Trade and use of building lime

- early 19th-century lime barrels from an excavation in Uddevalla, Bohuslän

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In the summer of 2014 four lime barrels were found during an archeological excavation in the town centre of Uddevalla, on the west coast of Sweden. This unique find consisted of three barrels of grey lime and one barrel of white lime. It is most likely that they were placed in the ground around the year 1800 and forgotten after a fire devastated the town in 1806. The consistency of the lime putty was such that it was still possible to use it for mixing mortar; the white lime more so than the grey. We try to place the find in its culture historical context through archival research, as well as through technical and chemical analyses of the lime. We try to show where it originated, who owned it and the purpose for which it was intended. Analyses of experimentally made mortars from the lime show how traditional sub-hydraulic or moderate hydraulic lime act after a longer time of storage, giving us new insight into how to make extremely fat, lime-rich mortars.

The setting

Uddevalla is first mentioned as a town in the year of 1495 and privileges were granted in 1498. It seems to have been established with a square just north of the river Bäve, and along an east-west oriented street. The settlement consisted of ordinary households without any clear archaeological evidence of specialized crafts. The town expanded during the 16th to 18th centuries, before being devastated by fire in 1806 (Svedberg 2005).

Today, the remains of the town's archaeological deposits agree approximately with the oldest city

Figure 1. Map of Scandinavia with the location of the town of Uddevalla and other places mentioned in the text.

plan from 1690. The topography is hilly, but close to the mouth of the river relatively flat, thus subject to seasonal flooding. Flooding was partly prevented by the construction of the docks to the south of the town square. During the summer of 2014, we found evidence of these docks. A riverwall, comprising timber-framed box revetments, each measuring 2 x 2 m, and two rows deep was built the length of Bäveån where it enters Byfjorden within the built-up part of Uddevalla. These box revetments were dendrochronologically dated to sometime after the spring of 1528. They were filled with a mix of household waste, dumped materials and brushwood. On top of the box revetments, we found settlement phases largely dating from the 17th and 18th centuries. The inhabitants lived in relative affluence that increased over time. Marco-fossils from latrines show that figs and oysters were eaten. Seeds include strawberries, lingonberries, cloudberries and crowberries. The high consumption of wild berries is interesting because this predates the wide availability of sugar. The varied osteological material confirms the overall picture of bourgeois wealth, confirmed especially by the presence of game such as hare and deer. We can also see early

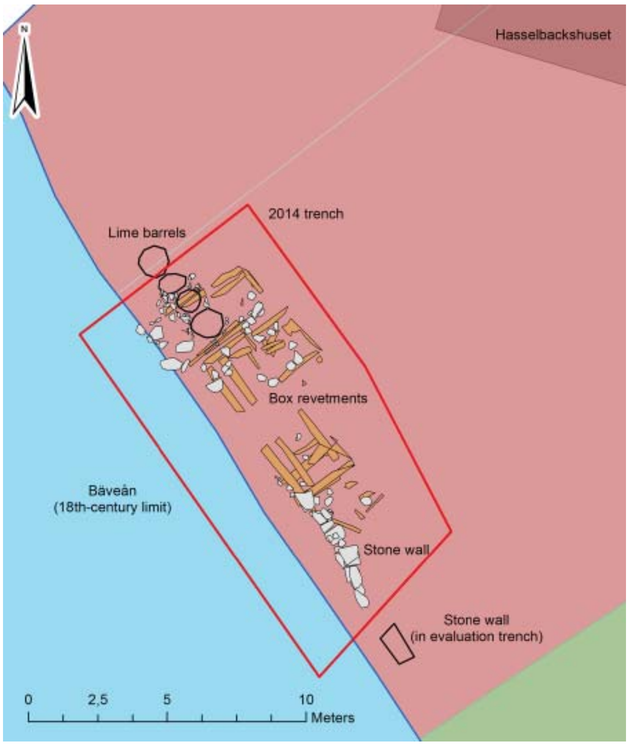

Figure 2. Plan showing the most important features and structures from the excavation in the town park, Hasselbacken, in Uddevalla during the summer of 2014.

18th century imports of chinaware in the material.

The most remarkable find however, was a feature parallel with and just about a metre from the old riverbank. The pit was quite large and contained the remains of four huge barrels filled with lime putty, most likely originally dug around 1800.

The find led to questions about trade and the use of building lime in the early modern period. Where did the lime come from? Which was the common trade routes for lime? How would lime have been transported?

Other questions more specifically concerning traditional lime-use could also be addressed. How was the lime slaked and stored? Is it possible to discern different kinds of lime, e.g. rich lime, sub-hydraulic or moderate hydraulic lime, and if so, for were they used differently in a mortar? And what was the actual purpose; can we find similar lime in the buildings nearby? Can the lime still be used, after two centuries of storage? And how does the workability of the lime putty compare with other locally produced lime putties in Scandinavia?

Four big barrels in a pit

The four large barrels full of lime putty were placed in a large pit, 4.7 by 1.6 metres wide and approximately 1 metre deep. The fill consisted of redeposited 17th and 18th century material from truncated earlier deposits, the most recent finds dating to c. 1770. On top of the barrels there were traces of a cover, consisting of at least ten slats of small dimensions, along with some nails. Directly on top of the cover we found significant amounts of

Figure 3a. Photo of the lime barrels (from the left) 4, 3 and 2, which were excavated during the summer of 2014. They have differing sizes but seem to hold similar lime putties. Photo: Kristin Balksten.

Figure 3b. Close-up of lime barrel 3 with the individual birch staves clearly visible. Photo: Niklas Ytterberg.

Figure 3c. Photo of the base of barrel 4, made of pine. Photo:Veronica Forsblom Ljungdahl.

large roof tile frag-ments and broken bricks. One could imagine the barrels wrapped in a now-degraded organic cover, on top of which the bricks were placed to ensure the contents were protected. A levelling layer had been dumped sealing the cover, consisted mainly of loose humus-rich sand with some gravel. A macrofossil sample from that layer has been interpreted as deriving from stable-dung. A sequence of thin deposits of seashell and gravel, dating to shortly after the devastating town fire in 1806, is interpreted as different levelling layers.. However, there was a notable absence of layers yielding charcoal and associated destruction material that might be expected following a fire; this indicates that earth has been moved away after the fire.

In order to gain a better understanding of how the lime putty was prepared and treated, a more detailed description of the barrels is required. The biggest barrel, to the north-west, measured 1.15 m in maximum width, and the second biggest, at the end of the row to the south-east, measured around 1 m. The two barrels in the middle were slightly smaller, c. 0.8 m. The height differed from c. 0.8 to 1 m, making the barrels a bit wider than they were high. The barrels were bulged slightly in the middle, as usual. The staves were very poorly preserved. Impressions of the staves in the lime putty revealed an individual width of 0.10 - 0.15 m (4 to 6 inches) and a thickness of about 25 mm (1 inch). Preserved fragments of hoops indicate that they appear to be made of birch, whereas the bases of the barrels are made of pine. No head or lids are preserved, but these may very well never have been present. Three of the barrels contained a more greyish, lumpy lime and one barrel a distinctly white, creamy lime. We saw quite a lot of lime lumps in the pit, especially in the top fill close to the barrels' mouths. A probable explanation for this is that quicklime spilled over in the process of tipping it from smaller barrels to these ground-fixed barrels.

Lime pits have been found in archeological contexts before, on Gotland, but most of the lime had already been used and removed (Zerpe 2013; Widerström 2014).

About lime, lime barrels and lime trading

In the 17th-19th centuries lime was produced all over Scandinavia. Where limestone occurred, the production of lime for construction was certainly going on. Remains in the landscape still bear witness to lime kilns and quarries. In the county of Bohuslän, the bedrock mainly consists of granite and the only local source of lime was mussel shells from shell banks (Linné 1978). A royal decree from 1717 informs us that lime kilns were in use at the shell banks outside of Uddevalla (Kristiansson 1953, p. 92). Nevertheless, lime from mussel shells was of poor quality and mostly used for agricultural use. When studying west coast trade routes between 1575 and 1850, Sandklef (1973) found evidence of many shipments of lime from the island of Gotland in the Baltic Sea and also from Slependen in the Oslo fiord in Norway. After 1645 Gotland became a part of Sweden and soon after, in 1658 Bohuslän also became Swedish. From this time on, the export of burned and slaked lime from Gotland to a range of destinations increased rapidly. Imports to Bohuslän included the Gotlandic lime although imports from the nearby areas in Norway continued as before (Sandklef 1973; Kittelsen 2005).

During the actual time period limestone with different qualities were used (e.g. Siöbladh & Engeström 1750; Henström 1869, p. 63 pp; Johansson 2006). The qualities depended on the types of limestone, the most important factor being the content of clay minerals. Lime was originally defined by Siöbladh & Engeström (1750) as fat versus lean lime or white versus grey lime. In the 19th century it was described as rich lime versus poor lime versus hydraulic lime (Pasch 1826; Vicat 1837; Rothstein 1890). In the middle of the 19th century, as industry grew in Sweden, demand for the rich, pure and fat lime increased, as it was used both in the iron and paper industries as well as for agricultural use (Thorslund 1936; Munthe et al. 1945). When Skokloster Castle in the county of Uppland was built in the 17th century, the cheaper grey lime was used as a bedding mortar and in the inner layers of renders and plasters, while the white fat lime of the preferred, best quality from Gotland was used for upper coat and lime wash (Andrén 1948).

The consistency of the white lime found in Uddevalla was creamy, probably close to the original consistency from the time when it was slaked. Before it was beaten, the consistency of the grey lime was more like hard soap. From an early 19th century description (Vicat 1837, p. 6pp) of the consistencies of different kinds of lime as rich, poor, moderately hydraulic, hydraulic and eminently hydraulic, we can identify the contents of the lime barrels from Uddevalla as one barrel of rich lime and three barrels of moderately hydraulic lime.

The lime was transported in special lime barrels, either as slaked lime or more seldom as quicklime (Munthe et al. 1945). Handling of quicklime would pose severe danger during transportation. It would react explosively if it came in direct contact with water, with fatal consequences as a result (cf. von Arbin 2014, p. 49-50). Quicklime is also extremely caustic.

When studying the Gotlandic lime export-trade it is apparent that the ships and their cargo were measured in lasts (sw. läst). One last contained 12 lime barrels of 110 litres (Munthe et al. 1945, p. 120), but after 1805 one last contained 13 barrels (sw. måltunnor) or 26 lime barrels/half barrels of 55 litres. Those smaller half barrels had a height of 0.75 m (30 inches) and a diametre of 0.3 (12 inches) (Munthe et al 1945). The total volume of one last from Gotland was then about 0.7 cubic metres, a volume corresponding approximately to the volume of each big barrel found in Uddevalla. The lime export of Slependen in Norway was made in lime barrels containing approximately 140 litres of lime after 1604 (Kittelsen 2005). Lime barrels used for transportation were thus normally smaller and easier to handle, compared with the big barrels found in Uddevalla. These lime barrels must have been intended only for storage, not for transport. If calculating roughly with the volume of a cylinder, the barrels seems to have contained some 0.4 to 1.0 cubic metres of lime, weighing some 0.9 to 2.2 tonnes each. The dimensions corresponds closely to the volume of three to seven ordinary Norwegian barrels each. During transportation, the total amount of lime would have corresponded to three and a half lasts as quicklime, or 2.3 lasts as slaked lime.

Henström (1869) also describes the storage of lime in barrels, especially where there was a wish to store unslaked lime for a period of time. He pointed out the importance of storing the lime in sealed barrels. If the lime was hydraulic, the barrels could not be sealed by letting the wood swell when in contact with water (which happens when stored underground). Instead the barrels had to be sealed from the outside, first with putty (sw. kitt) and then with thick paper attached with glue and soaked in oil. Hydraulic lime had to be stored as a very compressed powder. As a result, the barrels had to be completely filled and the lid placed tight on top of the lime powder. Thereafter the lid and the bottom had to be covered with putty and oil soaked paper as well. In this way barrels of lime could be stored completely protected from air and water for many years. The barrels found in Uddevalla were stored in the ground where it was moist and close to water. This suggests that the lime was not handled as hydraulic lime but as rich and poor lime. The barrels had not changed shape as a result of expansion from the lime in the slaking process, as would be shown on the staves in the barrels. Therefore, it is more likely that the lime was already slaked when it was placed in the barrels in the ground.

An interesting note in the Uddevalla church records of 1826 says: "150 barrels of Gotlandic good quality lime for future use on the exterior of the church, have been dug down in a planked trench on the church's plot […] at ground level just by the chancel. It cost 186 riksdaler 12 skilling 5 runstycken Banco." A later note tells us that "This lime was used for the belfry (sw. kyrktorn) in 1833" (Uddevalla C:7). The cost equals one to two years' wages for a labourer or industrial worker (cf. Edvinsson & Söderberg 2011). This tells us, also, that the slaked lime was buried for seven years before use and that it was bought from Gotland. The total amount is uncertain, but could be estimated in the vicinity of six times as much as the lime putty in our barrels.

The lime putty

Burned lime can be slaked in many different ways. There are two methods which have been traditionally employed on Gotland to prepare lime putty: i) wet slaking (sw. våtsläckning) and ii) earth slaking (sw. jordsläckning). Wet slaked lime is produced when enough water is added to hydrate the lime to form a putty. It is an exothermic reactions and the slaked lime is approximately double volume of burned lime than if it is a pure air lime. If it is a hydraulic lime the volume becomes smaller the more hydraulic it is. The wet slaked lime can be stored if kept protected from air. Still today, lime pits are used for storage (Lisinski et al. 1989). Earth slaked lime is produced when burned lime-stone is placed in a lime pit in the ground and protected from air. Tradition states that the lime must be slaked for at least 5-7 years, but that it will be even better in time. The lime crystals then become approximately 20 times larger than the crystals in wet slaked lime (Balksten & Steenari 2010); earth slaked lime can easily

Figure 4. Lime whip from Svenneby old church. Photo: Kristin Balksten.

be recognized by the specific lime lumps in historic mortars (Balksten 2010). To be able to use earth slaked lime as a binder it must first be beaten with a lime whip (Siöbladh & Engeström 1750; Hidemark & Holmström 1984, p. 12pp).

Both kinds of lime in the Uddevalla find were grainy and stiff when found, but it was possible to whip them. As the lime was experimentally whipped it also became more runny, suggesting to us that it might still be possible to use it. In order to try out its properties as a binder, mortar samples were taken from each type, see table 1. A direct comparison can be made between our samples and earth slaked and wet slaked Gotlandic lime, which are described more completely in Traditional lime mortar and plaster (Balksten 2007).

The feel of the lime and how it reacts together with sand in mortars can inform how much of the lime that is active as a binder. The white lime of barrel 1 still contains a more active binder than the grey lime of barrel 4. The difference is also visible as the white lime is a fat type and the grey lime is a lean type, just as described by Siöbladh & Engeström (1750). This find can contribute to the understanding of historic mortars that sometimes seem extremely fat in analysis (ex. Balksten 2010; Persson 2010; Balksten et al. 2013). It suggests to us that fat mortars were simply produced by lime that was slaked to be putty and then stored for a longer time before being used in mortar, with the effect that the hydraulic components acted as aggregate rather than binder.

Analyses of the lime

The lime samples have been subject to chemical analyses (Lindqvist

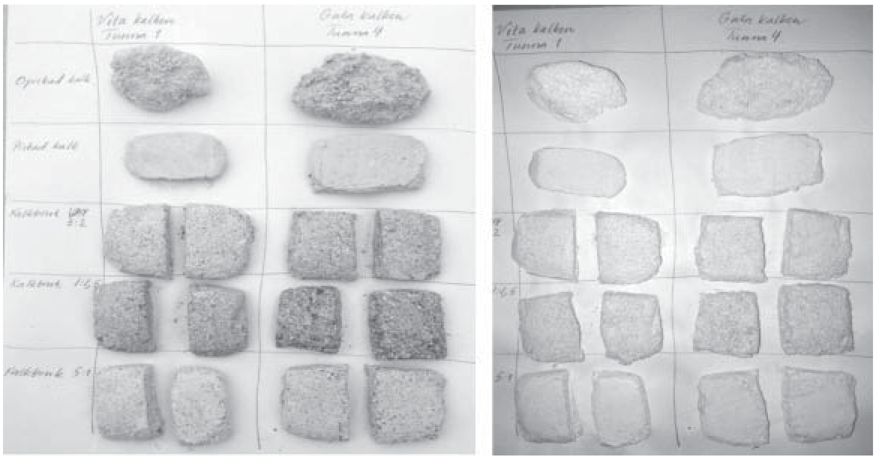

Figure 5. The experimental samples when they are fresh (to the left) and after two weeks (to the right), when they have been dried white. The samples that seamed very lean as fresh appeared more lime rich after hardening. Photo: Kristin Balksten.

Table 1. Description of lime and mortars in barrels 1 and 4 from Uddevalla.

	Lime barrel 1 (white lime)	Lime barrel 4 (grey lime)
a. Un-whipped lime	Grainy consistency with well distinguishable lime lumps. Warm white colour.	Grainy consistency with well distinguishable lime lumps. Grey-yellow colour with lime lumps in both yellowish and white colour and varied size.
b. Whipped lime	The lime can easily be beaten. As it is whipped it becomes runny and the lime lumps can be divided to pieces. The lime putty becomes smooth and homogeneous. The lime is not very sticky and gluey.	The lime can easily be beaten but there are many grains in the lime that can't be divided into pieces. The grains are often in the size of 2-3 mm. They can be identified as gravel and lime lumps.
c. Lime: sand 3:2 in volume	A mortar with a surplus of lime but it doesn't feel as fat a lime mortar in comparison with the earth slaked Gotland lime, more like 2:3.	Despite the surplus of lime in the mortar, it didn't act as a fat mortar. It feels leaner than the lime in barrel 1.
d. Lime: sand 2:3 in volume	This lime mortar feels more like a lime mortar of 1:3. The mortar is very lean and the sand becomes dominant.	Feels like a very lean lime mortar, approx. 1:4. The sand as well as the lime lumps becomes dominant in this mortar.
e. Lime: sand 5:1 in volume	This is an extremely fat lime mortar but it feels more like a lime mortar of 1:1 of earth slaked lime/sand.	A very fat lime mortar but it feels as 2:3 of earth slaked lime/sand.

Table 2. Chemical analysis of lime barrels 1 and 4 from Uddevalla. Cement index (CI) = 0-0.15 is a pure lime, 0.15-0.3 is a sub hydraulic lime and 0.3-0.5 is a feebly hydraulic lime.

	Al_2O_3	CaO	SiO_2	FeO_3	MgO	Cement index
Barrel 1	0.6	61	3.8	0.4	0.7	0.19
Barrel 4	1.1	56	4.8	0.5	0.8	0.26

2014) and with polarization microscope of thin sections. The chemical analyse shows that the lime of barrel 1 is a sub hydraulic lime and that the lime of barrel 4 is a feebly hydraulic lime, according to modern definitions (Lindqvist & Johansson 2009), see table 2.

When we use the term hydraulic lime, it means that the lime will harden in the presence of air and water. In a sub-hydraulic or a feebly hydraulic lime there will be some particles at least that will harden when stored in a wet environment, as we can see in the lumps present in the barrels found in Uddevalla.

Thin section analyses have been made from unbeaten lime and from mortars made of lime and sand (ratio 3:2), see samples 1a, 1c, 4a and 4c in table 1. Lime lumps can be

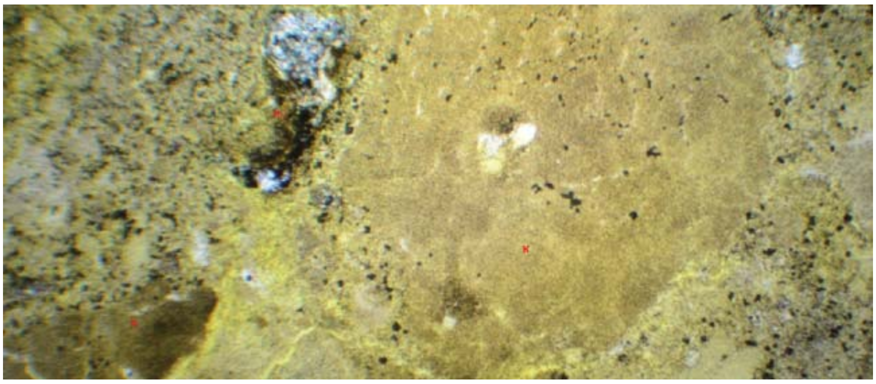

Figure 6. Thin section of unbeaten lime from barrel 1, enlarged 50x in polarization microscope. The lime paste is rather homogeneous and the lime lumps are of the same kind as the rest of the binder showing a rather pure lime. Photo: Kristin Balksten.

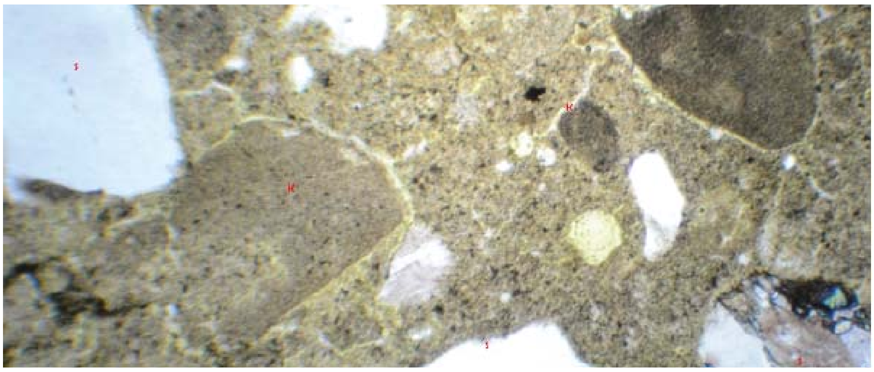

Figure 7. Thin section of lime mortar with sand (3:2 in mixing ratio) from barrel 1, enlarged 50x in polarization microscope. Most of the lime could be beaten and is therefore working as a binder. Lime lumps with hydraulic components exist in a small amount. Photo: Kristin Balksten.

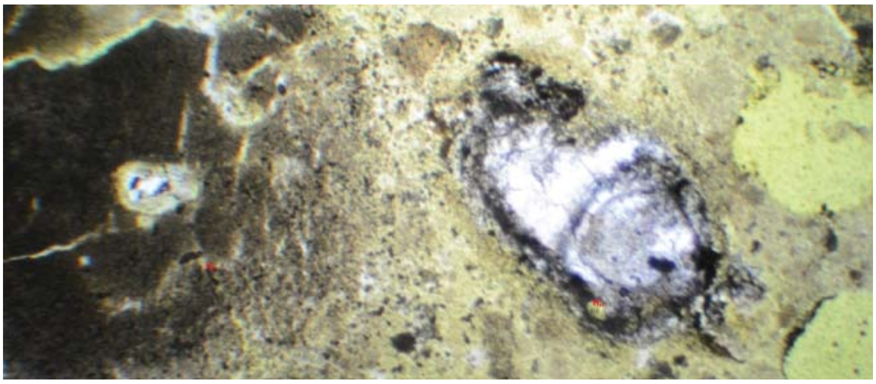

Figure 8. Thin section of unbeaten lime from barrel 4, enlarged 50x in polarization microscope. The lime paste is inhomogenous with distinct lime lumps of hydraulic components. The sample looks as if it contains some aggregate rather then pure lime, which is the hydraulic components that has hardened over two hundred years. Photo: Kristin Balksten.

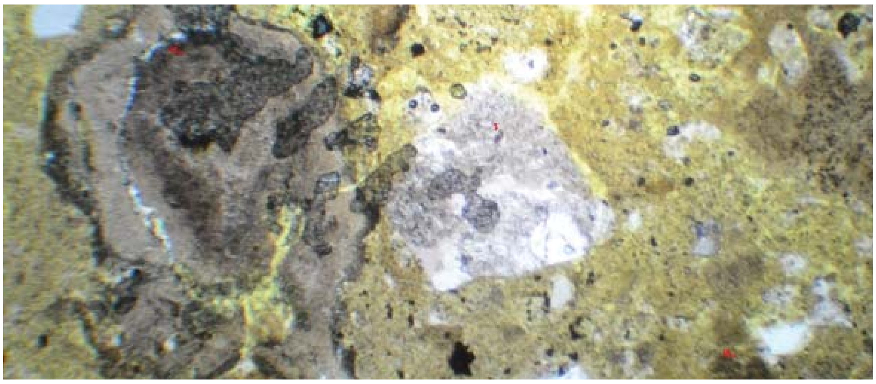

Figure 9. Thin section of lime mortar with sand (3:2 in mixing ratio) from barrel 4, enlarged 50x in polarization microscope. Both sand and hydraulic components act as aggregate in this mortar sample. Photo: Kristin Balksten.

identified as both unbeaten lime lumps and lime lumps of hydraulic lime. The amount of hydraulic particles is, as expected, much greater in the grey lime of barrel number 4. It is also interesting to note is that the hydraulic particles are not homogeneously present in the binder but as clear and distinct particles, now more visible as aggregate than as part of the binding function of the lime. The hydraulic particles are marked as KH, the pure lime particles are marked as K and sand is marked as S.

Limestone geology

The limestone used historically for producing building lime in Sweden and Norway is of three main kinds; Ordovician, Cambrian and Silurian (Shaikh 1990). The historic lime kilns can mainly be found in areas where the Ordovician and Silurian strata are present. The best known Silurian limestone in Scandinavia is from Gotland where the remains of historic Gotlandic lime kilns show that pure fat lime (95-100 % $CaCO_3$) was produced for export (Munthe 1945). Limestone from Ordovician and Cambrian strata comes in many variations and historically this kind of lime was produced in many areas of Sweden, such as Öland, Västergötland, Närke and Östergötland, as well as around lakes Siljan in Dalarna and Storsjön in Jämtland. In Skåne there is limestone from the Silurian and Ordovician periods as well as the younger period of the Cretaceous (Shaikh 1990).

In the Kristiania-field in the Oslo fiord, were Slependen is situated, there is limestone from both Ordovician and Silurian layers that was used for burning lime within a rather small geographical area (Hotledahl 1912; Kittelsen 2005). In Slependen, local peasants owned small lime kilns and lime of different qualities could therefore be produced within the same area. It is stated in the customs regulations of 1691 that “Sleben” was the only harbour in southern Norway where tolls on lime were eclared. The Oslo Castle probably contains limestone from the Slependen area, as does the fortress of Akershus and the medieval churches in the vicinity of Slependen (Kittelsen 2005). Lime with a similar chemical composition as the lime found in Uddevalla can be found in the various layers of limestone found in the Kristiania-field in the Olso fiord (Holtedahl 1912).

New knowledge about historical building lime

The lime barrel find has brought new knowledge to the research of historic lime mortars. Many of the historic mortars found are extremely rich in lime, especially those containing hydraulic lime particles (Balksten 2010; Persson 2010). As recently demonstrated by historical reconstruction, it is almost impossible to make such lime rich mortars with newly slaked lime (Persson 2012; Balksten et al. 2013). They cracked too much as they shrank during drying. However, with poor lime or moderately hydraulic lime stored, as with the Uddevalla find, for hundreds of years (and possibly much less), very lime-rich mortars can be made as parts of the binder now function as aggregate since the grains of hydraulic character have hardened. With this knowledge in mind we can analyse historic mortars of hydraulic lime and determine whether the lime was used as a hydraulic lime (directly after it had been slaked) or as a poor lime (after a certain time of storage); i.e. if the hydraulic particles are large and distinct or if they are small and part of the homogeneous binder mass. For both types of lime found in Uddevalla, more lime putty had to be used in the mixing ratio in order to make mortar with similar consistency as mortars of rich Gotlandic lime. More lime than sand had to be used for both lime putties in order to get a binding effect from the lime putty, just as can be found in historic mortars (Balksten 2010; Persson 2010).

The use of building mortar in the vicinity

Who owned the lime barrels and for what purpose did they have them? The present plot was designated a cultivated garden in the town plan of 1783, but previously a backyard to the corresponding household on the maps from 1750 and 1696. Interestingly, a house foundation was built sometime between 1750 and 1783 just to the south. It measured roughly 10 x 15 m and was situated directly on the quay-side. In 2014, we found a stretch of stone wall almost 8.5 m, corresponding with most of the western wall of the stone foundation on the 1783 map, only truncated in the northern end by recent cable trenches. This house and the household plot, as well as the garden with the lime barrel pit, were owned by the president of the town court (sw. kämnärsrätten) Count Jonas Gillerstedt. He was also a member of the magistracy and inspector of the Court of Appeal (sw. hovrättskommissarie). Gillerstedt lived until 1793, when he died aged 65 (Kristiansson 1953, p. 483). His widow Maria Katharina survived him until 1806 and both died in Bro parish in Bohuslän (Bro C:3). Obviously, he had a high social status and lived in relative affluence, as did the other inhabitants in this area. It is worth noting that the authorities issued constant regulations, due to the constant threat of fire, designed to promote the building of houses in brick or stone. In spite of that every house in Uddevalla, except the church and a hospital, were dovetailed log houses as late as 1747 (Almqvist 1949). The famous botanist Carl Linnæus describes them as large log houses, mostly with roofing tiles and wooden panels painted red. It was not until the 19th century that stone houses would become kind of a trade mark of Uddevalla (Kristiansson 1956, p. 245p).

Was the lime putty intended for the house at the quay-side? Or was it meant for the Hassel-backshuset, a great brick house with stone foundation a bit closer the town square. Unfortu-nately, there is a gap in the records regarding who owned the plot in question and the lime barrels between 1793 and 1806. Maybe the widow Maria Katharina who lived in Bro parish? After the fire in 1806, this area was meant to be laid out for house plots as before, but was changed into a big backyard a few years afterwards. A map from 1807 tells us that the then wealthy merchant C. J. Engelke (born in 1770) was to share this area with his new neighbours, such as another merchant, a lieutenant colonel, a widow of an admiral and a customs official. That never happened, as Engelke built his house over their plots only a few years later. The house Hasselbackshuset, which is still standing, was built in Dutch brick above mortared roughly worked granite footings in 1814. It is worth noting that the old vaulted cellar from a large

Figure 10. Parts of the wall in the 2014 trench with Hasselbackshuset in the background. The latter was built in 1814 and is one of the oldest standing houses in Uddevalla today. Mortar samples from the wall in the trench and the still standing house have been analysed in this study.

building still stood as a ruin a few years after the fire, not far from the current plot, and next to the main bridge. Stone from the cellars was probably used again in Hasselbackshuset (Kristiansson 1956, p. 46).

Most of the houses on the 1783 map were timber houses. Only a few had stone built cellars or foundations, which were probably erected as a consequence of increasing affluence during the latter part of the 18th century. Lime from our lime barrels could not have been intended for mortar and whitewash for either of these houses. The stratigraphic record speaks against such interpretations. Equally, it could not have been meant for the Hasselbackshuset on the same grounds. We interpret the find in the context of preparation for a forthcoming building project, which was halted by the devastating fire of 1806. This event should be dated to about the turn of the 19th century as significant evidence for the remarkable economic surge that Uddevalla experienced. It is a fact that the population of Uddevalla increased greatly, from a mere twentieth place among Swedish cities and towns in 1750, to a distinguished eighth place just 50 years later!

In an attempt to corroborate or refute such a hypothesis, additional chemical analyses were made of mortar from both the still standing Hasselbackshuset and the wall in the 2014 trench. The samples from the documented wall were both very similar, probably a subhydraulic lime of the same kind as in the barrels. A sample from the mortar between the granite footings of Hasselbackshuset was quite similar to these both. Finally, the mortar from between the bricks in the same house was clearly different, a feebly hydraulic lime with a mixing ratio different from the others (Brorsson 2015). It can be concluded that the lime putties and mortars evidently belong to the same tradition.

Conclusions

Scientific analyses of mortar is a relatively new method in Swedish archaeological research. The thin sectioning of mortar samples have proved to be rewarding, where the varied composition and quality of mortars can be used for detailed phasing of historical interpretations (Stilborg & Pettersson 2015). Earlier, visual inspection, by way of comparison with a reference collection, has enabled different building phases to be identified (cf. Feldt 2000, Eriksson 2005). This method was originally developed mainly for reconstructing good building mortars (cf. Andersson & Rosenqvist 1980; Hidemark & Holmström 1984; Kalkputs 1 1984).

The analysis of the unique lime barrels from around AD 1800 in Uddevalla has shown that they contained both a sub hydraulic lime (barrel 1) and a feebly hydraulic lime (barrel 4). The archival research and the chemical analyses together indicate that the probable origin of the lime is the area of Slependen in Norway. This stands whether or not a lot of lime was also bought from Gotland at that time, for example for the renovation of the belfry of Uddevalla church in 1833. The huge barrels must have been made specifically for storage. The lime had probably been placed in the barrels already as slaked lime, to be stored protected from the air, prior to being used as building lime. When Uddevalla burned in 1806 the barrels were forgotten and subsequently never used.

We have interpreted the find as a particularly strong expression of the accumulation of wealth in Uddevalla in the second half of the 18th century. This was as a result of trade, in particular to the great herring boom between 1747 and 1809. Wealthy burghers were keen to build houses in high status materials such as stone or brick. The actual plot for this unique find belonged, just before the turn of the 19th century, to one of the most preeminent burghers in the town. The same can be said just a few years later, when Hasselbackshuset was built close by in 1814; today, one of the oldest and most impressive houses in the town centre. In other words, this assemblage spotlights the contemporary bourgeoisie in the young town.

The find also shows that even impure lime such as a feebly hydraulic lime would be stored for some time in lime pits in the ground. Some parts of it will then harden and make the lime grainy, resulting in hydraulic particles becoming part of the aggregate rather than the binder. This information clarifies how it could have been possible to use and handle extremely fat and lime-rich mortars. It also clarifies why the rich Gotlandic lime could cost up to three times more (Andrén 1948) than lean or feebly hydraulic lime. This is due to the fact that all of the binder could be used as a binder even after long transportation and storage times, yielding up to maybe three times the amount of mortar.

Our experimental study has shown that both types of lime found in Uddevalla could still be used in a mortar after two centuries! Nevertheless, we lack craftsmen who can and want to handle extremely rich mortars, which is why it would be difficult in practice. It is also worth mentioning that if the lime were to be used today, it could not be handled as if it were hydraulic lime but, rather, as if it were only a lean lime. The hydraulic effect is long gone even if the grains of hydraulic particles are visible in the microscopic analyses.

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