Natural and Roman cements of the 19th and early 20th centuries: an early industrial binder of world-wide use

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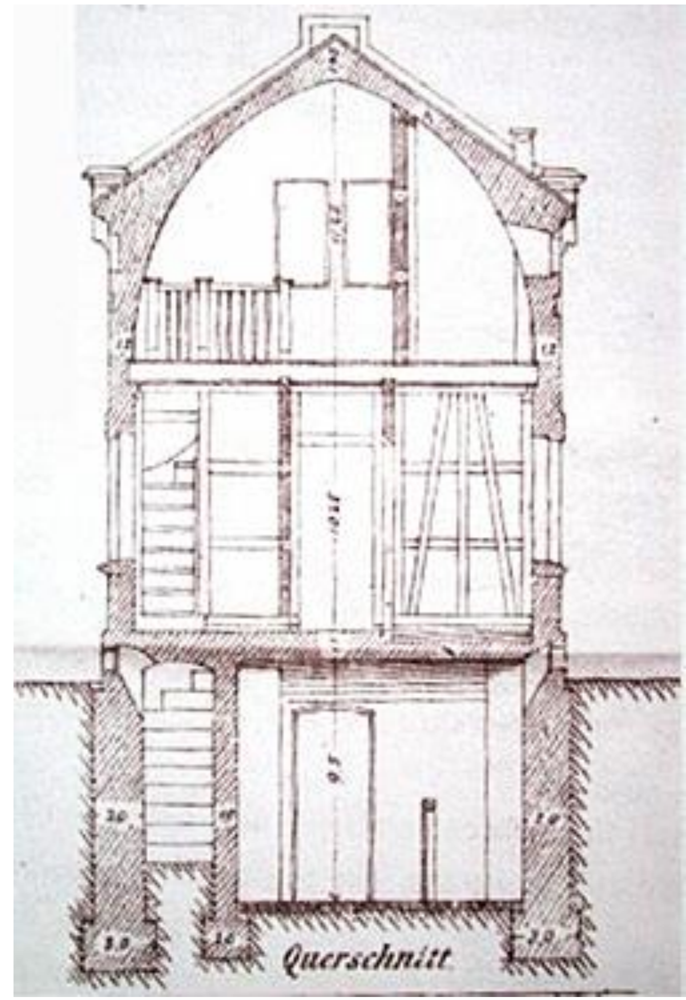
The range of application

tunnel and sewage construction

concrete construction



The range of application

Cast stones for construction

Terrazzo floorings

The range of application

bedding and pointing

stone repair and restoration

The range of application

Exterior renders and stuccoes

The range of application

cast façade or-
naments and
architectural
sculptures

The urban significance

UK (Harwich around 1850)

The urban significance

RC architecture shapes large aereas of central european cities

AT (Vienna 1870-1910)

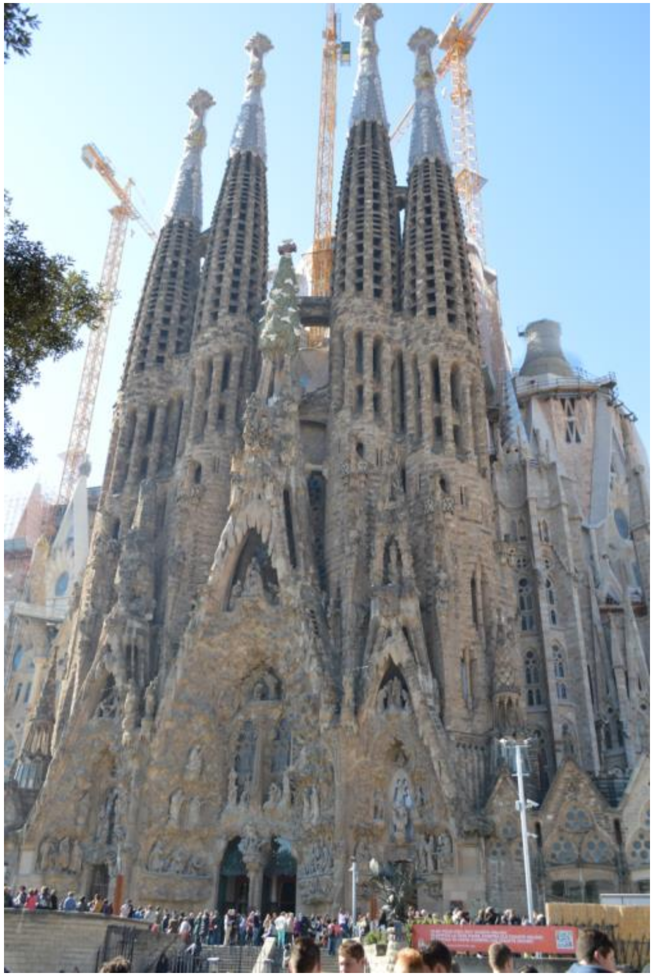
The urban significance

CZ (Prague 1870-1910)

The urban significance

FR (Grenoble 1879)

The urban significance



SP (Barcelona 1882 - recent)

Unique features of „Natural Cements“

Calcined from **natural marlstone** (carbonate + clay in fine-grained intimate mixture; minor constituents: quartz, feldspar, pyrite, …)

⇩

Variety of brands of differing composition and properties

Low temperature of calcination below sintering (ca. 900 °C)

⇩

Formation of „clinker“ with highly reactive and many unreactive phases
Quick set and early strength, slow further strength development

(virtually) **no free lime**

⇩

Purely hydraulic, no slaking just grinding

Sources of raw material

Septaria – nodules of marl in clay
(predominantly England)

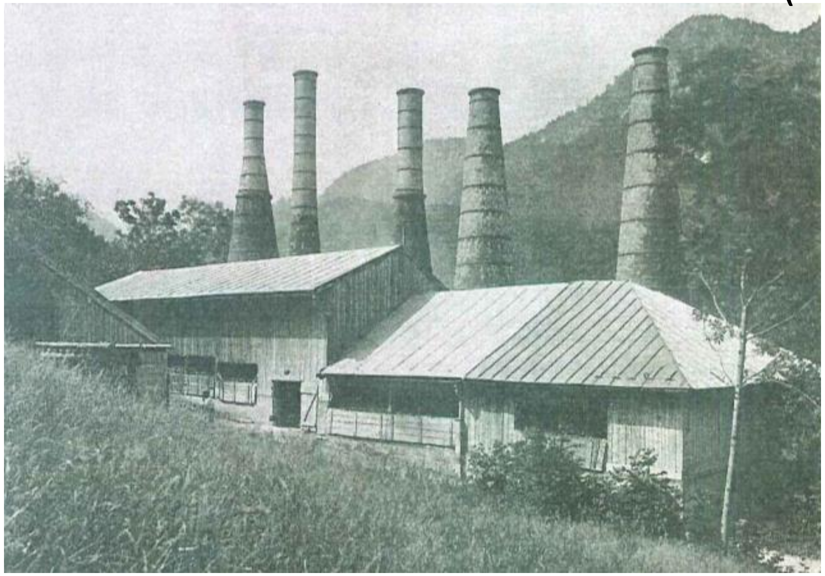
Sources of raw material

Historic (Austria)

Recent (Catalonia)

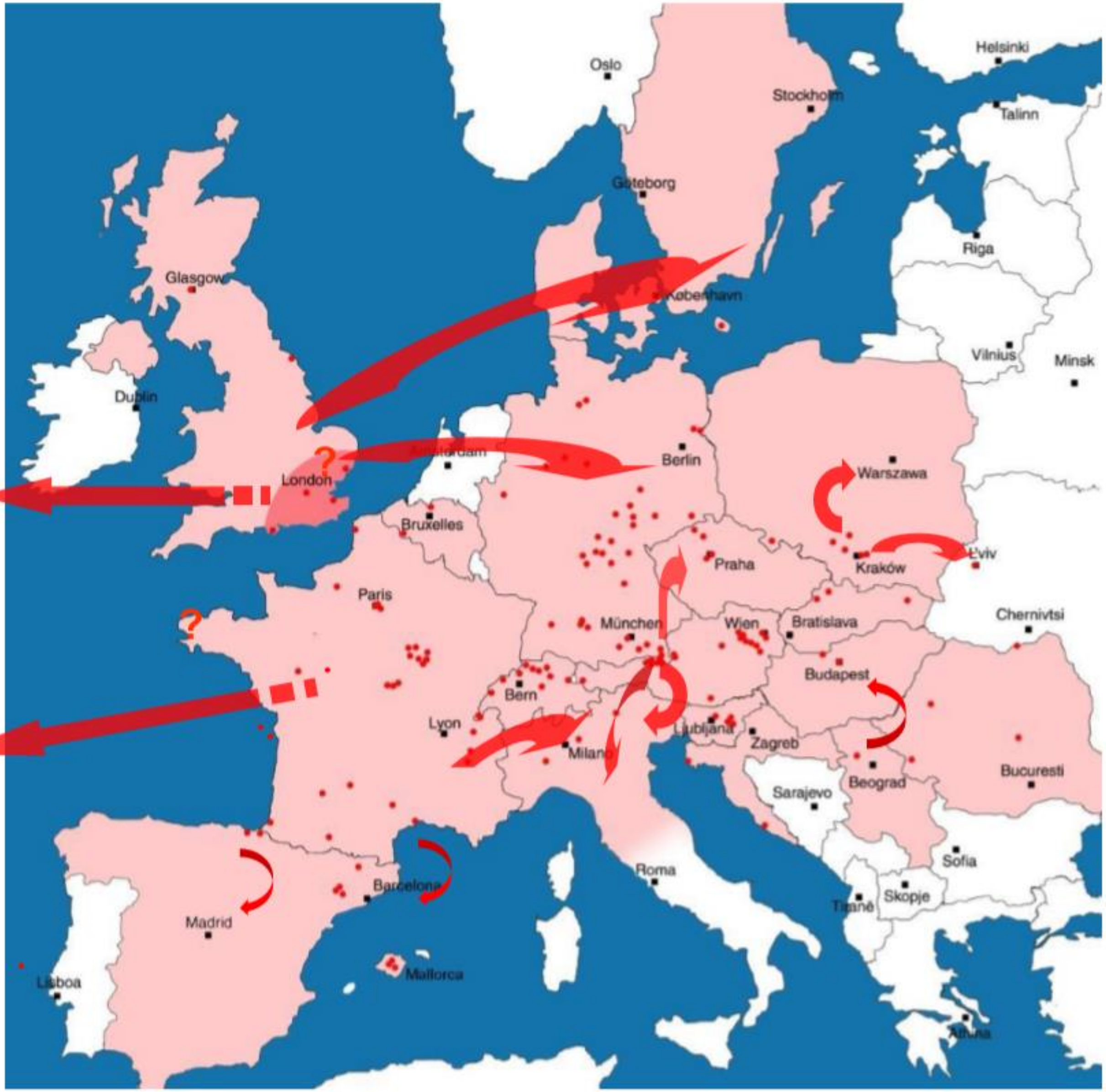
Shaft kilns

Historic (Austria, USA)



Recent (Catalonia)

Historic centers of production in Europe



Notes on history

1796: patented by James Parker (England) as „Parker's or Roman cement"

1st half of 19th century: eventually exported to continental Europe and the USA. Small centers of production in France and Southern Germany

2nd half of 19th century: boom of NC-production and use in most European countries

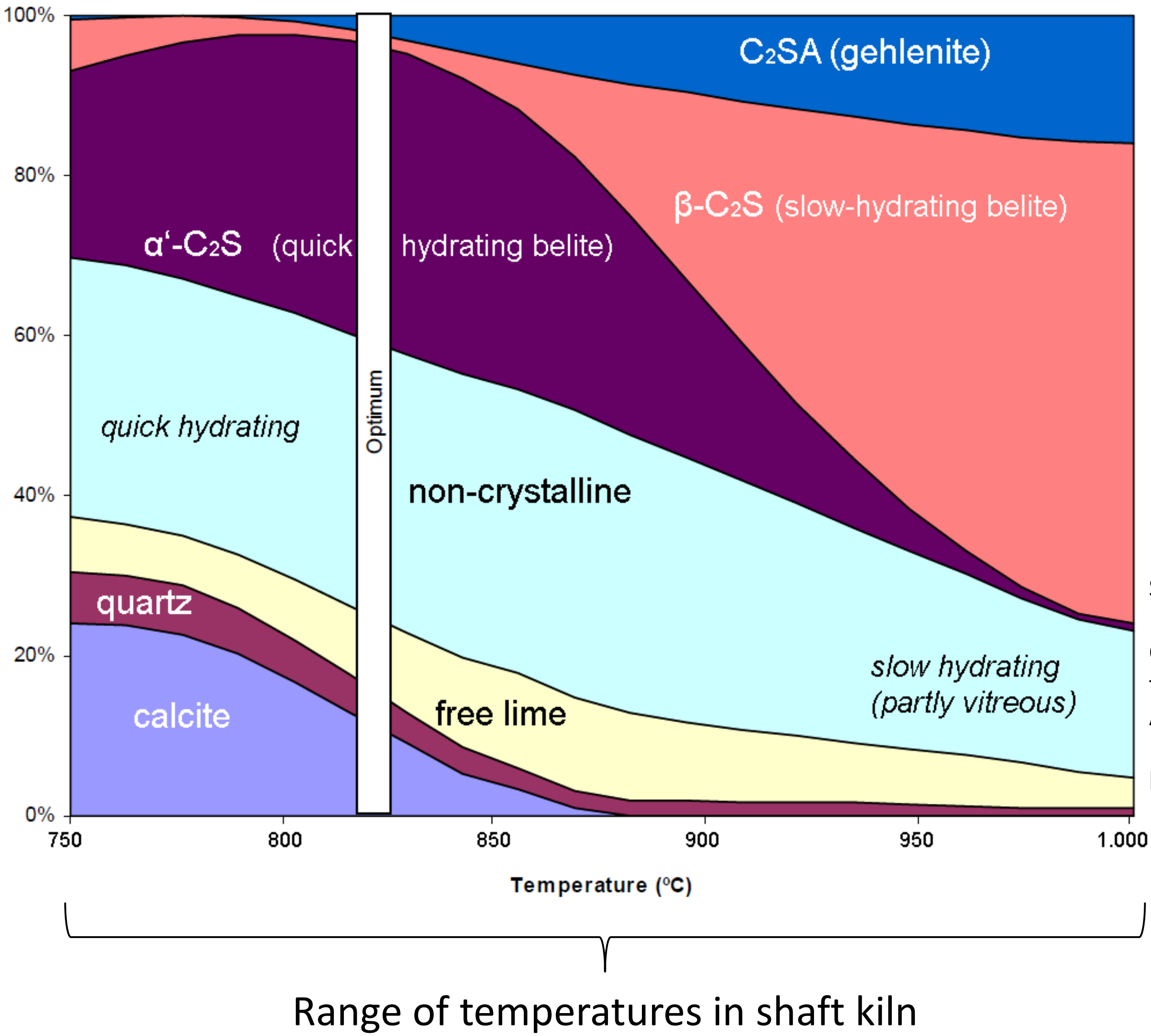
Around WWI: quick decline of NC in favour of PC-binders, only local centers especially in northern Spain (Catalonia)

Late 20th century until recent: only few producers and restricted size of market, but increasingly in the focus of architectural heritage sectors

Technical properties of NC versus PC and NHL

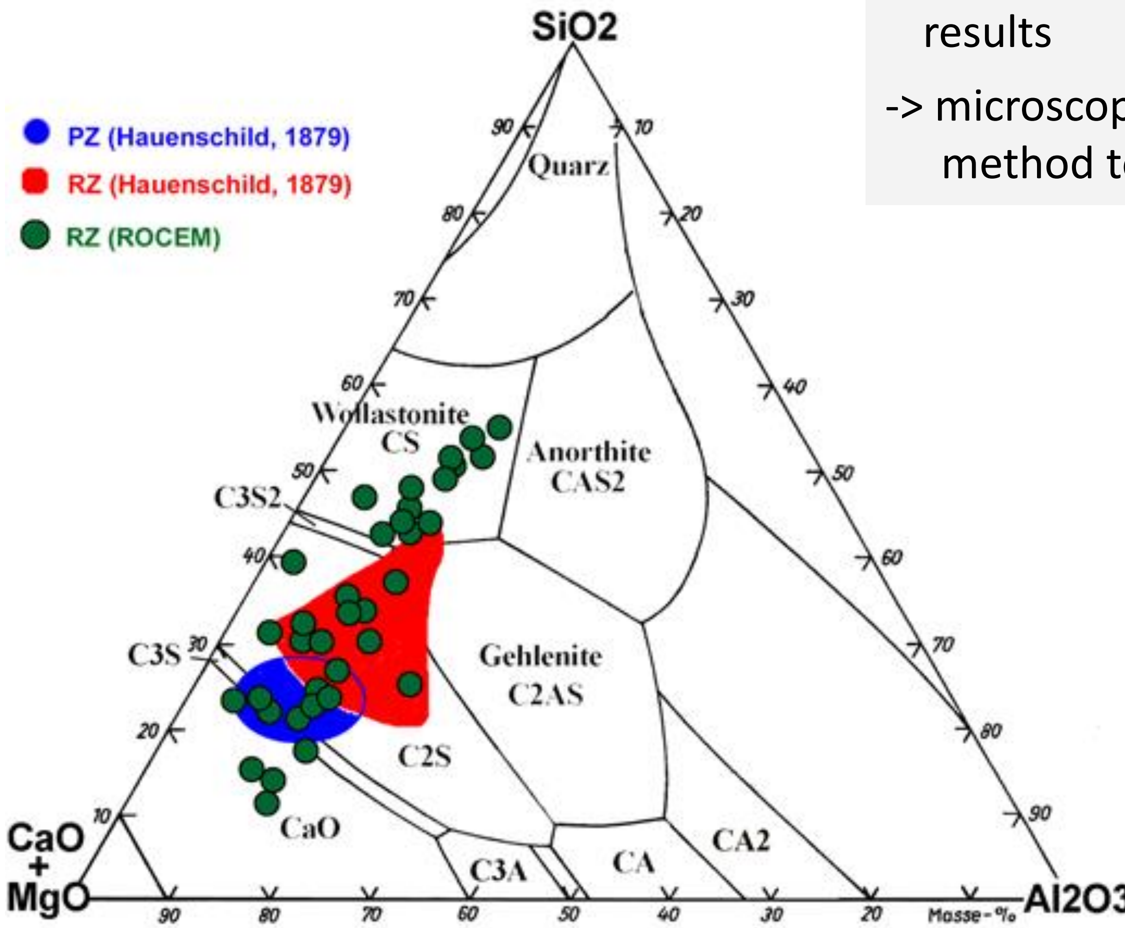
		Portland cement	Natural („Roman") Cement	Natural Hydraulic Lime
Source of raw feed	modern	artificial mixture limestone + clay	**natural mixture** of carbonate + clay (marlstone)	
	historical	sometimes: sandy marlstone		
Type of raw feed		pellets or similar	**fist-sized stones**	?
Usual type of kiln	modern	rotary kiln	**shaft kiln**	
	historical	Shaft kiln -> rotary kiln		
Peak temperature		approx. 1.450 °C	approx. **900 °C** (max. 1.200 °C)	
Melt formation		yes	**no** (only exceptionally small amounts)	
Cooling		quick	slow	
Products of calcination	reactive phases	C_3S, C_2S, C_3A, C_4AF	**non-cryst. C/A/S, α'/β-C_2S**	CaO, C_2S, non-cryst.?
	non-reactive phases	none	CS, C_3S_2, C_2AS, etc.	?
Factory processing	Additives	gypsum/anhydrite	**none**	
	slaking	-	-	+
	grinding	+	+	-/+
Products of hydration	early hydration	CSH (from C_3S)	AFm, AFt, C-S-H (from α'-C_2S)	? -
	final hydration	CSH (from C_2S)	C-A-S-H (from β-C_2S)	$Ca(OH)_2$, C-A-S-H
Set		intermediate	**rapid**	slow
Early strength		dependant on PC-type	rel. high	low
Final strength	achieved at age	28 d	**≥ 1 y**	?
	MPa	40 ... 100	**15 ... 50**	3 ... 10
Colour		grey (white)	**ochre to reddish**	light ochre
Capillarity		low	**high**	very high

Mineral composition of natural cement in dependence of temperature of calcination



See also:
Kozłowski R., Hughes D., Weber J. (2010) Roman Cements: Key Materials of the Built Heritage of the 19th Century. In: Dan M.B., Přikryl R., Török Á. (eds) Materials, Technologies and Practice in Historic Heritage Structures. Springer, Dordrecht https://doi.org/10.1007/978-90-481-2684-2_14

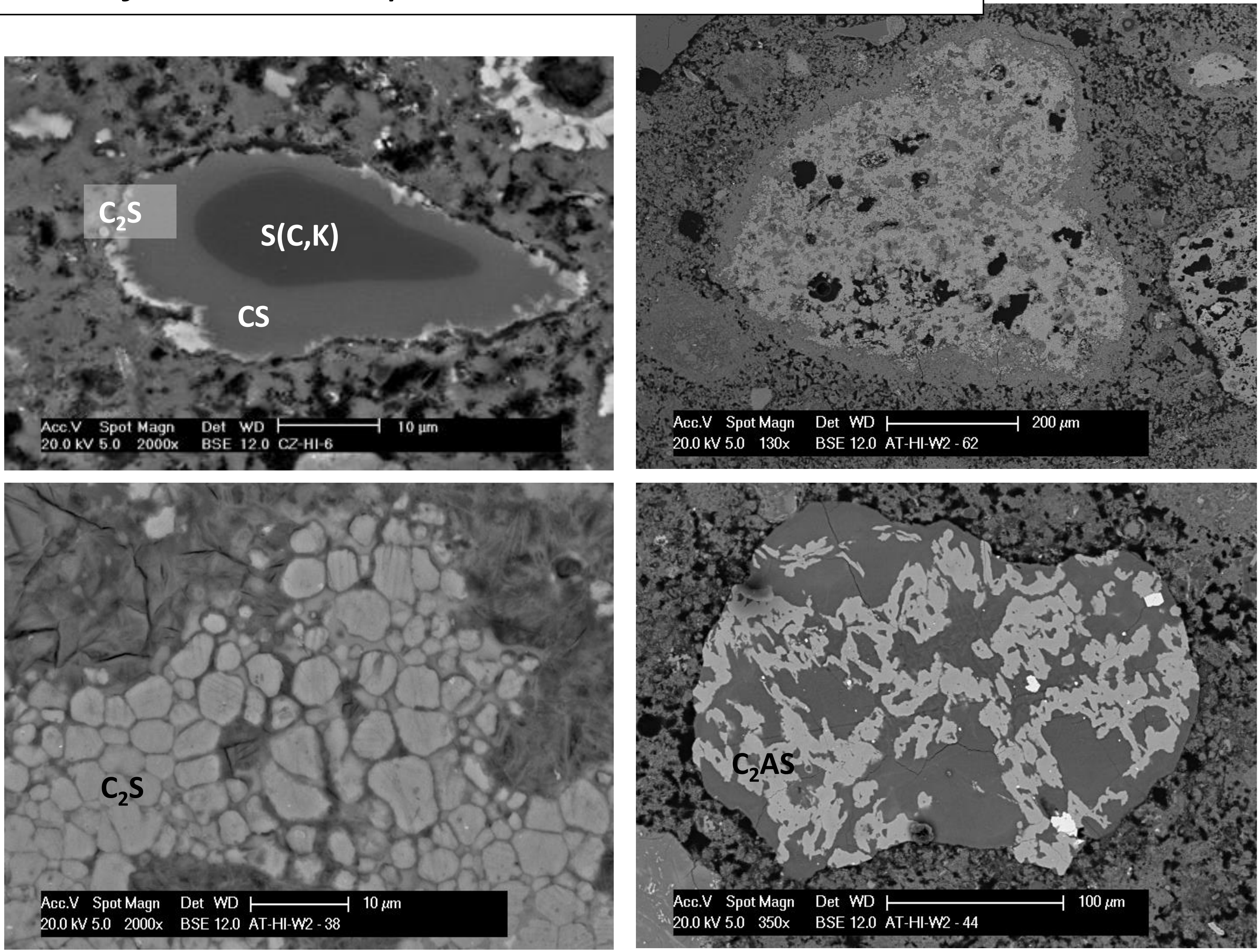
Chemical composition



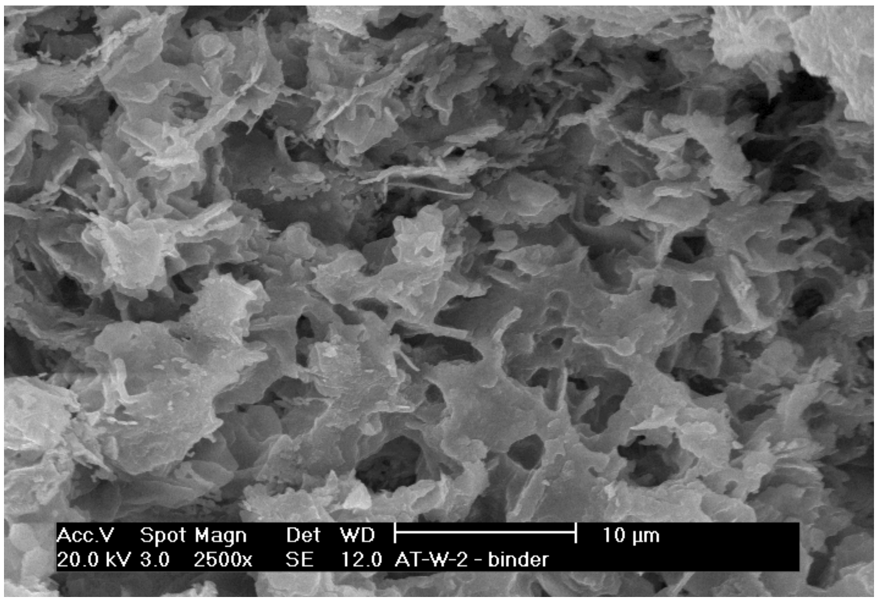
- Chemical composition is not indicative for natural cement
- Phase composition by XRD in historic mortars gives no clear results

-> microscopy and SEM is the best method to identify NC

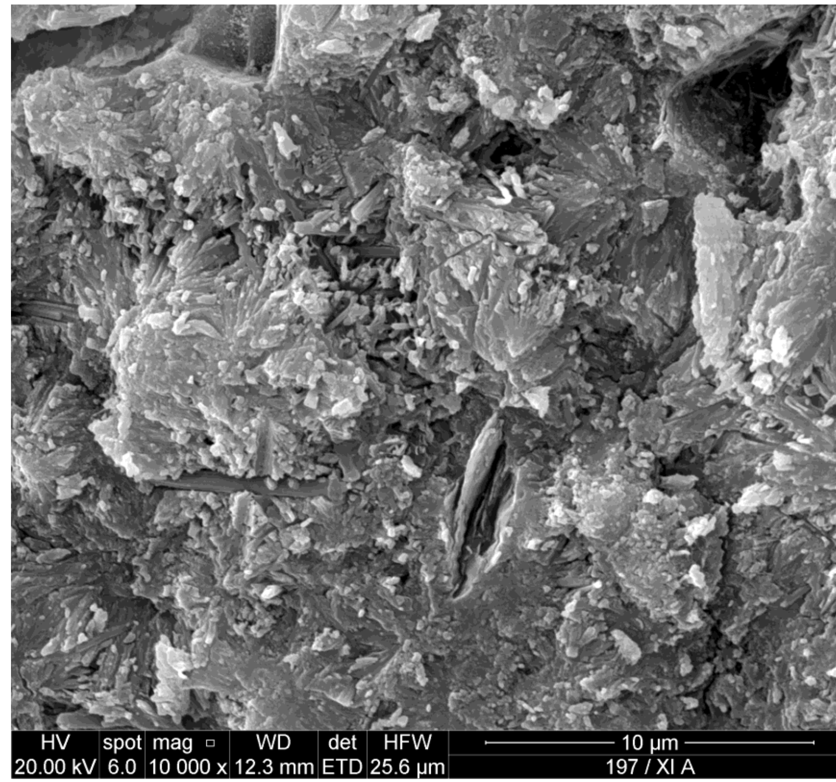
SEM of residual NC phases in historic mortar



Microstructure of cement matrix by SEM



(historic) Natural cement



(historic) Portland cement

Existing standards and products

Current products and standards

No single approach to specifying each cement, national standards are not fully consistent

- NF P15-314:1993 Liants hydrauliques: Ciment prompt naturel. AFNOR, Paris
- UNE 80309:2006 Cementos naturales: Definiciones, classificacion y especificaciones de los cementosnaturales. AENOR, Madri
- D. Hughes et al., ROCARE Standard for the classification of Roman cements (draft based on EN 196-1 to adjust for the rapid set and the high water demand of typical Roman cements)

A small number of producers:

- Prompt (Vicat, France)
- Tigre Rapido (Cemento Natural Tigre, Spain)
- Marfil (Cementos Collet, Spain)
- Cemento Rapido Figueres (Ciments Figueres S.A., Spain)
- Cemento Mallorquin (Sa Cimentara, Spain)
- Folwark (Institute of Ceramics and Building Materials, Poland)

Thank you for your attention!

In case of questions, please contact me at johannes.weber@uni-ak.ac.at