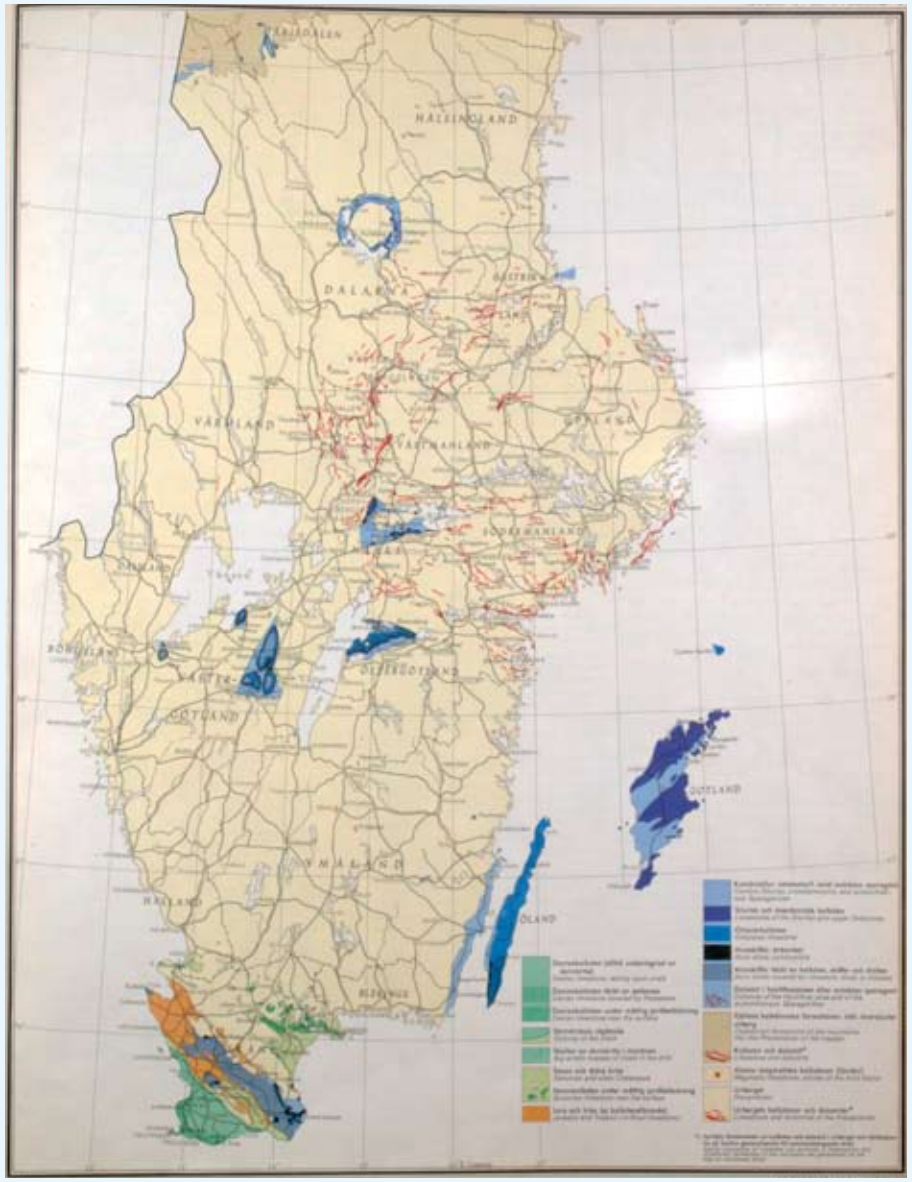
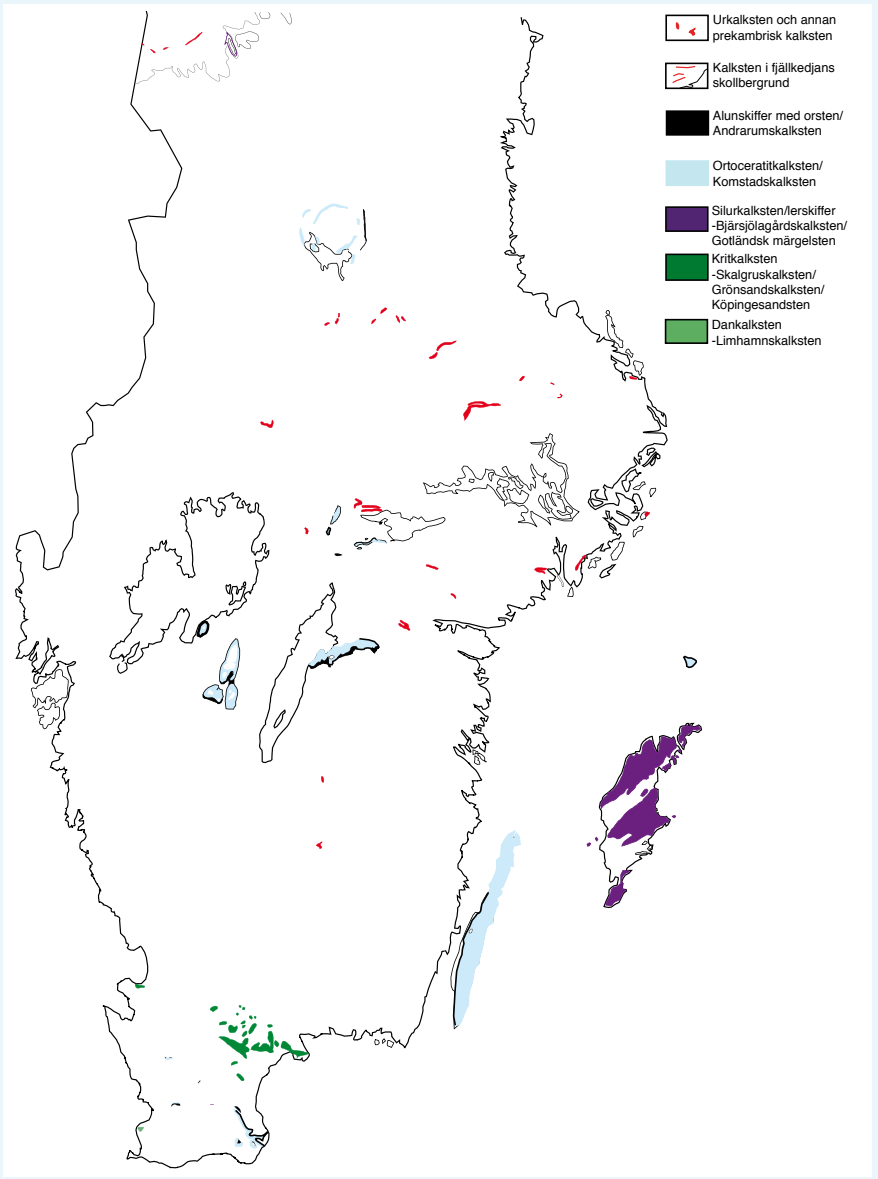
Hydraulic Lime Mortar in Sweden with examples of natural and early Portland cement

Limestone in Sweden

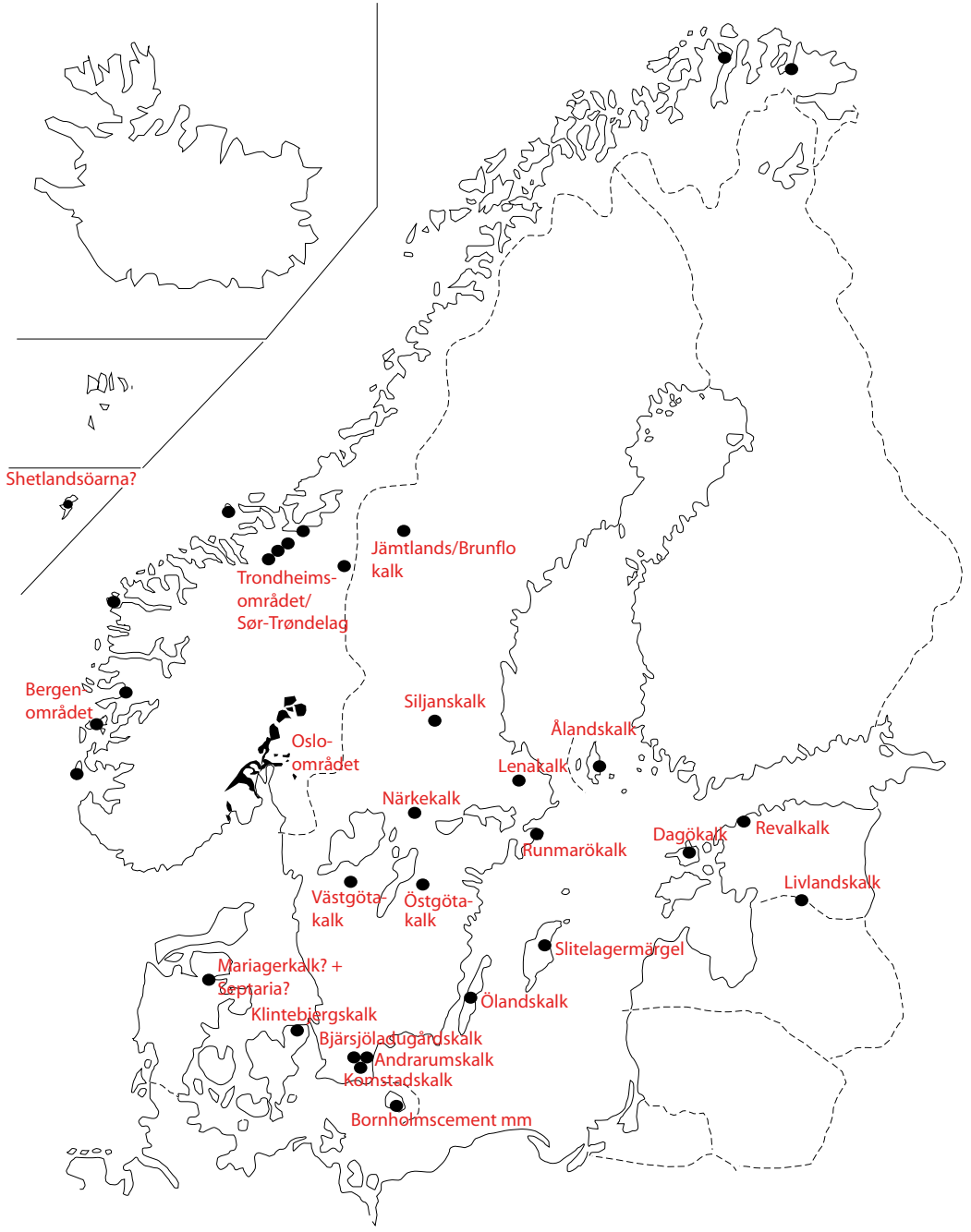


All occurrences of limestone in southern part of Sweden.



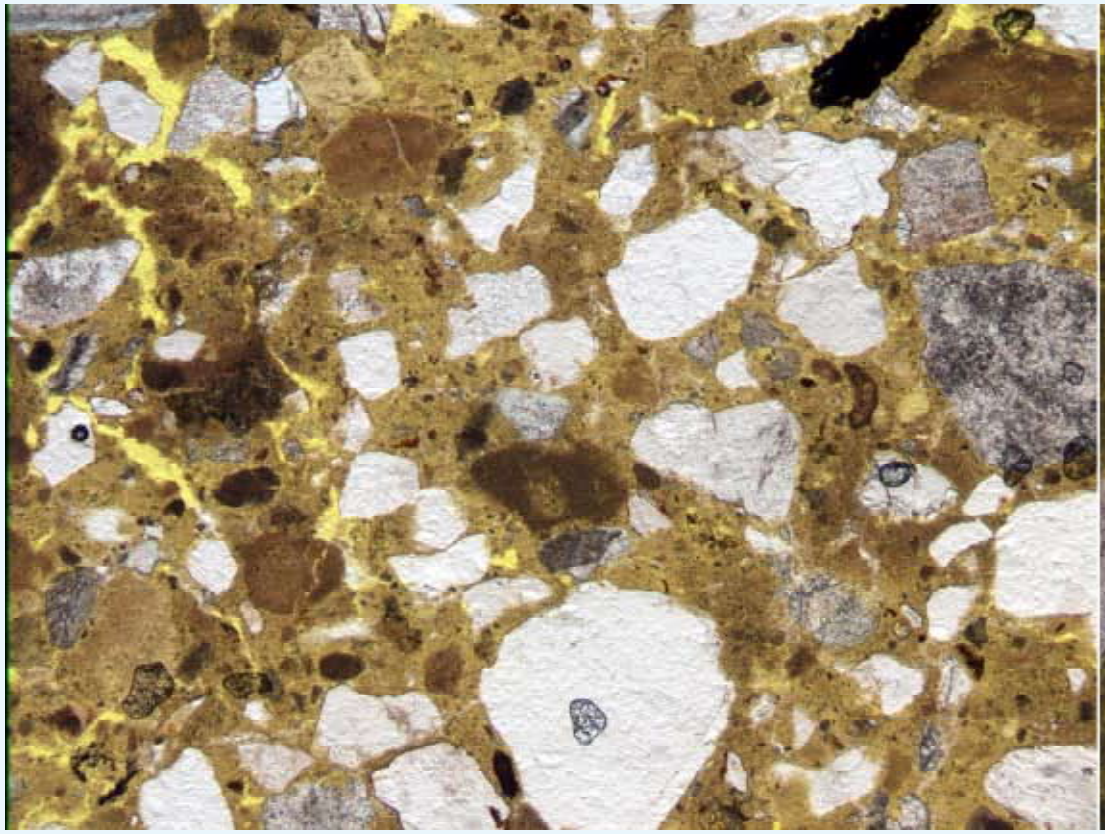
Occurrences and deposits of limestone with hydraulic components and alum shale (artificiel pozzolan).

Hydraulic Lime in Nordic countries

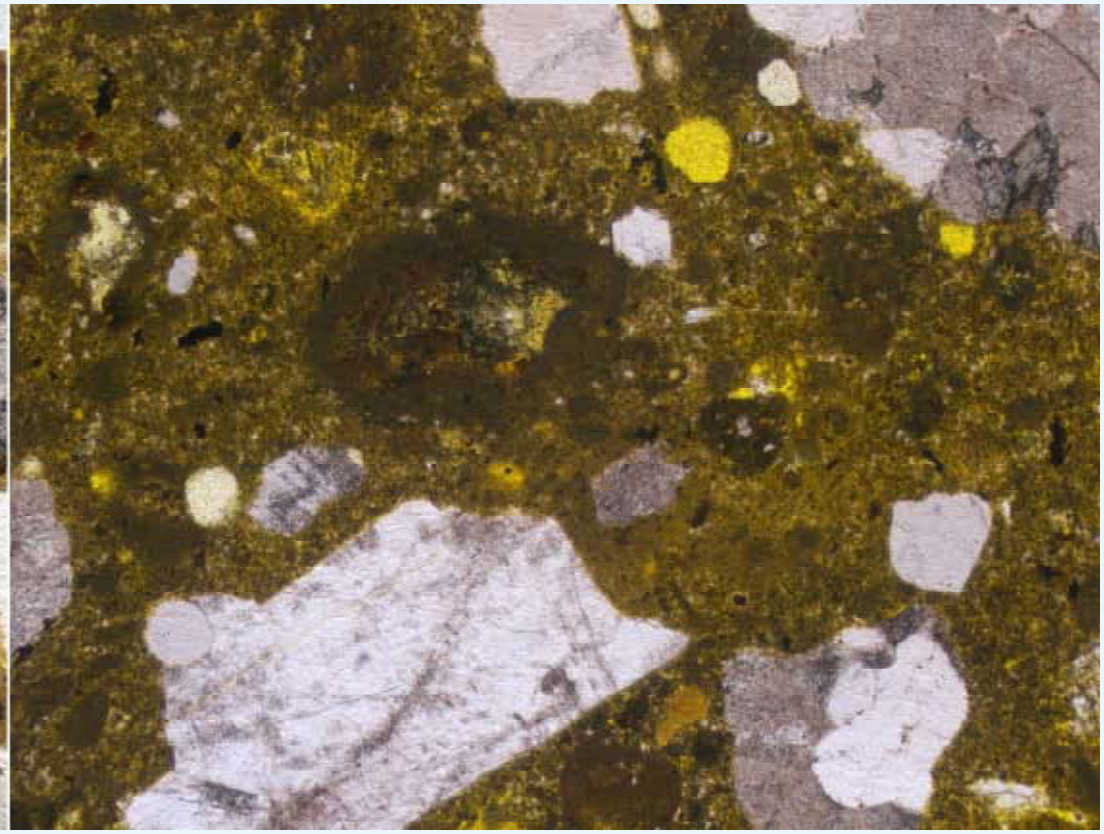


Deposits of natural sub-hydraulic and hydraulic lime and name of the limes.

Microscopical analyses of thin section



Pure lime mortar
from 12th Century



Sub-hydraulic lime mortar
from 17th Century

Chemical analyses - Cementation Index

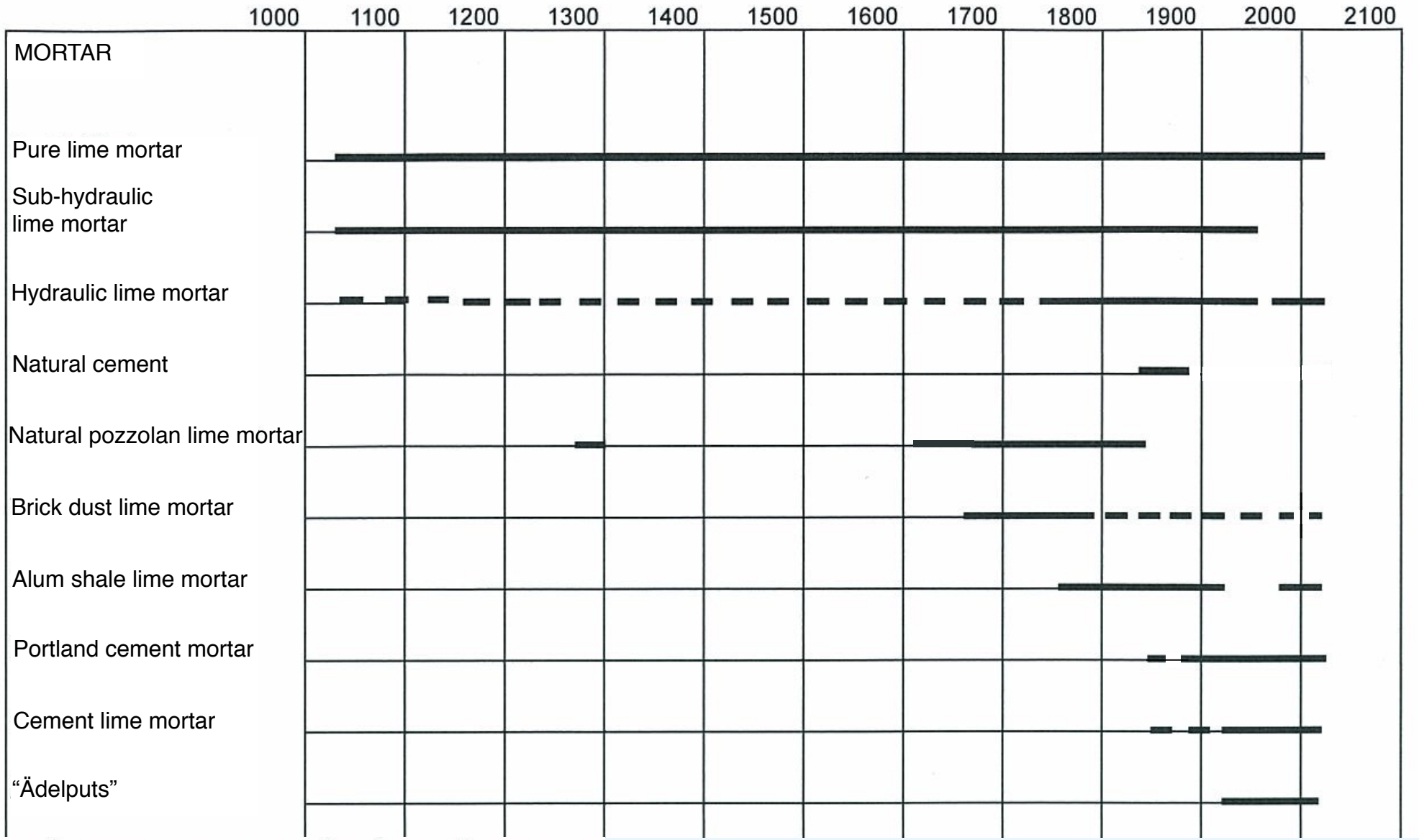
The Cementation Index CI (or Hydraulic module) is calculated according to Boynton, i.e. as follows:

$$CI = \frac{2{,}8x\%SiO_2+1{,}1x\%Al_2O_3+0{,}7x\%Fe_2O_3}{\%CaO+1{,}4x\%MgO}$$

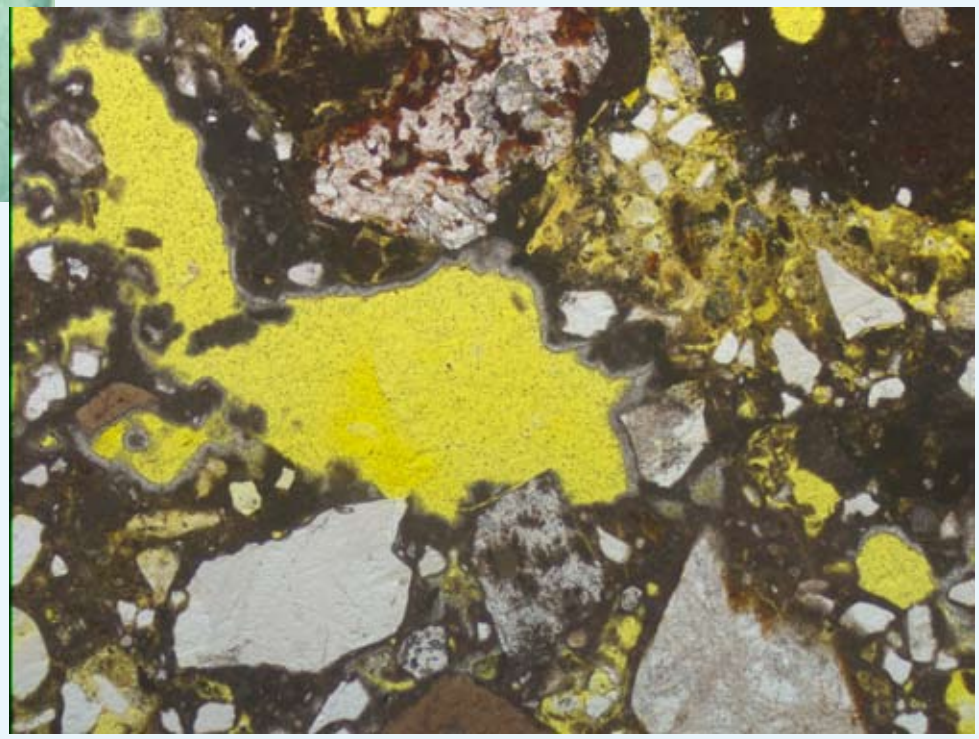
The Cementation Index for pure lime is about 0-0.3, for feebly hydraulic lime 0.3-0.5, for moderately hydraulic lime 0.5-0.7, for eminently or strong hydraulic lime 0.7-1.1 and for natural cement more than 1.1. In addition there is sub-hydraulic lime which has a Cementation Index of 0.15-0.3 according to Jan Erik Lindqvist and Sölve Johansson.

SiO2	=	Silica
Al2O3	=	Aluminium oxide
Fe2O3	=	Ferric oxide
CaO	=	Calcium oxide
MgO	=	Magnesium oxide

Development of mortars in Nordic countries



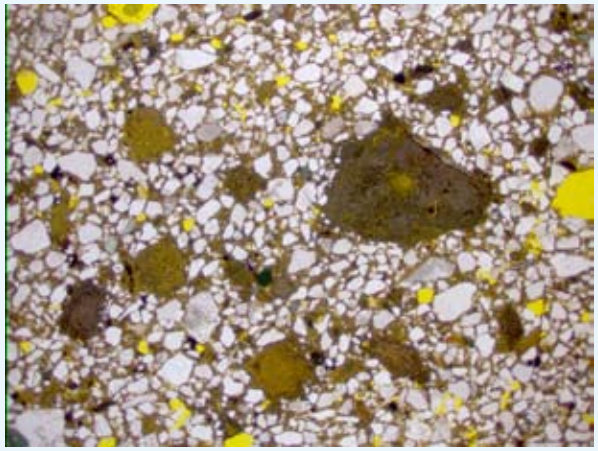
Pure lime mortar - Norwegian lime

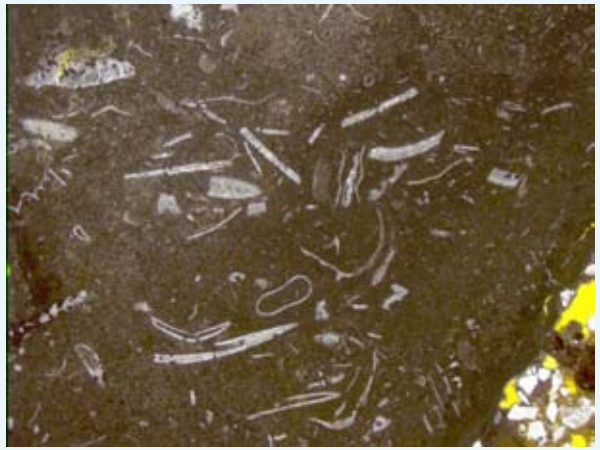


Bärfendal Church Bohuslän (1200).
Masonry mortar. Brown-grey. Lime from the Oslo region? CI = 0,09.

CI for pure lime is about 0-0,15 (0,3).

Natural sub-hydraulic lime mortar - Kinnekulle lime

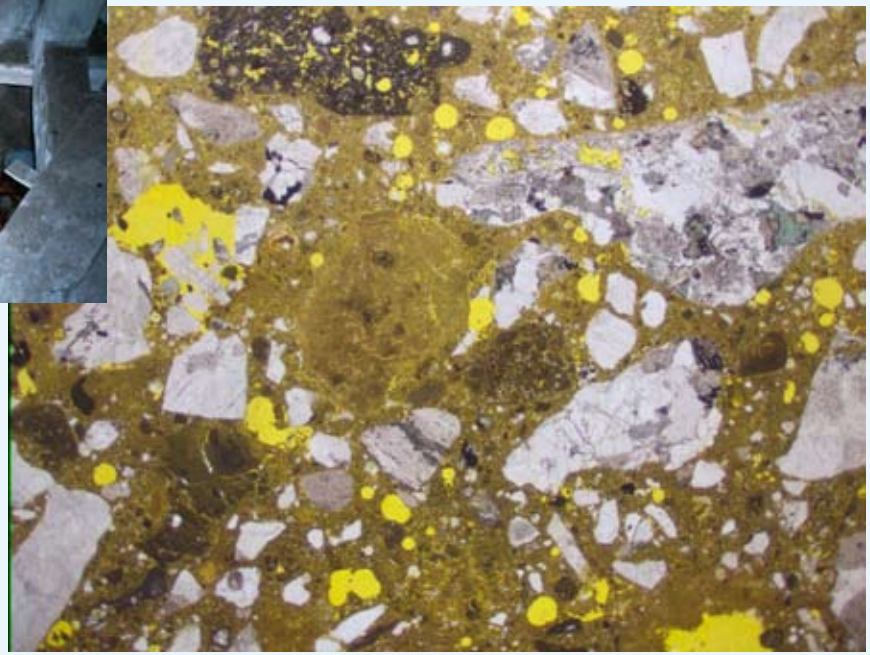




Old Ornunga Church Västergötland (1200). Masonry mortar and smoothed joints. Brown-grey. Lime from ortoceratite limestone Kinnekulle. CI = 0,23. There is even Kinnekulle lime based on stinkstone.

CI for sub-hydraulic lime is about 0,15-0,3.

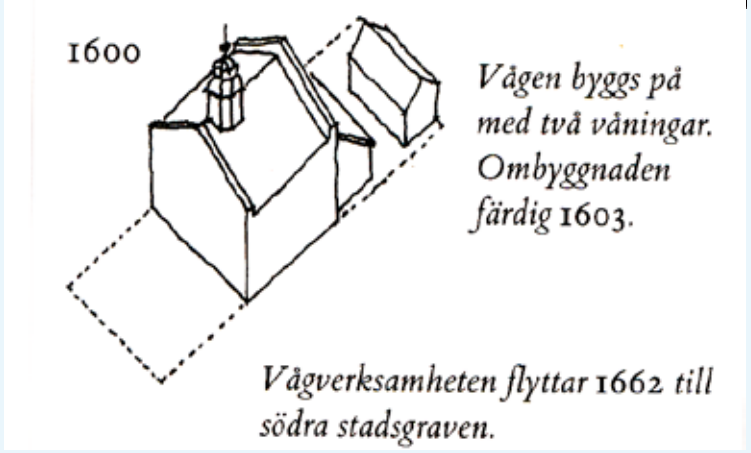
Natural sub-hydraulic lime mortar - Runmarö lime

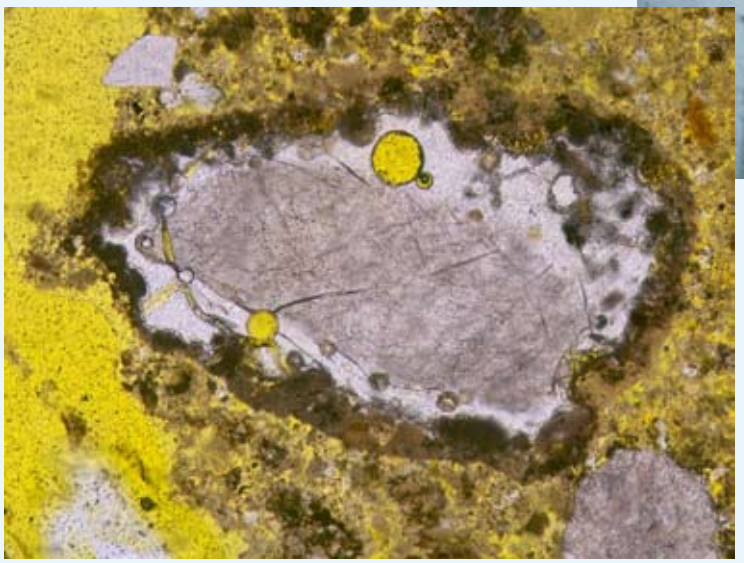


Franciscan Abbey Stockholm (now Riddarholm Church) (1270-92). Masonry mortar. Yellowich. Lime from Runmarö at the Stockholm Archipelago. CI = 0,17.

CI for sub-hydraulic lime is about 0,15-0,3.

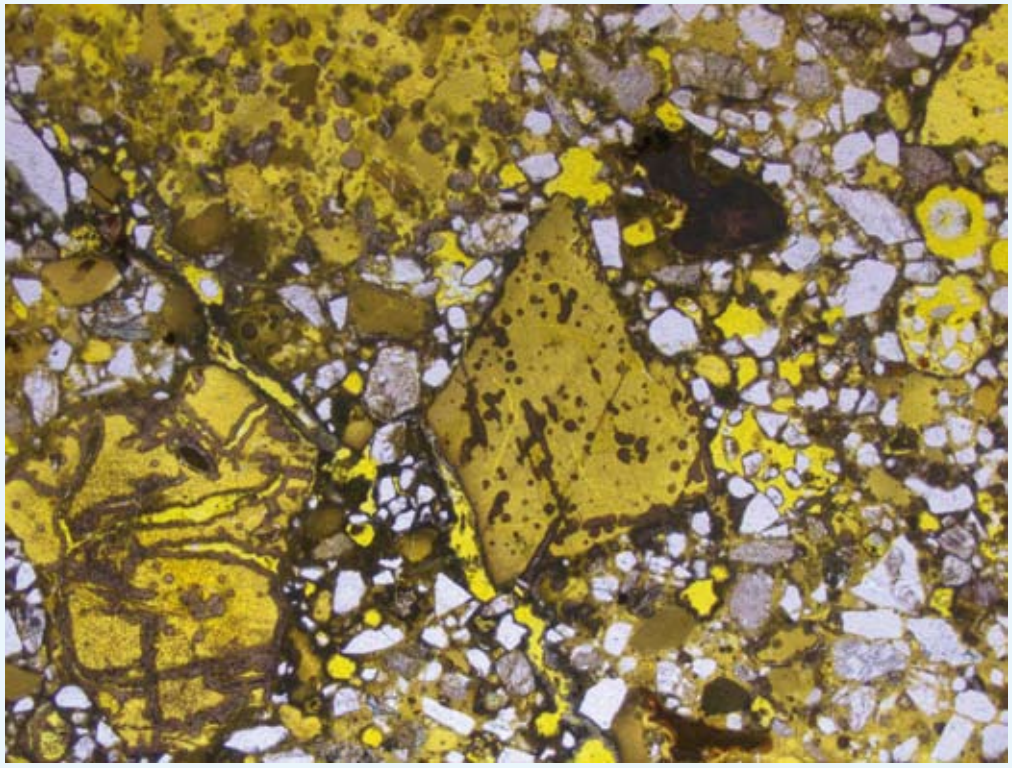
Natural hydraulic lime mortar - An early example





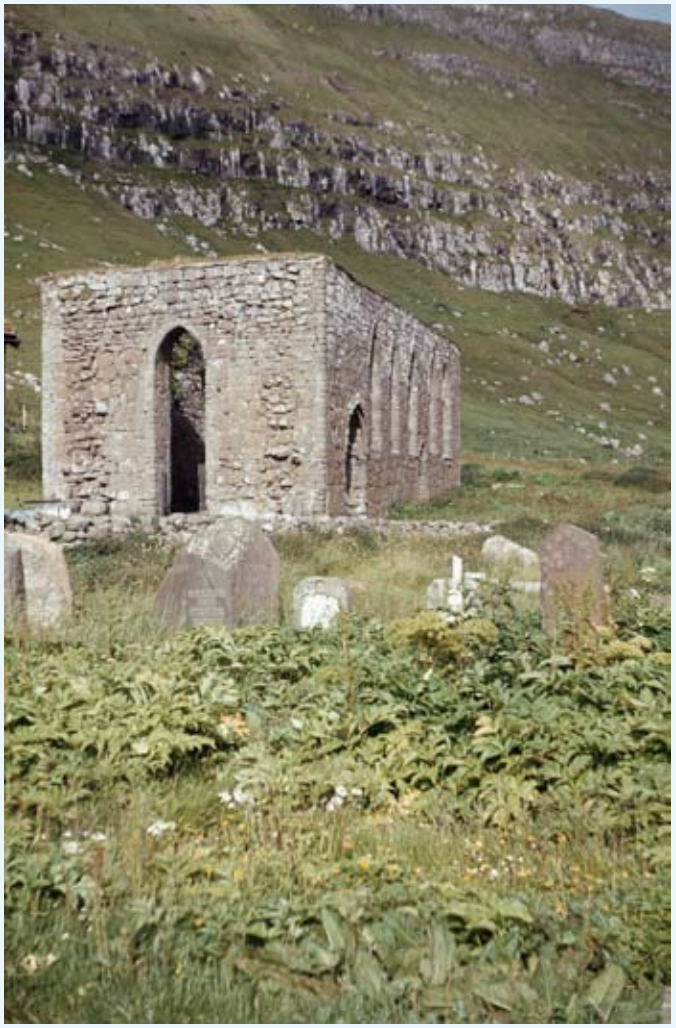
Weighing House Stockholm (1595-1603). Masonry mortar. White. Runmarö lime, lime from ordovician Åland lime stone or lime from Dagö in Estonia. CI = 0,37 (feebly hydraulic lime).

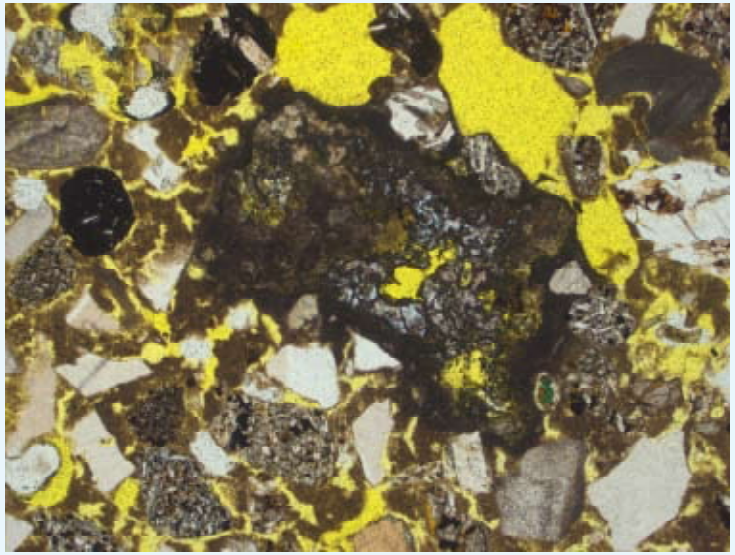
Natural hydraulic lime mortar - An infrastructure example



Lock Old Hjälmare Canal Västmanland (1770-76). Masonry mortar. White/grey-white. Lime from dolomitic limestone from Lena Uppland. CI = 0,51 (moderately hydraulic lime).

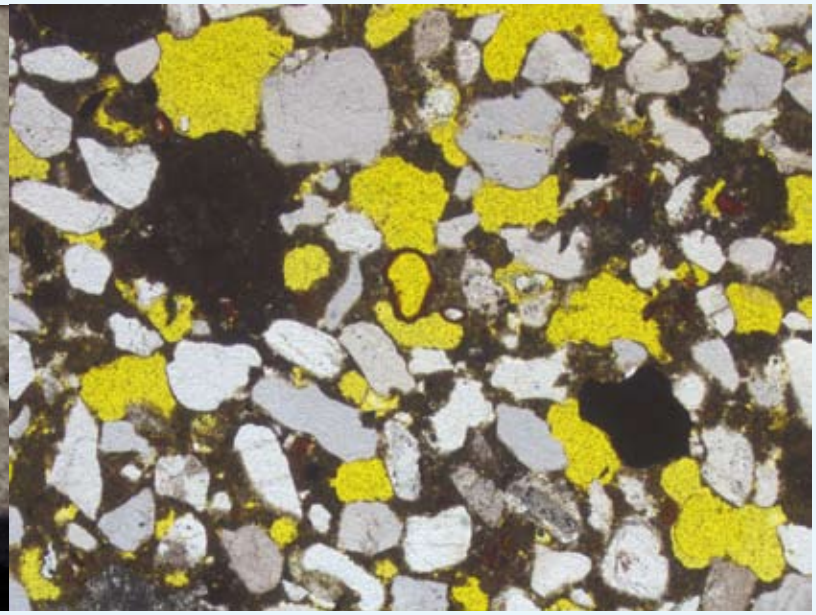
Natural pozzolan lime mortar - Kirkjubøur





Cathedral of Kirkjubøur Faroe Island (1300). Render/jointing, masonry mortar and inner wall mortar. Light. Lime from shells (pure lime) together with puzzolana from vulcanic ash or tuff. CI = 0,1-0,63 (pure lime - moderately hydraulic lime).

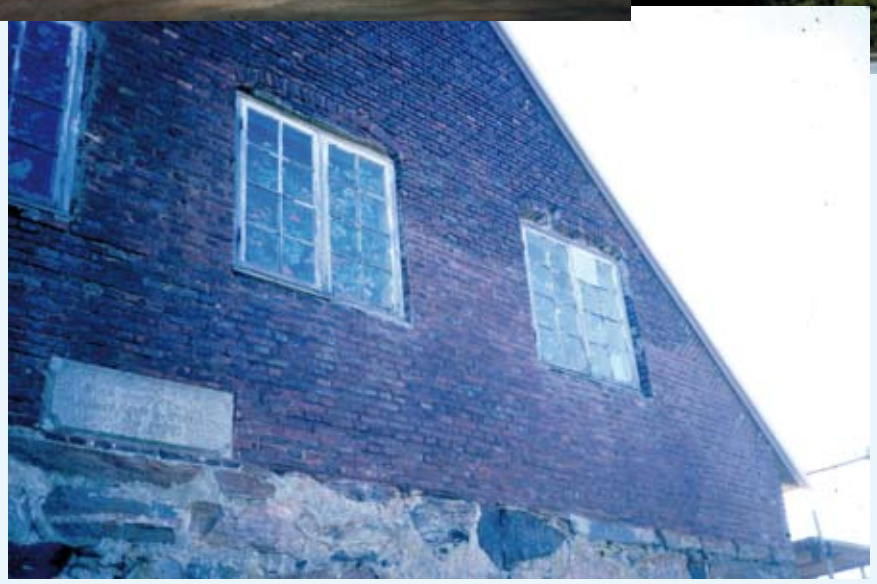
Brick dust lime mortar - “Tessinrender”

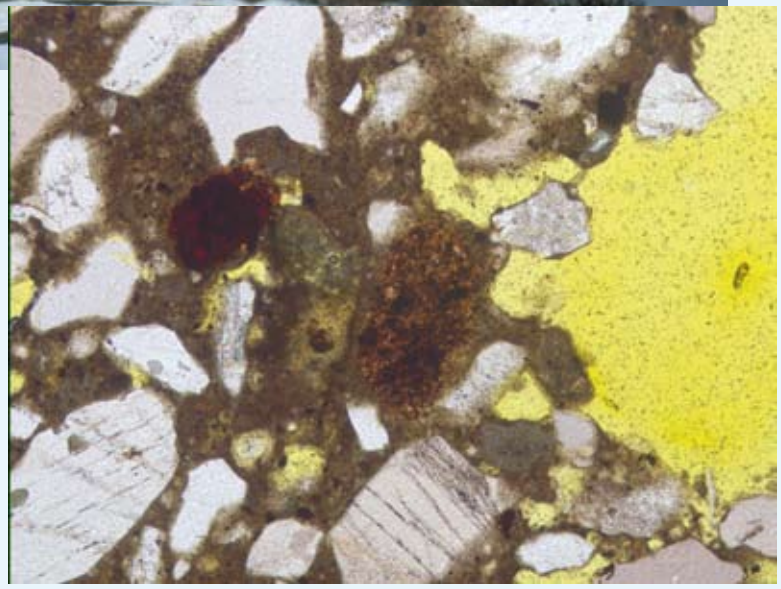


Ulriksdal Palace Stockholm (1671-1715). Arkitekt Nicodemus Tessin the elder. Render. Brown-red. Unknown lime together with an artificial pozzolan very fine brick dust.

CI = 0,22 (sub-hydraulic lime).

Burnt alum shale lime mortar - The Swedish cement





Onsjö manor Västergötland (1788).
Jointing. Red-brown. Lime from stinkstone (pure lime) together with an artificial pozzolan burnt alum shale from Hunneberg nearby. CI= 0,52 (moderately hydraulic lime.)

Natural cement - From Eastern England to Western Sweden

Septaria at Harwich in eastern England used for production of Roman cement. Exported to western part of Sweden during 1860th.

Swedish examples 1848-1887.

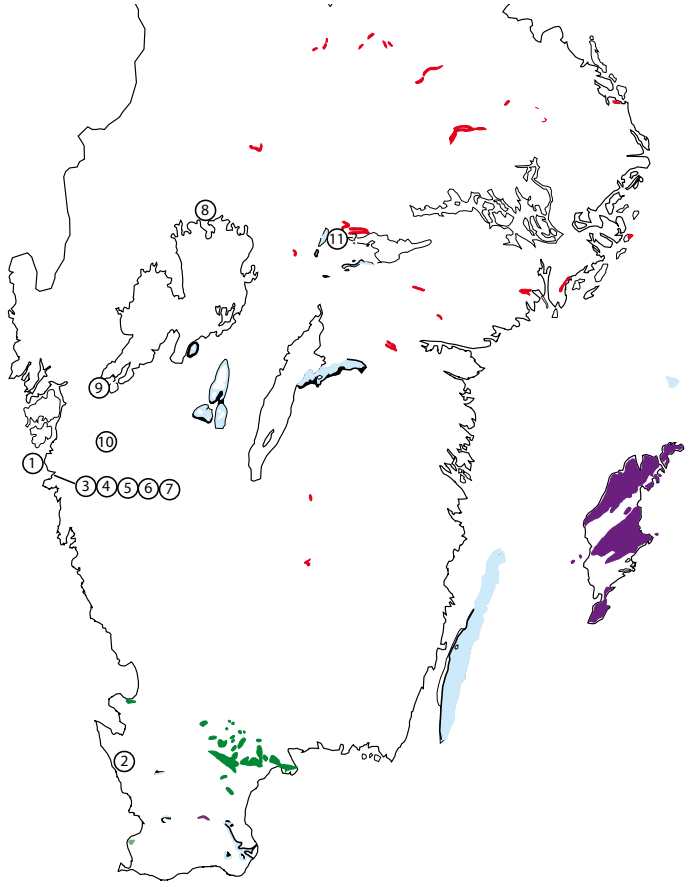


Fig. 4:69. Karta med naturcementsobjekt behandlade i doktorsavhandlingen.

Förklaringar:

B = Bruksundersökning utförd L = Litteraturuppgift e.d.

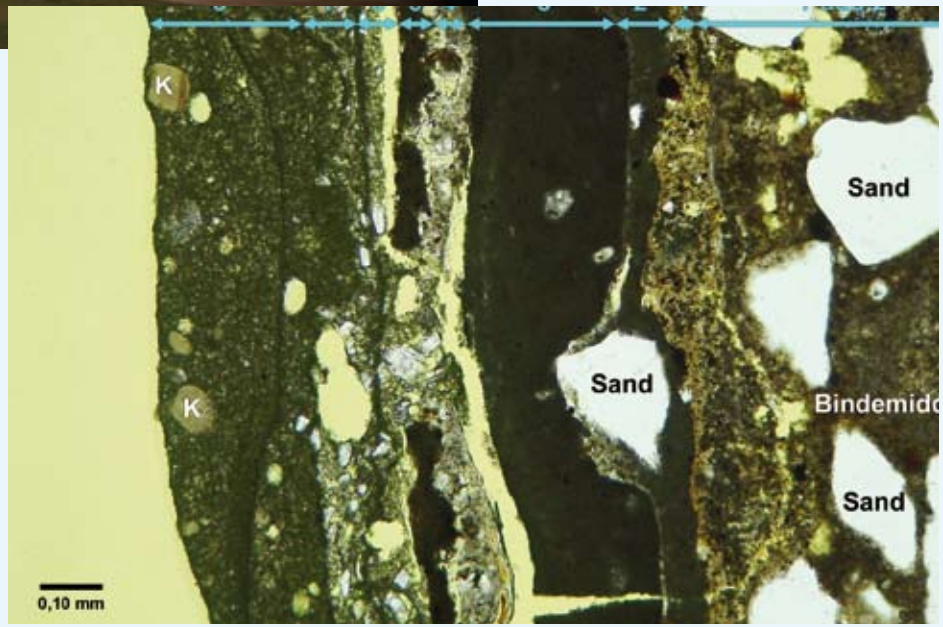
1 Rådhuset i Marstrand (B).
2 Essenska villan i Helsingborg (B).
2 Essenska villan i Helsingborg (B).
3 Börshuset i Göteborg (L).
4 Residensets tredje våning i Göteborg (L
5 Stora teatern i Göteborg (L).
6 Chalmerska slöjdskolan i Göteborg (B).
7 Kvarteret Almen 2:1 i Vasastaden i Göteborg (B).
8 Rådhuset i Karlstad (B).
9 Gamla lasarettet byggnad 1:1 i Vänersborg (B).
10 Nolhaga slott i Alingsås (B).
11 Stortorget 16 i Örebro? (L).

Natural cement - The first examples

Stock Exchange building Göteborg (1844-49). Architect P J Ekman. Render and certain façade ornaments. Produced in Hull. Craftsmen from Hamburg.

Painted first time with linseed oil paint (yellow-red).

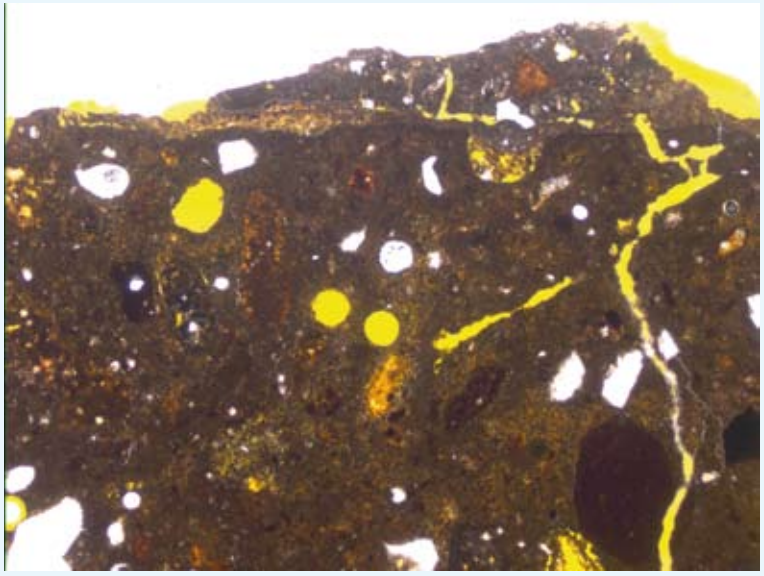
Not investigated.



Essen Villa Helsingborg (1846-48). Arkitekt G F Hetsch Denmark. Render and facade ornaments. Red-brown. Produced in England or Copenhagen. CI = 0,53 (moderately hydraulic lime)?

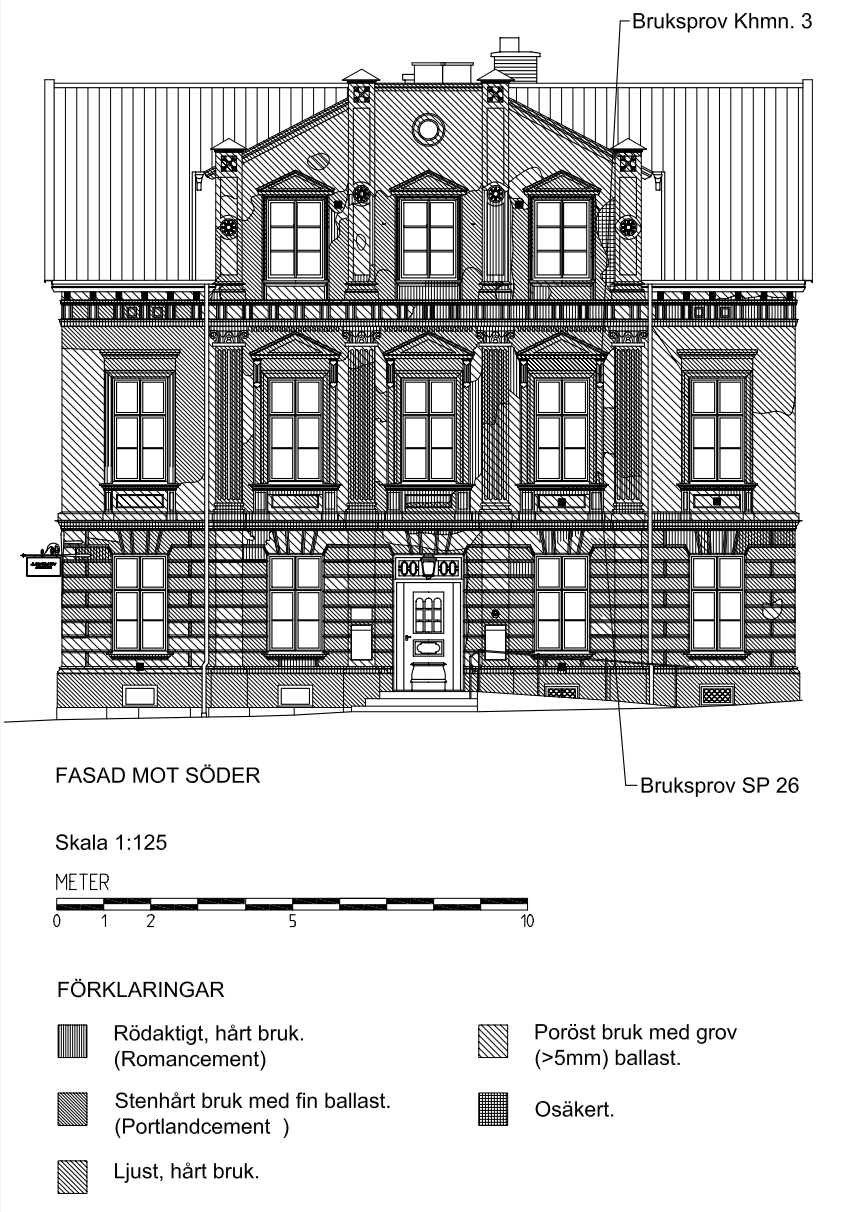
At first lime washed (grey-brown) and later painted with linseed oil paint (white and brown shades).

Natural cement - Town Hall Marstrand



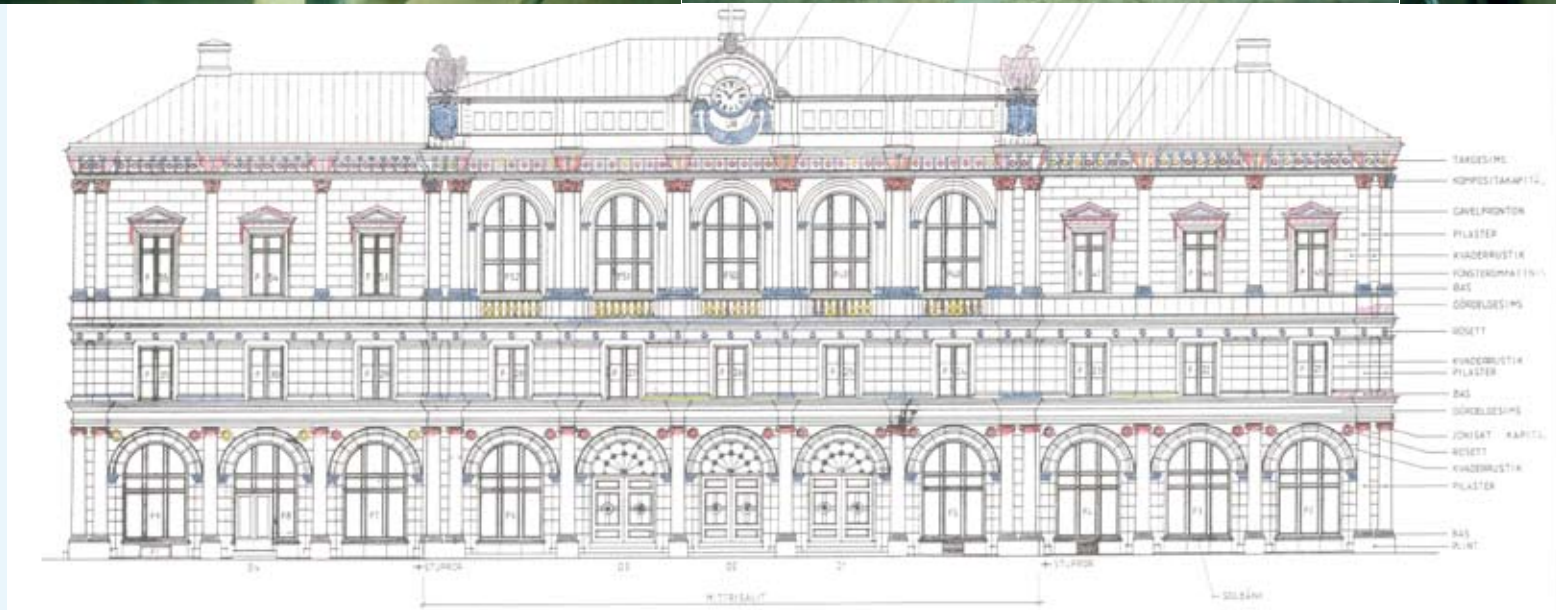
Town Hall Marstrand (1867). Facade ornaments of natural cement. Light or dark yellow-red-brown. Render of early Portland cement. Produced in Hull by cementstone from Whitby Yorkshire? CI = 0,55 (moderately hydraulic lime)?

At first no paint. Later limewashed with pure lime and hydraulic lime (red-brown) and painted with linseed oil paint.



Restored 2000 with portland cement, cement lime mortar and painted with linseed oil paint and cement lime paint (red-brown).

Natural cement - Town Hall Karlstad



Town Hall Karlstad (1868-69). Architect E A Jacobsson. Façade ornaments. Light yellow-brown. Original render was made of lime mortar (Kinnekulle lime?). Produced in Hull? Very alike the natural cement at Town Hall Marstrand.

At first limewashed with hydraulic lime and later painted with linseed oil paint.

Restored 2000 with portland cement and linseed oil paint.

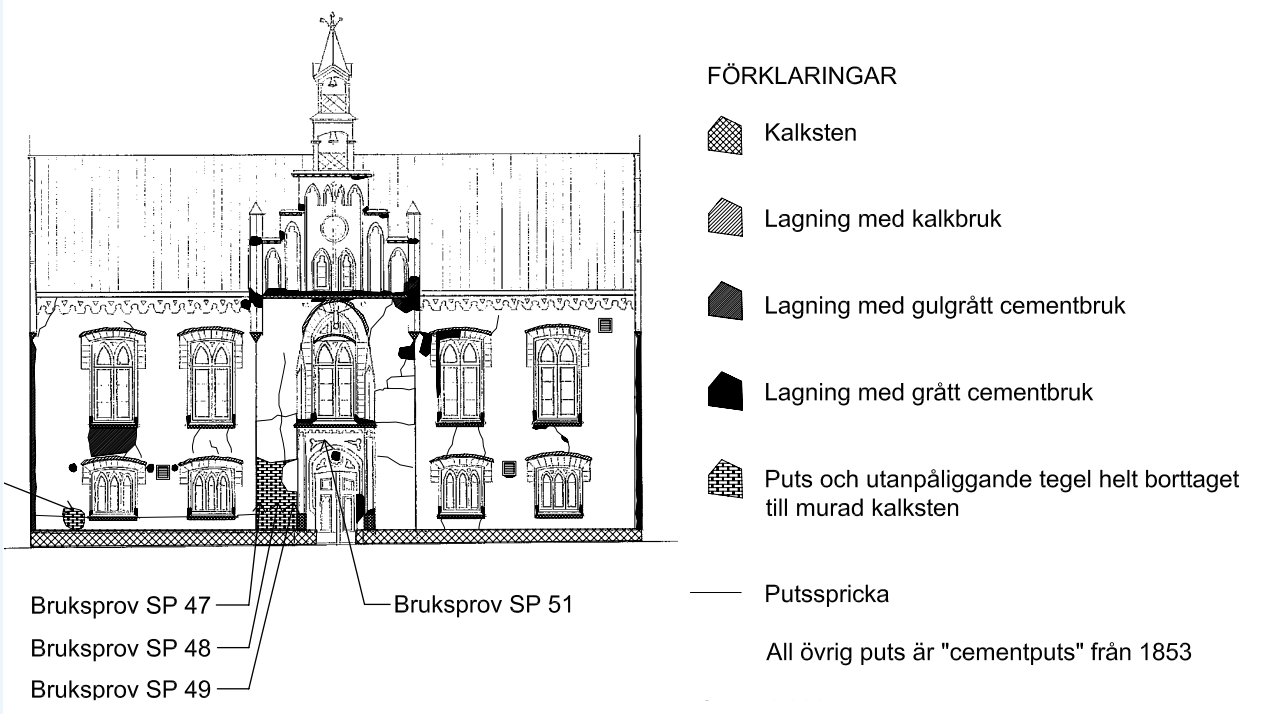
Natural cement - Heyman Villa Göteborg

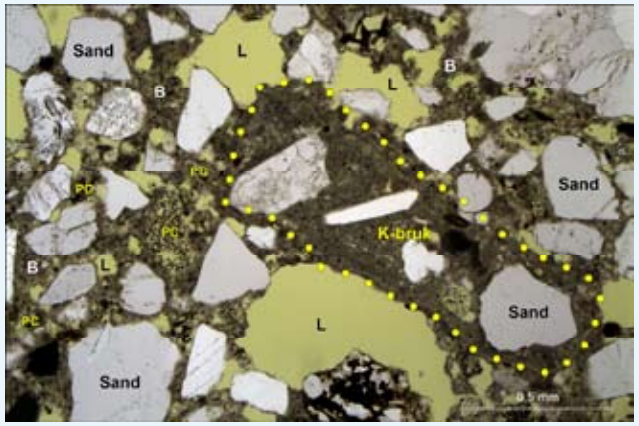
Heyman Villa Göteborg (1874). Architect Adrian C Peterson. Finishing and façade ornaments of natural cement above Portland cement. Brownish.

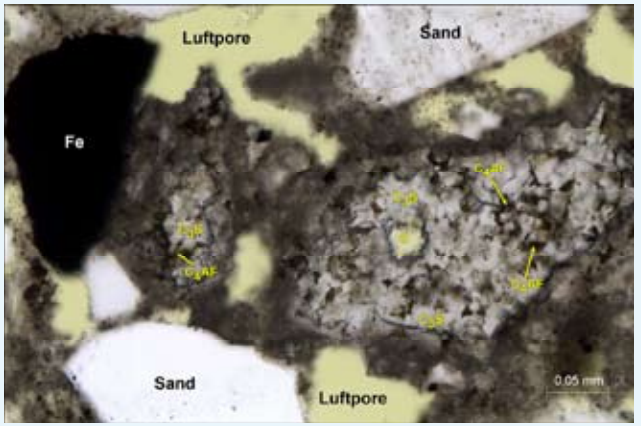
Painted with silicate paint 1882 and 2008.

Restoration going on 2008.

Early Portland cement - Old Town Hall Skövde







Old Town Hall Skövde (1852-53). Architect Hjalmar Wijnbladh. Render. Light grey/grey. Finishing of pure cement above a lime cement mortar (LC 80/20/600).

At first painted with linseed oil paint (light yellow).

Restored 2005 with lime cement mortar and lime cement paint (light yellow).

Thank You!

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