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# Soapstone in the North
# Quarries, Products and People
# 7000 BC – AD 1700

Gitte Hansen and Per Storemyr (eds)

UNIVERSITETET I BERGEN

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# Preface

This book has been a long time in the making. It is an outcome of the five Norwegian University Museums' joint research programme Forskning i Felleskap (FIF, 2010–2015), supported by the Research Council of Norway. FIF kindly facilitated a number of workshops and meetings between archaeologists, geologists and craftspeople, all with a common interest in premodern soapstone quarrying and use. The result is the chapters of this book, which are based on studies carried out over the last two decades and, for the most part, are published scientifically for the first time. We very much thank the authors for participating in this venture. We also thank several colleagues – archaeologists, geoscientists and craftspeople – that assisted the editors in peer-reviewing the chapters: Irene Baug, Birgitta Berglund, Laura Bunse, Poul Baltzer Heide, Richard Jones, Tor Grenne, Torbjørn Løland, Therese Nesset, Astrid J. Nyland, Lars Pilø, Kevin Smith, Lars F. Stenvik, Frans Arne Stylegard and Stephen Wickler; we are very grateful for the job you have done. Not least, thanks go to Tromsø University Museum, NTNU University Museum (Trondheim) and the University Museum of Bergen for their economic support in publishing the book.

Bergen/Hyllestad, Spring 2017
Gitte Hansen
Per Storemyr

# Contents

Per Storemyr and Tom Heldal

# Reconstructing a Medieval Underground Soapstone Quarry: Bakkaunet in Trondheim in an International Perspective

*Underground medieval quarries are rare, in Norway and elsewhere in Europe. Thus the question: Could a big underground soapstone quarry have been opened at Bakkaunet in Trondheim (central Norway) in the Middle Ages? This question of stone procurement for Nidaros Cathedral – which is Europe's northernmost medieval cathedral and a building heavily influenced by English traditions and fashions – has bothered us for the last 20 years. In this paper we discuss what we think the quarrymen did. It is a biography of the now almost lost Bakkaunet quarry, with a focus on the question about underground operations. But the paper also discusses stone procurement for Nidaros Cathedral in view of contemporary international, especially English, trends. The story is sad, for the open-cast part of this once great quarry, very close to the centre of Trondheim, has been successively destroyed by modern house building over the last century.*

## Gothic architecture and freestone in Central Norway

Stone from at least 30 individual quarries was used to build Nidaros Cathedral between 1070 and 1350. Gneiss and granitic rubble for various interior walls and masonry cores were provided from local and regional deposits along the Trondheim Fjord, whereas marble was shipped up to 140 km from two regional quarry areas by Sparbu and Allmenningen and used for an array of columns, pillars, floor slabs and gravestones. Slate for floors and (possibly) roofs may, in addition, have been provided from regional deposits by Orkanger and Stjørdal. But the most important stones, chlorite schist and soapstone used for ashlar and decoration, came from two of Norway's largest medieval quarry centres, Øysand at the mouth of River Gaula, some 35 km south of Trondheim (by boat), and – notably – from the town of Trondheim itself (Figure 1). These quarries also provided stone for many other regional churches, monasteries and secular buildings (Storemyr 1997, 2003, 2015a; Storemyr et al. 2010).

The Øysand quarry landscape includes chlorite schist and soapstone extracted from 10–15 interconnected quarries along a one km long valley. The landscape is quite well-preserved and has been subject of several investigations over the last 20 years (Heldal & Storemyr 1997; Storemyr 1997; Lundberg 2007; Storemyr et al. 2010). It has been shown that the evidence of stone extraction nicely correlates with what can be observed at the cathedral and other contemporary stone buildings (Figure 2). Chlorite schist was the principal stone sought after in the Romanesque building period, starting

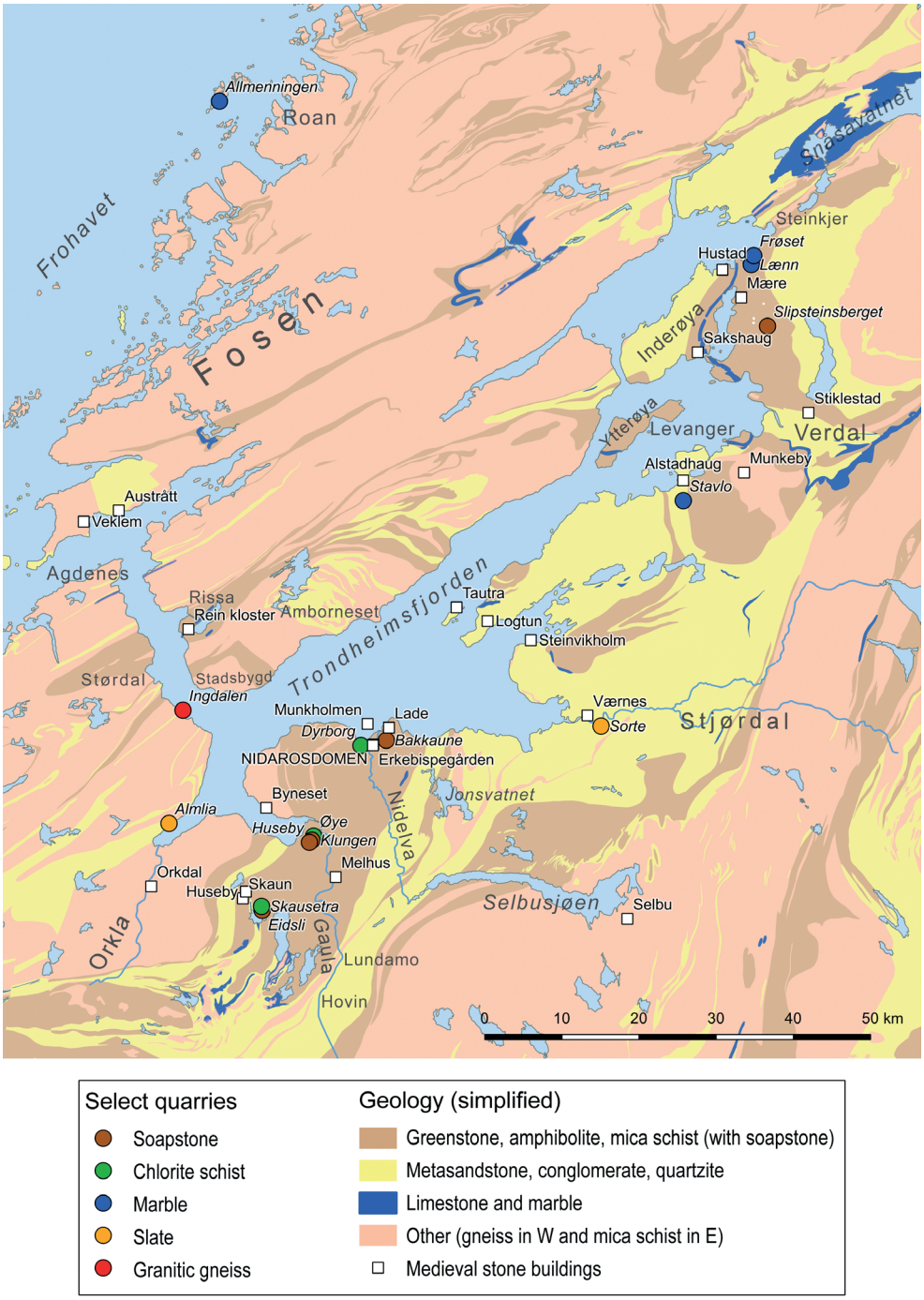



***Figure 1.*** *Simplified geological map of the Trondheim region with the location of secure and probable medieval quarries, as well as select stone buildings in the region. Geology after the online resources at www.ngu.no; location of quarries and buildings based on multiple sources, see Storemyr (2015).*

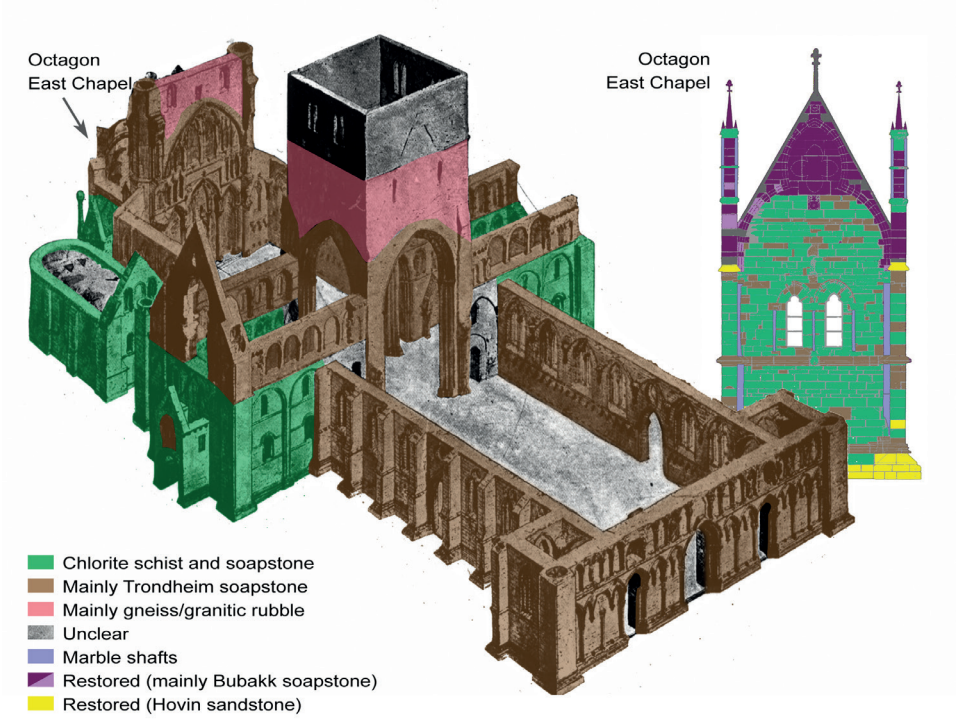



***Figure 2.*** *Rough overview of stone types in preserved medieval masonry at Nidaros Cathedral. Base drawing by Joakim Mathisen (NDR's archive). Base drawing of the octagon's east chapel by NTNU Department of Civil and Transport Engineering (1991). Stone types simplified after extensive mapping by Per Storemyr (Storemyr 1997).*

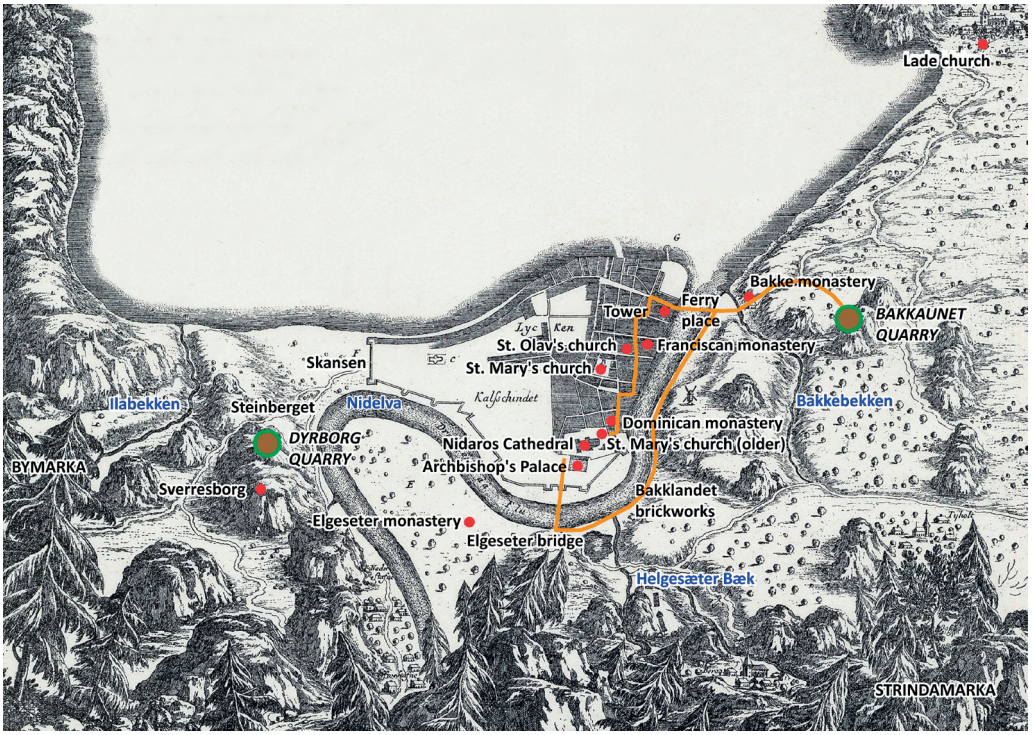
in the late 11th century and continuing until the Gothic style took over towards the 13th century. Although soapstone was also applied in the Romanesque period, both for ashlar and decoration, its use is mainly confined to the Gothic period, when the chlorite schist quarries were completely abandoned.

There may be several reasons why chlorite schist was abandoned as a building and ornamental stone around 1200, the most important of which ought to be its foliated fabric. In order to carve the much more intricate Gothic decoration (moulding, tracery, sculpture; Figure 3), as compared to Romanesque features, there seems to have been a need for a 'true' freestone – a uniform stone that could be carved 'in all directions' without greatly considering foliation and other, from the stone carver's perspective, weaknesses. Another Norwegian example of the same phenomenon is Stavanger Cathedral, which features a range of stones, including chlorite schist, in the Romanesque building phase, but only very good soapstone in the Gothic period (Stige 1997:40–43; Storemyr 2001).

True freestone is *very* scarce in the metamorphic geology of the Trondheim region. In the Middle Ages exploitable resources were, due to transportation restrictions, in practice confined to the soapstone deposits at Øysand and in Trondheim (Storemyr 2015a). Both deposits feature similar bluish-grey soapstone with networks of carbonate veins, a very characteristic type of soapstone rarely found elsewhere in Norway (Figure 3). Their properties are, in fact, so similar – reflecting a common geological origin – that it is still almost impossible to distinguish soapstone from Øysand and Trondheim (optically and geochemically). Hence, 'Trondheim soapstone' is commonly used as a

***Figure 3.*** *Trondheim soapstone used for intricate carving of a central Christian myth; the creation of Eva from Adam's ribs. To be seen at the so-called King's Porch at the south side of the choir, Nidaros Cathedral (first half of the 13th century). The scene was heavily restored in the late 19th century using Trondheim soapstone. (Photo: P. Storemyr).*

***Figure 4.*** *Excerpt of one of the earliest maps of Trondheim town and vicinity, drawn by Pufendorf (ca. 1796) on the basis of Naucler's map from 1658, reprint 1899 (source: kartverket). Though slightly imaginative, the map shows the structure of the medieval town, before it was totally changed after the town fire in 1681. Medieval quarries and select medieval stone buildings, as well as possible transport routes from the Bakkaunet quarry to Nidaros Cathedral.*



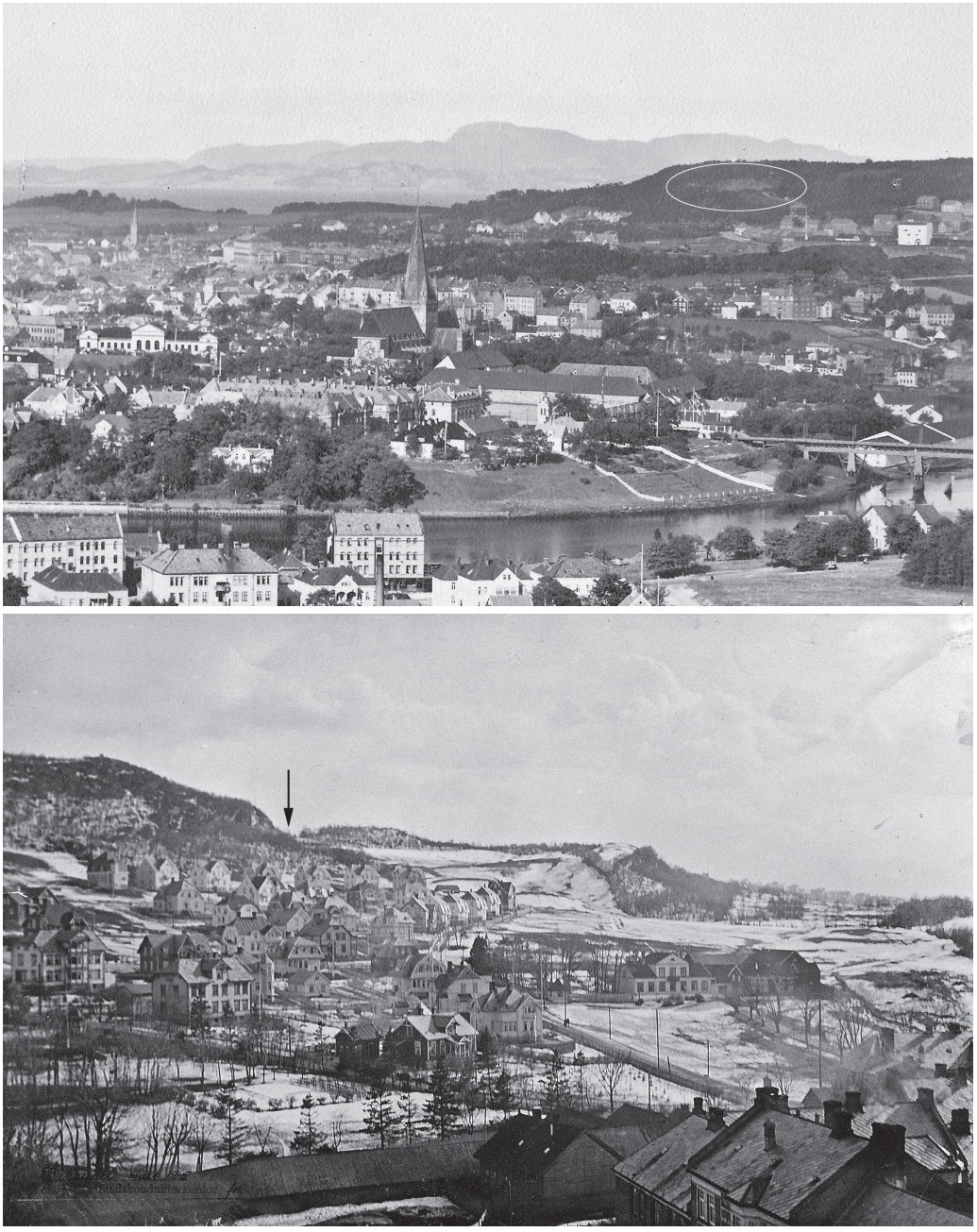


***Figure 5.*** *Location of Bakkaunet soapstone quarry. Above: As seen from the west, across the city with Nidaros cathedral under reconstruction in the centre. (Photo by Schrøder 1937), the quarry is indicated by an oval. Below: As seen from the north (1930), with the quarry indicated by an arrow. (Source: Trondheim byarkiv.)*


***Figure 6.*** *Bakkaunet quarry as seen from above 27. July 2008. The quarry is located below and behind the two large apartment buildings in the middle of the image. The old spoil heaps have been used as building ground. Compare with Figure 13. (Source: Google Earth).*

term encompassing stone from both quarry landscapes. It is likely that both provided soapstone from the late 11th century onward, until the Black Death in 1349–50 (and its aftermath) almost put an end to medieval stone building activities. As indicated by the size of spoil heaps, it seems that Øysand and Bakkaunet provided roughly similar amounts of *soapstone* in the Middle Ages. Øysand was a larger quarry landscape, though, since it also provided vast amounts of chlorite schist.

There is a snag, though. This is because there was a second medieval soapstone and/or chlorite schist quarry close to the Trondheim city centre, at Dyrborg in the hills less than two km west of Nidaros Cathedral (Figure 4) (Schøning 1979a:194; Storemyr 2015a:208–209). Unfortunately, this quarry has been completely destroyed by modern development; the only traces left being fragments of spoil heaps. Since there are hardly any local traditions connected to the quarry, it is presumed that it was relatively small, but its significance remains unknown.

The Bakkaunet quarry is also situated very close to the city centre, about 2.5 km east of the cathedral (Figure 4 and Figure 5). Already in the early 20th century urban development had reached the spoil heaps and the quarry was successively transformed to a residential area. But it was not until the 1980s and again around 2005 that the building of two large housing complexes destroyed the open-cast parts of the quarry (Figure 6).

Prior to the last building phase archaeological excavation was undertaken in a small, open-cast part of the quarry, giving a glimpse of its characteristics (Følstad 2002; Østerås 2008). The question is whether the excavations provided a representative picture of the design and organisation of the quarry as a whole in the Middle Ages. There are indications that the answer is negative, particularly in view of 19th century records hinting at underground operations.

## Geology, stone quality – and hints to open-cast and underground exploitation at Bakkaunet

The Bakkaunet quarry is located in a small valley by Kuhaugen, belonging to gentle hills that make up the eastern outskirts of Trondheim. Field survey and observations on old aerial photos (see www.norgeibilder.no) indicate that extraction once took place along a c. 140 m long stretch at the foot of a steep hill more than 30 m high. This hill (now called Skyåsparken) consists of metagabbro overlying the soapstone deposit, which also contains serpentinite, as well as chlorite schist at its periphery, all surrounded by the typical greenstone (metabasalt) of the Trondheim area. These rocks were formed during ordovician sea-floor spreading, and they were later altered during the Caledonian orogeny (c. 490–390 million years ago) (Carstens 1939; Fossen et al. 2008:224–226).

Given this geology, it is likely that the soapstone deposit is part of an ophiolite fragment and that the soapstone was altered from original peridotite. This has also left fragments of serpentinite, an intermediate stage in the geological transformation of peridotite to soapstone. Although the soapstone *outcrop* is restricted to a narrow zone at the foot of the hill, the actual deposit is likely much larger, presumably forming one or several squeezed lenses dipping towards the north, as indicated by the discovery of soapstone just beneath the area during recent construction of a new transport tunnel through Trondheim (Strindheimtunnelen) (Nikolaisen 2011).

The geology is very similar to the Øysand area, which has been mapped in detail (Heldal & Storemyr 1997), and which features quarries as mentioned above. Common both at Øysand and elsewhere in the Trondheim greenstone geology, granitic intrusions have penetrated the Bakkaunet deposit. One of these intrusions are, in fact, marked on the first geological sketch map of Bakkaunet (Figure 7), drawn by the geologist Amund Helland more than a hundred years ago (Helland 1893:145).

More importantly, the sketch also shows three adits (entrances to mines) at the foot of the hill. The adits are located behind the large apartment complexes built in the 1980s and by 2005 (Figure 6), but they are hardly visible today, due to the building activities as well as rock fall. Yet, we have observed two conspicuous places where adits perhaps might be located; both in small re-entrants, covered by scree (see location in Figure 13). Moreover, important traces of open-cast soapstone extraction below the hill were found during archaeological excavation prior to the last construction phase, which commenced in 2005.

These excavations will be described in detail below. However, the excavated areas showed that mainly a soft variety of the soapstone was extracted in the Middle Ages, whereas a harder, serpentine-rich type was, additionally, quarried in the late 19th century (Østerås 2008:93). This is very much

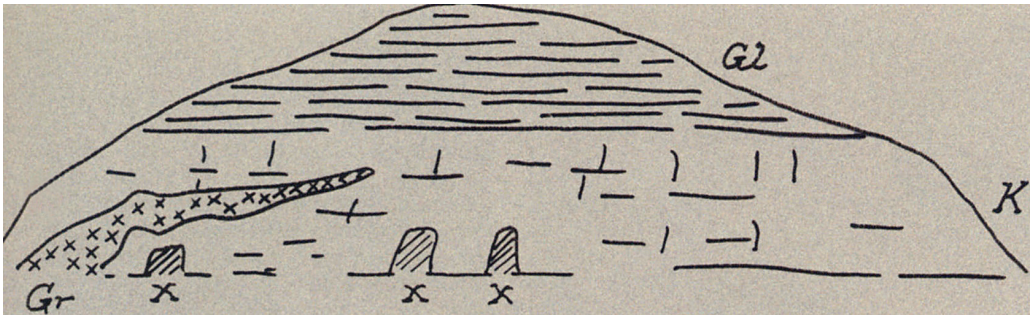



***Figure 7.*** *Sketch map of the geology at Bakkaunet quarry, with three ancient adits (X) indicated. K means soapstone, Gl means micaschist (in reality gabbro), Gr means granite. (Source: Helland 1893:145).*

in line with observations of the use of the stone at Nidaros Cathedral. The soft variety is, thus, of a quality similar to what can be seen on large parts of the cathedral, in particular at the early and high Gothic choir and nave, as well as the west front (Figure 2); all built from the first half of the 13th century on, starting with the choir (Fischer 1965; Ekroll 1997:149–159, 2015). In the bluish-grey, sometimes greenish matrix composed principally of talc and chlorite mainly, is a network of often thick carbonate veins (mainly dolomite), but smaller carbonate clusters are also present (Figure 3). The stone appears as massive, yet slight foliation may be present, as indicated in medieval mouldings that have lost strongly exposed/protruding parts. Such weathering may also be related to thin carbonate and talc veins. Although surfaces usually remain extremely well preserved after 800 years of exposure, despite a certain content of oxidising sulphide minerals (e.g. pyrite), these observations show that the Bakkaune soapstone generally is a good freestone. However, like most building stone, it also has certain weaknesses. For the stone carver it is the harder carbonate veins in particular that represent a challenge during cutting, but this is partially outweighed by the firmness of the talc-chlorite matrix, which makes it possible to cut very sharp lines and edges. In softer soapstone this is often a problem.

## History of the quarry and use of the stone: The Middle Ages

Since it is situated very close to the city centre and (Figure 4), in particular, near the Iron Age power centre at Lade (on the history of the Trondheim region, see e.g. Alsaker et al. 2005), it is likely that the Bakkaunet deposit was known prior to the foundation of Trondheim around AD 1000 and the early phases of stone building from the mid-late 11th century. However, it is not established whether the deposit was developed as an early quarry for production of vessels and small items like loom weights, spindle whorls, net sinkers, oil lamps and the like. Still, from the archaeological excavations (2002–2004) we do know that there was limited production of such items parallel to the extraction of building stone at some stage in the Middle Ages (Østerås 2008:87–88). This production has not yet been interpreted; whether it was of an occasional nature or part of more organised activities. Discovery of iron slag during the excavations also showed that there was, as expected, a smithy in the quarry, probably used for sharpening tools. The smithy would imply that a blacksmith worked in the quarry (Østerås 2008:88), similar to what is well known from medieval quarries on the British Isles, for instance in Yorkshire (Moorhouse 2007). In addition, cattle bones were found (Østerås 2008:88), perhaps indicating the sort of food served to hard-working, hungry quarrymen?

The most important results of the excavations were, however, related to quarry design and extraction techniques, which could be studied in-depth because a part of the excavated section at some stage had been rapidly buried under one or more screes from the steep cliff. Although there were many traces of 19th century extraction (boreholes), partially overlapping former extraction marks, it seems that the medieval quarrymen had entered the outcropping deposit at the foot of the hill by extracting blocks along a good vein of soapstone, thus creating a shallow 'ravine'. In this depression, block extraction had been undertaken in a rather chaotic manner, following natural cracks and foliation of the otherwise massive soapstone. An array of blocks nearly ready to be removed from the bedrock (Figure 8) was located at the inclining, north side of the ravine. They showed a pattern of remaining blocks resembling chocolate bar squares, with channels cut perpendicular to one another in a highly regular manner. Studies of tool marks indicate that pickaxes had been used for channeling, and on the underside of each block premade holes for wedging out the blocks had been cut (Østerås 2008) (Figure 9).

Although the rest of the quarry looked chaotic, the chocolate bar-pattern indicates a highly skilled way of cutting stone; we may assume that due to the shifting stone quality it was just not

***Figure 8.*** *Excavated part of the Bakkaunet quarry, the open-cast section, prior to the building of an apartment complex by 2005. Array of soapstone blocks ready to be extracted. (Photo: P. Storemyr 2004).*

possible to use this method in all parts of the quarry. The bar-method reflects a skilled approach to the stone because channels were not carved around each block to be removed from the bedrock one by one, but over longer distances, aiming at removing several blocks in a coordinated operation. A very similar extraction method is known from other contexts, e.g. from Ancient Egypt (c. 2500 BC) onward. In this and similar contexts, however, the method was used for manual extraction of *very* homogeneous, bedded sandstone and limestone – especially from the New Kingdom on, through the Roman period in the Mediterranean and Europe, the Middle Ages and all the way up to the modern period, e.g. in Swiss sandstone quarries. The idea behind the method is to reduce the difficult cutting of corners around each block, thus improving extraction efficiency, especially when flat platforms can be established (as in homogeneous sandstone and limestone), which are then sunk step by step down to the quarry floor. We may call it the 'descending platform' method (Harrell & Storemyr 2015).

This method is not known from pre-medieval extraction of e.g. vessels in Norway, and it is also uncommon in other medieval soapstone quarries across the country. But it was used with success in the Øysand chlorite schist quarries mentioned above (Storemyr 2015a:190–191). Thus, we may speculate that the method was introduced to Norway by English quarrymen, presumably informed about Roman extraction techniques, since we know that the English-style Nidaros Cathedral to a significant extent was built by English master masons and stone carvers. The chlorite schist crops out along a valley slope, as a sub-horizontal, rather homogeneous, thick and soft bed within the greenstone geology. Such deposits are suitable for applying the descending platform method. It is likely that the medieval quarry masters and quarrymen took advantage of the knowledge obtained in the chlorite schist quarry, trying to transfer the technique to Bakkaunet. But due to geological circumstances, it was not possible to establish the desired, regular platforms – at least not in the open-cast part of the quarry. It may, of course, have been different in the presumed underground sections that we will speculate on below. Notably, we know of very similar, regular manual channelling for extracting soapstone blocks in the first half of the 20th century in the Vesleseterberget quarry by Otta in Oppland county, Norway, but also here it seems that the rock was too inhomogeneous for establishing regular platforms – and, notably, too inhomogeneous to be worked efficiently by modern means (drilling, wedging, black powder) (Storemyr 2015a:196–198)

***Figure 9.*** *Close-up of an excavated part of the Bakkaunet quarry, prior to the building of an apartment complex by 2005. Soapstone block with carved-out wedge holes. (Photo: P. Storemyr 2004).*

Unfortunately, the excavated part of the Bakkaunet quarry has not yet been firmly dated, which would have been possible, given the presence of charcoal suitable for radiocarbon analyses. Thus, we do not really know if the stone extraction took place in the high-Gothic period, or rather in late medieval times. After the Black Death (1349–50) and due to political circumstances, as Norway ceased to exist as an independent kingdom, from now on being ruled from Copenhagen, it took more than 150 years before stone building practices again got a foothold. In the beginning of the 16th century, the octagon at Nidaros Cathedral was restored (Ekroll 2015), an operation that presumably involved extraction of Trondheim soapstone. Quarrying must also have taken place when the last medieval construction in the Trondheim region, Steinvikholm Castle, was erected between 1524 and 1532 (Storemyr 2015a 158–159, 245–247). Steinvikholm was the stronghold of the last Norwegian catholic archbishop, Olav Engelbrektsson, who fled the country as the Reformation was formally established in 1537. By then, Nidaros Cathedral and the neighbouring Archbishop's Palace, were also severely damaged, due to fire and warfare, respectively.

All this implies that the most active quarrying at Bakkaunet will have taken place over a 150-year period only, from c. 1200 to the mid-14th century. In addition to Nidaros Cathedral and the Archbishop's Palace, in this period soapstone resembling the one at Bakkaunet (generally called Trondheim soapstone, see above) was mainly used for decoration and to some extent ashlar (squared blocks) in finishing existing local and regional churches (e.g. St. Mary's church in Trondheim itself, Værnes church 30 km to the east of the city, and Sakshaug church 70 to the NE of Trondheim), but also in the original building period at Tautra monastery, 20 km NE of Trondheim. As at the cathedral, Trondheim soapstone can also be found in many of the regional churches and monasteries that were erected already in the 12th century, but to a much lesser extent (Storemyr 2003).

## History of the quarry and use of the stone: The post-reformation period

One of the founders of historical research in Norway, Gerhard Schøning, was the first to mention the Bakkaunet quarry, in his detailed 1762-description of Nidaros Cathedral (Schøning 1762:29):

> *In some of the soapstone at the cathedral there are veins or layers of a harder, white mineral, which looks like flint or quartz. This stone is quarried by a hill just east of Trondheim, from where a huge amount has been transported, which can be seen from the room where the stone has been taken, and from where stone is still extracted. (Our translation)*

Schøning's 'flint or quartz' most likely relates to the carbonate veins in the soapstone, but his 'room' in the quarry is more difficult to understand. Does he mean an actual underground gallery, or is the room rather referring to the depression-like, small valley in front of the steep hill? This area was called 'Gryta' (literally the pot or vessel) in modern times (Adresseavisen 4. March 1978; cf. Carstens 1939) (Figure 10), prior to the building of apartment blocks in the quarry. On aerial photos (see www.norgeibilder.no) it can be seen that Gryta was the largest open-cast section of the quarry, covering an area of roughly 70 m x 30 m. This section was probably a main target for quarrying in the latter half of the 19th century, as we shall see below.

Interestingly, Schøning informs us that stone was also extracted in the quarry by 1762. He cannot have meant that it was in regular operation, since there was very little use of the stone by then, as judged by relevant building activities known in the Trondheim area. Rather, he likely implies that occasional, smaller campaigns were carried out, whenever decorative stone was needed. It is, for example, probable that the stone was used to build the finest soapstone portal (around 1740) at the Kristiansten fortress in Trondheim (begun in the 17th century). This work was carried out by master mason Rasmus Banck, who also rebuilt St. Mary's church in the same period, likely with some use of Trondheim soapstone (Lysaker 1998).

And Schøning has more information, this time in his travel notes from the 1770s, when stone was still being extracted in the quarry, now for, among other features, the fine staircase at the royal residence in Trondheim, Stiftsgården (Schøning 1979b:7):

> *Further up, above the place where stone is now extracted, there has formerly been a large quarry, which now appears to be covered by scree (Our translation).*

The 'large quarry' may be the same as 'the room' that Schøning mentions in 1762, but now hardly accessible, so that quarrying had to take place 'below'. It is difficult to understand exactly where this is; it might have been a part of the quarry that later (in the 19th century) would be covered by spoil.

Although we have no sources, it is not unlikely that minor extraction campaigns were also undertaken to provide stone for the King in Copenhagen. The second half of the 18th century was the dawn of the modern Norwegian stone industry, initiated by the Danish king in his appetite for Norwegian marble. But soapstone was also shipped to Denmark, e.g. from the Øysand quarries (Schøning 1979a:201), though it is unknown where the stone was actually used.

Trondheim had seen significant growth in economy and population through the 18th century, and in 1814 Norway obtained independence from Denmark. This initiated discussions about restoring Nidaros Cathedral, now half-ruined, but still the greatest symbol of Norwegian independence and history, with the 'glorious' Middle Ages a reference for new nation-building, art and architecture in the era of Romanticism. Similar trends were seen across Europe. Thus, after 50 years of investigation and heated debate, restoration and reconstruction of the cathedral begun in 1869 (Fischer 1965; Lysaker 1973). It lasted for more than a century, and the workshop established is still active in conservation and maintenance, as one of the largest in Europe. It is known as the Restoration Workshop of Nidaros Cathedral (abbreviated NDR in Norwegian).

Bakkaunet was one of the first quarries that were used for the restoration – a work that has involved deliveries from as much as 70 quarries across the country and to some extent abroad.

***Figure 10.*** *Art historian Brage Irgens Larsen pointing out the Bakkaunet quarry prior to the last modern development in the quarry. (Photo: Adresseavisen, 4. March 1978).*

Helland, as already mentioned above, was very interested in the restoration, and he has given an intriguing description of Bakkaunet in his book on Norwegian slate and soapstone (*Tagskifere, heller og vekstene*) from 1893 (p. 174):

> *The old quarries at Bakkaunet have been reopened for the restoration of the cathedral, but since the stone has to be extracted by mining [NO: gruvedrift] and since economy did not allow for secure operation, work in modern times has been restricted to taking leftover stone and now operations have ceased. The stone is fine and blue and very suitable for decoration.(Our translation).*

Coupled with the previously mentioned sketch in Helland's book (Figure 7), which shows three adits, there can thus be very little doubt that underground quarrying took place in the Middle Ages, indeed. The question is how big such operations really were.

As Helland indicates, stone extraction for the restoration was not very extensive. On the basis of sources in the archives of NDR (account book of accountant Lundemo), we know that 460 $m^3$ of usable stone was delivered from the quarry, with a first extraction phase between c. 1870 and 1880, and the last one between 1892 and 1897 (cf. Storemyr 1997:appendix 2). Helland, writing around 1890, could, of course, not know that a serious attempt at larger-scale quarrying took place in the mid-1890s, but was abandoned by 1897 (cf. diaries of the architects in charge of the restoration, in NDR's archive; see also Storemyr 2015a:286–289). The ultimate reason for the failure was probably not related to economy, but to quarrying techniques: At the turn of the century, the quarrymen of the restoration workshop used standard contemporary methods (drilling, wedging and blasting with black powder), which, due to the uneven rock properties, were less suitable for quarrying at Bakkaunet. They needed much more homogeneous soapstone deposits for efficient extraction of large blocks, and they found such a deposit at Bjørnå by Mosjøen in Nordland County, 400 km north of Trondheim. This quarry became the key provider for the restoration over the next 60 years (Storemyr 2015a:315–323).

Recalling our interpretation of extraction at Bakkaunet in the Middle Ages, i.e. the trouble in establishing regular platforms for efficient quarrying, it is as if history repeats in the late 19th century. However, in the Middle Ages the quarrymen could not turn to distant deposits; they had no other option than working the Bakkaunet quarry, in addition to the Øysand quarries (where the restoration

workshop had exactly the same problems as at Bakkaunet in the late 19th century, cf. Storemyr et al. 2002; Storemyr 2015a:284–287). Thus, we can conclude that the deposit must have been difficult to work, indeed. The question is whether it was like this in the underground parts of the quarry as well. Open-cast operations may have been abandoned both as a result of diminishing 'outdoor' volumes and the quality of the rock.

## Spoil heaps and volumes extracted

If the Restoration Workshop had wanted to continue working the quarry beyond 1897 they probably would have had to reopen the underground adits and to resume the medieval method of manual channeling by pickaxes in order to produce suitable blocks for the restoration. This was out of the question back then, but the descision to abandon the quarry may also have been made against a general backdrop of residential areas expanding towards the quarry. According to historic maps, plans and photos (especially historic aerial photos in www.norgeibilder.no, from 1937 on), one of Trondheim's new 'building belts' was approaching the lower spoil heaps already by 1909, with the street Veimester Kroghs Gate winding its way literally within the quarry by 1932 at the latest (Bratberg 1996:68–69) (Figure 11 and Figure 12).

Prior to the 1980s, it was the spoil heaps that were regarded good building ground. By 1930 houses had been built on the two most substantial heaps in front of the quarry (A and B), with another house added a little later on a heap closer to the old extraction areas (C) (Figure 13). The latter house was built in the functionalistic style of the time and was, sadly, demolished when building the last residential block by 2005. Thus, heap C also vanished.

Clearly, road and house building required much levelling of the old spoil heaps, and currently, though also slightly levelled, heap A and B are the only ones relatively intact. They are substantial heaps, each about 40 m across and on average (according to detailed maps) some three m thick at the most. If we assume regularly sloping surfaces around the thickest point, this implies a volume of about 5000 $m^3$. Heap C adds another 2500 $m^3$. Then there is all the levelled spoil that presumably will equal the volume of the recognisable heaps. Thus, we end up with a total amount of spoil on the order of 15,000 cubic $m^3$.

Using this amount of spoil as a basis, it should be possible to roughly estimate the amount of sound stone extracted from the quarry and delivered for building purposes. The spoil will have a density of 1500–2000 kg/$m^3$, as opposed to bedrock soapstone with a density of about 2900 kg/$m^3$ (cf. http://www.simetric.co.uk/si_materials.htm).This implies that the volume of the stone heaps corresponds to a volume of soapstone bedrock of about 7–10,000 $m^3$. Of course, there will also be other stone, earth and whatever in the spoil heaps; thus, for the sake of simplicity, let's use 10,000 $m^3$ as a measure of the volume of solid bedrock that ended as waste.

Extracting stone with manual methods, as done in the Middle Ages, usually produces less spoil than in modern quarry operations, where the amount of waste regularly exceeds 90%. There are no known studies of the spoil rate in medieval building stone quarries, but if we use impressions from a range of quarries visited and studied, we can speculate that at least 50% of the stone extracted ended up as spoil in the Bakkaunet quarry, but probably not more than 80%. This implies that 3–10,000 $m^3$ of the extracted volume would have been useful for building purposes; let us use 7000 $m^3$ as a reasonable approximation. This is about half the volume of usable *freestone* that was delivered from all quarries to Nidaros Cathedral during the restoration period (1869–today). The largest quarry at Bjørnå in Nordland county provided 7500 $m^3$ alone (Storemyr 1997:appendix 2, based on primary sources in the NDR archive). More than half of the cathedral was reconstructed, which implies that


**Figure 11.** *Map of Bakkaunet quarry prior to the development into a residential area, by 1909, with the extent of the quarry indicated. (Source: www.strindahistorielag.no/Wikibilder/Lademoen%201909-red.pdf). Inserted: Photo of the quarry's spoil heaps and access road, looking north, shortly after 1900. (Source: www.strindahistorielag.no/wiki/index.php?title=Fil:M_Bakkeaunet_mot_Lade.jpg). Black lines indicating the view shown in the photo.*

some 25,000 m$^3$ of freestone would have been needed to build the whole cathedral in the Middle Ages.

But not all the stone from Bakkaunet ended up at the cathedral in the Middle Ages. We have to substract deliveries to other buildings in the Middle Ages, as well as the minor amount that was extracted in the post-reformation period. Thus, it is likely that a volume in the order of 5–6000 m$^3$ found its way to the cathedral. This would again imply that Bakkaunet provided about a fourth of the volume of freestone to the cathedral in the Middle Ages. This seems reasonable, given that the Øysand quarries, the other major provider, are bigger than Bakkaunet. In addition, we have to


**Figure 12.** *Early developments into a residential area at Bakkaunet. Note that walls/fences have been constructed below the old spoil heaps of the quarry to protect the new houses (right part of the image). (Post card : C.. A. Erichs 1915).*

consider some deliveries from the lost quarries at Dyrborg in Trondheim (see above).

Turning to the total volume of stone extracted at Bakkaunet in the Middle Ages, i.e. usable stone plus spoil, the estimates above suggest about 15–20,000 $m^3$. Let us be conservative and assume 15,000 $m^3$. It is difficult to estimate the proportion extracted in the known open-cast section, which would have measured about 3000 $m^2$. In theory, it is possible that there was a substantial hill of soapstone in the small valley before quarrying commenced. Such hills or knolls of ice-scoured soapstone deposits are not uncommon in Norway (see e.g. Storemyr 2015a:337–344), but given the general topography and geology it is less likely that a hypothetical knoll of soft soapstone would have survived erosion by the Ice Age glaciers at Bakkaunet. It is more probable that the sopstone deposit cropped out as a narrow band along the foot of the hill and that most of this area was 'peeled off' by open-cast operations. If, on average, the upper one to two m of the area (3000 $m^2$) was removed, the open-cast quarry operations would have produced, say, 5000 $m^3$ of usable stone and spoil. Thus, it may very well be that as much as two thirds of the stone volume was extracted in the underground sections of the quarry in the Middle Ages, i.e. up to 10,000 $m^3$.

All these estimates cannot, of course, be correct. There are way too many uncertainties preventing us from arriving at secure volumes. However, we think they give us *an idea of the order of magnitude*. 10,000 $m^3$ of stone extracted underground is a very large volume. It is a hall 10 m high, 10 m wide and 100 m long. If it is evenly distributed on the three adits mentioned by Helland (1893), it would mean that more than 3000 $m^3$ were extracted in each of them. This is a room 10 m high, 10 m wide and 30 m long (or 5 m x 5 m x 120 m, or 2 m x 2 m x 750 m). Even if only half of the stone was extracted underground, the space developed would still be substantial, and probably larger than known underground quarrying operations in Norway in the Middle Ages, with the bakestone quarries at Ølve/Hatlestrand and the soapstone quarries in Hardanger as the most important ones.

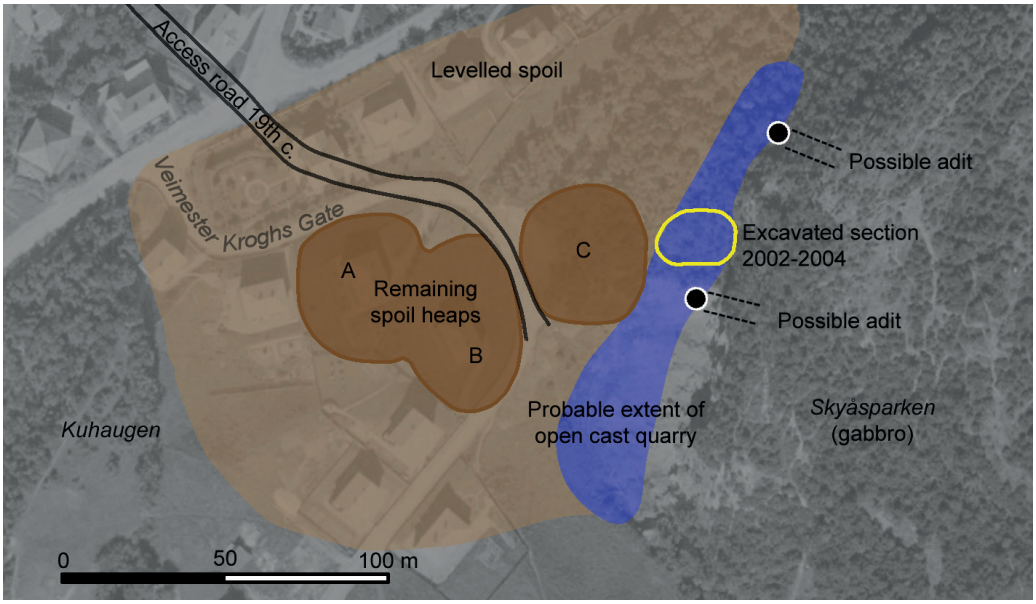



**Figure 13.** *Reconstruction of the Bakkuanet quarry by the beginning of the 20th century, as the development to a residential area started. Reconstructionby Per Storemyr based on all availaible sources mentioned in the text. Location of adits for underground operations are indicative. Base map: Aerial photo from 1937. (Source: www.norgeibilder.no).*

## Underground quarry types

At the moment there is no way that we can find out how the underground operations at Bakkaunet were actually carried out. But we can speculate on the basis of knowledge from other underground quarries. There are few historic underground quarries in Norway. The most substantial ones are located at Ølve and Hatlestrand in Hardanger in Western Norway, where soft chlorite schist bakestone and building stone were extracted from the Middle Ages on (Baug 2015, this vol.; Jansen & Heldal this vol.). This is one of the largest medieval quarry landscapes in Norway, and a substantial part of the stone was quarried in underground galleries several tens of metres long and deep. In each of the largest quarries, e.g. Hedlebergshidlaren and Mannahidlaren, more than 3000 $m^3$ were extracted. However, it is likely that major parts of the quarrying took place after the Middle Ages; thus the extent of underground activities in the Middle Ages is yet poorly known. These are typical gallery quarries, situated at the bottom of cliffs, where extraction followed thick, sub-horizontal layers of homogeneous soft chlorite schist into the bedrock, implying that there was a need to leave substantial pillars in order to prevent the gallery roofs from caving in (Baug 2015, this vol.). Such quarries are widespread across the Mediterranean and Europe, with particularly fine examples known from Bronze Age Egypt (e.g. at Gebel el-Silsila, cf. Harrell & Storemyr 2015) (Figure 14).

The few known underground soapstone vessel quarries in Norway are of an entirely different nature, with the largest ones located at the Folgefonna penninsula, near Kvitno and Måge in Hardanger (Skjølsvold 1961:70–75). These are adit quarries, up to 40–50 m long, but so narrow that they are often difficult to enter. The idea behind excavating such quarries was apparently to follow a good vein of soapstone and there was no need to leave pillars for securing the quarries, even though they occasionally may widen to minor halls. Clearly, they produced much less stone than the gallery quarries at Ølve and Hatlestrand, often only a few tens of $m^3$. Smaller adit quarries are also known at

**Figure 14.** *Typical ancient gallery quarry with pillars supporting the roof from caving in, here from New Kingdom Egypt (Gebel el-Silsila, Upper Egypt, c. 1500 BC). (Photo: T. Heldal).*

Slipsteinsberget in Sparbu (Central Norway) (Østerås 2002, this vol.) and by Piggåsen at Romerike (north of Oslo) (Skjølsvold 1961:71).

The third type of underground soapstone quarries is a variety of the adit quarries, but these are not known in Norway. They are typically developed with an adit for accessing larger volumes of usable stone within the rock, and so the adits widen significantly, often into large halls, with or without pillars. Such quarries are found in Switzerland and North-Italy, where they have a history back to the Roman period (e.g. Rütimeyer 1924; Lhemon & Serneels 2012). But they were typically developed for manual extraction of soapstone for ovens in the early-modern era, for example at Bagnes, close to the famous winter resort Verbier. One of the authors (Storemyr) has visited the quarries at Bagnes, where a narrow adit starts high up in a steep mountain slope for accessing a bigger volume of soapstone within the mountain. The adit widens into irregular and regular, often large halls, several tens of metres from the entrance (Figure 15).

A fourth type of underground quarries is not so relevant in our case; quarries developed in homogeneous limestone and sandstone deposits beneath the ground in flat-lying terrain. In such cases adits or shafts were dug to develop regular halls (with pillars) at a specific level, such as the huge quarries below Paris (Suttel 1993) and Caen (Dungué et al. 2010) in France. However, these quarries were not opened before the late- and post Medieval periods; in the Middle Ages open-cast extraction of building stone was the rule throughout Europe, with quarries typically developed along sloping terrain.

Given that Helland marked three adits on his sketch of Bakkaunet, it is unlikely that this quarry was developed as a gallery quarry. It is also unlikely that only narrow adits were used to carve out stone. If this were the case, the adits would be literally hundreds of metres long – a very inefficient

***Figure 15.*** *Early-modern underground soapstone quarry for production of soapstone ovens at Bagnes by Verbier in the Swiss Alps. One of the halls that can be accessed by a narrow adit, several tens of metres from the surface. (Photo: P. Storemyr).*

way of quarrying large amounts of building stone – and not least of transporting the stone out. Thus, the most likely design is something similar to the quarries at Bagnes in Switzerland: Adits, perhaps also shafts, cut to get access to a larger volume of soapstone, which was extracted in more or less regular halls, with or without pillars.

This, of course, has to remain a hypothesis until future investigations can be carried out. For the underground quarries must still be there, and given that we may possibly have located the wherabouts of two of the openings (see above, Figure 13), future studies ought to first concentrate on these places. If permission is granted, such a project would clearly become extremely expensive due to problems with security (rock fall and the like). Or perhaps it would be possible to explore the underground indirectly by geophysical methods?

## Transportation

From old maps (Figure 11) we can see that the 19th century access road entered the quarry in the traditional manner – between spoil heaps. It wound its way down to the Bakkaunet farm and probably took the straight route into the town, along Nedre Bakklandet, across the bridge Gamle Bybro and west to the cathedral workshop (Figure 4). Although this transport route is not mentioned in any sources, we know that a private carriage driver named Vinnan was responsible for transportation through the 1870s and that it was done by horse carriage in summer and sledge in winter, with sledge slightly more expensive than carriage (Storemyr 2015a:288–289). It is not straightforward to suggest that the same 2.5 km long route was taken in the Middle Ages, since the only bridge across river Nidelva at that time was the so-called Elgeseter Bridge, located to the south of the cathedral. This bridge is mentioned for the first time in 1178 and it is not entirely unlikely that its construction was related to transportation of stone from Bakkaunet, in addition to easing general transport from the south into the town, as well as from Elgeseter monastery (Figure 4). The bridge must have been reconstructed in the second half of the 13th century, as indicated by dendrochronological analyses of the preserved timber structures below modern Elgeseter Bridge (Sylvester & Ødegård 2010; cf. Storemyr 2015a:207–208).

If Elgeseter Bridge were used for stone transport in the Middle Ages, the route from the quarry may have been similar, but slightly longer, than in the 19th century. Or it may have followed a more direct route that descended to the bridge slightly south of Kristiansten fortress (built in the 17th and 18th centuries) and today's Singsaker area. But it is also possible that stone was just ferried across the river by today's bridge Bakke Bru (built in the late 19th century), which would have meant a

slightly shorter transport route. We know that this was a traditional ferry place before the building of the bridge (http://www.strindahistorielag.no/wiki/index.php?title=Bakke_bru), and – given the key location in the town, just by a (now disappeared) medieval tower/fortress (Ekroll 1995) – it is likely that this tradition goes back to the Middle Ages or beyond. Sledges carrying stone, driven by oxen or horse, may simply have been placed on rafts and taken across the river.

Due to the general lack of roads constructed for carriage, which first appeared in the 17th century, in the beginning related to the transportation of silver from the mines at Kongsberg to Drammen (e.g. Sellæg 2002), we have no indications that carriages were used for stone transport in the Norwegian Middle Ages. Thus, sledges probably was the rule, summer and winter (it is well known that sledges were used to transport heavy stones away from agricultural fields in the summertime, even in the 20th century, see e.g. www.digitaltmuseum.no, query: 'slede stein'). Yet, we cannot entirely rule out that a specific road was constructed for carriage transport from the quarry to the cathedral. After all, it would have eased transport significantly.

Quite a few loads must have been driven from the quarry to the cathedral. If we assume that 6000 $m^3$ were taken to the cathedral in the 150-year period from c. 1200 to 1350, this implies an annual output of some 40 $m^3$ (which is about half of the average annual output from Bjørnå, the largest quarry operated during the restoration of the cathedral, cf. above). Assuming activity in the Bakkaunet quarry for some six months each year, and that each load would have weighed about 500 kilos, we end up with about two sledge loads a day (or between 30,000 and 40,000 loads in total).

However, there would have been hectic periods of greatly enhanced activity, both at the building site and in the quarries, and in these periods we have to assume that stone was shuttled to the cathedral much more frequently. We can make comparisons with stone transport during the hectic building and restoration of small stone churches in the late 19th century, such as Orkdal church south of Trondheim, where 6731 loads of stone were needed over a two-year period, i.e. about nine loads per day (Leland 1993:67).

## Ownership, funding and income

One of the possible transport routes would have passed Bakke convent (probably of the Benedictine order), one of the five medieval monasteries in Trondheim, about one km from the quarry. The convent is mentioned by 1150 and was probably founded by the king (Bratberg 1996:72). Bakke became a mighty convent and a very big landowner in central Norway. By 1430 it would also have owned Bakkaunet, since the quarry at that time was part of the farm Skyås, which was in the possession of the convent. However, it is important to note that Skyås, according to archbishop Aslak Bolt's list of possessions, seems to have been 'transferred' (sold?) to Bakke monastery at some time prior to 1430 (Jørgensen 1997:51 A, B; cf. Dybdahl 1996). This could imply that the farm – and the quarry – formerly was in the hands of another owner, perhaps the Archbishopric (established by 1152/53). This would agree with our knowledge about the ownership of land on which all other medieval quarries used for Nidaros Cathedral in the Middle Ages were located: The land was firmly in the hands of the Archbishopric. Yet, the quarries may originally have been on private land, later perhaps confiscated by the King, as part of the state formation efforts commencing in the Viking Age and early Middle Ages (Storemyr 2003, 2009, 2015a).

If this is correct, a reasonable explanation is that the King, and later the Archbishopric, were keen on controlling the quarries, especially the freestone quarries, which were very scarce resources, greatly needed for building the cathedral and other churches; as a means for sustaining both Christianity and the State and thus power. In practice, this would mean that the quarries, by the 12th century onward,

were owned by the Archbishopric, financed by the cathedral fabrica (the fund usually established for cathedral construction and maintenance, cf. Knoop & Jones 1933; Vroom 2010) and operated, probably, by the cathedral workshop (or lodge). It was similar in many parts of Europe (cf. Salzman 1967:119–139; Binding 1993:312). This, of course, implies that there was nothing to earn from the quarrying for the fabrica as regards stone procurement for the cathedral. There were only expenses (e.g. wages for the quarrymen).

However, there is the possibility that the fabrica could earn money on stone extraction at Bakkaunet (and elsewhere) for *other* purposes than building the cathedral. Ashlar, moulding and decoration, even raw blocks, may have been commissioned by patrons and master builders and sold to build other local and regional churches in the Trondheim region. This is a reasonable interpretation, given that stone from the cathedral quarries were used in many of the local and regional churches (Storemyr 2003, 2015a, cf. above). A testimony to the cathedral's influence is the many, specific masons' marks that can be found not only at the cathedral itself, but also at local and regional churches – and, moreover, that the stylistic traits of the cathedral are repeated in the local and regional stone churches (e.g. Ekroll 1997). Yet, we have to recall that it was very much in the interest of the Archbishopric to get the local and regional churches built, especially in the latter half of the 12th century, and so it is not entirely unlikely that they were given rights to extract stone without other compensation than payment of the workforce. Supporting the latter is a paragraph in the Central Norwegian Law (*Frostatingsloven*) on privileges as to stone extraction (Larson 2011:323 [VII, 26] see also Ekroll 1997:276):

> *And if stone (or the sort) that is needed for a church is found on any man's land, a man may break [quarry] what is needed; but it is more proper to ask (permission), though the owner has no right to refuse.*

Though *Frostatingsloven* was written in the middle of the 13th century, it is likely that it reflects common practice also earlier. The paragraph is probably less democratic than it looks; it may simply have given the elite, i.e. those that were responsible for building costly stone buildings (king, church, monasteries, and aristocracy) access to any useful deposit of stone, wherever it was located. But the question is, of course, whether an already active quarry, such as Bakkaunet, was looked upon in a similar way. We know of no historic sources to inform us in this matter.

As we have seen above, it is, in theory, possible that the nearby Bakke convent owned the Bakkaunet quarry from the 12th century on. If so, it may have increased its wealth by selling stone or, more likely, renting the quarry to the cathedral fabrica. The latter is the more probable option because the local cathedral workshop must have possessed superior skills to extract stone. In other words: it may not have been easy for a nunnery to employ quarrymen to do the same – and then sell off stone to the cathedral. Also, cathedrals renting quarries was a rather common practice on the British Isles (and elsewhere), whether the owner was a monastery or a private landlord (Salzman 1967:119–139). However, monasteries could, in fact, also *sell* stone to building projects, whether to cathedrals or secular constructions (Knoop & Jones 1933:10). Such a situation may, interestingly, have occurred in Norway in the 12th and 13th centuries, at the Cistercian Lysekloster Abbey, which may have sold soapstone from its own quarry to building construction in Bergen (Hommedal this vol.).

Anyway, the procurement of stone to build cathedrals and churches in the Norwegian Middle Ages was in all likelihood not undertaken by private companies, controlled and run by a private quarry master. Even the procurement of utilitarian stone for true commercial markets (like grinding stone and bakestone), was basically controlled by elite institutions, such as bishoprics, monasteries or very rich landowners (see especially Baug 2015, this vol.). The building stone market in Norway

probably was too small for private enterprises to get a foothold, which is, presumably, a different situation from large parts of mainland Europe and the British Isles, where commercialisation of building stone procurement started in the high – late Middle Ages. By then, patrons and builders could buy standard moulding and tracery (or other objects) directly from the biggest quarries, like Caen in France and many quarries in England, e.g. Purbeck in Dorset (Salzman 1967:119–139).

## Who worked in the Bakkaunet quarry?

There is too little space available to discuss all the possible modes of organisation of the Bakkaunet quarry, drawing e.g. from what we know from English medieval sources. As is very well known, there are hardly any preserved, written sources on stone extraction in the Norwegian Middle Ages. Yet, it seems clear that building in central Norway was heavily influenced by English models – and craftsmen, for instance from York (Syrstad 2001) – and so we have to assume that also stone procurement, at least to some extent, followed English patterns. Bakkaunet and other Norwegian quarries were usually smaller than many of their English counterparts, but, as we have seen, we can use the organised way that open-cast operations in this quarry (and at Øysand) was carried out as an indication of skills that went far beyond traditional stone procurement in the region – and also the fact that underground operations were initiated.

Much of what has been written on stone delivery to church building in Norway has focused on a paragraph in the Frostatingsloven, which imposed free farmers and farmers that rented land (*leilendinger*) to deliver stone to the building of county churches (*fylkeskirker*). There is, in other words, an element of forced labour in the paragraph, but it is not unlikely that this relates to the delivery of simple rubble stone (not freestone), from which many of the county churches are built (cf. Storemyr 2015a:19–23). But there is also another intriguing note, often overlooked, in King Sverri's Saga on quarry work, from the civil war period, about 1189–1190. King Sverri talks to Archbishop Eirik Ivarsson, his enemy (Sephton 1899:145 [chapter 117]):

> *I should think it more righteous before God if the Archbishop had no Guardsmen beyond what is lawful, for no one will plunder him or the church property, and if he used the cost to set men to the quarries, to transport stone, to do masons' work, so as to advance the building of the minster, for which preparations have already been made.*

A reasonable interpretation of this statement, which refers to one or several quarries in the Trondheim region, is that quarry and transportation work aimed at providing freestone for the cathedral was indeed paid work. We can compare this with the famous York Fabric Rolls, related to the building of York Minster, from the 14th century on, with their detailed accounts of all elements of quarry operations; from rent of quarries, payment of quarrymen to repair of stone transport routes (for a overview, see Moorhouse 2007). From other English sources we get the impression that quarrymen could have a diverse background, sometimes unskilled (but surely with often great experience), sometimes expert stone masons temporarily extracting stone, sometimes specialist quarriers, the latter of which implies that they were regarded as craftsmen, albeit at the lower end of the scale, and thus they were free to climb the career-ladder (Salzman 1967:126; Knoop & Jones 1933:75–78; see also Binding 1993:312–313 for the situation in Central Europe, where specialist quarriers were often called *Steinbrecher*).

Importantly, many quarries became nurseries (places of recruitment) for stone masons that finally ended up as stone carvers at cathedrals and other stone building works (Knoop & Jones 1933:75–78).

This is, in fact, a very similar situation to what happened in central Norway when many old and new quarries were (re)opened as the major restoration and reconstruction works at Nidaros Cathedral took place from the late 19th century on: Local guys looking for work often started their careers to become specialist stone masons and stone carvers as unskilled quarry workers. They eventually had to finish more or less formal education as masons (Storemyr 2015a:259ff).

Surely, we cannot directly transfer such accounts to the Bakkaunet quarry in the Middle Ages. In particular, it is often difficult to interpret who were really involved in medieval quarry work since there were so many different types of quarries that provided diverse types of stone (from rubble and rag to freestone) – all of which required different types of craftsmanship and skill. Also, many quarries in England and elsewhere in Europe provided finished and half-finished products, like standard mouldings and tracery, from the high – late Middle Ages onward, as we have seen above. This implies that highly specialised stone carvers were active in the quarries themselves, and not just at the building sites. We have found half-finished ashlars at Øysand, (Storemyr et al. 2010), but never finished moulding or tracery in Norwegian freestone quarries. Given the limited archaeological excavations that have been carried out, this certainly does not mean that finishing never happened.

In conclusion, given that Bakkaunet was a valuable freestone quarry, we believe that a range of workers with different skills were active in the quarry in the Middle Ages; from specialist (perhaps also foreign) quarriers and perhaps a few stone masons, to local lads looking for employment, some of whom may eventually have ended up at the cathedral workshop as specialist stone carvers. In addition, the operations must have involved a range of workers responsible for everything from carrying stone to preparing food, as well as an expert smith to operate the smithy.

This said, we understand that running a big quarry was not very different from running the complex construction of a major building, like Nidaros Cathedral. Many types of skills were needed – and the workforce had to be supervised in one way or another. Supervision, including anything from planning stone extraction to paying the workforce, is in itself a field of study, but in substantial English and European quarries it was done by a quarry master, just as it had been done in the Roman world – and thousands of years ago in Ancient Egypt (Storemyr 2015a).

## Concluding remarks

Building Nidaros Cathedral was based on very scarce freestone resources, as opposed to England and much of Europe with their big, homogeneous limestone and sandstone deposits. But, as we have seen, there are strong indications that the medieval quarry masters and quarrymen were experienced enough to embark on underground quarrying in order to solve the stone delivery problems. This, suggested, development at Bakkaunet to become a key provider of soapstone for a full-fledged Gothic cathedral in the 13th century can be better understood when also including other stone resources that were needed, in particular marble.

Roughly at the same time as Bakkaunet may have developed to the largest contemporary Norwegian underground quarry, delivery of marble for columns commenced – from a quarry on the small island of Allmenningen, off the coast at Fosen, some 140 km north of Trondheim (Figure 1 and 16). The use of marble for free-standing columns started in the late 12th century and was in all likelihood directly inspired by the contemporary English developments, which resulted in most English cathedrals being equipped with columns of Purbeck marble or its substitutes, such as Frosterly marble (Storemyr 2015b:90–101; Blair 1991). As far as we know, Nidaros Cathedral is the only other building in Europe that became part of the same fashion or tradition. One the one hand, this shows how English developments influenced building in Trondheim, on the other hand it underpins the

***Figure 16.*** *Part of the substantial medieval marble quarry at the island of Allmenningen off the coast of Central Norway, some 140 km north of Trondheim. This quarry produced about 10.000 marble shafts in the Middle Ages. Wedge holes for splitting blocks can be seen on the picture. (Photo: P. Storemyr).*

will, knowledge – and economy – for exploration and engineering.

For the Allmenningen quarry did not provide a couple of columns only, but on the order of 10,000 shafts, up to six m long, mainly in the 13th century. Situated close to the coastal shipping route, it would not have been awfully difficult to develop the quarry, yet a costly infrastructure would have been needed for extraction and shipping, as well as for carving and polishing (Storemyr 2015a:219–223; Storemyr 2015b).

Development of a major underground soapstone quarry in the same period fits, we believe, very well with the marble exploitation. Though both rather short-lived, these were major industries that developed in a crucial period in Norwegian history. They were, after all, meant for the largest cathedral in the North, comparable to many of its sisters in England and on the Continent. On this backdrop, it is very sad that the open-cast parts of Bakkaunet quarry has been successively destroyed, the last phase of which happened just a decade ago – with the blessing of the cultural heritage authorities. Thus, we hope that this paper may also be a contribution to future preservation of medieval and other old quarries throughout Norway. Old quarries are key resources for understanding building practices in the Middle Ages.

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# Soapstone in the North. Quarries, Products and People. 7000 BC – AD 1700

Soapstone is a remarkable rock. While it is soft and very workable, it is also durable and heat-resistant, and with a high heat-storage capacity. These properties have been recognised and valued around the world since prehistoric times, and soapstone has been used for a multitude of purposes, ranging from everyday household utensils to prestigious monuments and buildings. This book addresses soapstone use in Norway and the North Atlantic region, including Greenland. Although the majority of the papers deal with the Iron Age and Middle Ages, the book spans the Mesolithic to the early modern era. It deals with themes related to quarries, products and associated people and institutions in a broad context. Recent years have seen a revival of basic archaeological and geological research into the procurement and use of stone resources. With its authors drawn from the fields of archaeology, geosciences and traditional crafts, the anthology reflects cross-disciplinary work born of this revival.

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