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Testing of Balmoral Grey Slate Sample

This Test Report was made for our supplier who called the slate another name.
We have substituted the suppliers slate name with our name Balmoral Grey Slate in this Report.
The slate supplied by Roofslates.com as Balmoral Grey Slate is the slates Tested in this Report.

Roofslates.com

Date:	16th April 2012
File Reference Number:	0001333/R2
Your Reference Number:	DB02808
Document Reference Number:	M5340R2

Testing of Balmoral Grey Slate Sample
Roofslates.com

Prepared and Approved by:	A Ali Msc
Title:	Senior Materials Consultant
Signature:	

Date:	16th April 2012
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Contents

Introduction

In accordance with your instructions contained in your Order No. DB02802 we have carried out a series of tests on a slate sample in accordance with BS EN 12326-2 : 2000.

This report describes the test methods and presents the results of tests.

The testing was conducted in the period of 28th February 2012 to 6th April 2012.

Details of Samples

A sample of 50 slates each measured approximately 500 x 250mm was received from yourselves on 24th February 2012The sample was identified by you as "Balmoral Grey" slate.

The sample was given our laboratory reference number EE 7308.

Details of Testing

The following tests were conducted on the slate sample generally in accordance with BS EN 12326-2 : 2000.

3.1 Determination of the Length and Width, Clause 5

3.2 Determination of the amount by which the edges deviate from a straight edge, Clause 6.

3.3 Deviation of Rectangularity of Slates, Clause 7.

3.4. Thickness of Individual Slates, Clause 8.2

3.5 Determination of the Deviation from Flatness, Clause 9.

3.6 Determination of the Failure Load in Bending, Clause 10.

3.7 Water Absorption, Clause 11.

3.8 Determination of Non-Carbonate Carbon Content, by Catalytic Thermal Decomposition, Clause 13.1 (see Note 1)

3.9 Determination of Carbonate Content, by Catalytic Thermal Decomposition, Clause 14.1

(see Note 1)

Note 1 The test procedure was as described in the standard except that an amount 0.5g from each powdered slate was added to 500 ml of Hydrochloric acid. This was then filtered, washed and dried before 0.01 g was analysed from each sample.

3.10 Sulphur Dioxide Exposure Test for Slates with a Calcium Carbonate Content of less than 20%, Clause 15.1.

3.11 Thermal Cycle Test, Clause 16

Test Results and Test Requirements

Length and Width

The length of the slate sample was 501mm.

The difference between the measured length and the nominal specified length (500mm) is 1mm.

The width of the slate sample was 251mm.

The difference between the measured width and the nominal specified width (250mm) is 1mm.

Test Requirement

The test requirement as stipulated in of BS EN 12326-1 : 2004 is that rectangular slates shall not deviate from the manufacturers declared length and width by more than ± 5mm.

The Amount by which the Edges Deviate from a Straight Edge

The maximum deviation of the edges of the slate Sd_1 and Sd_2

Sd_1 = 1mm
Sd_2 = 0mm

Test Requirement

In accordance with BS EN 12326 – 1, for slates less than or equal to 500mm in length the deviation shall not exceed 5mm.

Rectangularity of Slates

The deviation R_d of the slate edges from a rectangle is

Rd_1 : 1mm
Rd_2 : 1mm
Rd_3 : 1mm
Rd_4 : 1mm

Deviation from a rectangle Rd = 0.2%

Test Requirement

In accordance with the BS EN 12326-1 rectangular slates which have not been shouldered shall not deviate from rectangularity in any corner by more than 1% of their length.

Thickness

Thickness of Individual Slates

The thickness measurements of the slate sample are given in Table 1

Table 1:Thickness Results

Sample Ref	Measurement No. (mm)				Mean	Max Deviation
	1	2	3	4	4	%
EE 7308	6.3	7.3	6.1	6.2	6.5	12.3

Requirements for Thickness

In accordance with BS EN 12326-1, the packed slates shall not deviate by more than ±15% of the declared nominal thickness.

The variation of the individual thickness shall be within the declared range which shall not be greater than ±35% of the nominal thickness.

Deviation from Flatness

The deviation from flatness was found to be 0.17%.

Requirement for the Deviation from Flatness

When tested in accordance with Clause 9 of BS EN 12326-2 : 2000 rectangular slates for normal use shall not deviate from flat by more than the percentage shown in the following table.

Slate Type*$_1$	Deviation as a percentage of length
Smooth	< 1.0
Normal	< 1.5
Texture	< 2.0

*$_1$ As specified by the manufacturer

since the deviation of the slate from flat is 0.17%, it meets all the requirements of the above table.

Failure Load in Bending

The results of the modulus of rupture tests are given in the following Tables 2 and 3

TABLE 2 Sample EE7308, Transverse Bending Tests BS EN 12326-2

Sample Ref	Ultimate Load Pi, N	Width b, mm	THICKNESS,e (mm)									Modulus of Rupture
			1	2	3	4	5	6	7	8	Av	3Pi.lt/2be^2
EE7308/14	643	125	5.25	5.25	5.51	5.59	5.59	5.82	5.52	5.61	5.52	45.62
EE7308/15	896	125	5.99	5.79	6.24	6.04	6.01	6.08	5.79	5.47	5.93	55.11
EE7308/16	998	125	6.47	6.12	5.90	5.73	5.30	5.59	6.23	6.16	5.94	61.15
EE7308/17	1192	125	7.32	7.22	6.81	7.06	6.63	6.83	6.60	7.01	6.94	53.53
EE7308/18	1118	125	7.01	6.73	6.71	6.79	6.67	6.64	6.80	6.61	6.75	53.08
EE7308/19	1205	125	5.59	6.26	6.52	6.65	5.69	5.78	6.05	6.03	6.07	70.61
EE7308/20	1720	125	8.60	8.50	8.42	8.21	8.23	8.16	8.21	8.48	8.35	53.27
EE7308/21	972	125	5.67	5.50	5.45	5.70	5.93	5.63	5.66	5.42	5.62	66.47
EE7308/22	734	125	5.67	5.84	5.22	5.06	6.05	5.83	5.77	5.58	5.63	50.06
EE7308/23	983	125	6.04	6.18	6.32	6.78	6.09	6.26	5.93	6.05	6.21	55.13
EE7308/24	1135	125	6.97	7.03	6.88	7.01	6.92	6.98	7.18	7.04	7.00	50.01
EE7308/25	1558	125	8.12	8.19	8.03	8.15	8.20	8.07	8.16	8.14	8.13	50.88
EE7308/26	1136	125	7.31	7.05	6.81	6.46	6.88	6.72	7.12	7.17	6.94	50.95
EE7308/27	1780	125	7.42	7.19	7.58	7.50	7.98	7.62	7.56	7.91	7.60	66.65
EE7308/28	1359	125	6.79	6.95	7.96	7.83	7.56	7.07	7.02	6.74	7.24	56.00
EE7308/29	1177	125	6.41	6.48	6.43	6.31	6.69	6.58	6.97	6.61	6.56	59.08
EE7308/30	1540	125	7.77	8.05	7.74	7.26	7.37	7.55	7.35	7.65	7.59	57.70
EE7308/31	1252	125	6.62	6.74	6.53	7.00	6.41	6.67	6.50	6.53	6.63	61.61
EE7308/32	1554	125	7.52	7.63	7.40	7.21	7.09	7.30	7.36	7.61	7.39	61.46
Mean												**56.87**
Standard Dev												**6.43**
Characteristic Modulus of Rupture												**45.75**

TABLE 3 Sample EE7308, Longitudinal Bending Tests BS EN 12326-2

Sample Ref	Ultimate Load Pi, N	Width b, mm	THICKNESS,e (mm)									Modulus of Rupture
			1	2	3	4	5	6	7	8	Av	$3Pi.lt/2be^2$
EE7308/13	664	125	5.67	5.89	5.65	5.45	5.40	5.60	5.48	5.32	5.56	46.44
EE7308/14	842	125	7.42	7.22	7.13	7.08	6.71	6.83	6.83	6.86	7.01	37.01
EE7308/15	819	125	6.39	5.92	6.82	7.17	7.75	8.20	8.63	8.52	7.43	32.09
EE7308/16	760	125	7.05	6.80	6.48	6.17	6.74	6.96	6.48	6.29	6.62	37.44
EE7308/17	896	125	6.62	6.75	7.16	7.03	6.25	6.58	6.45	6.65	6.69	43.29
EE7308/18	772	125	6.47	6.24	6.22	6.53	6.12	6.03	6.01	6.07	6.21	43.22
EE7308/19	1430	125	8.57	8.69	8.28	8.15	9.03	8.90	8.49	8.03	8.52	42.58
EE7308/20	885	125	5.73	5.72	6.09	5.79	6.13	6.59	7.02	6.39	6.18	50.01
EE7308/21	727	125	5.87	6.44	6.45	6.28	6.30	6.56	6.71	6.62	6.40	38.29
EE7308/22	837	125	6.30	6.21	6.45	6.43	6.83	6.84	6.60	6.25	6.49	42.94
EE7308/23	1263	125	7.79	8.01	8.31	8.26	7.88	7.90	7.98	7.92	8.01	42.56
EE7308/24	1054	125	6.84	6.62	6.92	6.72	7.16	6.79	6.85	6.65	6.82	48.96
EE7308/25	1173	125	7.62	7.42	7.69	7.77	7.41	7.56	7.83	7.63	7.62	43.68
EE7308/26	1656	125	8.34	8.54	8.70	8.00	7.89	7.94	7.86	7.49	8.10	54.59
EE7308/27	924	125	6.35	6.41	6.69	6.92	6.24	6.67	6.78	6.90	6.62	45.54
EE7308/28	1310	125	7.60	7.76	7.98	7.89	7.87	8.19	8.10	7.80	7.90	45.35
EE7308/29	1221	125	7.02	7.16	7.16	7.47	7.53	7.54	7.41	6.84	7.27	49.95
EE7308/30	852	125	6.42	6.50	6.52	6.54	6.66	6.86	7.01	6.56	6.63	41.82
EE7308/31	984	125	6.89	6.91	6.85	6.86	7.21	7.10	7.36	7.35	7.07	42.57
EE7308/32	664	125	5.67	5.89	5.65	5.45	5.40	5.60	5.48	5.32	5.56	46.44
Mean												**43.60**
Standard Dev												**5.24**
Characteristic Modulus of Rupture												**34.53**

Bending Strength and Modulus of Rupture Test Requirements

There is no limit for the modulus of rupture of slates, as indicated in BS EN 12326-1 : 2004.

Water Absorption

The results of the water absorption test are given in Table 4 below.

Table 4 : Water Absorption Test Results

Specimen		Thickness (mm)					Water Absorption %
		1	2	3	4	Mean	
EE 7308/	1	7.2	6.4	7.6	7.3	7.1	0.28
	2	6.6	6.4	7.0	6.8	6.7	0.28
	3	5.8	6.6	6.8	6.2	6.4	0.29
	4	7.1	6.6	5.8	6.2	6.4	0.27
	5	7.3	7.3	7.1	7.2	7.2	0.25
Mean							**0.27**

The slate sample was found to meet code A_1 requirements as indicated in BS EN 12326 – 1.

Water Absorption Requirements

In accordance with BS EN 12326-1 : 2004 the slate shall conform to code A_1 or code A_2 as follows:

Code	Water Absorption %	Requirement
A_1	< 0.6	Acceptable
A_2	$\geq$ 0.6	Shall conform to Clause 4.3

Non-Carbonate Carbon Content

The non-carbonate carbon was found to be 0.6%

Requirement for the Non-Carbonate Carbon Content

In accordance with BS EN 12326-1:2004 the non-carbonate carbon content of the slate when tested to Clause 13 of BS EN 12326-2 shall be less than 2%

Carbonate Content

The mean carbonate content was 1.3%.

Requirement for the Carbonate Content

In accordance with BS EN 12326-1, the carbonate content of the slate when tested to Clause 14 of BS EN 12326-2 shall be no higher than upper limit declared by the manufacturer.

Sulphur Dioxide Exposure Test

After the exposure period to solutions A and B of sulphur dioxide the test specimens did not show any obvious signs of colour changes, swelling, softening or splitting along the edges. The sample was therefore given Code S1 as indicated in BS EN 12326-1.

Requirement for the Sulphur Dioxide Test

In accordance with BS EN 12326-2 the slate shall be allocated a code S_1, S_2 or S_3 that is dependent on the carbonate content. In this case, the carbonate content of the slate was less than 20%, therefore Clause 4.6.1 applies.

Thermal Cycle Test

After 20 cycles of water immersion and drying, the test specimens did not exhibit any obvious signs of surface oxidation or runs of discolouration. The specimens did not show any splitting along the edges, swelling or flaking. The sample was therefore given Code T1 as indicated in BS EN 12326-1

Requirement for the Thermal Cycle Test

When tested to Clause 16 of BS EN 12326-2 : 2000 the following observations apply

Code	Observation in the test	Conformity to Standard
T1	No changes in appearance. Surface oxidation of metallic minerals. Colour changes that neither affect the structure nor form runs of discolouration	Acceptable
T2	Oxidation or appearance changes of the metallic inclusions with runs of discolouration but without structural changes	Acceptable
T3	Oxidation or appearance changes of metallic minerals which penetrate the slate and risk the formation of holes.	Acceptable subject to the note below

It shall not be acceptable for the slates to exhibit exfoliation, splitting or other major structural changes.

Conclusions

On the basis of the test results and the test requirements stipulated in the BS EN 12326-1 : 2004, the slate sample identified as “Balmoral Grey ” was found to meet the test requirements. The sample was given Codes A1, S1 and T1.

Quality Statement

We confirm that in preparing this report we have exercised all reasonable skill and care.

Any information relating to the sample received for testing has been supplied by the client unless otherwise specified.

This report does not provide „product approval" status but shows only the results of the material or sample tested.

Any samples relating to this report will be retained for a period of one month from the date of the report, unless you request differently.

APPENDIX I

Petrographic Examination

Test Method and Results

Petrographic Examination

The slate sample was subjected to petrographic examination in accordance with BS EN 12326-2:Clause 16:2011.

Note: The examination was carried by our approved sub-contractor.

The sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests.

Representative portions from the sample were taken as follows:-

A slice specimen was taken parallel to the cleavage of the sample; another 2 No. slices along the length of the slate across the thickness and perpendicular to the cleavage; and another 2 No. slices perpendicular to the length of the slate across the thickness and perpendicular to the cleavage of the sample.

These representative portions were used to prepare three large area thin sections which were then examined under a high power Leica DM4500P petrological microscope employing magnifications up to x1000.

A detailed description of the petrographic examination of the slate sample is given in Table 1-A.

The sample was dark grey/green, fine to very fine grained, very well compacted slate, dense and robust. The stone exhibited generally smooth cleavage planes, close slatey cleavage and no apparent grain (i.e. secondary cleavage) was identified. In two places on the underside of the sample clusters of fine pyrite grains (up to 1mm across) were observed.

X-ray Diffraction Analysis

Representative portion from the slate sample was prepared and subjected to X-ray diffraction analysis in accordance with the method given in BS EN 12326-2:2000.

A powder specimen and a polished slab specimen parallel to the cleavage of the slate were prepared from each sample and each subjected to X-ray diffraction.

The detailed X-ray diffraction results for the sample are presented in Table 1-B.

Discussion

The sample was found to exhibit a dark green/green colour. It was found to contain mainly mica, chlorite and quartz.

Feldspar was also identified by the X-ray diffraction analysis. Pyrite grains and calcite were observed to be present in trace proportions (i.e. below 1% which is the limit of detection by the X-ray diffraction).

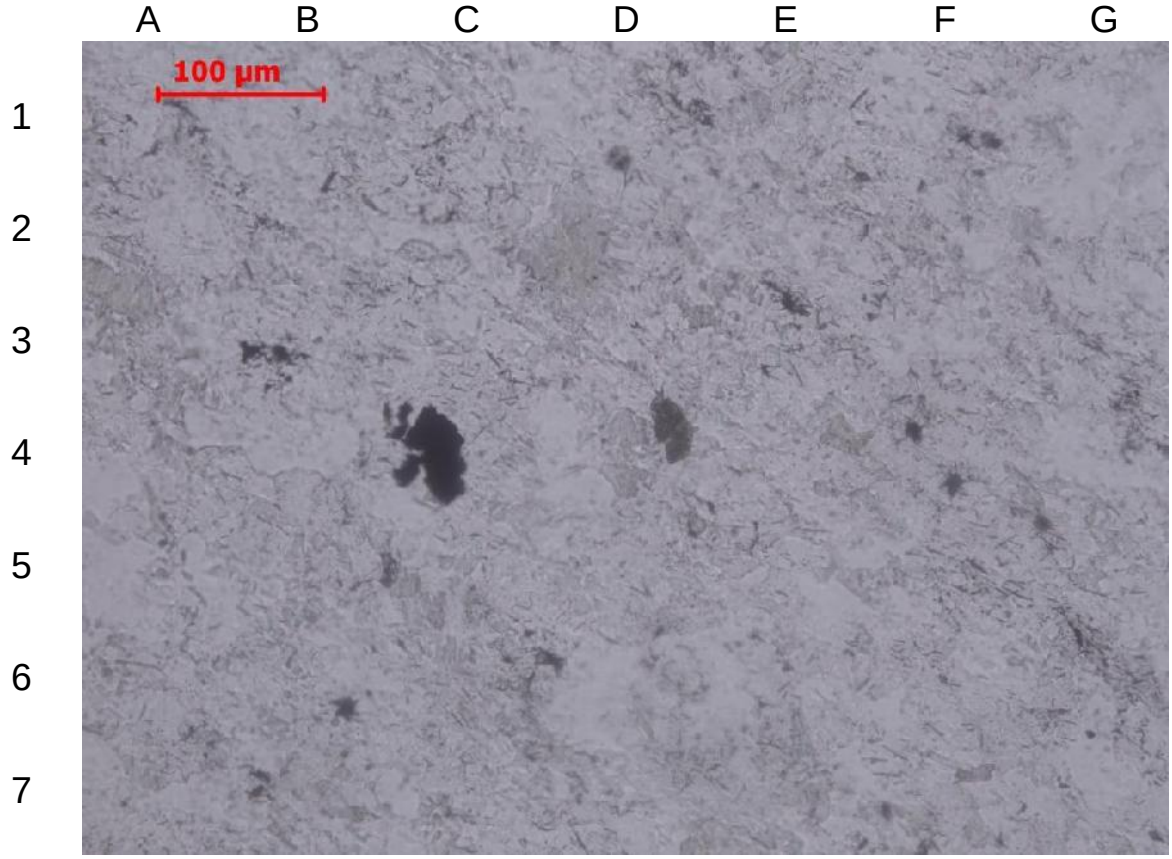
The pyrite content was in trace proportions, unevenly distributed and did not appear to be associated with calcite.

Pyrite is an undesirable constituent in slate as it can undergo oxidation and cause unsightly staining and may expand causing damage such as delamination and flaking.

Table 1-A

Sample Reference	EE 7308/34		
Sample type, source and Sampling Location details	Slate		
Condition on Receipt:	Dry	Sample Dimensions, mm	500 x 250 x 6
Methods of Preparation of Specimens and Examination Procedures	The sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests. Three representative specimens from the sample were diamond-sawn and used to prepare large area thin sections which were examined under a high power petrological microscope employing magnifications up to x1000.		
Any Other Details	A slice specimen was taken parallel to the cleavage; another 2 No. slices along the length of the slate across the thickness and perpendicular to the cleavage; and another 2 No. slices perpendicular to length of the slate across the thickness and perpendicular to cleavage of the sample. Thin section dimensions, : 50 x 68mm and 2 No. thin sections each containing 2 No. slices 7 x 68mm each.		
Material Description	Dark grey/green fine to very fine grained, very well compacted slate, dense and robust. The stone exhibited generally smooth cleavage planes, close slatey cleavage and no apparent grain (i.e. secondary cleavage) was identified. In two places on the underside of the sample clusters of fine pyrite grains (up to 1mm in size across) were observed.		

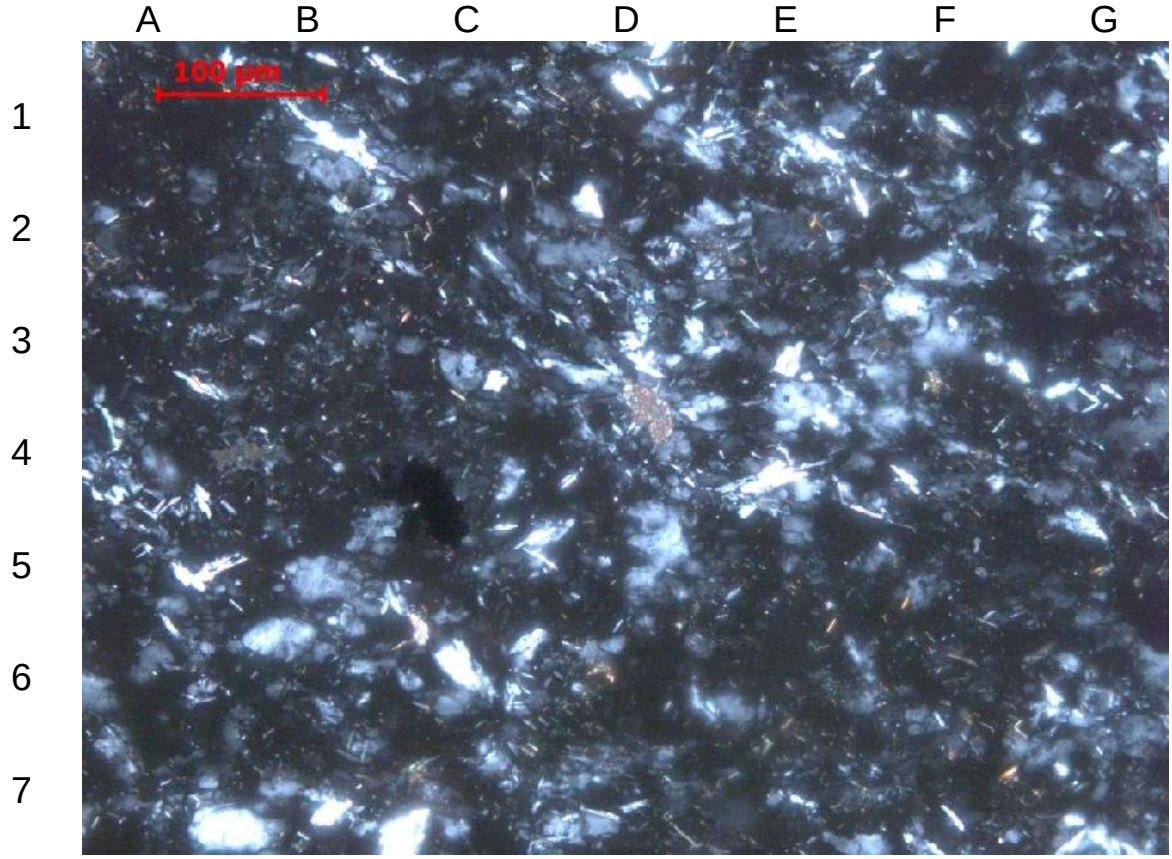
MATERIAL COMPOSITION		PETROGRAPHIC DETAILS
Component	Volume % (estimated)	
Quartz Mica Chlorite Calcite Pyrite Carbonaceous material Chloritoid	40 35 25 <1 <1 <1 <<1	The stone was a very well compacted slate comprising quartz, mica, chlorite, sporadic calcite, generally sparse extremely finely disseminate carbonaceous material and rare pyrite and possibly chloritoid. The stone was mainly fine to very fine grained (i.e. <2µm to 200µm across and up to 300µm long and most common size 20µm across) with predominantly aligned quartz, mica and chlorite lenses of mainly chlorite, quartz and sporadically calcite. The cleavage was delineated by quartz, mica, chlorite, sparse calcite and black fine to very fine opaque material, possibly carbonaceous material and rare pyrite. Thin lenses, up to 100µm across and 300µm long, comprising quartz, mica, chlorite, calcite and generally sparse opaque material of carbonaceous dust and rarely pyrite were present.
Total	100	
		Mica was mainly white, up to 150µm long and was associated with chlorite. Pyrite anhedral to euhedral grains, up to 100µm across, and grain aggregations, up to 200µm across and 300µm long were present and unevenly distributed. Calcite mainly micrite elongate clusters, up to 50µm across, up to 120µm long were seen throughout the stone. Chloritoid was rarely seen associated with chlorite and mica. The extremely fine grained carbonaceous material was unevenly distributed and was concentrate in places forming irregular patches or linings along lenses and cleavage traces. X-ray diffraction analysis also identified plagioclase feldspar which was not possible to definitively identify in the thin section.



Photomicrograph 1 of Sample EE 7308/34
Parallel cleavage

Microscope light: Plane polarised
Objective Magnification: x20

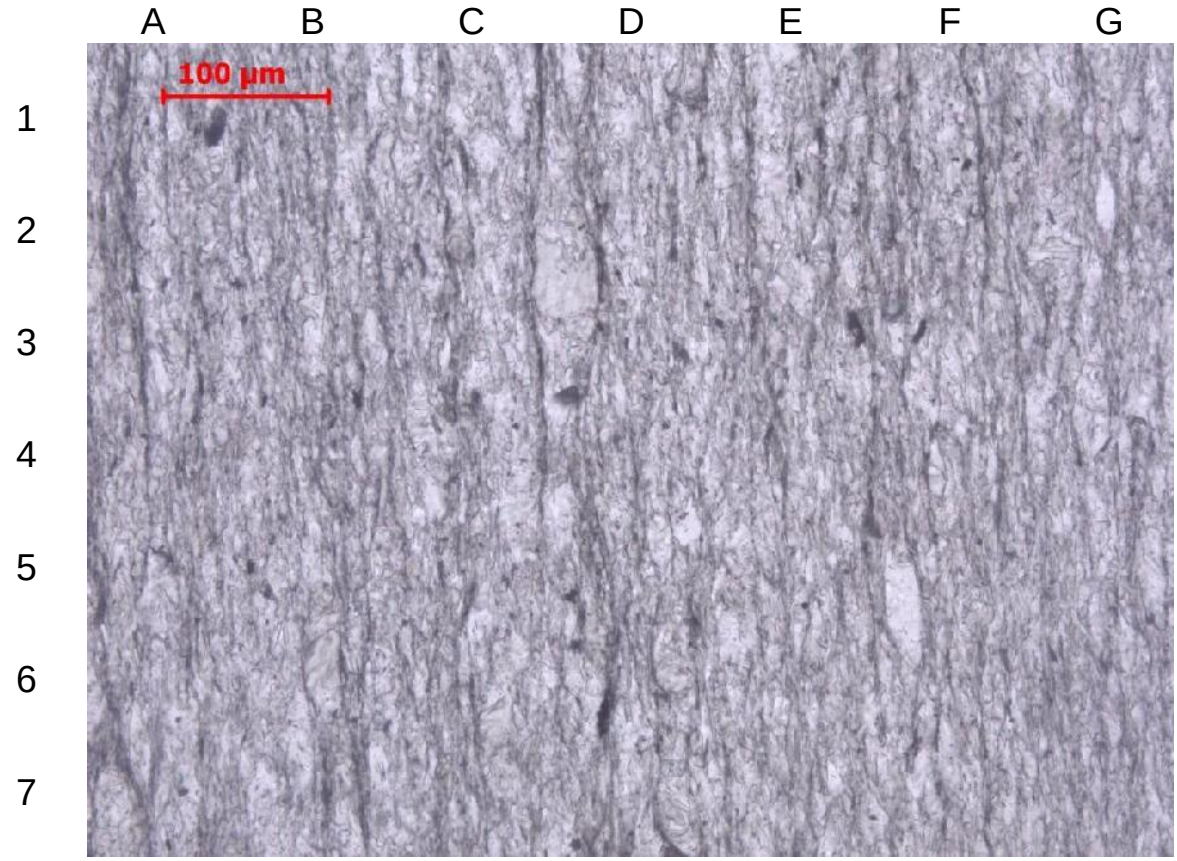
General view of stone structure. Pyrite subhedral grain at B-C/4. Calcite (micrite) is present at D/4. The extremely fine grained carbonaceous material is very sparsely disseminated.



Photomicrograph 2 of Sample EE 7308/34
Parallel cleavage

Microscope light: Cross polarised
Objective Magnification: x20

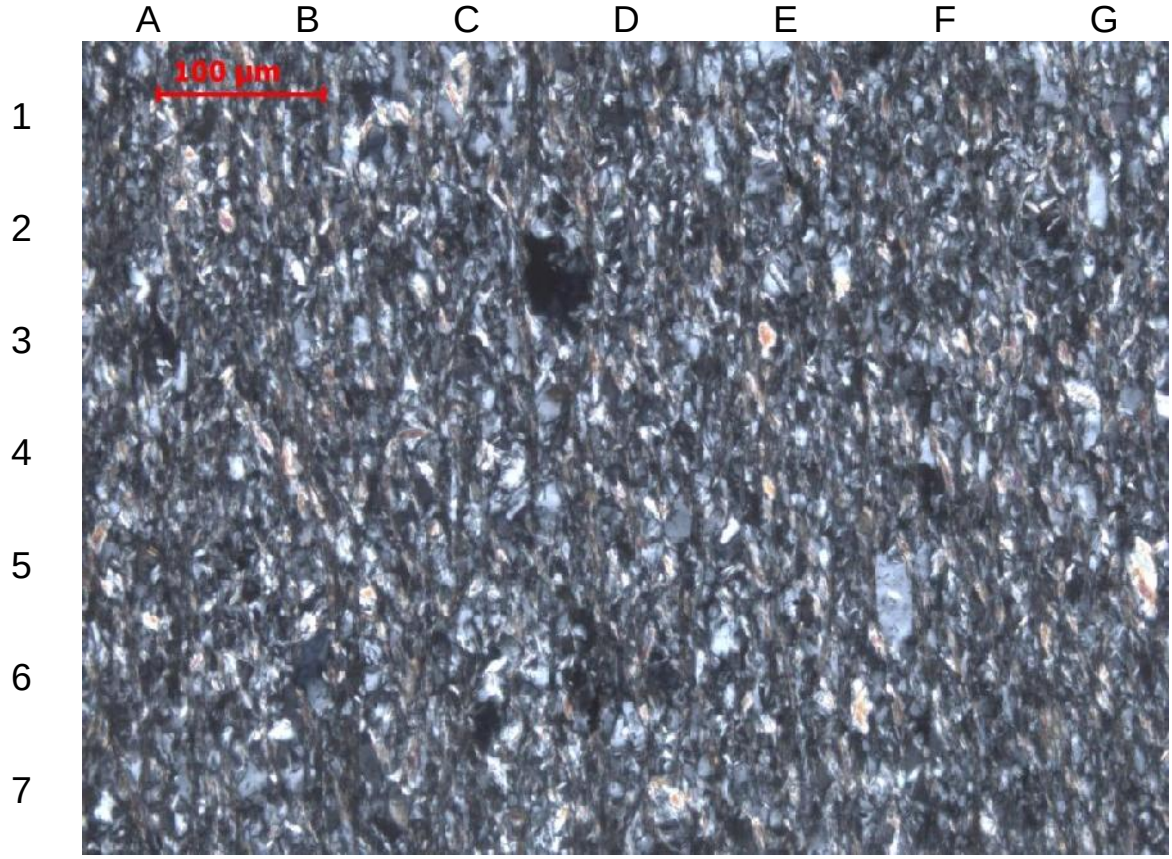
General view of stone structure. Pyrite subhedral grain (black) at B-C/4-5. Calcite (micrite) is present a D/4. The extremely fine grained carbonaceous material is very sparsely disseminated. The matrix, consists mainly of quartz, chlorite and mica (fine elongate grains)



Photomicrograph 3 of Sample EE 7308/34
Perpendicular cleavage, parallel length

Microscope light: Plane polarised
Objective Magnification: x20

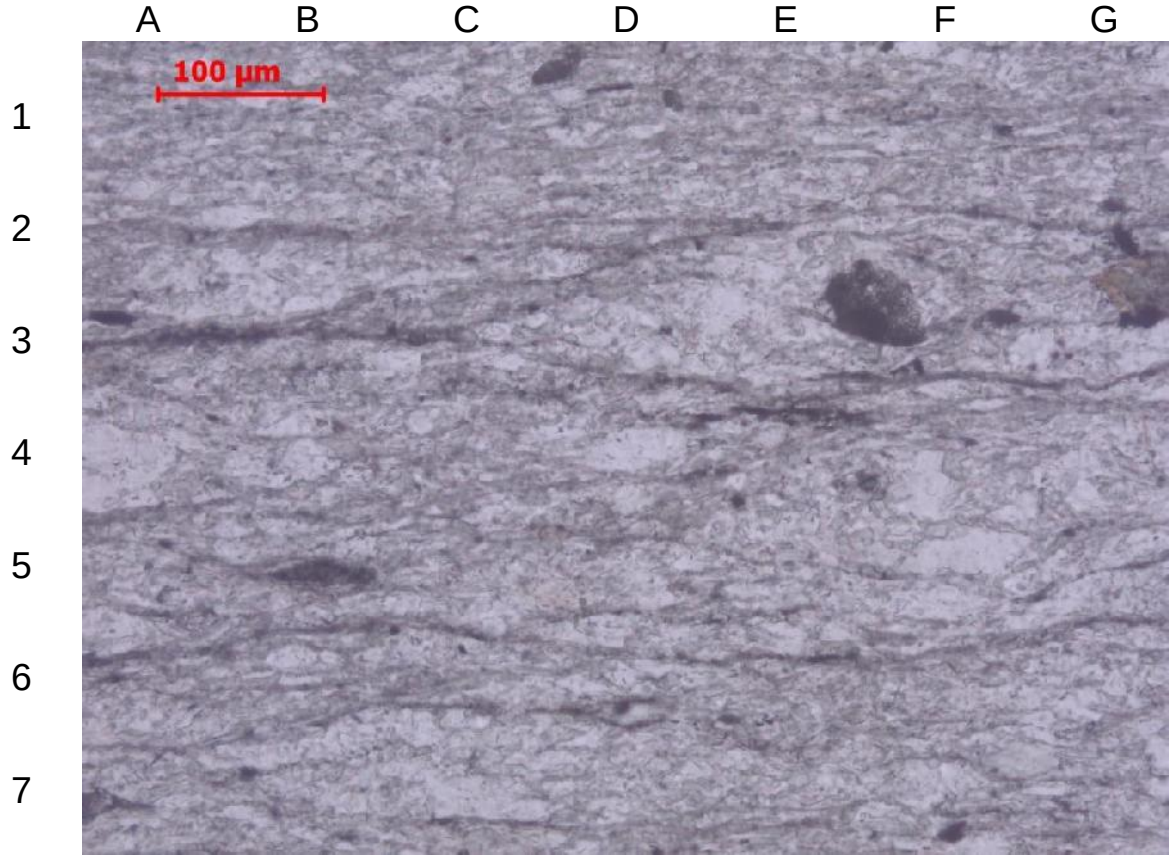
General view of stone cleavage structure. Lenses (e.g. C-D/1-4) and cleavage traces are bordered with extremely fine carbonaceous material. Note the fine extremely fine material along the cleavage traces.



Photomicrograph 4 of Sample EE 7308/34
Perpendicular cleavage, parallel length

Microscope light: Cross polarised
Objective Magnification: x20

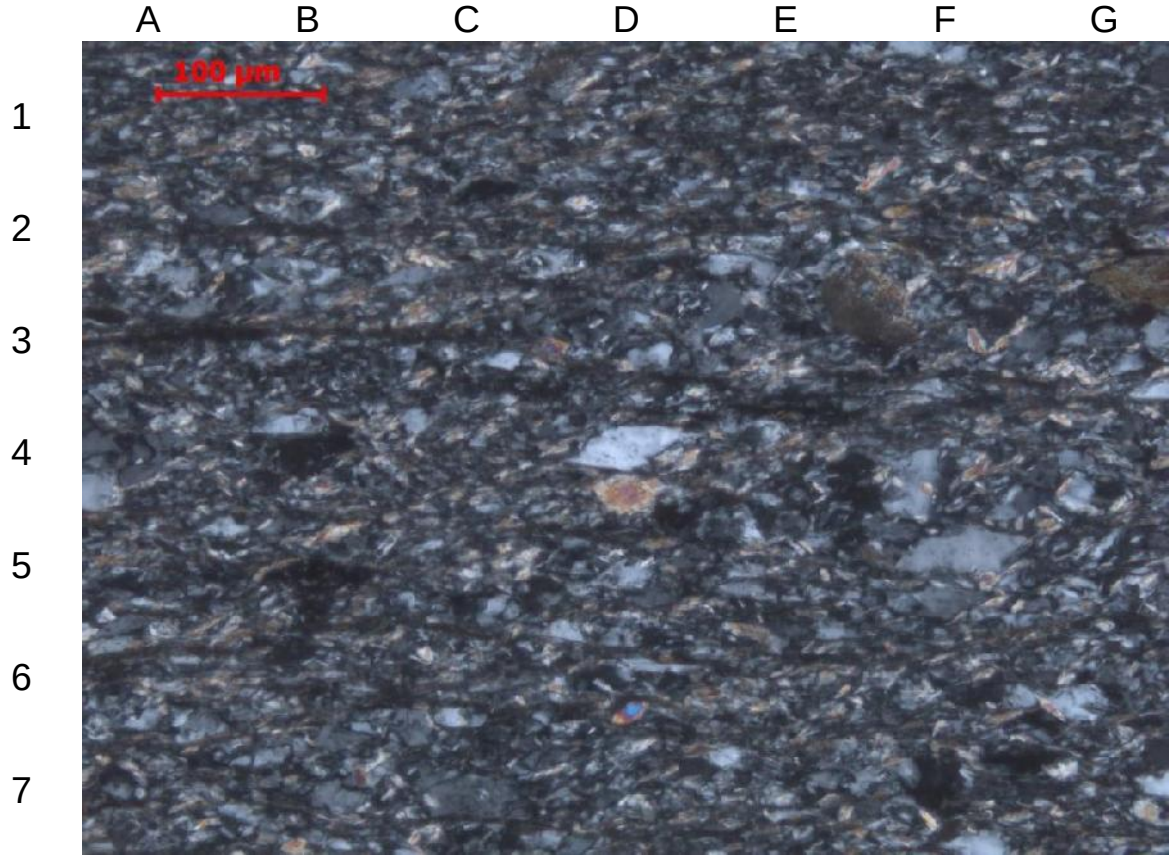
General view of stone cleavage structure. Lenses (e.g. C-D/1-4) and elongate grains (e.g. G-5-6 & E=F.5-6) in parallel arrangement to the length and cleavage of the slate



Photomicrograph 5 of Sample EE 7308/34
Perpendicular cleavage, perpendicular length

Microscope light: Plane polarised
Objective Magnification: x20

General view of stone cleavage structure. Lenses (e.g. D-G/2-3) bordered by very fine carbonaceous material. Micrite (calcite) is present at E-F/2-3)



Photomicrograph 6 of Sample EE 7308/34
Perpendicular cleavage, perpendicular length

Microscope light: Cross polarised
Objective Magnification: x20

General view of stone cleavage structure. Micrite (calcite) is present at E-F/2-3. Lenses and elongate grains quartz, mica and chlorite are orientated along the cleavage planes (east-west)

APPENDIX B

XRD Spectra

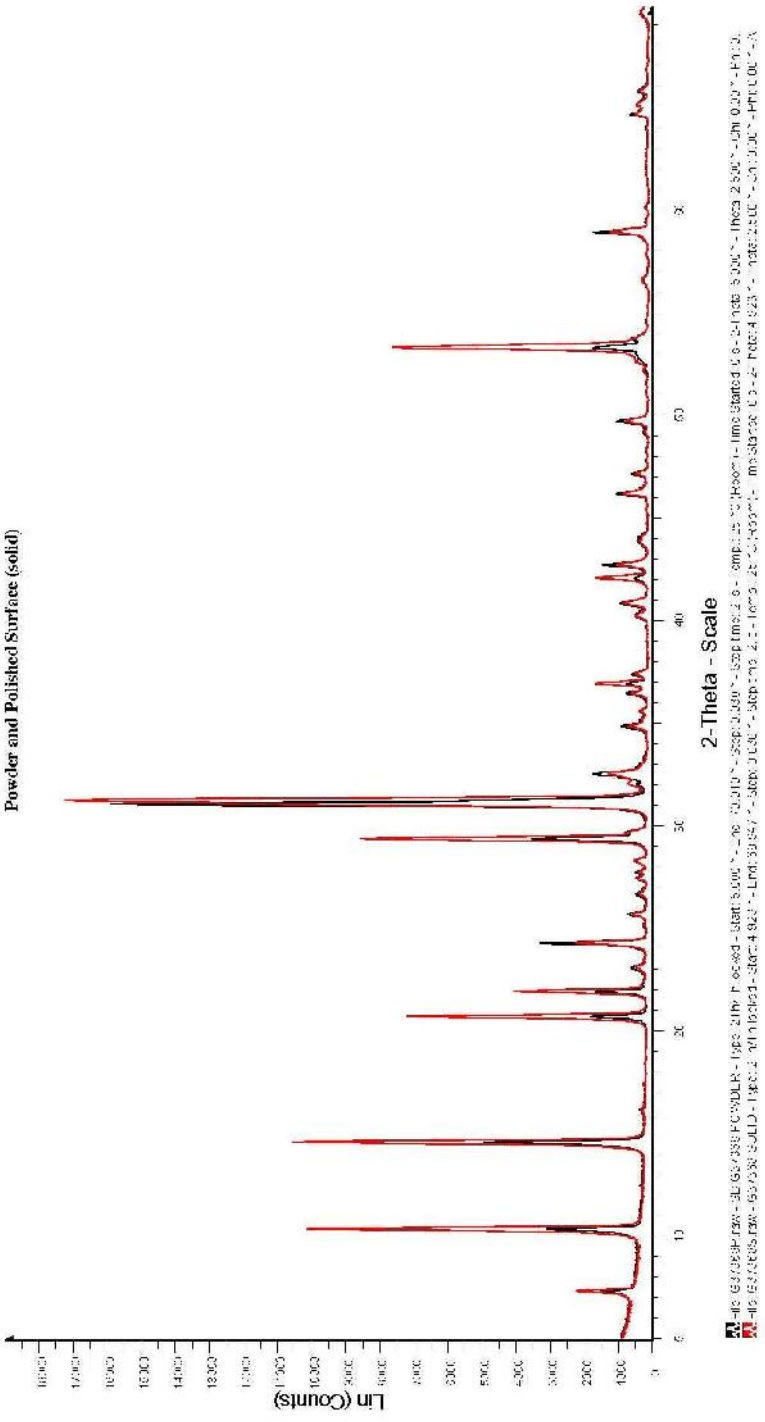


Table 1 B

Siroquant Semi-Quant Analysis (wt%)	EE 7038 – Powder	EE 7038 – Solid
Chlorite	17	28
Illite/Muscovite	32	30
Plagioclase	10	10
Pyrite	tr	tr
Quartz	41	32