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Exploring Natural Stone and Building a National Identity: The Geological Exploration of Natural Stone Deposits in the Nordic Countries and the Development of a National-Romantic Architecture

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Academic Editor: Marco Sosa Received: 22 February 2017; Accepted: 2 May 2017; Published: 12 May 2017

Abstract: In the second half of the 19th century, new methods for quarrying and processing natural stone were developed. In the Nordic countries Sweden, Norway, and Finland, this technological progress went hand in hand with a systematic geological mapping and large-scale exploitation of natural stone deposits. As a result, new constructions were developed, changing the building practice in these countries. With the end of historicism, a new architecture arose that, particularly in Norway and Finland, acquired a national-romantic character. This paper examines the interaction between geological exploration, commercial development, technical inventions, and the development of national-romantic architecture.

Keywords: architecture; 19th century; 20th century; Nordic countries; natural stone; national romanticism; geology

1. Introduction

In the second half of the nineteenth century, the methods for quarrying and processing natural stone were developed tremendously—parallel to the industrialization of brick production and later the advent of concrete construction. A number of technical innovations, such as the invention of the band saw or the use of power machines and explosives from the 1860s and 1880s onwards respectively, facilitated the hitherto laborious quarrying of natural stone, especially of hard rock varieties (Elliott 1992, pp. 23–45).

In the Nordic countries Sweden, Norway, and Finland, this technological progress was accompanied by systematic geological exploration and later by large-scale commercial exploitation of natural stone deposits. As a result, new constructions were developed that changed the practice of building. From this enthusiasm for natural stone, a new architectural language detached from historicism evolves. In Sweden, it is neutrally labeled as "material realism"—a term coined by the Swedish architectural historian Elias Cornell (1916–2008) and used, e.g., for the work of Ragnar Östberg (1866–1945) (Cornell 1965). While in Norway and Finland it acquires a national-romantic character and is seen as a contribution to an independent cultural identity in the struggle for national independence (Lane 2000).

This article traces the transition from geological exploration and commercial development of natural stone deposits in the Nordic countries to the application in a national-romantic architecture that emerges as a result. It examines the collaboration between geologists, entrepreneurs, and architects—including the role of the geological services—as well as the interplay between technical inventions and the changes in design and construction practices. This sheds not only new light on

the material origins of national-romantic architecture, but comparing the varying geological and commercial developments also helps to explain the differing architectural manifestations.

2. The Geological Exploration of the Nordic Countries and the Establishment of a Natural Stone Industry

In the Nordic countries, the systematic mapping and development of natural stone deposits began in Sweden in the middle of the eighteenth century. Norway and Finland lagged somewhat behind, and Denmark remained sidelined since it hardly possesses comparable natural stone deposits. In Sweden, the range of easy-to-access and easy-to-use rock varieties was quite large, and traditional artisan mining, such as that of Silurian limestone in Gotland and Öland, that of marble in Kolmården, and that of porphyry in Álvdalen, still existed at this time (Sundnér 1996, pp. 20–52). In addition, Sweden was the scientifically most advanced Nordic country. In 1739, the Royal Swedish Academy of Sciences ('Kungliga Vetenskapsakademien') was established, and shortly thereafter the first publications on the country's geology appeared. In 1758, the chemist and mineralogist Axel Fredrik Cronstedt (1722–1765) published the first comprehensive mineralogy. He approved of sandstone as a building material, but dismissed other types of stone, such as granite and porphyry, as exotic and useless (Cronstedt 1758). However, natural stone played a subordinate role in late 18th-century Swedish architecture. Carl Hårleman's (1700–1753) Övedskloster Manor (1768–1776) near Sjöbo, Skåne, was one of the few prominent examples with pilasters, gables, and rusticated basement of red sandstone (Sundnér 1996, pp. 53–56). Övedskloster came to literary fame through Selma Lagerlöf's (1858–1940) novel, "Nils Holgerssons underbara resa genom Sverige" ('The Wonderful Adventures of Nils', 1906-1907).

The impetus for the establishment of a natural stone industry originates from early 19th century large-scale infrastructure projects. For the construction of the Trollhättan lock (1796–1800) and for the Göta Canal (1810–1832)—part of the enormous waterway from the Swedish east coast to the west coast—a modern limestone quarry was established in Borghamn, east of Lake Vättern. This limestone was also used for two architectural projects: the fortress of Karlsborg (started in 1819), the largest fortification project in Sweden at that time, and the facade of the National Museum in Stockholm (1847–1866) designed by Friedrich August Stüler (1800–1865). In both cases, the use of limestone can be attributed to the military engineer Johan af Kleen (1800–1884) (Hedström 1908, p. 45). A few years later, granite was quarried on the island of Malmön for the expansion of the Carlsten fortress (1834–1851). This quarry was privately operated by the merchant Carl August Kullgren (1793–1851), who even presented the products of this first private quarry in the Crystal Palace at the First World Exhibition 1851 in London (Hedström 1908, pp. 50–51).

Starting from these first pioneers, a blossoming natural stone industry grew until the end of the 19th century. By the end of the century, the number of quarries had risen rapidly, from 18 quarries in 1881 to 229 quarries in 1901—the majority of which were located in the provinces Ostergötland, Blekinge, and Skåne; similarly, the number of employees rose from 1319 to 11,646. A key role in this was played by the Geological Service of Sweden ('Sveriges Geologiska Undersökning')—a government agency founded in March 1858 and at the time headed by the Ministry of Trade, Industry and Maritime Affairs, the so-called Civil Department ('Civildepartementet'), today by the Ministry of Economy and Innovation ('Näringsdepartementet'). It systematically explores and maps the country's geology and frequently presents local natural stone suitable for building at trade fairs and exhibitions (Sundnér 1996, pp. 60–61). Machines were initially rather sparingly used for quarrying, and for a long time, traditional artisanal mining methods, i.e., sawing or splitting, were applied. Not least due to these rough and waste-intensive stone-quarrying techniques, the stone was for a long time considered unsuitable for architecture. Granite was primarily mined in blocks and paving stones and used for domestic road construction as well as for export to Germany. In the early 1850s, the first steam-driven conveyor belts were installed in Borghamn, and in 1870 Kullgren's company in Malmön introduced the first steam-driven channelling machine invented in the United States in the 1860s. This early

phase of the Swedish natural stone industry was summed up in 1871 by August Wilhelm Hoffstedt (1841–1907)—an engineer loosely associated with the Geological Service—in his article "Om svenska stenarters användning inom byggnadskonsten samt deras framställande i ett mera förarbetadt tillstånd" ('On the use of Swedish rock in architecture and the processing of stone') published in Illustrerad Teknisk Tidning ('Illustrated Technical News') (Hoffstedt 1871). In 1877, he reported in another article in Teknisk Tidskrift ('Technical Journal') on the latest steam-powered machines for natural stone processing, such as band saws, stone saws, and stone planers, which he encountered at the 1876 World Exposition in Philadelphia and which were subsequently introduced in Sweden (Hoffstedt 1877).

In Norway, the Geological Service of Norway ('Norges geologiske undersøkelse'), a government agency originally run by the Ministry of the Interior ('Departementet for det Indre'), today part of the Ministry for Trade, Industry and Fisheries ('Nærings- og fiskeridepartementet'), was established in February 1858—one month earlier than its Swedish counterpart. In Norway, however, the exploitation of natural stone resources started considerably later than it did in Sweden, not least because in Norway—unlike Sweden—there were few remnants left of a medieval natural stone tradition. In 1882, the country's first natural stone company—which still exists today—was founded ('Den Ankerske Marmorforretning'). It mainly quarried marble in the Iddefjord region and, to a lesser extent, syenite and granite in Drammensfjord; the main market was in both cases Germany (Vogt 1897, pp. 104–11, 299–302, 330–32). It was not until the last decade of the 19th century that the Norwegian natural stone industry gained momentum—thanks mainly to the geologist Johan Herman Lie Vogt (1858–1932), who promoted the use of modern grinding and polishing machines (Vogt 1886).

The foundation of the natural stone industry in Finland differed in two aspects from that in Sweden and Norway: on the one hand, it was limited to the very hard rock types of granite and gneiss—there was hardly any marble or sandstone; on the other hand, the development originated in Russia. It was the clergyman and amateur mineralogist Samuel Alopaeus (1721–1793)—from 1755 until his death dean of the Karelian town Sortavala—who explored the region's natural stone deposits and in 1765 brought them to the attention of Mr. Pilugin, emissary of the Imperial Academy of Arts in St. Petersburg (Alopaeus 1787, pp. 15–18; Ringbom 1987, pp. 39–40). As a result, Finnish natural stone deposits were increasingly used for buildings in St. Petersburg. Finnish granite was, for example, used for the construction of the Kazan Cathedral (1801–1811), and the typical porphyry-red Finnish granite became famous for its use at the Isaac Cathedral (1818–1858) and the Alexander column (1832–1838)—the latter being a monolith 47.5 m high, weighing 600 t, quarried in Virolahti near Viborg, transported to St. Petersburg, and erected in 1832 (Hirn 1963, pp. 17–19). A systematic geological mapping of the country began comparatively late. In 1885, Tsar Alexander III (1845–1894) established a Finnish Geological Service ('Suomen geologinen tutkimus') that is today part of the Ministry of Labour and Economy. Its work was modelled on the Swedish service and tried with a series of exhibitions, events, and publications to boost the sales of Finnish natural stone (Sederholm 1896; Sederholm 1898). In the following year, the first private company, which invested in modern stone saws and grinders and which quarried granite at various locations along the coast, was founded; the foremen were sent to Sweden, Denmark, and later Scotland for education. Up to the end of the 19th century, this first exploitation of the Finnish natural stone deposits did not entail the development of an industry; quarrying and mining was mostly accomplished by simple means and without the use of machines (Ringbom 1987, pp. 39–42).

3. Natural Stone in Architecture

With the growth of a natural stone industry and thanks to the efforts of the Geological Services, natural stone was gradually picked up by architects. Once again, Sweden was leading the way among the Nordic countries.

One of the first architects to use natural stone was Adolf Kjellström (1834–1932), who from 1863 worked on the restoration of the medieval Nicolai church in Örebro, a limestone building, and he consequently also built his own house in 1879 in limestone (Julin 1963, p. 145). This house was

highlighted by Isak Gustaf Clason (1856–1930)—one of the most prominent Swedish architects of the time—in an overview over contemporary Swedish architecture and it became a model for many other subsequent buildings (Clason 1896).

The most important mediator between the natural stone industry and architecture in Sweden was the engineer Hjalmar Lundbohm (1855–1926), who from 1879 onwards worked for the Geological Service (Astrom 1965). In the 1880s, he systematically inspected quarries and natural stone companies in Sweden and later travelled abroad: in 1888 to England, in 1891 to Scotland, and in 1891–1892 to the United States. In numerous lectures and publications, he not only reported on natural stone deposits and possibilities of development, but also vigorously promoted the use of natural stone in architecture (Lundbohm 1888; Lundbohm 1889a; Lundbohm 1889b; Lundbohm 1889c; Lundbohm 1891; Lundbohm 1893). Alongside his travel impressions, he published numerous suggestions for different types of cyclops-, polygonal-, as well as ashlar-masonry and he explained how these constructions could be used in the Nordic countries (Lundbohm 1892, pp. 109-11). He also engaged in the architectural discourse and participated, for example, in the discussions of the Stockholm Group "De Byggande Bröderna" ('The Building Brothers'), a circle of successful young architects that included Gustaf Wickman (1858–1916), Ferdinand Boberg (1860–1946), and Ludvig Peterson (1853–1931), and the already-mentioned Isak Gustaf Clason (Kåring 1983). Finally, Hjalmar Lundbohm also advised architects on individual projects, such as Herman Holmgren (1842-1914) with the Central Building of Uppsala University (1877–1887) or Ferdinand Boberg and Frans Gustaf Abraham Dahl (1835–1927) with the Central Post Office in Stockholm (1898–1903) (Ringbom 1987, p. 34). Towards the end of the 19th century, natural stone, as Hjalmar Lundbohm notes, was firmly established as a facade material in Sweden. However, he regretted that Swedish architects preferred rather colorless native rock varieties and that they used natural stone only for the cladding of brick constructions (Lundbohm 1896).

In Norway, similar things took place with a few years' delay: In 1888, the young Norwegian geologist Hans Reusch (1852–1922) took over the management of the Geological Service of Norway and based his work on that of Lundbohm's in Sweden. An important contribution to the breakthrough of natural stone was the 1896 conference "Om huggenstens anvendelse i vor husbygningskunst" ('On the use of carved stone in our art of building') organized by The Norwegian Engineers and Architects Association ('Den norske ingeniør- og arkitektforening'). On this occasion, the Norwegian architect Adolf Schirmer (1850–1930) hoped that the use of sandstone, soapstone, granite, and marble would soon be just as widespread in Norway as in England or Scotland; as an example, he referred to the building of the Trondheim Savings Bank (1879–1882) that had already showed signs of a newly emerging national-romanticism (Om huggen stens anvendelse 1896; Nissen 1896). After the 1896 meeting, natural stone became increasingly popular. In 1904, a commission was founded to promote it; the architect Andreas Bugge (1859–1945), who was appointed chairman, gave a much-lauded lecture published in Teknisk Ugeblad ('Technical Weekly'), in which he not only referred to the experiences in Great Britain, but also to a number of Finnish examples (Foreningsefterretninger 1904). This commission, led by Bugge, not only propagated natural stone masonry as an everyday method of building, but also actively promoted the development of new constructions; it published numerous articles on different aspects of natural stone masonry in Teknisk Ugeblad and advertised in particular three types of constructions that were later chosen by many architects and applied in their national-romantic architecture: irregular stonework, a combination of irregular and regular masonry, and masonry with different layer heights (Anvendelse 1904).

In Finland, the transition from geological exploration to the breakthrough of natural stone in architecture took place faster than in any other Nordic country. In 1893, the geologist Jakob Johannes Sederholm (1863–1934) took over the Geological Service and hired the engineer Hugo Blankett (1872–1949) to map the country's granite deposits; he later also travelled to Sweden to Lundbohm as well as to Germany, Austria, England, and Scotland. Back in Finland, Blankett established in 1900 the company Finska Stenindustri ('Finnish Stone Industry'), which rapidly grew into the country's largest natural stone producer. To promote sales, Blankett invited a number of architects, such as

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Onni Tarjanne (1864–1946) and Lars Sonck (1870–1956), to become shareholders. Subsequently, the light gray granite quarried by Finska Stenindustri was used in a number of prominent new buildings, such as Onni Tarjanne's Finnish National Theatre (1899–1902) and the Finnish National Museum (1904–1910) by Herman Gesellius (1874–1916), Armas Lindgren (1874–1929), and Eliel Saarinen (1873–1950) (Ringbom 1987, pp. 41–45).

4. Natural Stone and National Romanticism

In the second half of the 19th century, a wave of modernization, industrialization, and urbanization began in the Nordic countries, which catapulted backward and rural countries into the industrial age. However, these great upheavals toppled the Nordic countries into a profound social and cultural crisis that resulted from a consciousness of backwardness compared to the countries on the European continent as well as from the insight that a nostalgic nationalism drawing on a mythical past had become obsolete in the industrial age and was no longer sufficient for the establishment of a cultural identity. In response to this crisis, a national-romantic renewal movement that was fuelled by the arts and crafts movement as well as different artistic and literary reform movements arose and, inspired by rural traditions as well as progressive social ideas, attempted to establish a new national everyday culture (Lane 2000, pp. 19–73).

In architecture, this movement found its expression in the search for a new national monumental architecture that differed decidedly from 19th century historicist styles and instead was derived from models that were regarded as particularly national, traditional, or typical for the heyday of the respective country. Popular models included the Håkons Hall in Bergen (1247–1261) in Norway, the Vasa-era castles (15th–17th centuries) in Sweden, and the numerous medieval churches and cathedrals that were renovated in the late 19th century. The buildings of this national-romantic monumental architecture varied considerably from country to country and in terms of historical references, but they were almost universally regarded as monumental sculptures that were made to strengthen national identity. This can above all be seen in the building tasks; they could almost always be called national monuments, such as government buildings or town halls, museums, and churches dedicated to national heroes or national saints (Lane 2000, pp. 174–75). In many cases, the reference to national or traditional models found a continuation in a material iconography, i.e., a building material that was regarded as correspondingly national—in many cases natural stone, in particular granite (Lane 2000, pp. 172–73). This referred to the discourse on the origin of historical architectural styles that emerged in the late 18th and early 19th century in the wake of the revival movements on the European continent and that established a reference to natural stone (Hirt 1809, p. 38; cf. Kruft 1985, pp. 334–36). Hjalmar Lundbohm, for example, referred in 1891 to the 1850 travel report by the German archaeologist Ludwig Ross (1806–1859), who described how the different forms of cyclopean masonry could be traced back to the type of stone and stone-splitting technique used (Lundbohm 1892, p. 109). In addition, this was tied to a material semantics that has its roots in antiquity and from 1790 onwards gained particular significance in the European continent (Raff 1994, pp. 114–20, 166–89). Important influences for equating stone and nation in the Nordic countries were the aforementioned renovations of medieval natural stone buildings (Lane 2000, p. 32-48), Julius Langbehn's (1851-1907) book Rembrandt als Erzieher ("Rembrandt as Teacher," 1890) (Langbehn 1890, p. 221; cf. Lane 2000, pp. 172-75), in which he designated granite as a Nordic and Germanic stone, and the use of natural stone for monuments in contemporary Scottish and American architecture (Ringbom 1987, pp. 50–51).

In Sweden, the use of natural stone for a particular national architectural style was least pronounced, and the equivalency of natural stone and a specific national style most drawn in doubt. In 1886, at the Second Engineering Conference ('Andra Teknologmötet') in Stockholm, plaster architecture was unanimously condemned and natural stone propagated, but this did not imply a demand for a national style (Protokoll 1887, pp. 140–42). For example, Adolf Kjellström argued that material did not necessarily entail a style and he doubted that there could be a uniform Swedish national style: the different climatic conditions and varieties of stone would result in different styles,

such as a Nordic sandstone style or a Nordic granite style—very similar to the difference between the sandstone Gothic and the brick Gothic in Germany (Protokoll 1887, pp. 142–43). This attitude can be attributed on the one hand to the great diversity of the regions in Sweden and to the many different types of stone and on the other hand to the fact that late 19th-century Swedish historicism is characterized by a variety of different foreign influences. Significantly, many Swedish architects aimed for pluralistic, regional, and material diversity. This can be seen, for instance, in the work of Gustaf Wickman (1858–1916), who used sandstone from Skåne for the Skånebank building in Stockholm (1897–1900), but marble from nearby Ekeberg for the Örebro Enskilda Bank (1909–1912)—in both cases he chose rock types that correspond to the regional origin of the respective banks and thus demonstrated this materially (Bedoire 1974, p. 53).

In contrast, the debates in Norway and Finland were much more nationally oriented, fostering nationalist cultural currents and actively working towards a Norwegian or Finnish national architecture. In both countries, there was a passionate struggle for national rights and an independent cultural identity—in the case of Norway for freedom from the rule of the Swedish king and in the case of Finland from the Russian Tsar. In Norway, this struggle ended in 1905 with the dissolution of the Union with Sweden, in Finland with the fall of the Tsarist Empire in 1917.

In Norway, numerous architects, above all the royal antiquarian Herman Major Schirmer (1845–1913), supported a new national architecture (Ringbom 1987, pp. 47–50). Henrik Nissen (1848–1915) was one of the first to establish a link between national architecture and natural stone. In 1896, he demanded that "every national architecture must of course be constructed from the respective country's natural materials" (Nissen 1896, p. 43). However, there was no consensus on the question of how this national stone architecture should look, since there were hardly any suitable models for natural stone buildings, apart from a few exceptions such as the Håkons Hall in Bergen and the Cathedral in Trondheim. For this reason, many young Norwegian architects looked towards contemporary natural stone architecture in the United Kingdom and the United States-most notably the buildings of Henry Hobson Richardson (1838–1886). In 1900, Hans Jacob Sparre (1861–1937) attempted to describe a Norwegian national architecture independently of historical or contemporary models. He rather prescribed four basic principles to it: first, that it lives up to the country's harsh climate; second, that it takes the long dark winters and short bright summers into account and is therefore distinctively profiled; third, that it corresponds to the simple and poor cultural tradition, and fourth, that it corresponds to the country's exceptionally hard and difficult-to-process types of stone (Sparre 1900). In the years up to the dissolution of Norway's union with Sweden in 1905, the urge for a national stone architecture continuously grew—there were very few voices that warned of excessive nationalization. Numerous architects like Andreas Bugge urged, "No imported stone on Norwegian soil" (Bugge 1901). The Association of Young Architects ('Yngre arkitektforening') proclaimed in 1901—on its ten-year anniversary—that it saw its task in "promoting a style of architecture on a national basis, that [is] [...] deeply and inextricably rooted in the character of our people and the nature of our country" (Berner 1901). Henrik Nissen's Christiania Sparebank (1896–1901) and Henrik Bull's (1864–1953) governmental buildings in Oslo (1898–1904) were considered the most prominent examples for this national spirit (Regjeringsbygningen 1902; cf. Lane 2000, pp. 198–99).

In Finland, the efforts to build a particular national architecture were—similar to Norway heavily influenced by the building materials available, that is to say, the very hard stones gneiss and in particular granite that was regarded as *the* Finnish material par excellence. This equating of Finland and granite was repeatedly picked up and symbolically exaggerated by the country's national independence movement; the Finnish–Swedish writer and rector of the University of Helsinki, Zacharias Topelius (1818–1898), for instance, compared the country's hard stone with the sober and serious character of its people (Wäre 1979). In the search for a national architecture that met these requirements, Finnish architects—similar to their Norwegian colleagues—either drew on historical models or on contemporary natural stone architecture in Great Britain and the United States. The choice of models was often a generational question. For example, Hugo Lindberg (1863–1932), as a representative of a somewhat older generation, still retained a conventional historicism in his design for the Historical Museum in Helsinki (1899)—despite the use of granite. The Finnish architects of the next generation, such as Lars Sonck (1870–1956) and Eliel Saarinen (1873–1950), built on earlier experiences, but after the turn of the century they invented their own anti-historical and proto-modern national-romanticism that caused quite a sensation (Lane 2000, pp. 96–102; Quantrill 1995, pp. 1–20).

Shortly after the turn of the century, it was foreseeable that this national-romantic granite architecture would remain a short episode and would be passé with Finnish independence; after all, people in Finland hoped that they would be able to break away from Russian rule within a few years. As early as 1906, Sigurd Frosterus (1876–1956) wrote in his article "Framtidskonst" ('The art of the future') that, quite soon, "the national question will be replaced by the social question. [...] National art will be ousted by an art of class struggle that will be characterized by cosmopolitanism" (Frosterus 1906).

5. Conclusions

In the 19th century, the geological exploration and commercial exploitation of natural stone deposits, combined with technological inventions and the changes in building and construction practices, led to the emergence of a new natural stone architecture in the three Nordic countries of Sweden, Norway, and Finland.

The transition from geological exploration and commercial development to architectural applications arose from a close collaboration between geologists, entrepreneurs, and architects. The development was carried out to a great extent by geologists and the geological services in the respective countries, who were familiar with one another and who maintained a lively exchange. The connections between architects were less significant and are more difficult to trace. This is partly due to the different ways of applying natural stone in the respective countries. While Sweden was the leading Nordic country in terms of science and industry, and a thriving natural stone industry first emerged here, natural stone ultimately remained only a means to represent the pluralistic, regional, and material diversity of late 19th-century Swedish historicism. In Norway and Finland, on the other hand, local natural stone, and granite in particular, became an important feature of national-romantic architecture and played a significant role in breaking away from historicism.

Conflicts of Interest: The author declares no conflict of interest.

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