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Mobility of Scandinavian commodities in the Middle Ages and modern period: identification of Norwegian whetstones in northern France, Belgium and the Netherlands

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ABSTRACT

The sampling of several series of whetstones from medieval sites in the northern quarter of France and Belgium has revealed the (omni-)presence of specimens originating from Norway. This origin, assumed by macroscopic observation of the rocks, has been verified by previously unpublished EDS analyses acquired using the Scanning Electron Microscope (SEM). The rock is a fine ash-grey to green-grey micaceous quartz schist, rich in flakes of muscovite, chlorite and biotite, sometimes extending as far as the green-tinted quartz mica schist. The phyllosilicates bear a signature that ascertains their identification.

The first Norwegian whetstones appeared in Western Europe with the arrival of the Vikings in the late 8th – 9th centuries, and the same supply seems to have lasted throughout the Middle Ages and the modern era. The production area of these whetstones is well known in the county of Telemark in Norway, where the exploitation of multiple quarries began in the Iron Age and ended around 1950.

This study distinguishes Eidsborg stone from the macroscopically similar Mostadmarka stone, which crops out in the Caledonides region of western Norway and supplied whetstones from the 8th to the 11th century. The latter material appears to be absent from our collections, whereas the Eidsborg quarries supplied the French-Belgian region. These observations are in line with those made over the last decades around the North Sea basin, and illustrate that its southern part was connected to the same trading system. These discoveries shed light on an underestimated part of the medieval economy and reveal an exceptionally long-lived trading circuit.

1. Introduction

Stone closely accompanied the development of metallurgy, making it easier to shape and maintain the metal tools produced. For this action to be effective, it was necessary to find materials that were harder than the material being worked. Practice soon led to the choice of rocks with hard grains embedded in a softer matrix, which caused abrasion to form and maintain cutting edges and points. Local stones were often collected and used without prior shaping. Given the quantity of these stones in the protohistoric, antique and medieval find assemblages, the result must often have been satisfactory and did not require the mobilization of capital for the acquisition of manufactured whetstones. However, from the Bronze Age onwards (Boutoille, Peake, 2023), and then more intensively and widely from the Roman period onwards (Thiébaux et al., 2016), specific rocks were recognized as being particularly effective. They were quarried and shaped to give the whetstone the value of a manufactured object. From the Merovingian period onwards, the first rotary grindstones were introduced and were used for the sharpening of

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blades in Western Europe (Donnart et al., 2022). The bar-shaped whetstones as well as the rotary grindstones became consumer goods and objects of exchange or trade. For archaeologists, an ideal proxy for tracing commercial and exchange networks and socio-economic relations.

Research into the origin of whetstones has recently benefited from two doctoral theses in Belgium, dealing extensively with the subject for the Roman period, one by Aurélie Thiébaux at the University of Liège (Thiébaux, 2018), the other by Sibrecht Reniere at Ghent University (Reniere, 2018). In the same study area, less research has been carried out on medieval whetstones, but has increased in recent years. The most recent contribution is a Master's thesis on Norwegian whetstones found in the Zwin region (Belgium), which has added a valuable inventory to this paper (Naessens, 2024).

The rock under investigation is consistently identified in medieval contexts as an important source material used for manufacturing portable, parallelepiped-shaped whetstones. This type of whetstone has been well known in Anglo-Saxon, Dutch and Scandinavian literature since the 1960s, but is still quasi absent in Franco-Belgian research. It presents a range of variations between quartzite, quartzitic sandstone and schist quartz sandstone, and contains micas and chlorite. It is known in the European literature by various names: "Norwegian Ragstone", "Eidsborg schist", "Grey, laminated psammitic mica-quartz-schist", "Quartz-muscovite schist", "Muscovite quartzite" (e.g., Moore, 1978), or more recently "very fine-grained muscovite-quartz schist" (Mitchell et al., 1984; Askvik, 1990, 2008; Baug et al., 2019, 2024).

In 1978, D.T. Moore explained the wide distribution of Eidsborg stones by their quality: the ratio between hard elements and soft matrix is perfect (Moore, 1978: 61). Quartz is the dominant mineral, with a hardness of 7 on the Mohs scale, higher than that of steel (hardness of 6). The edges and peaks of the angular grains, which are less than 100 µm in size, finely abrade the metal. In addition, the poor particle sorting prevents the formation of a finely polished film. Soft phyllosilicates are abundant, leading to wear on the whetstones: concavities appear with use, but the surface is naturally resurfaced to maintain the bite. The rock is difficult to drill, but easy to split along the schistosity planes. It comes in slabs 1–2 m long and a few centimeters thick, providing standard modules of 30 x 5 x 3 cm in modern times (Myrvoll, 1985: 31). Moreover, the material is fairly homogeneous and its properties as a whetstone are the same whatever the stone.

This material first garnered significant attention in the 1920s through the work of Norwegian state geologist Rolf Falck-Muus, who drew up a historical inventory of Telemark's geological resources. He noted the exceptional longevity of the use of Eidsborg rock as a whetstone (Falck-Muus, 1920). Mining was still flourishing at the time, and only ceased in the 1950s with the development of synthetic stones. Later, historians recounted the history of these productions (Seierstad, 1958; Johansen, 1963), and the rock was further characterized by geologists using new petrographic and radiometric analysis methods, in particular K-Ar dating methods. These made it possible to identify the Eidsborg stone with little risk of confusion: few source rocks in Europe can claim a Precambrian age of 1000 Ma.

Since then, Norwegian stones have continued to be identified on the shores of the North Sea, creating an increasingly accurate distribution map. In Great Britain, following the first petrographic analyses carried out in Yorkshire in the 1950s (Morey, Dunham, 1953), an initial distribution map was drawn up some fifteen years later by S.E. Ellis (Ellis, 1969), subsequently completed in the 1970s by V.I. Evison (Evison, 1975) and D.T. Moore (Moore, 1978). The South Scandinavian sector and the area around the port of Skien were investigated by S. Myrvoll (Myrvoll, 1984; Myrvoll, 1985; Myrvoll, 1986), and Great Britain again by D. Crosby and J. Mitchell (Crosby & Mitchell, 1987). At the same time, H. Kars identified Norwegian whetstones in the Carolingian *emporium* of Dorestad, established shortly upstream of the Rhine estuary in the Netherlands (Kars, 1983), whereas H.G. Resi and H. Askvik analyzed them in German Jutland at Haithabu/Hedeby (Resi, 1990; Askvik, 1990). The same authors applied K-Ar dating methods to stones from several Viking age sites on the initiative of J. Mitchell (Mitchell et al., 1984), and more recently took up the data from the Norwegian site of Kaupang (Askvik & Resi, 2008; Resi, 2011). As recently as the 2000s, P. Nymoen tackled the question of the whetstone trade via Norwegian wrecks that had delivered cargoes of whetstones, in particular the medieval wreck known as *Bøleship* in Skien and the 19th century wreck of Lake Flåvann (Daly, Nymoen, 2008; Nymoen, 2009; Nymoen, 2011). The remote nature of this distribution was addressed in 2009 by S. Hansen, who inventoried Icelandic whetstones as part of a Master thesis (Hansen, 2009 & 2011).

Finally, the most comprehensive data on the exploitation of Norwegian lithic resources and exchanges between the Viking Age and the end of the Middle Ages, are due to I. Baug's PhD thesis and subsequent work (Baug, 2015; Baug et al., 2019; Baug, 2022; Baug et al., 2024). As well as addressing the question of the distribution of Eidsborg whetstones, the researcher identified for the first time the deposits at Mostadmarka (Trøndelag), in the Norwegian Caledonides, which are thought to have provided the whetstones identified at the earliest sites (8th- 11th centuries).

2. Aims, materials and methods

2.1. Aims

The expansion of preventive archaeology has resulted in a significant increase in discoveries, leading to a substantial growth in the number of datasets that can now systematically be analyzed. In this study, a transnational team of archaeologists and geologists aimed to determine the geological origins of the rocks used in the production of medieval whetstones in northern France and Belgium. In this study area, the provenance of the manufactured whetstones has traditionally been inferred to originate from the Ardennes and Armorican massifs or the Paris Basin. However, the recurrence of a more exogenous material in the archaeological corpus led this team to open up its research.

For this study, several whetstones suspected to originate from exogenous Norwegian sources were selected for analysis, alongside others crafted from macroscopically similar rocks and reference source materials for comparative purposes. This study aims to characterize the Eidsborg fine-grained muscovite schist, and to differentiate it from other Norwegian materials from Mostadmarka.

The first stage is to provide solid geological evidence for the occurrence of Eidsborg whetstones in the research area. Until recently, these whetstones were almost entirely absent from (geo-) archaeological research in the area, and with this study, we seek to address that gap.

A secondary aim is to conduct a non-exhaustive mainly macroscopical petrographical investigation of whetstones, to demonstrate the widespread presence of these imported whetstones in the research area based on rigorous geological evidence, an aspect that has been undervalued until now. This non-exhaustive review should provide a solid base to build further research on in the near future.

2.2. Geological and archaeological material

The sampled and analysed material consists of 23 whetstones from several medieval and modern period archaeological sites in Northern France and Belgium: the hamlet of Bonneuil-en-France (Val d'Oise, France), the rural settlement of Crépy-en-Valois (Oise, Fr.), the medieval city centre of Tourcoing (Nord, Fr.), and a district of the city of Saint-Omer (Pas-de-Calais, Fr.) as well as the banks of the Senne river in Brussels (Belgium) and the castle of Huy (Namur Province, Be.) (Table 1; Fig. 1). Most of them were initially macroscopically attributed to Eidsborg. About the origin of the other samples, there was more uncertainty, despite their macroscopical similarities with the Eidsborg stones.

Furthermore, some geological materials were selected and sampled from the historic quarry dumps of Eidsborg (n = 4) and Mostadmarka (n

Table 1
List of the sampled whetstones from archaeological sites, and of the samples taken in the quarries. Eidsborg-1, 2 and 3 have been collected at locality 6.2 in Dons (1960); Eidsborg-4 from Flepostore collection, UGent (https://www.flepostore.ugent.be/rock/no-32-0001), Mostadmarka-1 and 2 from A. Martinus and G.J.L.M. de Haas.

Country	Archaeological studied samples Sites	Id/arch. unit	Material	Age	Attribution
France	Bonneuil-en-France	20	Metamorphic fine-grained sandstone	Lower Devonian, Lower Palaeozoïcum	Brittany? (metamorphic contact zone)
France	Bonneuil-en-France	29	Fine-grained sandstone + frequent heavy minerals, stratification plane	Lower Devonian, Lower Palaeozoïcum	Ardenne, Brittany?
France	Bonneuil-en-France	56	Metamorphic fine-grained sandstone, stratification plane	Lower Devonian, Lower Palaeozoïcum	Brittany? (metamorphic contact zone)
France	Bonneuil-en-France	57	Fine-grained sandstone + frequent heavy minerals	Lower Devonian, Lower Palaeozoïcum	Ardenne, Brittany?
France	Bonneuil-en-France	59	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Belgium	Brussels	1014	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Belgium	Brussels	2543	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Belgium	Brussels	1128	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Belgium	Monnikerede	MR-4230	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Belgium	Hoeke	HO-1788	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Crépy-en-Valois	1747	Fine-grained sandstone + frequent heavy minerals, stratification plane	Lower Devonian Lower Palaeozoicum.	Ardenne, Brittany?
France	Crépy-en-Valois	1748	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Crépy-en-Valois	1754	Fine-grained sandstone	Lower Devonian, Lower Palaeozoïcum	Ardenne, Brittany?
Belgium	Huy	326	Fine-grained clayey sandstone	Lower Devonian, Lower Palaeozoïcum	Ardenne
France	Saint-Omer	2460	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Saint-Omer	2461	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Saint-Omer	2752	Very fine-grained sandstone	Lower Devonian, Lower Palaeozoïcum	Ardenne?
France	Saint-Omer	22,991	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Saint-Omer	22,992	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Tourcoing-8	289	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Tourcoing-10	344	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Tourcoing-11	416	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
France	Tourcoing-13	534	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
	Geological studied samples				
Country	**Sites**	**Id**	**Material**	**Age**	**Provenance**
Norway	Eidsborg-1	TN725	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Norway	Eidsborg-2	TN725	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Norway	Eidsborg-3	TN725	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Norway	Eidsborg-4	Flepostore coll.	Quartz-muscovite schist	Precambrian	Eidsborg (Norway)
Norway	Mostadmarka-1		Quartz-muscovite schist	Ordovician	Mostadmarka (Norway)
Norway	Mostadmarka-2		Quartz-muscovite schist	Ordovician	Mostadmarka (Norway)

= 2) to compare with the archaeological material and the descriptions found in literature (Table 1).

Eidsborg — At Eidsborg, Telemark, South Norway, fine-grained muscovite schists have been quarried as whetstones in several quarries at the mountains Steinbergnutten and Grødknutten. The area is part of the Precambrian Southwest Scandinavian Domain, built up by the Gothian (1660–1520 Ma), Telemarkian (1520–1480 Ma) and Sveconorwegian (1150–900 Ma) orogenies (Bingen et al., 2021) (Fig. 2). In the west of Telemark, the Eidsborg Formation represents the top of a sequence of well-preserved Precambrian metavolcanics and metasediments (Laajoki et al., 2002; Lamminen, 2011; Fig. E1). It comprises feldspathic and sericitic quartzites, quartz schists and meta-conglomerates at both the base and higher up in the stratigraphy (Laajoki et al., 2002). The depositional age of the Eidsborg Formation is constrained by U-Pb detrial zircon ages of 1118 ± 38 Ma (De Haas et al., 1999) and 1118 ± 17 Ma (Spencer et al., 2014).

Mostadmarka — The Mostadmarka whetstones originate from supracrustals from the Ordovician Støren Group, part of the Caledonian Støren nappe southeast of Trondheu (Wolff, 2005, Fig. 3). In the Mostadmarka-Selbustrand area, the Støren Group mainly comprises a variety of greenstones including recognizable metavolcanics such as pillow lava's, tuffaceous rocks and pyroclastics (Torske, 1965). Within these, subordinate metasediments occur: quartzites, quartz schists and phyllites. Some layers show two well-defined cleavages, enabling easy splitting. At Heingruva, at a small occurrence within greenstones, north of the Selbusjøen and east of the lake Foldsjøen (Wolff, 2005), and at Rollset, between the latter lake and Heinfjorden, these have been quarried as whetstones (Baug et al., 2019; Baug, 2022).

K-Ar dating dated this rock type to between 403 ± 10 and 446 ± 7 Ma (Mitchell et al., 1984).

2.3. Methods

Archaeological and geological samples were analyzed using two complementary characterization techniques in the laboratories of the Geological Survey of Belgium (Belgian Institute of Natural Sciences). For optical petrography (OP), samples were thin sectioned using standard techniques. Petrographic uncovered polished and covered thin sections (45 x 35 mm) were made from 23 whetstones and from 6 geological reference samples. The sections were examined using a Nikon Optiphot-Pol polarizing light microscope.

Some sawed fragments were embedded in epoxy resin and silicon carbide-polished (1200 mesh). Fabric observations on uncoated polished sections and uncovered thin sections were made by Scanning Electron Microscopy (MEB FEI Quanta 200, BSE 23 kV and spot 6–7) while chemical analyses were performed by Energy Dispersive X-ray

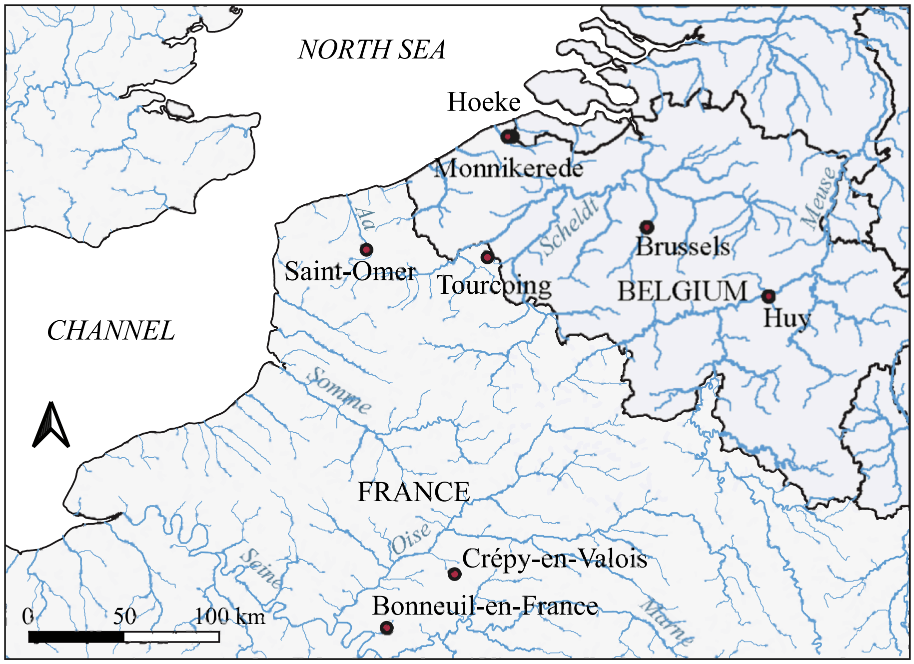

Fig. 1. Localisation of the sites where whetstones have been sampled and analyzed in Northern France and Belgium. Map by P. Picavet.

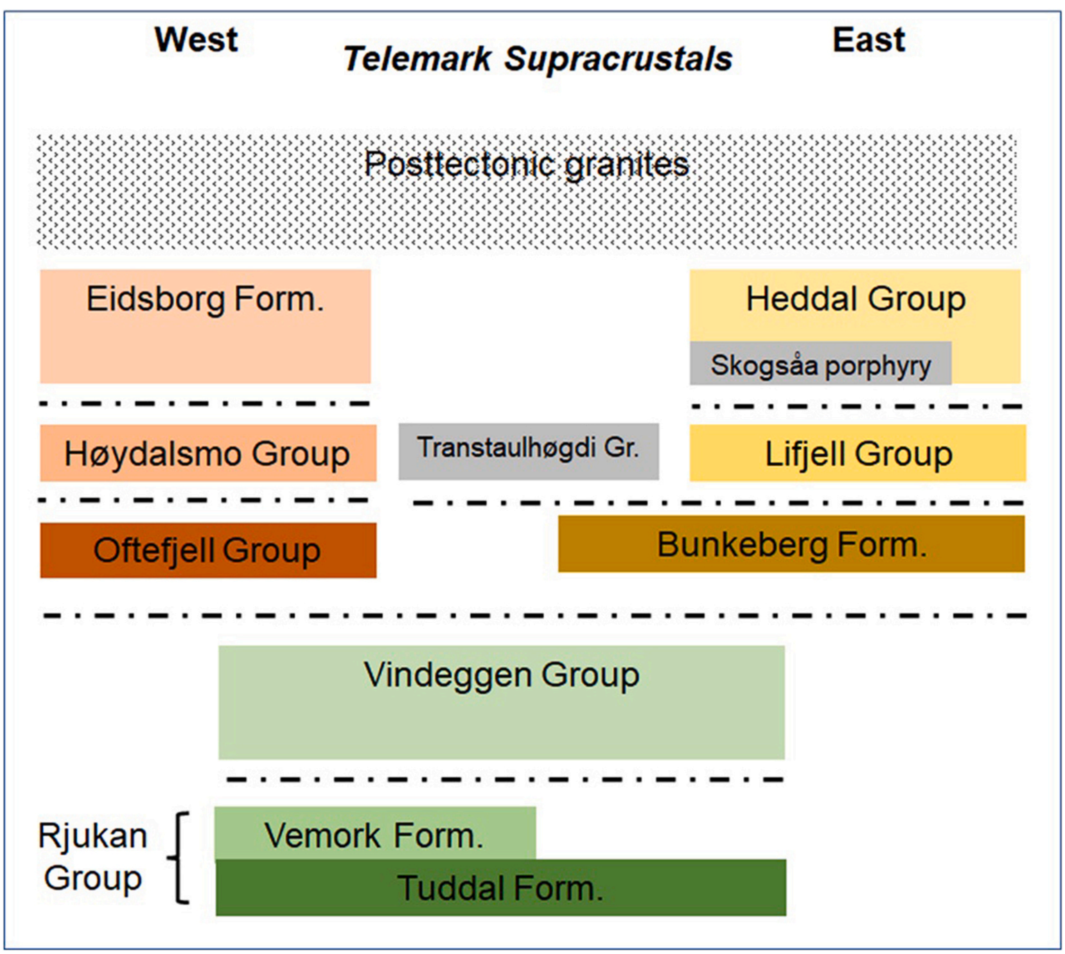

Fig. 2. Simplified statigraphy of the Telemark supractustals (After Laajoki et al., 2002, Lamminen, 2011).

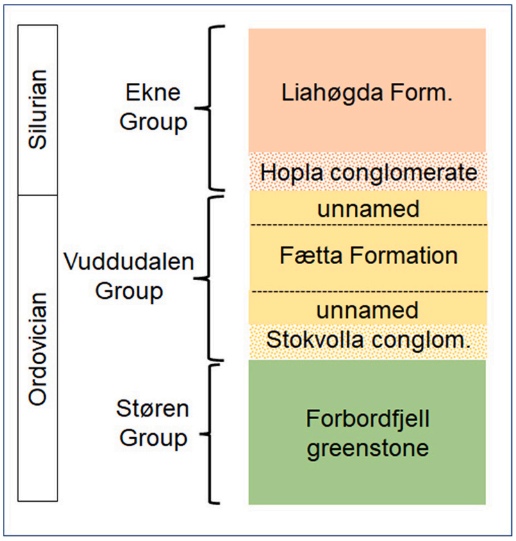

Fig. 3. Simplified stratigraphy of supracrustals in the Støren nappe (After Roberts et al., 2019).

spectroscopy (EDAX Apollo 10 SD, 23 kV). Several analyses were carried out for each mineral specie identified, accompanied by verification of the absence of chemical zonation within particles. Elemental ratios are derived from EDS point analyse (same spot size for all analyses) and standardless quantitative EDS method was used.

3. Geological analytical results

3.1. Macroscopical and microscopical description of the geological material from Norway

The Eidsborg ash-grey to green-grey quartz-muscovite schist contains alternating fine- and coarse-grained lamination, with a bimodal distribution of quartz grains (the largest quartz grains float in a matrix of fine quartz and muscovite grains) (Fig. 4). In the coarse-grained laminae, coarse-grained calcite can even be found. Muscovite flakes are preferentially oriented along metamorphic bands/cleavage planes. Opaque minerals (magnetite, ilmenite?) are disseminated throughout the rock and show brown oxidation spots, clearly visible on the surface of the rocks.

The stone from Mostadmarka is a light-green micaceous well-sorted coarse siltstone (50/60 % quartz, 20/30 % phyllosilicates, 10 % opaque minerals, <2% of other minerals) (Figs. 5 and 6). It has a well-developed quartzitic structure (microquartzite) with automorphic crystals of magnetite. The phyllosilicates content is higher in the fine-grained laminae.

Micas and chlorites are present in the form of flakes mainly of 30 to 600 μm length and 5 to 80 μm width. These flakes can be separated from each other (Mostadmarka and Eidsborg) or locally grouped, either in spots (Eidsborg) or clusters forming more or less continuous laminae (Eidsborg).

One of the differences between Eidsborg and Mostadmarka lays in the hues of colours: more grey-green for the Eidsborg material and more grey-bluish to purplish for the material from Mostadmarka. Microscopically, the differences between the two sources are small (Fig. 7). The cleavage is better expressed by the material from Eidsborg with "micas-chlorite flakes" spots, clusters, and alignments (Fig. 4). In contrast, the rocks from Mostadmarka show well separated individual flakes (in place of concentrations) with a weak orientation, as well as more equant, mosaic quartz grains (Fig. 5). It cannot be excluded that this observation is due to the limited number of samples. Abundancy of phyllosilicates varies from one sample to another and also inside each sample, probably reflecting the initial stratification plane and internal (little) variations in the clay content.

3.2. SEM observations and EDS analyses

EDS analyses were performed both on phyllosilicates flakes (n = 220) and on other minerals (n = 78).

Micas show large compositional variations and belong to two groups (Figs. 8 to 11). The first group concerns phengitic micas from the muscovite group. "Phengite" is a non-IMA (International Mineralogical Association) recognized mineral name representing the series between muscovite and celadonite. Therefore, the name "muscovite" is used in the ternary diagram although pure muscovite does not occur in the studied samples. Our analyses show the significant occurrence of Mg and Fe in the composition, normally in substitution for Al. Petrographically, phengites show a light green colour with a very light pleochroism weaker than the pleochroism of chlorite.

The second group concerns biotite with a solid-solution series between the Mg-endmember (phlogopite) and the Fe-endmember (annite). Biotite in thin section shows (untypical) moderate pale-greenish pleochroism. The name biotite was used in the ternary compositional diagrams.

Finally, chlorites represent the third group of minerals occurring in all whetstones studied as well as in geological Norwegian source material. Many mineralogical species occur in the geological record, depending on their chemical composition. EDS analyses indicate that chlorites from Norwegian source material and whetstones attributed to Norway, are clinochlore. The chlorites from the whetstones made from Belgian/northern France Palaeozoic rocks clearly differ by a lower Mg content. All these analyses plot within the chamosite-clinochlore domain (Figs. 8, 9 and 12). Note that whetstones from Tourcoing and Saint-Omer contain the clinochlore richest in Mg, suggesting a common geological origin for these whetstones.

Fresh feldspars occur in very low amounts. EDS analyses indicate the occurrence of K-feldspars and albite without Ca-plagioclase. Polysynthetic twinning was observed in albite grains. Xenomorphic grains of apatite were also identified. Opaque minerals are frequent and dominated by idiomorphic crystals of magnetite of different sizes. Ilmenites and mixture of fine-grained alteration products after Ti-minerals occur as well, together with accessorial detrital zircon, rutile and tourmaline. Very rare chromite has been identified in Ardennan whetstones, whilst it is totally absent in the Norwegian material.

The chemical composition of phyllosilicates does not differ between the two Norwegian geological sources. However, titanite and epidote occur exclusively in the material from Eidsborg as well as in some archaeological whetstones. Hornblende was identified in only two cases in one sample. Whereas the interstitial poikilitic calcite occurring in the geological material of Eidsborg is almost pure, the calcite of two samples of Mostadmarka is distinguished by a high Mn content (CaO/MnO^2 between 3.5 and 4.9 for Mostadmarka compared to values between 43 and 60 for Eidsborg) and higher contents of Fe and Mg.

Compared to the two Norwegian sources, whetstones made in French/Belgian micaceous sandstones/quartzites show significant differences in the composition of phyllosilicates (Fig. 11), with both chlorites and biotite significantly richer in Fe, whilst there is no significant difference within the muscovite group. The high Mg content of the phyllosilicates stands for a chemical signature for both rocks from Norway.

3.3. Comparison between geological material and sampled whetstones from France and Belgium

The petrographic analysis makes it possible to characterize the stones of Norwegian origin well and to separate them from the slightly metamorphic fine-grained micaceous sandstones (with a partly developed quartzitic structure) and quartzites of the Belgian Paleozoic massifs

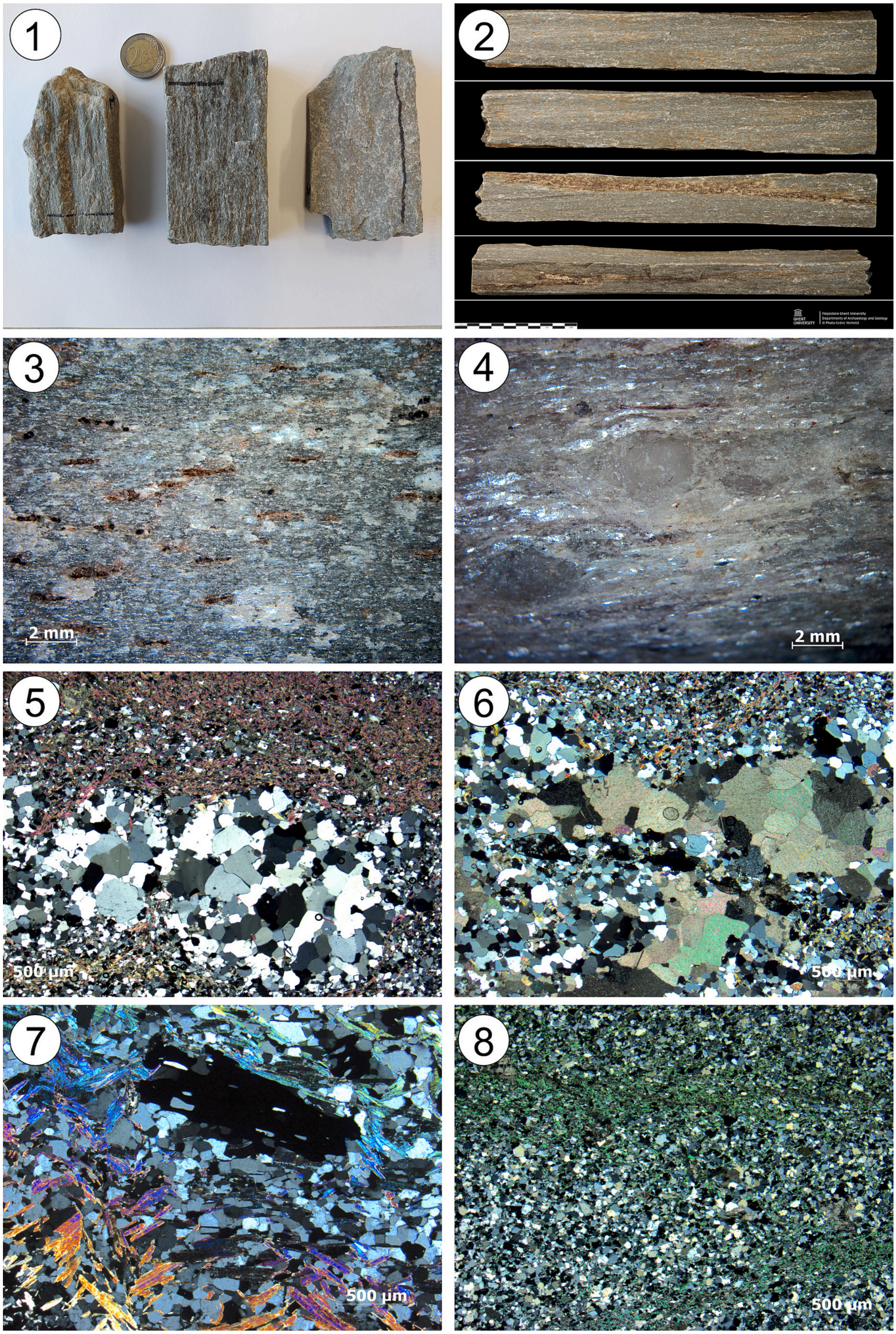

Fig. 4. Pictures and MOP micrographs of stones from Eidsborg. **1-2.** Macroscopical view of the three geological specimens sampled in the disused quarries of Eidsborg, showing greenish grey (fresh) and brownish colours (result of weathering?) as well as the conspicuous foliation (cleavage). Black lines indicate the position of the thin sections; **3.** Macroscopic view of the surface. Note foliation and oxidation of opaque minerals. White areas possibly point to calcite-rich (?) patches; **4.** Close-up of the surface showing a supposedly porphyroblastic texture; **5.** Micrograph of the quartz micaschistshowing details of a quartz-rich mosaic patch (corresponding to the porphyroblastic texture mentioned above) and the preferential orientation of the micas. XPL; **6.** Micrograph of the quartz micaschistshowing details of apoecilitic calcite mosaic. XPL; **7.** Micrograph showing the chevron-like orientation of the micas (crenulation; mainly muscovite) and the presence of opaque minerals (magnetite?). XPL; **8.** Micrograph of a fine-grained micaschist facies showing alternating quartz-rich and mica-rich bands. XPL. Pictures and micrographs by E. Goemaere (1) C. Verhelst (2) and R. Dreesen (3 to 8).

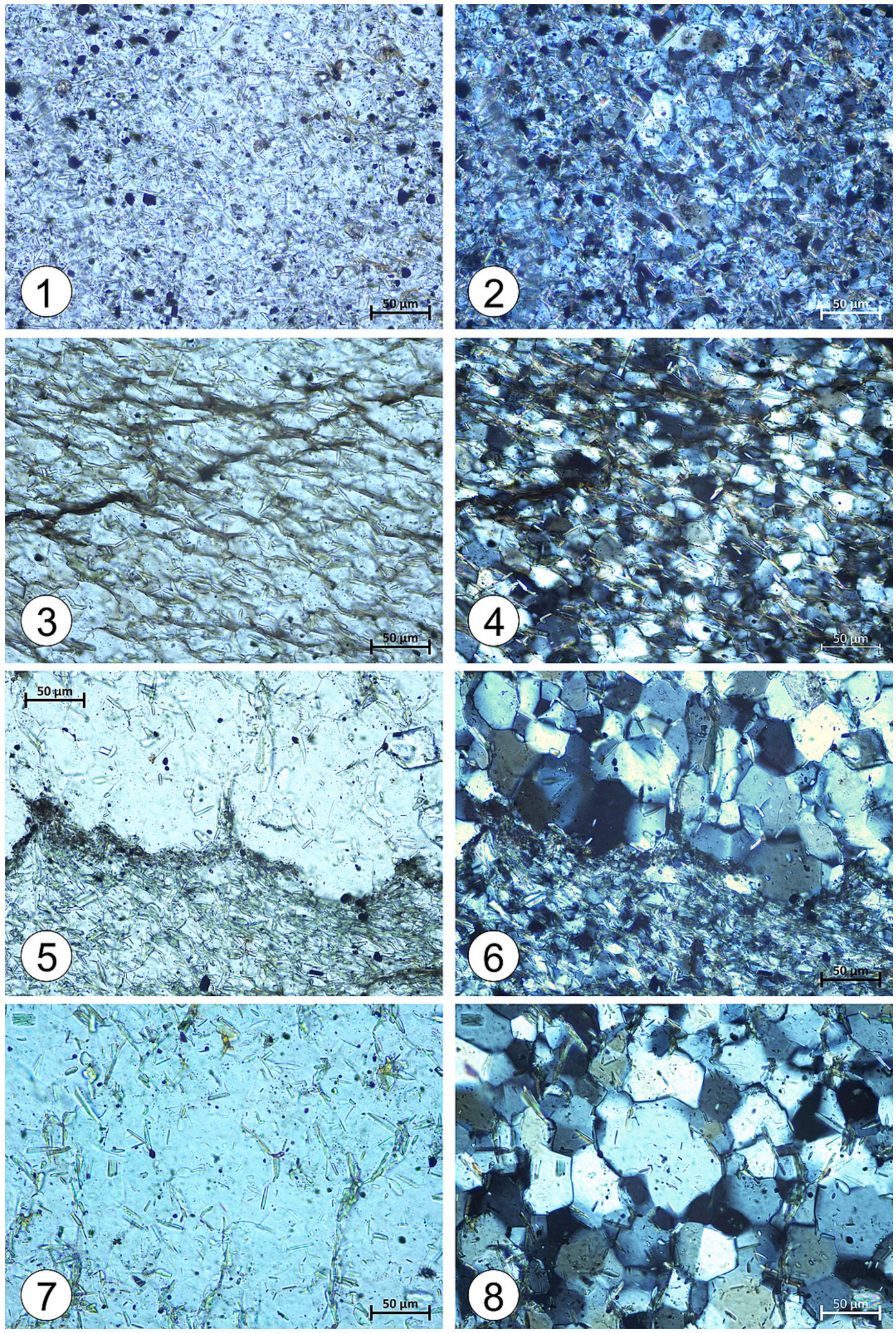

Fig. 5. MOP micrographs of stones from Mostadmarka. **1.** Very fine-grained chlorite-rich microquartzite. The size of quartz grains is in the silt range (<63µm) and not in the sand size range. The acicular grains of chlorites are arranged in all directions without any particular concentration, and none reaches 50µm of length, for 2 to 5 µm of thickness. PPL Sample MOS-1; **2.** Idem 1, XPL. The quartzitic structure is disturbed by chlorite flakes. Sample MOS-1; **3.** Sample MOS-2 shows two areas, one with fine-grained quartz grains (the one shown in this picture) and one for coarser grain (see images 7 and 8). This is a microquartzite rich in acicular chlorite, more abundant than in micrographs 1 and 2. Chlorites are oriented in two directions following the stratification plane and cleavage plane. PPL; **4.** Idem 3, XPL. Sample MOS-2; **5.** Contact between the microquartzite rich in green needles of chlorite (lower) and the fine-grained quartzite and poorer in chlorite needles. PPL. Sample MOS-2; **6.** Idem micrograph 5, XPL. Sample MOS-2; **7.** Very fine-grained quartzite showing the quartzitic texture interrupted by very thin silt-size needle flakes of chlorite PPL. Sample MOS-2; **8.** Idem micrograph 7, XPL. Sample MOS-2. Micrographs by E. Goemaere.

and the northern half of France. All whetstones from archaeological sites examined in this research are attributed to the Eidsborg region. No stone matches those of Mostadmarka.

These stones are fine-grained micaceous metamorphic rocks from the same geological deposit at Eidsborg (Fig. 13). Two facies come from different beddings. They are distinguished by their mineral concentration and by the unsystematic presence of calcite. They have been described in literature (Falck-Muus 1920): the *blue-grey schist* known as "***Hardstein***" and the *silver-grey schist* known as "**Blaustein**". The Blaustein facies contains more muscovite and opaques (Tour-10) and less quartz and calcite than the Hardstein facies (Tour-8–11-13).

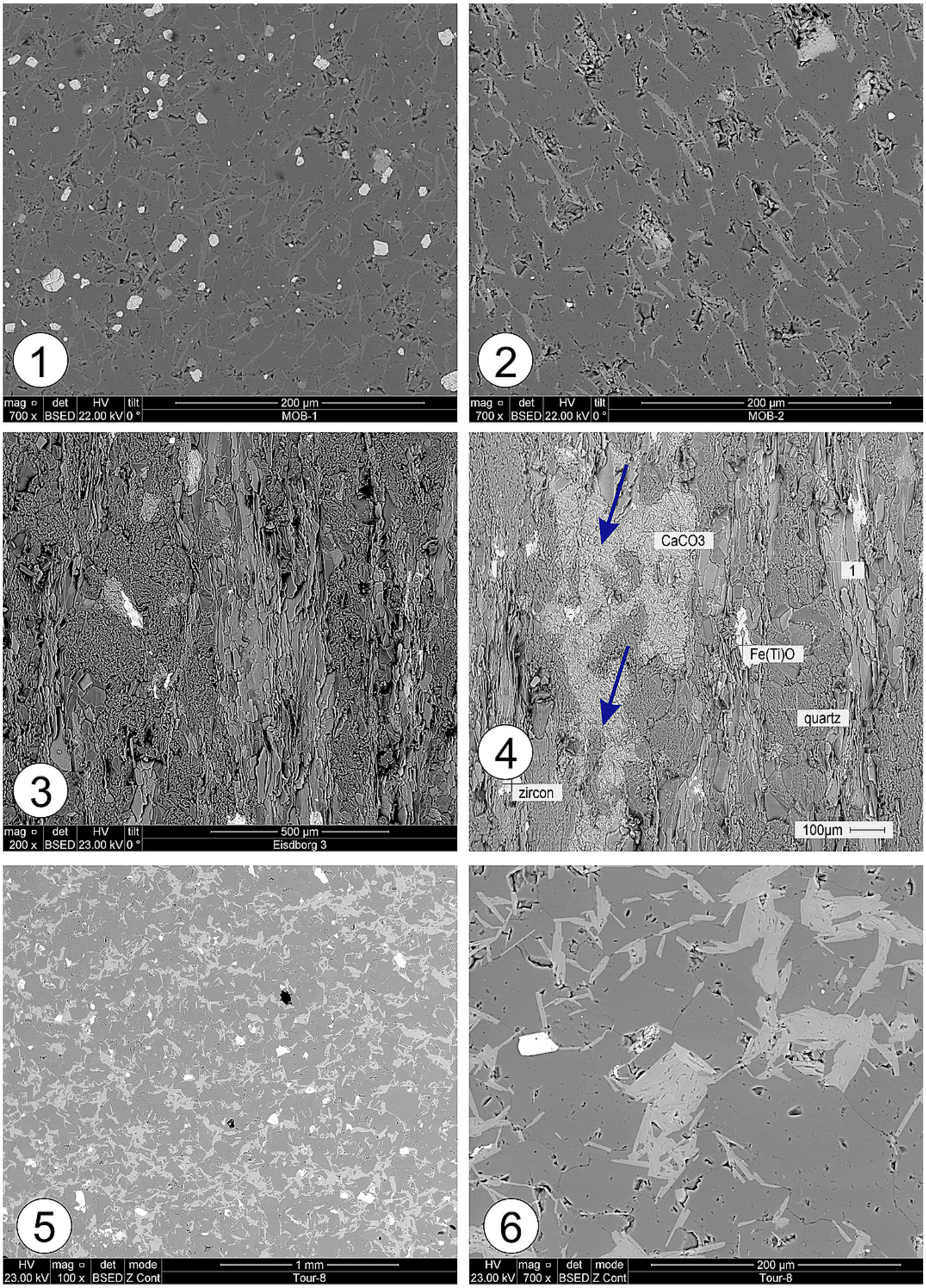

Fig. 6. SEM micrographs of the stones from Norway, both from geological samples (Mostadmarka and Eidsborg) and from archaeological specimen (Eidsborg). **1.** General view of the micaceous microquartzite from Mostadmarka. Quartz grains in dark grey, phyllosilicates in light grey and magnetite in white. Polished sample MOS-1; **2.** Idem 1 but with coarser quartz grains. Polished sample MOS-2; **3.** Aligned micas and chlorite flakes forming laminae separated by laminae of quartz (irregular natural surface). Opaque minerals in white. Unpolished surface, sample Eidsborg-3; **4.** Idem micrograph 3 with poikilitic calcite (blue arrows). Unpolished surface, sample Eidsborg-3; **5.** Overview of the petrofacies of a whetstone from Tourcoing. Polished thin section, sample Tourcoing-8; **6.** Close-up of the petrofacies of a whetstone from Tourcoing with quartz (middle grey), grouped phyllosilicates (light grey) and opaque minerals (white). Polished thin section, sample Tourcoing-8. Micrographs by T. Leduc.

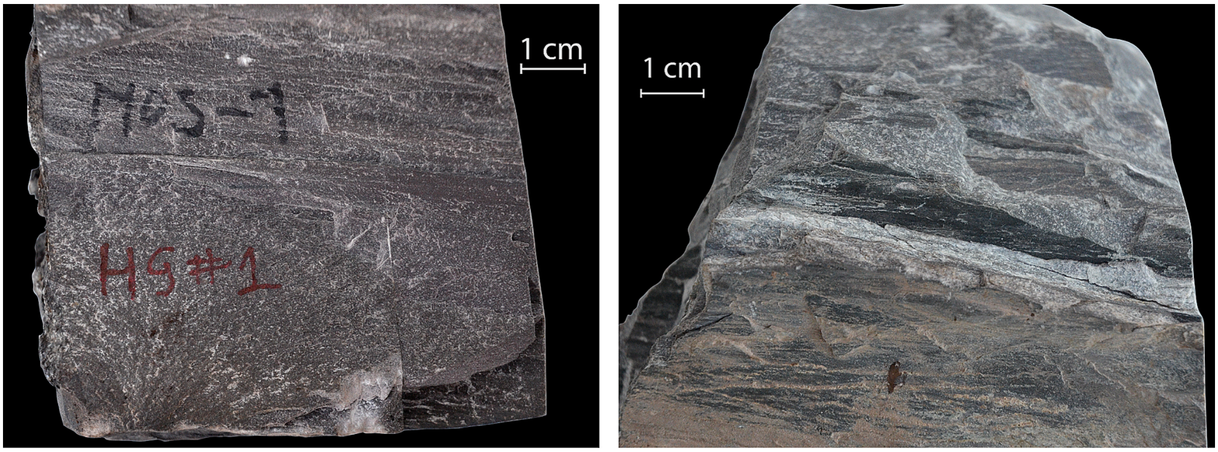

Fig. 7. Pictures of stones from Mostadmarka. **1-2.** Macroscopical view of the two geological specimens sampled in the disused quarries of Mostadmarka, showing purplish and bluish grey colors. Pictures by E. Goemaere.

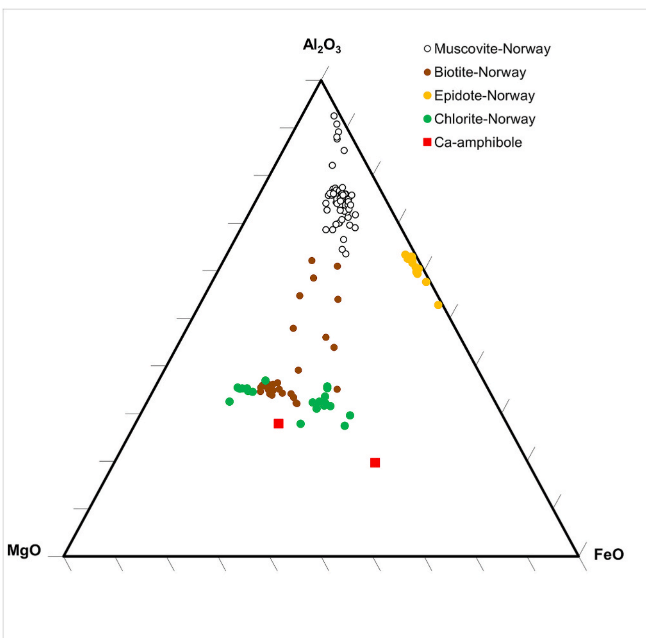

Fig. 8. Ternary diagram representation of the composition of phyllosilicates (n = 136) determined by EDS (expressed in wt% of oxides) from the whetstones attributed to Eidsborg and geological material from the two places in Norway.

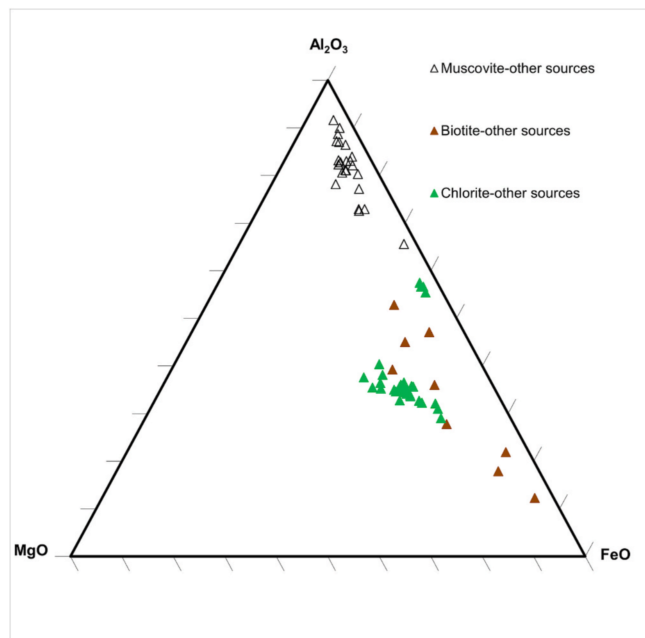

Fig. 9. Ternary diagram representation of the composition of phyllosilicates flakes determined by EDS (expressed in wt% of oxides) from the archaeological whetstones not attributed to Eidsborg. Infography by E. Goemaere.

4. For an archaeological study of the Eidsborg whetstones

4.1. Distribution and context

Confirmation of the Norwegian origin of 15 analyzed whetstones over 23 sampled ones (Table 1) led to the re-examination of several other archaeological assemblages in Northern France, Belgium and the Netherlands. Consequently, an additional set of 182 stones was identified through a combination of macroscopic analysis (n = 142) and a review of grey literature (n = 40). It was beyond the scope of this paper to analyze this entire dataset through petrographic analysis and SEM-EDS. In the future it would of course be interesting to verify some of the determinations through the investigation of a random sampling. This brings the corpus to 197 whetstones from 69 sites (square symbol on map Fig. 14; Table 2). The archaeological contexts were dated by a combination of relative stratigraphy, typochronological studies (for example ceramics, coins, brooches and other typologically representative artefacts), radiocarbon dating and dendrochronology. Since whetstones are not often found in closed contexts, they can usually only be dated in a general manner.

The earliest identified Eidsborg whetstone comes from the rural settlement of Ruien (West Flanders, Belgium), situated at the banks of the river Scheldt, today 75 km inland. It dates from the middle of the 8th to the end of the 9th century, a period during which Danish marauding took place on the Frankish coasts (Tys, Deckers, Wouters 2019, 131). Another one comes from the rural site of Bourbourg (Nord department, France), situated near the North Sea shore, and dates from the 10th or 11th century. Another early stone is not directly dated by the accompanying finds, but comes from the early medieval site of Bonneuil-en-France (Val-d'Oise department, Fr.), in the heart of the Paris Basin and 5 km from a loop of the Seine river. The site was a rural hamlet from the Merovingian period until the early 12th century. Another isolated whetstone has been found in the small rural hamlet of Crépy-en-Valois (Oise department, Fr.) in the Paris Basin, near structures dating from

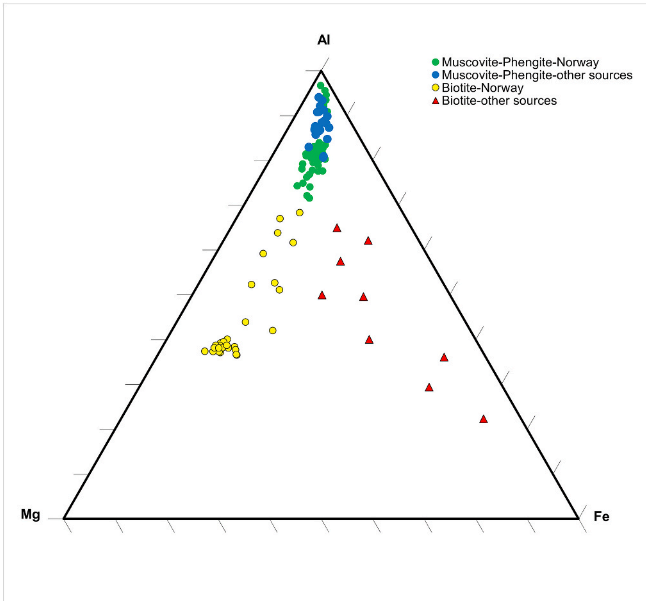

Fig. 10. Ternary diagram representation of the composition of the micas group (muscovite-phengite and biotite) determined by EDS (expressed in atomic %) from the archaeological whetstones not attributed to Eidsborg. Infography by E. Goemaere.

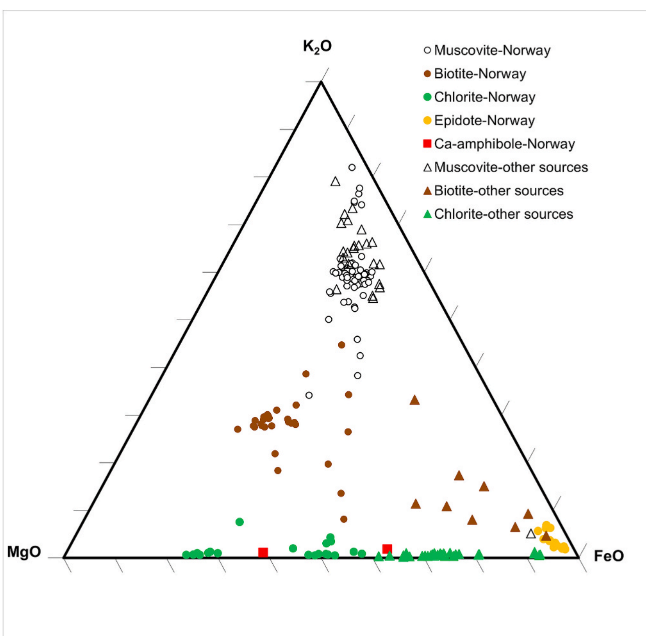

Fig. 11. Ternary diagram representation of the composition of phyllosilicates flakes determined by EDS (expressed in wt% of oxides) from the archaeological attributed to Eidsborg and geological material from the two places in Norway. Infography by E. Goemaere.

before the 11th century.

For the following centuries, the largest and most homogenous series came from the towns of Saint-Omer (Pas-de-Calais department, Fr.), which is a port on the river Aa leading to the North Sea, Dieppe (Seine-Maritime department, Fr.), a maritime port on the English Channel, and inland from the towns of Lille and Tourcoing (Nord department, Fr.). All archaeological excavations in the various districts of Saint-Omer yielded this type of whetstone. This indicates that its trade and use was

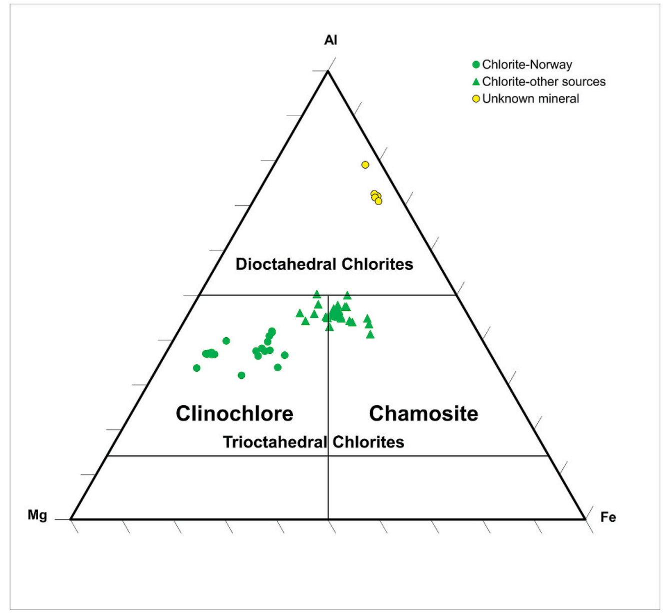

Fig. 12. Ternary diagram representation of the relative atomic proportions of Al, Mg and Fe in chlorites (and other phyllosilicates) determined by EDS (expressed in atomic %). Archaeological material attributed both to Norway and no-Norway, as well as the geological material from Eisdborg and Mostadmarka. Infography by E. Goemaere.

widespread among the population from the 13th to the 15th century. Among the dozen stones studied from this city, only one was made of another rock than Eidsborg schist. The same holds for the city center of Tourcoing at the same period, with twelve whetstones out of thirteen made with Eidsborg schist, and only one coming from the Ardennes Massif. In Tourcoing, the whetstones come from the excavation of an artisanal neighborhood specialized in wool processing, where scissors had to be regularly maintained. The three whetstones found in the craft district of Dieppe, the three from the quays of the Senne river in Brussels, eight out of twelve coming from the city of Lille and the majority of those found along the Zwin inlet north of Bruges, also date from the same period. In the latter region, the harbour towns of Monnikerede and Hoeke (West Flanders) are considered as important places of the German Hanseatic League. Besides Eidsborg whetstones also other imports from Scandinavia were found, such as wood, leather, goatskins (Dumolyn, Brown, 2018, 101), bakestones, quernstones and Balto-Scandinavian ballast cobbles (Trachet, 2016; Dreesen, De Clercq, 2020).

Rural sites also yielded Eidsborg whetstones in this period, but provide relatively few examples: one from Marck (Pas-de-Calais) and one from Bourbourg (Nord) on the North Sea coast between the mid-13th and mid-14th centuries, two from Fiennes near Saint-Omer (Pas-de-Calais) in the 14th century, one from Carvin (Pas-de-Calais) on the banks of the Deûle river dating between the mid-13th and 15th centuries.

A number of whetstones date from the Renaissance and younger times, both in urban and rural contexts. However, there is insufficient data to confirm that continuity of the trade exists. The town of Conchil-le-Temple (Pas-de-Calais) provided 2 whetstones dating from the 15th century, Saint-Omer from between the 16th and early 18th century, while those from Marck and Steene (Nord) are mainly dating from the modern to contemporary periods. Finally, a series of whetstones were found during surveys of undated rural sites. They may correspond to tools lost in the fields during the harvest or from unexcavated occupations.

Regardless the period, all the sites are characterized by their proximity to waterways, either sea or river. This was the case from the Early Middle Ages onwards, when the whetstones penetrated quite far into the

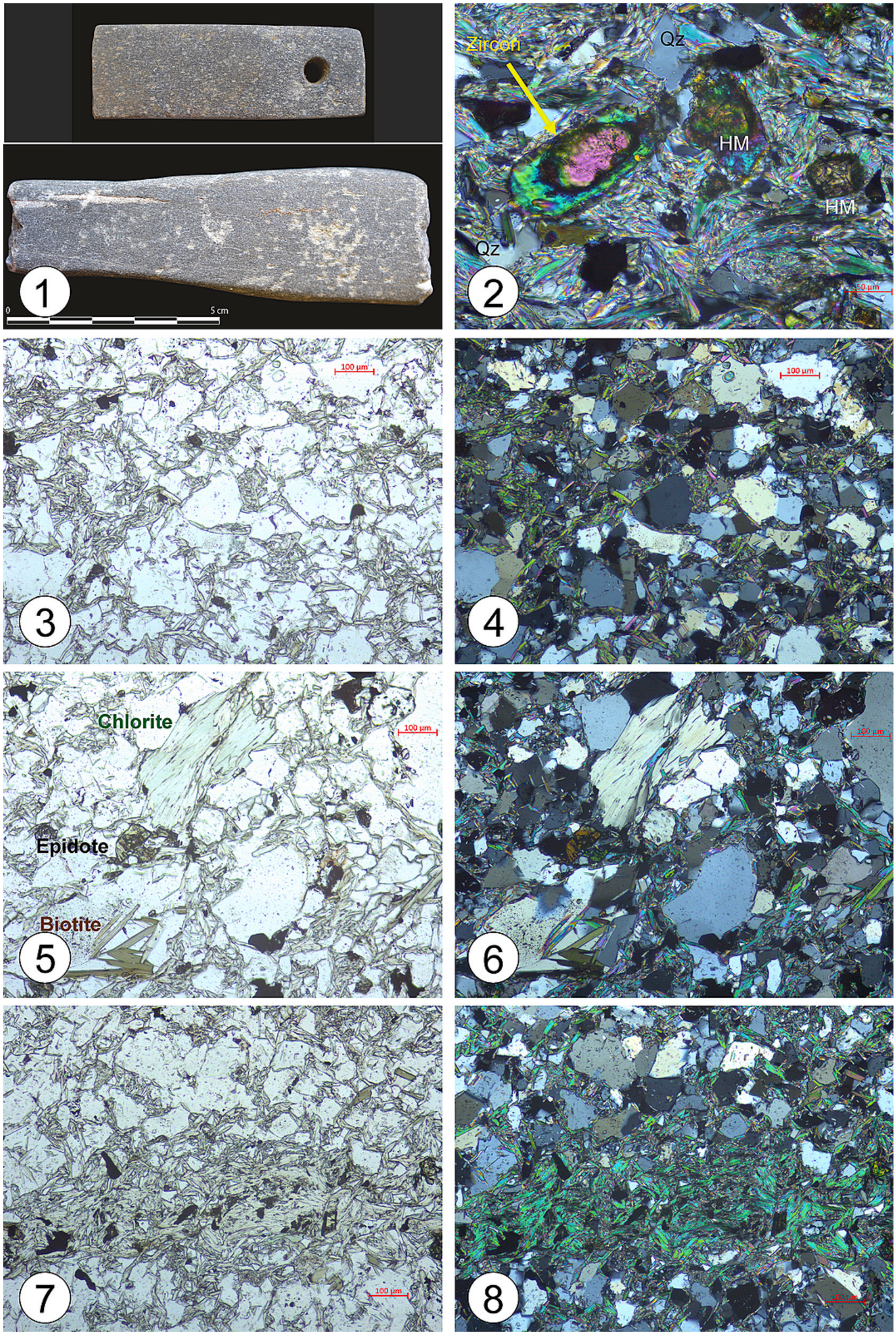

Fig. 13. Picture (image 1) and micrographs (MOP, images 3 to 8) of stones from Tourcoing (France). **1.** Macroscopical view of three whetstones from Tourcoing "Grand Place"; **2.** Close up showing numerous flakes of phyllosilicates, rare quartz (Qz) grains and detrital rounded heavy minerals (HM). A grain of zircon with a rounded core is put in evidence by a yellow arrow. XPL; **3.** General view of the petrofacies showing a mosaic of (very fine to fine-grained) bad sorted quartz grains with colourless and greenish flakes of phyllosilicates. PPL; **4.** Idem 3 observed in XPL; **5.** Idem 3 with thick flakes of very light green chlorite and thin biotite highly pleochroic flakes. PPL; **6.** Idem 5 observed in XPL; **7.** Very thin layer enriched in phyllosilicates (dominated by "phengites") and opaque minerals (magnetite and Fe-Ti minerals). PPL; **8.** Idem 7 in XPL. Picture 1 by P. Picavet; micrographs 2 to 8 by E. Goemaere.

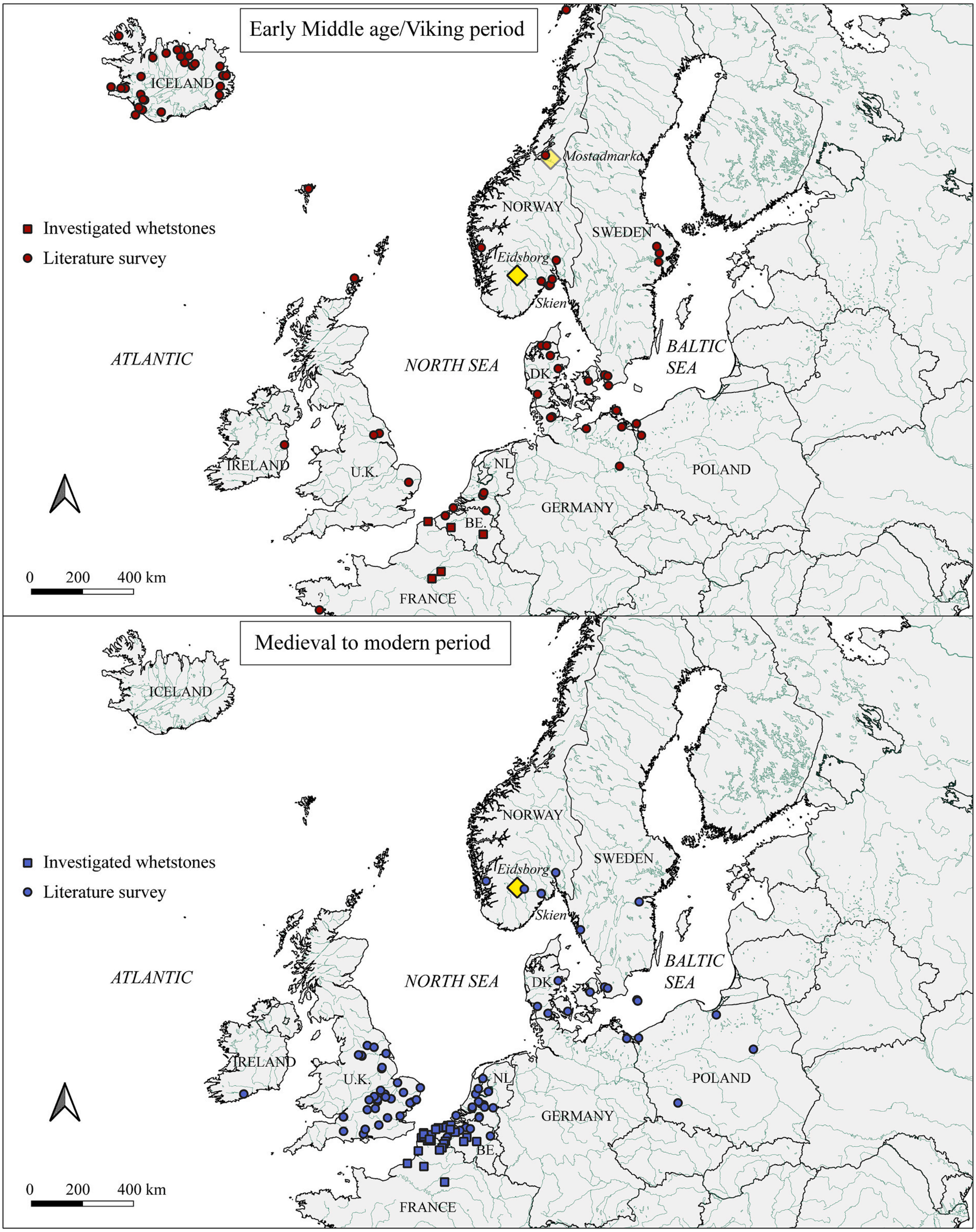

Fig. 14. Distribution of the Eidsborg whetstones in Early Middle Age and Medieval to modern periods. Note that the survey has been made in Iceland for the Viking period only, not for the Medieval to modern period but the Eidsborg whetstones are widespread. **Denmark** after Mitchell et al., 1984; Myrvoll, 1984; Crosby and Mitchell, 1987; Nielsen, 2008; Rossignol, 2018. **Germany** after Bautsch 2001. **Iceland** after Hansen, 2009. **Ireland** after Alden, O'Mahony s.d. **The Netherlands** after Kars, 1983; Kars, 1995. **Norway** after Myrvoll, 1986; Nymoen, 2009; Skre, 2017; Kresten 1996; Ellis, 1969; Moore, 1978; Christensen, 1970. **Poland** after Mitchell et al., 1984; Myrvoll, 1985; Baug et al., 2024. **Sweden** after Myrvoll, 1986; Crosby and Mitchell, 1987; Hansen, 2009; Hansen, 2017. **United Kingdom** after Ellis, 1969; Moore, 1978; Crosby and Mitchell, 1987; Batey et al., 2012; Shaffrey, 2011a, 2011b; Shaffrey, 2017. Maps by P. Picavet.

Table 2
List of the still unpublished sites where whetstones from Eidsborg have been identified in Northern France, Belgium and the Netherlands. SR: Sibrecht Reniere; FN: Fien Naessens; PP: Paul Picavet; EG: Eric Goemaere.

Site Name	Chronology	Type Site	Nb.	Determination	Reference
BELGIUM					
Beveren	1400–1900	Farm	1	Literature	Alma & Van der Velde, 2013
Brugge	1300–1500	Abbey	1	Macro SR-FN	Hillewaert, 1998, 5-6; Naessens, 2024
Brugge	1200–1500	Urban	1	Macro SR-FN	Decraemer et al., 2011; Naessens, 2024
Brugge	1250–1500	Urban	12	Macro SR-FN	Roelens et al., 2023; Naessens, 2024
Brugge	1000–1500	Rural	1	Macro SR	Unpublished
Brugge	1200–1400	Urban	2	Macro SR-FN	van den Dorpel, Genbrugge, 2019; Naessens, 2024
Brugge	1300–1500	Urban	1	Macro SR-FN	Hillewaert, Van Besien, 2005; Naessens, 2024
Brugge	1300–1500	Urban	1	Macro SR-FN	Bot, 2024; Naessens, 2024
Brugge		Urban	1	Macro SR-FN	Naessens, 2024
Bruxelles	1200–1350	Urban	3	MEB-EDS	Unpublished report Goemaere, 2021
Damme	1200–1400	Urban	3	Macro SR-FN	Termote, 1992; Naessens, 2024
Damme	1200–1300	Urban	1	Macro SR-FN	Naessens, 2024
Damme	1100–1200	Urban	1	Macro SR-FN	Deconynck et al., 2021; Naessens, 2024
Gent	1200–1325	Urban	2	Macro SR	Unpublished
Hoeke	1450–1550	Harbor	1	Macro SR-FN	De Clercq et al., 2022; Naessens, 2024
Hoeke	1200–1500	Harbor	9	Macro SR-FN	Trachet, 2016; Naessens, 2024
Huppaye	1400–1500	Rural	4	Macro EG	Unpublished report Goemaere, 2024
Huy	900–1000	Rural	1	MEB-EDS	Unpublished report Goemaere, 2021
Knokke-Heist	1200–1500	Fishing village	1	Macro SR-FN	Hillewaert, Huyghe, Van Besien, 2010; Naessens, 2024
Koksijde	1100–1600	Abbey	6	Macro FN	van Royen, 2003; Naessens, 2024
Kortrijk	1250–1500	Urban	3	Macro FN	Naessens, 2024
Kuurne	1250–1500	Rural	1	Literature	Kars in Kalshoven & Verbeek, 2015
Lanaken	1000–1500	?	1	Literature	Augustin et al., 2019
Lier	1000–1200	Rural	1	Literature	Cryns et al., 2014
Lokeren	1250–1500	Farm	1	Literature	Scheltjens & Veraart, 2015
Monnikerede	1100–1600	Harbor	8	Macro SR-FN	Trachet, 2016; Naessens, 2024
Oostende	1200–1400	Fishing village	28	Macro SR-FN	Pieters, 2003; Naessens, 2024
Oudenburg	1000–1500	Urban	1	Macro SR	Unpublished
Ruien	750–900	Rural	1	Macro SR	Verbrugge et al., 2021
Tubize	1200–1600	Rural	3	Macro EG	Unpublished report Goemaere, 2024
Varsenare	1000–1500	Rural	xx	Literature	Hollevoet, 1997/1998
FRANCE					
Ardres	1000–1900	Rural	3	Macro PP	Unpublished
Avion	1000–1900	Rural	1	Macro PP	Unpublished
Bonneuil-en-France	750–1050	Rural hamlet	1	MEB-EDS	Ben Kaddour, 2021
Bourbourg	1250–1350	Rural	2	Macro PP	Lançon, 2024
Bourbourg	900–1099	Rural	1	Macro PP	Lançon, 2024
Carvin	1250–1500	Rural	1	Macro PP	Praud, 2015
Conchil-le-Temple	1400–1500	Rural	3	Macro PP	Cercy, 2011
Craywick	1000–1900	Rural	1	Macro PP	Lançon, 2024
Crépy-en-Valois	900–1100	Rural	1	MEB-EDS	Flucher in prep.
Croixrault	1000–1900	Rural	1	Macro PP	Gapenne, 2019
Dieppe	1275–1400	Harbor	3	Macro PP	Guillot, 2018
Fiennes	1300–1400	Urban	2	Macro PP	Willot, 2014
Lille	1100–1500	Urban	8	Macro PP	Cense in prep.
Lille	1000–1900	Urban	2	Macro PP	Lascour, 2015
Marck	1275–1425	Rural	1	Macro PP	Bouche in prep.
Marck	1500–1900	Rural	1	Macro PP	Blondeau, 2011
Marck	750–1500	Rural	1	Macro PP	Boueilh in prep.
Saint-Omer	1200–1400	Urban	4	MEB-EDS	Huber in prep.
Saint-Omer	1225–1725	Ubran	1	Macro PP	Maniez, 2022
Saint-Omer	1500–1600	Ubran	1	Macro PP	Cercy, 2012
Saint-Omer	1225–1725	Ubran	7	Macro PP	Cercy, 2018
Steene	1000–1900	Rural	1	Macro PP	Delauney in prep.
Tourcoing	1300–1500	Urban	12	MEB-EDS/Macro PP	Barbieux in prep.
Villers-Cotterêt		Castle	2	Macro PP	Guillot in prep.
THE NETHERLANDS					
Alblasserdam	1000–1500	Rural	4	Literature	Van Pruisen& Kars, 2006
De Stenen Kamer	1000–1500	Rural	1	Literature	Kars, 2001b
Flevoland	1522–1537	Shipwreck	xx	Literature	Overmeer, 2018
Geldermalsen	850–1050	Rural	4	Literature	Boreel, 2015
Houten	1125–1250	Rural	3	Literature	Kars, 2001a
Huis Malburg	1250–1500	Rural	4	Literature	Oudhof et al., 2000
Nederlek	1250–1500	Rural	1	Literature	Pruissen& Kars in Labiau, 2007
Nijmegen	800–1300	Rural?	1	Literature	Pruissen & van den Broeke in van den Broeke & Braven, 2009
Paalvoetsijde	1200–1500	Rural	3	Literature	Pieters, 2003
Stavoren	1500	Shipwreck	xx	Literature	Opdebeeck et al., 2014
Tilburg	650–1200	Rural	3	Literature	Knippenberg in Zon & Dijkstra 2015
Tilburg	1000–1900	Rural	1	Literature	Drenth in Tol, 2015
Utrecht	1150–1300	Farm	9	Literature	Van der Kamp, 2019
Warder	1540–1550	Shipwreck	1	Literature	Opdebeeck & Coenen, 2021

Fig. 15. Selection of Eidsborg whetstones found on different early-medieval, medieval and modern sites of Northern France. Pictures and cross-sections scale 1:2, by P. Picavet.

heart of the Paris Basin and along the Meuse and Scheldt valleys.

4.2. Whetstones morphology

Three types of wear coexist and reflect three distinct types of use: a central concavity reveals passive use of the stone held in the hand; a thinning of the ends testifies to active use, notably for sharpening scythe blades; U and V shaped longitudinal grooves are associated with an abrasive function, for example to sharpen needles. The stones are very intensively used until the surfaces completely wear down and finally break. This high degree of fragmentation makes it difficult to determine their original shape and dimensions. They belong to type IIB1 of what Kars called "bar-shaped whetstones" (Kars, 1983: 3 & 11) and have a parallelepiped shape and a rectangular to square cross-section (Fig. 15). When the corners are too worn, the cross-section appears elliptical. In some rare cases, simple splinters appear to have been (re-) used (Saint-Omer 2700–2). These may be broken fragments that have been reshaped or reused after breaking, or, in the earlier periods, these can be blanks directly imported from the quarries.

Only one whetstone coming from Tourcoing has a perforation at one end. These perforations are sometimes mentioned from the Eidsborg productions: 7 stones out of 400 are perforated at Dorestad (The Netherlands), with a cylindrical to biconical hole of 0.2 to 0.5 cm in diameter (Kars, 1983: 14); 19 out of 870 are perforated and 10 partially perforated at Kaupang (Norway; Resi, 2011: 389). A stone from Conchil-le-Temple, of late-medieval date (15th century), is incomplete but approaches the dimensions of a complete one: a length of 19.6 cm, a width of 3.7 cm and a thickness of 1.8 cm for a weight of 194 g. In general, the length of the whetstones is rarely measurable but the width/thickness ratio is fairly constant. By establishing the deciles of the statistical series, 90 % of the widths are between 2.04 and 3.6 cm (median 2.65 cm), the thicknesses between 0.87 and 2.8 cm (median 1.5 cm). This allows a certain standardization to be considered.

5. Discussion

Although Viking and medieval times were heydays of the Eidsborg whetstone production and distribution, supposedly pre-medieval finds are reported from archaeological excavations in the northern Netherlands (Huisman, 2017). In order to confirm this early appearance, these early cases would deserve a thorough (petrographic) examination.

Norwegian whetstones were already widely distributed between the 8th and 10th centuries in the areas where Scandinavian influence was most intense (Hansen, 2011; Baug et al., 2024) (Fig. 14). The Eidsborg and Mostadmarka rocks we have studied are frequently found in these areas and may account for 1/4 to 1/3 of the supply of whetstones in the main trading ports (the *emporia*): material from Mostadmarka from the 8th century onwards, Eidsborg muscovite schist from the first half of the 9th century onwards. Whetstones from Mostadmarka have been quarried and exported in Viking times, but declined rapidly from the 11th century onwards, leaving the entire market to the Eidsborg quarries. Later quarrying in Mostadmarka is known in the 17th century and possibly 19th and 20th centuries, but no intermediate exploitation is known (Bakmark, Rø, 2014; Baug, 2022). Our study shows that this rock did never reach the Belgian and French coasts, neither in the Middle Ages nor in modern times.

Between 800 and 900, southern Scandinavia was already well supplied with Eidsborg whetstones around the commercial hubs of Kaupang in southern Norway and Ribe and Hedeby/Haithabu on the west coast of the Jutland peninsula (Myrvoll, 1985: 43; Baug et al., 2019: 45-46). Sweden, however, does not seem to have received any until the 10th century (Kresten, 1997: 206). If they did occasionally reach Western Europe during this period, it was as a result of diffuse and potentially indirect interpersonal connections. However, a large series of 20 Eidsborg stones and 18 from Mostadmarka have been identified at Dorestad (now Wijk bij Duurstede) in the Netherlands, in association with Scandinavian soapstone vessels (Kars, Wevers 1982). The *emporium* of Dorestad played an essential role in trade between the Frankish Empire and the North Sea, as the port served as a transshipment point between the Rhine and the sea. This is evidenced by the large quantities of quernstones made from Eifel volcanic rock found all around the North Sea as far east as Jutland from the middle of the 8th century (Parkhouse, 1997; Parkhouse, 2014; Picavet, 2021: 330-335). Imports of whetstones in this *emporium* proved to be particularly early for the southern North Sea region, as the destruction of the port took place around 860 (Kars, 1983). In view of this distribution, one could expect some Eidsborg whetstones in the earlier layers of the *emporium* of *Quentovic*/La Calotterie in Northern France, but none has been identified so far.

Following the movements of Scandinavian populations, the stones also reached the coasts of Iceland from the 9th century onwards. According to S. Hansen (Hansen, 2011), the whetstones were transported as personal equipment in the luggage of migrant populations without any real commercial nature being attributed to this movement. From another perspective, I. Baug interprets the quantity of Norwegian whetstones from the 9th/10th century in Poland and Denmark as the result of long-distance trade (Baug et al., 2024: 63). A quick comparison could point to a Scandinavian presence in Dorestad and therefore to relations with the Carolingian Empire, to which the dynamic Frisian merchants travelling the North Sea belonged (Lebecq, 1989). The occasional presence of these whetstones quite far inland could therefore be explained as well by the passage of the Vikings as by the mobility of merchants in the Early Middle Age.

For much of the early Middle Ages, the port of Kaupang was controlled by the Danish kings and served as a commercial hub until its decline and the development of the port of Skien in the 10th century. A wreck excavated at Klåstad (Tjolling near Larvik on the south coast of Norway) in 1970, dating from around 800 and carrying a cargo of 50 Eidsborg whetstones, ensures the link between the places of production and use (Christensen, 1970). At Kaupang (Resi, 2011: 373 & 384), Bergen, Hedeby and Ribe, several whetstones from the Viking period were found in the form of rough-outs and slabs (Baug, 2022: 219), indicating that they could be shipped as blanks for further finishing. The 10/11th century whetstone from Bourbourg in Nothern France is also a blank without any trace of shaping other than the detachment of the rough block. In contrast, in Iceland, no traces of local shaping have been identified during the same period, which suggests that the whetstones arrived as finished products accompanying the migrants and not as trade objects (Hansen, 2011: 71).

In the 10th-11th centuries, the Eidsborg whetstones became commodities for trade when the Scandinavian colonies established direct exchanges with the local populations, in conjunction with the development of trading towns. This was the case in Great Britain, where Norwegian stones are virtually absent during the Anglo-Saxon period (Evison, 1975: 78), but are present on the east coast when Viking incursions were most frequent and violent (Moore, 1978: 67, Fig. 3). They did spread over a wider area of the territory from the 11th century onwards (Ellis, 1969; Moore, 1978), which can be linked to the Norman conquest of England, completely opening up the markets to Scandinavian trade (Crosby, Mitchell, 1987: 491). In Iceland, during the same period, a few clues (rough blocks and cut waste) suggest that the stones were finished before being redistributed in the ports of Gásir and Kolkuós. Trade then took the form of the exchange of goods, which can be seen in Scandinavia in the form of Belgian, German, Dutch and English ceramics (Myrvoll, 1986: 163), luxury goods, clothing, salt and Rhenish millstones (Baug et al., 2019: 48).

Between the 11th and 15th centuries, whetstones from Eidsborg became widely available throughout the North Sea and Baltic basins, potentially via the major fairs that attracted traders from all over Europe. The proportions vary across different sites, but in certain locations as in the Zwin region, Eidsborg schist occasionally constituted the majority of the assemblage during various centuries of the Middle Ages, suggesting a consistent and regular supply. In addition to the Tourcoing and Saint-Omer sites mentioned above (§ 5.3.), the Winchester site (UK) has 56 Eidsborg whetstones out of 136 between the 10th and 15th centuries, Northampton has 12 stones out of 17 between the 10th and 15th centuries, and Hull has 8 stones out of 8 between the 10th and 15th centuries (Moore, 1978). In Flanders, the toll rate from the merchant settlement of Lettersswerve shows that the import of whetstones was regulated at the entrance of the Zwin inlet as early as the second half of the 12th century (De Groote, 2000; Verhulst et al., 1998). The origin of the whetstones is not specified in this text, but given the dominance of Eidsborg material on medieval sites in this coastal area (cf. sites of Hoeke, Monnikerede, Damme and Brugge), we can assume that the text was talking about Norwegian ones. In 1358, the whetstone trade was one of the privileges of the town of Skien (Myrvoll, 1985: 31), which served more than before as a transshipment port between inland Norway and the North Sea. A wreck discovered 100 m upstream from Skien (the Bøleship), loaded with whetstone blanks and dated to around 1380, illustrates the delivery of semi-finished products to the finishing workshops in Skien before redistribution (Daly, Nymoen, 2008). After shipment, however, as in Iceland, there is still some evidence to suggest that the stone was sometimes transported in the form of blanks: stone chips from Eidsborg have been identified in London in 13th-14th century layers (Myrvoll, 1985: 37).

Trading posts and associations of foreign merchants were set up to bring goods to the cities of the low countries, with the task of defending their interests and defining, in the form of charters, the way in which they would negotiate in trading ports. One of these, the Germanic Hanseatic League, took on unprecedented importance and dominated trade in the Baltic and North Sea from the 12th to the 17th century. Although whetstones were never transported as entire cargo loads in shipwrecks and instead circulated as part of mixed shipments, they still reached Western Europe on a large scale, at times nearly monopolizing whetstone trade (eg: Saint-Omer).

From the 15th century onwards, the data are sparse due to the absence of stone-tool studies for more recent periods. In 1460, the Hansa diplomas from Lübeck (Northern Germany) still mentioned the shipping of whetstones from Eidsborg (Falck-Muus, 1920). However, both in Great Britain (Ellis, 1969: 182) and in the Ardennes area (Goemaere, Declercq, 2012), other productions developed and conquered part of the markets. This explains the loss of commercial niches for Eidsborg stones. Nevertheless, they are still present on certain sites: in France at Marck and Saint-Omer, in Belgium at Beveren. They were still in the majority on certain sites in Great Britain in the 16th and 17th centuries (Myrvoll, 1985: 39) and still made up 80 % of Icelandic assemblages (Hansen, 2011: 69).

Two wrecks dating from the 16th century delivered the Netherlands (Manders et al., 2014: 26-27; Opdebeeck, Coenen, 2021: 66) and illustrate the permanence of their long-distance transport at that time. The wreck of Lake Flåvannen in Norway, discovered between the quarries of Eidsborg and the port of Skien, demonstrates that at least the start of the same circuit still existed at the beginning of the 19th century (Nymoen, 2009). Unfortunately, the entire distribution during this period cannot yet be assessed.

We do not have any data in northern France and in Belgium for the contemporary period. Further research is needed on museum collections and find assemblages derived from preventive excavations. On the Norwegian side, production remained significant and reached impressive scales. I. Baug estimates that with the widespread use of explosive mining in the first half of the 19th century, a worker could extract 400 to 1000 blanks per day, and up to 2000 with good quality rock (Baug, 2022: 216). In 1850–1851 alone, 2,691,000 whetstones (about 820 tons) were exported (Berg et al., 2016). In 1920, Falck-Muus estimated that 20,000,000 hones were shipped to Skien in the period between 1861 and 1918 (Falck-Muus, 1920). The diffusion of Eidsborg stones reached a global scale as early as the beginning of the 19th century. The 1804–1805 records at the Commerce Collegium in Copenhagen, cited by P. Nymoen (Nymoen, 2009) show that the Eidsborg whetstones were exported to the West Indies to be used as scythe stones on the sugar plantations.

6. Conclusion

The interdisciplinary efforts of archaeologists and geologists consistently yield valuable results, as demonstrated once again by the scope of this collaboration. For the first time, the Norwegian origin of medieval whetstones from 6 sites in northern France and Belgium is demonstrated. The phyllosilicates of the analyzed stones show high magnesium and iron contents, a signature of Norwegian (either Eidsborg or Mostadmarka) whetstones. The analysis of biotites and chlorites makes it possible to discriminate those from Eidsborg from all other rocks and particularly those from Mostamarka.

The highlighted trade routes show an exceptional longevity of more than a millennium, reaching distances of more than 1500 km by sea. The Scandinavians established new commercial and consumption habits when they settled in the Channel – North Sea basin, and these continued until the 19th or even the 20th century by going through different political, economic and social changes that Europe experienced during this time.

During the "Viking period", Eidsborg whetstones were present in *emporia* around the North Sea but very rare inland. These commercial places, whose multicultural and multi-ethnic character is evident, bring together goods from the four corners of the North Sea (Rossignol, 2018), but not all of them are found in the hinterland. In Dorestad, Norwegian stones are even concentrated in the port areas, indicating that they are not yet really the subject of long-distance trade. They can have been exchanged in the form of barter, but can also indicate the presence of Scandinavian personnel in the main markets.

Throughout the remainder of the Middle Ages, the establishment of a quasi-monopoly can be explained by a very regular connection between Scandinavia and the various ports of the North Sea, as well as by the establishment of trading posts and inland relay stations along the navigation axes, ensuring the redistribution of commodities. The Hanseatic League undeniably played a central role in the continuation of these networks between the end of the Middle Ages and the Modern era.

However, according to historical sources, whetstones often accompanied other commodities in mixed cargo: wood, dried cod, iron, etc. Although the latter have often disappeared or have been recycled, whetstones are a valuable proxy for the reconstruction of commercial networks due to their good conservation and not being recycled.

Despite very inconsistent documentation from one country to another (it was almost non-existent until now for France and Belgium), the inventory of whetstones described in European literature already contains more than 650 pieces dating from the Early Middle Age to the modern period, distributed over 155 sites in north-western Europe. As such, this collaboration of French, Belgian and Dutch researchers contributes to the complex puzzle of the Channel – North Sea economic system in the Middle Ages.

Uncited references

Alden and O'Mahony, Batey et al. (2012), Ben Kaddour (2022), Bill and Rødsrud (2017), Blondeau (2017), De Boer (2006), Foslie (1949), Hansen (2017), Kars (2000), Kars (1995), Munch (2003), Nielsen (2008), Roberts et al. (2019), Shaffrey (2011a), Shaffrey (2011), Shaffrey (2017), Skre (2017), Trachet et al. (2017), Van Os (2021), Van Pruissen and Kars (2007), Van Pruisen and van den Broeke (2009).

CRediT authorship contribution statement

Paul Picavet: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Investigation, Conceptualization. **Roland Dreesen:** Writing – review & editing, Validation, Resources, Methodology. **Thomas Goovaerts:** Methodology, Formal analysis.

Thierry Leduc: Methodology, Investigation, Formal analysis. **Fien Naessens:** Resources, Data curation. **Timo G. Nijland:** Validation, Resources, Methodology, Investigation, Formal analysis. **Sibrecht Reniere:** Writing – review & editing, Validation, Resources, Methodology, Investigation. **Éric Goemaere:** Writing – review & editing, Validation, Resources, Methodology, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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