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BRE Test Report

Testing of Ancaster White Base Bed Limestone

Prepared for: Phil Kerry
Date: 22 December 2020
Report Number: P118422 - 1001 Issue: 1

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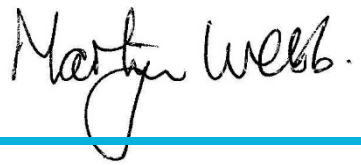
Prepared by

Name Dr Martyn Webb

Position Principal Consultant, Fire and Building Technology Group

Date 22 December 2020

Signature 

Authorised by

Name Dr Tim Yates

Position Technical Director, Fire and Building Technology Group

Date 22 December 2020

Signature 

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Table of Contents

1 Introduction 3

2 Test programme 3

2.1 Masonry 3

3 Test Results 4

3.1 Masonry BS EN 771 -6 4

4 Appendix Detailed Test Results 5

1 Introduction

Following instruction from Phil Kerry (Goldholme Stone Ltd.) BRE has completed a series of tests on the Ancaster White Base Bed 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	2230	kg/m^3
Open Porosity	BS EN 1936	17.8	% by volume
Water Absorption at atmospheric pressure	BS EN 13755	6.5	% by weight
Water Absorption by capillarity	BS EN 772 - 11	40	g/(m2.s0.5)
Compressive strength	BS EN 772 -1	68.2	MPa
Frost Resistance	BS EN 12371	14	cycles
Water vapour resistance factor dry*	EN ISO 10456	200	
Water vapour resistance factor wet*	EN ISO 10456	150	
Specific heat capacity*	BS EN 1745	1000	J/(kg.K)
Thermal conductivity in dry state $\lambda_{10\ dry\ unit}$*	BS EN 1745	1.7	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

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BSEN 1936: 2006: Determination of open porosity and apparent density

Name of Stone:	Ancaster White Base Bed		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
P118422/20/02/					
	g	g	g	kg.m^{-3}	%
251	277.62	175.64	300.17	2220	18.1
252	281.01	177.65	303.18	2230	17.7
253	290.00	183.38	311.41	2260	16.7
254	280.11	177.11	302.86	2220	18.1
255	279.53	176.84	302.15	2230	18.1
256	280.11	177.28	303.31	2220	18.4
			Mean	2230	17.8

* The calculation of apparent density assumes the density of water to be 998 kg.m^{-3} at 20 ^{o}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): **17.8** %

Mean apparent density (ρ_b) **2230** kg.m-3

Approved by: Martyn Webb. Date: 15/10/2020

UKAS TESTING 0578

Name: Dr Martyn Webb

Position: Principal Consultant Fire and Building Technology Group

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BSEN 13755: 2008: Determination of water absorption at atmospheric pressure

Name of Stone:	Ancaster White Base Bed		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 P118422/20/02/	**1 hr md**	**48 hrs mi2**	**72 hrs ms**	Difference (ms-mi2)	**Water Absorption**
	g	g	g	%	**%**
241	280.59	299.00	299.19	0.066	**6.6**
242	286.80	306.82	306.94	0.040	**7.0**
243	289.23	307.23	307.36	0.043	**6.3**
244	287.38	306.91	307.03	0.040	**6.8**
245	288.57	308.13	308.24	0.038	**6.8**
246	289.87	306.22	306.31	0.031	**5.7**
				Mean	**6.5**

Mean Water Absorption (A_b): 6.5 %

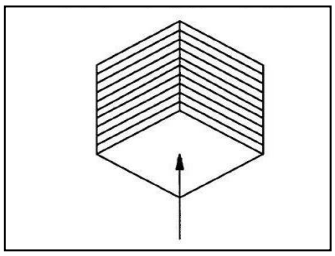
Approved by: Martyn Webb. Date: 15/10/2020

Name: Dr Martyn Webb

Position: Principal Consultant Fire and Building Technology Group

UKAS TESTING 0378

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 White Base Bed		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	30/08/2020	Tested by:	I. Rance

	Width 1	Width 2	Water absorption *
BRE No			
P118422/20/02/	m	m	$gm^2s^{-0.5}$
116	0.0703	0.0705	38
117	0.0703	0.0701	41
118	0.0704	0.0704	48
119	0.0703	0.0704	48
120	0.0704	0.0705	35
121	0.0707	0.0703	30

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

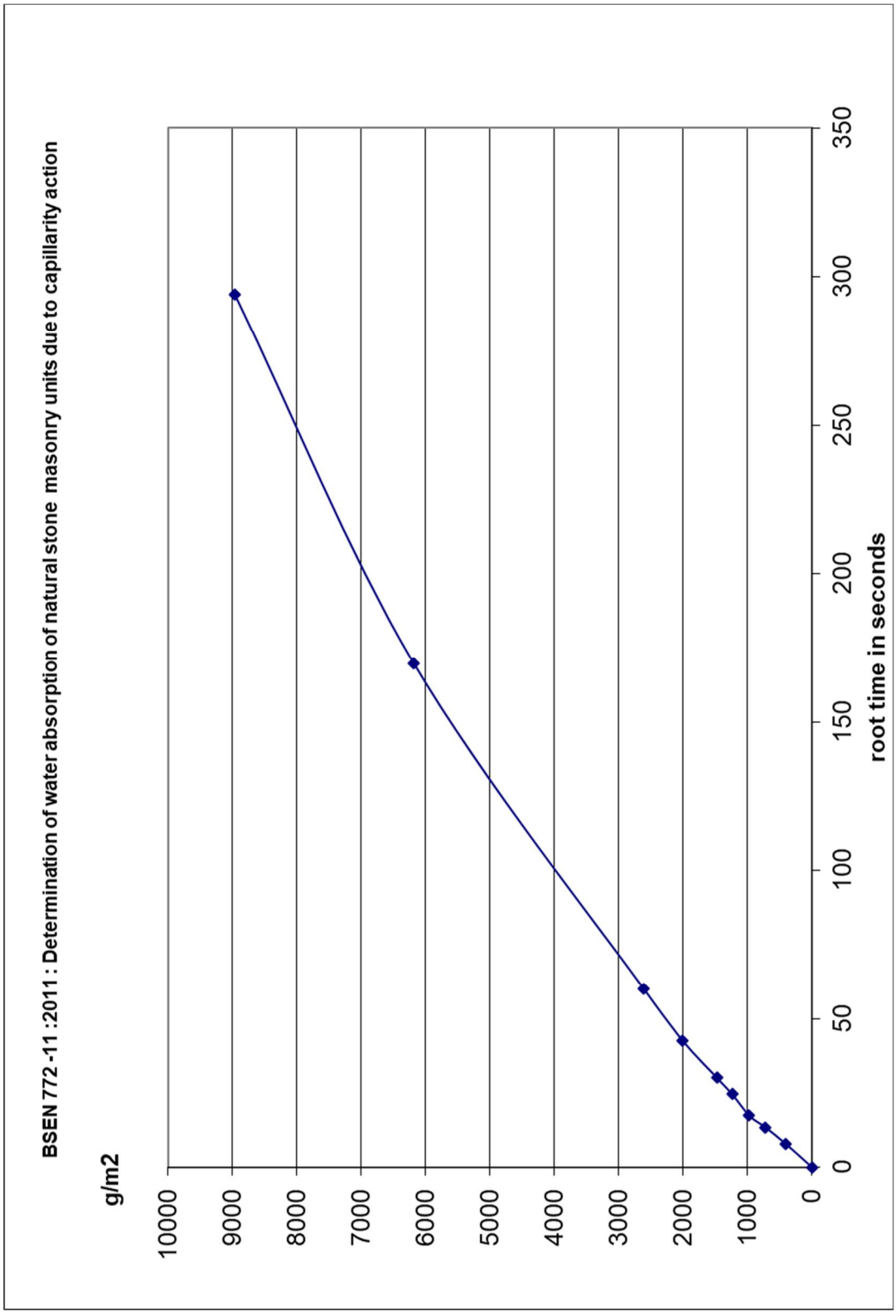
Mean Water absorption: c_1 **40** $g/(m^2.s^{0.5})$

Approved by: Martyn Webb. Date: 15/10/2020

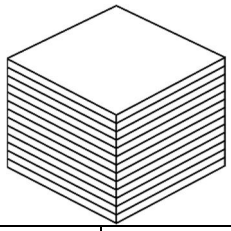
Name: Dr Martyn Webb

Position: Principal Consultant, Fire and Construction Technology Group

UKAS TESTING 0578



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



Name of Stone:	Ancaster White Base Bed	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
P118422/20/02/	MPa s-1	mm	mm	mm	kN	MPa
165	0.6	69.4	70.6	70.3	345	69.4
166	0.6	69.8	70.7	70.3	358	72.1
167	0.6	69.9	70.4	70.5	332	66.9
168	0.6	69.8	70.3	70.5	357	72.0
169	0.6	70.2	70.4	70.4	330	66.6
170	0.6	70.2	70.4	70.7	355	71.3
171	0.6	70.2	70.6	70.3	360	72.6
172	0.6	70.3	70.5	70.3	309	62.3
173	0.6	70.2	70.5	70.3	320	64.5
174	0.6	69.9	70.5	70.4	317	63.9
					Mean	**68.2**
					St. Dev	**3.80**
					Co of var	**0.06**

Note. Tested dry to BSEN 772-1 Part 7.3.2

Approved by: Martyn Webb. Date: 15/10/2020

Name: Dr Martyn Webb

Position: Principal Consultant Fire and Building Technology Group

UKAS TESTING 0378

BS EN 1745:2012 Masonry and masonry products -
Methods for determining thermal properties - Tabulated design values

Name of Stone:	Ancaster White Base Bed
Block No:	No data supplied
Country of Origin:	UK
Supplier:	Client
Date Assessed	15/10/2020
Petrographic Nature:	Limestone
BRE Project number	P118422

Property	Value	units
Density	2230	Kgm-3
Thermal conductivity in dry state $\lambda_{10\ dry\ unit}$	1,7	W/(mK)
Specific heat capacity	1000	J/(kgK)

Approved by: Date: 15/10/2020

Name: Dr Martyn Webb

Position: Principal Consultant 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 White Base Bed
Block No:	No data supplied
Country of Origin:	UK
Supplier:	Client
Date Assessed	15/10/2020
Petrographic Nature:	Limestone
BRE Project number	P118422

Property	Value	units
Density	2230	Kgm-3
Water vapour resistance factor - dry	200	
Water vapour resistance factor - wet	150	

Approved by: Date: 15/10/2020

Name: Dr Martyn Webb

Position: Principal Consultant 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 White Base Bed	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 21/09/2020	Tested by:	A. Cantellow	

	0 cycles	**14 cycles**					
BRE no P118422/20/02	E MPa	E MPa	% Change	Visual Inspection	E MPa	% Change	Visual Inspection
101	32070	33950	6	0			
102	32168	32888	2	0			
103	32412	33800	4	0			
104	32977	33119	0	0			
105	32874	33196	1	0			
106	31751	32060	1	1			
107	34619	33675	-3	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: Martyn Webb. Date: 03/12/2020

Name: Dr Martyn Webb

Position: Principal Consultant, Fire and Building Technology Group

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BS EN 12407 Petrographic Examination of Natural Stone

Sample Description

Name of Stone:	Ancaster White Base Bed	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	P118422/20/02	Sample I.D Number	P118422/20/02/146

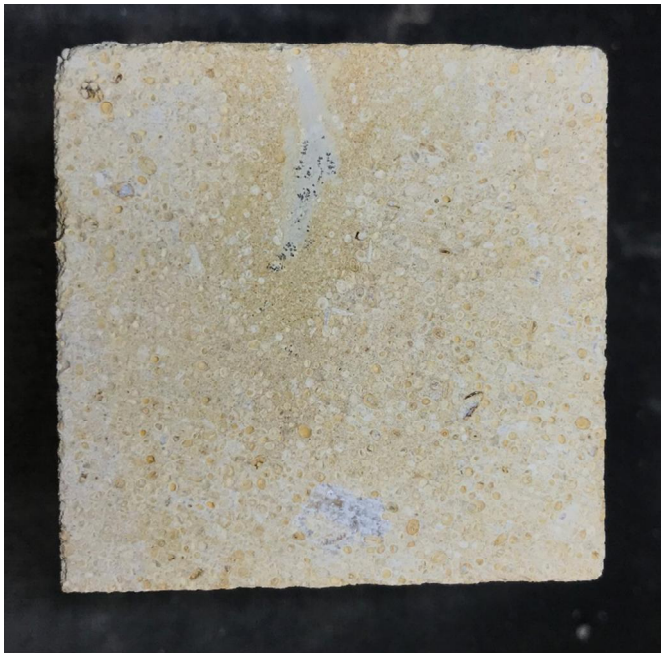

Figure 1: Image of hand specimen, width of sample is 50 mm

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 P118422/20/02/146

In hand specimen the stone was cream to buff in colour, sometimes showing patchy colouration (Figure 1). The stone consisted predominantly of micritic ooliths with nuclei visible, sparitic bioclasts, which were generally elongate in shape. Smaller grains and cement were visible around the principal constituents.

The stone appeared quite dense although it scratched easily, and it absorbed water readily in the drop test.

There was no evidence of weathering or deterioration.

Microscopic Examination of P118422/20/02/146

The dominant visible constituents were ooliths, typically up to 1.5 mm in diameter. These ooliths formed greater than 25 % of the allochems within the stone. Bioclasts were also present. The typical appearance of the stone is shown in Figure 2.

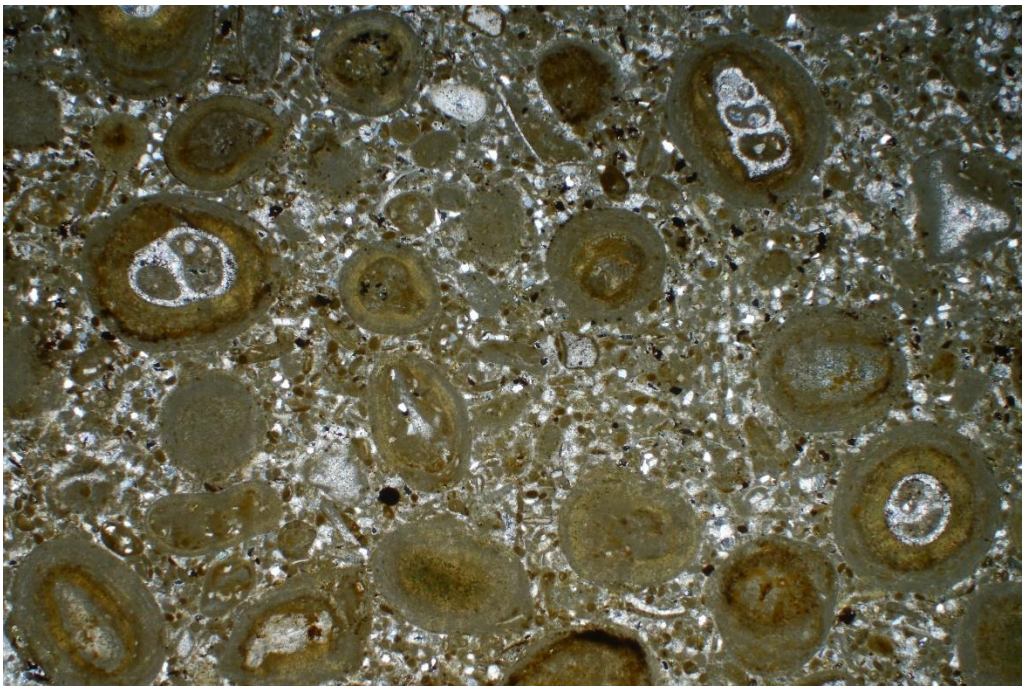

Figure 2. Typical appearance of Ancaster White Base Bed in thin section. Cross polarised light, magnification x25.

The ooliths usually showed the presence of a seed formed from a fragment of intraclast or bioclast, with concentric structure generally present outside this. These were composed of micrite, with some of the layers showing concentrations of iron minerals (visible in Figure 2). A few sparite bioclasts were observed, often showing a micrite cortex (Figure 3).

The principal constituents (ooliths and bioclasts) were evenly and openly distributed across the section, and in between was a matrix formed from 0.15 mm down pellets of broken bioclast pieces micrite peloids, some containing iron. Some sub-50 micron quartz grains were present within this matrix (Figures 4 & 5). These fine particles were held within a sparite cement, which also cemented the stone overall.

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).**

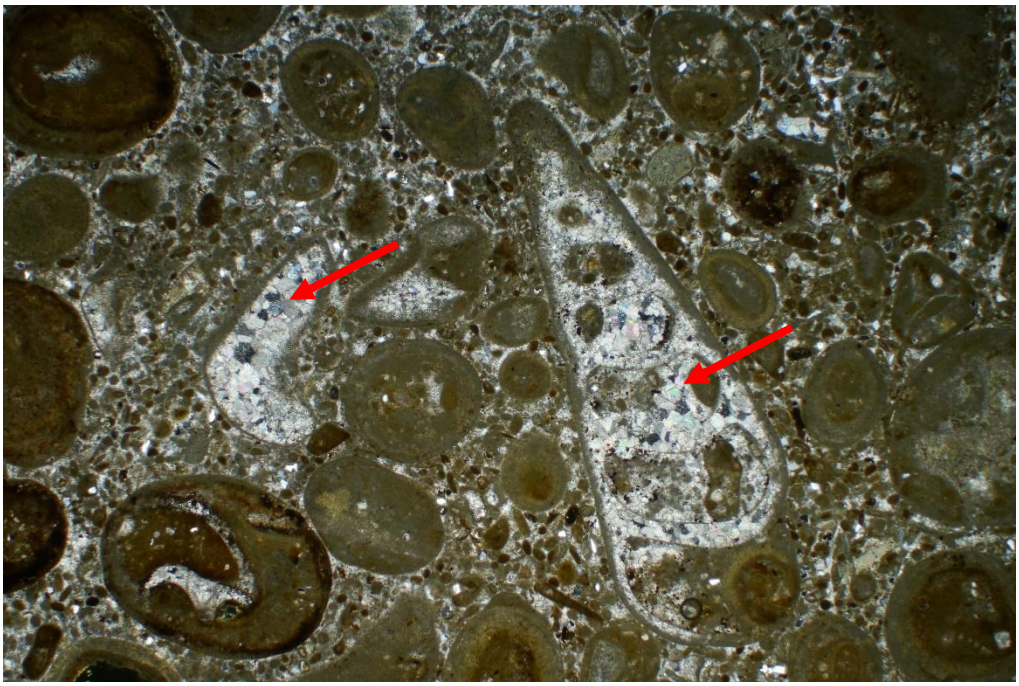

Figure 3. Sparite bioclasts (arrowed). Cross polarised light, magnification x25.

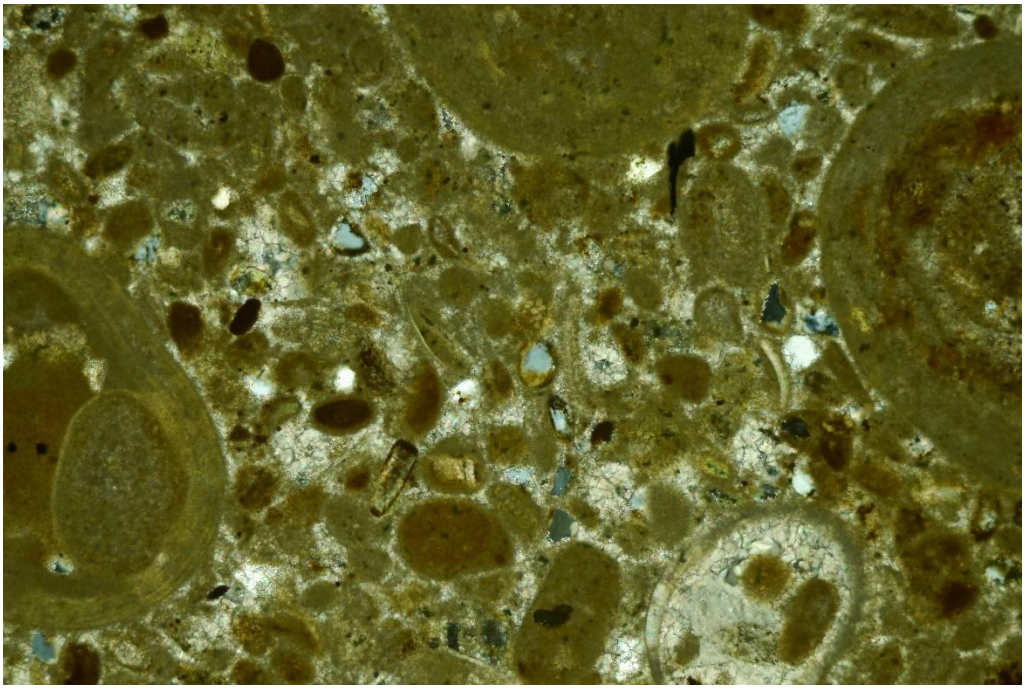

Figure 4. Showing the finer matrix/cement. Cross polarised light, magnification x100.

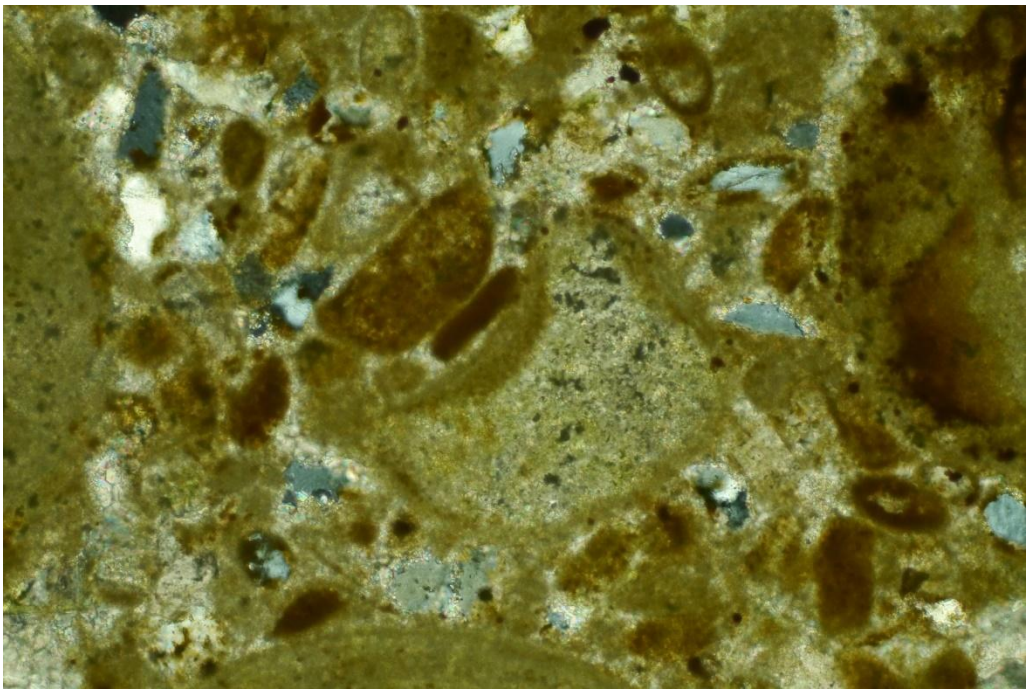

Figure 5. Further detail of the finer matrix/cement (quartz grains are grey in image). Cross polarised light, magnification x200

Report Ends