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Lede Stone: A potential “Global Heritage Stone Resource” from Belgium

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Lede Stone is an important dimension stone with major relevance for Belgian and Dutch cultural heritage. It is sourced from the Eocene (Lutetian) Lede Formation, mainly in the region to the southeast of Ghent in Belgium. The oldest known use dates back to Roman times. With the rise of Gothic architecture during the middle ages, the use of Lede Stone increased substantially. Quarries arose at different locations at different times. Today only one active quarry remains, after a period of non-production during the 20th century. Current production is mainly used for restoration purposes. A major concern is the use of alien stones as a substitute for Lede Stone in cultural heritage restoration. In the light of the establishment of the “Heritage Stone Task Group”, this paper deals with requirements of its “Terms of Reference” and illustrates the stone’s nature, technical properties, utilization and associated issues. It should contribute to the cultural appreciation and preservation of this stone.

Introduction

Lede Stone is an important historic building stone from northwestern Belgium. It combines the unique aesthetic quality of a pale, workable sandy limestone with petrophysical values typical of high-strength rocks. The stone represents a valuable part of the built cultural heritage of northern Belgium and the Netherlands. In the light of the recent establishment of the “Heritage Stone Task Group” (HSTG), this paper deals with the proposed “Terms of Reference” for Lede Stone to be designated as “Global Heritage Stone Resource”. Not only would this recognize the value of the Lede Stone in the built heritage of northern Belgium and the Netherlands. Moreover, designation of Lede Stone as Global Heritage Stone Resource would be beneficial for conservation of geological outcrops, preservation

of Lede Stone in the built environment and would invigorate the importance of ongoing production.

Lede Stone has long been used as a dimension stone for buildings, artwork and other constructions. The stone is closely associated with specific architectural styles and the socio-economic history of its source and application regions. It is strongly intertwined with the charming appearance of several historical centres of cities such as Ghent, Brussels, Bruges and many others.

Despite existing active quarries, the introduction of alien stones as replacement can be seen as a threat to cultural heritage. This is an issue which has concerned specialists for more than a century. It may be addressed by the recognition of Lede Stone as a heritage stone of international significance.

Geology and petrography

Lede Stone is a sandy limestone quarried from the Lede Formation. The shallow marine sands from the Lede Formation were deposited during the Lutetian (Eocene) in a southern North Sea bight (Jacobs and Sevens, 1993; Jacobs and De Batist, 1996). These sands are interpreted as a stepwise transgressive deposit with correlative unconformities overlying a ravinement surface. Some lithified horizons, commonly up to three, within these sands gave rise to the natural building stone resource. Fobe and Spiers (1992) recognised 3 facies types in the Lede Formation. They describe the most important Meldert facies as a shallow marine facies with storm deposits. This facies includes the principal building stone resource (see below). A deeper marine facies without storm beds is found to the north, where these NNE-dipping layers are buried by younger Cenozoic sediments, and to the west, where outcrops can be found in the hill flanks of some outliers. The third facies from the southernmost outcrop represents more near shore deposits. The latter two facies are less relevant as a stone resource.

Lede Stone is mainly quarried between the Rivers Scheldt and Dyle (Fobe, 1990), with its principal production centre to the southeast of Ghent (Figure 1). Its major resource location is the town of Balegem (Oosterzele) and its surrounding communities. Therefore, the alternative name Balegem Stone is not uncommon. Lede Stone, on the other hand, is a more correct reference to its lithostratigraphical

Figure 1: Map with geographical locations mentioned in the geological description. The main production centre is marked by the shaded area.

status, which was first described in Lede where there was also historic production. Some outliers of the Lede Formation occur in the hills to the east and west of this region, as far as Cassel in France and east of Brussels. In the latter, Lede Stone was quarried in underground galleries.

Lede Stone is a mixed siliciclastic-carbonate rock, consisting of

a quartz fraction together with other detrital grains of glauconite and carbonate allochems with a matrix/cement (Figure 2). Therefore it has been classified either as a sandy limestone or as a calcareous sandstone. Since the amount of carbonate exceeds 50 vol-% of the rock, this rock can be preferably classified within carbonate rock classifications. In general, it can be determined as an ‘arenaceous sparry packstone’ (Dunham) or a ‘poorly washed sandy biosparite’ (Folk) or a ‘sandy allochem limestone’ (Mount). Given the natural variability in the stone, more precise denomination is best provided to individually assessed stone blocks.

The nature of the bioclasts indicates a shallow marine fauna. The most diagnostic fossils are the foram *Nummulites variolarius* and the serpulid *Ditrupastragulata*. Echinoderms, bivalves, gastropods and shark teeth are the most common macrofossils, which are commonly deposited as shell beds. The microfauna is predominantly milioloid and textulariina forams. The siliclastic composition is dominated by a bimodal quartz population (up to 40 vol-%) of subangular very fine sand fraction supplemented with rounded medium sized sand. Glauconite is commonly present in 2-3 vol-%. Accessory minerals are feldspars, zircon, tourmaline, micas and opaque minerals (e.g. pyrite).

Matrix may be present, but is sometimes washed away. Epitaxial crust can occur around echinoderm fragments and not uncommonly around nummulitids. Cement is most commonly present, from fine grained microsparite to coarse grained sparite in some cases, and is mostly rich in iron. There is no silicification.

The porosity is mainly defined by intergranular and intragranular porosity; however moldic porosity can considerably contribute to porosity and appearance.

Figure 2. (A) Natural variability within the Lede Stone. (B) PPL micrograph of Lede Stone. (C) XPL micrograph of Lede Stone.

Historic production and use

The oldest evidence of quarrying and use of Lede Stone dates back to Roman times. Archeological finds prove the mining and use of Lede Stone around Balegem during the 2nd and 3rd century. Such records are considered at the Provincial Archeological Museum (PAM) in Velzeke (Nijs, 1990). Since the 11th century, Lede Stone has been quarried and used for larger constructions. The production of ‘white’, workable Lede Stone benefited from the emerging Gothic architecture. Many production sites arose at different towns during the Middle Ages (De Smet *et al.*, 2003). These were exploited by the abbeys, stonemasons or private owners. The Abbey of Affligem was one of the first commercial producers in the 12th and 13th century; they probably exported stones to the Netherlands and Germany (Groessens, 2011). Nearby, quarrying delivered stone for constructions in Aalst, Gent and Antwerp.

By the beginning of the 14th century Lede Stone was sought by architects for prestigious buildings. Architect Jan van Haelst ordered the stone from Vlierzele for the building of the Belfry and St Michael’s Church in Ghent (Van der Kelen, 1996; De Smet *et al.*, 2003) and architect Peter Appelmans, working on the Our Lady’s Cathedral of Antwerp visited the quarries owned by the Abbey of Affligem (Groessens, 2011).

It is impossible to determine the production rate or total volume. The total volume of Lede Stone for constructing the 15th century St Walburga Church in Oudenaarde amounted 1108 m³ (Van der Kelen, 1996). A small recalculation demonstrates that this is equivalent to a quarry pit with a surface area of more than 1000 m², assuming a useable total thickness of 1 m for the typical occurrence of three stone banks. The total surface over which stone has been quarried over the centuries must therefore be reasonably high.

During the 16th century, the centre of gravity of quarry production shifted towards Balegem (De Smet *et al.*, 2003). The “House of the Free Boatmen” and the “Guildhouse of the Bricklayers” in Ghent are magnificent examples of late Gothic constructions in stone from Balegem.

Since the 17th century, Lede Stone was increasingly used as a

decorative element in combination with brick masonry. Quarries in the area of Brussels remained important during the 17th and 18th century, but had disappeared by the 20th century (Gulinck, 1949). By this time, Lede Stone was being used for restoration, with only limited use for new constructions, such as the St Peter Railway station in Ghent. In the area of Balegem, production ceased and by beginning of the 20th century, the last quarry closed in Bambrugge (Figure 3).

The production of such large volumes of Lede Stone was and remains dependent on quarrying at many locations with only limited volumes of stone being sourced from the subsurface. This contrasts with many other natural resources, where quarries produce large volumes from one location.

Contemporary availability and issues

In 1966, Verlee BVBA started to produce Lede Stone as by-product from a sandpit in Balegem. In 2011, Balegro BVBA took over the sand pit and the associated stock of Lede Stone. Production continues today and Lede Stone remains available for restoration works. However, because of low quantity, diverse stones have been imported as replacement material for Lede Stone, both in Belgium (De Kock *et al.*, 2014) and in the Netherlands (Quist *et al.*, 2013). This was already an issue more than hundred years ago, as a consequence of the actions of architects Mortier in Belgium and Van der Veen in the Netherlands (Quist and Nijland, 2013). Mortier, charged with the restoration of the “House of the Free Boatmen”, investigated the resources in an abandoned quarry wall in Balegem (Mortier, 1898). Van der Veen often travelled to Belgium to purchase Lede Stone from the remaining quarry in Bambrugge or utilised stone recovered from the demolition of buildings in Belgium for restoration in the Netherlands (Quist and Nijland, 2013). By the end of the 20th century, replacement of Lede Stone in monuments was so drastic, that architect Breda described the use of dissimilar foreign stones in a metaphor as a disease (Breda, 2005). This awareness suggests that the use of authentic materials is not only beneficial for aesthetic purposes, but also for stone compatibility and durability.

Figure 3: (A) Occurrence of Lede Stone as discrete stone banks (arrow) in Balegem quarry in 2010. (B) Remnants of quarry pit in Bambrugge. Arrow indicates remnant stock.

Technical publications and illustrations

More technical information about Lede Stone has been incorporated in several professional magazines and books published in Belgium and the Netherlands. These works also illustrate its use in some prominent buildings. Among the most leading publications have been Berends *et al.*, 1982; van Hees *et al.*, 2005; Cnudde *et al.*, 2009 and Duser *et al.*, 2009. New technical tests have been performed

recently at Ghent University on the demand of and delivered to the Balegro BVBA company (Table 1).

A non-exhaustive illustrative list of Lede Stone in buildings can be found at <http://www.belgiumview.com>. An illustration of Lede Stone as building stone in a historic building in Belgium (Fig. 4), historic bas-relief (Fig. 5), modern house (Fig. 6), modern sculpture (Fig. 7) and as building stone in a historic building in The Netherlands (Fig. 8) is provided in this paper.

Figures 4-8. (4) St Bavo's Cathedral (Ghent) with Lede Stone and other white stone types such as Brussels stone, Gobertange Stone and Euville Stone. (5) Bas-relief in Lede Stone above the entrance of the House of the Free Boatsmen (Ghent). (6) Modern house in Lede Stone (Leeuwerikstraat, Zottegem). (7) Sculpture 'De Schepenbrief' in Lede Stone in Dikkelvenne; monument for a charter from 1249: 'Schepenbrief van Bochoute'. (8) City Hall Veere (the Netherlands), built by the end of 15th century with masonry in Lede Stone.

Table 1: GHSR Nomination/Citation requirements

Formal Name	Lede Stone
Other Names <i>Historical</i> <i>Regional</i>	witten ordu(y)n Balegem Stone, Dender Stone, Afflig(h)em Stone, Houtem Stone
Place of Origin	northwestern Belgium
Resource location <i>Principal</i> <i>Secondary</i>	Balegem (Oosterzele) and surrounding communities underground in and around Brussels
Quarrying	Since 11th/12th century by stone masons and abbeys, mainly in open air except for Brussels. Since 1966 at Balegem in open air sand pit, before by Verlee BVBA, nowadays by Balegro BVBA
Heritage issues	No outcrops or quarries are currently protected or preserved. Some legacy of old quarrying can be seen in the landscape, although always overgrown. The holostratotype was defined by Mourlon (1887) in the Balegem sandpit, but is no longer visible. Many buildings in Lede Stone are listed as cultural heritage. Lede Stone is also prominent in the Grand Place of Brussels, which is inscribed by UNESCO World Heritage.
Petrographic Name	Sparry arenaceous packstone (Dunham), Poorly washed sandy biosparite (Folk), Sandy allochem limestone (Mount)
Colour	Greenish-gray or yellowish-gray in reducing conditions, yellow-brown to orange or ochre in oxidizing conditions
Natural variability	From compact and low-porous to coarse moldic high-porous; high differences in concentrated fossil content
Suitability	Durable dimension stone, used for ashlar and for sculpting
Stratigraphy	LedeStone belongs lithostrati-graphically to Lede Formation, which is of Eocene (middleLutetian) age, nannofossil zone NP15b
Commercial designations	Only one commercial stone type. Distinctions are sometimes made for shell beds and associated stone with elevated porosity called 'lumachelles'. Historical designations can refer to the quarry location.
Physical properties (Mean) <i>Apparent density</i> <i>(NBN EN 1936:1999)</i> <i>Open Porosity</i> <i>(NBN EN 1936:1999)</i> <i>Mean Saturation coefficient</i> <i>Capillary absorption</i> <i>coefficient</i> <i>(NBN EN 1925:1999)</i> <i>Compressive strength</i> <i>(NBN EN 1926:1999)</i> <i>Flexural strength</i> <i>(NBN EN 12372:1999)</i> <i>Ultrasound velocity</i> <i>(NBN EN 14579:2004)</i> <i>Abrasion resistance</i> <i>(NBN EN 1341:2001)</i> <i>Frost resistance</i> <i>(NBN EN 12371:2010)</i>	$2448 \pm 29 \text{ kg/m}^3$ $8,27 \pm 1,09 \text{ vol.}\%$ $0,75 \pm 0,07$ $11,98 \pm 4,07 \text{ g/(m}^2\text{vs)}$ $48,4 \pm 12,6 \text{ Mpa}$ $17,6 \pm 3,9 \text{ Mpa}$ $4359 \pm 41 \text{ m/s}$ $19,00 \pm 1,19 \text{ mm}$ Nc 168
Vulnerability & maintenance of supply	Lede Stone is suitable for use as dimension stone and is only produced at Balegem, Belgium. Supply issues result from the limitations of quarry sites and the need for new resource extraction locations given competition with residential expansion and nature conservation areas. The occurrence of Lede Stone as discrete stone banks results in a relatively low quarry production efficiency.
Historic use:	Lede Stone has been used since Roman times and has been utilised extensively since the 11th century in Belgium and The Netherlands. Lede Stone has been used for major architectural buildings in both countries. Since the end of the 20th century, its resources mainly supply restoration projects.
Illustrations: <i>Belgium</i> <i>The Netherlands</i>	Saint-Bavo Cathedral (Ghent); St Peter's Abbey (Ghent); St Martinus Church (Aalst) City Hall (Veere); St-Lievensmonster Tower (Zierikzee); Church of Our Lady (Breda); City Hall (Hulst)

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