

BRE Test Report

Testing of Ancaster Weatherbed Limestone

Prepared for: Phil Kerry
Date: 21 December 2020
Report Number: P118422 - 1000 Issue: 1

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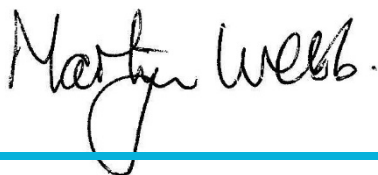


Prepared by

Name Dr Martyn Webb

Position Principal Consultant, Fire and Building Technology Group

Date 21 December 2020

Signature 

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Name Dr Tim Yates

Position Technical Director, Fire and Building Technology Group

Date 21 December 2020

Signature 

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1 Introduction

Following instruction from Phil Kerry (Goldholme Stone Ltd.) BRE has completed a series of tests on the Ancaster Weatherbed Limestone.

The stone was delivered to BRE on the 13/08/2020.

This report provides a factual account of the testing carried out.

2 Test programme

BRE have carried out the following tests:

2.1 Masonry

BS EN 12407:2007, Natural stone test methods. Petrographic examination*

BS EN 1936:2006, Natural stone test methods. Determination of apparent density*, and open porosity*

BS EN 13755:2008, Natural stone test methods. Determination of water absorption at atmospheric pressure*

BS EN 772-1:2011, Methods of test for masonry units — Part 1: Determination of compressive strength*

BS EN 772-11:2011, Methods of test for masonry units - Part 11: Determination of water absorption of aggregate concrete, manufactured stone and natural stone masonry units due to capillary action and the initial rate of water absorption of clay masonry units*

BS EN 12371: 2010, Natural stone test methods. Determination of frost resistance - identification test*

BS EN 1745:2012 Masonry and masonry products. Methods for determining thermal properties

BS EN ISO 10456:2007 Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values

BS EN 13501 2007 + A1 2009 Fire classification of construction products and building elements. Classification using test data from reaction to fire tests - Commission Decision 96/603/EC

* BRE is UKAS accredited for this test.



3 Test Results

Given below is a summary of the test results, full details can be found in the Appendix.

3.1 Masonry BS EN 771 -6

Test	Standard	Result	Unit
Petrographic Examination	BS EN 12407	Oolitic limestone (Oosparite)	
Apparent Density	BS EN 1936	2460	kg/m ³
Open Porosity	BS EN 1936	9.5	% by volume
Water Absorption at atmospheric pressure	BS EN 13755	2.9	% by weight
Water Absorption by capillarity	BS EN 772 - 11	15	g/(m ² .s ^{0.5})
Compressive strength	BS EN 772 -1	81.1	MPa
Frost Resistance	BS EN 12371	14	cycles
Water vapour resistance factor dry*	EN ISO 10456	250	
Water vapour resistance factor wet*	EN ISO 10456	200	
Specific heat capacity*	BS EN 1745	1000	J/(kg.K)
Thermal conductivity in dry state $\lambda_{10 \text{ dry unit}}$ *	BS EN 1745	2.3	W/(m.K)
Reaction to fire Declared statement if combustible material is less than 1% *	ISO 13501- 1	A1	

* Results derived from tabulated values.



4 Appendix Detailed Test Results



BSEN 1936: 2006: Determination of open porosity and apparent density					
Name of Stone:	Ancaster Weatherbed	Petrographic Nature:	Limestone		
Block No	No data supplied	Anisotropic Features:	Bedding marked		
Supplier:	Client	Country of Origin:	UK		
Dimensions (mm):	50 x 50 x 50	Project Reference:	P118422		
Surface Finish:	Sawn	Preparation:	Prepared to BS EN 1936		
Date Tested:	18/08/2020 20/08/2020	Tested by:	I. Rance		
BRE No	Md	Mh	Ms	Apparent Density	Open Porosity
P118422/20/01/					
	g	g	g	kg.m ⁻³	%
251	320.77	203.10	332.48	2470	9.0
252	319.32	202.18	330.46	2480	8.7
253	320.22	202.74	333.66	2440	10.3
254	316.85	200.63	328.90	2470	9.4
255	312.08	197.60	324.05	2460	9.5
256	308.42	195.31	320.79	2450	9.9
			Mean	2460	9.5
* The calculation of apparent density assumes the density of water to be 998 kg.m⁻³ at 20 °C Open Porosity is defined as the ratio of volume of open pores to the apparent volume of the specimen Apparent Density is defined as the ratio of the mass of the dry specimen to its apparent volume Mean open porosity (p_o): Mean apparent density (ρ_b) 9.5 % 2460 kg.m-3					
Approved by:		Date: 13/10/2020			
Name: Dr Martyn Webb					
Position: Principal Consultant		Fire and Building Technology Group			



BSEN 13755: 2008: Determination of water absorption at atmospheric pressure					
Name of Stone:	Ancaster Weatherbed		Petrographic Nature:	Limestone	
Block No	No data supplied		Anisotropic Features:	Bedding marked	
Supplier:	Client		Country of Origin:	UK	
Dimensions (mm):	50 x 50 x 50		Project Reference:	P118422	
Surface Finish:	Sawn		Preparation:	Prepared to BS EN 13755	
Date Tested:	21/08/2020	28/08/2020	Tested by:	I. Rance	

	Dry mass	Wet mass	Wet mass		
BRE No	1 hr md	48 hrs mi2	72 hrs ms	Difference (ms-mi2)	Water Absorption
P118422/20/01/	g	g	g	%	%
241	312.25	321.17	321.20	0.009	2.9
242	324.31	334.19	334.22	0.010	3.1
243	313.91	323.06	323.11	0.014	2.9
244	319.17	327.80	327.83	0.008	2.7
245	326.37	336.67	336.69	0.008	3.2
246	311.03	319.64	319.68	0.012	2.8

Mean **2.9**

Mean Water Absorption (A_b): 2.9 %

Approved by:

Name: Dr Martyn Webb

Position: Principal Consultant

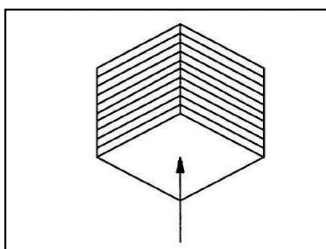
Date: 13/10/2020

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BSEN 772 -11 :2011: Determination of water absorption of natural stone masonry units due to capillarity action - Tested perpendicular to bedding



Name of Stone:	Ancaster Weatherbed	Petrographic Nature:	Limestone
Block No	No data supplied	Anisotropic Features:	Bedding marked
Supplier:	Client	Country of Origin:	UK
Dimensions (mm):	70 x 70 x 70	Project Reference:	P118422
Surface Finish:	Sawn	Preparation:	Prepared to BSEN 772-11
Date Tested:	24/08/2020	26/08/2020	Tested by: I. Rance

	Width 1	Width 2	Water absorption *
BRE No			
P118422/20/01/	m	m	gm ² s ^{-0.5}
116	0.0704	0.0704	6
117	0.0705	0.0702	16
118	0.0702	0.0703	16
119	0.0703	0.0703	21
120	0.0699	0.0705	16
121	0.0705	0.0703	16

*Calculated following the method given in clause 8.2 of the standard

Mean Water absorption: c_1 15 g/(m².s^{0.5})

Approved by:

Martyn Webb

Date:

13/10/2020

Name:

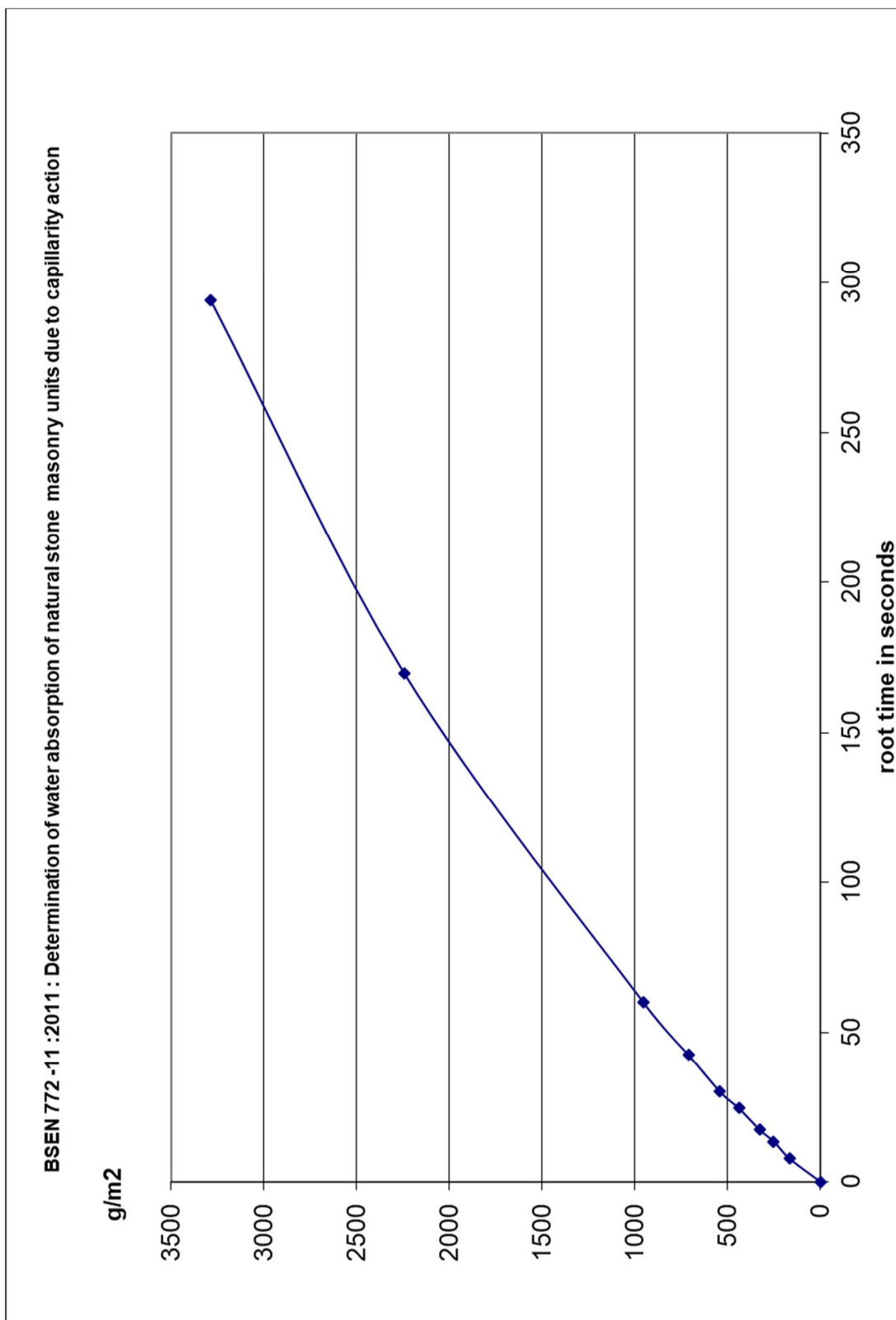
Dr Martyn Webb

Position:

Principal Consultant, Fire and Construction Technology Group

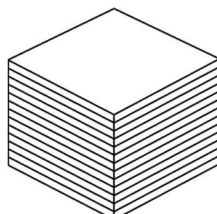


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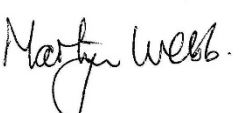
**BSEN 772 -1: 2011 Methods of test for masonry units. Determination of compressive strength,
Tested dry perpendicular to bedding**



Name of Stone:	Ancaster Weatherbed	Petrographic Nature:	Limestone
Block No	No data supplied	Anisotropic Features:	Bedding marked
Supplier:	Client	Country of Origin:	UK
Dimensions (mm):	70 x 70 x 70	Project Reference:	P118422
Surface Finish:	Sawn	Preparation:	Prepared to BS EN 772-1
Date Tested:	23/09/2020	Tested by:	I. Rance

BRE No	Load Rate	Height	Mean Width	Mean Length	Failure Load	Comp. Strength
P118422/20/01/	MPa s-1	mm	mm	mm	kN	MPa
165	0.6	70.1	70.2	69.9	363	74.0
166	0.6	70.4	70.1	70.3	365	74.1
167	0.6	69.9	70.5	70.3	455	91.9
168	0.6	70.3	70.4	70.3	406	82.1
169	0.6	70.2	70.4	70.2	427	86.4
170	0.6	70.5	70.4	70.2	379	76.6
171	0.6	70.1	70.3	70.4	411	83.1
172	0.6	70.4	70.5	70.2	431	87.1
173	0.6	69.8	70.0	70.3	359	73.0
174	0.6	70.6	70.3	70.2	408	82.6
					Mean	81.1
					St. Dev	6.44
					Co of var	0.08

Note. Tested dry to BSEN 772-1 Part 7.3.2

Approved by:  Date: 13/10/2020

Name: Dr Martyn Webb

Position: Principal Consultant Fire and Building Technology Group





BS EN 1745:2012 Masonry and masonry products - Methods for determining thermal properties - Tabulated design values														
Name of Stone:	Ancaster Weatherbed													
Block No:	No data supplied													
Country of Origin:	UK													
Supplier:	Client													
Date Assessed	13/10/2020													
Petrographic Nature:	Limestone													
BRE Project number	P118422													
<table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; padding: 5px;">Property</th> <th style="text-align: left; padding: 5px;">Value</th> <th style="text-align: left; padding: 5px;">units</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">Density</td> <td style="padding: 5px;">2460</td> <td style="padding: 5px;">Kgm-3</td> </tr> <tr> <td style="padding: 5px;">Thermal conductivity in dry state l 10 dry unit</td> <td style="padding: 5px;">2.30</td> <td style="padding: 5px;">W/(mK)</td> </tr> <tr> <td style="padding: 5px;">Specific heat capacity</td> <td style="padding: 5px;">1000</td> <td style="padding: 5px;">J/(kgK)</td> </tr> </tbody> </table>			Property	Value	units	Density	2460	Kgm-3	Thermal conductivity in dry state l 10 dry unit	2.30	W/(mK)	Specific heat capacity	1000	J/(kgK)
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Density	2460	Kgm-3												
Thermal conductivity in dry state l 10 dry unit	2.30	W/(mK)												
Specific heat capacity	1000	J/(kgK)												
Approved by: Name: Position:	 Dr Maryn Webb Principal Consultant Date: 13/10/2020 Fire and Building Technology Group													



BS EN ISO 10456:2007 Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values														
Name of Stone:	Ancaster Weatherbed													
Block No:	No data supplied													
Country of Origin:	UK													
Supplier:	Client													
Date Assessed	13/10/2020													
Petrographic Nature:	Limestone													
BRE Project number	P118422													
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Property	Value	units												
Density	2460	Kgm-3												
Water vapour resistance factor - dry	250													
Water vapour resistance factor - wet	200													
Approved by: Name: Position:	 Dr Martyn Webb Principal Consultant Date: 13/10/2020 Fire and Building Technology Group													



BS EN 12371: 2010, Natural stone test methods. Determination of frost resistance Using the Identification Test - change in dynamic modulus of elasticity							
Name of Stone:	Ancaster Weatherbed		Petrographic Nature:	Limestone			
Block No:	No data supplied		Anisotropic Features:	Bedding marked			
Supplier:	Client		Country of Origin:	UK			
Dimensions (mm):	300 x 50 x 50		Project Reference:	No data supplied			
Surface Finish:	Sawn		Preparation:	Prepared to BS EN 12371			
Date Tested:	21/08/2020	03/12/2020	Tested by:	I. Rance			
	0 cycles		14 cycles				
BRE no	E	E	%	Visual	E	%	Visual
P118422/20/01	MPa	MPa	Change	Inspection	MPa	Change	Inspection
101	42175	40582	-4	0			
102	42313	41575	-2	0			
103	40347	38939	-3	0			
104	41019	39347	-4	0			
105	39520	38824	-2	0			
106	39409	38618	-2	1			
107	37816	37489	-1	0			
The test continues until two or more of the specimens are classed as failed using either of the following criteria: Score of the visual inspection attains 3; Decrease of dynamic elastic modulus reaches 30 %. Declared cycles of frost resistance 14 Approved by: Date: 21/12/2020 Name: Dr Martyn Webb Position: Principal Consultant, Fire and Building Technology Group							

BS EN 12407 Petrographic Examination of Natural Stone
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Sample Description

Name of Stone:	Ancaster Weatherbed	Petrographic Nature:	Limestone
Block No:	No data supplied	Anisotropic Features:	None
Supplier:	Client	Country of Origin:	UK
Dimensions (mm):	50 x 50 x 50	Project Reference:	No data supplied
Surface Finish:	Sawn	Preparation /Conditioning:	Prepared to BS EN 12407
Date Tested:	27/10/2020	Tested By:	Martyn Webb
Project no	P118422/20/01	Sample I.D Number	P118422/20/01/146



Figure 1: Image of hand specimen, width of sample is 50 mm

Results summary

Based on the mineralogy identified in thin section and the texture seen in hand specimen, the stone has been given the classification of **Oolitic limestone (Oosparite)**.

Final approved by:



Date: 02/11/2020

Name:

Dr Tim Yates

Position: Technical Director



Macroscopic Examination of P118422/20/01/146

In hand specimen the stone was variable in colour, dominantly buff but with defined patches of light and dark material. The pale patches consisted of carbonate with the darker areas being iron minerals which were often the source of orange iron-oxide/hydroxide discolouration (Figure 1). A few pore spaces were noted.

Large randomly orientated bioclasts were present as were ooliths, all held within a sparry carbonate cement. The stone appeared quite dense and hard, although it absorbed water easily in the drop test.

There was no evidence of weathering or deterioration.

Microscopic Examination of P118422/20/01/146

In thin section the stone consisted of a poorly sorted assemblage of bioclasts, ooliths and intraclasts. The typical appearance of the stone in thin section is shown in Figure 2.

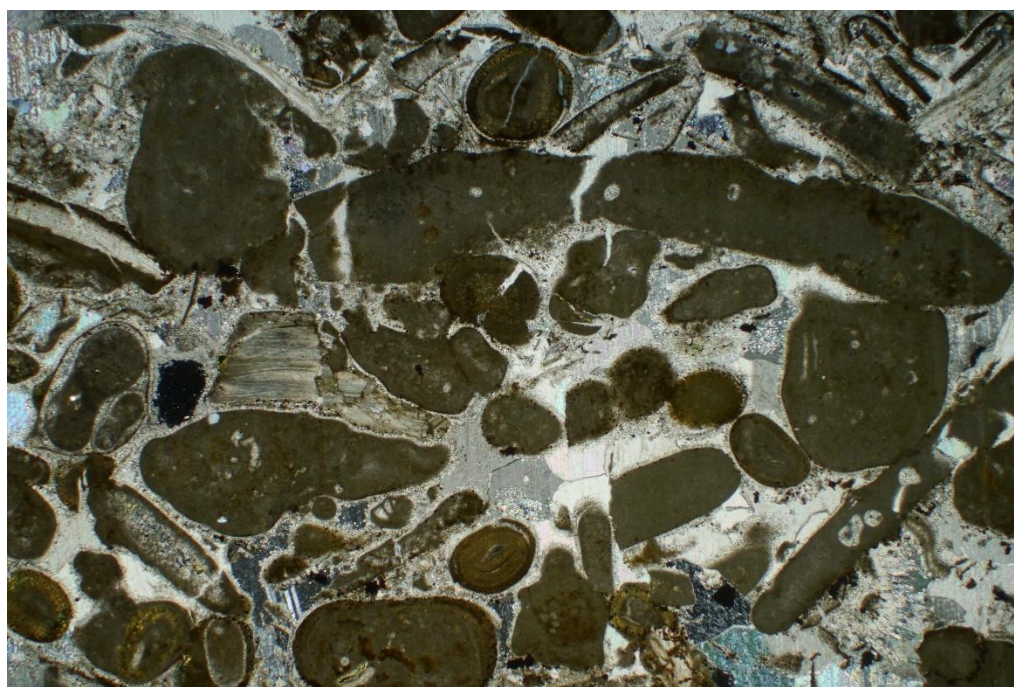


Figure 2. Typical appearance of Ancaster Weatherbed in thin section. Cross polarised light, magnification x25.

The major constituents were micritic in nature or possessed a micrite rim, but often any internal structure was not visible or had recrystallised. However, concentric structure was still identifiable in many ooliths (Figure 3) and the intraclastic origins of certain particles was visible. Ooliths comprised more than 25 % of the total allochems. Only very low levels of compaction were observed throughout the section.



Bioclasts consisted primarily of bivalve fragments of various types and sizes, and having a dominantly fibrous fabric, sometimes with a micrite rim discernible.

A number of the constituents sometimes contained or were coated with opaque iron minerals (Figure 4). Locally these have produced some orange discolouration which is evident in the stone in hand specimen.

A coarse sparite cement was present throughout much of the stone, leaving only very few unfilled pore spaces. In between some constituents it was possible to identify what appeared to be a finer earlier phase of carbonate crystallisation (Figure 5).

Based on the mineralogy identified in thin section and the texture seen in hand specimen, the stone has been given the classification of **Oolitic limestone (Oosparite)**.



Figure 3. Concentric structure (arrowed red) and sparite cement (arrowed blue). Cross polarised light, magnification x50.

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Figure 4. Iron minerals (black in image) producing orange colouration to the surrounding stone. Plane polarised light, magnification x50.

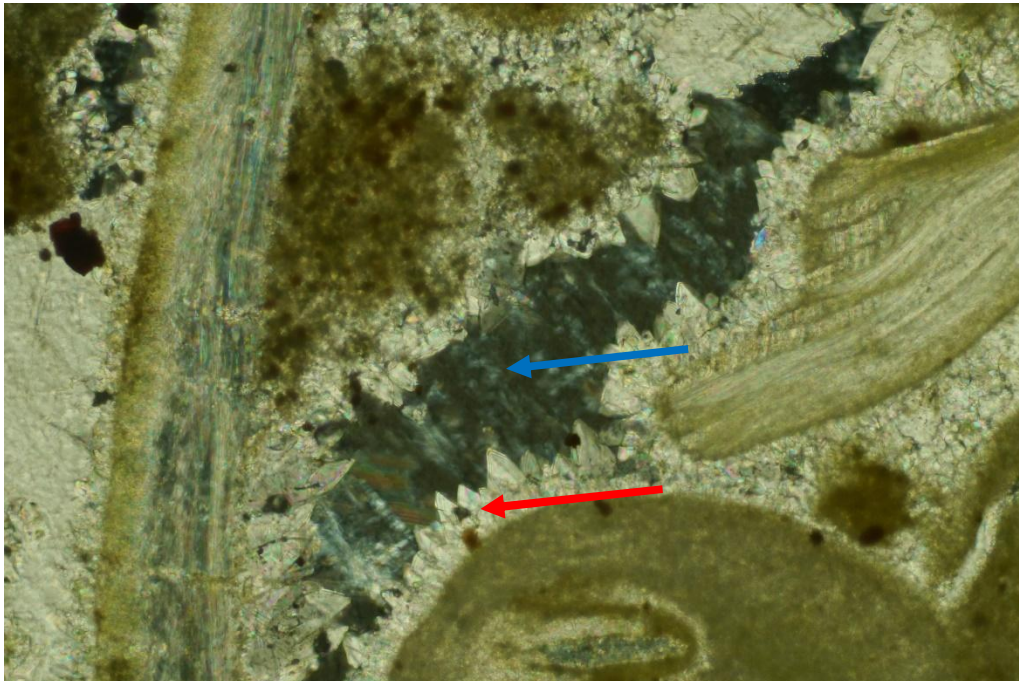


Figure 5. Early stage sparite (arrowed red) and later stage sparite cement (arrowed blue). Cross polarised light, magnification x200