stones from nearby quarries. It reflects the vibrant stone economy that was integral to Queenston's history. Discarded stones with special markings are selected to emphasise the unique human work that shapes the stones. Reusing stones pays an important tribute to the art of dry-stone stacking and craft heritage preservation. It also shows the material's agency by decreasing the design's environmental impact. All of which align with Willowbank's values in material and heritage preservation. Drawing my learnings from part two, the traditional dry-stone stacking technique is selected to showcase the craftspeople's skill and creativity. As a workspace for communal making, this design abandons the conventional school setting and favours a collaborative learning environment that allows students to learn from observing others' activities. Contextually, the pavilion structure also responds to the stone pavilion building on Willowbank's main campus. The outdoor workspace displays the crafting process to visitors approaching the site, which becomes an opportunity to strengthen the relationship between the school and the Queenston Community. Through this exercise, it becomes evident that the design form must stem from understanding the embedded relationships within the materials. At the same time, it establishes new connections with the proposed building site.

Epilogue

Summary

After completing the study into the Queenston Quarry, crafting with the material and designing at Willowbank, I concluded key takeaways from this learning experience as follows:

From part two, I investigated the non-human forces that shaped Queenston limestone's material properties, which gave the material its aesthetic and cultural value. The marks left on Queenston Quarry's faces were evidence of the human work in extracting Queenston Limestone. I also aligned the transformation of Queenston Limestone with the development of Queenston's local history, showing the material's agency in influencing its surroundings. The three material experiments in part two showcased the human creativity that goes into crafting Queenston Limestone. Traditional stone craft had the power of conveying the materials' embedded relationships, and these relationships were what informed the crafting process. The process of the craft was a bodily experience that allowed me to establish a personal connection with the material. Reusing stones also enabled craft practice through practising improvisation, which provided heritage value to the material. Designing with Queenston Limestone at Willowbank brought together the material background of the place. For designers, the developed form was an opportunity to respond to the local context, establishing new relationships for Queenston Limestone. Reusing discarded stones through communal making with local craftspeople was a way of preserving the material relationship of Queenston. The act of reuse also showed the materials' agency, where what was considered waste had the power to reduce environmental impact. The time I took to study and the knowledge I gained from Queenston Limestone made the material valuable to me. I formed a personal connection with the stones when observing, learning, drawing, shaping and designing with the material.

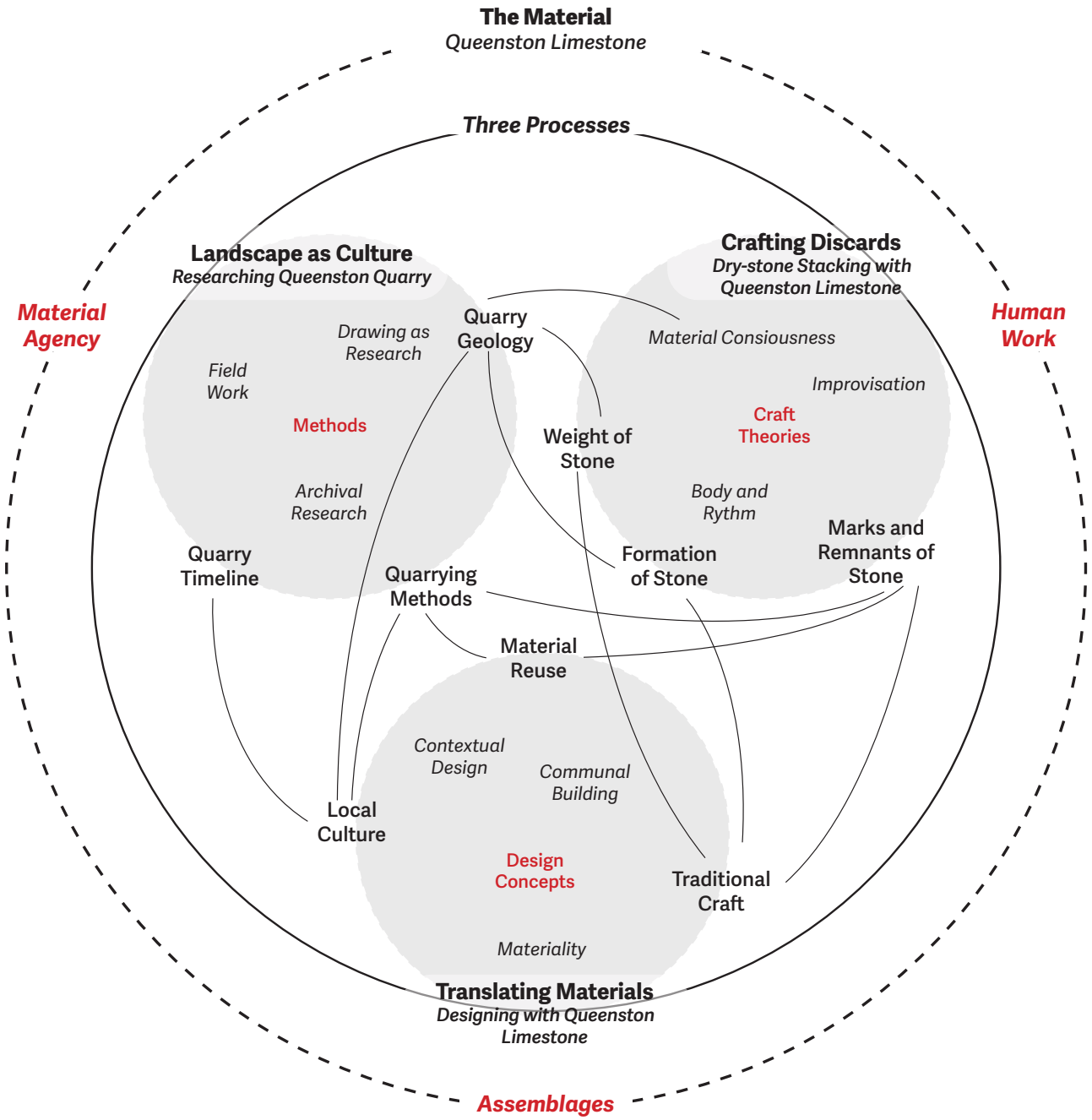


Fig. 4.1 Thesis Diagram Part III, by author.

Reflections

This study into Queenston Limestone is performed as a protest to the broader material reality of the current building industry. It becomes apparent that the value of Queenston Limestone comes from the network of relationships formed when interacting with elements of the built environment. The following section re-evaluates my relationship with building materials and outlines what I learned as a designer from this thesis.

Understanding Material Culture

Reiterating what is stated at the beginning of this thesis, this thesis challenges the ingrained notion in the building industry of materials being inert objects. To truly understand the implications behind the transformation of materials, I must abandon the consumeristic thinking of materials as static objects. Such thinking neglects materials' complex relationships with other beings and amplifies the extractive nature of resource consumption. I position this investigation as part of a more-than-human world, foregrounding the material to discover the cause and effects materials have on their surroundings. The three themes developed from material culture studies oriented and guided me when I deviated from a non-human-centric way of thinking. Materials are parts of assemblages, forming relationships with other elements in a network. Thus, they have agency in influencing and shaping their surroundings. When engaged in human activities, they transform through human work while reciprocally shaping the human experience. As materials move across space and time, they carry over relationships from previous assemblages while developing new relationships that connect assemblages for dialectic thinking.

Methods for Material Research

In addition to a different way of thinking, this thesis also proposes new methods of studying materials compared to the teachings in architecture school. I question the methodology where we study materials as isolated entities rather than them in relation to their environments. The methodology I applied to study Queenston Limestone from three locations has potential. This method removes the human-centric position that dominates the industry to uncover material and environment interactions. Due to the limitations in time, resources and location, it is inevitable that there are sites absent from this thesis. In a globalised world, the transportation chain of the material, and the market where materials become capital are crucial sites to study materials' economic and political implications. Within each site, specific research methods bring different perspectives together to gain a more holistic understanding of the material. Activities such as field work, drawing, and archival research engage the researcher through sensorial experience, while distancing them from the

subject to perform objective analysis once information is retrieved from the experience. Hands-on practices with the material involve the craftspeople who hold knowledge about the material from long-standing crafting traditions. Design, as an interdisciplinary practice, benefits immensely from including these perspectives when working with materials.

Designing with Materials

Throughout this thesis, I witnessed how the material's embedded relationship becomes more tangential when they are further removed from its extraction site. The designer's role is to understand and preserve these material relationships through the design form. Because design is also a creative expression, designers can establish new connections to create new value for materials. This thesis identified methods such as using traditional craft for said materials, material reuse, and connecting the material to its local context to achieve this goal. These methods stem from not only an understanding of the materials, but also respect materials' agency by giving them room to transform organically. This means giving freedom to craftspeople to improvise and allowing the materials' relationships to inform design decisions. I also recognise that the scale of this project vastly differs from most construction projects currently in the world. The difference is its locality. Connecting parts two to four, I studied Queenston Limestone from its original extraction site, through crafting, and returned to the town of Queenston where I designed a workshop with the material. However, living in a globalised world, the environmental impact of transporting and processing materials must not be overlooked. This experience shows that handcrafting and using local materials are ways to mitigate such impact. This circular relationship also allows the material to resonate better with the local context, telling the stories of the materials and the site. There is value in designing and building with local materials.

Moving Forward

This experience of interacting with Queenston Limestone humbles me as I begin to understand my limitations in perspective and the very things I design with. As a designer, I must make conscious and responsible design decisions when working with materials. Moving forward, I will adapt the methods used in this thesis as an epitome of how I approach other materials. However, there are still outstanding questions left in this thesis. What relationships are kept or lost when materials are part of a global commodity chain? What other methods can be adapted to communicate material relationships in the design process? If, as a designer, I am limited to personal understandings and perspectives, how do I pick and choose the material relationships I wish to preserve or build upon? But what makes one set of relationships more valuable than the other? From an educational standpoint, if it took me two years to study a single material to this extent, how do we reform the current education model to become less human-centric? These are all questions that I wish to investigate further after this thesis is completed. For now, I will hold my learnings from this experience, and continue to educate myself in the complex world of materials.

Epilogue

Moving Forward

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