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TRANSPORTATION OF GRANITE FROM SOUTH-EAST FINLAND TO SAINT-PETERSBURG

Nasta-project

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TIIVISTELMÄ

Tämän opinnäytetyön tarkoituksena oli selvittää, millainen luonnonkiven logistinen ketju Kaakkois-Suomesta Pietariin on nyt ja millainen se voisi parhaimmillaan olla. Osakysymykset liittyivät logistiikkaketjun kuljetusmenetelmiin, kustannustehokkuuteen, ympäristöystävällisyyteen, haasteisiin ja pullonkauloihin kuljetusketjussa sekä luonnonkiven markkinointiin ja viennin kasvattamiseen. Tämä opinnäytetyö oli osa hanketta nimeltä ”Luonnonkiven historia ja tulevaisuus arkkitehtuurissa (Nasta) – silta Kaakkois-Suomen ja Venäjän välillä”. Hankkeen tarkoituksena on ylläpitää Suomen ja Venäjän rajat ylittävää yhteistyötä ja luoda liiketoimintamalli luonnonkiven käyttöön Pietarin historiallisesti arvokkaisiin kohteisiin.

Tämä opinnäytetyö oli kvalitatiivinen eli laadullinen tutkimus. Teoreettinen viitekehys pohjautuu luotettaviin suomen- ja englanninkielisiin painettuihin lähteisiin ja verkkolähteisiin. Empiirisen tiedon aineistonkeruumenetelmäksi valikoitui puolistrukturoitu teemahaastattelu. Haastateltaviksi saatiin viisi henkilöä ja kaikki haastattelut tallennettiin ja litteroitiin. Koko tutkimusaineisto käsiteltiin sisällönanalyysin keinoin.

Aineiston perusteella selvisi, että luonnonkiven nykyisessä kuljetusketjussa Kaakkois-Suomesta Pietariin käytetään Venäjältä saapuvia rekka-autoja. Haastatteluaineiston perusteella syynä tähän oli kuljetuskustannusten alhaisempi hinta Venäjällä. Vaihtoehtoinen kuljetusketju vaatii myynnin kasvua suomalaiselle luonnonkivelle. Luonnonkiven loppuhintaan vaikuttavista tekijöistä yksi tärkeimpiä on logistiset kustannukset. Myyntiä voidaan kasvattaa lisäämällä markkinointia ja keksimällä uusia tapoja tuoda suomalainen luonnonkivi paremmin esille Venäjällä ja muualla maailmassa. Myynnin kasvu mahdollistaa myös paremman kustannustehokkuuden ja ympäristöystävällisyyden kuljetusketjuissa.

Tutkimuksen johtopäätöksenä voidaan todeta, että jatkotutkimusta tarvitaan siitä, miten suomalaisen luonnonkiven sopivuutta rakennusprojekteissa voidaan nostaa esille ja markkinointia ja myyntiä kehittää. Opinnäytetyöhön asetettuihin tutkimuskysymyksiin onnistuttiin vastaamaan. Toimeksiantajan kannalta tämä tutkimus auttaa selventämään luonnonkiven kuljetusketjua tällä hetkellä sekä löytämään parempia kuljetustapoja luonnonkivelle tulevaisuudessa.

Asiasanat: logistiikka, logistiikkaketju, kuljetus, luonnonkivi

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ABSTACT

The purpose of this thesis was to describe the logistical chain of natural stone from South-East Finland to Saint-Petersburg and explore what it could be at its best in the future. Other topics were transportation methods, cost-effectiveness, and environmental aspects, challenges, and bottlenecks for logistical chains as well as marketing issues and prospects of exports of rapakivi granites. This thesis was part of the project called “History and future of natural stones in architecture (Nasta) – the bridge between South-East Finland and Russia”. The purpose of the project is to maintain cross-border cooperation and create a business model for the use of natural stone in valuable historical buildings in Saint-Petersburg.

This thesis was qualitative research. The theoretical framework was created from reliable Finnish and English printed sources and online sources. A half-structured theme interview was chosen as the data collection method for the empirical data. Five people were interviewed, and interviews were voice recorded and transcribed. The research data was processed using content analysis.

The transportation of natural stone from South-Eastern Finland to Saint-Petersburg is currently arranged by using trucks arriving from Russia. According to the interviews, the reason was the lower price of transport costs in Russia. An alternative transport method requires increased sales of Finnish natural stone. One of the most important factors influencing the price of natural stone is logistical costs. Sales can be increased by better marketing and inventing new ways to market Finnish natural stone in Russia and globally. The increase in sales also enables better cost-efficiency and environmental friendliness.

As a conclusion of the study can be stated, that the research area could be further explored on how to improve the marketing of natural stones and how to increase the importance of natural stones in construction projects. The research questions set for this thesis were answered. From the commissioner`s point of view, this study will help to give a better understanding of logistical chains of natural stone, as well as help finding better transport methods in the future.

Keywords: Logistics, logistical chain, transportation, natural stone

SISÄLLYS

1 INTRODUCTION

The purpose of this thesis is to describe what the logistical supply chain for rapakivi granite from South-East Finland to Saint-Petersburg is and what kind it could be at its best in the future. Rapakivi granites mostly occur in the Wiborg batholith, which is the biggest production area for Finnish rapakivi granite. Wiborg batholith is located in the South-East part of Finland. Rapakivi granites are natural stones and Finland plays an active role in the global natural stone market. (Härmä, Selonen 2018, 2.)

This thesis is a part of a larger project called “History and future of natural stones in architecture – the bridge between South-East Finland and Russia”, Nasta-project for short. The project aims to support and improve the natural stone market and disseminate information about the opportunities and possible substitutes in renovation works of natural stone among medium-sized companies. The project also aims to develop networking activities, commercial activities, as well as preserve and revitalize the cultural and historical natural stone heritage and image in the project area, thus supporting tourism and tourism business. (GTK 2019.)

International Nasta–project started on 01.10.2019 and it is scheduled to end on 31.7.2022. This co-operation project between Finland and Russia is investigating possible granite needs in Saint-Petersburg, as well as the stone reserves of Finland and the Karelian isthmus. The aim is also to promote cross-border trade and create a common cluster between countries. (Kiviniitty 2020, 147.)

The subject is current because Finnish granites have been used in buildings in north-western Russia and especially in Saint-Petersburg since the late 18th century. Now, these buildings have undergone renovation activities in recent years and therefore Saint-Petersburg has a demand for Finnish rapakivi granite. For example, the historical center of Saint-Petersburg is constructed by using Finnish granites and it is on the list of UNESCO World Heritage Sites.

(GTK 2019.) Two of the most famous targets of Finnish granite in Saint-Petersburg are the St. Isaac´s Cathedral and the Alexander I Column (Härmä, Selonen 2018, 9).

The natural stone subject has lately been studied in geologist Paavo Härmä´s dissertation about the Wiborg batholith. Another valuable source of information is a book describing how Finnish granite was used and transported in major construction work in Russia in the 19th century. The Finnish transport infrastructure agency and Finnish Customs provide important information from the logistical point of view of this topic. Also, many other published studies have been used to gather information for this study.

This study has been narrowed between South-East Finland and Saint-Petersburg. To get a comprehensive picture of the research problem, this study has also covered subjects, such as the history of the material, natural stone production in Finland, social and environmental aspects, criteria for feasible natural stone, contracts, and permits required for the extraction of natural stone, and radiation in natural stones. Also, export statistics of Rapakivi granites are pointed out.

Primarily, it is known that rapakivi granites are now in demand in Russia and therefore this project exists. It is also known that according to Paavo Härmä´s (2020) dissertation and other reports, there are good reserves of rapakivi granite in the Wiborg batholith. Finnish quarrying companies also have the capacity to produce more granitic natural stones.

1.1 Key concepts

Natural stone = Natural stones are defined as a piece of naturally occurring rock. A natural stone product is a worked piece of naturally occurring rock used in buildings and for monuments. Natural stones do not include “aggregates” or man-made products such as concrete or brick. (Härmä 2020, 7.)

Granite = Granite is the most known and one of the most common deep rock types on the planet. Deep rocks are formed from magma, deep under the crust of Earth. (Kivilajien jaottelu ja syntytavat.)

Rapakivi granite = Rapakivi granites are granitic natural stones. Rapakivi texture consists of ovoids and two generations of quartz and feldspar. Rapakivi granites are divided into two different types called viborgite and pyterlite, but in addition to this, there are several porphyric- and uniform-grained granites. (Lehtinen, Nurmi & Rämö 1998, 257-258.)

Batholith = A large area of deep rocks consisting of one or more rock types with an area of more than 100 square kilometers (Lehtinen et al 1998, 359).

Logistics = It is controlling of material flows from the point of origin to the end customer (Tapaninen 2018, 26). Logistics is the management of material flows, information flows, and capital flows. It also includes procurement, distribution, recycling, maintenance and support services, warehousing, and overall management and development of business relations. (Hokkanen, Karhunen & Luukkonen 2011, 13.)

Infrastructure = The fundamentals that are required for developed industrial production. These fundamentals are transportation connections, energy distribution, housing production, and telecommunications. (Hokkanen et al 2011, 161.)

Transport = Moving of material from point A to point B. Different transport methods are road transport, railway transport, water transport, airway transport, and pipe transport. (Hokkanen et al 2011, 82-85.)

Export = Exports are goods or services that are produced in one country and sold to buyers in another (Segal 2021).

2 RESEARCH FRAME

This chapter outlines the aim, objectives, and programme area of this thesis, as well as the research approach, research problem, research questions, research methods, and the theoretical framework. Figure 1 illustrates how the research frame is built on this study.

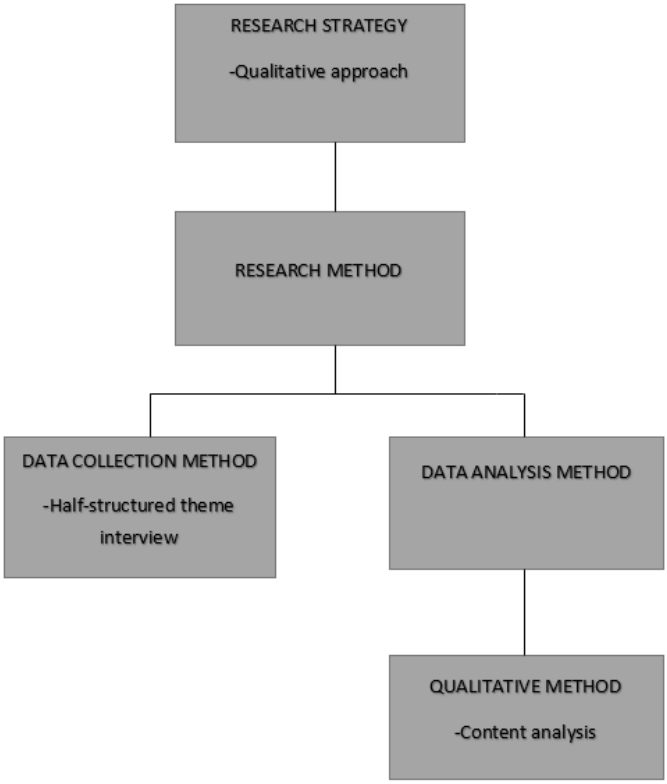

Fig 1. Research frame on this study

2.1 Aim and research approach

The main objective of this study is to produce new knowledge on the logistical supply chain for rapakivi granites from South-Eastern Finland to Saint-Petersburg. The aim is to explore and describe the logistical supply chain for natural stone from quarries located in Finland to restoration constructions in Saint-Petersburg, Russia. The study area of this thesis has been narrowed between South-Eastern Finland and Saint-Petersburg because it is where the Nasta project takes place. (see chapter 1 the objectives and aim of the Nasta-project).

South-Eastern Finland and the rapakivi granite batholith comprise the main production area for granitic natural stone in Finland and there are good reserves for future quarrying (Härmä, Selonen 2018, 20). Consequently, this geographic limitation is reasonable for this study. Transport methods are focused on land- and water transport, that is road transport, railway transport, and waterway transport.

The theoretical part of this study was gathered from books, articles, and studies made on this subject. Only reliable sources were used such as a doctoral thesis or studies published by larger institutes. Also, different agencies, for example, Finnish customs or Finnish Transport Infrastructure agency, were reliable sources for this thesis.

To acquire the best possible answers for the research problem, this study will apply qualitative methods. The reason for this is that qualitative research gives extensive and rich data to understand the phenomena and answer the research problem. (Kananen 2015, 127-128.)

2.2 Research problem and research questions

The research problems are often posed in the form of research questions because answering a question is always easier than answering a problem. When research questions are solved, the study will be completed. (Kananen 2015, 55.) The research problem can generate multiple research questions. Figuring out the research problem can be described as a type of mission or vision in the study. In the empirical part of the thesis, the goal is to find answers to research questions. (Kananen 2015, 88.)

In this study, the research problem was to find out what the logistical supply chain for rapakivi granites from South-East Finland to Saint-Petersburg is, and for this reason, the main research question was posed as:

- *What is the logistical supply chain for rapakivi granites from South-East Finland to Saint-Petersburg and what kind it could be at its best in the future?*

The sub-questions are as following:

- *What are the best transportation methods for this task?*
- *What are the most inexpensive methods for this task?*
- *What are the challenges, problems, and bottlenecks for logistical chains of natural stone exports from Finland to Saint-Petersburg, and are they solvable?*
- *How could the sales of Finnish natural stones be increased?*
- *How could sustainability be increased?*
- *How is the future of Finnish natural stone exports?*

2.3 Research methods

Research methods are used to solve the research problem. Research methods consist of collection methods and analysis methods. There are many different methods to use, and a mix of these methods will form the research approach. The research approach is divided into qualitative and quantitative methods. (Kananen 2015, 63-64.) Qualitative research is expressed in words, whereas quantitative is expressed in numbers and graphs (Streefkerk 2020).

Qualitative research

Qualitative research is used to gather in-depth insights into a problem or generate new ideas for research. It is meant for collecting and analyzing non-numerical data. (Bhandari 2020.) The qualitative methods for gathering data are observation, interviewing, documents, and sometimes inquiries. Qualitative research aims to understand the phenomena “what is this about?”. In qualitative research, there is no possibility to know how much data you need to have beforehand. That is why qualitative research aims to reach so-called saturation in collecting data. The researcher strives to collect the widest and most comprehensive data possible about the phenomena to gain an understanding. (Kananen 2015, 128.)

Qualitative approach in this inquiry

The plan for acquiring empirical data is to use a qualitative method by conducting half-structured theme interviews with professionals who have experience in this field, such as quarrying entrepreneurs. An interview is a good way of gathering data, if you study opinions, behaviour, or subjects that are not so well known (Boyce & Neale, according to Kananen 2015, 143). If the study deals with future, the only possible qualitative method is an interview (Kananen 2015, 143).

A half-structured theme interview is a relatively informal interview, in where the researcher is discussing with an interviewee by asking opinions and views about topics or themes which are beforehand defined. This kind of interview will give the researcher information from topics that are less known or rarely studied. The advantages of a half-structured theme interview are that researcher has a possibility to make further questions or sometimes solve possible misunderstandings, whereas in normal interviews the topics are strictly followed. Usually, interviewees explain their opinions with illustrative examples and stories. This is valuable information to the researcher. A half-structured theme interview is the most applied style of an interview in qualitative research. (Puustinen 2013, 5.)

2.4 Theoretical framework

The theoretical framework of this study has been created to help to solve the research problem, which is to find out what the logistical supply chain for natural stone from South-East Finland to Saint-Petersburg is. The theoretical framework is the structure that supports the research study. The meaning of theoretical framework is to explain and describe the theory on the study and by that, it explains why the research problem of a study exists. (Abend 2008, according to USC Libraries 2021.)

The theoretical framework begins in chapter three by defining what natural stones are and what kind of natural stone production there is in Finland. Chapter three includes criteria for feasible natural stone, contracts and permits required for the extraction of natural stone, radiation in natural stone, and social and environmental aspects of natural stones. The first heading will give the reader a good insight into the material that is playing the central role in this study.

Chapter four explains the actual rapakivi granites in more detail. For example, when rapakivi granite began to appear in Finnish soil and who was the first to study them. It also includes the texture of rapakivi granites, current production, the beginning of industrial quarrying, and information about the largest rapakivi area, the Wiborg batholith. On behalf of this study, it is important to know where rapakivi granites are found and what style of rapakivi granites are found in the Wiborg batholith.

The Nasta-project aims to invigorate the natural stone business and increase knowledge on natural stones used in historical constructions. The purpose of the fifth chapter is to tell about the use of rapakivi granite and natural stone in Saint-Petersburg, especially in Isaac´s Cathedral, Alexander Column, Canal structures of Neva river, and streets of Saint-Petersburg.

Chapter six begins by defining the word “logistics” and what its purpose is. It is necessary to know since the research problem is based on the best logistical routes. There are also explanations about the importance of supply chain management. The rest of the sub-titles are about Finland´s logistical performance, road network, railway network, and waterway network. There is also a discussion about the most important roads and waterways connecting South-East Finland and Saint-Petersburg.

The last chapter of the theoretical framework focuses on the border traffic between programme areas. Moreover, there is information about the border crossing statistics and export statistics of granite from Finland to Russia and the world market.

3 NATURAL STONES

Natural stones are defined as a piece of naturally occurring rock. A natural stone product is a worked piece of naturally occurring rock used in buildings and for monuments. Natural stones do not include “aggregates” or man-made products such as concrete or brick. In natural stone production, blocks of stone are quarried from solid bedrock using a drill, saw, or blasting. The blocks are then cut into slabs or tiles or other products which after are mechanically finished e.g. by polishing. Natural stones can also be used in tombstones and monuments, exterior and interior tiles, curbstones, and nugget and dice stones. Furthermore, natural stones are often used as a special feature in interior design, fireplaces, tabletops, small objects, and environmental construction. (Härmä 2020, 7). The picture below (Fig 2.) is a stone block that is extracted from the bedrock. The lines on the left of the block are boreholes made for explosive charges. After the boreholes are filled with explosives, they are blown up in series to make a straight line as it is in the picture. The letters indicate the brand name (BB = Baltic Brown) and the numbers tell how many blocks have already extracted from this specific quarry.

FIG 2. Baltic Brown stone block in Hujakkala, Finland

Rock types can be divided into three main groups by their way of forming: Magmatic rocks, sedimentary rocks, and metamorphic rocks (Lehtinen et al 1998, 33).

Magmatic rocks are formed from molten rock or magma. Magma is formed deep under the crust of Earth. The molten rock penetrates upwards in the shell. The rise of magma can stop at a certain depth and then it will form a magma reservoir. Magma releases thermal energy into its environment and starts cooling down. When the temperature drops low enough, magma begins to crystallize and form into minerals, deep rocks.

Sedimentary rocks are formed by weathering. Weathering removes mineral granules from the bedrock. These minerals are then moved around by the wind, water, or ice and can continue to grind into smaller granules until they layer into sediments as conditions change. Over millions of years, these sediments petrify and form sedimentary rocks.

Metamorphic rocks are born from both magmatic rocks and sedimentary rocks when they are exposed to different pressure and temperature conditions. Metamorphic rocks are usually formed during rock placement in the collision zone of continents e.g., the Himalayas or Alps. Granites are formed from magmatic rocks or metamorphic rocks. (Kivilajien jaottelu ja syntytavat.)

3.1 Natural stone industry in Finland

Finnish natural stones are esthetically beautiful and extremely durable. Buildings constructed by using Finnish rapakivi granites can last for over 100 years. In addition to this, as buildings age over time, beauty is further emphasized as the surface becomes covered with patina and the angles of the building become rounded. This is called “valuable aging”. (Räisänen, Härmä & Torppa 2020.)

Finland produces natural stones, such as granite, soapstone, schist, and marble. At present, granite is 80% of the production and soapstone 20%. Finland

plays an active role in the natural stone market, exporting to approximately 40 countries. In 2018 Finland exported around 210 000 tons of natural stone with a value of 18 million euros. (Härmä 2020, 7.) The main export countries are China, Italy, Poland, and Russia (Luonnonkiviteollisuus).

There is potential growth for the Finnish natural stone industry. Finland has strong knowledge and long traditions working within the business area, as well as good infrastructure built around it. The most important thing is to increase marketing to gain more exports. (Kiviaines- ja luonnonkiviteollisuuden kehitysnäkymät 2015, 4.)

There is a lot of material to be mined, and not everything has even been found yet. Geological Survey of Finland (GTK) has studied new areas for red rapakivi granite and crushed stone in South-East Finland. The project lasted 3 years and geologists explored through 900 rock areas and took 22 samples for strength tests. The research group found new deposits of red granite from Virolahti, as well as 15-20 areas for a suitable crushed stone between Kymenlaakso and South Karelia. Crushed stone is used as rubble on highways or railways. (Pesu 2020.)

There are around 200 active companies in the Finnish natural stone industry. Most of the companies are small-sized family businesses and the industry employs roughly 1500 people. Stone business can be divided into two groups, natural stone quarrying, and stone products manufacturing. In 2012 quarrying employed 266 people and products manufacturing 1210 people. (Romu 2014, 12.) Figure 2. is a picture of a natural stone quarry in Finland. This quarry was located in Hujakkala, South-Eastern Finland. The main production of this quarry was Baltic Brown granite. The picture was taken when the quarry was not operative.

70% of the produced granitic material in Finland consist of rapakivi granite. The main production area is called the Wiborg rapakivi granite batholith in South-Eastern Finland. Wiborg batholith is a source of famous rapakivi granites such as Carmen Red, Karelia Red, Eagle Red, and Baltic Brown. (Härmä

2020, 7.) More about rapakivi granite and Wiborg batholith in a later section of this thesis.

FIG 2. Granite quarry in Hujakkala, Finland

3.2 Socially and environmentally responsible stone industry

Nowadays, an important factor to consider when sourcing natural stone is socially responsible production methods. In public procurement, the natural stone should be procured responsibly because the city image might turn unpleasant when the origin of the production comes to the attention of end-users and citizens. For example, the production chain for natural stone originated from Asia is not transparent. There is no certainty that the stone is produced without labor exploitation or child labor. Also, there are no clarifications about the quality of the stone.

According to Kivi ry (2019), Finland has 80% lower carbon dioxide emissions on stone products than Asia. A key factor in reducing the carbon footprint of stone products is to avoid emissions from logistics. This why domestically produced stones should be used more. A responsible customer always buys stone products as close as he/she can. Natural stones could reduce the use of

the world's most known building material, concrete. The making of concrete produces a large amount of carbon dioxide and recycling is difficult and costly. (Räisänen, Härmä & Torppa 2020.)

Natural stone production produces crushed stone. It is the same material as stone blocks but not as suitable because of its size, shape, or color. Crushed stone is excellent for infrastructure building. It can be used on constructing roads as crushed aggregate mixed with asphalt. When procuring natural stone, the purchase cannot be based solely on price anymore. Responsible and transparent production will give a competitive advantage in the market-place. (Räisänen et al 2020.)

3.3 Criteria for feasible natural stone

The two most important criteria for potential natural stone are the appearance and soundness of the stone (Härmä 2020, 10). The commercial aspect is also considered. What these criteria mean is explained in more depth below.

Appearance of stone

The aesthetic properties of natural stone are critical when selecting natural stone for architectonic purposes. The appearance of the stone is influenced by its color, texture, pattern, and structure. Natural stones can have only one color (monochromatic), or they can consist of several colors (polychromatic). Monochromatic stones include rapakivi granites and polychromatic stones include migmatites, gneisses or gneissose granites, and marbles with a vivid and strong design.

Natural stones are priced by their color. Usually, blue, yellow, and black colors are the most highly priced. Monochromatic stones must be homogeneous throughout the deposit or it is not accepted as a first-class stone, whereas in polychromatic stones these variations are accepted and sought after. (Härmä 2020, 10.)

Soundness of stone

When assessing the soundness of a rock deposit for natural stone production the stone must have a feasible pattern and spacing of fractures to be an object for extraction. It also must be economically feasible to quarry. This means that the deposit should be sparse and regularly cracked to produce the required block size. A suitable stone block size is 2.40-3.45 m in length, 0.80-2.40 m in height, and 1.30-1.95 m in width.

When natural stones are used in the construction industry, the stone must meet the requirements of physical and mechanical durability. These requirements are numerical values set by European EN standards. (Härmä 2020, 13.)

Commercial criteria

The market demand indicates whether the stone has value in the international marketplace. Even if the stone would meet the needed requirements, it will have no value without an appreciation from the market. Architectural style and fashion can change rapidly which affects the value of the stone. Furthermore, different countries have different demands for certain stone types and colors. (Härmä 2020, 14.)

3.4 Contracts and permits required for the extraction of natural stone in Finland

The laws that monitor the extraction of natural stone are the Land Extraction Act*,* the Mining Act, and the Environmental Protection Act. Applied law depends on the type of stone being mined. For example, in quarrying granite or slate, you need to apply the Land Extraction act, but when quarrying soapstone or marble, you need to apply the Mining Act. Environmental permits are needed in both cases. When assessing a place to quarry granite or slate, you might need to do a sample test, and for this, you need a sample permit. The

permit is usually agreed upon in writing with the landowner. For quarrying on a specific area, a lease agreement with the landowner is usually required. Before doing this, it is recommended to find out whether it is possible to obtain quarrying permits for the area. When searching for marble, soapstone, and gemstones you need to get an exploration permit from the Finnish Safety and Chemicals Agency (Tukes). (Romu, Selonen & Härmä 2017, 5-7.)

Extraction of granite and slate requires a permit in accordance with the Land Extraction Act. In this application, you are required to explicate e.g. natural conditions of the area, describe the intake activity itself, and landscaping. As mentioned before, environmental permits are also needed for quarrying natural stones. Muraus regulation defines that a natural stone quarry may not be located at less than 300 meters from a residential or holiday home building or under 400 meters from hospitals, kindergarten, or schools. Muraus regulation also sets time limits for noise if the quarry is located less than 500 meters away from residences. In addition, for crushing of side rock in a quarry there must be an environmental permit if the operating time is a total of at least 50 days. These permits are given for a maximum of 10, 15, or 20 years. (Valtioneuvoston asetus kivenlouhimojen, muun kivenlouhinnan ja kuvenmurskaamojen ympäristönsuojelusta 9.9.2010/800; see also Romu et al 2017, 6.)

According to the Land Extraction Act, all quarrying operations also need to have an extractive waste management plan (Maa-aineslaki 24.7.1981/555).

Since 2015 all permits governed by the Land Extraction Act and the Environmental Protection Act are dealt with by the local environmental authority (Romu et al 2017, 6). However, there are some exceptions to this regulation. Before the permit is granted, the permit authority shall request the opinion of the regional environment center (ELY). If the site holds national or other major significance for nature conservation, or it is important for the protection of waters or the extraction of resources has a direct impact on the land of another municipality, it must be assessed by the ELY. (Maa-aineslaki, 7 §).

3.5 Radiation in Natural stones

All types of rock contain small amounts of natural radioactive elements that produce ionizing radiation (Pöllänen 2003, according to Romu 2014, 85). This harmful radiation is described as an effective dose, which is measured with sievert (Sv). Sievert is a measurement that measures radiation doses. A Finn receives an average of 3.2 millisieverts (msv) a year from various radiation sources, of which radon is about half of this. Radon is present in the air we breathe, and so cannot be avoided. (Romu 2014, 85.)

Radiation and Nuclear Safety Authority (STUK) supervises and monitors radiation safety in Finland. STUK issues general instructions, known as Radiation Safety Guides (ST Guides), concerning the use of radiation and operations involving radiation (Radiation safety in practices causing exposure to natural radiation 2011/ST12.1). These guidelines are based on the Council Directive, which lays down basic safety standards for protection against the dangers arising from exposure to ionizing radiation (Council of the European Union 2013/Directive 13675/13). The Directive is particularly regarded to people who work with natural radiation or who are exposed to radon in indoor air or radiation from building materials.

An employer who is running a radiation practice is responsible for the safety of the operations. Actions need to take place if workers are exposed to radiation, which is more than 1 msv per year, not including radon. If the exposure in the workplace is more than the permitted action level, the employer must arrange the necessary protective measures, such as limiting the working time. (Romu 2014, 85.)

In Finnish quarries, the radiation exposure of workers is less than 1 msv and so natural stone quarries can be considered as workplaces where separate monitoring of radiation exposure is not required (Aatos 2003, according to Romu 2014, 87–88).

The action level for the radon concentration in inhaled air is 400bq/m3 and must be measured in workplaces where people work on a permanent basis

(working hours more than 600 yearly) (Radiation safety in practices causing exposure to natural radiation 2011/ST12.1; Romu 2014, 85–86).

The radioactivity of building materials is limited through action levels by using activity indexes. Activity indexes are used to assess the exceeding of action levels and are calculated from radioactivity concentration measurements of the material. When calculating activity indexes Radium (Ra226), Thorium (Th232) and Potassium (K40), and Caesium (Cs137) from fallout are taken into account. (The radioactivity of building materials and ash 2010/ST12.2.)

The activity index is used to assess the suitability of building material for construction for different applications. There are no restrictions for the building material in construction if the activity index is less than 1. If the material is used as a coating in thin floors or coverings, the action level needs to be less than 6. All studied Finnish stone types were below the action level 6 on the activity index (Fig. 4), and so they can be used as a conventional coating material in constructions. (Aatos 2003, according to Romu 2014, 87–88.)

Kivilaji	^{40}K [Bq/kg]	^{226}Ra [Bq/kg]	^{232}Th [Bq/kg]	Aktiivisuusindeksi
Gabro	86	2	4	0.06
Gabro	400	21	19	0.30
Granitoidi	1070	10	50	0.64
Granitoidi	1410	57	79	1.06
Granitoidi	1590	170	380	3.00
Migmatiitti	650	20	22	0.39
Migmatiitti	860	25	68	0.71
Migmatiitti	1500	42	170	1.49
Serpentiniitti	50	2	4	0.04
Vuolukivi	50	2	2	0.03
Vuolukivi	50	17	2	0.08

FIG 4. Variation of activity indexes in Finnish natural stones (Aatos 2003, according to Romu 2014, 87)

4 RAPAKIVI GRANITES IN FINLAND

Rapakivi granites are natural stones that emerged over 1600 million years ago in Finnish soil. The first scientific research about rapakivi granites is J. Moliise´s dissertation from 1768. J.J Sederholm however was the first Finnish ge-

ologist who brought up rapakivi granites to worldwide literature. Rapakivi granites are popular building stones, due to their beauty, color, and structure as well as durability. Rapakivi granites have been used in various large cities such as Saint-Petersburg and Canadian and American cities. Besides the Finnish word “sauna”, the word “rapakivi” is an internationally accepted term for a definite type of granite. The name comes from the local people who used to describe rock as “crumbly stone” due to its weathering which formed a gravel-like surface. The rapakivi texture consists of ovoids and two generations of quartz and feldspar. Rapakivi granites are divided into two different types called viborgite and pyterlite, but in addition to this, there are several porphyric- and uniform-grained granites. (Lehtinen et al 1998, 258-259.)

Formally, rapakivi granites are defined as “*A-type granites characterized by the presence, at least in the larger batholiths, of granite varieties showing rapakivi texture*” (Haapala & Rämö 1992, according to Härmä 2020, 18). Rapakivi granites have been identified in several other areas, such as Sweden, the Baltic countries, Russia, Ukraine, Greenland, Canada, The United States, Brazil, Venezuela, Botswana, and Australia (Rämö & Haapala 2005, Muller 2007, according to Härmä 2020, 18).

The largest rapakivi granite deposits in Finland are found in four different batholiths (Åland, Laitila, Vehmaa, and Wiborg) and several smaller batholiths are in the southern part of Finland (Härmä, Selonen 2018, 2). The largest batholith in Finland is the Wiborg batholith and it is shown in figure 5. This batholith covers over 12 000 square meters and the total area of it is approximately 18 000 square meters. It is located in South-Eastern Finland. The Wiborg granite batholith consists of seven main granite types: wiborgite, dark wiborgite, pyterlite, porphyritic rapakivi granite, even-grained rapakivi granite, dark rapakivi granite, and aplitic rapakivi granite. (Härmä 2020, 20.) 80% of the Wiborg batholith consists of normal wiborgite or dark wiborgite granite (Vorma 1976, according to Harju 2014, 10).

Industrial quarrying of granite in Finland on a large scale started in the 1970s when a company called Lehdon Kiviliike Oy discovered brown wiborgite granite (Baltic Brown) in the Wiborg batholith. The discovery of Baltic Brown started an intensive development of Finnish natural stone quarrying and processing. Demanding markets with a good supply of granites, lead to accelerated growth of exports of Finnish granite. Nowadays, the Wiborg batholith is the main location for Finnish granite production and especially for brown granite. (Selonen, Härmä 2018, 9-10.)

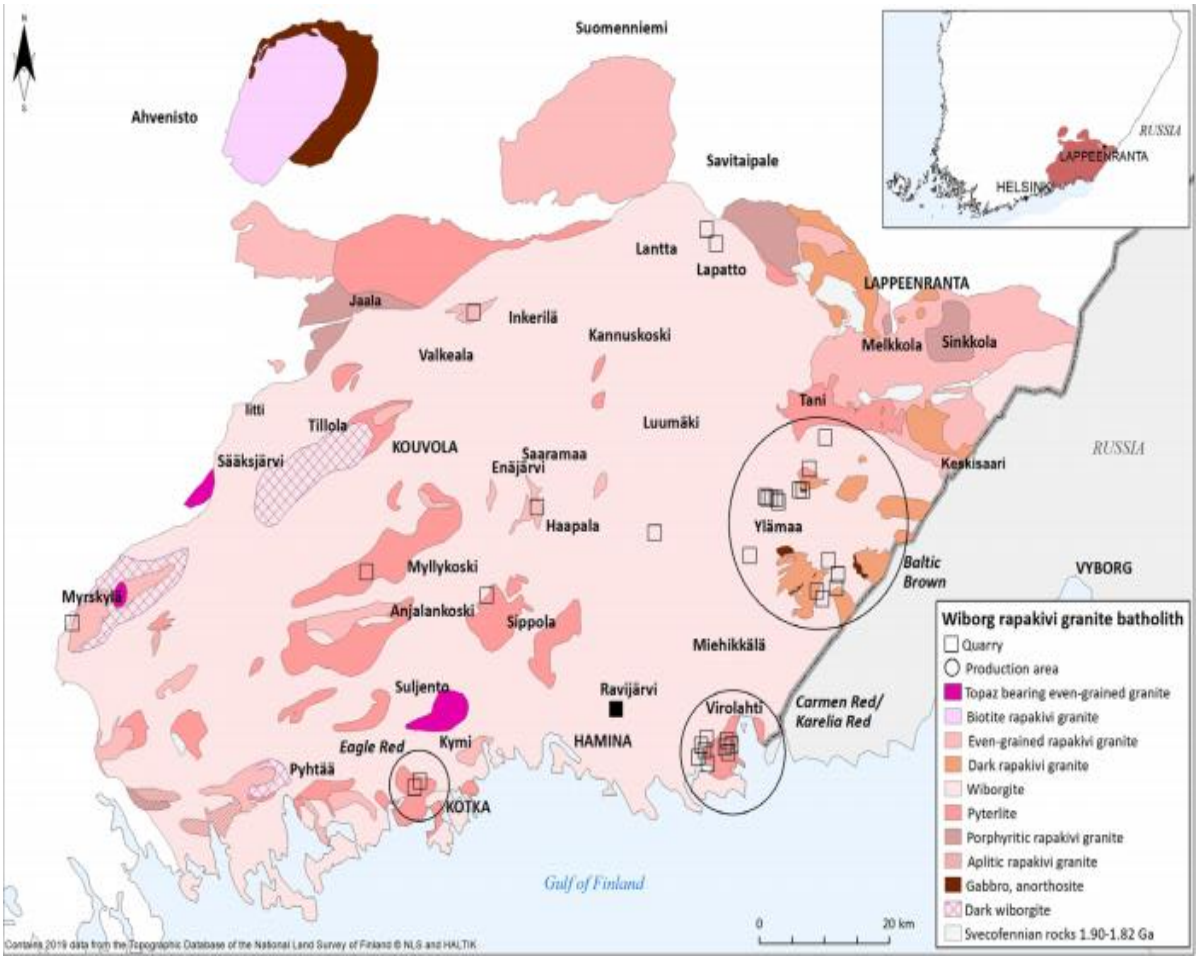

FIG 5. Geological map of the Wiborg granite batholith (Härmä 2020, 11)

4.1 Current production in Wiborg batholith

Currently, wiborgite and pyterlite are the main granite types extracted from the Wiborg batholith. From the 1970s, other important industrial quarrying sites in the Wiborg batholith have included Kotka, Virolahti, Anjalankoski, and Savitaipale. (Härmä 2020, 23.)

Baltic Brown, Carmen Red/Karelia Red

Baltic Brown (Fig. 6A) is a brown wiborgite extracted from several quarries in the eastern part of the batholith. It is suitable for all interior and outdoor uses, including larger projects. The stone is mostly exported to China, but also to Italy, Spain, and Egypt. *Carmen Red* (Fig. 6B) or *Karelia Red* (Fig. 6C) is a red pyterlite from the Wiborg batholith. It is quarried from several different mines. It is suitable for all interior and outdoor uses. It is also usable on larger projects. This granite is highly sought after in the world market, especially in China, Taiwan, and Spain. (Härmä 2020, 23.)

Eagle Red, Baltic Green and New Balmoral

Eagle Red (Fig. 6D) is a red pyterlite and it is quarried from two different mines in the batholith. It can be used for all interior and outdoor uses, including larger projects. This granite is mainly exported internationally, especially to Italy and therefore it is produced as large blocks. *Baltic Green* (Fig. 6E) is a green pyterlite extracted from two quarries in the batholith. The granite can be used in all interior and outdoor uses and is mainly exported to Baltic countries and Poland as well as Russia. *New Balmoral* (Fig. 6F) is a red even-grained rapakivi granite. It is suitable for interior and outdoor uses, mainly used for small or medium-sized projects. The granite is also used for monuments in domestic and export markets. This stone is quarried in only one mine in the Wiborg batholith. (Härmä 2020, 24.)

Myrskylä Red, Kymen Brown and Kymen Red

Myrskylä Red (Fig. 6G) is an even and fine-grained rapakivi granite. It is mainly used as paving stone, kerbstone, gravestone, and environmental stone in Finland. This granite is traditional Finnish paving stone quality. It is quarried from one quarry in Wiborg batholith (Suomessa louhittavat kivilaadut). *Kymen Brown* (Fig. 6H) is a brown pyterlite and is used in interior and outdoor uses.

The granite is found from one quarry and sold for domestic and Baltic countries. (Härmä 2020, 24.) *Kymen Red* (Fig. 6I) is an even and fine-grained rapakivi granite and it is suitable for monuments and building material in interior and outdoor uses (Suomessa louhittavat kivilaadut). It is mainly used in the Finnish markets. The granite is quarried from one quarry (Härmä 2020, 24).

Karelia Beige, Brownhill, Spectrolite

Karelia Beige (Fig. 6J) is a porphyritic rapakivi granite and it is colored as red or beige. It is used in domestic markets and is suitable for all interior or outdoor uses. *Brownhill* (Fig. 6K) is a medium-grained granite that has orbicular features. The color varies from gray to light grey-brown. It is a very rare stone with limited availability. It is suitable for small tabletops, bowls, dishes, and other small objects. *Spectrolite* (Fig. 6L) is a well-known gemstone type all over the world, but it is also used as a natural stone. It is a coarse-grained deep grey or black anorthosite with iridescent spectrolite crystals. It is especially used in tabletops and interior decoration. (Härmä 2020, 24–25.)

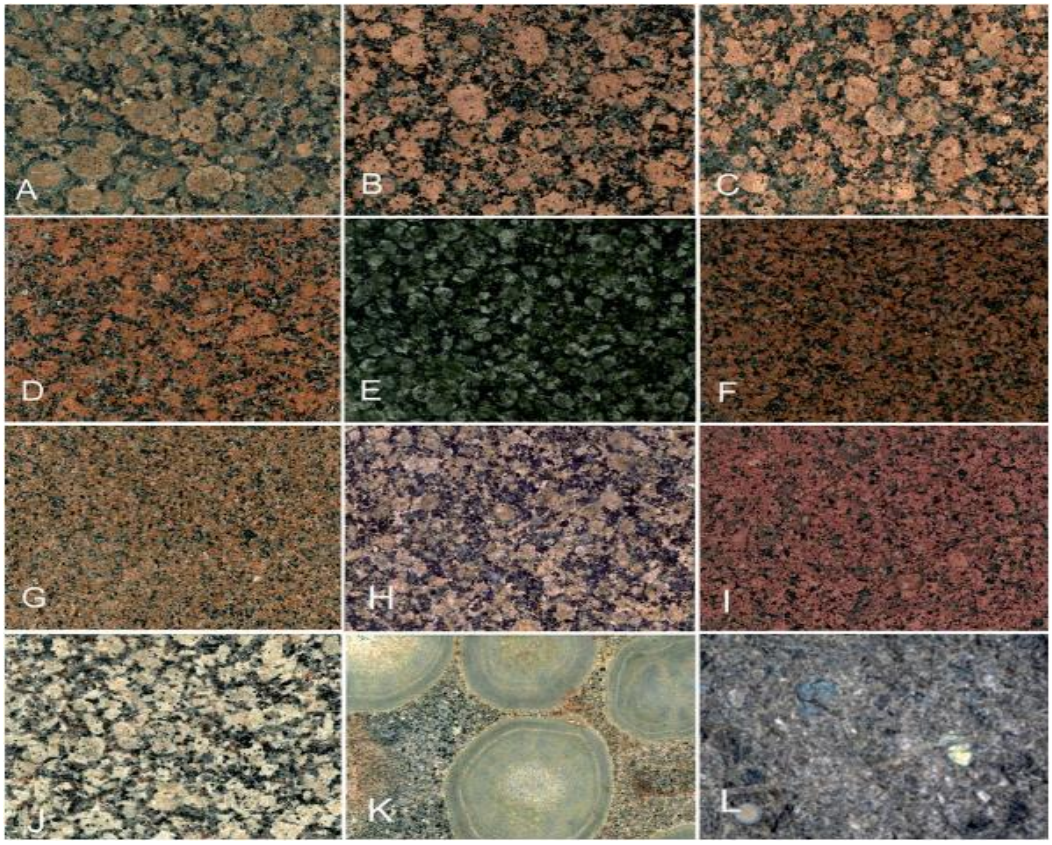

FIG 6. Natural stones quarried in Wiborg batholith (Härmä 2020, 25)

5 USAGE OF RAPAKIVI IN THE 19TH CENTURY IN SAINT-PETERSBURG

The most important age of using rapakivi granites in Russia was the 19th century. Most of the granite was found from the Wiborg batholith when the city of Saint-Petersburg was being constructed. However, granite was already used in the foundations of buildings in the mid-1700s, but the prime time for granite was from 1795 to 1915. The population of Saint-Petersburg increased tenfold in that time, therefore it was needed to construct thousands of more building foundations. (Kaukiainen 2016, 131–132.)

Buildings needed durable building material, therefore granite was suitable material for this. In addition, there was no granite near the building sites, so the material was retrieved from South-Eastern Finland. All the granite quarries were located near the shoreline in the archipelago of Virolahti and Hamina as well as the city of Vyborg. (Kaukiainen 2016.)

The granite from Virolahti and Hamina was extensively utilized in the wall and canal structures of the Neva River. It was used also in the structures of bridges, quays, foundations of buildings as well as in street pavings in Saint-Petersburg.

It is estimated that more than a million cubic meters of granite were moved to Saint-Petersburg from Virolahti alone. Most of the granite was used in more mundane objects, such as stone foundations and embankments of the Neva river. In comparison, probably less than 15 000 cubic meters of granite was needed in building the Isaac´s Cathedral and the Column of Alexander the First. (Hintsala 2016.)

Saint Isaac`s Cathedral and the Monument of Alexander the First are the largest single pieces where Finnish granite has been used in Saint-Petersburg (Kaukiainen 2016).

5.1 112 red granite columns in Saint Isaac`s Cathedral

Saint Isaac`s Cathedral (Fig. 7) is one of the most famous attractions in Saint-Petersburg. The church was built 40 years from 1818 onwards till 1858. There are 112 monolithic red granite columns (carved from a single stone) quarried from Pyterlahti in Virolahti. 48 columns were used in portals, 24 for the dome, 32 in clock towers, and 8 were installed at the edges of the windows. The excavation of these columns started in the summer of 1819 and continued into 1830. The largest columns weighed over 150 tons. (Kaukiainen 2016, 65–88.) According to Yrjö Kaukiainen (2016), the cost of these columns was over five hundred thousand silver rubles. For that amount, you could have bought 550 kilos of gold at that time.

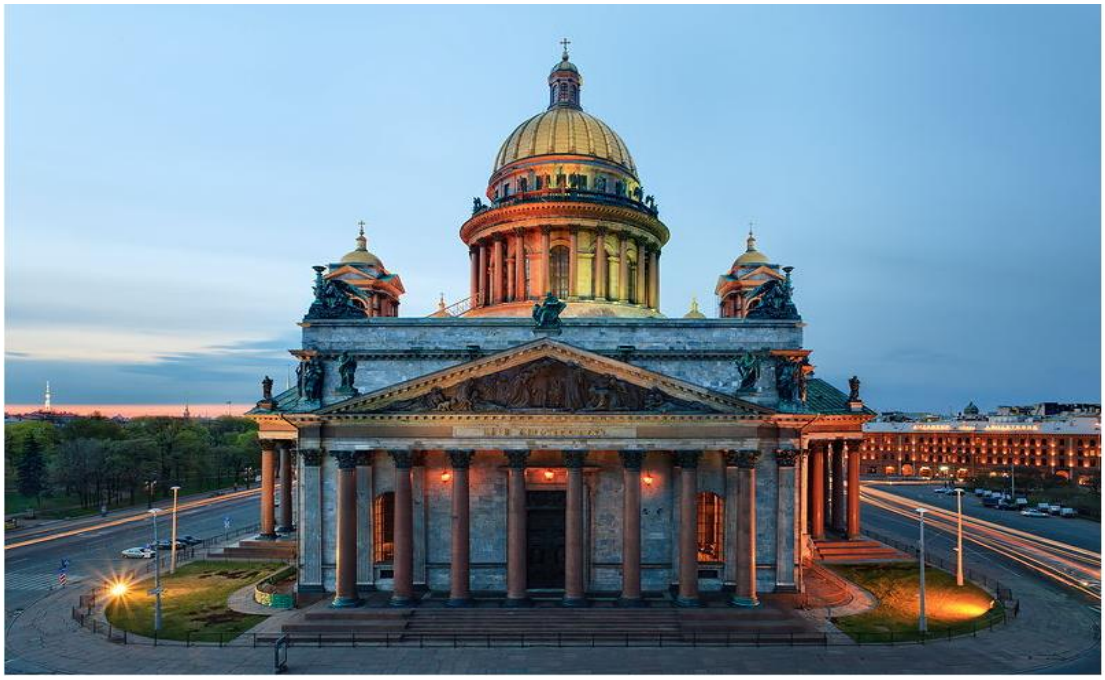

FIG 7. Saint Isaac`s Cathedral (Saint-Petersburg)

5.2 Alexander I Column

The Alexander Column (Fig. 8) is a large memorial built from 1829 to 1834. It is named after Emperor Alexander the First of Russia, who reigned from 1801 till 1825.The Alexander Column mainly consists of a monolith of red rapakivi granite extracted from Pyterlahti quarry in Virolahti. The monolith has a diameter of 3.5 m and a height of 25.6 m. This single piece of red granite weighs over 640 tons, which is four times the weight of the largest pillars of Isaac´s

Cathedral. The total height of the monument is 47.5 m, and it is the tallest of its kind in the world. Rumors tell that the column stands only on its weight, but this is not true. Kaukiainen (2016, 103) proofs this by saying the monolith was cemented into its stand when it was raised. (Kaukiainen 2016, 89–112.)

FIG 8. The Alexander Column in the Palace Square in Saint-Petersburg (Saint-Petersburg.com)

5.3 Canal structures of the Neva river

In addition to building foundations, a large portion of the granite was used on the structures of the Neva river (Fig. 9). When Catherine the Great came to power in 1762, she started to systematically build the city center area on the rivers of Saint-Petersburg. The riverbanks were edged with promenades and stone walls. The first bridge was built at this time and it was the Hermitage bridge. Also, the riverbanks of the rivers Moika and Fontanka were built and the Krivusa stream was merged with the Catharine Canal (called Gribojedov Canal today).

These building projects lasted decades and it was a matter of truly extensive construction work. Solely the banks of Moika, Catharine Canal, and Fontanka are 30 kilometers long and on top of that tens of stone bridges had to be built. The walls of the Neva river were especially hard to build because the river was deep, and the currents were strong, therefore solid foundations were needed. The walls were added with a roughly meter-high barrier to prevent a possible flood.

The constructions of the Neva river lasted till the World War One. It is highly possible that even more stone was used in canal constructions than building foundations during 150 years. (Kaukiainen 2016, 132-133.)

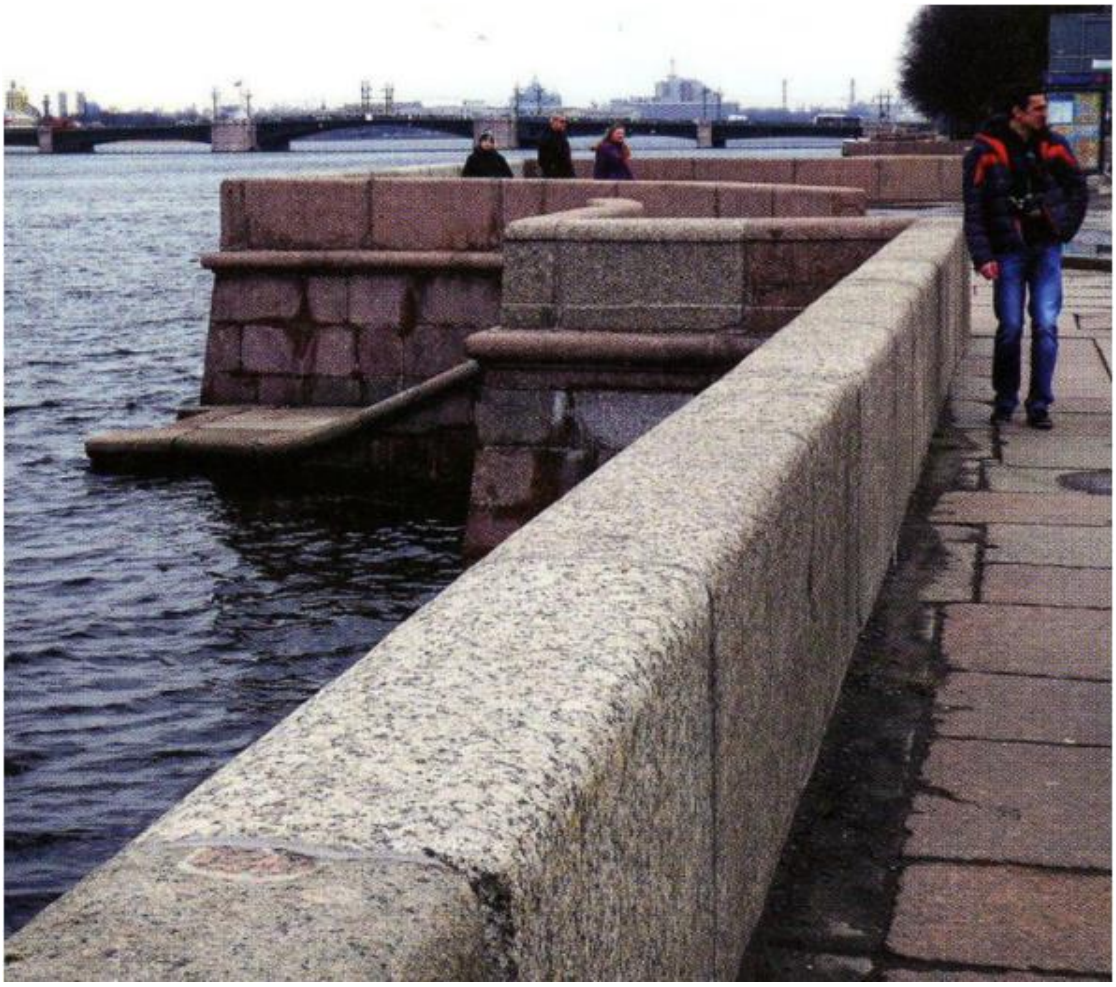

Fig 9. Granitic walls of the Neva river with added flood barrier (Kaleva 2017)

5.4 The streets of Saint-Petersburg

Building the streets of Saint-Petersburg was also one of the largest projects which consumed a lot of natural stone. Still, in the early 19th century, the paving and maintenance of the streets had been left to the landowners. Only the maintenance of the main roads and city center was paid from the public funds.

In the late 1700s, there was already a shortage of suitable paving stone, therefore the stone began to be brought from the coast of the Karelian Isthmus. In the mid-1800s, over ten thousand tons of cobblestone were imported to Saint-Petersburg from the Karelian Isthmus. Later the stones were also brought from the Gulf of Finland. When the stones ran out from land and shallow waters, they were lifted from deep waters. The large scale of exporting the stone is also indicated by the fact that also women worked on lifting and loading the stone. (Kaukiainen 2016, 133–134.)

6 LAND- AND WATER TRANSPORT INFRASTRUCTURE IN FINLAND AND ROUTE TO SAINT-PETERSBURG

The logistical performance of Finland is at a good level. Helsinki, Turku, and Tampere are the most important cities for transport flows. Finnish railways play a crucial role in the transport flows utilized by industry and transit traffic, especially in the northern and south-eastern parts of Finland. Finnish harbors are responsible for most of the foreign trade transports and Finland´s road network is in charge of the domestic transportations. The operational reliability of the transport system is affected by, the condition and capacity of transport infrastructure, availability and cost of transport equipment, the intensity of extreme weather conditions, and the general safety situation in society. (Liikennejärjestelmän nykytila…2020, 158-159.)

6.1 Functioning logistical chain

Logistics means the controlling of material flows from the point of origin to the end customer. According to Tapaninen (2018, 26), the purpose of logistics is:

- Product is available on time and when it is needed and it is done so that costs, environmental effects, and waste and security risks are minimized.

Logistics is managing the transports and warehousing, but it includes tele- and money communications as well as considering the environmental- and social aspects. (Tapaninen 2018, 26.) Logistics is often used as a synonym to Supply Chain Management (SCM) and vice versa, but there is still a difference between these two. The basic difference between logistics and SCM is that logistics management is the process of integration and maintenance (material flow and warehousing), whereas SCM strives for the coordination of the entire cooperation network. Logistics is usually about managing the material flows of one company or industry. (IIMU 2019.)

As mentioned, SCM means managing the operations. These operations include procurement of raw materials, processing raw materials into finished products, and distribution to the end customer. Well-managed Supply Chain Management ensures your business maintains a balance between demand and supply. All companies benefit from good Supply Chain Management because it aims to streamline the processes. At each step, the supply chain ensures that the consumer is receiving the correct amount of the correct item when they need it. For example, when a company is procuring raw material from the supplier, and the supplier fails to ensure the correct number of raw materials in time, the whole supply chain slows down. Being able to deliver your promises and be a reliable business partner, will grant you more business in the future and allows you to have an advantage over other companies. SCM needs to be efficient for operations to be able to reduce waste, costs, increase profit and ensure on-time deliveries. (PlanetTogether 2019.)

There are five different functions in SCM. It is extremely important to understand these five functions to improve the manufacturing operations efficiency. The five functions are as follows:

Purchasing

The first function is purchasing. Raw materials are required to produce goods in manufacturing processes, therefore it is important that the raw materials are procured and delivered on time. For this to happen, coordination with suppliers and delivery companies is required to avoid any potential delays.

Operations

Demand planning and forecasting are usually required before buying the materials, as the demand market will dictate how many units should be produced. This is an important function because the organization must accurately forecast demand to avoid having too little or too big inventory. Therefore, demand planning and forecasting must be tied with inventory management, production, and shipping to avoid such mistakes.

Logistics

Logistics is the part of SCM that coordinates all aspects of planning, purchasing, production, warehousing, and transportation so that the goods will reach the end-consumer without any hindrances. Adequate communication between different departments is needed, so the products can be shipped to customers rapidly and for the lowest cost.

Resource Management

Resource management ensures that the right resources are allocated to the right activities in an optimized manner. Resource management is tied with the operations because a production schedule is needed to maximize efficiency.

Information Workflow

Sharing the information for the whole network is the key to successful Supply Chain Management. If the information workflow and communication between

organizations and departments is poor, it can break apart the entire chain. (PlanetTogether 2019.)

The purpose of this thesis is to describe the logistical aspects and routes for natural stone from South-Eastern Finland to Saint-Petersburg Russia. Therefore, this inquiry does not go more in-depth on Supply Chain Management.

6.2 Finland´s logistics evaluation

The state and future of Finnish logistics have been studied regularly since the 1990s. The latest logistics report was published in 2018. Finland´s logistical performance is assessed by using the Logistics Performance Index (LPI) made by the World Bank. The index is based on a survey where logistics professionals around the world are asked to evaluate a specific country´s efficiency in logistics. Performance is comprised of 6 different dimensions; border crossing and customs, traffic- and tele infrastructure, availability to international transportation, level of competence in logistics, and ease of tracking shipments together with their timelines. Finland is often ranked high on this index. In 2018 Finland was ranked number 10, and in 2012 it was ranked third place out of 160 countries. (Liikennejärjestelmän nykytila…2020, 50-51.)

6.3 Road network

The Finnish road network is very extensive, it reaches every property or forest in Finland. It consists of national roads, municipal roads, and private roads. The busiest roads are in the south and near big cities. Altogether, the Finnish road network is the same size as German, Spain, French, Italy, and Poland's road network, though the population there is tenfold. (Tapaninen 2018, 43.)

The Finnish road network is approximately 454 000 km long. Around 350 000 km consists of private- and forest roads and 26 000 km of municipal roads. 78 000 km of highways are state-owned and are taken care of by The Finnish Transport Infrastructure Agency. Of these highways, 13 000 km are main roads, which of 900 km are motorways. The majority of the highways, 64 900 km to be exact, are regional and connecting roads, but these represent only a third of all traffic. Roughly 65% or 50 000 km are paved. These highways are separated into class 1 and class 2 roads. (Tieverkko.)

Finland started to improve strategically important roads and bridges in the year 2014 to improve logistics. The aim was to improve Finland´s competitiveness and reduce the gap between transport costs in Finland and Central Europe. Due to the long distances, Finland has higher transport costs compared to many other countries. According to the Finnish Transport Infrastructure Agency, approximately 1.6–3.2 billion euros could be saved in logistics costs over the next twenty years. To improve competitiveness Finland increased the maximum authorized dimensions and mass for heavy vehicles and trailers- or semi-trailers attached to heavy vehicles. The height for vehicles was also increased from 4.2 meters to 4.4. meters and the maximum mass from 60 tons to 76 tons. This regulation came into force at the end of 2013. (Kuljetuskaluston massat ja mitat.) In 2019, Finland gave permission to even longer trucks to enter the country. This has proven to have a beneficial effect on sea container transport, general cargo transport, and food transport. (Liikennejärjestelmän nykytila…2020, 62.)

FIG 10. Major road highways in Finland. Main roads are marked in blue (Väylävirasto)

Main roads connect Finland´s nationally and internationally largest centrals and hubs together (see Fig. 10). All major cities are also connected with rail-road and highway access. Main roads also have maintenance year-round, so passenger and goods traffic have no hindrance or slowness. If the road has more than 6000 passenger vehicles or 600 heavy vehicles daily, it is defined as the main road. Roads that ensure connectivity on the whole transportation network are also specified as main roads. (Pääväyläverkko.)

Nearly 300 million tons of goods are transported on Finland´s roads yearly, but more than a third of this is comprised of gravel and soil transportation. Transports are divided into two separate sections, value- and volume transports. In Finland, value transports are focused more on the southern part, whereas volume transports are heavily focused on main roads 3 and 4. (Liikennejärjestelmän nykytila…2020, 60.)

The strength of road transport is flexibility. It enables desirable quantities in a timely manner. A steady flow of materials makes it possible to have a small inventory for raw materials and finished goods. Road transport is also a practical solution for the inexpensive transportation of occasional shipments. On the other hand, the challenge is the potential inefficiencies caused by thin and fragmented transport flows. Small batches of material will also cause inefficiency. These issues can be noticed as low occupancy and empty driving. The pricing of road transport consists of transport distance, terms of delivery, customer relationship, necessary additional services, and fuel prices. (Liikennejärjestelmän nykytila…2020, 61-62.)

Most important roads connecting south-east Finland and Saint-Petersburg

The main road transport link is the highway E18 that connects Saint-Petersburg via Vaalimaa. E18 is part of the Nordic triangle railway and road axis within the Trans-European Transport Network, in short TEN-T. (CBC 2014-2020, 27.) In 2018 E18 Hamina-Vaalimaa road part was upgraded, due to the large traffic volumes generating up to 30 km long queues at the border. (E18 Hamina-Vaalimaa). From the Finnish border, E18 continues road A181 all the way to Saint-Petersburg. The road A181 does not go through Vyborg and near Saint-Petersburg, the route runs through suburbs, such as Sestroretsk and Olgino. (European route E18.) Road 13 is the main route from western- and northern parts of Finland going to Saint-Petersburg via the Nuijamaa border (CBC 2014-2020, 27).

6.4 Railroad network

Finland´s railroad network differs from other European countries, by its track gauge and the possibility to use the same rails for passenger- and goods traffic. Track gauge in Finland is 1524 millimeters and in Russia, it is close to the same, 1520 millimeters. (Tapaninen 2018, 50.) Russia is one of the largest countries using rail transport in the world. Their usage of rail transport is four times the size of Europe´s altogether. The compatibility of Finnish and Russian gauges is a great opportunity for Finland. (Itäinen rantarata 2020, 6.)

Finland has 5926 km of roadway rails, of which 3330 km are electrified. For the most part, the biggest allowed mass for axle weight is 22.5 tons, but in some parts, 25 tons is also permitted. The maximum speed limit for passenger trains is 220 km/h and for freight trains, it is limited to 120 km/h. Finland's railroad connects with Russia in Vainikkala, Imatrankoski, Niirala and Vartius. (Railway network.)

According to the Ministry of Transport and Communications, approximately 40 million tons of goods are transported yearly by rail in Finland. 7 million are transit transport and mostly from Russia. (Liikennejärjestelmän nykytila…2020, 67.)

In Finland, railways are mainly used for exporting heavy forest- and metal industries from production facilities to harbors. Also, a large majority of gross tonnages transported by rail are Russian metal- and chemical industry transit traffic. According to Tapaninen (2018, 53), domestic transports are moving by rubber tires and exports heading to harbors are moving by rail. The largest gross tonnages moving in Finnish rails are imports from Russia and their transit traffic through Finland to other countries. Finland mainly exports paper- and metal industry products to Russia. (Tapaninen 2018, 53.)

Figure 11. is showing the transported gross tonnages by rails. As we can see, the volumes are heavily focused on southern and south-east Finland.

Railroad transports are not as flexible as road transports and it is a usually slower method as well. In addition to this, the railroad requires a terminal for unloading the cargo. Rail transport usually needs road transport to the beginning and the end of the transportation. This increases the risk of damaging the goods, throughput time, and costs. (Hokkanen et al 2011, 101.)

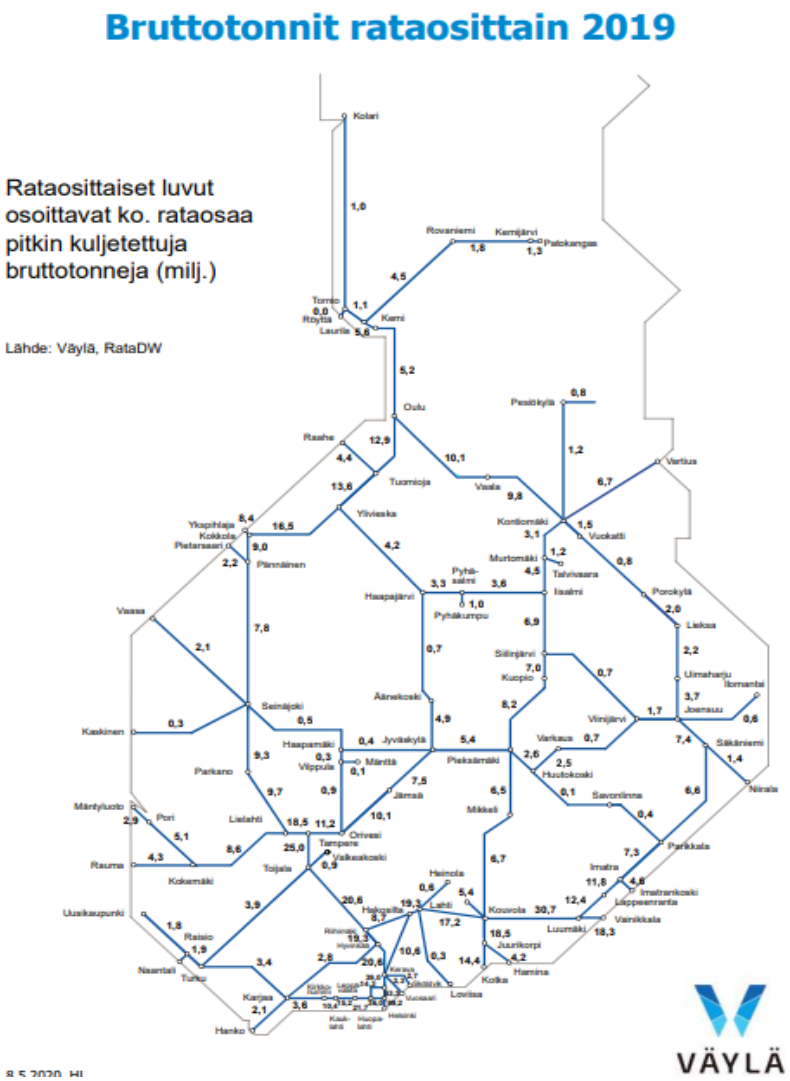

FIG 11. Gross tonnages moved by rail in year 2019 (Väylävirasto)

6.5 Waterway network

Finland has around 20 000 km of public, mapped fairways recorded on maps. 8 300 km are coastal fairways and 8 000 km of inland waterways and the

Finnish Transport Infrastructure Agency is responsible for maintaining these. Of these, 16 300 km are waterways, nearly 4 000 km are used for merchant shipping. (Waterways.)

Finland´s foreign trade mostly uses waterways. Shipping accounts for 83% of foreign trade transport. Finland´s waterway transports are mainly focused on neighboring countries. The most valuable trading partners are Sweden, Germany, and Russia. (Tapaninen 2018, 70.) In 2018, tonnage volumes for maritime transport were 91 million tons. In comparison, road and rail transports in the same year were only 14 million tons. (Tulli 2020.)

In global sea transports, large unit transports, e.g. containers, trailers, and trucks have become the most important mode of transport and this also reflects Finnish export transport. Finland´s most important goods in exports in 2018 were general cargo, petroleum products, paper and cardboard, ores, and refined products. The main products imported in the same year were crude oil, and petroleum products, general cargo, ores and refined products, crude minerals, and cement. (Liikennejärjestelmän nykytila…2020, 62.)

In 2016, Finland´s domestic waterways transported 5,7 million tons of goods. 5 million were transported on coastal fairways and only 0,7 million through inland fairways. Finland´s inland fairway usage is low due to the difficult navigation conditions in Saimaa. This is leading to the use of maritime pilots, thus raising the expenses. Another major reason is the traffic slowing for the winter because fairways freeze, and it generates more logistical expenses. (Tapaninen 2018, 70.)

Finland has around 80 harbors designated for transporting goods. Of these, 30 are open year-round. The ports are incorporated and are mainly owned by municipalities, but there are few exceptions. Finland has an extensive and comprehensive port network, and it is particularly built around the exporting industry. Foreign maritime transports are handled in a total of 44 different harbors. 10 largest harbors are accounted for 83% of the total foreign transport of

goods. Finland´s biggest universal ports are Hamina-Kotka- and Helsinki harbor. The largest tonnages are in Kilpilahti (Sköldvik) harbor, but it is not a universal port, and it focuses more on bulk transportation. Other worth mentioning ports are in Kokkola and Rauma. Transit traffic is conducted from Kokkola, Hamina-Kotka-, Hanko-, Helsinki-, and Pori harbors. (Liikennejärjestelmän nykytila…2020, 64.) Figure 12. is showing the total international import and export of goods by a port in 2018.

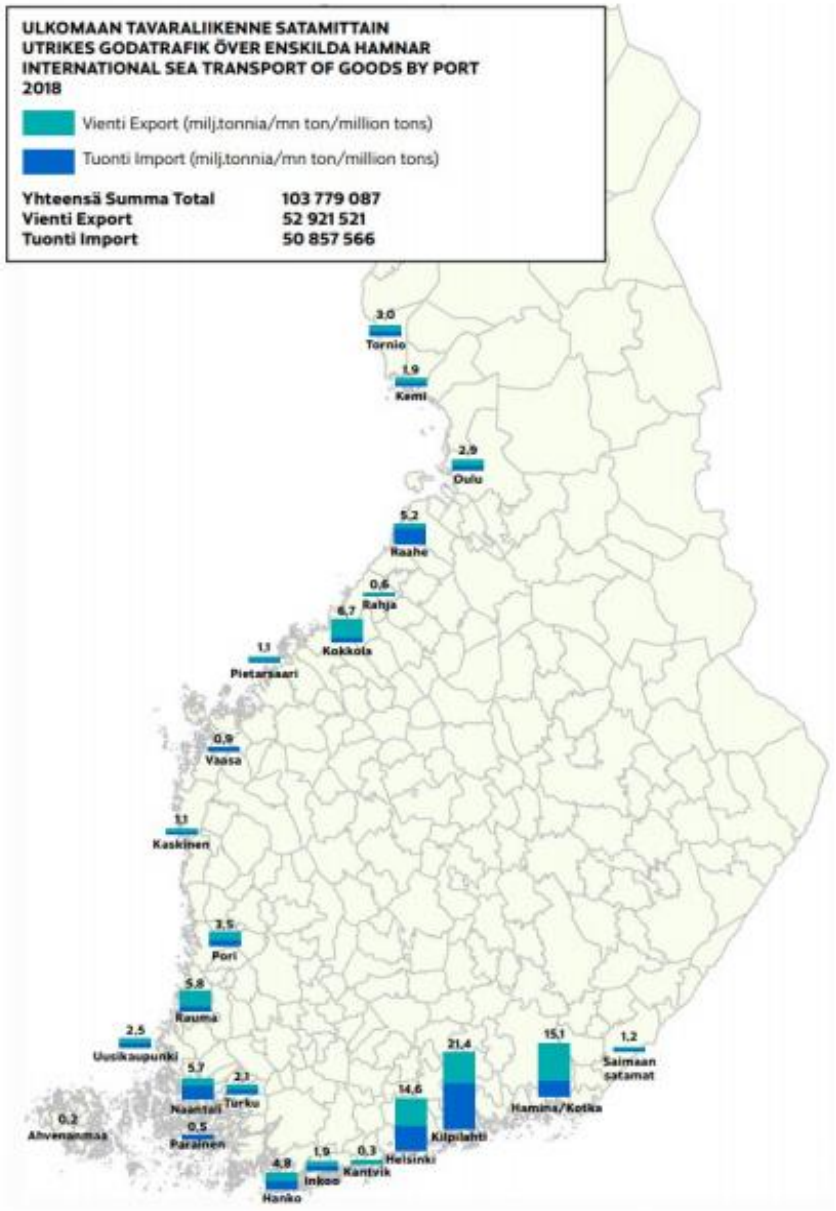

FIG 12. International sea transport of goods by ports in 2018 (Liikennejärjestelmän nykytila...2020, 65)

Waterway transport to Saint-Petersburg

Saint-Petersburg is the largest industrial- and transport center and the marine capital of Russia. The port of Saint-Petersburg is the transport link between East and West. The port of Hamina-Kotka plays a significant role in waterway transports between countries due to its location, thus it has grown one of the biggest and modern export ports. (CBC 2014-2020, 28.)

The port of Hamina-Kotka is the biggest container port in Finland. The port has connections to all significant ocean ports in Europe and almost half of all container transport to and from Finland is carried through Hamina-Kotka port. The distance between Hamina-Kotka and Saint-Petersburg harbors is approximately 250 km. All container services are available from Kotka-Hamina harbor. (Port of HaminaKotka.)

Leningrad Region, Saint-Petersburg, and Finland have access to sea routes via the Baltic Sea; thus, the Gulf of Finland (Fig. 13) is the most important waterway access between Finland and Russia. Also, Saimaa Canal in Vyborg has access to a ferry road to east Finland´s inland waters. (CBC 2014-2020, 28.)

FIG 13. Gulf of Finland and cities surrounding it (CBC 2014-2020, 30)

Ocean freight is the cheapest way of transporting goods over longer distances. Although it is a slow transportation method, the freight expenses are

so low that it is profitable for the customer (Hokkanen et al. 2011, 113). Finnish granite quarry company called TG Granit is located near Kotka in Taavetti. This company is using multimodal transportation. Multimodal transportation is defined as the movement of cargo from origin to destination by using at least two kinds of different transportation carriers (Hokkanen et al 2011, 114). TG Granit uses trucks to transport granite from quarry to Kotka-Hamina harbor and afterward, granite is put into containers to ship it to ports around the world. (TG Granit.) This method is typical for all Finnish stone industries when granite is transported to the Far East or long distances.

7 BORDERS CONNECTING SOUTH-EAST FINLAND AND SAINT-PETERSBURG

There are four international border crossing points between South-East Finland and Russia. They are Nuijamaa, Vaalimaa, Imatra and Vainikkala. Vainikkala is the only crossing point for railroad crossing and there is also a temporary crossing point in Parikkala. (Kaakkois-Suomen Rajavartiolaitos.) Figure 14. is showing the border crossing points excluding Vainikkala. Vainikkala border is located between Vaalimaa and Nuijamaa.

An international border crossing point is a crossing point intended for international passenger traffic and it serves a purpose for vehicle- and goods traffic as well. The temporary crossing point is intended for Finnish and Russian passenger traffic, as well as a vehicle- and goods traffic. (Valtiosopimukset 14.9.1994/66.)

New international border crossing point in Parikkala

As mentioned, Parikkala is at present serving as a temporary crossing point, but in the future, Parikkala is planned to be an international border crossing point. Currently, only Finnish, and Russian citizens who have obtained prior authorization can cross the border in Parikkala. The border has been used for the transport of goods and especially timber. (Repair work at the Parikkala…)

Construction work on the Parikkala has been scheduled to begin in 2022 and be ready in the year 2024. Russia has already improved highway A-121 for traffic connection. Highway begins from Saint-Petersburg and continues towards the Republic of Karelia and the northwestern shores of Ladoga. This new border crossing point would be nearly as fast as other routes to Saint-Petersburg. (Schönberg 2019). The beginning of the construction work however seems to delay because Finland´s Ministry of Finance has not funded the project for the year 2021. And this is because the diplomatic notes are still not exchanged between the countries and the Covid-19 has influenced the situation as well. Exchanging the diplomatic notes means an agreement of the new international border between Finland and Russia. (Sormunen 2020.)

FIG 14. The border crossing point in Parikkala is the northest crossing point in southeast Finland (Sormunen 2020)

Development projects for border crossing points

The infrastructure of Parikkala, Imatra, Vainikkala, and Vaalimaa border crossing points are being upgraded. The project is a part of the South-East Finland – Russia CBC program. The project started in 2019 and will be completed by the end of 2022. In Parikkala, the plan is to enhance roads and improve the identification systems. In Imatra, a new X-ray scanner for trains will be built. At

the Vaalimaa border crossing point, the old parking area for lorries will be renovated to meet the current standards and the X-ray equipment will be upgraded. Also, the working conditions of the personnel in the passenger transport center will be improved by renewing the customer service points. In Vainikkala, the plan is to improve the working conditions of inspection staff by building a new border control station and developing the control systems. (Development projects for border…)

7.1 Border crossing statistics

For these statistics, I have used the year 2019 results because ongoing Covid-19 have had a drastic impact on transport traffic year 2020. Furthermore, these statistics only focus on the borders shown in Figure 14 including the Vainikkala railway border because they are located in the study area of this study.

Light traffic departing across the borders was around 1,15 million and arriving traffic was 1,17 million in the year 2019. Light traffic is heavily focused on Nuijamaa, Vaalimaa, and Imatra. For light traffic, Nuijamaa is the busiest border, Vaalimaa closely second place, and Imatra third. (Rajaliikennetilasto 2019.)

The number of departing heavy vehicles in 2019 was 101 000 and arriving was 104 000. In departing, Vaalimaa is by far the biggest border crossing point for heavy vehicles. Over 89 000 heavy vehicles passed the Vaalimaa border to Russia, which is almost 90% of all heavy traffic departing from South-East Finland. Imatra had 12 000 crossings of heavy vehicles and Nuijamaa only 3800.

On Arriving heavy vehicles, the statistics are a little different. Vaalimaa had 32 000 vehicles, Imatra 18 000 and Nuijamaa 45 000. There were also 9000 vehicles from the Parikkala border. As we can see, the heavy vehicle traffic on road varies when arriving from Russia or departing from Finland.

Container traffic is heavy in Vainikkala. The number of loaded containers departing was 3279 and the number of arriving containers was 20 583. Empty

containers departing was 19 445 and arriving was 3071. (Rajaliikennetilasto 2019.)

7.2 Finnish export statistics of granite to Russia and the global market

These statistics have been collected from the Finnish customs database called ULJAS. It is the official information source on imports, exports, and balance of trade in Finland. There are two different classifications for granite in ULJAS-database, roughly cut granite, and cut granite. Most of the trade is roughly cut granite, which can be seen in figures 15A and 15B below. Cut granite exports are shown in figures 15C and 15D. The charts show granite trade from Finland to Russia and from Finland to the global market.

China is still the biggest market area for Finnish granite. Close to 70% of all exported granite is going to China. For example, out of 159 000 tons, 118 000 tons were exported to China in 2019. (ULJAS – International Trade in Goods Statistics.) But, as of mid-2016, the Chinese economy has been slowing down, so the Finnish granite industries are operating well below peak production capacity (Litosonline 2016).

Roughly cut granite exports

The chart below (Fig. 15A) is showing the total trade of roughly cut granite from Finland to Russia. When looking at the statistics starting from year 2010 up to 2019, there are significant changes on the exports. From 2010–2014 the revenue of granite was half a million euros (excluding the year 2014), but onwards it has decreased to approximately 200 000 euros annually. Years 2011 and 2013 were especially good for granite exporting to Russia. Almost a million in revenue in 2013 and over 700 thousand in 2011.

		Value (euro)	Quantity
2019	Exports by countries	147 292	1 495 599 kg
2018	Exports by countries	182 422	1 933 900 kg
2017	Exports by countries	246 760	2 188 964 kg
2016	Exports by countries	184 432	1 875 900 kg
2015	Exports by countries	190 944	2 130 422 kg
2014	Exports by countries	414 626	4 756 317 kg
2013	Exports by countries	994 522	10 442 347 kg
2012	Exports by countries	565 167	6 686 400 kg
2011	Exports by countries	735 650	8 559 020 kg
2010	Exports by countries	592 242	6 658 540 kg

FIG 15A. Roughly cut granite exports from Finland to Russia 2010–2019 (ULJAS – International Trade in Goods Statistics)

When we look at the total export trade of roughly cut granite from Finland to around the world (Fig. 15B), we can see that the granite trade has decreased there as well. In the year 2010 the revenue was 32 million and the year 2012 it was a staggering 47 million. But since 2016 it has gone down from 18 million to 13.8 million in 2019. And by watching the year 2020 it seems the trade is keeping the same pace. Only quarters 1, 2, and 3 have been published by the time of writing, therefore the year 2020 is not included in the charts.

		Value (euro)	Quantity
2019	Exports by countries	13 825 123	159 593 895 kg
2018	Exports by countries	17 448 463	207 048 654 kg
2017	Exports by countries	16 920 784	183 191 875 kg
2016	Exports by countries	18 353 254	168 219 326 kg
2015	Exports by countries	27 601 199	243 472 157 kg
2014	Exports by countries	36 368 828	323 759 856 kg
2013	Exports by countries	45 864 991	378 256 619 kg
2012	Exports by countries	47 331 398	398 682 640 kg
2011	Exports by countries	45 554 906	411 907 994 kg
2010	Exports by countries	32 106 791	308 353 749 kg

FIG 15B. Roughly cut granite total exports from Finland 2010–2019 (ULJAS – International Trade in Goods Statistics)

Cut granite exports

When looking at the chart in figure 15C. of cut granite exports to Russia, the numbers are significantly smaller than roughly cut granite. But an interesting factor is that the values have increased a lot in recent years. As a matter of fact, in the year 2018, over a third of all cut granite was exported to Russia. This indicates that Russia has a demand for Finnish granite, and it is likely because of the repairing of the historical buildings.

		Value (euro)	Quantity
2019	Exports by countries	35 940	338 660 kg
2018	Exports by countries	62 472	569 737 kg
2017	Exports by countries	14 400	94 900 kg
2016	Exports by countries	2 400	798 kg
2015	Exports by countries	2 396	849 kg
2014	Exports by countries	15 604	11 660 kg
2013	Exports by countries	7 059	21 150 kg
2012	Exports by countries	-	-
2011	Exports by countries	2 027	300 kg
2010	Exports by countries	8 201	1 149 kg

FIG 15C. Cut granite exports from Finland to Russia 2010 – 2019 (ULJAS – International Trade in Goods Statistics)

Figure 15D. is showing the total exports of cut granite from Finland. Revenues have not been great, less than 100 000€ annually. The last 3 years have shown improvement, but Russia has had an impact on this. (ULJAS – International Trade in Goods Statistics.)

		Value (euro)	Quantity
2019	Exports by countries	213 683	1 310 333 kg
2018	Exports by countries	224 104	1 511 599 kg
2017	Exports by countries	93 052	482 194 kg
2016	Exports by countries	59 297	137 529 kg
2015	Exports by countries	74 475	206 790 kg
2014	Exports by countries	83 595	209 260 kg
2013	Exports by countries	68 615	191 170 kg
2012	Exports by countries	63 661	200 871 kg
2011	Exports by countries	46 986	179 300 kg
2010	Exports by countries	44 638	150 459 kg

FIG 15D. Cut granite total exports from Finland 2010–2019 (ULJAS – International Trade in Goods Statistics)

8 EMPIRICAL RESEARCH

As stated before, the empirical part of this thesis was conducted by doing semi-structured theme interviews. The original plan was to carry out both semi-structured theme interviews and an inquiry. The plan was to formulate the inquiry based on the data collected from the semi-structured theme interviews. Unfortunately, the arrangements for the interviews took too long, and I wanted to make sure that this study will be completed by the end of the spring semester. As the study progressed, I also noticed that there are not many quarrying companies or granite producers in Finland, so the sample data from inquiries would have been small. Also, the response rate for inquiries sent to email is only approximately 10% (Kananen 2015, 208). Furthermore, I believe that interviews will give the study more in-depth knowledge about the research

problem than sending out inquiries. Altogether, eight interview requests were sent out and five of them agreed to be part of this interview. The semi-structured theme interviews were conducted between March and April 2021.

Two of the interviewees work in the management of the granite industry. The other two work in granite forwarding, and the fifth interviewee is the customs chief in the Vaalimaa border. The first two interviews were done as face-to-face interviews, but the last three interviews were done via telephone due to the worsening corona-virus situation in Finland. All interviews were voice recorded and the interviewees were asked permission to do this, as well as if the business information can be used in this thesis. All the interviewees consented to this. Each interview took between thirty minutes to one hour.

Every participant had extensive knowledge of the subject, ranging from 10-40 years in the business area. Before the semi-structured theme interview, an interview frame was built (see appendix 1), in which the topics to be discussed were written in advance. These topics addressed the phenomenon studied in this thesis. The interview was divided into five different topics, which were as follows:

- Logistical chains of natural stone exports from Finland to abroad.
- Logistical chains of natural stone exports from Finland to Saint-Petersburg.
- Changes in natural stone exports from Finland to Russia and abroad.
- Cost-effectiveness and environmental aspects in natural stone logistical chains.
- Future of natural stone industry.

Under every topic, there were a couple of sub-questions. The voice recordings ensured that all possible data was saved and transcribed afterward. To transcribe the interviews, this study used summary transcription. With summary transcription, the interview recordings are represented in written form only roughly, by listing or summarizing main points or topics. Direct quotations are rarely written down. (Finnish Social Science Data Archive.) The voice recordings and transcriptions of the interviews are stored on my computer.

Also, different questions were formulated in the custom chief's interview (see appendix 2). The custom chief´s interview consisted of the procedures that are happening on the border, the relationship between Finland and Russia, and the traffic of heavy vehicles between the borders.

Palin Granit Oy and Suomen Kiviteollisuus Oy

Palin Granit Oy is the leading producer of high-quality Finnish granite blocks. The company is a respected granite producer in Finland and abroad. They are known for delivering their promises to the customers and they ensure their promises with solid, decades-long professionalism. The company is 100-year-old and ran by the same family since the beginning of 1921. (Palin Granit.) The interviewee was Heikki Palin, who is the CEO of the company. He is the third-generation representative, and he was appointed CEO in 1989. He has 40-years of experience in the field. Heikki Palin is also a deputy chairman in Kivi ry, which is the former Finnish Natural Stone Association. He has personally known and participated in the Nasta-project since its inception. The interview was conducted via telephone.

Suomen Kiviteollisuus Oy is also one of the oldest stone companies in Finland. The company was founded in 1900 and it focuses on quarrying and exporting granite blocks. To ensure customer satisfaction with their product, the company pays special attention to uniformity of color, block size, block shape, the physical properties of the stone, and strict quality control. (Suomen Kiviteollisuus Oy.) The interviewee was Juho Penttilä, the work manager of the company. The interview was held as a face-to-face interview in the company's quarry in Hujakkala, a small town near Lappeenranta. After the interview, Juho Penttilä kindly gave me a tour around the quarry.

Sagittex Oy and Greencarrier Shipping & Logistics As

Sagittex Oy is a European logistic company, and they offer their customers a full range of services for international transport, freight forwarding, and customs clearance. The company was founded in 2020. The location of the office and warehouse are on the territory of the largest Finnish port of HaminaKotka, and it allows the business to offer customers a full range of services. (Sagittex Oy.) The interview was conducted with the CEO of the company Ksenia Ross. Although the business is new, Ksenia has 15 years of experience in forwarding and she is especially interested in natural stone exporting. Besides forwarding, the business also buys granite from Finland and sells it to their business partner in Karelian Isthmus.

Greencarrier Shipping & Logistics As is a forwarding company also located in the port of HaminaKotka, Finland. It is a branch office of The Greencarrier, which is an international company having over a thousand employees working in 11 countries. (Greencarrier.) The Greencarrier Shipping & Logistics As specializes in forwarding of granite in maritime transport. Typical ways of moving granite as sea transport are open cargo or container, depending on the weight or size of the stone block. The branch office was established in 2010 and the interview was conducted with Mika Vuorinen who has the authority to sign documents on the behalf of the Greencarrier company.

8.1 Logistical chains of natural stone exports from Finland to abroad

All interviewees said that truck is the best transportation method for short-distance and for longer distances, maritime transport is the best. From Finland, there is hardly any transportation of natural stone on a train due to the geographical location. The work manager from Suomen Kiviteollisuus said that once there was some granite transportation on a train from Finland to China, but it was not cost-efficient due to low sales. He believes that the rail gauge difference between Europe and Finland is the reason why train transports are not so heavily used. Though, train transports are strongly used in central Europe.

The CEO of Palin Granit said that Palin Granit is mostly using trucks for short-distance transport, for example, Baltic countries, Russia, Poland, and sometimes France. If Palin Granit transports to Germany, Spain, or Italy, they use RORO vessels, and for even longer voyages (The Far East) they use container transport. Suomen Kiviteollisuus is using similar methods for its transports. Both companies used to have their own transport equipment (trucks), but these services are nowadays outsourced. Multimodal transportation methods are often used in logistical chains when transporting granites.

8.2 Logistics chain of natural stone exports from Finland to Saint-Petersburg

All the interviewees said that the transportation for granitic natural stone from Finland to Saint-Petersburg is arranged by using trucks that arrive from Russia. Using Russian trucking companies is a lot cheaper than using Finnish trucking companies or any other mode of transport. Granite is low-priced material and therefore logistical expense is a big factor. In Russia, for example, salaries and fuel prices are much lower than in Finland. The CEO of Sagittex sums it up as follows: *"Transport from Lappeenranta to Saint-Petersburg with a Finnish transport company costs 1000 euros, but with a Russian transport company it is about 600 euros."*

According to the CEO of Sagittex, it is sometimes difficult to arrange a vehicle to transport granite. Some companies are not eager to transport granite and they prefer easier products, such as timber or general cargo. Granite is a heavy material, and it requires a driver with skill, a truck made for heavy transports, and special equipment for tying the load. Another problem was that the transport companies occasionally do not have any cargo when arriving in Finland, thus leading to empty driving. Therefore, they do not want to take the shipment. This is a problem especially in less populated areas, such as Karelian Isthmus. Near Saint-Petersburg or Moscow, there are a lot more production facilities and therefore a lot more cargo to transport. To always have transport available, the CEO stated that it is important to use same the trucking companies to work with, so you can rely on that they will always accept the transportation.

The CEO of Sagittex also mentioned the usage of inland waters to transport granites as a viable option. Currently, though, the sales are not high enough for it to be cost-effective and the Saimaa canal should be upgraded, so bigger vessels could pass the canal with heavy cargo. The route could start from Mustola port in Lappeenranta and continue through Saimaa to Saint-Petersburg. The vessel would have to transport 2-3 blocks of stone to be profitable. The CEO of Palin Granit said that they used to transport via inland waterways, but it is not cost-effective at the current state of sales to Russia.

When I asked the CEO of Palin Granit about the possibilities of using train transportation, he answered that it could be a good solution if the bureaucracy of tying loads of granite were easier in Russia. In the past, Palin Granit used to use train transports, but it became difficult and too expensive as the bureaucracy changed.

As a summary of all the answers, the most significant factor causing problems in the logistical chain of granite seemed to be the border control between Finland and Russia. Despite the traffic jams sometimes occurring at the border, the trucks that have been stopped at the border due to the weight can be considered as a real bottleneck for the logistical chain. In Finland and Russia, there are different standards on truck weights. Vaalimaa customs chief confirmed this as well. The CEO of Palin Granit also said that Russian customs officers are extremely strict that the weight of the stone is the same as reported in the customs declaration. Palin Granit has integrated a system into all its quarries to weigh the stones with a scale to ensure that the stone is exactly the right weight. In the past, they measured weight by calculating the lengths of the stone, but it was usually around 3% less or more than the actual weight. To avoid difficulties at the border, it is important to find out the different standards the countries have and make sure that the documents are done correctly.

The Vaalimaa customs chief stated that for arriving trucks in Vaalimaa and Nuijamaa it takes around 15 minutes to passage through the border. This presupposes that there are no queues, the documents are truthful, and no further

inspection is required for equipment or goods. Furthermore, I asked the chief about the radiation measuring. He said that there is an automatic radiation measurement device for vehicles, as well as a manual measurement with a separate device. He stated that from time to time there are trucks where the radiation measurement detects a reading exceeding the alarm limit on the incoming traffic side. If this happens, the load will be further inspected. Information on these is forwarded to STUK (Radiation and Nuclear Safety Authority). Finnish and Russian customs and the Border Guard regularly hold meetings and work closely together to continuously enhance the operations.

8.3 Changes in natural stone exports from Finland to Russia and abroad

There has been increasing interest in Finnish granites in Russia, but according to the CEO of Sagittex, there is competition with Russian granite suppliers, at least in the Republic of Karelia. Russia is also a big natural stone producer, and they produce granite, such as Gabro Diabase and which is often used in making tombstones.

The changeability rate of the ruble and the political EU sanctions has caused changes as well. The work manager from Suomen Kiviteollisuus Oy believes that the sanctions are the reason why Russian customers began buying only products that were produced in Russia. I asked the CEO of Palin Granit the same question, he points out that signs of rising patriotism can be seen in Russia lately, though he thinks that Russia has always been a country where people like to use their products unless there is a significant price difference.

To increase the exports of Finnish granites, all interviewees emphasized marketing. The work manager of Suomen Kiviteollisuus had an interesting solution for marketing Finnish granites. He suggested that it would be good for quarrying companies to cooperate in stone marketing. Instead of selling the same material under a different tradename, it should be marketed as “Finnish stone”. The marketing should be focused on the strengths and uniqueness of Finnish granites, which are environmentally friendly products, distinctive colors, and the durability of the stone. The manager has also heard from Russian

buyers that they are uncertain where to buy Finnish granite. This only confirms that the marketing should be increased. He continues and mentions stone exhibitions as one solution to make the Finnish stones more visible. Exhibitions are the most effective channel to get new contacts and gain more visibility. The work manager also mentioned that at a time when China was buying large quantities of granite, companies were not so much focused on marketing elsewhere because the trade was so easy. He believes that this may have had an impact on the situation today.

The main reason for the decline in exports has been China. At the turn of the millennium, China became one of the greatest economic powers in the world and for that reason, China began doing massive building projects. The Finnish granite was the perfect material for these projects, being a beautiful and durable building stone. The work manager from Suomen Kiviteollisuus said that at that time Chinese buyers bought almost every stone the company produced. At present, the exports of Finnish granites to China are still high, but the tonnage amount has decreased massively. The cause for the decline is because China has become one of the biggest granite producers itself in the world. Also, the economic growth has become slower, so there are not so many building projects anymore. The interviewee from the Greencarrier & Shipping and logistics had also experienced the decline of granite exports to China. Approximately 2500 containers containing granite were forwarded through their business in 2020, but 5 years ago it was 7500. China is still their biggest exporting country being 80% of the exports, but this was only an estimate.

Lately, the ongoing pandemic has also affected maritime transportation drastically. Containers are stuck in ports, which results in fewer containers being available and this raises its price. Palin Granit´s CEO stated that they are unable to transport some of the products to customers due to the pandemic situation.

8.4 Cost-effectiveness and environmental aspects in natural stone logistical chains

“To further improve the carbon footprint reduction, the quarries should be located near the production facilities”, stated the CEO of Palin Granit. After this he continues as follows: “*It would also be better to handle the stone to a semi-finished product before transporting it from Finland*.” The processing of natural stone inevitably generates a lot of waste stone. By producing the stone to semifinished product, it would reduce the weight of the product and making the transportation lighter and resulting in a lower carbon footprint.

By using more environmentally friendly fuels would also reduce the carbon footprint, but these fuels tend to cost more, and logistical expenses are an important factor in heavy products. Bigger sales would also increase sustainability and cost-effectiveness because it would allow using inland waterways and train transport to Russia, which are more environmentally friendly. In charge of the Greencarrier Shipping & Logistics company added that vehicles have developed and are developing as we speak, so the environmental aspect is getting better all the time.

8.5 Future of natural stone industry

The CEO of Palin Granit believes that the future of natural stone is looking positive. The global worry for environmental matters has brought natural products to new light. Formerly the required lifetime of building material was 25 years, now it is 50 years and in the future, it can be up to 100 years. As the requirements increase, natural stone will become an even more desirable building material. Furthermore, the large construction projects in the Middle East are yet to begin. The political protests and the restless riots and wars in the Middle East have halted the starting of the projects. A lot of infrastructure and buildings have been destroyed due to these unrests. When the situation settles down, and financiers feel safe to invest, the construction projects can begin.

Finland was one of the first countries to produce and export natural stones and so the Finnish stone has been a part of many important buildings around the world. The CEO of Palin Granit stated that it is a competitive advantage in the global markets because the reparation of the buildings and new projects tend to be built from the same material. In addition to this, the life cycle of Finnish quarries can be up to 100 years, whereas in Indian quarries it can be only 5 years. The strength of Finnish stone is also a well-cut and processed stone, and it is another competitive advantage according to the CEO of Sagittex.

Although the future of Finnish natural stone is looking positive, the Finnish stone industry needs to keep on working to improve its marketplace globally. The work manager from Suomen Kiviteollisuus stated that the global natural stone industry has grown, for example, Brazil, China, and India have become big exporters of natural stone. In countries with a lower standard of living, it is possible to produce the material at fewer costs and it is difficult to compete against these prices. Also, the fashion trends in granitic natural stone tend to vary around the world frequently. The manager said that the global trend is on grey and black colors right now, whereas Finland has a lot of brown and red colors of granite. The aging of the workforce is also a problem in the Finnish natural stone industry. *"If the business is cyclical, it is difficult to hire permanent people."* The youth´s perception of working outdoors has also been declining. The work manager stated this as follows: "*Nowadays, the youth want to work indoors, not outdoors. If this continues for a long time, then before long there will be no more employees to share know-how and training."*

9 SUMMARY AND CONCLUSIONS

The research question of this study was to find out what the logistical chain of natural stone from South-East Finland to Saint-Petersburg is and what it could be at its best in the future. In addition to this, six sub-questions were formulated to give a clear idea of the research area. The sub-questions were as follows:

- *What are the best transportation methods for this task?*
- *What are the most inexpensive methods for this task?*
- *What are the challenges, problems, and bottlenecks for logistical chains of natural stone exports from Finland to Saint-Petersburg, and are they solvable?*
- *How could the sales of Finnish natural stones be increased?*
- *How could sustainability be increased?*
- *How is the future of Finnish natural stone exports?*

The interviews provided answers to the research questions. The research findings presented that the logistical chain of Finnish natural stone to Saint-Petersburg is conducted by using Russian trucking companies. It seems that the sole reason for this was the lower price of transportation in Russia. The interviews presented that logistical expenses are a major factor in the pricing of natural stones, so this supports the fact why Russian trucking companies are preferred in transporting. However, with higher sales, transportation could be done using alternative transportation methods, such as train or inland waters. This also answered the question of what it might look like at best in the future. Above all, Finland and Russia have the same rail gauge and inland waters connecting South-East Finland and Saint-Petersburg. Still, there are unsolved problems on the train- and inland transportation, such as the bureaucracy on a train transporting and the improvements needed on the Saimaa canal.

The biggest reason causing bottlenecks in the logistical chain is the border control between countries. In general, interviewees stated that everything was working as it should work, but sometimes long queues, the weight of the trucks or the incorrect documents were delaying the shipments. The reasons were understandable because the border control is doing its job and following the regulations set by the countries. However, if the regulations on truck weights were the same in both countries, it would ease the stone industry, forwarding and trucking companies, and possibly the work on border control. In addition to this, other bottlenecks and challenges are faced in arranging trucking companies for transport. The interviewees stated that it is important to use the same trucking companies and reliable partners to prevent and overcome troubles.

To change the current method of transporting natural stones to Saint-Peterburg, the industry needs to grow in sales. Growth in sales would give the industry the possibility to use alternative, more cost-effective transportation methods. As stated before, train or river transports are a far more environmentally friendly solution than road transports, because they allow transporting more tonnes at once and that way reduces the harmful impacts on the environment.

New sales promotion methods are needed to increase sales. A couple of promising ideas came up during the interviews. For example, participation in stone exhibitions would be an effective tool to get new contacts and gain more visibility. Another idea is to strengthen the collaboration. Finnish quarrying companies and granite producers should cooperate more and market their products under the brand “Finnish stone”. This would be a competitive advantage in promoting exports to Russia and abroad.

Furthermore, the rise of the natural stone industry in countries where the standards of living are lower, causes a marketing barrier to Finland, because we can not compete for low costs with them. So, in this situation, it is even more important in the future that the Finnish stone industry is recognized for its reliable service, strong know-how, and unique, high-quality natural stones. They are the competitive advantages of Finland’s stone industry in global markets.

Another important factor that should be taken into consideration is how to revive the attraction of the Finnish stone industry among the students and young workforces. The image of the stone industry should be improved so that it becomes more attractive for young people who are looking for a job. This is the only way to shift the responsibility and know-how to younger generations and ensure that the industry can thrive and develop in the future.

As a conclusion of the empirical data, the future of the logistical chain from South-East Finland to Saint-Petersburg seems to be tied to the growth of

sales. Bigger sales will make alternative transport methods more cost-effective, which are also more environmentally friendly, but currently, the Russian trucking companies seem to be the best solution for the Finnish stone industry. However, theoretical data pointed out that sales have already increased, based on statistics from the Finnish custom`s database. The theoretical framework also ensured that there is a need for Finnish granites in the city of Saint-Petersburg and this was also stated in the interviews by the CEO of Palin Granit and Sagittex.

10 RELIABILITY OF THE STUDY AND DISCUSSION

The Nasta-project originated when extensive restoration projects were required in the buildings of Saint-Petersburg. The project began at the end of 2019 and later, in the autumn of 2020, I was given the opportunity to participate in this project in a form of a thesis. My supervisor told me that the Nasta-project needed someone to research the logistical side of the project, so the research question for this thesis was formed to find out what the logistical chain of natural stone from South-East Finland to Saint-Petersburg is and what kind it could be at its best in the future. Sub-questions were formulated as the study progressed to provide the most comprehensive knowledge base possible for the main question. I believe that this study succeeded to provide a comprehensive answer to the research question.

There are five criteria of quality in qualitative research. They are credibility, transferability, dependability, confirmability, and saturation. (Trockim & Donelly 2008, 149; Guba & Lincoln 1981; according to Kananen 2015, 352.)

Credibility means, that the research findings are trustworthy and the interpretation corresponds to reality. Credibility is earned through documenting strictly enough the research process: choosing the interviewees, conducting and recording the interviews, and analyzing the research data. Without the documentation, an outside auditor can not check the authenticity of the conclusions. (Kananen 2015, 353.) In Chapter 8 the reader will find a thorough description of how the interviewees were chosen, how the interviews were conducted and recorded, and how the research data was analyzed and stored.

Qualitative research aims to understand the phenomenon, not a statistical generalization. This is the biggest difference between qualitative and quantitative research. Transferability in qualitative research is achieved by providing a thick description (Geertz 1973) of the phenomenon and its context. Transferring the research findings is always in charge of readers. Researchers can only offer rich and detailed descriptions of the research process and data. (Kananen 2015, 353.) In Chapter 8, a rich description of the research findings and a detailed summary of the interviewees ’speech including some quotes, are produced for readers so that they can consider transferring the research results to their own action.

Dependability is quite near to credibility. To prove the dependability, an outside auditor should recheck that the conclusions trace back to the empirical data. (Kananen 2015, 353.) Member-checking was not used in this study due to a strict time schedule.

According to Kananen, there are two means to achieve conformability. Firstly, the researcher can share the research report with interviewees and ask for their feedback and affirmation. Secondly, conformability can be achieved by using many methods to collect data on the same research problem. (Kananen 2015, 354.) In this study conformability is proved by using triangulation. The theoretical framework was based on reliable literature, statistics, and other documents and it correlated with the interviewees’ statements, who were professionals in this study area.

Saturation in qualitative research means saturation in collecting data. The researcher does not know beforehand how much data is needed. The researcher strives to collect the widest and most comprehensive data possible about the phenomena to gain an understanding. (Kananen 2015, 128, 355.) The saturation of this study can be evaluated by the fact that the most recent interviews started to have no new significant observations compared to the

first interviews conducted. Therefore, this study achieved its saturation. In addition to this, the interviewees came to the same conclusions as the theoretical framework presented.

The research area could be further explored on how to further improve the marketing of natural stones and how we can increase the importance of natural stones in construction projects. Furthermore, another research topic could be based solely on the better utilization of the crushed stone generated in the stone industry. My supervisor and interviewees told that there should be better solutions for crushed stones, for example in infrastructure projects, but this subject was too extensive to include in this thesis.

This study has been a big learning process for me. I have learned a lot about natural stones and the natural stone industry in Finland. Furthermore, this study has given me confidence in my English and given me important knowledge on how to write and study research literature. I will express my sincere gratitude to everyone who has been part of this study and made it possible. First of all, I want to thank all the interviewees for their extensive knowledge and time that they gave for this study. It was crucial for this study. Furthermore, I am grateful to my supervisors, who always helped me, if I had any difficulties during the research process and writing.

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Figure 14. The border crossing point in Parikkala is the northest crossing point in southeast Finland. Sormunen. 2019. Yle. Tie on jo kunnossa, seuraavaksi pitää rakentaa rajatarkastusasema – Venäjällä valmistaudutaan Parikkalan rajanylityspaikan avaamiseen. WWW document. Availabe at: https://yle.fi/uutiset/3-11004804 [Accessed 16 January 2021]

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Appendix 1

TEEMAHAASTATTELURUNKO/Johannes Männikkö

Yrityksen taustatiedot

Yrityksen nimi	
Toimiala	
Liikevaihto	
Henkilöstömäärä	
Perustamisvuosi	

Teemahaastattelun toteutus

Haastattelija	
Ajankohta	
Haastattelun kesto	
Haastateltava henkilö	
Haastateltavan asema yrityksessä	

Keskusteluteemat

- **Logistiikkaketjut luonnonkiven viennissä Suomesta ulkomaille**
- **Luonnonkiven logistiikkaketju Suomen ja Pietarin välillä**
- **Luonnonkiven viennin muutokset Suomesta Venäjälle ja muualle maailmaan**
- **Luonnonkiven logistiikkaketjun kustannustehokkuus ja ympäristöystävällisyys**
- **Luonnonkivialan tulevaisuus**
- **Onko vielä jotain, mitä haluaisitte tuoda esille?**

Appendix 2

HAASTATTELURUNKO/Johannes Männikkö

Yrityksen taustatiedot

Yrityksen nimi	
Toimiala	

Haastattelun toteutus

Haastattelija	
Ajankohta	
Haastattelun kesto	
Haastateltava henkilö	
Haastateltavan asema yrityksessä	

Kysymykset

1) Mitkä ovat rekkojen painorajat Suomessa ja Venäjällä

2) Tapahtuuko rajalla säteilymittausta?

3) Paljonko luonnonkiveä kulkee Suomen ja Venäjän itärajalla?

4) Mitä asiakirjoja tarvitaan tullissa kiven vientiin?

5) Tuleeko rekat pääsääntöisesti Venäjältä hakemaan kiven ja palaavat kuorman kanssa?

6) Millainen suhde Suomella ja Venäjällä on rajalla?

7) Ovatko Venäjälle asetetut EU-pakotteet vaikuttaneet rajatoimintaan tai kuljetusten määrään?

8) Millaisessa kunnossa Venäläiset rekat pääsääntöisesti ovat?

9) Kauanko aikaa raskaalla kalustolla keskimäärin kestää rajalla?

10) Onko vielä jotain, mitä haluaisitte tuoda esille?