



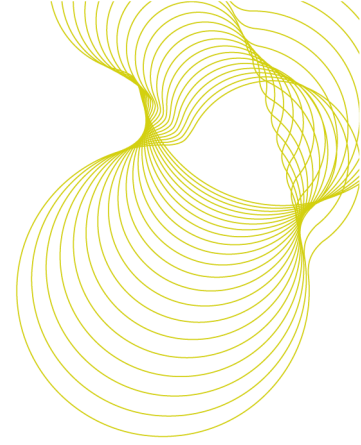
bre

**Testing of Lincolnshire  
Limestone**

Prepared for:  
Phil Kerry  
Goldholme Stone Ltd.  
Irnham Grange  
Irnham Road  
Corby Glen  
Grantham  
Lincolnshire  
NG 33 4 NE

25<sup>th</sup> July 2013

Test report number 287818 - 3



**Prepared by**

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Name Geoff Ashall  
Position Principal Consultant, Building Technology Group  
Date 25/07/13

Signature 

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**Approved on behalf of BRE**

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Name Dr. Martyn Webb  
Position Principal Consultant, Building Technology Group  
Date 25/07/13

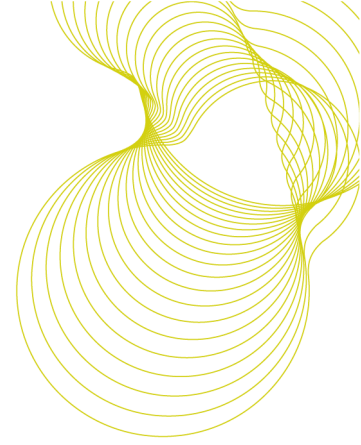
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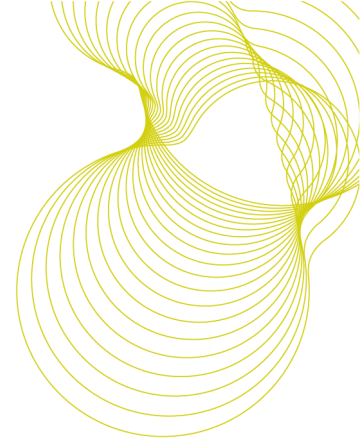
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## 1 Introduction

Following instruction from Phil Kerry (Goldholme Stone Ltd.), BRE have completed a series of tests on specimens of stone reported to be Lincolnshire Limestone. The stone was delivered to BRE on the 29/05/13. This report provides a factual account of the testing carried out.

## 2 Test Details

The following tests were carried out:

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

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

BS EN 772-1 Natural stone test methods. Determination of uniaxial compressive strength\*

BS EN 12372: 2006, Natural stone test methods. Determination of flexural strength under concentrated load.

BSEN 772-11, 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\*

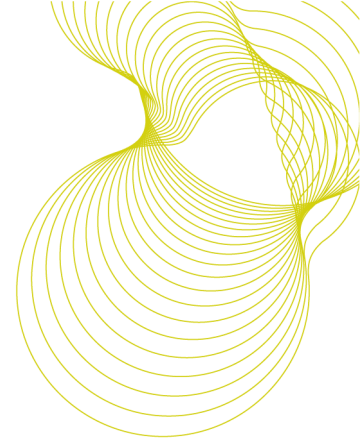
BS EN 12407:, Natural stone test methods. Petrographic examination

\* Please note BRE is UKAS accredited for this test.

Tabulated data has been used to provide

BSEN 13501 – 1, Fire classification of construction products and building elements. Classification using test data from reaction to fire tests

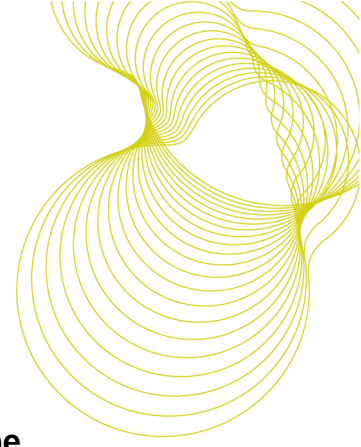
BSEN 12524, Building materials and products. Hygrothermal properties. Tabulated design values



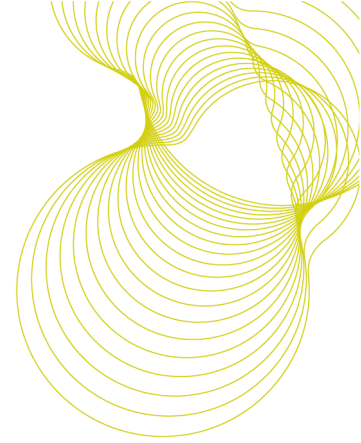
### 3 Test Results



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

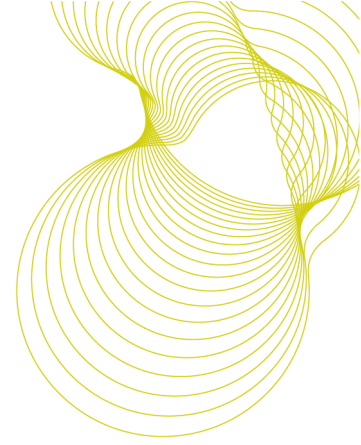
Test	Standard	Value	Unit
Determination of Open Porosity	BSEN 1936	<b>15.5</b>	% by vol.
Apparent Density	BSEN 1936	<b>2290</b>	Kgm <sup>-3</sup>
Water Absorption	BSEN 13755	<b>6.4</b>	% by mass
Compressive Strength (Lower expected value)	BSEN 772-1	<b>44 (31)</b>	MPa
Flexural Strength (Lower expected value)	BSEN 12372	<b>4.0 (3.2)</b>	MPa
Water Absorption by Capillarity	BSEN 772-11	<b>171.5</b>	g.m <sup>2</sup> .s <sup>-0.5</sup>
Petrographic Examination	BSEN 12407	<b>Oosparitic Limestone</b>	
Design Thermal Conductivity	BSEN 12524	<b>1.84</b>	Kgm <sup>-3</sup>
Specific Heat Capacity	BSEN 12524	<b>1000</b>	J(kg.K)
Water Vapour Resistance Factor dry	BSEN 12524	<b>200</b>	
Water Vapour Resistance Factor wet	BSEN 12524	<b>150</b>	
Reaction to fire (Declared value)	Without testing (see decision 96/603/EC, as amended)	<b>A1</b>	





#### 4 **Appendix A: Detailed Test Results for Lincolnshire Limestone**

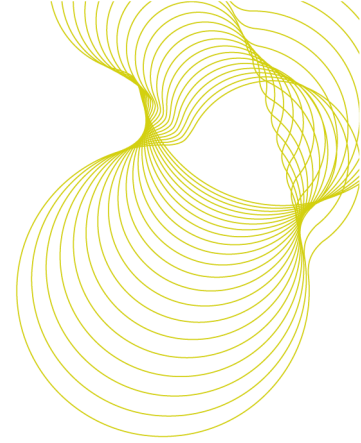


<b>BSEN 1936: Determination of Open Porosity And Apparent Density</b>					
Name of Stone:	Lincolnshire Limestone		Petrographic Nature:	Limestone	
Block No:	Data not supplied		Anisotropic Features:	Visible	
Supplier:	Goldholme Stone		Country of Origin:	UK	
Dimensions:	50 x 50 x 50 mm		Project Reference:	Data not supplied	
Surface Finish:	Sawn		Preparation /Conditioning:	Prepared to BSEN 1936	
Date Tested:	17/06/2013	19/06/2013	Tested by:	Ian Rance	
BRE No	Md	Mh	Ms	Apparent Density	Open Porosity
287818/13/03	g	g	g		
211	303.08	191.59	324.05	2280	15.8
212	302.50	191.24	323.28	2290	15.7
213	305.71	193.26	326.53	2290	15.6
214	305.20	192.94	325.42	2300	15.3
215	304.40	192.43	325.17	2290	15.7
216	308.10	194.76	327.94	2310	14.9
			<b>Mean</b>	2290	15.5
<p>* The calculation of apparent density assumes the density of water to be 998Kgm<sup>-3</sup> at 20<sup>o</sup>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</p>					
<b>Mean open porosity (%):</b>				<b>15.5</b>	
<b>Mean apparent density (Kgm<sup>-3</sup>)</b>				<b>2290</b>	
Approved by:			Date:	25/07/2013	
Name:	Geoff Ashall				
Position:	Principal Consultant, Building Technology Group				
				 0378	

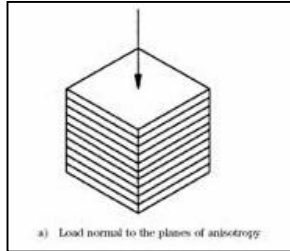


<b>BSEN 13755: Water absorption at atmospheric pressure</b>					
Name of Stone:	Lincolnshire Limestone		Petrographic Nature:	Limestone	
Block No:	Data not supplied		Anisotropic Features:	Visible	
Supplier:	Goldholme Stone		Country of Origin:	UK	
Dimensions:	50 x 50 x 50 mm		Project Reference:	Data not supplied	
Surface Finish:	Sawn		Preparation /Conditioning:	Prepared to BSEN 13755	
Date Tested:	14/06/2013	21/06/2013	Tested by:	Ian Rance	
	Dry mass	Wet mass	Wet mass		
BRE No	<b>1 hr</b>	<b>48 hrs</b>	<b>72 hrs</b>	Difference	<b>Water</b>
287818/13/03	<b>md</b>	<b>mi</b>	<b>ms</b>	(ms-mi)	<b>Absorption</b>
				%	%
221	306.34	325.59	325.68	0.028	<b>6.3</b>
222	307.56	326.49	326.58	0.029	<b>6.2</b>
223	306.40	325.51	325.62	0.033	<b>6.3</b>
224	304.72	324.49	324.59	0.031	<b>6.5</b>
225	307.36	326.76	326.88	0.036	<b>6.4</b>
226	300.88	320.95	321.03	0.026	<b>6.7</b>
				<b>Mean</b>	6.4
					<b>Mean Water Absorption of Sample: 6.4 (%)</b>
Approved by:			Date:	25/07/2013	
Name:	Geoff Ashall				
Position:	Principal Consultant, Building Technology Group				
					 0378

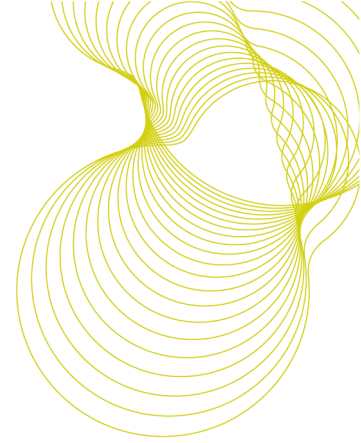




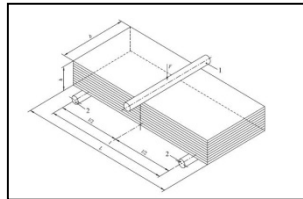
**BSEN 772-1: Determination of Compressive Strength (Dry)**



Name of Stone:	Lincolnshire Limestone	Petrographic Nature:	Limestone			
Block No:	Data not supplied	Anisotropic Features:	Visible			
Supplier:	Goldholme Stone	Country of Origin:	UK			
Dimensions:	70x 70 x 70 mm	Project Reference:	Data not supplied			
Surface Finish:	Sawn	Preparation /Conditioning:	Prepared to BSEN 1926			
Date Tested:	05/07/2013	Tested by:	Ian Rance			
	Load	Height	Mean	Mean	Failure	Comp.
BRE No	Rate		Length	Width	Load	Strength
287818/13/03	KPa s-1	mm	mm	mm	kN	MPa
171	600	71	71.1	71.0	223	44
172	600	71	71.0	70.9	238	47
173	600	71	71.0	71.0	239	47
174	600	71	71.4	70.7	143	28
175	600	71	70.9	70.9	244	49
176	600	71	71.0	70.9	233	46
177	600	71	70.8	70.7	210	42
178	600	71	70.9	70.8	241	48
179	600	71	70.8	71.0	232	46
180	600	71	70.9	70.7	237	47
					<b>Mean</b>	<b>44</b>
					<b>St. Dev</b>	<b>6.1</b>
					<b>Co of var</b>	<b>0.14</b>
					<b>LEV</b>	<b>31</b>
Approved by:			Date:	25/07/2013		
Name:	Geoff Ashall					
Position:	Principal Consultant, Building Technology Group					



**BSEN 12372: Determination of Flexural Strength under Concentrated Load**



Name of Stone:	Lincolnshire Limestone	Petrographic Nature:	Limestone
Block No:	Data not supplied	Anisotropic Features:	Visible
Supplier:	Goldhome Stone Ltd.	Country of Origin:	UK
Dimensions:	300 x 75 x 50 mm	Project Reference:	Data not supplied
Surface Finish:	Sawn	Preparation /Conditioning:	Prepared to BSEN 12372
Date Tested:	18/06/2013	Tested by:	Geoff Ashall

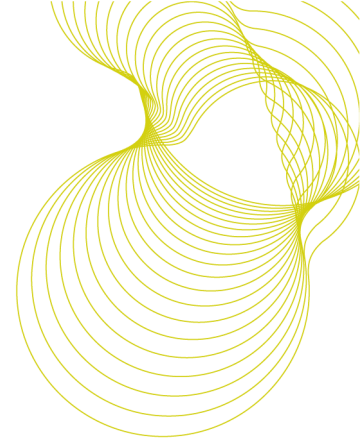
BRE no	Load Rate	Span	Width	Thickness	Failure Load	Flexural Strength
	MPa.s <sup>-1</sup>	mm	mm	mm	N	MPa
287818/13/03						
191	0.25	260	75.9	51.8	1790	3.4
192	0.25	260	76.0	51.6	2320	4.5
193	0.25	260	75.9	52.1	1830	3.5
194	0.25	260	76.0	52.0	2200	4.2
195	0.25	260	75.9	52.3	2350	4.4
196	0.25	260	75.8	52.1	2200	4.2
197	0.25	260	75.8	51.9	2290	4.4
198	0.25	260	75.7	51.9	1760	3.4
199	0.25	260	75.9	52.2	2250	4.2
200	0.25	260	75.6	52.1	2160	4.1

<b>Mean</b>	<b>4.0</b>
<b>St. Dev</b>	<b>0.43</b>
<b>Co of var</b>	<b>0.11</b>
<b>LEV</b>	<b>3.2</b>

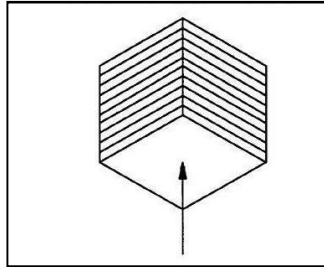
Approved by:  Date: 25/07/2013

Name: Dr. Martyn Webb  
 Position: Principal Consultant, Building Technology Group





**BSEN 772-11 : Determination of Water Absorption Coefficient by Capillarity  
Perpendicular to Bedding**



Name of Stone:	Lincolnshire Limestone	Petrographic Nature:	Limestone
Block No:	Data not supplied	Anisotropic Features:	Visible
Supplier:	Goldholme Stone	Country of Origin:	UK
Dimensions:	70 x 70 x 70 mm	Project Reference:	Data not supplied
Surface Finish:	Sawn	Preparation /Conditioning:	BSEN 1925
Date Tested:	07/07/2013	09/07/2013	Tested by: Ian Rance

	Width 1	Width 2	Water absorption *
BRE No			
287818/13/03	m	m	gm <sup>2</sup> s <sup>-0.5</sup>
251	0.0711	0.0708	154.1
252	0.0711	0.0708	171.1
253	0.0708	0.0701	142.6
254	0.0709	0.0707	188.0
255	0.0709	0.0710	194.2
256	0.0709	0.0710	178.9

\*Calculated following procedure in note 1

**Mean Water absorption: 171.5 g.m<sup>2</sup>s<sup>-0.5</sup>**

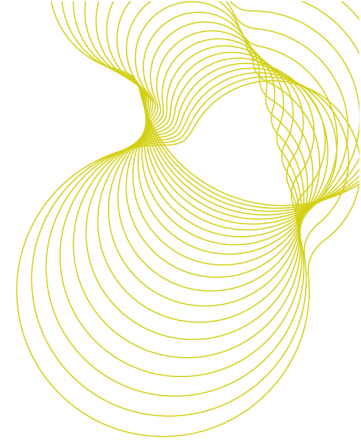
Approved by: 


Date: 25/07/2013

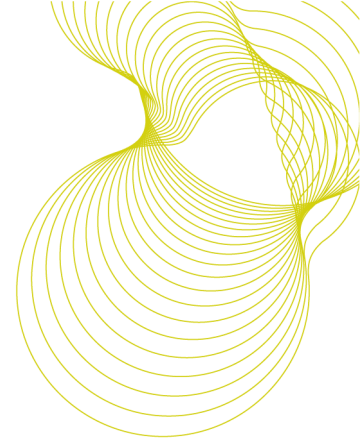


Name: Mr Geoff Ashall

Position: Principal Consultant, Building Technology Group



<b>EN 12524:2000 Building materials and products - Hygrothermal properties - Tabulated design values</b>																			
Name of Stone:	Lincolnshire limestone																		
Block No:	Data not supplied.																		
Country of Origin:	UK																		
Supplier:	Goldholme Stone Ltd.																		
Date Assessed	25/07/2013																		
Petrographic Nature:	Limestone																		
<table border="1" style="margin: auto; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Property</th> <th style="text-align: center;">Value</th> <th style="text-align: center;">units</th> </tr> </thead> <tbody> <tr> <td>Density</td> <td style="text-align: center;">2290</td> <td style="text-align: center;">Kgm-3</td> </tr> <tr> <td>Design thermal conductivity</td> <td style="text-align: center;">1.84</td> <td style="text-align: center;">W/(mK)</td> </tr> <tr> <td>Specific heat capacity</td> <td style="text-align: center;">1000</td> <td style="text-align: center;">J/(kgK)</td> </tr> <tr> <td>Water vapour resistance factor dry</td> <td style="text-align: center;">200</td> <td></td> </tr> <tr> <td>Water vapour resistance factor wet</td> <td style="text-align: center;">150</td> <td></td> </tr> </tbody> </table>		Property	Value	units	Density	2290	Kgm-3	Design thermal conductivity	1.84	W/(mK)	Specific heat capacity	1000	J/(kgK)	Water vapour resistance factor dry	200		Water vapour resistance factor wet	150	
Property	Value	units																	
Density	2290	Kgm-3																	
Design thermal conductivity	1.84	W/(mK)																	
Specific heat capacity	1000	J/(kgK)																	
Water vapour resistance factor dry	200																		
Water vapour resistance factor wet	150																		
Approved by:		Date:	25/07/2013																
Name:	Dr. Martyn Webb																		
Position:	Principal Consultant, Building Technology Group																		



**BS EN 12407 Petrographic Examination of Natural Stone**

**Sample Description**

Name of Stone:	Lincolnshire Limestone	Petrographic Nature:	Limestone
Block No:	Not applicable	Anisotropic Features:	None
Supplier:	Goldholme Stone Ltd.	Country of Origin:	UK
Dimensions:	75 x 50 mm x 30 µm	Project Reference:	Data not supplied
Surface Finish:	Cut	Preparation /Conditioning:	Prepared to BS EN 12407
Date Tested:	17/07/13	Tested By:	Martyn Webb
Project no	287818-HCV059	Sample I.D Number	287818/13/03/117



**Figure 1:** Image of hand specimen, width of image approximately 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 **Oosparitic limestone**.

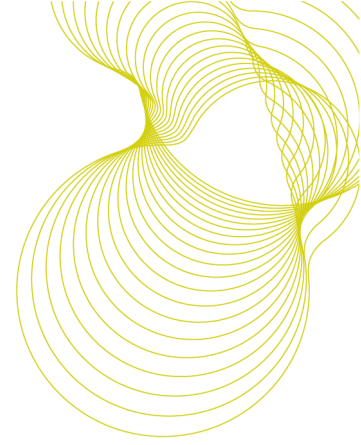
Final approved by: 

Date: 18/07/13

Name: Geoff Ashall

Position: Principal Consultant





### **Macroscopic Examination of 287818/13/03/117**

In hand specimen the stone was buff in colour and medium to coarse grained (Figure 1). The fabric was dominated by the presence of ooliths, with occasional large (bivalve) fragments also visible. The texture appeared quite dense, and all the constituents appeared to be contained within a sparite cement. There was no particular orientation to the more elongate particles.

The stone reacted vigorously to dilute hydrochloric acid, and water was only slowly absorbed in the water drop test.

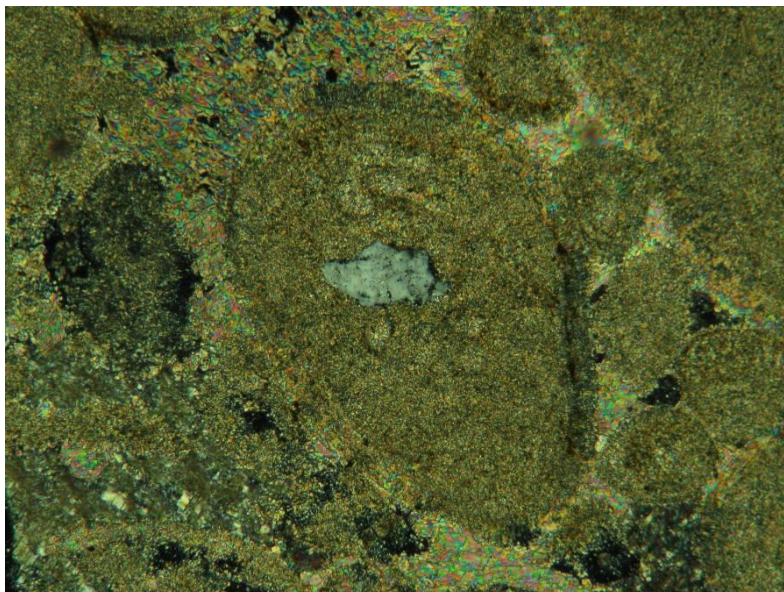
There did not appear to be any evidence of weathering and/or alteration at this level of examination.

### **Microscopic Examination of 287818/13/03/117**

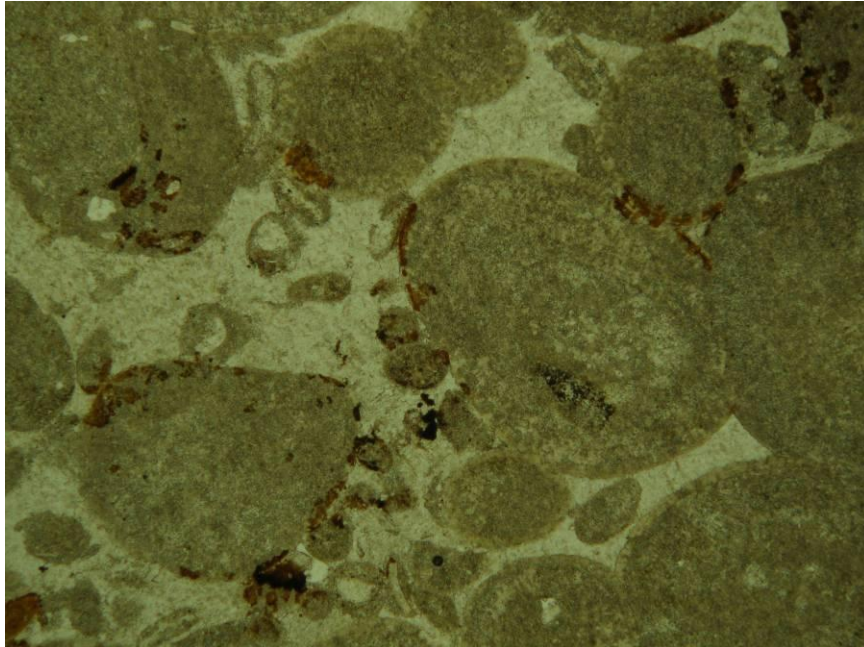
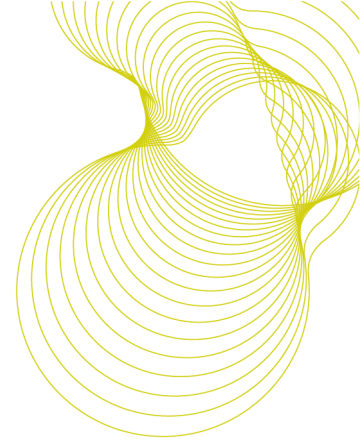
In thin section the mineralogy was dominated by ooliths, these being mainly micritic in nature and with a concentric structure often visible. Some were seeded with individual or clusters of quartz grains (Figure 2). The majority of the ooliths had a nominal diameter of 0.5 mm. There was close packing of many of the constituents, with some compaction deformation being visible.

Occasional patches of iron/organic discolouration were observed (Figure 3), but these were not seen throughout the section. All the constituent particles were held within a coarsely crystallised sparite cement (Figure 3), with only very few pore spaces noted.

Staining with Alizarin Red S showed the constituents and cement to be composed of calcite.



**Figure 2.** Typical appearance of an oolith seeded with a quartz grain. Cross polarised light, magnification x100.



**Figure 3.** Localised discolouration seen in sample 287818/03. Plane polarised light, magnification x 50.

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

=====REPORT ENDS=====