LEARNING FROM ABERDEEN

to graknit a community together in 2015 Helsinki

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ABSTRACT

From Egyptian antiquity to nowadays, **granite** has been used in numerous ways. Firstly, the considerable strength, durability and availability of granite constituted an attractive building material throughout history. If its roughness always made it suitable for walls and paving, late twentieth century and twenty-first century technologies gave it a new dimension, as they allow more and more precise work to be made in granite, and a wide range of more intricate items to be produced in an economic (because less time consuming) way. These new machines are nowadays both more accessible and workable. As a result, it is now possible to reach the same degree of complexity with granite as with traditionally more workable materials and retain at the same time granite's characteristic of strength and durability that surpass all other types of stones.

In a first part, the thesis will extensively look at Aberdeen granite industry in the nineteenth and early twentieth century as a case study: the local presence of granite as a raw material generated the creation of an economy, a knowledge, a city: a community. Evolution of quarrying and manufacturing techniques, accompanied by the modernization of transports in Britain will be covered, as well as the impact on the population, the causes of its decline and the legacy it left.

A second part is looking at the future of granite through the prism of Aberdeen. Together with the design project of a communal park and workshops built in Helsinki's granite bedrock, the thesis will speculate about what twenty-first century granite quarry and workshop could be. Through technological innovations, as well as the social and economic reality in a northern European city in 2015, it will look at how a natural resource of granite can be generative of a community and how a contemporary design project of stone extraction might differ from the industrial Aberdeen precedent. Aberdeen and Helsinki project have in common a rich underground and share a dynamic relationship between the **material stock**, the **technology** and eventually the **community**. However, the solutions and the outcome are different although articulated around the unmovable relationship: extracting, quarrying / making, manufacturing. The thesis will investigate as well, through objects made by the author, a part of the wide possibilities modern machining offers to granite.

CONTENTS

INTRODUCTION

The thesis subject first interests lie in the formal vocabulary of stone quarries. In use or abandoned, these exposed, raw, carved pieces of Earth have a great spatial potential (fig.1). Unfortunately their condition and *raison d'être* is just the one of a commercial extraction site. From this fact, together with the observation of Helsinki's brutal, and urban, granite outcrops (fig.2), emerged the question of the relationship between the rock, the city and the people. Helsinki 2015 aspires to extrapolate on what "extracting stone in a city" could become in the present and near future, disconnected from any direct economic requirement.

In this perspective, Aberdeen nineteenth century granite industry precedent is interesting for what it engendered socially. Alongside the dynamics between the economy, the production and the people, a close look at this period gives key elements about the stone extraction techniques evolution through history.

Helsinki has a very different, but very strong, history with granite that mainly deals with infrastructures and natural landscapes. Furthermore, Finnish progressive society offers an interesting background to speculate on a design for a granite public space and workshops that involves the people in a different way to an industry. Clearly, this is closely related to recent technologies, as they allow more to be done by more: more design, more complexity accessible to a larger part of the population. In this sense, exploring the material possibilities in the "granite workshop" offers to get closer to the reality of contemporary granite manufacturing, even though limits in the experiments need to be drawn for economic reasons and the limited amount of machinery available to the author.

Fig.1. *Rock of Ages* abandonned granite quarry in Vermont, USA.
Source: http://www.edwardburtynsky.com/

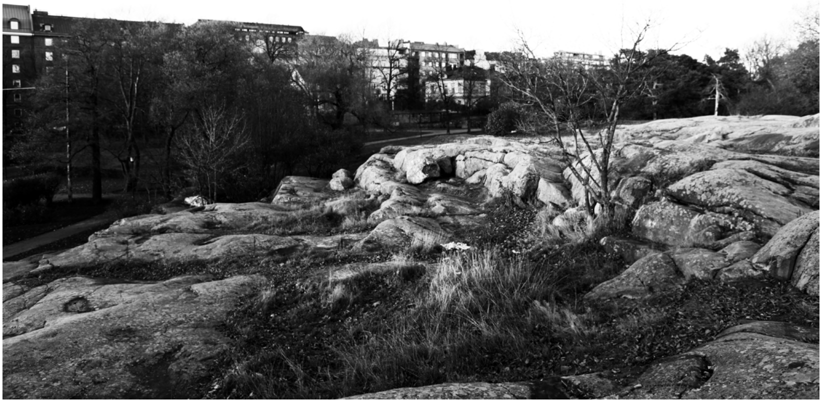

Fig.2. Granite outcrop in Kaivopuisto park, central Helsinki.
Source: Author.

ABERDEEN: INDUSTRIAL GRANITE CITY

GRANITE CONTEXT

Aberdeen granite consists of an Ordovician (485 to 430 million years ago) suite of volcanic origin[1]. Since medieval times, granite has been used as a building stone in Aberdeen and its region but commercialization didn't begin before 1750. Although it was not the only place in Britain where granite was quarried (smaller deposits were worked in Wales, Cornwall and South West Scotland), Aberdeen industry came to dominate the market. A few Castles in the region of Aberdeen, as well as St Machar's Cathedral in Old Aberdeen, were made during the middle age. The stone then was not quarried the way one would imagine nowadays. Masons simply collected boulders from granite outcrops on fields and transported them to the site where they were needed. The first quarry was opened in 1602 for the purpose of providing the masons in the city with door lintels and windowsills. Until the middle of eighteenth century however, wood was the main building material and stone structures were generally made of imported freestone, softer and easier to cut than granite. Eighteenth century knowledge of geology made a clear overview and understanding of the underground impossible, therefore the methods of identifying and picking locations for quarries relied widely on observation and testing, which was made possible by the fact that almost 50% of Aberdeenshire surface mineral deposits consist of granite or granitoid rock, for a total surface of roughly 90 km^2. Until 1830, the Aberdeen granite field evolved in parallel with industry, techniques and economy to truly become an industry of its own[1].

GRANITE ECONOMY

It is estimated that between 1750 and 1939, approximately 150 quarries were exploited in the region of Aberdeen, among which 50 were worked intensively. For most of the exploitation history, the majority of the companies were widely relying on hand labour. Without investing in expensive machinery, setting up in the business was relatively inexpensive. Therefore, small firms dominated the industry. Before the industrialization began, the first rise in production was the consequence of a fire that damaged badly a part of Aberdeen in 1741[2]. As a result, a law imposed to rebuild all damaged houses and warehouses in stone, and not wood, for protection. From then until the industrial era, quarried granite was used locally for the ongoing roads construction. If the most important single outlet for the stone was Aberdeen itself (it is estimated that by the middle of nineteenth century, 65% of the granite quarried was staying in Aberdeen), exportations to London and the East of England soon became an important source of trading. It is estimated that roughly 50% of the stone exportations were going to London until the end of nineteenth century, mainly as building stones and paving setts [3].

Distinct groups of quarries emerged, according to the quality of stone produced. Larger quarry produced masonry stone (eventually available for polishing as well), also suitable for engineering projects. A second group of quarries produced stones unsuitable for polishing but fitted for paving setts. Finally, a third type of quarries was producing road stones, as they were not of a good enough quality for any other purpose.

The stone economy vastly depended on transport and it evolved symmetrically to the railways, road networks and waterways with the industrialization. Modernization of roadways in Northern Scotland was an important local market for stones considers of poorer quality and not suited for buildings. The apparition and generalization of railways in the nineteenth century were a major shift for different reasons. Firstly, it allowed quarry masters to exploit numerous new, formerly inaccessible reserves of granite, as the "reachable" quarries (fig.3) were lacking availability. It also offered a faster, more reliable way to transport the material between quarries and yards, building sites or to the harbour for shipment. Interestingly, the construction of railways, as well as the expansion of docks and harbours in Aberdeen and across the East of England both favoured the granite industry for evident reasons of easier trading, but it also opened wide markets for the industry, as all these infrastructures needed to be built, renovated, extended[4]… As an example, bad quality granite was crushed and used along the railway tracks. The expansion of economy until the end of 19th century (the years 1880s and 1890s appear as the peak of granite quarrying in Aberdeenshire) also induced the growth of Aberdeen urban area and therefore a constant market and demand of building stones.

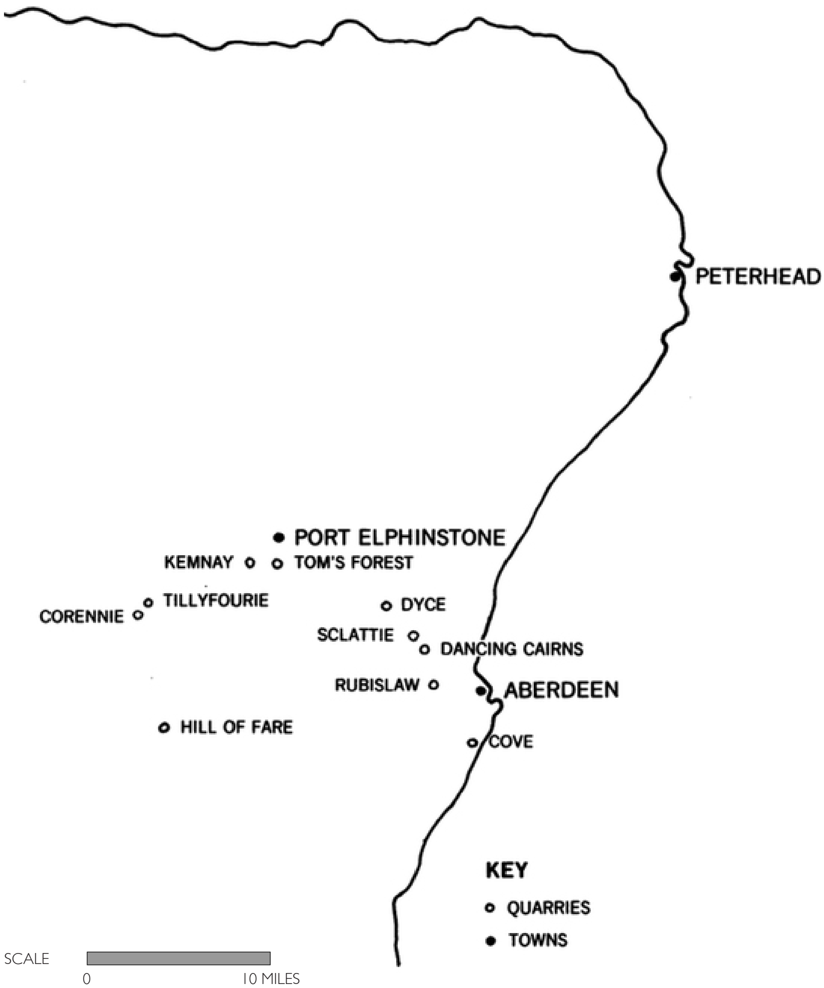

Fig.3. Major granite quarries of Aberdeenshire.
Source: http://www.jstor.org/stable/41613604

In parallel to the stone quarrying and shaping, manufacturing took places in granite yards in Aberdeen. With the technological progresses made in polishing and carving after 1830, monumental and gravestones works slowly changed along nineteenth century from a mainly local business to a much more important, worldwide, industry. Until 1880, with peak during the American civil war, gravestones export to the Eastern cities of the United States represented the highest demand of stones manufacturing. For different reasons, headstones coming from Aberdeen were valued: Scots exiles wanting to erect a Scottish made monument to their departed, Aberdeen craftsmanship being valued as of better quality than the American one, the "fashionable" aspect of a gravestone coming from the old world. Another important explanation for the growth of this particular market was the higher cost of labour in the United States at a time when most of the cutting and carving work had to be hand made. However, outside a few decorative works in Aberdeen and across Britain (the fountains in Trafalgar Square were made in Aberdeen at that time), the manufacturing side of Aberdeen granite industry remained relatively small until the 1880s and the building boom coinciding with an increased demand in polished slabs all over England to cover the fronts of buildings such as bank and insurances offices[5].

GRANITE PRODUCTION

Aberdeen granite industry was divided between two distinct sectors: quarrying and on one side, manufacturing on the other side.

QUARRYING

The early quarrying sites were generally chosen at top of hills, as it is safer to work downwards to avoid over overhang. Until the first major improvements in 1819, drilling acted as a considerable limit in the quantity and size of extracted blocks, as only small blast holes of 1,5 metres could be drilled. These improvements allowed Aberdeen quarries to start providing material for large-scale projects such as London Bridge (1820s)[6]. The increase of granite demand in the second half of nineteenth century led to technological developments such as steam borer and electric blasting. At this time, very arduous works like hammering and drilling were exclusively made by hand, which still persisted in the smaller quarries for economic reasons. Methods to reduce in size the blasted stone remained until early twentieth century an evolving version of the plug and feather technique. Progress made in boring, blasting and splitting necessitated better methods to transport the extracted stone out of the quarry. It was achieved in the late decades of nineteenth century with the invention of a steam powered crane (Scotch Derrick, fig.4) and a suspended cableway (Blondin, fig.5) that slowly took over most of the quarries and resulted in an augmented production. The basic techniques of quarrying did not change a lot over the time, but the growing depth of working sites and increasing demand in the early twentieth century necessitated better drilling equipment, which was initiated by pneumatic technologies. Pneumatic drills for blast holes were a major development, as they divided the length of work by more than ten[7].

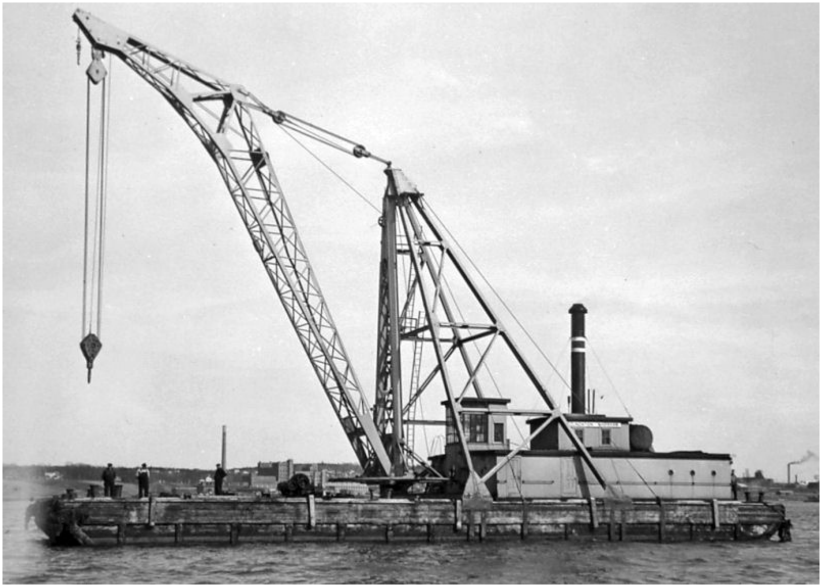

Fig.4. Steam powered Scotch Derrick
Source: http://www.hazegray.org/

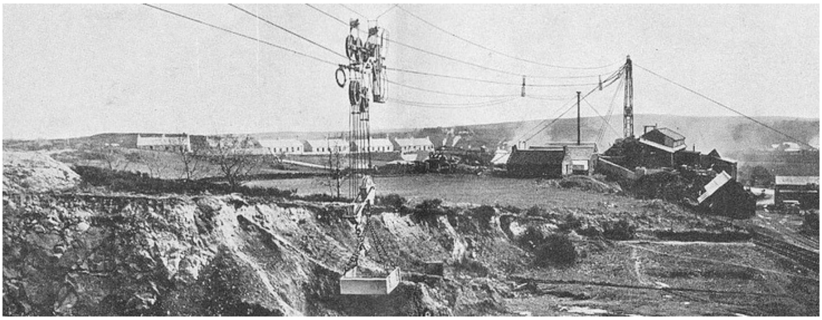

Fig.5. A Blondin Cableway in Aberdeen.
Source: http://www.mcjazz.f2s.com/

MANUFACTURING

Similarly to quarrying, surface working of granite (cutting, carving, polishing) started being assisted by machines along the nineteeneth century. If granite blocks sawing has been performed by hand in most of Aberdeen quarries until the end of nineteenth century, the time factor was too much of issue for bigger firms. Hand sawing a 2,5 metres by 1,5 metres block of granite of 0,5 metre height would take over four months[8]. When cutting the same block with the assistance of a steam-powered machine would take less than ten days. Consequently, these machines created a dividing line between big companies working on building stone and smaller ones focusing mainly on monumental carving. The patent axe, that arrived from the USA in the 1930s considerably facilitated monumental masonry and was used until the twentieth century and the apparition of pneumatic tools. Its utilization spread to building masonry for the carving of facade stones or columns to make granite a much more malleable material. Unlike cutting and carving, polishing did not really take off before a machine was first introduced in the 1830s. Although hand-polishing pieces was possible since antiquity, it proved to be too slow and therefore not economically profitable[9].

END OF THE INDUSTRY

Granite is subject to fashion and to the limit of stocks. After its peak from 1880s to the early years of twentieth century due to American orders and building boom, both quarrying and manufacturing businesses suffered of the recession and other factors. The quarries started lacking available, accessible stone and the range of disposable colors of stone in the region (a few tints of grey) prove to be a weakness. Therefore, Aberdeen manufacturers started importing stone from northern Europe by the end of nineteenth century. The manufacturers placed a lot of hope in the inter war period, after the recession and the heavy immigration that hit Aberdeen, for the economy to restart but they were proven wrong by the growth of the competition coming from Northern Europe, Germany and France where labour was cheaper and granite was more diversified. The patterns that occurred between the wars resumed after the Second World War. Yards and quarries kept on closing and only the longest-established firms, run by older people remained until the 1960s. By the end, quarries were mainly producing road aggregates and the young labour force was showing less and less interest for the granite industry, until the last yards and quarries had to shut down in the late 1960s[10].

PEOPLE OF ABERDEEN

An early nineteenth century comment gives an insight about the qualify of work at the early stage of Aberdeen industry:

> *"I have been speaking to several gentlemen who are good judges and they agree that your quarries are exceedingly ill-managed in the working of them and that they are in very bad condition at present; all pitted and patched here and there, rubbish laid down improperly and no proper plan to carry off the water."*[11]

The history of Aberdeen granite industry is also the one of men of all conditions who contributed to create a knowledge, a culture. It is acknowledged that by the end of nineteenth century, local stonemasons' reputation was very good and they were often recruited by American firms opening granite quarries and yards.

The source of investment and entrepreneurship for granite quarrying was mainly local to Aberdeen or the North East of Scotland. People in charge of the quarries and manufactures, as well as managers, were mainly stonemasons, builders, and stonecutters from the industry that emerged from the rank of journeyman. Industry funding was also helped by the great accessibility of capital in nineteenth century. Once again, it was usually Scottish banks that participated to the financing of the industry. If it safe to speculate, although little information remains, that no large profit was generally made in Aberdeen granite industry, it promoted social ladder, as many workers of poor social background were encouraged to become entrepreneurs. Being part of the industry also had a meaning in the city or village, as "firms became not only an economic prop to families, but part of a way of life that provided a certain degree of social standing in the community."[12]

Another interesting example is the village of Kemnay, in Aberdeenshire:

> *"The first thing that strikes a visitor to Kemnay is its brand new appearance. Have sprung up medium cottages of a tasteful design and some detached two storey houses of a commodious and substantial nature. It is satisfactory to note that the quarrymen of Kemnay are taking advantage of the immense facilities which the district offers for building with the best possible materials at the lowest prices and building their own homes."*[13]

Fig.6. Kemnay quarry in early twentieth shows a railway and a Blondin cableway.
Source: http://www.mcjazzf2s/

Fig.7. A granite house in Kemnay.
Source: http://www.mcjazzf2s/

This highlights the relationship between the worker's knowledge, his technology and facilities / granite possibilities that create more than just homes (fig.6, 7).

The down side of this rather socially efficient system was that the multiplication of small granite structures didn't favorize the growth of Reasearch & Development, that generally happens in bigger units[14]. Aberdonian workers knew well what they were doing but were relatively limited to evolve, learn new techniques, etc. It contributed to the fall of the industry and the loss of markets to European and American rivals.

On a different note, as will be developped further in the thesis, because of its toughness and because women were employed elsewhere (mainly in textile industry), the granite indusutry remained only reserved to men workers.

CHAPTER ENDNOTES

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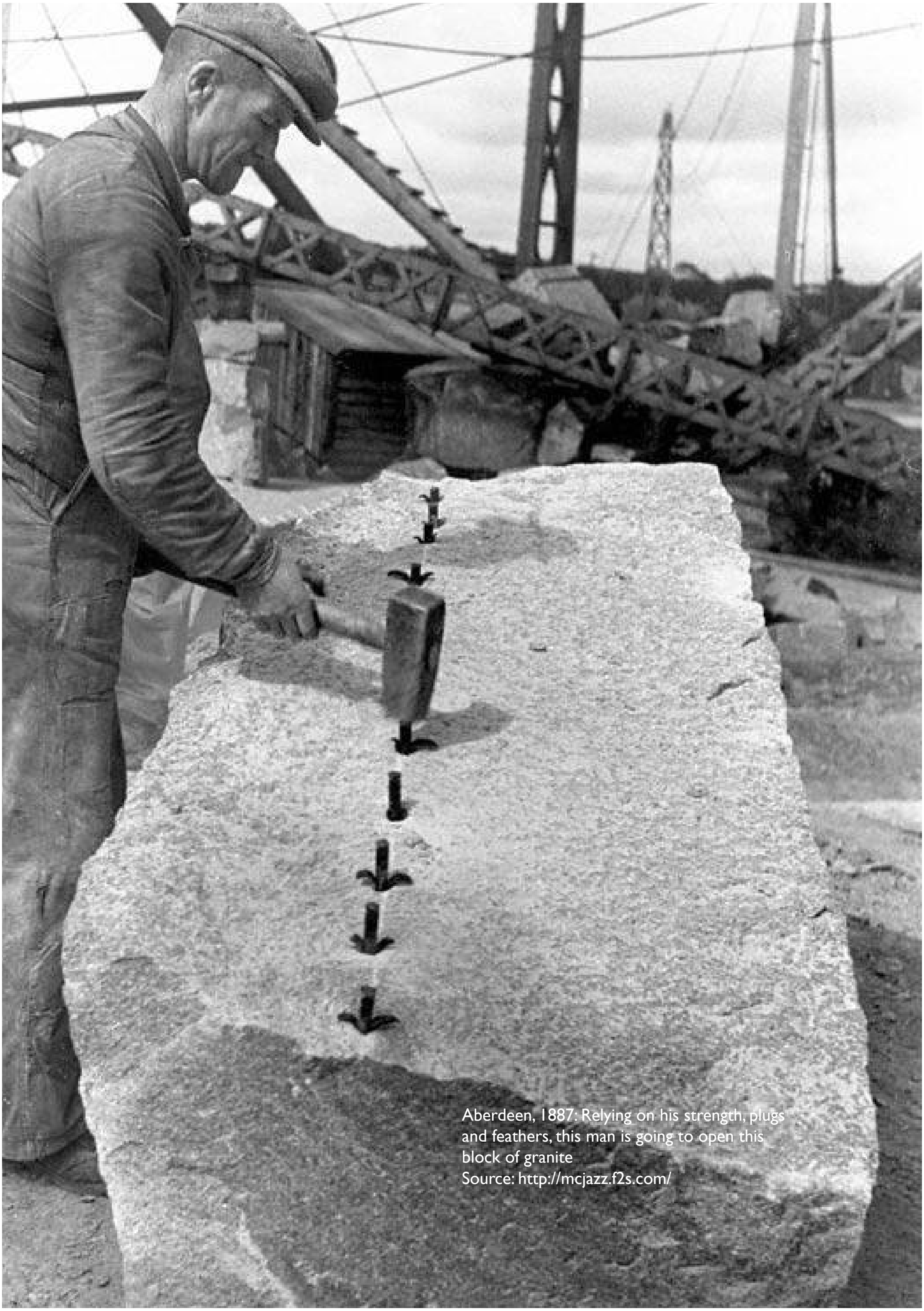
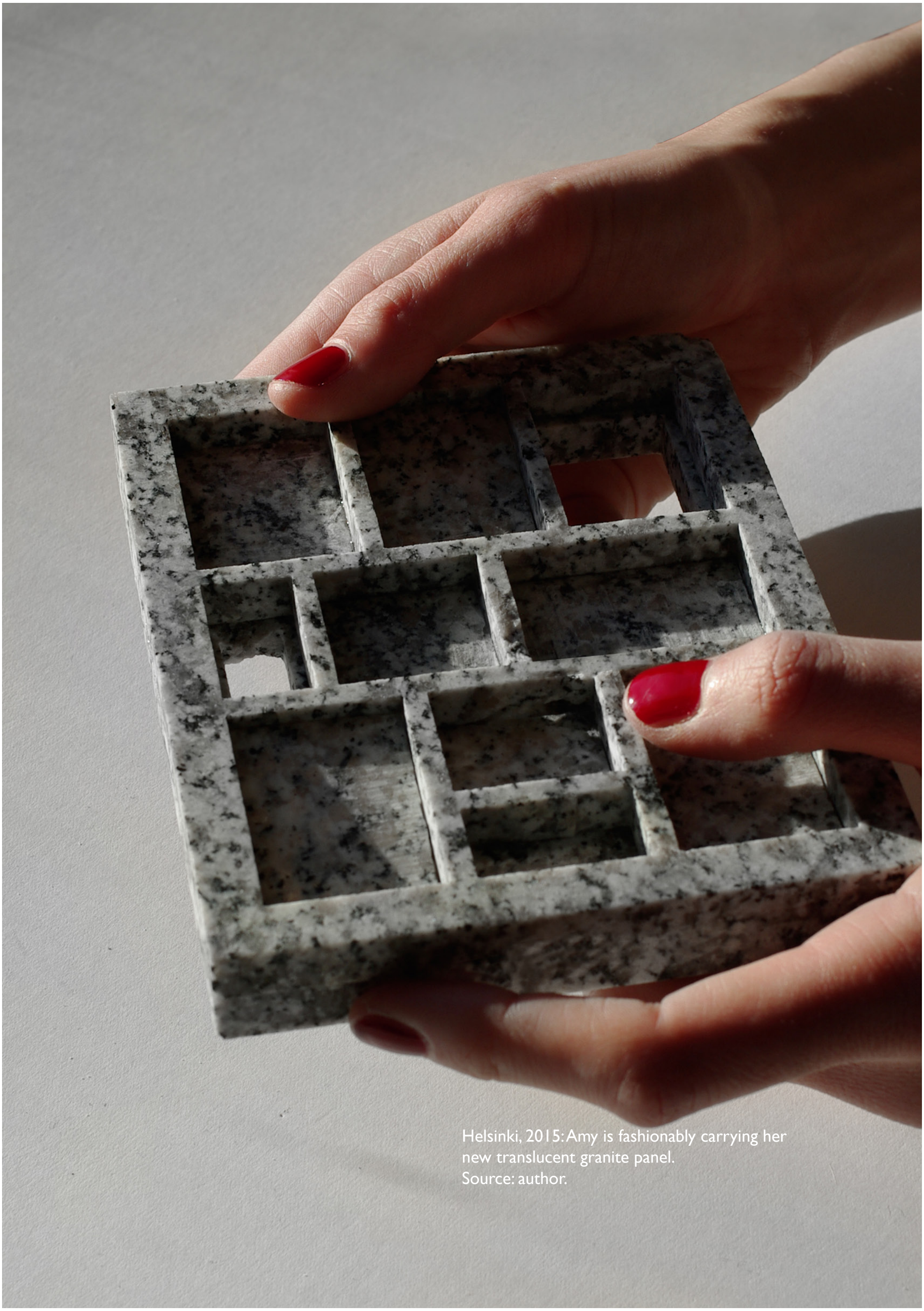


Aberdeen, 1887: Relying on his strength, plugs and feathers, this man is going to open this block of granite
Source: http://mcjazz.f2s.com/

Helsinki, 2015: William is looking very closely at the water jet cutter doing the work for him. Source: author.

Aberdeen, 1921: 12 happy men are being lifted up from Rubislaw quarry after a long day at the office.
Source: http://mcjazz.f2s.com/



Helsinki, 2015: Amy is fashionably carrying her new translucent granite panel.
Source: author.

Aberdeen, 1901: a strong man is about to split this granite block.
Source: http://www.mcjazzf2s/

Helsinki, 2015: Calum is designing his next granite piece while his hot water gra-tle keeps him warm...
Source: author.

HELSINKI 2015:
THE FUTURE OF GRANITE

HELSINKI AND GRANITE

Helsinki is located on the Baltic Sea, in southern Finland and has a humid continental climate. On average, temperatures go as low as -5°C in winter and as high as 21°C in the summer. Because of its latitude, the days are very short around the winter solstice (approximately six hours) and very long around the winter solstice (up to nineteen hours).

Helsinki is the northernmost capital with a population of more than 1 million people. The city centre, occupying a southern peninsula, has a high density with neighborhoods being as high as 16 500 inhabitants per square kilometer.

Southern Finland and Helsinki granite and granitoid bedrock have been formed by the solidification of magma 1.6 to 3.2 Billion years ago. It is considerably older rock than in most places in the world, therefore harder and more uniform. When a construction takes places in Helsinki, rock is generally having a part. The soil layer is thin and the bedrock frequently erects from the ground in numerous outcrops around the city. (fig.8) These weathered outcrops interrupt the urban rhythm and create natural parks. A first time visitor in Helsinki will be very intrigued by these large bits of raw stone sporadically popping out of the urban density. Cohabiting with a environment where surface empty spaces are so praised show a real will from Finland to preserve these landscapes as part of its identity.

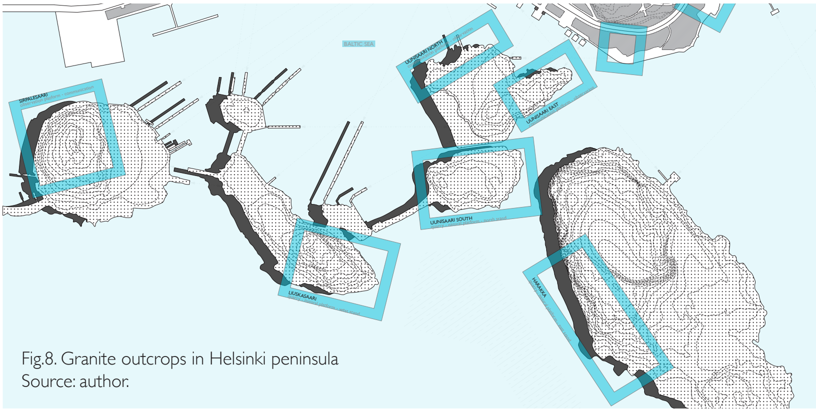


Fig.8. Granite outcrops in Helsinki peninsula
Source: author.

Granite is the main type of natural stone produced in Finland. Its main production locations are the rapakivi granite areas in the South of Finland. Although it does not emerge has a big part of its economy, Finland imposes itself as one of the world leading granite producers. The natural stone industry employs over 2000 persons in approximately 200 companies. Some twenty-five to thirty sites produce large amounts of granite, extracted in rough blocks. Typically, they are red, grey, black, green and brown. If overall, the granite industry is expanding constantly, governmental associations such as the Geological Survey of Finland carried on surveys about the stone production environmental impact. Although it remains local to the quarries, an issue has been pointed with the treatment of wastes and the management of leftover stones. Thereby, a "Finnish Centre" was open in 2003. It encompasses spaces to do with education, testing, production, as well as exhibition premises. Interactive and oriented towards the public, it demonstrates the variety of the use of stone in an educational way. [1]

TUNNEL CITY

Finland's old Precambrian bedrock is to a large extent ideal for building underground spaces, tunneling and excavating. There is also very little sedimentary rock in the region of Helsinki. As a result, the excavations in Helsinki are exclusively processed with the drill-and-blast method, which consists of drilling holes into the rock that are then filled with explosives and blasted to remove the stone. Helsinki's stone quality allows economy to be made on the reinforcing of the excavated stonewalls as no cast concrete lining is necessary, unlike in most similar projects around the world. [2]

Over the last decades, Finland has been trying to deal with a problem: its too little land per person in cities. Numerous unsuccessful attempts have been made to tackle this until the 1970s when Helsinki adopted a strategy of digging underground the space they could not find on the surface. Tunneling has predominantly been used for governmental and public purposes (fig.9, 10) such as transportation, defense shelters, sports facilities, car parks, coal and oil storages and of course the metro with the result that more than 25% (10 million cubic meters) of the space used by Helsinki public buildings is underground. Nevertheless, with an average of 1m2 of underground space under every 100m2 of surface area, Helsinki's subsoil still offer many possibilities. The law imposes on property owners to have a « civil defense shelter » that nowadays is often built underground and able to serve other purposes. One consequence of the city density is that more facilities (suitable for different purposes) are being placed underground. There is also an increasing demand for connections between underground spaces, as well as open spaces in the city centre that can cope with the sever winter climate conditions. During the 2000s, the Helsinki City Planning Committee worked out an underground master plan that would enhance safety and economy efficiency, as well as public services.[3]

Fig.9. Itäkeskus underground swimming hall, in Helsinki.
Source: http://www.flickr.com/

Fig.10. Temppeliaukion Church, in Helsinki
Source: http://www.wikipedia.org/

In parallel, various prospective competitions have evoked a tunnel between Helsinki and its 50 miles away neighbor Tallinn to create a twin-city and major northern Europe urban development. Although bedrock on Tallinn side is subject to question, Helsinki municipality has accepted the principle.

TESTING, QUARRYING, MACHINING

TESTING

> "Research and exploitation activities relating to ornamental granite destined for the construction industry have, in recent years and in various parts of the world, become increasingly significant. The increase in production can be explained by technological advances that have permitted the extensive usage of modern, sophisticated machinery and extraction equipment." [4]

> "Compared to other materials with an industrial origin, stone has the advantage of being a natural material that requires minimal industrial trans- formation other than that necessary for its final positioning. Consequently, given that the quality of the rock in the quarry itself determines the quality of the final product, control of this aspect is of the utmost importance." [5]

The first step when choosing a site to extract or excavate stone from is to find out about the physical quality of the material in accordance with its future use. The most widely used data for civil and mining engineers to design surface and underground stone elements is the uniaxial compressive strength. The International Society for Rock Mechanisms standardized a procedure for testing stone cores. Although it is relatively simple, the disadvantages of this method are it is expensive, time consuming and requires good quality rock samples. Therefore, different test methods, called indirect, were developed to estimate the compressive strength of rock in situ, such as Schmidt rebound number, impact strength, point load index and sound velocity. They are much easier to execute, they necessitate less or no material (non-destructive) and the required equipment is less sophisticated. As a result, these tests, compared to the uniaxial compression test, prove faster, easier to carry out and cheaper economically. In Helsinki project context, indirect testing would be a more valuable option to look into excavation locations.

Manufactured in 1954 and frequently used with rock and concrete since, the Schmidt hammer (fig.11) is precise, easy to handle and very cost effective. The rebound value is read directly on the instrument. It is called the rebound number. A table was created to deduct the rock's compressive strength from this rebound number. Besides, this technique is also used to determine numerous

Fig.11. A Schmidt hammer at use in-situ
Source: http://www.geo-design.co.uk/

Fig.12. A point load test is being held in-situ
Source: http://www.stuba.sk/

data concerning rock, such as its abrasiveness, rippability, excavatability and estimated penetration rate of drilling machines.

If granite was traditionally used in compression, its new uses engendered by modern machining technologies can include employing the rock in tension. The point load test (fig.12), despite the fact that it is destructive, is appreciated for its simplicity, the easiness of the samples preparation and its manageable size when needed on site.

> "All [these] empirical methods […], except the impact strength, can be used to predict the compressive strength of rock. However, the prediction equations derived by different researchers are dependent on

rock types and test conditions. One who wants to use the prediction equations must not forget this reality." [6]

In addition, methods were developed based on the observation of the surface of a granite extraction site. J. Taboada, A. Vaamonde and A. Saavedra describe a process of evaluation of the quality of a granite quarry. They distinguish two types of determining geological factors for the exploitation potential of a block of granite: lithological and structural.

"Lithological factors are the intrinsic properties of a block that indicate its suitability as a specific kind of construction material. These features are textural characteristics, composition, colour, mechanical characteristics, alteration and transformability. Structural factors include all those elements that define both the geometry of a geological body and its internal structure." [7]

A granite block, authors argue, should be considered as a "mass that consists of a series of very varied internal structures." A set of granite inner structures is determined (fabrics, schlieren, oriented enclaves, fractures) and described to identify possible points of ruptures, as well as aesthetic flaws for ornamental use of the stone. The article suggests a system of evaluation according to these characteristics resulting in the attribution of a quality level to the stone (top, inferior, reject). In support, writers detail:

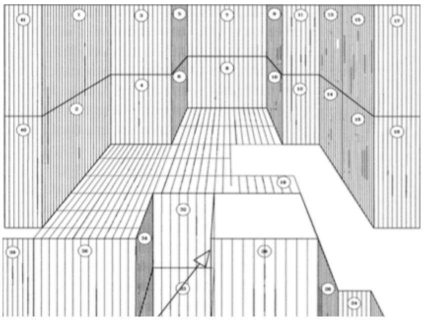


Fig.13. Distribution of the supports on the extraction bank
Source: J. Taboada et al. / Engineering Geology 53 (1999) 1–11

"In order to collect data, a 5 m x 1 m grid was traced on the three accessible faces of the extraction bank (fig.13), so as to obtain a total of 569 supports or samples. Each of these samples may be considered representative of the characteristics corresponding to a 5 m x 1 m x 1 m block."

Interestingly, this grid gives the quarry a very innovative dimension. Thereby rationalized, the "extraction space" naturally and clearly delimits itself into different categories and subcategories of feasible utilization for the stone depending on visual and physical qualities. It stands as a possible satisfactory generating process for the excavated master plan of Helsinki 2015 project.

QUARRYING

"Abrasive water jet cutting (fig.14) is a technique for separating materials by means of a high- velocity slurry jet, formed as a result of injecting abrasive particles to a water jet ejected by an orifice. The main advantages of the water jet machining process are being able to cut versatile geometries and its ability to cut both ductile materials like aluminum, brass, steel and titanium and brittle materials like glass, stone and ceramics without any influence on their microstructure. The water pressure, combined with the water flow rate defines the ability of the water jet cutter, since both factors define the maximum available power of the abrasive-water mixture." [8]

The roots of water jet cutting in quarries date back to 1970s, as demonstrated by this U.S. Patent:

"The invention provides a rock cutter which uses high pressure water jets. The jets are emitted from nozzles carried by pressure intensifiers, which are mounted on a head that is movable along a frame. The nozzles are movable with the pressure intensifiers and the jets emitted by the nozzles cut slots in the rock face." [9]

Abrasive water jet cutting has started being used in quarries in the 1990s as a cutting and drilling tool, and improved along the 2000s (fig.15) (Slotting of

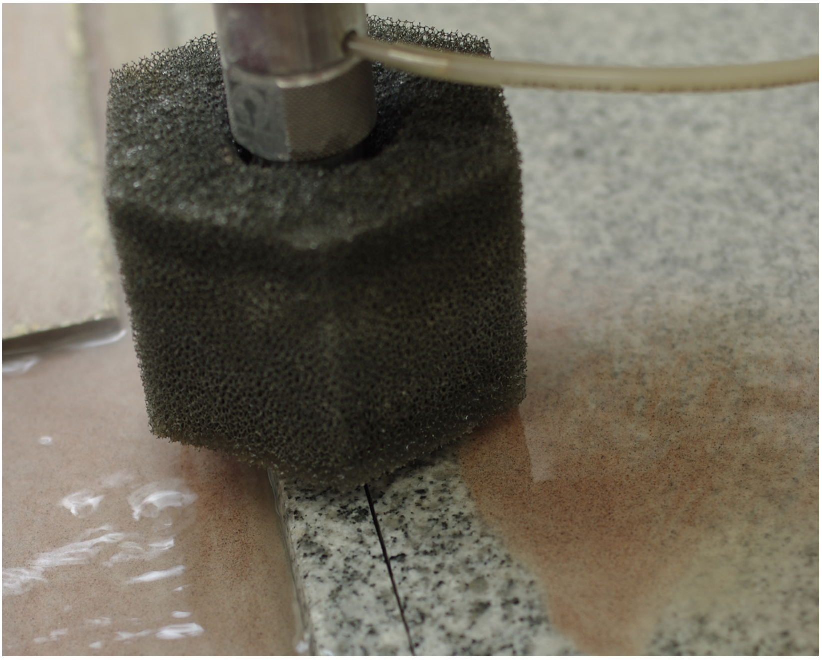


Fig.14. A water jet cutter is machining granite. The yellow tube brings the abrasive (sand)
Source: author.

Concrete and Rock Using an Abrasive Suspension Water jet System) to become today the preferred method of quarrying hard granites. Modern machines allow cutting blocks as long as 30 meters at a depth of 6 meters and appear as interesting alternatives to the traditional quarrying methods.

Automation of the process of water jet cutting involves an operator, in charge of setting up the machine with all the cutting parameters (length and depth of cut, rise and fall speed, etc.). The cutting goes on with no man labor until the desired cut is obtained, unless the system is shut down by an alarm or an obstruction in the cut.

Utility of the use of a water jet cutter for stone extraction compared to the traditional methods is examined under different aspects: economy, health and safety, production efficiency. Outside a consequent price of investment, water jet technologies appear as very interesting in most categories. It doesn't involve

Fig.15. Four water jet cutters in action in a granite quarry
Source: J.Vasek / 9th American Waterjet Conference (1997) 34

much man labor and none of it is physical outside the lifting and transporting. As the water jet does not create any dust, no silica (main respiratory hazard in a granite quarry) is threatening to be inhaled. Also, unlike blasting it doesn't damage stone and appears as a very safe solution for workers as removing the man from the quarry reduces risks relevant to large mobile equipment mixed with foot traffic. The only down side is the relatively high maintenance these machines necessitate.

Outside the increased cutting rate, speed and overall quality, water jet cutting in quarries contributes to make the social space of a quarry evolve. By leaving the man out of the quarry, not only the health, safety and work conditions of the people progress, but the quarry is becoming a computerized, very precisely arranged and schemed place. On top of the new, methodical ways of assessing the quality and potential of parts of a granite quarry by observation and indirect testing described earlier, this computer-assisted method for cutting leads to make rock extraction an almost "vectorial" process.

Nevertheless, techniques used in a quarry worth mentioning are drilling, slot drilling, blasting, burning, wire sawing, splitting.

Typically, the most widely used tool for extracting a block of stone in a quarry is the diamond wire saw. It often used as well to shape the block in a manufacturing company. Using diamonds to cut rock dates back to the 1950s. A diamond wire is made of a steel cable on which diamonds are threaded. Up to 40 diamonds beads per meter of wire interact with the rock to remove the material. Prior to cutting, the process requires to drill vertical and a horizontal hole that are connected perpendicularly to each other through the block of stone. The diamond wire is then threaded through the holes and its two ends are attached together around a wheel. Two movements are necessary for the wire to cut into the block: the wheel rotates the diamond wire, while the machine movement away from the rock surface on a rail provokes the required tension force. Meanwhile, water is released both as a coolant and as a way to eliminate the dangerous, flying particles emitted by the stone cutting. Diamond wire cutting appears as a fairly fast and relatively quiet solution. However, its down sides are its long setting up time and its difficulty, therefore slowness, to cut through the hardest types of granite. However, if diamond tools in general revolutionized the sector by greatly increasing the rates of cutting, their cost, induced by the wear of diamonds (lost of adhesion to the saw, scratching of the diamond surface, fracture of the diamond) acts as a limit in certain cases.

MANUFACTURING

Segmented circular diamond saws are the principally used cutting devices for granite manufacturing.

This section will focus on the latest stone manufacturing technologies, consisting of computer-aided machines, instead of the more traditional electric polishing and cutting hand tools. Unlike the excavating process that, historically, has been assisted by machine for a long time, the manufacturing, or shaping, methods have always involved the hand of man rather than a machine. Therefore, it appears as a big change that today, the action of giving a form to a block of granite (or any stone in general), designed on a computer, can be made without the intervention of the hand, without a contact with the rock at any moment.

Contemporary manufacturing of granite consists of similar techniques (diamond cutting and drilling, water jet cutting) to quarrying at a smaller scale. If the literature on the subject is light due to the youth of these technologies, the industry is evolving fast and nowadays, the market of stone CNC shaping is very similar to the more traditional one of foam, wood, etc. The main difference is the necessity for the stone machining process to always be accompanied by a constant water flow, for reasons raised earlier. The bed sizes of the sawing machines allow a relative freedom in the dimensions of the block being taken to the granite plant. From a roughly cut block of granite to an extremely finely designed shape, the whole process can be carried out in one, relatively small, warehouse with no man labor involved. Furthermore, all the parts of the process being each controlled by a computer, the whole procedure itself, including the transporting of the blocks can be automatized to create a system only monitored by vectors.

However, the methods brought up above describe shapes that, although made possible in a much quicker and more precise way, more or less resemble historically hand made stone craft. Machining, profiling flat granite shapes (fig.16), on the other hand, is a process that opens a completely new way of exploiting stone. Indeed, if granite blocks have been stacked, carved, sculpted throughout history, they have never been considered as two dimension components to machine and assemble, the way wood or metal is often processed through laser cutting machines. If, economically, it is hard to make it a viable solution at large scale, due to granite physical properties and in a specific context such as Helsinki project, it appears as a stimulating and generative formula.

PEOPLE OF THE GRANITE

2015 and onwards Helsinki granite people have, to conclude have a very different relation to the extraction and manufacture of stone to their Aberdeen ancestors. Between the raw material and the outcome, it is shown that the whole process doesn't involve much contact with the rock, much hand labour.

However, this computerised, rational connexion with the extracting and machining can be stimulating and community binding in different ways, to do with the combining of hard, unchangeable material with modern technologies and the fact that the sector is relatively new and therefore has space for improvement.

Fig.16. A water jet cutter at use in the workshop, cutting a granite slab
Source: author

CHAPTER ENDNOTES

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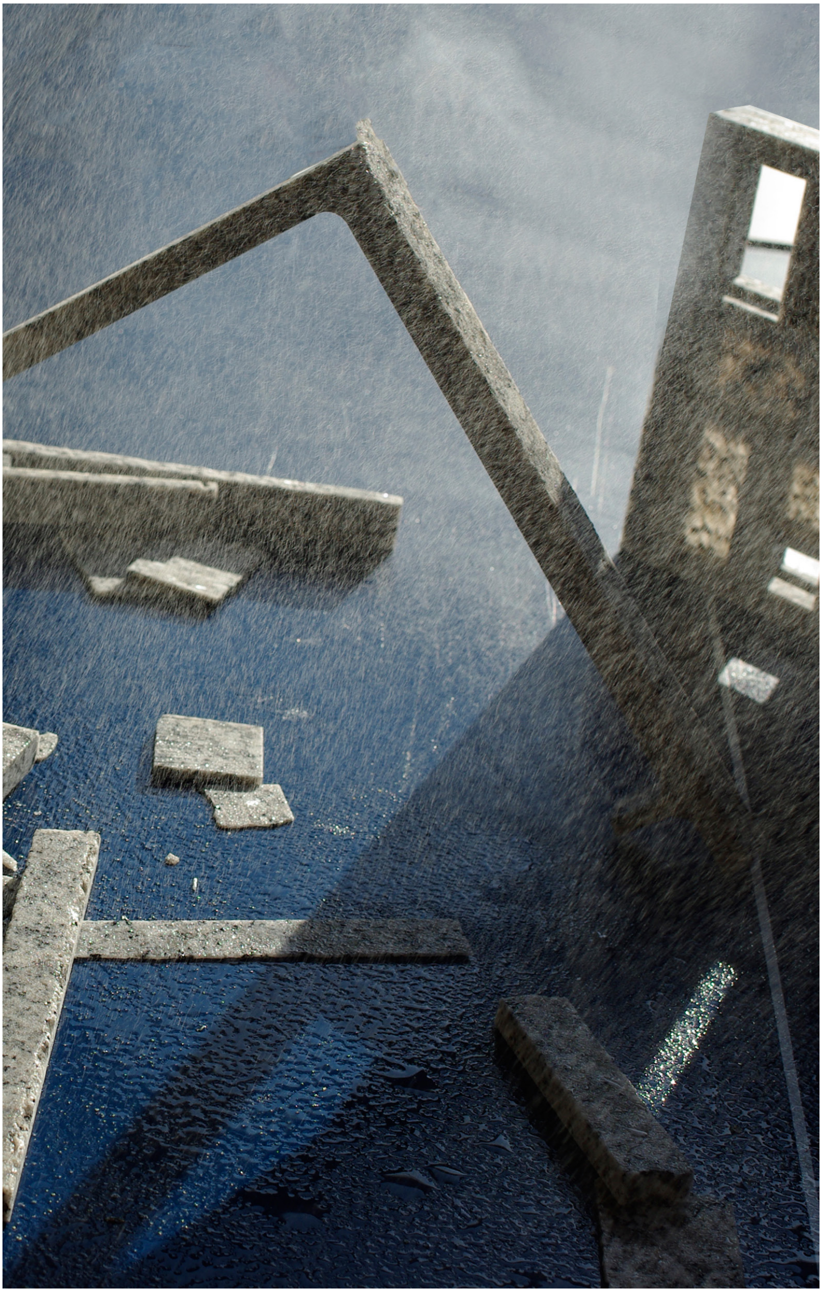
HELSINKI
GRANITE WORKSHOP



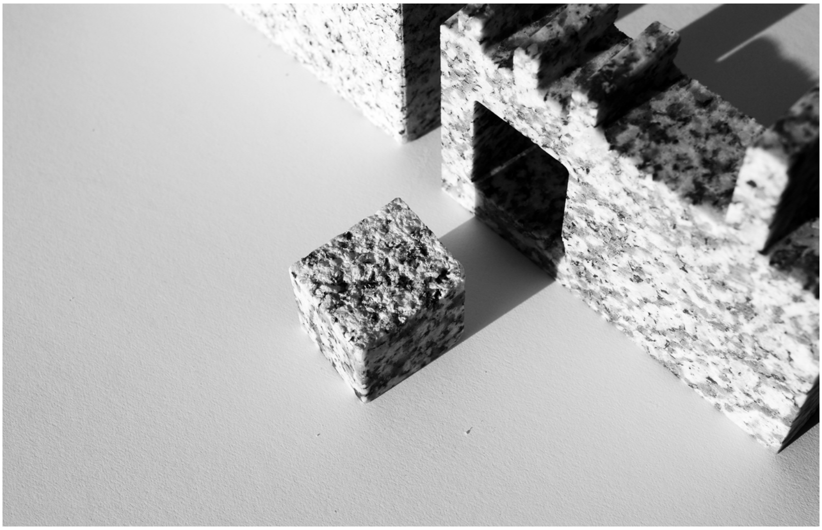
THE GRANITE YARD

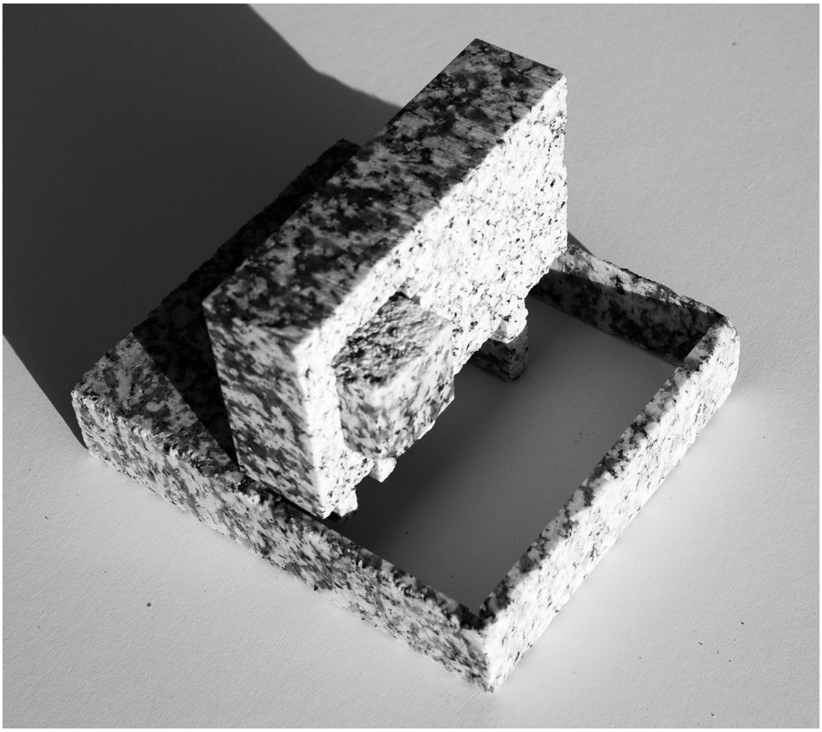
To experiment with granite abilities, a series of objects were produced with a water jet cutter. The granite employed was of diffierence thickness, colour and origin, although for economic reasons, it mainly was slabs of Chinese origin. The available thickness were 10, 17, 20 and 30 mm.

These objects are dealing with the stone physical properties, as well as its limits, texture, representation and its combining with other materials.

It should be said as well that this research, although it is of a relatively small size, could easily be extended as the water jet cutters allow very large pieces to be machined.

All photos are the author's.

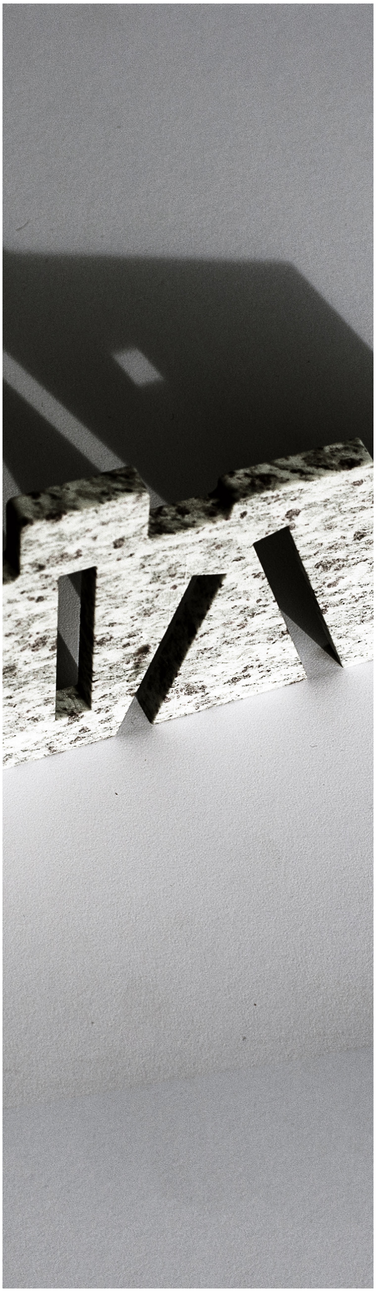




1
THE CORNISH ROCKY

This first test was made with 30 mm thick granite from Cornwall. By cutting rather simple geometric shapes in a square, the *Rocky Cornish* is testing the machine precision in curves, as well as in a relatively thin bits.

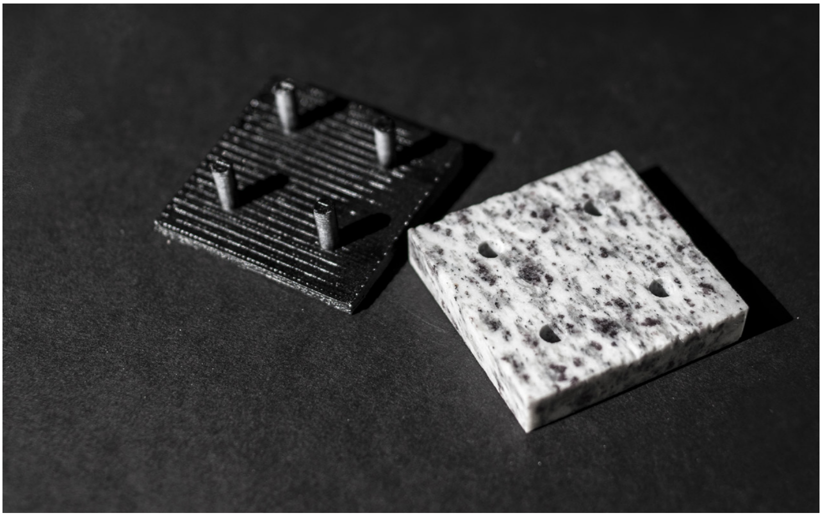
Outside the general accuracy and sharpness of the object, the first interesting result is the tendancy the cut part and its negative tend to fit into each other nicely. It is due to the offset of 0.7 mm created by the water jet cutter when removing material.



2
THE TANGLY WALL

Made with a poor quality 10 mm granite floor slaab, the *Tangly Wall* proved very successful: the main piece had slits and holes designed to be interlocking with other parts cut in the same granite. It all fitted very well. The L shape beam seemed interestingly strong for a 10 mm x 10 mm section element.

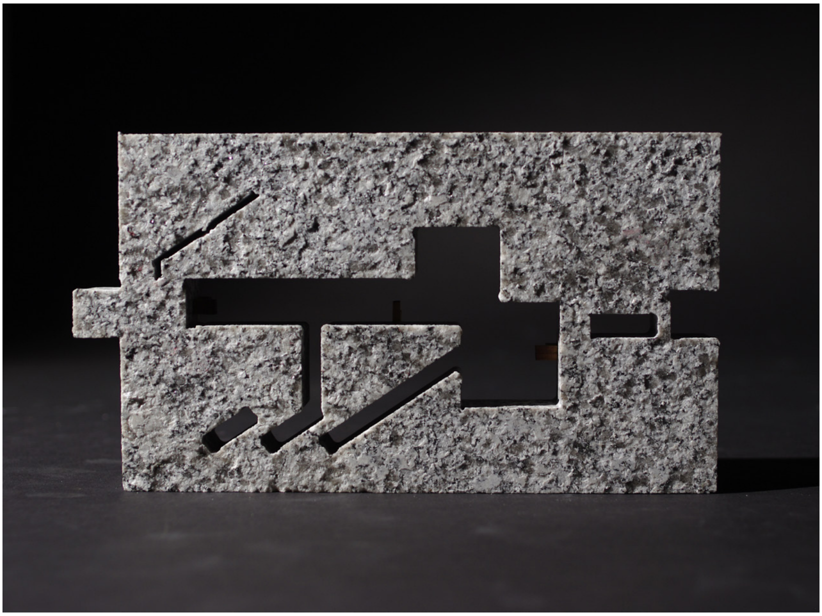
Moreover, the precision of the curves and edges was impressive, as well as the light slits of different shape and thicknes integrated in the main wall.

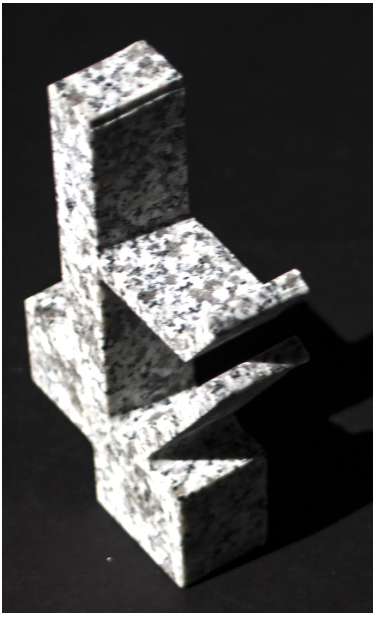


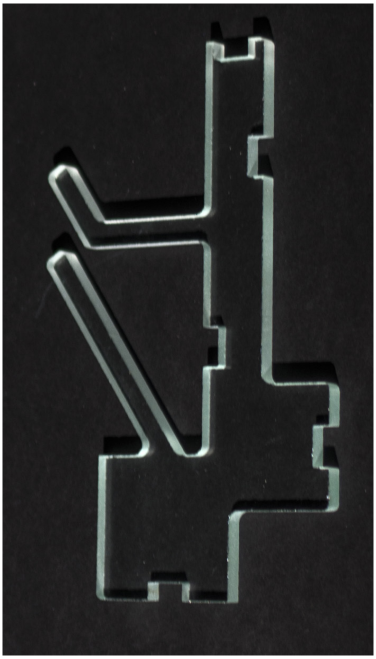
3
THE MODULAROCK

Together with 3D printed plastic elements, the *Modularock* is experimenting with granite as a module. The twelve square shape items each have a different type of connection to what could be a wall or a facade. The plastic bases angles give the whole set a faceted quality which, for instance, could be pursued in an auditorium, added to granite excellent acoustic properties.

The combination of the 3D printing to the granite 2D precise cutting offers a wide range and possibilities.



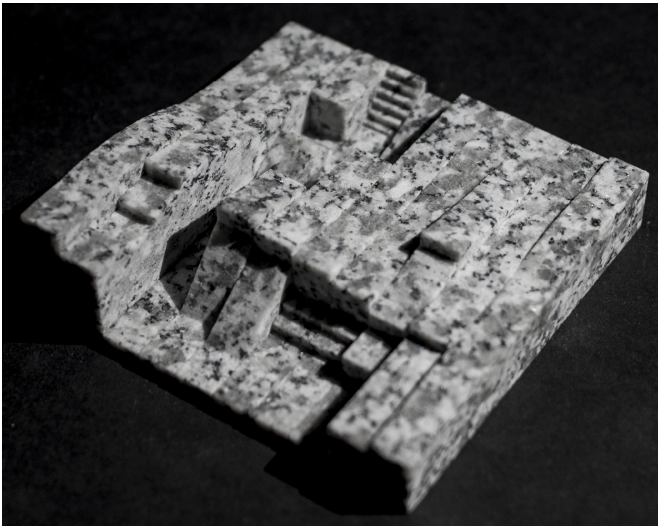




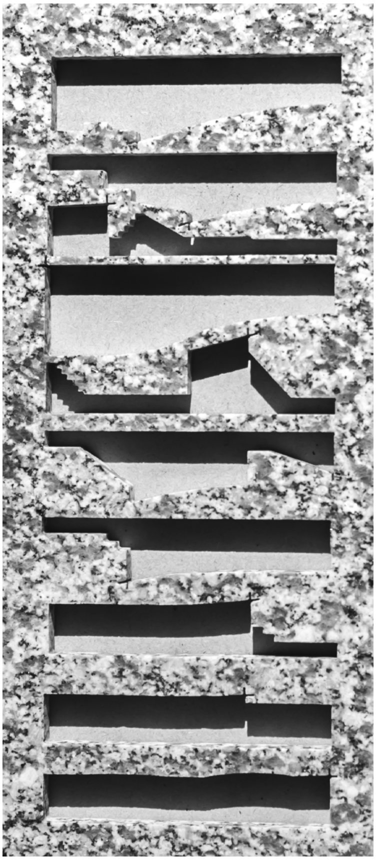
4
GLASS ON THE ROCKS

Glass on the rocks is cut in 30 mm thick good quality granite. It is a proposition for a plug-in panel with window and slit openings. The complex shape of the opening is challenging the granite that successfully holds together. This design, easily reportable for an approximately 3 metres high panel, shows the freedom of drawing water jet cutting allows with such a thick and hard material.

Using the water jet cutter was machined as well a window of the exact shape and fixings to hold together the whole assemblage.



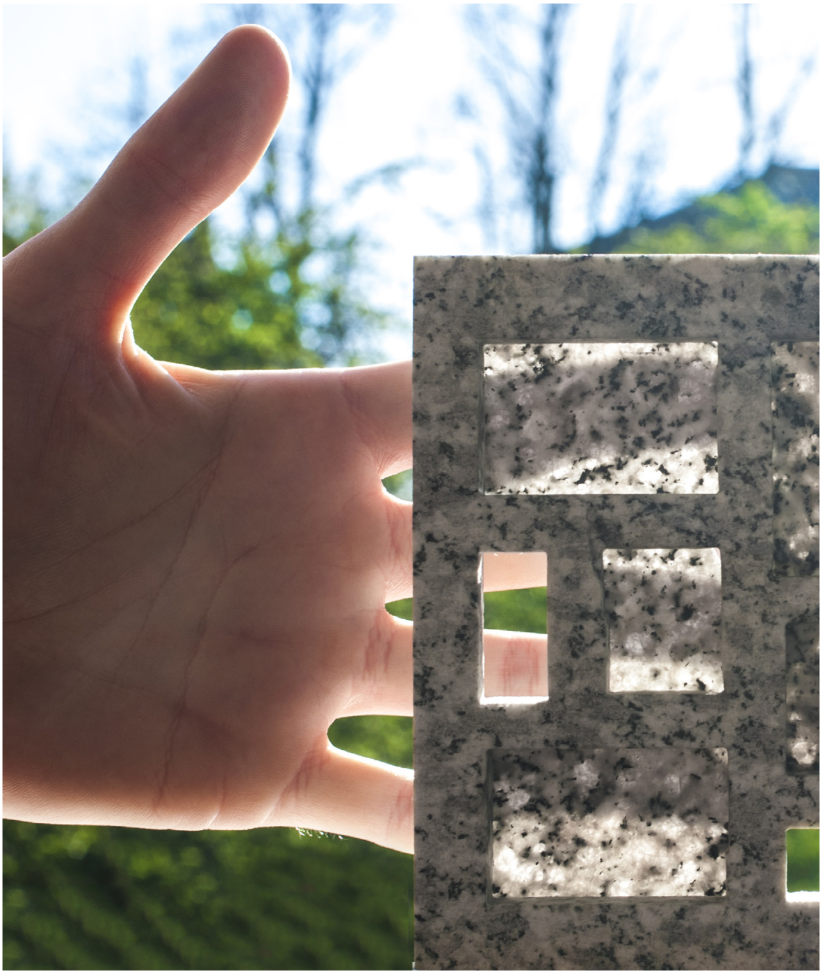
5
STRATAGRANITE



10 mm thick granite is used in *Stratagranite* as a representation material. The profiles of a designed underground space were cut and laminated.

The thickness of the material (the minimum available for these experiments) is a limit to the precision of the object, however, at the scale of an architectural model, it reprensents a space well.

Interest is also carried on the negative version of the cut as the left rectangle with holes in it emphasizes how granite became a 2 dimension material and was used the same way MDF or Playwood is generally used.



6
LIGHT ROCKS

This panelled granite frame lets light go through in different ways according to the thickness of the pieces.

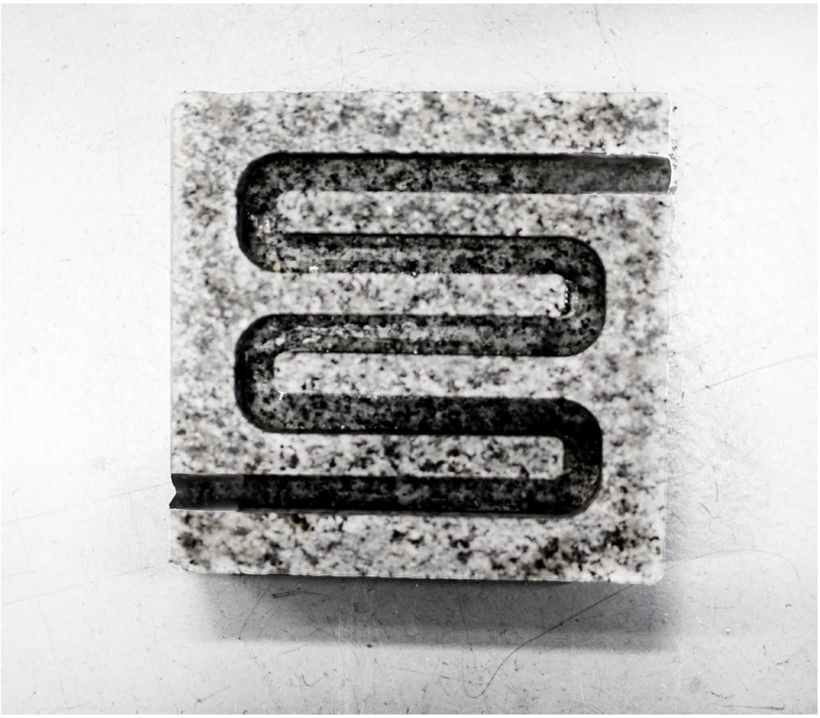
The translucent granite was sliced with the water jet cutter and ranges from 1 to 2 mm thickness. Below 1 mm, the effect was extraordinary but the part would collapse and therefore couldn't be integrated to the frame.

This object is contributing to explore different, new sides of granite and particularly to do with letting the light through: a permanent topic in Helsinki.

7
OFFCUTIC COLUMN

This object voluntary uses offcuts of odd shapes from old projects that are then recut to create a dynamic column with steps.

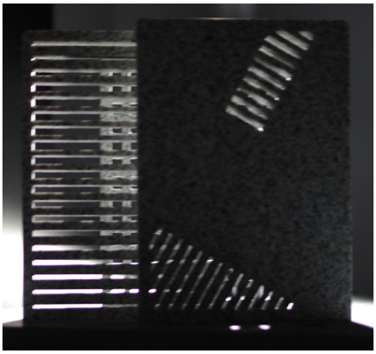
Ten times bigger, and still using piled offcuts, it is a staircase to access the quarry.

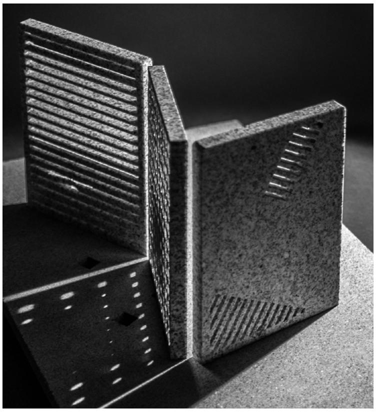


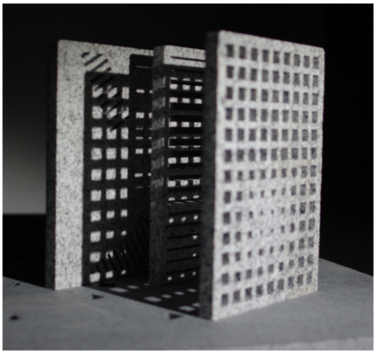
8
HOT WATER GRA-TLE

Cut in 30 mm thick granite, the middle part of this granite radiator uses the material thermal properties. The portable object is first filled with boiling water and sealed. Then, its user can enjoy the granite slowly returning the heat.

Eventually, it could integrate an access for a pipe to bring a flow of hot water and then improve its heating capacity.







9
OPTICAL GRANITE

Inspired by Optical Art patterns, these three panels are 17 mm thick and about 20 cm high. Staying within the granite width limit, they explore different ways of letting the light through by playing with the density of openings.

Once again, Helsinki's special relation with the daylight and sunset make these granite light filters relevant, as well as a strategic density can play with letting the light through but hide the viewer...

The panels are equiped with square section feet that allow them to be re-placed and accomodated in multiple configurations on the provided base that has square holes cut in it.

CONCLUSION

The compared analysis of historical Aberdeen granite industry with a fictional contemporary quarry and manufacture in Helsinki highlight a common ground: the cultural, sensitive relation to the material rock. Preserving this "extra" connection with granite cannot be done in today's Helsinki through the industry, therefore the project is seen as public funded rather than economically profitable.

Aberdeen precedent is the success of a community-based labour. Its success is it integrated the local builder to make him participate to something bigger and glorifying. If building the country's infrastructures and monuments or the city's homes as Aberdeen industry did is not pertinent today, the prominent idea behind it is the richness of using the available raw material, techniques and population to build something of public interest.

If Aberdeen was not the only place in the world or Britain with a large-scale granite industry, it was still among the main ones and the time knowledge, combined to fast evolving technologies implied experimenting to learn. For this reason, Aberdeen quarrymen and manufacturers became experts at it. Although not particularly inventive, they were very talented stone workers. The acknowledged quality of the work, on top of the localness of material sourcing, appears as an important aspect as it means this community-based work doesn't just create the minimum but the excellence. Considering today's knowledge of the machines and methods mentioned earlier, one could speculate that a serious and ambitious project of contemporary extracting and building with granite in Helsinki would become a reference and a source of more knowledge and more creativity if combining the technical and academic sides of the work. Eventually, it is likely

Helsinki 2015 granite community's social angle differs from Aberdeen's ideal of the stonemason becoming an entrepreneur. First, Aberdeen granite industry was reserved to men, when contemporary Finland is one of the leading countries for gender equality. Combined to a very "connected" and computerized society, this tends towards a much more mixed and egalitarian community, based on research and creation rather than a pyramidal structure in which people are making careers.

The clear, geographical separation of extracting and manufacturing was explained by the fact that quarries had to be where the available deposits were: mainly in the outskirts of the city and the granite yards were in the East of Aberdeen, nearer the harbour for exportation. This question is not the same in today or tomorrow's Helsinki as the stone deposits are in urban areas. If the dichotomy extraction / machining still exists, the border between the two sides has reduced as the same tools tend to be used, although at different scale. A synergy work of fast turnover and exchange between the quarry and the workshop can be considered.

Aberdeen granite golden age exists today through its buildings, as well as its grand fathers memories. Unfortunately, the heart of the industry, the quarries seem to have been left behind and are often hidden, filled with water. However, more than its remaining granite architecture, Aberdeen as "Granite City" lives today through an exceptional industrial and social history. If that time's stonemason is today behind a computer in Helsinki and a large part of the laborious work has been removed, it is believed that the granite transformation from raw material to a chair, a radiator or an excavated theatre, will be made through technology and knowledge: the ingredients for a granite community.

Fig.17. Rubislaw quarry in Aberdeen, nowadays...
Source: http://cwmags.co.uk/

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