A local millstone quarry at Nord-Talgje in Southwest Norway: mapping, interpretation and age estimate

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Introduction

This paper is a contribution to the project The Norwegian Millstone Landscape, an interdisciplinary project conducted by the Geological Survey of Norway (NGU). The project evolved due to a strong wish to study the complex groups of Norwegian millstone quarries (Fig. 1), as these quarries vary in size and time depth, and thus pose significant challenges with regard to cultural heritage management (Baug 2002, Heldal & Bloxam 2007, Grenne et al. 2008, Heldal & Meyer 2011).

At present, “industrial-scale” millstone production can be dated back to at least the 8th century at Hyllestad in Norway (manually operated querns) and continued into the early 20th century (water-driven mills) i.e. in Selbu (Grenne et al. 2008).

One of the mica schist quarries that were selected for more detailed investigations is situated on the island of Nord-Talgje in the Boknafjord area in Southwestern Norway (Fig. 1 and 2). This quarry belongs to a group of small quarries with local/regional significance rather than national, i.e. the production was most likely consumed in neighbouring areas. The size, availability and exposure of the quarry made it suitable for such detailed studies (Fig. 3).

A millstone quarry of local or regional significance, on the island of Nord-Talgje in the Boknafjord area in Southwest Norway, has been studied in order to identify different episodes in the history of the quarry. The quarry covers an area of approximately 20,600 m², situated in bedrock consisting of garnet-mica schist. Approximately 500 negative imprints from extracted rotary millstones are visible, ranging from manually operated rotary hand quern stones, with diameters of 46–57 cm, to water-driven millstones, with diameters of 58–120 cm. The quarry is topographically divided into five separate fields with two observed extraction techniques: direct carving from bedrock (all fields) and carving from blocks extracted by wedging (one field). Sea-level displacement curves indicate that the lowermost part of the quarry is younger than the 11th century. It is suggested that the different sizes of extracted rotary millstones can be tied to old Norwegian standard length units, in particular the short ell, which was officially in use up to 1541. Together with a lack of historical records of millstone quarrying, the data may suggest that production took place predominantly from the 11th century to the early modern era (prior to the 16th century).

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Nord-Talgje and its quarry landscape

The millstone quarry at the island Nord-Talgje, is situated in the southernmost islands of the Sjernarøyane archipelago. The islands form a circular enclosure with sheltered bays. This group of island is situated in the Bokna fjord area, 30 km north of the city of Stavanger in Norway. The name talgje refers to an Old Norwegian
term that designates the form of the island shaped as an axe with a handle (Rygh 1915:254) (Fig. 2). Another plausible explanation is that talgje is derived from another old word related to stone quarrying with reference to the occurrence of the marble and marble quarries on the island (Særheim 1982, 1998, 2007). Nevertheless, Talgje appears in written sources back to 1288 as a place name for this island.

Nord-Talgje is particularly known for its occurrences of marble and marble quarries, where the most well-known is situated in Søre Rossmorkvågen. This quarry was in use in the period 1898–1960. The many finds of huge marble phallos stones in this archipelago and further south in Jæren most probably originate from either this island or from the island Sør-Talgje further south in the Boknafjord area. The phallos stones range back to Early and/or Late Iron Age (Petersen 1930, Løken 2006, Myhre 2006). These finds witnesses the earliest production and use of the rocks at Nord-Talgje. However, the traces of this “industry” are in this case overprinted by the modern marble industry. The striking white banks of marble have served as beacons (sailing marks) throughout historical times. However, the nearest sheltered harbours to the millstone quarry are located approximately 2 km further to the west at Søre Rossmorkvågen and in the narrow sound Helgøysund to the east of the quarry.

Previous records and investigations

The millstone quarry at Nord-Talgje has not been published earlier; neither in geological reports nor in the latest comprehensive local historical work by Næss (2006), and no manufactured products have yet been identified in museum collections. Nord-Talgje is neither mentioned in diplomas nor other historical sources prior to 1500. This anonymity may indicate that the quarry might have been in use before written sources were available. Although the quarry might have been known by the local farmers, it was first visited by cultural heritage authorities in 1980 as part of the general cultural heritage registration on the island (Topographical Archive, Museum of Archaeology, University of Stavanger). At that time, the quarry was interpreted as belonging to historical periods (post Reformation). In 1986, the quarry was visited by the geologist Johanne Margrethe Dahl, attached to the Museum of Archaeology in Stavanger (diary notes). She noted the similarities with the shape and sizes of the negative imprints from millstone extraction at Nord-Talgje and the known prehistoric rotary hand quern stones from the Migration Period farm at Ullandhaug near Stavanger. In 2004, the quarry was visited by the marine archaeologist Endre Elvestad (2006), Stavanger museum. He suggested that the quarry could date back to the Medieval Period.

New investigations by the present authors (Prosch-Danielsen & Heldal 2012) resulted in automatic protection by the Norwegian Cultural Heritage Act in 2009.

Geological setting and petrography

Geological mapping of Nord-Talgje and the other islands in Boknafjorden was carried out by Müller & Wurm (1970). These works and others were compiled and a preliminary map of the bedrock geology was published by Tellefsen et al. (1990).

The islands comprise mainly metamorphic rocks of assumed Proterozoic age, belonging to the Boknafjord Nappe. The rocks displayed at Nord-Talgje include gneiss, dolomite marble and mica schist (Fig. 4). The millstone quarry is located in garnet-bearing layers in mica schist along the south coast of the island. The
planar schistosity of the rock, along which the millstone blanks were split, is nearly horizontal and facilitates extraction of millstones in shallow pits spread out over a wide area (Fig. 3 and 5a).

The schist displays a notable stretching lineation on the cleavage surface (Fig. 5b), a feature which makes it rather easy to distinguish from other known quarries in garnet mica schist. The rock surface is naturally divided in blocks by cross-cutting joints, facilitating extraction of squared blocks (Fig. 5a).

In addition to garnet, the major minerals in the schist are muscovite, biotite and quartz (Fig. 5c–d). Small amounts of plagioclase, kyanite, chloritoid, apatite and tourmaline occur. The schist exhibits a distinct banding (cm to dm scale) defined by variations in grain-size and muscovite-biotite ratio, as well as cleavage-parallel quartz veins. The garnets are less than 3 mm in size, most of them between 1 and 2 mm. They are normally anhedral to subhedral, and display a zonation with a “dusty” core (Fig. 5c). The garnets are enveloped by quartz and are apparently well fixed to the matrix, which is an indication of good millstone quality. A second group of garnets are in the range of 0.1–0.3 mm; these do not display zoning, and have a more euhedral shape than the larger ones.

The matrix (predominantly mica and quartz) is fine-grained, and it is not common to find single grains larger than 0.5 mm. Quartz is frequently seen concentrated in thin bands, and displays partly recrystallised mylonitic texture (annealed mylonitic texture) (Fig. 5d) indicating deformational growth of quartz during the formation of the main schistosity.

Extraction techniques
Two different extraction techniques have been recorded in the quarry at Nord-Talgje; carving millstones directly from the bedrock surface, or by using wedges for the primary extraction of blocks or slabs for further preparation.

Most of the extraction at Nord-Talgje involved the first technique (Fig. 6). When the size of the millstone was decided, a circle (perimeter) was drawn from a centre point using a compass with a fixed radius. The next step was to draw a new circle outside the first one. The shallow grooves were widened and deepened by pecking/hewing, resulting in a w-shaped channel around the millstone blank. After removing the ridge in between the grooves, the process was repeated until the channel around the millstone was deep enough (around 15 cm for hand-querns) and wide enough. The channels were always made perpendicular to the schistosity of the rock. The last step in the extraction process involved loosening the freestanding millstone blank by splitting its base from the bedrock by inserting thin wedges until the blank came loose.

This extraction technique left circular, negative imprints in the bedrock surface, side by side, leaving a honeycomb-shaped pattern (Fig. 3). Groups of imprints
often follow natural fractures or fissures in the bedrock surface. This arrangement was efficient and saved time as rock debris and edges between separate millstone extractions easily could be removed. When one layer of millstones had been extracted in an area, the next one could be initiated. The extraction technique is similar to what is described from Hyllestad (Baug 2002) as shallow quarries (Heldal & Meyer 2011).

The second extraction technique involved splitting squared slabs from the bedrock, which thereafter were carved to millstone blanks. The vertical joints in the bedrocks decided the size of the slabs, so that the only operation needed for loosening them was to insert wedges along the cleavage plane until the slab split (Fig. 7). Afterwards, single millstones were marked and prepared from the slabs as described above. Extraction of slabs is only recorded in field B. Marked perimeters are found on three defect slabs and all of them denote water-driven millstones. This technique had several advantages; the millstone could i.e. be prepared at specific work areas. This technique was most likely younger than carving directly from bedrock. Such issues will be addressed below.

Survey methods
The millstone quarry at Nord-Talgje has a modest scale. Located on small crags and rock beds near the seashore, the quarry is exceptionally well exposed and negative millstone imprints are highly visible. With these advantages, we decided to survey the entire quarry using a Leica total station, measuring with a 2–3 cm precision. Defined points were measured by a Leica-GPS, given both Eu.ref.- and ngo.ref.- coordinates. The individual imprints were measured as fixed points (central point used) and later plotted as defined circles on the separate field maps. Other archaeological features were plotted as lines.

The sizes of the individual negative imprints
The size of the extracted millstone was determined by measuring the diameter of the preformed quern as defined by the perimeter (or pass) that the quarrymen had made with a compass. However, these favourable circumstances are only met when the extraction did not succeed and the blanks were left in situ. In some cases, we also find imprints with a central point

Fig. 6. Quarrying by cutting millstones directly from the bedrock. Top: schematic drawing of the process A-E (from Grenne et al. 2008:Fig. 17). Below: photos illustrating different stages. The diameter of the extracted millstone (A and B) was estimated using the diameter between the chisel points on a negative imprint (E). Photos: Lisbeth Prøsch-Danielsen.
encircled by two passes or one or several grooves. Here
the inner circle gives the intended size of the mill-
stone. However, to measure the successfully exploited
querns only the negative imprints are left. Hence, it is
not possible to detect exactly the size of the extracted
blank. To obtain an approximate measure of the size
of the quern, the diameter between the outer limits
of the wedge marks was measured (Fig. 6a–e). A key
issue during the investigation of the quarry was to (if
possible) establish a relative chronology of quarrying,
based on the relationship between the imprints from
extracted millstones (overlapping and other indica-
tions of relative timing of extraction events); is it
possible to find patterns, i.e. variations in size through
time? Thus, a table was made containing infor-
mation about each imprint; field A–E, number, success-
fully extracted or not, preformed (only central point
visible, central point plus perimeter and/or grooves) or
extracted, defect blanks, diameter of negative imprint,
nature of the channels and grooves, etc.

Dating methods

There are several ways of dating a quarry. Besides written
sources, radiocarbon dates of charcoal from a fixed
archaeological context seem to give the most precise
age estimates (Baug 2002, Grenne et al. 2008, Helberg
2010, Belmont 2011, Grenne & Meyer 2012). At Nord-
Talje however, organic material or charcoal particles
are missing, even within the house remains, so dating
has to be based on indirect approximate methods.

The Iron Age is divided according to Sloman (1971):
Pre-Roman Iron Age (500–1 BC), Roman Period (AD
1–400), Migration Period (AD 400–600), Merovingian
Age (AD 600–800) and Viking Age (AD 800–1030).

Shore level displacement curve

A sea-level displacement curve has been constructed
from Tjødå, a small lake situated 6.5 m.a.s.l. on
Kyrkjøy, one of the islands in the Sjernarøy archipelago
(Prøsch-Danielsen 1993). The lake was isolated from
the sea 2935±135 uncal. yrs. BP. This curve gives an
idea of the isostatic rise in the area over the last 3000
uncal. yrs. BP, with an average of 0.22 cm per radio-
carbon year, and allows us to give a maximum age for
the lower seashore parts of the quarry.

Rotary hand querns and water
millstones – relative chronology

The oldest rotary hand querns date back to the Roman
Period in Norway. In Rogaland, the introduction is
dated to AD 80–320 (Prosch-Danielsen & Soltvedt 2011). These querns differ in shape and sizes and were probably locally produced in smaller quarries or, more likely, from a variety of erratic blocks and boulders (Dahl 1986). However, from AD 700, standardised rotary hand querns were available at least in Hyllestad in Western Norway (Baug 2002, 2008). From that time, the querns were cut in quarries comprising soft mica schists with different types of hard minerals (Heldal & Bloxam 2007, Grenne et al. 2008). Water millstones may have been introduced as early as the Late Viking Age and at least around 1100 (Carelli & Kresten 1997, Baug 2002, Helberg 2010). From then and onwards, both quern types were used.

Most of the extracted negative hand quern imprints stand apart in a honeycomb-shaped pattern, and some imprints, particularly in the marginal part of the quarry, are isolated from the others. In addition, some imprints overlap in separate layers along the cleavage plane of the bedrock. This observation is useful for making a relative chronology, as the youngest ones cut into the older ones. It is also a general trend that larger (water-driven) millstones are cut into the smaller (hand-operated) querns. This will be discussed below.

Shift in extraction technique

Detailed mapping of the quarry in Hyllestad since the 1970s has revealed different quarry landscapes, with different quarrying techniques, covering the last 1300 years (Baug 2002, 2008, Heldal & Bloxam 2007, Grenne et al. 2008). In addition, by adding the knowledge acquired from the quarry in Selbu (dating back at least to the 16th century) (Rolseth 1947, Grenne et al. 2008) it is possible to suggest an overall evolution in the quarrying techniques in Norway.

The oldest standardised extraction technique, with carving directly from the bedrock, is recorded in quarries that date back to the Viking Age and Medieval Period, both in Hyllestad (Baug 2002) and in Salten (Helberg 2010). This is the most prominent technique found at the quarry at Nord-Talgje. Although the technique evidently was applied as late as the mid-19th century, coexisting with other techniques, it seems to have been the dominating one before the Reformation (AD 1536) (Grenne et al. 2008).

Splitting of slabs, solely by using wedges, is recorded at the quarry at Nord-Talgje as well as in Saltdal, at Øvre Rønseth in Hyllestad and in Selbu. The technique is interpreted to postdate carving directly from bedrock and predate the more advanced technique combining wedging with blasting. This technique may have been extensively applied already by the 13th century in Saltdal (Grenne et al. this volume). In Selbu, splitting of slabs was in use in the 16th and 17th century, while black powder was introduced in quarrying early in the 18th century (Rolseth 1947, Grenne et al. 2008). In Hyllestad, this technique has been documented from quarries that are assumed were active in the early 18th century (Baug 2002, Heldal & Bloxam 2007).

Old Norwegian length units

The diameters of the negative imprints were measured and compared to the old Norwegian length measurement units used; ålen (ell), fot (foot), tomme (inch) and kvart (quarter). Several national forms existed side by side, with different lengths throughout both prehistoric- and historical time. This was also the case abroad (Table 1).

In the Medieval Period, two types of ells were in use; the above mentioned short ell, measuring 47.4 cm, and the long ell, or stikka, measuring 55.3 cm (Steinnes 1936). One ell then measured 47.4 cm given by the modern form of the international metric system (1959–60), the SI-system (http://no.wikipedia.org/wiki/SI-systemet). Deviations may have existed in the Viking Age. The units were defined in Magnus the Lawmender’s rural law of 1274 (Taranger 1915). The stikka was in use from the late 12th century. In some places in Mid- and Western Norway, they kept the name ell, but there stikka comprised two ells measuring 110.6 cm (Steinnes 1936, see also http://no.wikipedia.org/wiki/Alen).

In Iceland, a parallel to the Norwegian stikka developed in the 13th century, measuring 98.286 cm. That means that the Icelandic ell measured 49.143 cm. Later on, it was defined as 51.208 cm called þumalalin.

The Danish Zealandic ell was introduced in 1541. This ell then measured 63.26 cm. This length unit was used until 1683, when it was replaced by a new system called “the foot system”. From that point on, one Zealandic ell was two feet from Rhineland, equivalent to 62.80 cm. From 1698, it was equivalent to 62.77 cm. At present, one ell measures 60.96 cm.

However, in Selbu in Mid-Norway, the old measurement units were still in use from the 16th century up to the early 20th century (Rolseth 1947), with one stikka or long ell measuring 55.3 cm. Two ells then measured 110.6 cm as in the Medieval Period.
In the Medieval Period, two additional lengths of ells existed; one from Jutland, measuring 57 cm and later on another from the southern part of Jutland, measuring 58–60 cm kept until the 16th and 17th century. These might extend back to the Iron Age (Rasmussen & Stigum 1956:71–75, Rasmussen et al. 1959:441–446, Bjørkvik 1974:455).

### Results

**The millstone quarry**

The millstone quarry at the island of Nord-Talgje covers an area of approximately 20,600 m². The quarry is situated at the southernmost headland called Hildrane, facing the fjord to the south and delimited by a steep cliff to the north. The quarry is spread out in the terrain, mostly due to the great variability of the quality of the bedrock. The lower part of the quarry is no more than 0.94 m above present mean sea level, while the upper part stretches up to 20 m. The highest concentration of extracted millstones is situated in the westernmost part. A small hilltop separates the western part from the more remote eastern part of the quarry. The area has been further divided into five fields (fields A–E) based on differences in topography, the bedrock quality, quarrying techniques and other features related to the quarrying (Fig. 8).

**Field A**

The majority of negative millstone imprints are found in field A (Fig. 9). Both imprints of hand-operated quern stones, as well as water millstones ranging from 58 cm up to 100 cm, are visible. At the lowermost part and close to the shore, the imprints are strongly eroded and nearly blurred.

Only one extraction technique is recorded, carving directly from the bedrock, exploiting layer by layer of mica schist. Field A seems to be one of two core areas for the production of smaller hand querns (48–52 cm, green ones on Fig. 9). Negative imprints are widely distributed, partly scattered, but also concentrated in shallow extraction pits displaying honeycomb-shaped extraction patterns (Fig. 3). This is not the case for the larger, water-driven millstones, which occur more scattered, apparently because they were extracted in pre-existing hand quern quarries. However, there are also examples of hand querns being extracted on top of failed water millstones (Fig. 10), implying that extraction of hand-operated querns and water-driven millstones was in part contemporaneous.

It is a general trend that the imprints from the water-driven millstones measuring 58–60 cm, 80 cm and 100 cm are clustered in separate areas. Another group of water-driven millstones, those that measure 70–75 cm and 90 cm in diameter, seems to be younger than the other extracted millstones. Especially in the inner part of the field, they overlap and penetrate the others. In some cases, at least three levels of millstone extractions have been recorded.

**Field B**

A small cleft, partly filled by rock debris, separates field A from field B eastwards. Judged from their shape and size, some of the blocks may once have been selected as millstone roughouts.

Two extraction techniques are recorded; direct carving from bedrock and carving from slabs released by wedging. Only the smaller, hand-operated querns were carved by using the first technique, with the majority clustered with a diameter around 48–50 cm. Two groups form a honeycomb-shaped pattern. In addition, two larger areas covering 6 x 11 m and 4 x 8 m, have been interpreted as “cleared” areas previously used for making hand querns in honeycomb-shaped

### Table 1. Old Norwegian units of length-measurements based on Steinnes 1936, Rasmussen & Stigum 1956, Rasmussen et al. 1959 and Wikipedia (http://no.wikipedia.org/wiki/Alen).

<table>
<thead>
<tr>
<th>Def. year AD and terms</th>
<th>1274 Norwegian short ell</th>
<th>1274 Norwegian long ell or stikka</th>
<th>1100–1200 Icelandic ell</th>
<th>1541 Danish Zealandic ell</th>
<th>1683 The foot system of Ole Rømer</th>
<th>1824 Revised</th>
<th>1875 SI-system introduced</th>
<th>1959–60 International SI-system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alen (ell) in cm</td>
<td>47.4</td>
<td>55.3</td>
<td>49.14 or ƥumalalin 51.21</td>
<td>63.26</td>
<td>62.94</td>
<td>62.75</td>
<td>62.74</td>
<td>60.96</td>
</tr>
<tr>
<td>Fot (foot) in cm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>31.63</td>
<td>31.47</td>
<td>31.375</td>
<td>31.37</td>
<td>30.48</td>
</tr>
</tbody>
</table>
Fig. 8. Overview map of the quarry at Nord-Talgje separated into five different fields A-E. Contour lines = 1 m. Black dots = separate negative imprints from millstone extraction. In field B; dotted areas mark ‘cleared areas’ previously used for making hand querns in honeycomb-shaped pattern. In field E; blue squares mark house remains and a built up platform. The dotted area is a pathway. Drawing: Even Bjørdal 2011.
patterns. This interpretation is based on the fact that two defect imprints of hand querns have been recovered within the squares. There are no visible imprints of water-driven millstones carved directly from the bedrock.

Three slabs found in the area demonstrate the extraction of water millstones with a diameter measuring 110 cm, significantly larger than the imprints found in field A (Fig. 7). Their size corresponds to two Norwegian long ells or stikka. Several vertical rock walls display either marks from wedges driven into the rock along the cleavage plane, or more closely spaced and smaller holes made by a pickaxe, which was struck repeatedly along the cleavage plane. In both cases, the intention was to split slabs loose from the bedrock before shaping the millstones (Fig. 7). The variations in field B may represent different stages and changes in production techniques through time, where the cutting of hand querns directly from the bedrock is most probably the oldest one.
Northwards, at the rear edge of the field, some blocks have been arranged in steps, interpreted as a stairway leading directly up to a work area and a pathway.

Fields C and D
Fields C and D are situated to the east and on the periphery in relation to the core areas. The extensions of the fields are limited by the topography (steep cliffs to the north and the seashore to the south) and the quality of the rock. Field C is located on top of a rock outcrop, while field D constitutes the rim of the quarry, situated just inside some skerries, Småskjera. Altogether, a total of 27 negative imprints have been recorded. All represent the smaller hand-operated querns. The technique used is solely carving directly from bedrock. Both fields are interpreted as trial extraction fields to test the qualities of the mica schist. The imprints are rough and eroded. Here we also find the best records of preformed querns with a central point encircled by two passes (perimeters).

Field E
Field E is wedged in between field B and a wall of steeper cliffs to the north. Several man-made structures appear in this part of the quarry, probably related to the quarry’s infrastructure.

The most prominent feature is a pathway that winds down the hillside from Kyrkjehaugen. Part of this is a built up rubblework, otherwise it follows the natural terrain. It is still used as a tractor path by the local farmer. In the lowermost curve, the cliffs form an overhanging rock, were stones have been built up. This may have served as a shelter for the craftsmen or perhaps as a tool shed. The pathway ends where the terrain levels out. Just in front of this, and hardly visible, we have recorded a built-up platform. It is suggested that this platform may have served as a work area where the querns have been finished.

Some preformed querns are recorded along the seaside of the pathway. This also links the pathway to the extraction of quern stones.

Two small house remains in close proximity to each other, have been found on a small ledge/shelf approximately 30 meters west of the working platform. The houses measure 3 x 4 m and 3 x 4.5 m, with the end walls only 0.5 m apart. A low row of blocks form the fundament for the buildings (syllmur), but these have partly slid off. Unfortunately, no cultural layer has been built up as the houses partly rest directly on to the bedrock surface. Some test-pits have been made to see if charcoal for radiocarbon dating were available, without any success inside the house walls. The house remains are covered by grass and partly by a dense juniper shrub. The house remains are most likely associated with the infrastructure of the quarry, and may have served as a shelter for the craftsmen or perhaps as a tool shed or smithy.

The number of hand querns and water millstones
In the quarry, rotary querns have been extracted that vary in diameters between 46 cm and up to 110 cm. In

<table>
<thead>
<tr>
<th>Type of quern stone</th>
<th>Successful imprints (No.)</th>
<th>Unsuccessful imprints: preformed (p) and defect (d) roughouts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand querns (46 to 56 cm)</td>
<td>443</td>
<td>28p + 15d = 43</td>
</tr>
<tr>
<td>Water driven millstones (58 to 110 cm)</td>
<td>53</td>
<td>8p + 9d = 17</td>
</tr>
<tr>
<td>Total</td>
<td>Σ 496</td>
<td>Σ 36p + 24d = 60</td>
</tr>
</tbody>
</table>
this work, we have put the dividing line between hand querns and water-driven millstones at 57 cm. However, this can be disputed. An ongoing study of the collection of querns at the archaeological museums in Norway, has showed that hand querns and water-driven millstones can overlap in diameter in the interval between 50–60 cm (Gurli Meyer, pers.comm.).

In our study, the majority are hand-operated querns, with a diameter of 48–50 cm. In Table 2, the distribution between negative imprints of quern types, based on both successful and defective extractions, is given. Totally, 443 hand querns and 53 water-driven millstones extracted by direct carving from the bedrock are recorded.

The cleared squares in field B, covering approximately 100 m², may have provided space for some additional hand quern stones, theoretically at least 260 if the querns were extracted in a honeycomb-shaped pattern. The total number of hand quern stones could then be increased to ca. 700. This would give a production of 350 pairs of hand querns comprising an upper and a lower stone.

Nearly all imprints from water-driven millstones extracted by direct carving from bedrock have been recorded in field A. Only one exception is recorded in field B, in layer two in one of the cleared squares. In addition, three imprints of preformed water millstones (diameter 110 cm) have been recorded on slabs in field B. When considering all the vertical bedrock sections with wedge marks, it is obvious that the extraction of water millstones from slabs most likely had a greater extent. This gives a total of 53 visible extractions of water millstones, all from field A. The number of extractions from slabs is unknown.

The diameter of the negative imprints and the chronology within the quarry

In Fig. 8, only the quern stones extracted by direct carving from bedrock are included. The overview picture shows that hand querns have been extracted from all fields A–E, while the water millstones only have been extracted from field A using this extraction technique.

The rotary hand querns

This group varies in diameter but the majority clusters around 48 cm and 50 cm in diameter. This corresponds fairly well with the Norwegian short ell, measuring 47.4 cm in the time interval 800 to 1541. The variation in size seems to be the consequence of uncertainties when measuring the chisel-marks, their width, angle and exposure of erosion rather than the result of real size variations. It is also obvious that many of the imprints from hand querns belonging to the trial field D, with diameters from 50 cm and up to 52 cm. This may be due to the use of rougher tools or erosion later on, complicating the evaluation of the original chisel marks. There is also the possibility that the Icelandic ell, measuring 49.143 cm might have been in use paralleled to the Norwegian ell around 1100–1200 (Steinnes 1936, see also http://no.wikipedia.org/wiki/Alen).

A small group of negative imprints (13) measures 54 cm or 55–56 cm in diameter. These are mainly found in field B close to the seashore. The imprints are highly eroded and thus there are some doubts regarding the accuracy of the measurements. However, one may speculate whether these display the use of the Norwegian long ell, or stikka, measuring 55.3 cm.

The water-driven millstones

The water-driven millstones in field A (Fig. 9) vary from 58 cm up to 100 cm in diameter, where the majority of clusters are around 60 cm, 70–75 cm and 90 cm. Only a few have a diameter of 80 cm and 100 cm.

It is noticeable that all millstones measuring 60 cm in diameter have been extracted in the same rock layer as the smaller hand querns, occurring either separated from the hand querns or tangential to such imprints. The majority of the millstones measuring 70–75 cm in diameter also occur in separate areas, but a few have been extracted on top of hand querns. In a couple of cases where the extraction did not succeed, new hand querns were extracted from the bedrock within the larger enclosure. This situation implies that hand querns and water millstones with a diameter of 60 cm and 70–75 cm were extracted contemporaneously for a period. A measured diameter of 60 cm is equivalent to a Norwegian short ell plus a quarter (kvartstikk) (47.4 cm + 11.85 cm) = 59.25 cm, and 70 cm is equivalent to a Norwegian long ell plus a quarter (55.3 cm +13.83 cm) = 69.13 cm. Both units were in use prior to 1541.

Five imprints of water millstones with a diameter of 80 cm have been recorded. As for the smaller ones, evidence of simultaneous extraction with hand querns are found, and it is likely to assume that they are from the same period. The 80 cm millstones could also have been standardised products, i.e. 5½ Norwegian long ell (spanstikk) was used = 79.08 cm.

The water millstones measuring 100 cm correspond to the Icelandic stikka (equivalent to two ells = 98.286
cm. This measure was in use around 1200. The three 100 cm millstones were all found separately, so a dating relative to other millstone formats is impossible.

When it comes to the group (13) with a diameter of 90 cm, they most often penetrate through both hand querns and other water-driven millstones. This may imply that these millstones are younger. This size seems to be quite functional and recorded in many other quarries in Norway.

Water-driven millstones extracted from slabs are only recorded in field B. Normally, no imprints are left when using this technique. However, three slabs embodying preformed water millstones are found. The diameters of the perimeters are all 110 cm. This may give us an indication of the sizes of those millstones that have been removed from the quarry. The measured diameter corresponds to two Norwegian long ells.

**Discussion**

**The quarry in time and space**

The sea-level curve constructed from the area (Prøsch-Danielsen 1993) reveals a mean yearly isostatic rise of about 0.22 cm for the last 3000 uncal. yrs. BP. However, a higher rate is expected in the oldest part, steadily slowing down to present time. The lower parts of the quarry are situated only 0.94 m above present sea level. This means that these parts were situated below sea level before ca. 1570. Bringing in a calculated ±1 m for high and low tide, this means that the lower parts of the quarry cannot be older than 1057. There is no reason to assume that the craftsmen could not have quarried in the low-tidal zone.

The extraction techniques display two main methods; carving directly from bedrock and from pre-loosened slabs. Based on evidence in other millstone quarry areas, we suggest that the first method represents the oldest, recorded in Hyllestad from 715–890 and onwards through the Medieval Period (Baug 2002). Carving from pre-split slabs has been recorded from the 13th century in Saltdal (Grene et al. this volume).

Although the study of measurements did not give conclusive answers to the age of extraction, we find it likely that they indicate periods of quarrying. The diameter of the hand querns fall into two major groups: those measuring 48–50 cm (≈ Norwegian short ell = 47.4 cm) and those measuring 54–56 cm (≈ Norwegian long ell = 55.3 cm). These diameters correspond fairly well with the Norwegian length measurement units defined by Magnus the Lawmender’s rural law of 1274. There is direct written evidence from 1323 that quern stones were measured using defined units of ell (http://www.dokpro.uio.no/perl/middelalder/regest_vise_tekst.pl?b=3623&s=n&str=). Although these measurements were officially discontinued in 1541 (see Table 1), there are several indications that the ell, measuring 47.4 cm, was still in use at least until 1737 in the Boknafjord area (http://home.online.no/~akvitrud/1700-1749-skjoter.htm and http://home.online.no/~akvitrud/1600-1699-skjoter.htm).

The extraction of water-driven millstones with diameters < 90 cm might have been contemporary with some hand quern extraction. This is also the situation for the three separate millstones measuring 100 cm in diameter. However, the 100 cm millstones do not fit into the Norwegian length measurement units, but might encompass the Icelandic stikka from the 12–13th century. The millstones with a diameter of 90 cm seem to be younger than the others, as they penetrate through both the imprints left from the hand querns and other sized water-driven millstones. This diameter does not fit into any of the Norwegian measurement units, possibly indicating the introduction of measurements more related to the function of the millstones rather than standard measurements.

The recorded millstones extracted from pre-split slabs all measure 110 cm. This measurement corresponds to twice the Norwegian long ell and would thus indicate that they were extracted in the late Medieval Period or later. The measurement of 110 cm does not fit into the Norwegian length measurement units as defined from 1541 and onwards. However, one must make some reservations about age limits because 110 cm millstones are recorded from much younger contexts elsewhere, i.e. Selbu.

Combining the evidence, it seems viable to suggest that millstone production at Nord-Talgje took place primarily between 1100 and 1541, with an older phase comprising hand querns only, and a later evolution towards more and larger water-driven millstones. The latest stage of quarrying included only production of large water-driven millstones, which may date to the Late Medieval or Early modern period.

**Nord-Talgje in prehistory and in historical time**

No millstones from the quarry at Nord-Talgje have been identified in the large collection of the Archaeological Museum in Stavanger, even though rotary hand querns were in use since AD 80–320 in this part of the country. This apparent contradiction may be due to the fact that
the majority of many excavations in Rogaland since the end of the 19th century have focused on farm complexes from the Migration Period (Petersen 1933, 1936, Løken 1991, 2003, Prøsch-Danielsen & Soltvedt 2011), a period that predates the “industrial” production of querns. Just a few farm complexes have been excavated from the Viking Age and the Medieval Age. Another possible explanation for the lack of millstone finds from the Nordic-Talgje quarry might be that the rotary querns were exported abroad or out of the district.

In the Viking Age, it is well documented that the inhabitants from this area had contact with people abroad. In the municipality of Finnoy, artefacts from Ireland, Germany, Denmark and Great Britain have been found belonging to the Viking Age (Petersen 1930). Particularly notable is the rich find, comprising 776 silver coins from the island Foldoy north of Nordic-Talgje, a find that can be dated back to approximately 1055.

Some cultural monuments at Nordic-Talgje date back to the Late Iron Age. The farm complex Stolshauane is situated approximately 400 m NNE of the quarry and comprises two house remains, clearance cairns, a burial mound (Idsoe 2005), and a nearby barn. The barn is interpreted to date back to the Medieval Age. In addition, a large farm complex called Storeskogen from the Late Iron Age is situated approximately 1 km NNW of the quarry, near the foundation of the new bridge to the island Tjul. This comprises the remains of three houses with an infield system, a boathouse, eight burial mounds and a possible cooking pit.

Nord-Talgje is not mentioned in diplomas or other historical sources prior to 1500. Tax-registers show that two men named Jakob and Jon lived on the farm Talgje around 1520 (NRJ 2:413, NRJ 3:359, 363, 370). When a farm was inhabited at this time, it is common among historians to assume that it had not been deserted during the Late Middle Ages. Jakob and Jon were tenant farmers. The landowner at that time, who probably also lived on Nord-Talgje, was Tore Sæbjørnsson (Næss 2006:193–194). His wife came from the Aga family in Hardanger, which belonged to the lower strata of the Norwegian aristocracy. The ancestry of Tore is unknown, but it is very likely that he descended from a family of high social standing in the region. Tore and later his two sons were significant landowners with holdings in both Rogaland and Hardanger. The land rent of Nord-Talgje in the 17th century was paid in grain and butter (Skattematrikkelen 1647:131). Neither the land registers of 1668 and 1723 nor the court records (tingbøker), starting in 1616, indicate that the people living on Nord-Talgje had any other outcome than the normal subsistence economy of farming and fishing. The historical records thus do not tell of any quarry on the island in the 16th or 17th centuries.

Consequently, we do not know who owned Nord-Talgje in the period that the quarry was in use. Nevertheless, some tentative remarks may be made. The king, the church and the nobility possessed most of the farms in the Boknafjord region during the Middle Ages (Helle 1987:124–134, Bjørkvik 1995). At least from the Late Viking Age, families belonging to the upper strata of the Norwegian aristocracy lived on the farm Hesby at Finnoy, just south of Nord-Talgje, and on the island of Sør-Talgje (Bjørkvik 1993:320–323, Bjørkvik 1997:249–255). In the High Middle Ages, they wore titles like baron and knight. These noble families must have owned farms in the area and they probably also controlled royal land on behalf of the king. Land rent from tenant farmers made up an important part of their economic basis. We do not know if their estates included Nord-Talgje, but it is quite possible.

In fact, if Nord-Talgje belonged to the aristocratic family at Sør-Talgje in the High Middle Ages (1130–1350), it makes sense that the island was owned by local farmers of high social standing in the 16th century. In the Late Middle Ages (1350–1536), the noble families, both at Hesby and Sør-Talgje, died away. The Hesby estate became crown land, whereas the holdings of the family at Sør-Talgje were split up through marriage and inheritance (Helle 1987:131). However, the main farm, Gard on Sør-Talgje, had aristocratic owners until the first half of the 17th century (Bjørkvik 1997:253).

The noble families at Hesby and Sør-Talgje were involved in trading activities. They possessed large ships and probably sold some of the products obtained as land rent, for instance in towns like Bergen and Stavanger. Thus, they had an apparatus for trading other goods as well. Baron Isak Gautesson of Talgje owned Isakbussen around 1300, a trading ship that visited English ports. The ship called at Lynn in both October 1305 and July 1306 (Regesta Norvegica 3:106, 122). Millstones are not mentioned as part of the cargo but, besides being a commodity, such heavy freight would, of course, also be useful as ballast both in the North Sea and along the Norwegian coast.

A quarry almost right outside the doorstep of the nobility at Hesby and Sør-Talgje would certainly have caught their attention. It is thus likely, but not proved, that the leading aristocratic families of Southwest Norway were engaged in the production of millstones at Nordic-Talgje.
Conclusions

The millstone quarry at Nord-Talgje displays different techniques of millstone extraction, ranging from direct carving of millstone blanks from the bedrock to carving of millstones from pre-split slabs. This may reflect a change of technique in the Medieval Period (1030–1536) or later. The carving started with hand querns only and later contemporaneous extraction of both hand querns and water-driven millstones. Based on sea-level studies and prehistoric and historical records, it seems likely that the date of quarrying was between the 11th and the 16th centuries. The size of the quarry (ca. 350 pairs of hand querns and minimum 53 water millstones) indicates production for a limited market, probably regional. However, the indications of a wide trade network, at least in the 14th century in the area, may point towards distribution of the querns also outside the region. The quarrying involved a high degree of standardisation (like the much more significant production at Hyllestad), and it is suggested that such standardisation was based on contemporary measurement units.

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