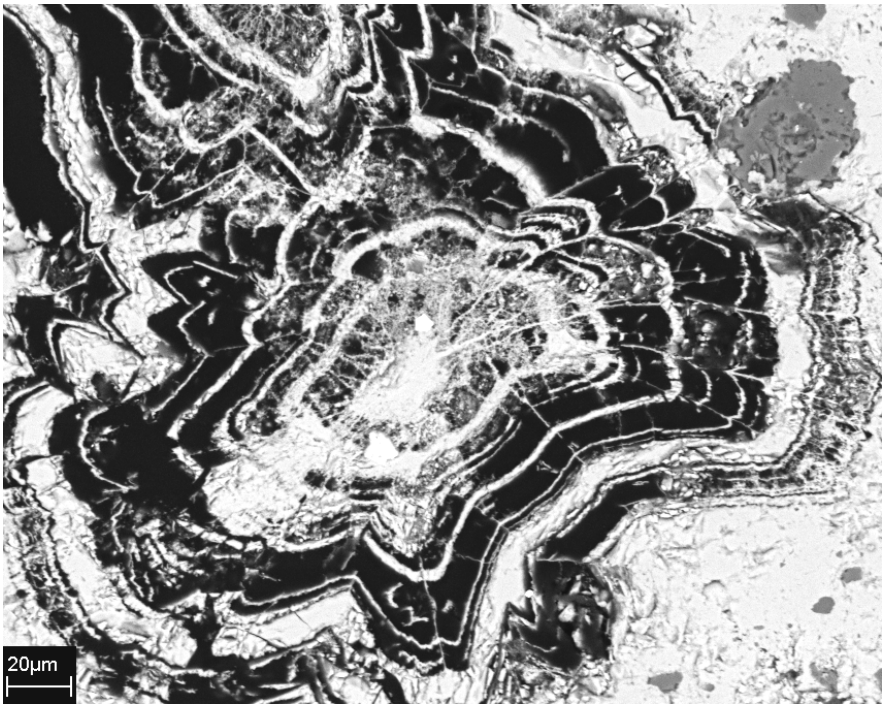
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

SEM Petrography of samples of the Wealden Group of southern England

Physical Hazards Programme

Internal Report IR/07/029



BRITISH GEOLOGICAL SURVEY

PHYSICAL HAZARDS PROGRAMME

INTERNAL REPORT IR/07/029

SEM Petrography of samples of the Wealden Group of southern England

J E Bouch

Keywords

Weald Clay, SEM, Petrography, Shrink-Swell.

Front cover

Concretionary cement (Sample MPLM250).

Bibliographical reference

BOUCH, J.E.. 2005. SEM Petrography of samples of the Wealden Group of southern England. *British Geological Survey Internal Report*, IR/07/029. 44pp.

Keyworth, Nottingham British Geological Survey 2005

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham, Edinburgh and London; see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

Keyworth, Nottingham NG12 5GG

☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.geologyshop.com

Murchison House, West Mains Road, Edinburgh EH9 3LA

☎ 0131-667 1000 Fax 0131-668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE

☎ 020-7589 4090 Fax 020-7584 8270
☎ 020-7942 5344/45 email: bgslondon@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU

☎ 01392-445271 Fax 01392-445371

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast, BT9 5BF

☎ 028-9038 8462 Fax 028-9038 8461

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB

☎ 01491-838800 Fax 01491-692345

Sophia House, 28 Cathedral Road, Cardiff, CF11 9LJ

☎ 029–2066 0147 Fax 029–2066 0159

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Foreword

This report is the published product of a study by the British Geological Survey (BGS). It refers to work carried out as part of the Science Budget project investigating the shrink-swell properties of Weald Formation mudstones in England, under the Physical Hazards Programme. The work provides petrographical descriptions (based on scanning electron microscope observations) of material derived from the Weald Clay.

Acknowledgements

This work has benefited from advice received from various members of the Shrink/Swell project team. Gren Turner is thanked for assistance in preparing the SEM stubs from occasionally difficult materials.

Contents

FIGURES

TABLES

Summary

This report summarises work undertaken in support of the Ground Movements: Shrink/Swell Project undertaken as part of the BGS Physical hazards Programme. It provides petrographical descriptions acquired using scanning electron microscopy (SEM) of a suite of samples (n =24, from 9 sites) from the Wealden Group (Wessex Clay, Weald Clay and Wadhurst Formations) Clay from the Weald and Wessex Basins of southern England.

1 Introduction

1.1 GEOLOGICAL BACKGROUND

The Wealden Group outcrops the Weald and Wessex Basins of Southern England (Figure 1), with the Wealden deposits in each basin displaying variation in facies, flora, fauna and relative age (Radley 2006 and b). Summary lithostratigraphies for the Wealden Group in both basins are given in Figure 2. In the Weald basin, the mudstones are interpreted to have been predominantly deposited in lakes, muddy channels, coastal lagoons and on mudflats (Radley 2006),

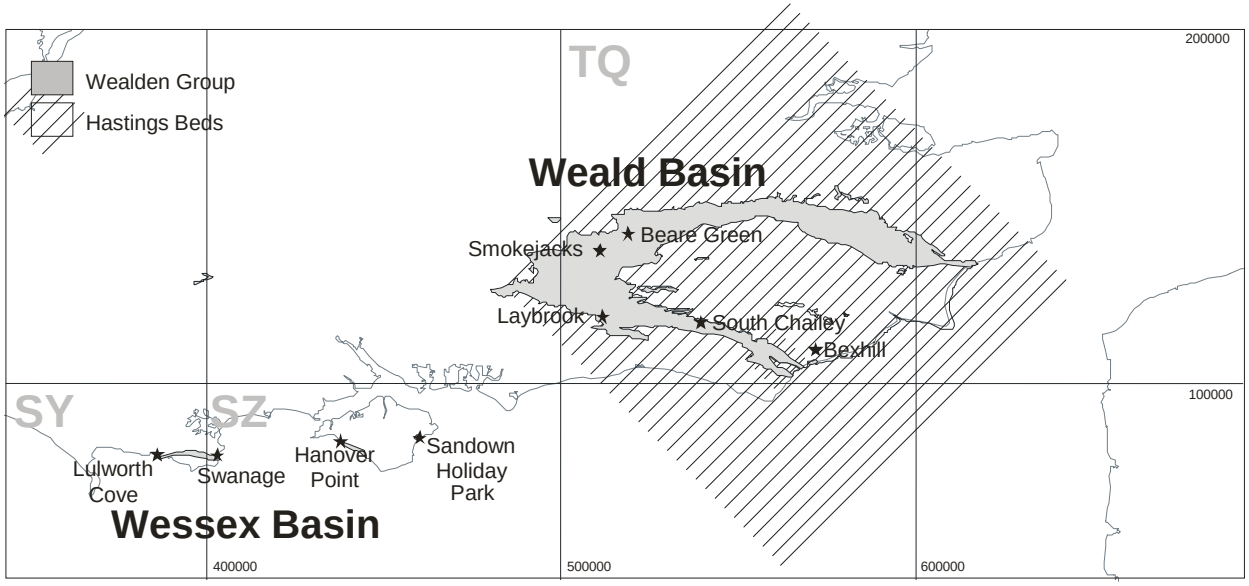


Figure 1 Map of southern England showing the extent of the Wealden Group and Hastings Beds at surface, and the locations of the study sites.

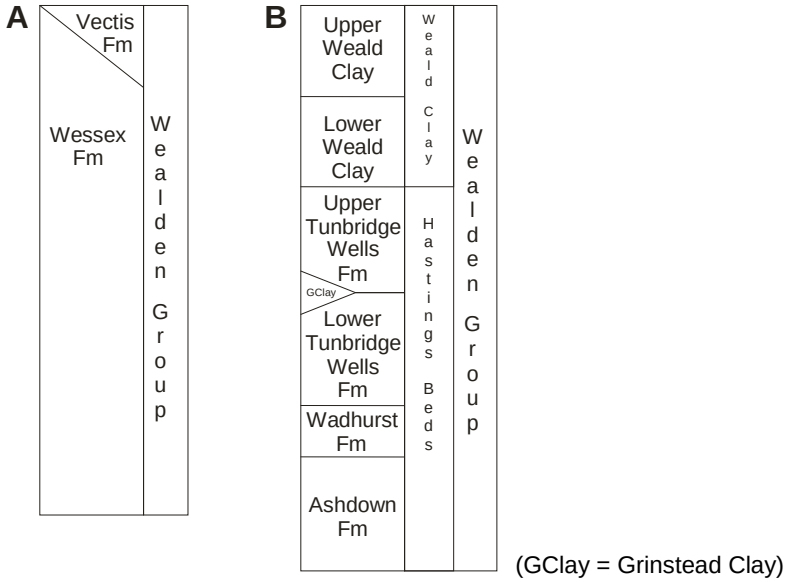


Figure 2 Wealden Group Stratigraphy in (A) the Wessex Basin and (B) the Weald Basin.

2 Samples and Methods

The studied samples were collected from 9 sites across southern England (Figure 1). The locations, stratigraphy and the general characteristics of the 24 samples are given in Table 1. Throughout this report the samples are referred to using the site name, and the Mineralogy and Petrology Laboratories "MPL" sample code of the sub-sample used for petrographical analysis.

For scanning electron microscope (SEM) analysis, approximately centimetre-sized blocks of material were excavated from the central (i.e. least likely to be disturbed) portions of the hand-specimen samples, and were air-dried. Once dry, a fresh fracture surface was prepared for each stub, with at least one fracture surface perpendicular to lamination prepared for each sample where possible. In addition to these fresh fracture surfaces, a number of samples also had surfaces prepared by cutting with a scalpel. Whilst this preparation disturbs some details of the structural relationships between the fine particles, it has the advantage of creating a relatively flat surface upon which compositional variations, as inferred from variations in back-scattered electron intensity (BSEM), are more apparent. Polished thin-sections of a sub-set of the samples were prepared using standard techniques in the BSG thin-sectioning facility.

The stubs were carbon-coated, whereas the polished thin-sections were left uncoated. All samples were analysed using a LEO435VP SEM fitted with an Oxford Instruments INCA system (for mineral identification by qualitative and semi-quantitative energy-dispersive X-ray analysis; EDXA). The stubs were analysed in under high vacuum, whilst the polished thin-sections were analysed using low vacuum conditions.

Table 1 List of sampling locations and samples studied.

Basin	Formation	Site	Grid Reference	Sample MPL Code	Original Sample ID	SEM Stub(s)	Polished thin-sections	Engineering Sample	*Stratigraphic Position (informal)*	*Comments*
Weald	Wadhurst Clay Formation	Bexhill	TQ 71990 09707	MPLM227	S1	Y	Y	Y	*Top Blue Clay*	
			TQ 71990 09707	MPLM228	S2	Y	-	-	*Top Blue Clay*	*Silty lamina*
			TQ 72029 09678	MPLM229	S3	Y	-	-	*Lower Blue Clay*	*Silty lamina*
			TQ 72029 09678	MPLM230	S4	Y	Y	Y	*Lower Blue Clay*	
	Weald Clay Formation	Beare Green	TQ 19102 42247	MPLM231	S1	Y	Y	Y	-	
			TQ 19102 42247	MPLM232	S2	2	-	Y	-	*Slightly silty*
			TQ 19098 42170	MPLM233	S3	Y	Y	-	-	
		Smokejacks	TQ 11026 37589	MPLM234	S1	Y	Y	Y	*Lower Blue Clay*	-
			TQ 11011 37587	MPLM235	S2	Y	Y	Y	*Upper Brown Clay*	-
			TQ 11011 37587	MPLM236	S3	Y	Y	-	*Upper Brown Clay*	*Ironstone*
			TQ 11011 37587	MPLM237	S4	Y	-	-	*Lower Blue Clay*	*Silty lamina*
		Laybrook	TQ 12245 19104	MPLM238	S1	Y	Y	Y	*Lower Mottled Red-Green Clay*	-
			TQ 11947 18868	MPLM239	S2	Y	-	-	*Upper Grey Clay*	*Ironstone*
		South Chailey	TQ 39300 17592	MPLM240	S1	2	Y	Y	*Lower Mottled Red-Green Clay*	-
			TQ 39290 17571	MPLM241	S2	2	Y	Y	*Lower Grey Clay*	*Near water seep*
			TQ 39297 17560	MPLM242	S3	Y	-	-	*Lower Grey Clay*	*Silty*
			TQ 39297 17560	MPLM243	S4	Y	-	-	*Lower Grey Clay*	*Weathered*
			TQ 39297 17560	MPLM244	S5	Y	-	-	*Lower Grey Clay*	*Ironstone*
Wessex	Wessex Formation	Lulworth Cove	SY 86617 80214	MPLM245	S1	Y	Y	Y	-	
		Hanover Point	SZ 37822 83783	MPLM246	S1	Y	Y	Y	-	
			SZ 37822 83783	MPLM247	S2	Y	Y	Y	-	
		Holiday Park	SZ 41500 81940	MPLM248	S1	Y	Y	Y	-	
		Swanage	SZ 03304 80144	MPLM249	S1	Y	Y	Y	-	
			SZ 03304 80144	MPLM250	S2	Y	Y	Y	-	

3 Results

Descriptions of individual samples, including representative photomicrographs are given in Appendix 1, and this section provides a summary of the mudstones found at each sampling site.

3.1 WEALD BASIN – WADHURST CLAY FORMATION

The Wadhurst Clay Formation was only sampled at one location (Bexhill; Table 1), where two intervals, a "Lower Blue Clay" and an upper "Top Blue Clay", were sampled. This pit also has a "Dark Blue Clay exposed at it's base, but this was not accessible at the time of sampling.

The **Lower Blue Clay,** as sampled by MPLM230, is a relatively silt-poor mudstone with a massive fabric, which commonly has a microfractured/brecciated character with numerous polished and/or slickensided fracture surfaces seen in hand specimen. The mudstone is finer-grained than that seen in the Top Blue Clay (see below) and only minor amounts of detrital quartz and feldspar, and rare bioclastic debris are present (Figure 3A). Minor amounts of rhombic siderite cement are locally developed. Minor mm- to cm-scale laminae of more silty material is locally observed (sampled by MPLM229), however, these are finer grained and more clay rich than those seen in the Top Blue Clay (Figure 3B).

The **Top Blue Clay,** as sampled by MPLM227, is a typically well-laminated mudstone which in addition to clays, contains relatively abundant platy flakes of muscovite and minor amounts of silt-grade quartz and feldspar grains (Figure 4A). SEM-EDXA of the matrix clay yields ambiguous results with Si:Al ratios close to unity, suggesting kaolinite, but also minor amounts of K detected by EDXA suggesting an illitic component also.

The quartz and feldspar silt grains occur throughout this part of the formation, but locally silt-rich laminae typically a few mm to a few cm thick, and of limited lateral extent are observed (sampled by MPLM228; Figure 4B). The silt particles in these laminae are of comparable grain size to the particles in the background mudstones, but abundances of mica and platy clays are less abundant, and this difference is evident when Figure 4A and B are compared. Minor authigenic, bookleted kaolinite cement is noted within the silty laminae.

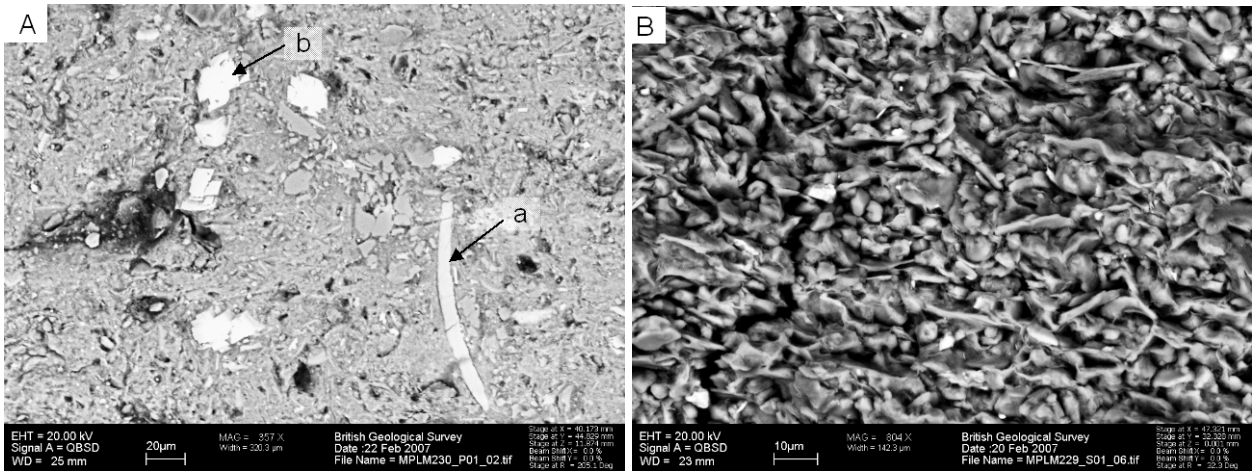


Figure 3 Representative SEM photomicrographs of samples from the "Lower Blue Clay" of the Wadhurst Clay Formation in Bexhill Clay Pit.

A) BSEM image showing a massive mudstone with rare bioclasts (a) and patchy, fine-grained rhombic authigenic siderite (b; Sample MPLM230).
B) BSEM image of one of the thin siltier lamina that are locally encountered in the Lower Blue Clay. The sediment comprises a mixture of fine-silt grade quartz grains, platy micas and matrix clay, and is very well-laminated (Sample MPLM229).

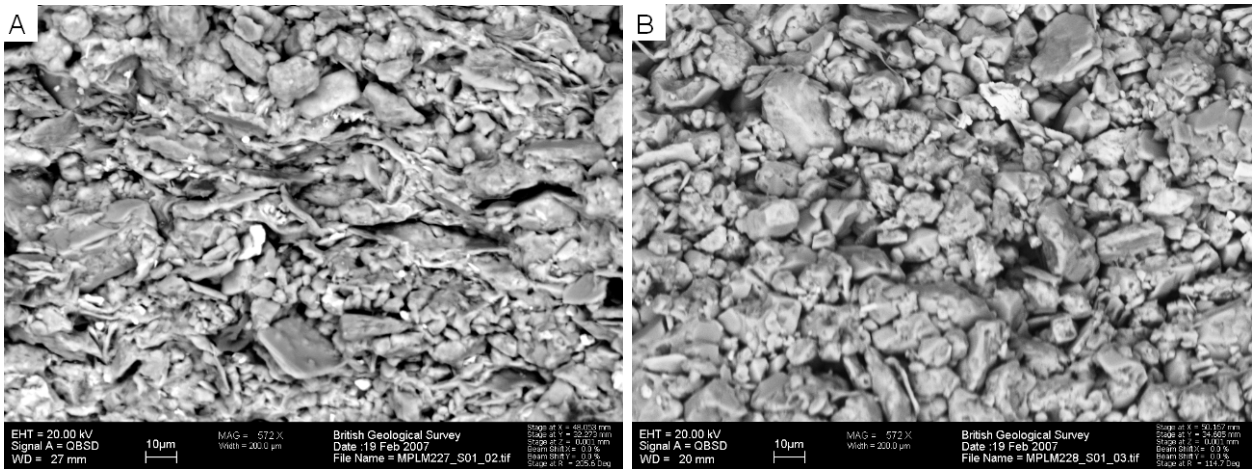


Figure 4 Representative SEM photomicrographs of samples from the "Top Blue Clay" of the Wadhurst Clay Formation in Bexhill Clay Pit.

A) BSEM image showing a well-laminated, but silty mudstone. Shows rounded to tabular grains of quartz and feldspar sit in a matrix of flat-lying mica and clay plates, which locally wrap around the quartz /feldspar grains (Sample MPLM227).
B) BSEM image of one of the thin silt-rich, clay-poor laminae that are locally encountered in the Top Blue Clay. The sediment is dominated by variably rounded grains of quartz of comparable grain size to that seen in (A) but with only minor amounts of clay/mica present (Sample MPLM228).

3.2 WEALDEN BASIN – WEALD CLAY FORMATION

This formation was sampled in four pits (Beare Green, Smokejacks; Laybrook and South Chailey) and a number of different informal stratigraphic divisions were used at each site.

3.2.1 Beare Green

Three samples were taken from this pit (MPLM231-233). No informal stratigraphic divisions were applied, and the three samples reveal a typically well-laminated clay-rich mudstone with minor siltier horizons. SEM-EDXA of the matrix clay reveals small peaks for K and Fe and large peaks for Al and Si. The Al:SI ratio of approximately 1 is suggestive of kaolinitic clay, however, the presence of K and FE suggest illitic compositions. This type of spectra is observed for the majority of the matrix clay seen in all the studied samples. Minor strings of pyrite framboids are locally present.

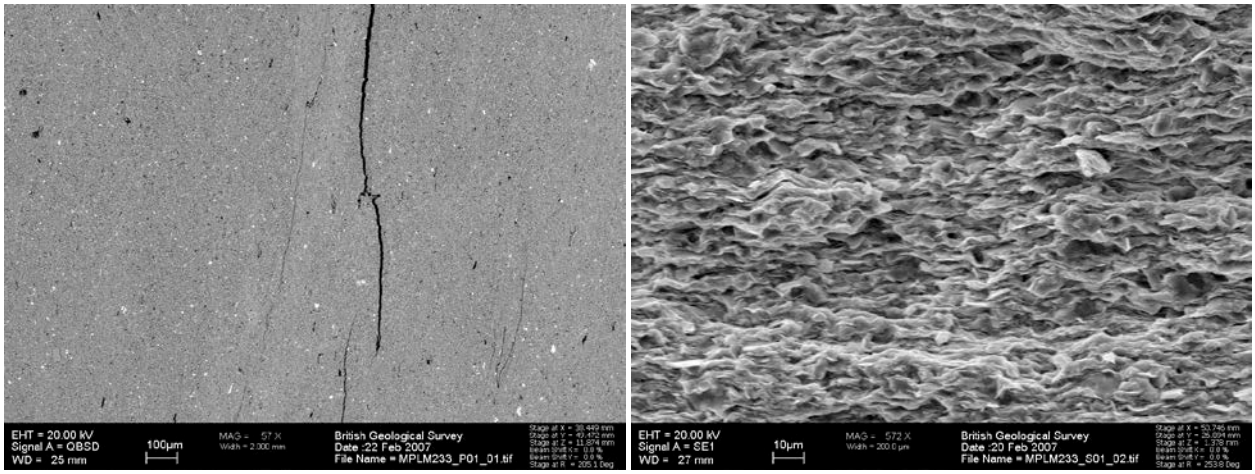


Figure 5 Representative SEM photomicrographs of samples from Beare Green Clay Pit.

A) Low magnification BSEM image showing a well-laminated clay-rich mudstone (Sample MPLM233).
B) Higher magnification SEM image showing a well-laminated, silt-poor mudstone (Sample MPLM233).

3.2.2 Smokejacks

Two samples were taken from the "**Lower Blue Clay**" here. The first (MPLM234; Figure 6A) was taken of a typical mudstone bed, and was found to be a well laminated, predominantly clay-rich mudstone, with thin siltier laminations and elongate strings of pyrite framboids (possibly replacing organic matter). SEM-EDXA returns a K-Fe-Al-Si-bearing composition for the clay suggestive of illite, although the Al:Si of close to one is suggestive of kaolinite. The second sample (MPLM236) was taken from a siltier laminae, and correspondingly has a higher content of silt grade quartz and feldspar grains, and a more massive fabric.

Two samples were also taken from the "**Upper Brown Clay**". The first (MPLM235; Figure 6B) is considered to be representative of this unit, and is less well-laminated than the mudstone seen in the Lower Blue Clay, with a higher content of silty and sandy material. The silty/sandy material occurs in mm-scale lenses which are dominated by sub-rounded quartz grains with minor muscovite mica. The quartz locally has thin authigenic overgrowths, and kaolinite is developed both replacing muscovite mica and as a pore-filling cement. An Fe-rich clay mineral, possibly chlorite, is also developed within these sandy patches. The second sample from this unit (MPLM237) was of an ironstone band, which is found to comprise very finely crystalline siderite, with minor apatite, quartz and clay.

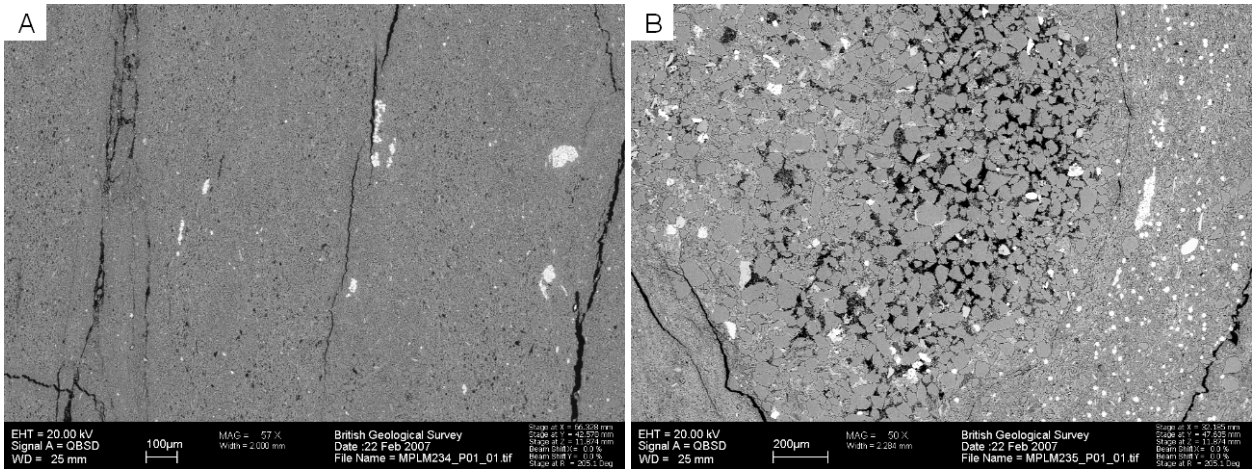


Figure 6 Representative SEM photomicrographs of samples from Smokejacks Clay Pit.

A) Lower Blue Clay. BSEM image showing a well-laminated mudstone with some siltier lamination. More clay-rich laminae have microfractures parallel to lamination produced during sample drying/thin-section preparation. Elongate patches of framboidal pyrite white (Sample MPLM234).
B) Upper Brown Clay. BSEM image showing a porous sandy lens within this laminated silty mudstone. Pyrite (appears white) is well-developed in the vicinity of this lens (Sample MPLM235).

3.2.3 Laybrook

A single sample was taken from the "**Lower Mottled Red-Green Clay**" at this pit (sample MPLM238). This sample is highly heterogeneous with mm- to cm-scale red-green mottling in hand specimen. This mottling is reflected in the SEM imaging, with the red mottles having higher iron contents associated with the matrix clay than the green mottles. Apart from this irregular mottling, at the fine scale the mudstone has a massive fabric. Silt contents are moderate throughout, and the sample is cut by numerous randomly oriented microfractures, which tend to be better developed within the red-mottled areas. The polished thin-section from this sample is also cut by a c.3mm wide feature along which mm-scale concretions are developed where matrix clay has been completely replaced by hematite.

No mudstone samples were taken from the "**Upper Grey Clay**" at this pit, however, one sample of an ironstone band within the Upper Grey Clay was taken (sample MPLM239). This sample was found to be petrographically indistinct from that seen in the Upper Brown Clay at Smokejacks, being a very fine-grained siderite-rich cemented band.

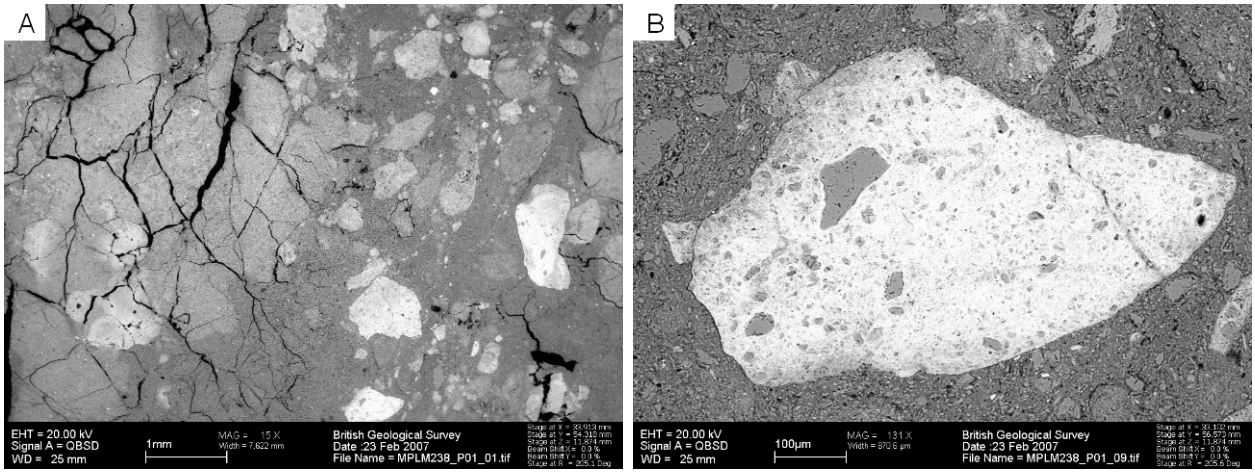


Figure 7 Representative SEM photomicrographs of samples of Lower Mottled Red-Green Clay from Laybrook Clay Pit.

A) BSEM image showing the variable chemistry of the mudstone as detected using BSEM. In the brighter areas the matrix has been impregnated by hematite. On the right hand side of the image a number of hematite cemented concretions (appear white) are present. (Sample MPLM238).
B) BSEM image showing a hematite cemented concretion (white), within which the matrix clay have been replaced. Minor amounts of silt and fine-sand grade grains float within the hematite cement (Sample MPLM238).

3.2.4 South Chailey

At this site, a face exposing an approximately 13m thick succession of "Lower Grey Clay" and "Lower Mottled Red-Green Clay" was sampled. The upper part of the face had a lightly weathered zone extending down to c.2m from the top of the face, which was underlain by c.8m of Lower Grey Clay, which in turn is underlain by c.3m of Lower Mottled Green-Red Clay which was also exposed over the floor of the pit. In the exposed face of the Lower Grey Clay, purplish bands which contained organic/plant debris were clearly evident.

Four samples were taken for petrographical analysis from the **Lower Grey Clay** (MPLM241-MPLM244 inclusive). One of these samples (MPLM244) is of an ironstone band dominated by very finely crystalline siderite as seen elsewhere and is not considered further. The other three samples reveal that the Lower Grey Clay is a variably silty and variably well laminated mudstone, with stronger fine-scale lamination observed in the more clay-rich/silt-poor mudstones. Silt contents range from practically zero (sample MPLM243) up to c.30% (sample MPLM241). EDXA of the matrix clay indicates the same K-Fe-Al-Si-bearing composition seen elsewhere being suggestive of illite, although the Al:Si ratios close to unity also suggest kaolinite. Microfractures are developed with random orientations in the massive mudstone (sample MPLM241), and in many cases fines have been washed out along the fractures. This possibly reflects the position of this sample close to a groundwater seep.

A single sample from the **Lower Mottled Red-Green Clay** was taken (MPLM240). In some respects, this sample resembles the other sample taken from this unit at Laybrook (MPLM238, see above), however the mudstone here is considerably more silt and sand-rich, and also contains minor amounts of opaque organic matter in small (<100µm) blebs/grains. The fabric is massive, and as seen elsewhere, the mottling reflects variations in Fe-content, with higher iron contents observed associated with the matrix clays in the reddened areas. Rare apatite cement locally lines small pores, possibly left after the removal of organic matter.

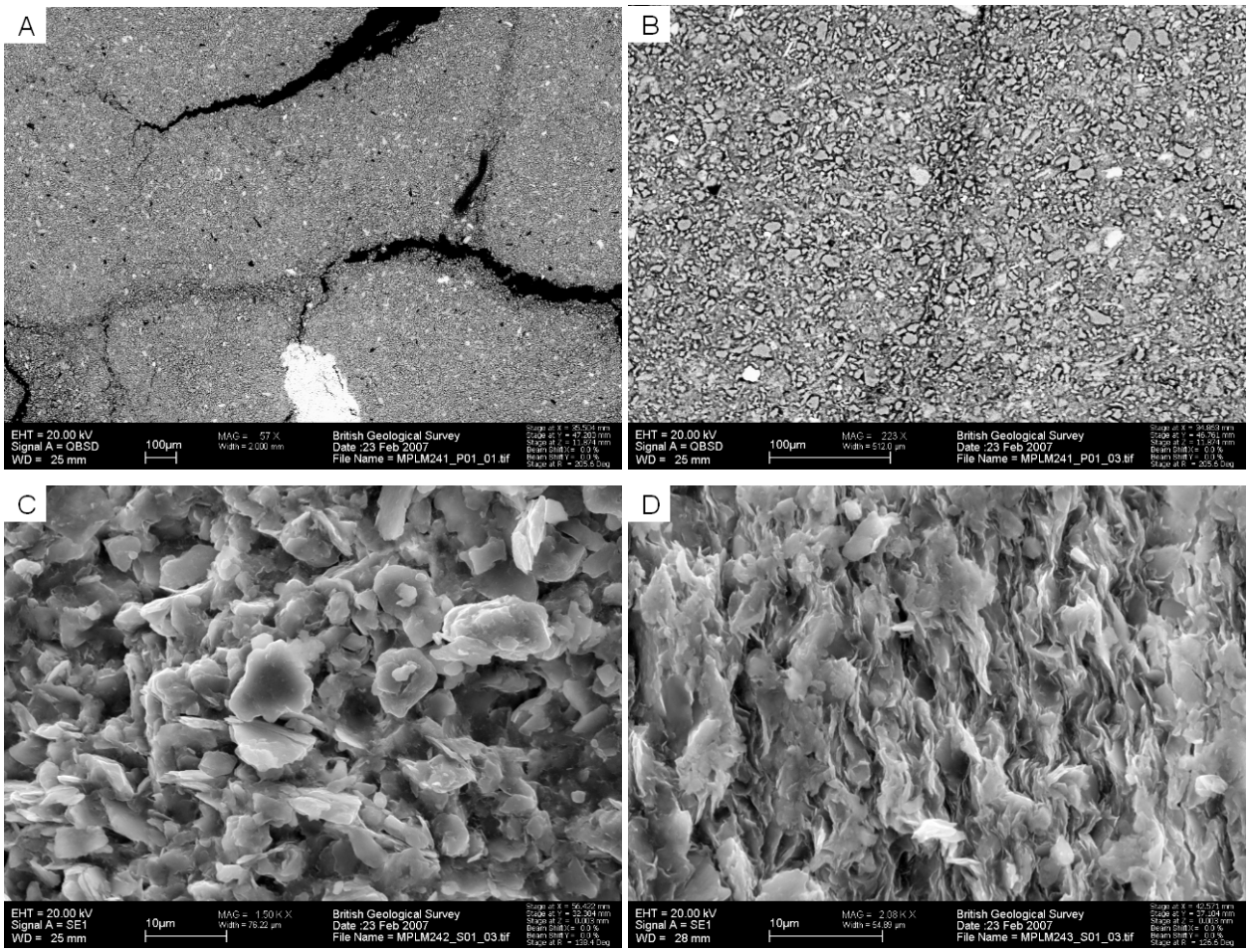


Figure 8 Representative SEM photomicrographs of samples of the Lower Grey Clay from South Chailey Clay Pit.

A) Low magnification BSEM image of a massive and relatively silt-rich mudstone. the mudstone is cut by a number of randomly oriented microfractures, along which fines have been washed out (Sample MPLM241).
B) Detailed BSEM image of the sample shown in (A), showing the abundance of silt-grade clay material within a clayey matrix. An incipiently-developed microfracture runs N-S through the centre of the image (Sample MPLM241).
C) SEM image showing the generally randomly oriented, and slightly platy, nature of the clay particles within the silty parts of the unit (Sample MPLM241).
D) SEM image showing the very finely laminated nature of the more clay-rich/silt-poor parts of the unit. Note the very strong preferred alignment of the individual clay particles and the fact that they are more sheet-like in habit than those shown in (C). (Sample MPLM243).

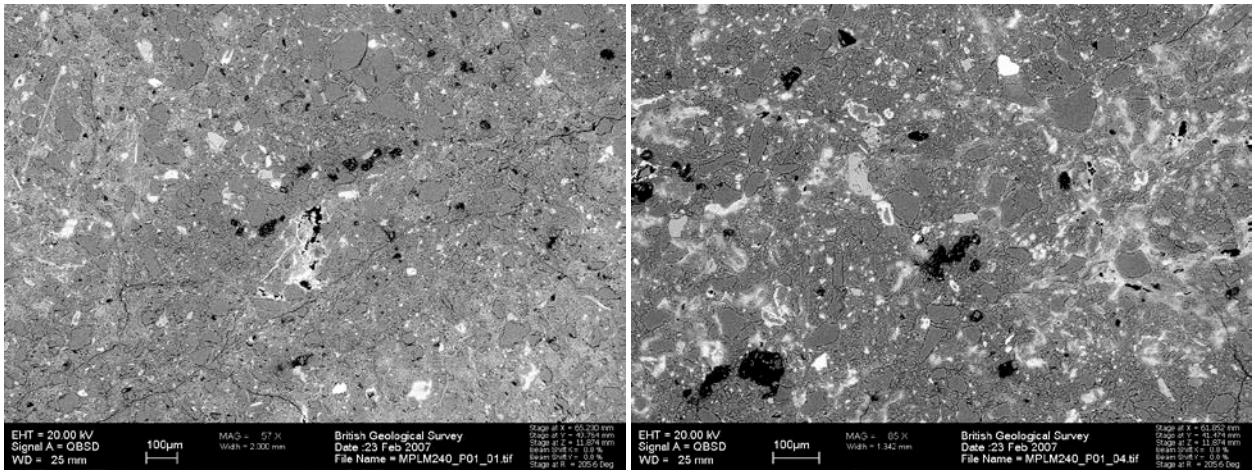


Figure 9 Representative SEM photomicrographs of samples of the Lower Mottled Red-Green Clay from South Chailey Clay Pit.

A) Low magnification BSEM image of a massive and relatively silt-rich mudstone. The variations observed in grey scale intensity in the matrix clay reflects the iron content associated with the clay, which in turn reflects the patterns of mottling seen in hand specimen. The dark grains/blebs are fragments of organic matter (Sample MPLM240).
B) Higher magnification BSEM image (Sample MPLM243).

3.3 WESSEX BASIN – WESSEX FORMATION

This formation was also sampled in four locations (Lulworth Cove, Hanover Point, Holiday Park and Swanage).

In the analysed samples the Wessex Formation shows a number of differences relative to the Weald Clay Formation. Most notably, it tends to contain significantly higher content of silt and very fine-sand grade material. This material occurs dispersed throughout the samples (Figure 10D), however, some samples (e.g. MPLM246 from Hanover Point; Figure 10A) also display grain size lamination with alternating bands of silt-rich/clay-poor and silt-poor/clay-rich material. Within the sand-rich laminae, fabrics are massive (Figure 10D), whereas a faint lamination is developed within more clay-rich laminae (Figure 10E). Millimetre-scale, organic-lined, clay-filled burrows are locally noted (sample MPLM249 from Swanage; Figure 10C).

SEM-EDXA of the clays indicates K-Fe-Al-SI-bearing compositions suggestive of illite, although Al:Si ratios are close to one, which is suggestive of kaolinite.

Detrital Fe-Ti oxide grains are locally abundant, as are commonly elongate fragments of organic matter, up to 1mm in length. Elongate clusters of framboidal pyrite are locally developed possibly replacing organic matter although this is not proved. Within some of the more silty/sand-rich laminae authigenic dolomite, apatite and gypsum/anhydrite are noted (Figure 10B). Finally, one sample (MPLM250 from Swanage) contains 100-100µm diameter authigenic siderite concretions (Figure 10F).

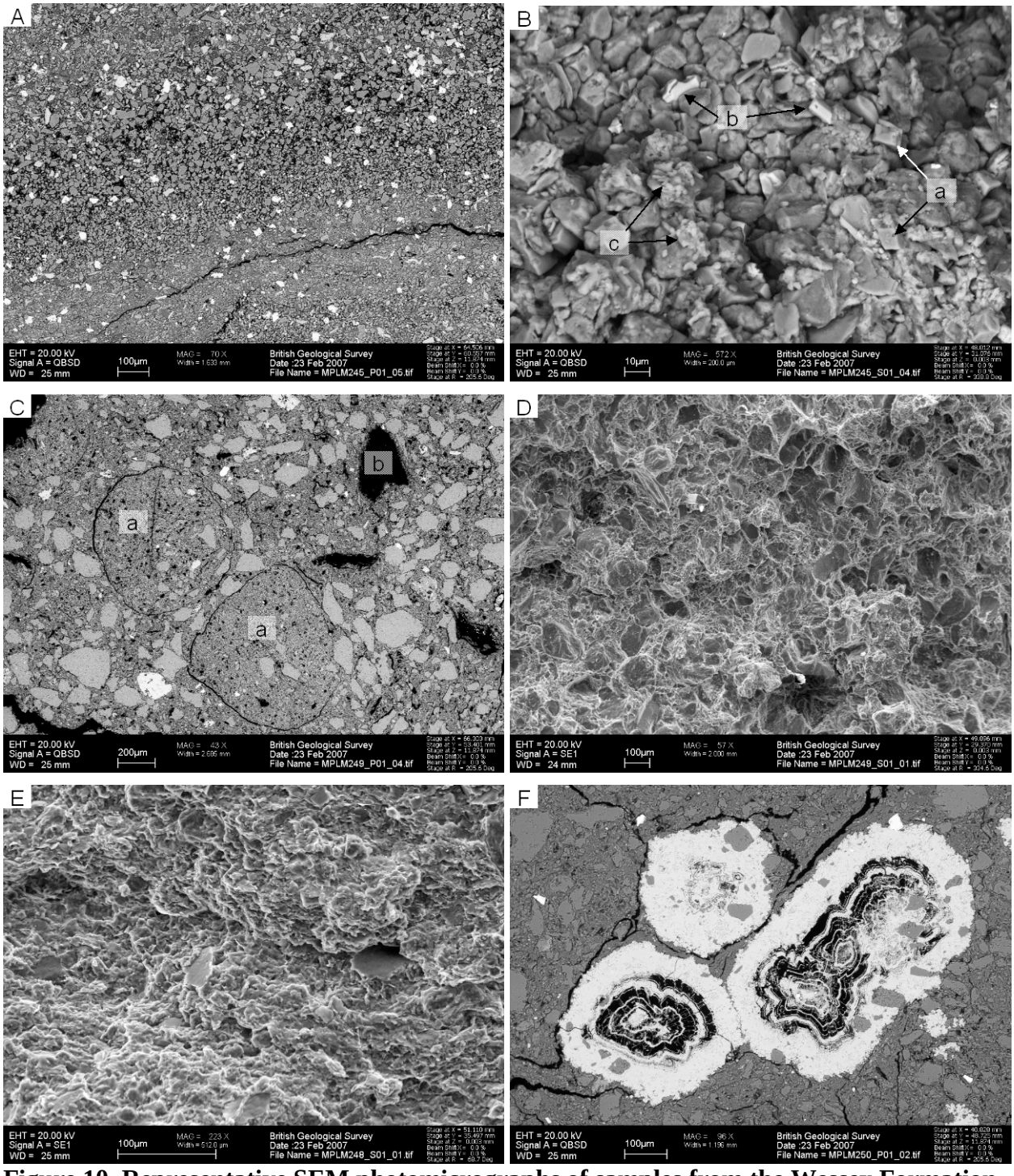


Figure 10 Representative SEM photomicrographs of samples from the Wessex Formation in the Wessex Basin.

A) Low magnification BSEM image showing a laminated silty mudstone with alternating bands of silt-rich and clay-rich sediment (Sample MPLM245; Lulworth Cove).
B) BSEM image showing the silt-rich, clay-poor nature of the silty laminae, and minor dolomite (a), apatite (b) and gypsum (c) cement (Sample MPLM245; Lulworth Cove).
C) BSEM image showing a massive sandy mudstone with two mm-scale organic-lined, clay-filled burrows (a) and fragments of organic matter (b) (Sample MPLM249; Swanage).
D) Detailed SEM image showing the typical sand-rich nature of the Wessex Formation mudstones, with sand grains sitting in a clay-rich matrix. (Sample MPLM249; Swanage).
E) Detailed SEM image of a more clay rich domain. Faint lamination is locally evident, but this is discontinuous (Sample MPLM248; Holiday Park).
F) Authigenic siderite concretions with well-defined internal zonation. (Sample MPLM250; Swanage).

4 Discussion and Conclusions

This study of a suite of samples from the Wealden Group from the Weald and Wessex Basins of Southern England indicates differences in the nature of the mudstones both between the basins, and also between different units within the basin.

In the **Weald Basin**, the Weald Clay Formation and the Wadhurst Clay Formation are seen to comprise variably silty mudstones. The fabrics of the mudstones show considerable variability with a range of highly-laminated to massive fabrics observed. Some units, in particular the "Lower Mottled Red-Green Clay" seen at Laybrook and South Chailey are particularly massive. More typically, however, the Weald Clay and the Wadhurst Clay Formations display mm-scale grain size lamination, with variable relative proportions and thicknesses of clay-rich/silt-poor and clay-poor/silt-rich layers. Within the clay-rich laminae, the clay particles display well-developed lamination, whereas microfabrics tend to be more massive/random in the more silty layers.

The matrix clay in almost all the studied samples returns an ambiguous K-Fe-Al-Si-bearing composition, suggestive of ilite, but with Al:Si ratios suggestive of kaolinite. In the mottled units however, the matrix displays variations in Fe-content. This is interpreted to represent the concentration of hematite within the reddened mottles.

Diagenetic overprinting is typically obscured by the very fine-grained and clay-rich nature of the material, however, minor amounts of authigenic siderite, apatite, pyrite, kaolinite and quartz cement are observed both within the mudstones, and also within rare, clay-poor sandy intercalations, where the kaolinite is particularly prominent.

Ironstone bands are observed at various levels in the stratigraphy. These are composed of very fine-grained, anhedral siderite crystals and also contain minor amounts of authigenic apatite. No significant differences in the petrographical character was observed between the sites/samples studied.

In the **Wessex Basin**, the Wessex Formation is notably siltier, typically coarser grained and tend to have more massive fabrics. The matrix clay however returns similar chemistry by SEM-EDXA to that seen in the Weald Basin. Again, the diagenetic overprinting is obscured by the clay rich nature of the samples, but minor pyrite, gypsum/anhydrite and siderite are noted. The siderite in one sample (MPLM250) forms highly distinctive, internally zoned 100-1000μm diameter concretions dispersed through the mudstone,

References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

RADLEY, J.D. 2006a A Wealdon guide I: the Weald sub-basin. G*eology Today, v. 22, p. 109-118*.

RADLEY, J.D. 2006b A Wealdon guide II: the Wessex sub-basin. G*eology Today, v. 22, p. 187-193*.

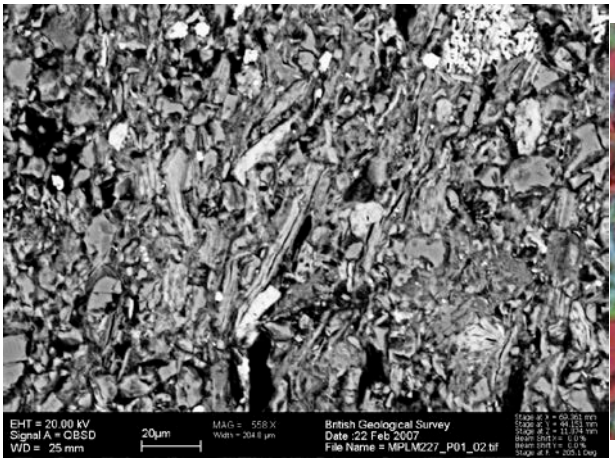
Appendix 1 SEM Sample Descriptions

WEALD BASIN - WADHURST FORMATION

Site:	**Bexhill**	Sample ID:	**Bexhill S1**
Basin:	**Weald**	Division:	**Wadhurst Fm** *(Top Blue Clay)*
MPL Sample Code(s):	**MPLM227_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM227_P01		**Polished thin-section, uncoated.**

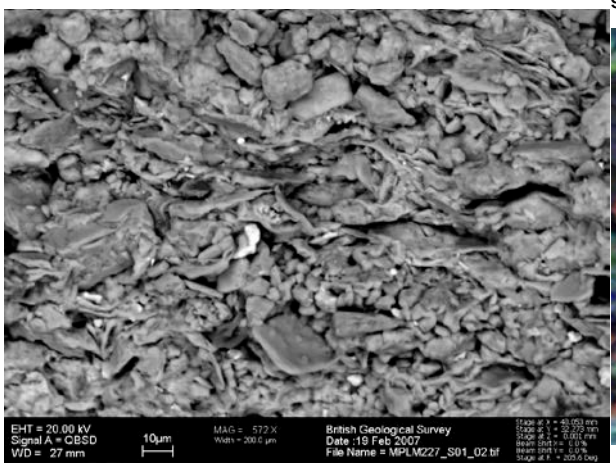
Sampling Comment: Faintly laminated mudstone.

Description: SEM imaging indicates that this sample is well-laminated and relatively silty with abundant <20µm diameter grains of quartz, feldspar and mica. The micas are flat-lying and predominantly muscovite, although minor biotite and kaolinitised muscovite is also seen. The matrix clay is of ambiguous chemistry with Si:Al ratios suggestive of kaolinite, but also minor amounts of K detected by EDXA suggesting an illitic component also. Rare Ti-oxides and apatite are locally present.

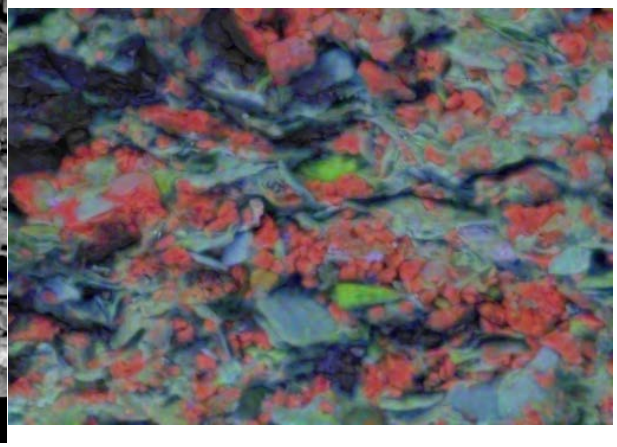


BSEM image showing the moderately well-laminated and silty nature of the mudstone.

False-colour SEM-EDXA image of the field of view shown to the left. Quartz grains appear red, muscovite mica is cyan, matrix clay appears green, and feldspar is blue-purple.



BSEM detail showing the laminated, but silt-rich nature of the mudstone.

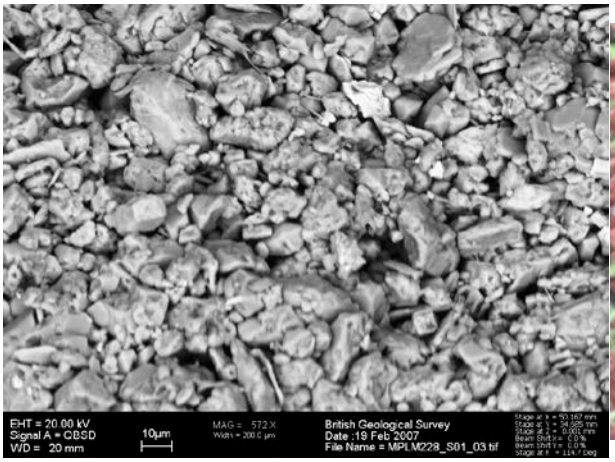


False-colour SEM-EDXA image of the field of view shown to the left. Quartz grains appear red, muscovite mica is cyan/blue, matrix clay appears green, and feldspar is blue-purple.

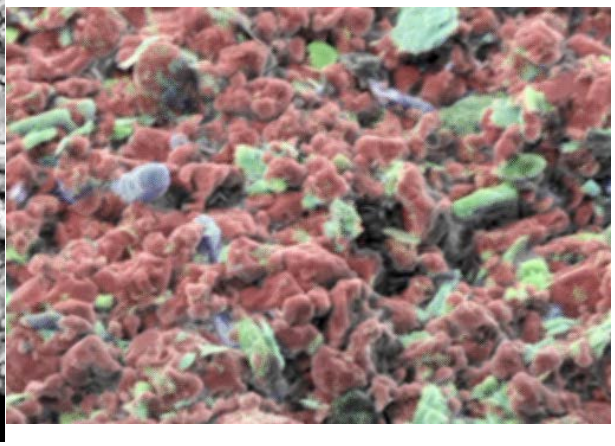
Site: **Bexhill** Sample ID: **Bexhill S2**
Basin: **Weald** Division: **Wadhurst Fm** *(Top Blue Clay)*
MPL Sample Code(s): **MPLM228_S01** Preparation: **Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Siltier horizon within material sampled as MPLM227.

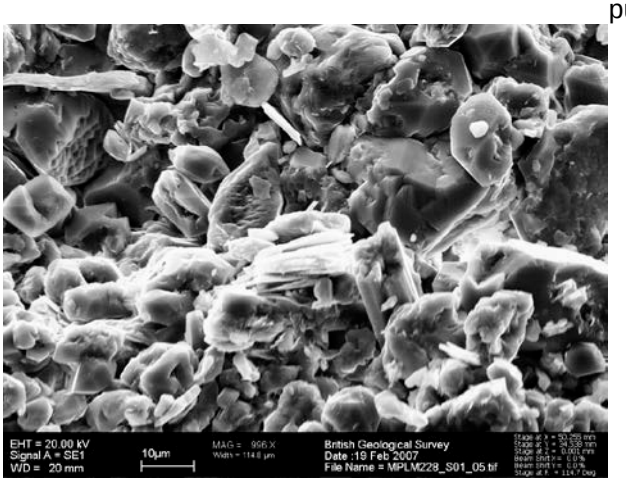
Description: This sample is notably siltier relative to MPLM227, and is dominated by silt-grade grains of quartz with subordinate feldspar and mica and rare tourmaline. Quartz overgrowths are patchily developed and rare authigenic kaolinite is noted.



General view of this sample showing its relatively silty nature.



False-colour SEM-EDXA image of the field of view shown to the left. Quartz grains appear red, muscovite is green, and feldspar is blue-purple.

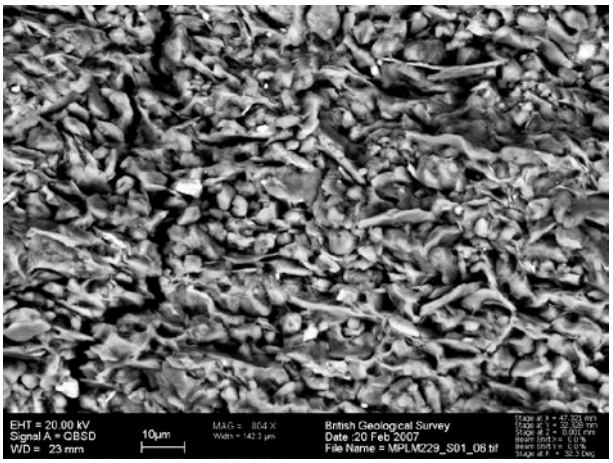


Detailed SEM image showing the quartz-rich nature of the sample. Note the presence of possible quartz overgrowths (top right), a small patch of c=kaolinite (centre), corroded feldspar (top left), and an acicular fragment of probable tourmaline (just right of centre).

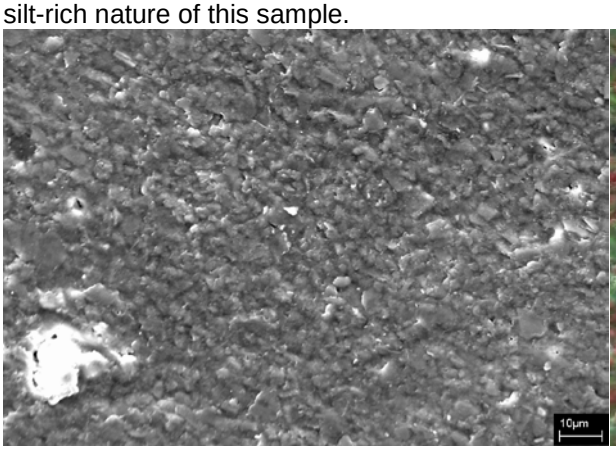
Site:	**Bexhill**	Sample ID:	**Bexhill S3**
Basin:	**Weald**	Division:	**Wadhurst Fm** *(Lower Blue Clay)*
MPL Sample Code(s):	**MPLM229_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Hard, siltier horizon within material sampled as MPLM230.

Description: This is a well-laminated silty mudstone (finer grained than the silty horizon sampled as MPLM228). It contains alternating mm-scale relatively clay-rich well-laminated horizons and siltier horizons. EDXA of clays indicates variable composition – some kaolinite, but also some K-rich clays (probably illite), and also some Fe- Mg- bearing clay.



BSEM image showing the laminated, moderately silt-rich nature of this sample.



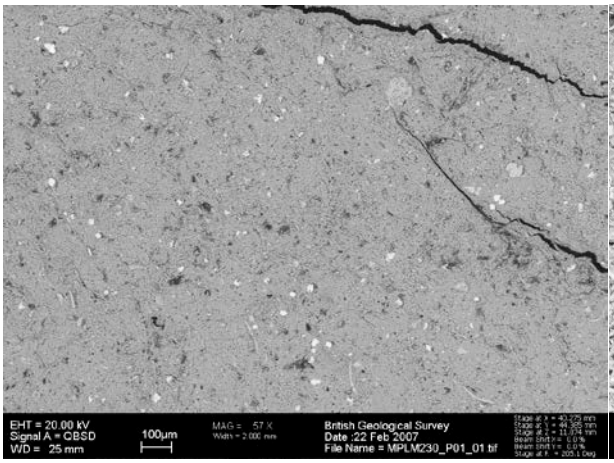
SEM image of a part of the sample surface cut with a scalpel.

False-colour colour SEM-EDXA image of the field of view shown to the left. Quartz grains appear red, muscovite is green, and feldspar is blue-purple.

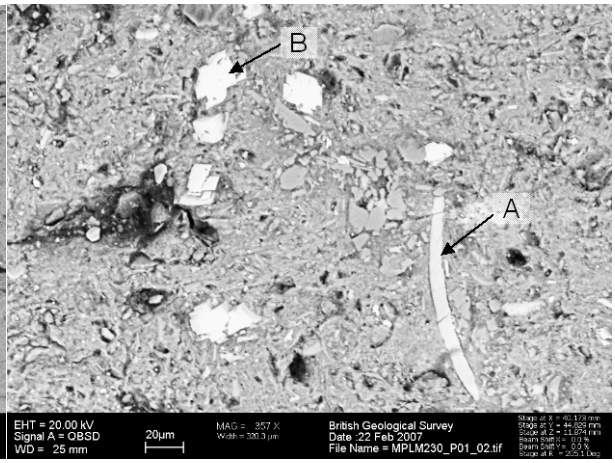
Site:	**Bexhill**	Sample ID:	**Bexhill S4**
Basin:	**Weald**	Division:	**Wadhurst Fm** *(Lower Blue Clay)*
MPL Sample Code(s):	**MPLM230_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM230_P01		**Polished thin-section, uncoated.**

Sampling Comment: Massive green-blue mudstone, with numerous slickensided or polished fracture surfaces.

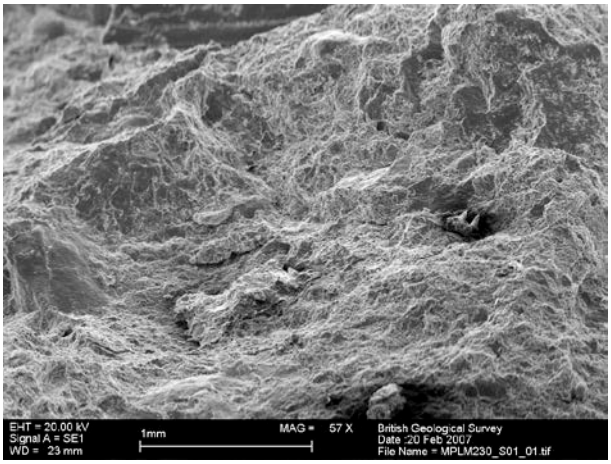
Description: A massive, clay-rich and silt-poor mudstone which contains minor amounts of authigenic siderite. EDXA of the matrix clay suggests K-Al-Si-bearing compositions (?illitic).



Low magnification BSEM image showing the massive fabric of this sample.



Detailed BSEM image showing the massive, clay-rich and silt-poor nature of this sample. Minor bioclastic material (A), and authigenic siderite (B) is present.



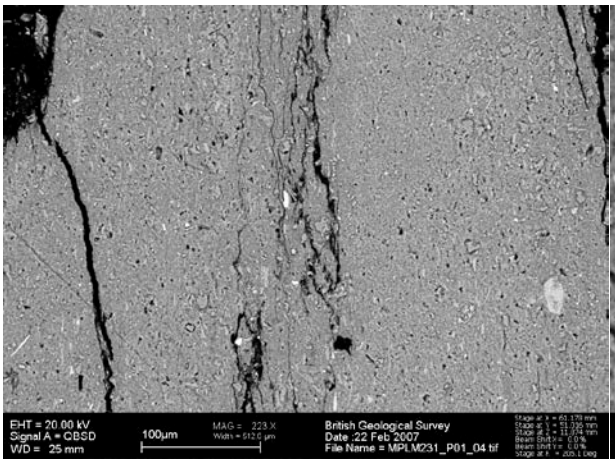
Low magnification SEM image of the rough fracture surface showing the massive nature of the sample.

WEALD BASIN – WEALD CLAY FORMATION

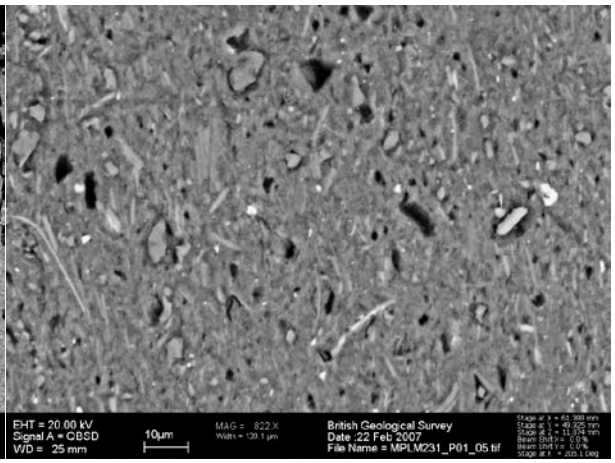
Site:	**Beare Green**	Sample ID:	**Beare Green S1**
Basin:	**Weald**	Division:	**Weald Clay Fm**
MPL Sample Code(s):	**MPLM231_S01** **MPLM231_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

Sampling Comment: Dark grey, laminated, plastic clay, with minor silty lenses.

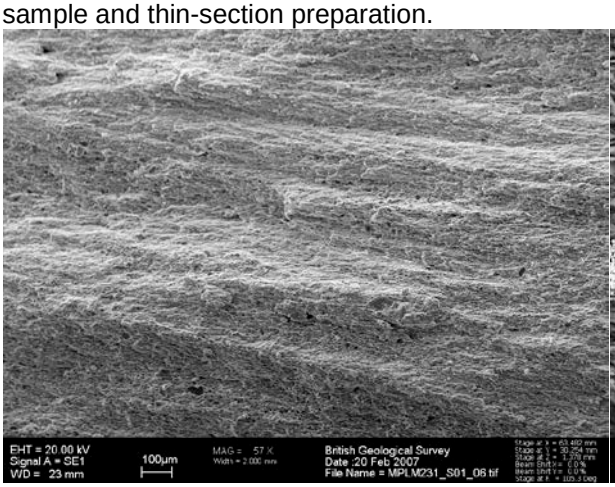
Description: A very well-laminated, clay-rich and typically silt-poor mudstone, although silt lenses a few mm long are noted in hand specimen. In detail small flakes of mica in a muddy matrix define the lamination. The sample has also developed fractures parallel to lamination during drying out and thin-section preparation. Strings of finely crystalline framboidal pyrite are locally developed and the morphology of these strings suggests that they are possibly replacing organic matter. EDXA indicates that the clay has a Al:Si ratios suggestive of kaolinite, but that minor amounts of K- and K-Fe-bearing clay (?illite) is also present.



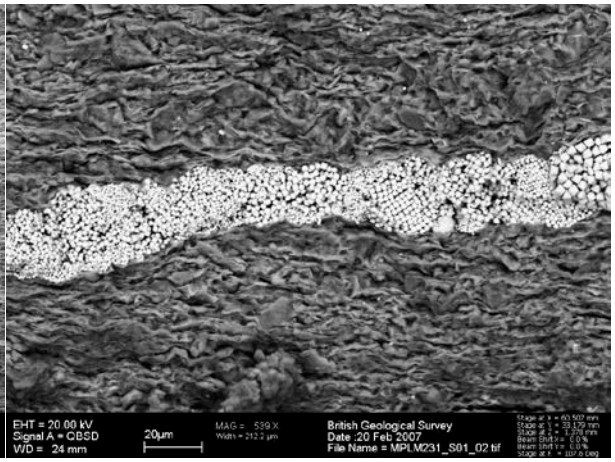
BSEM showing the very well-laminated and fine-grained, clay-rich nature of this mudstone. A number of microfractures have developed parallel to lamination during drying out of the sample and thin-section preparation.



Detailed BSEM image showing the presence of small mica flakes in a matrix of very fine clayey material.



Low magnification SEM image of the rough fracture surface showing the fine-grained, well-laminated nature of the mudstone.

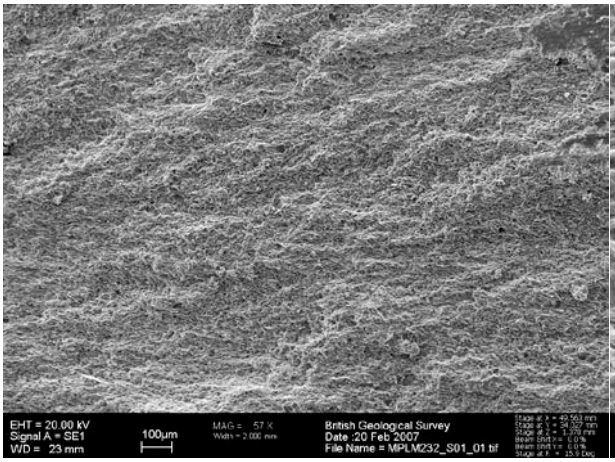


Detailed BSEM showing the finely laminated nature of the clay, and an elongate string of pyrite framboids.

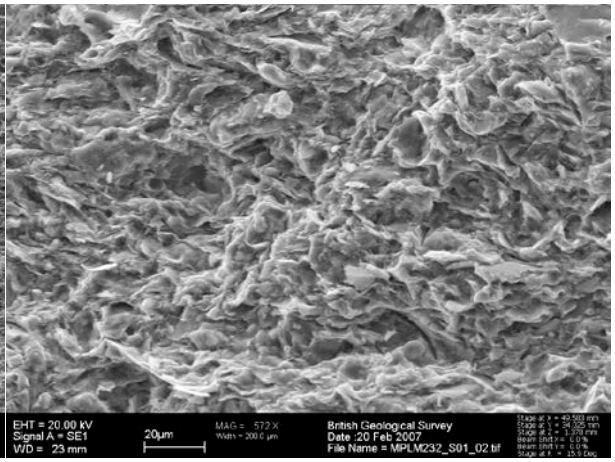
Site:	**Beare Green**	Sample ID:	**Beare Green S2**
Basin:	**Weald**	Division:	**Weald Clay Fm**
MPL Sample Code(s):	**MPLM232_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM232_S01		**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Slightly silty mudstone.

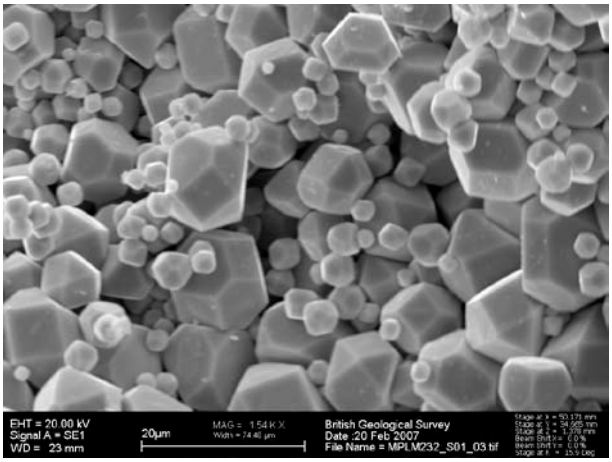
Description: This sample is similar to MPLM231, however, silty material is more abundant, and lamination is less well developed. As seen in MPLM231, the clay has a mixed illitic/kaolinitic composition. Patches of pyrite euhedra are locally developed, probably replacing organic matter.



Low magnification SEM image of the rough fracture surface showing the moderately laminated nature of the mudstone.



Detailed SEM image showing the laminated clay particles.

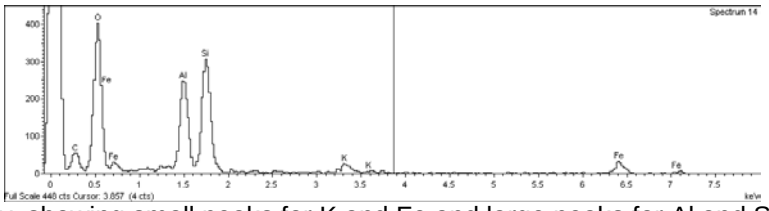


Detailed SEM images of euhedral pyrite crystals within a pyrite framboid.

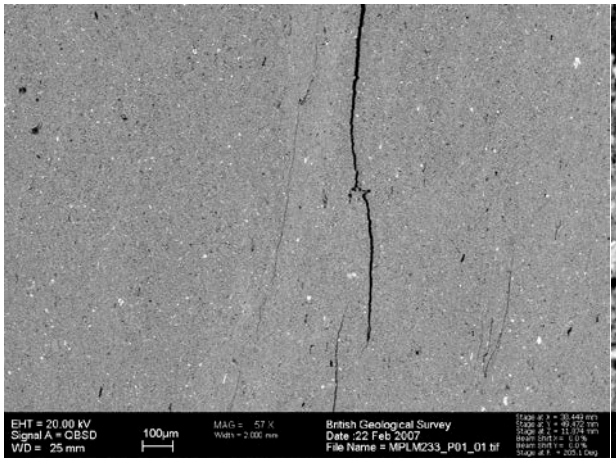
Site:	**Beare Green**	Sample ID:	**Beare Green S3**
Basin:	**Weald**	Division:	**Weald Clay Fm**
MPL Sample Code(s):	**MPLM233_S01** **MPLM233_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

Sampling Comment: Dark grey/black, highly laminated, plastic clay.

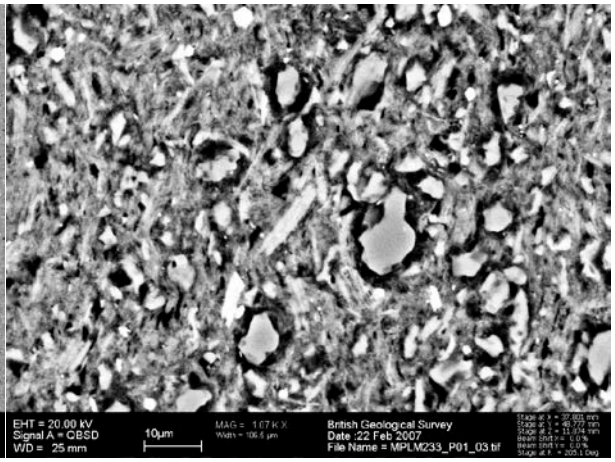
Description: As seen in sample MPLM232, this mudstone is also very strongly laminated however it does have a higher silt content. In detail the matrix clay also appears to be less densely packed relative to MPLM231. EDXA of the clay (see EDXA spectrum below) suggests an K-Fe-bearing possibly illitic composition. However the Al:Si ratio is relatively high and is more suggestive of kaolinite.



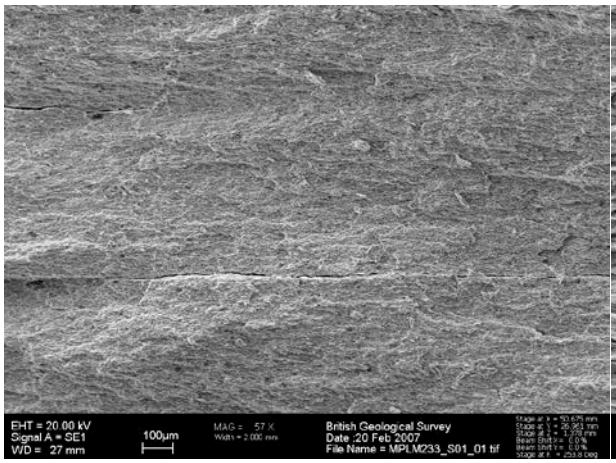
EDXA profile of clay, showing small peaks for K and Fe and large peaks for Al and Si. The Al:SI ratio of approximately 1 is suggestive of kaolinitic clay, however, the presence of K and Fe suggest illitic compositions. This type of spectra is observed for the majority of the matrix clay seen in all the studied samples.



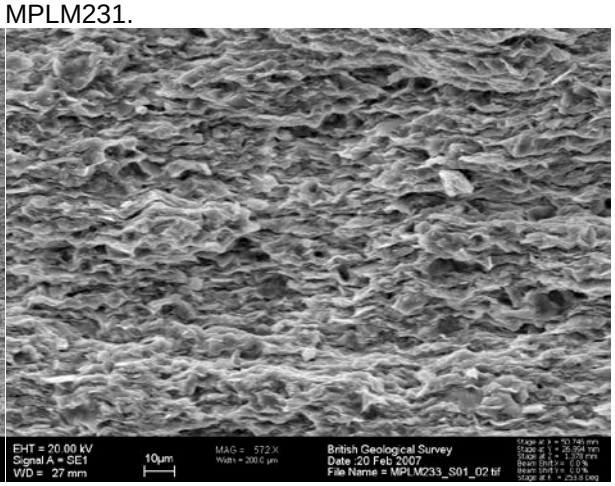
Low magnification BSEM image of the polished section showing the very fine-grained, well-laminated nature of this mudstone. Note the microfractures developed parallel to lamination in response to the sample drying out.



Detailed BSEM image of the polished section showing the presence of appreciable fine silt-grade quartz within the sample. Also note the relatively platy, loosely packed nature of the matrix clay relative to that seen in sample MPLM231.



Low magnification SEM image of the rough fracture surface showing the well-laminated nature of the sample.

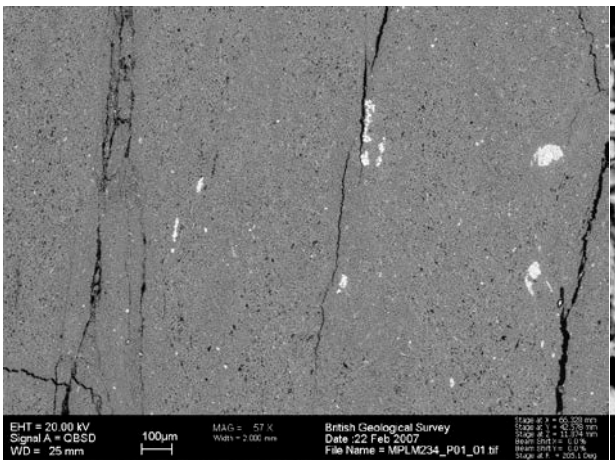


Detailed SEM image of the rough fracture surface showing the well-laminated, and in this area of the sample, relatively silt-poor nature of the sample.

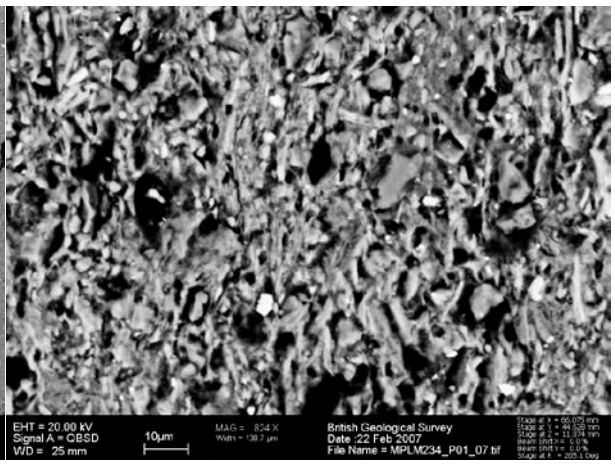
Site:	**Smokejacks**	Sample ID:	**Smokejacks S1**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Blue Clay)*
MPL Sample Code(s):	**MPLM234_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM234_P01		**Polished thin-section, uncoated.**

Sampling Comment: Finely-laminated dark grey Mudstone

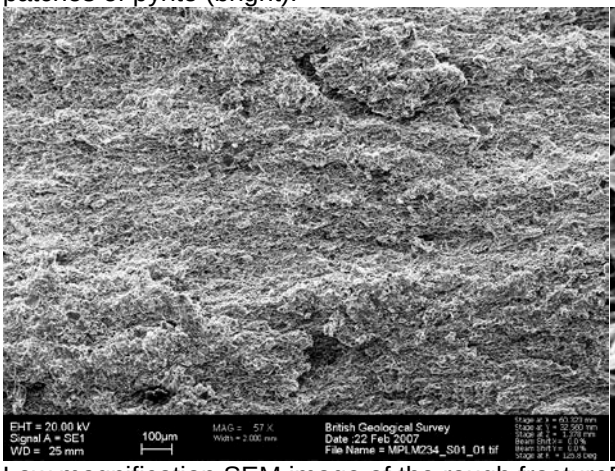
Description: This is a well-laminated clay-rich mudstone with siltier laminations, with elongate strings of authigenic framboidal pyrite. EDXA indicates that the clay is predominantly K-Fe-Al-Si-bearing compositions suggestive of illite. However, as noted elsewhere Al:Si ratios are comparable to those expected from kaolinite. In addition, EDXA analysis of the SEM stub sample consistently returns apparently high concentrations of Ca- and S, suggesting that this sample also contains appreciable amounts of very finely disseminated gypsum/anhydrite.



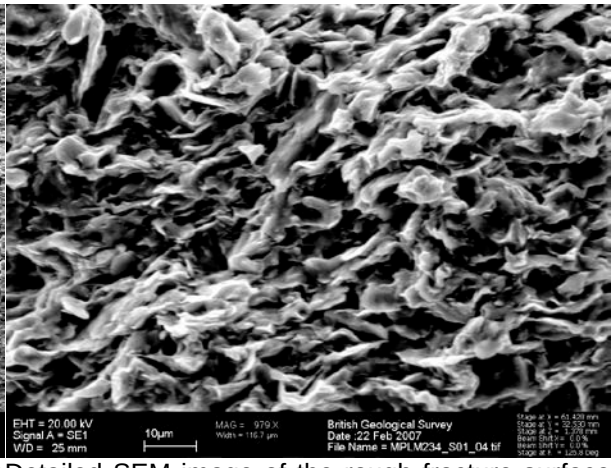
Low magnification BSEM image of the polished thin-section sample showing the well-laminated nature of the mudstone, the presence of lamination-parallel microfractures (developed as the sample dried out) and typically elongate patches of pyrite (bright).



Detailed BSEM image of the polished thin-section showing the laminated fabric and the presence of minor amounts of silt-grade quartz grains. The bright grains are detrital Ti-oxides.



Low magnification SEM image of the rough fracture surface showing the laminated fabric.



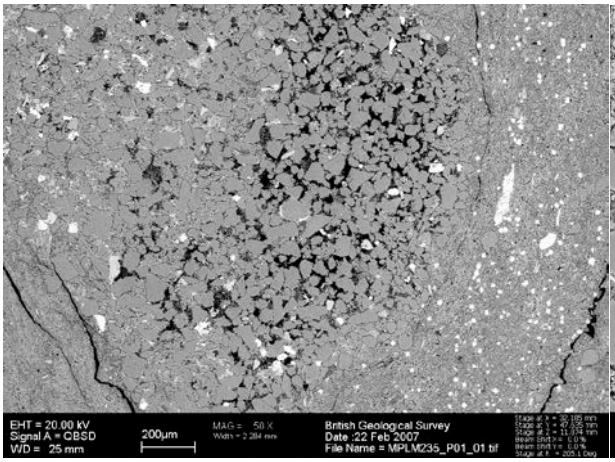
Detailed SEM image of the rough fracture surface showing the laminated nature of the clay particles.

Site:	**Smokejacks**	Sample ID:	**Smokejacks S2**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Upper Brown Clay)*
MPL Sample Code(s):	**MPLM235_S01** **MPLM235_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

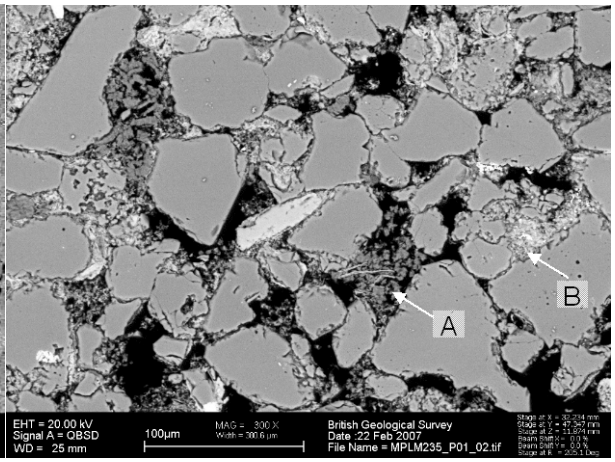
Sampling Comment: Fine-grained laminated mudstone with silty lenses.

Description: This mudstone is less well laminated that that sampled by MPLM234. It also contains irregular laminae and patches/lenses of coarser grained (up to fine sand grade material). Within the sandier lenses the mineralogy is dominated by sub-angular to sub-rounded quartz grains with minor muscovite mica. The quartz locally has thin authigenic overgrowths. Muscovite is locally replaced by kaolinite. Kaolinite is also seen as both a grain-replacive (?after feldspar) and a pore-filling cement. In some sandy lenses an Fe-rich authigenic clay, possibly chlorite, is developed.

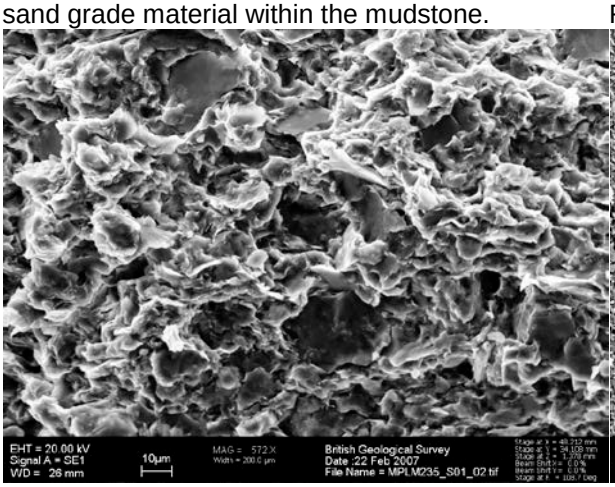
The muddy laminae are dominated by fine-grained platy clay with minor amounts of silt-grade quartz. Pyrite is locally abundant but seems to be restricted to certain laminae. EDXA of the matrix clays is the same as seen in MPLM233, suggestive of illitic and/or kaolinitic compositions.



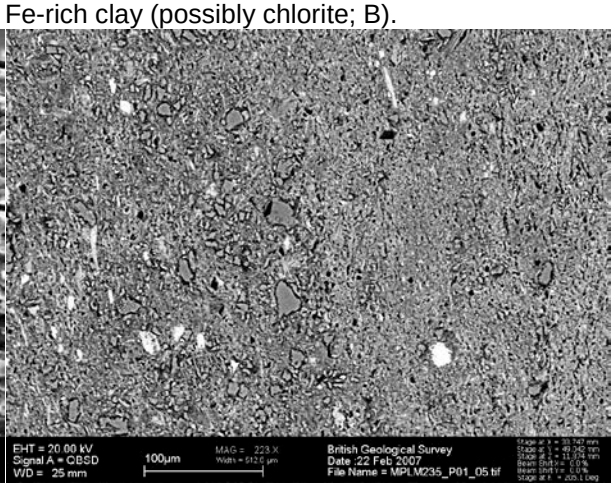
Low magnification BSEM image of the polished thin-section showing an irregular lens of fine sand grade material within the mudstone.



Detailed BSEM image of a sand-rich lens showing relatively abundant kaolinite (A) and an Fe-rich clay (possibly chlorite; B).



Detailed SEM image of the rough fracture surface sample showing fine-grained platy clays wrapped around coarser mica flakes.

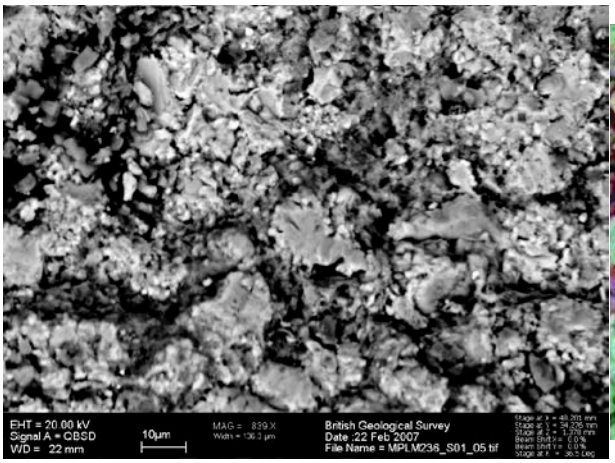


Low magnification BSEM image of the polished thin-section showing the silt-poor, well-laminated nature of the muddy laminae.

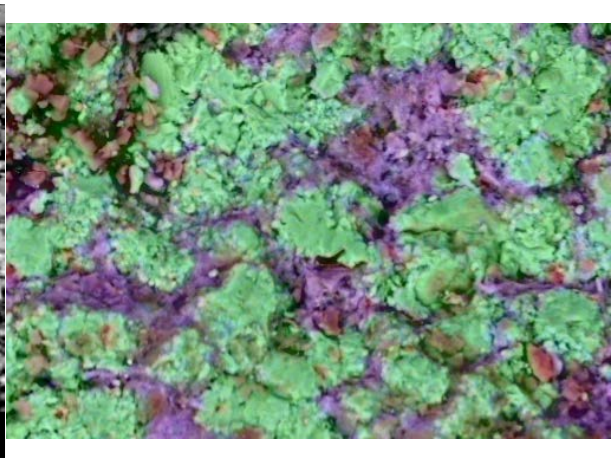
Site:	**Smokejacks**	Sample ID:	**Smokejacks S3**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Upper Brown Clay)*
MPL Sample Code(s):	**MPLM236_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM236_P01		**Polished thin-section, uncoated.**

Sampling Comment: Ironstone band.

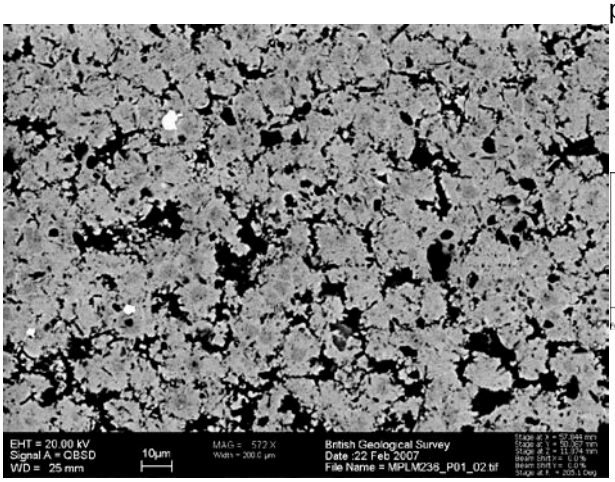
Description: This massive, and very fine-grained sample is seen to comprise a combination of fine-grained anhedral siderite crystals, with interstitial patches and local inclusions of apatite and minor quartz. The siderite crystals are typically very small (10-20µm). Although in hand-specimen the sample appears to be non-porous, in detail it is seen to contain relatively high volumes of small pores between the crystals. Rare small patches of kaolinite are locally identified.



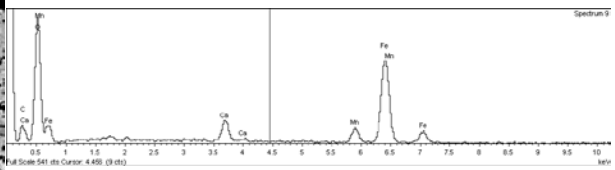
BSEM image of the rough fracture surface showing anhedral siderite with interstitial apatite.



False-colour colour SEM-EDXA image of the field of view shown to the left. Green = siderite, purple = apatite and red = quartz



BSEM image of the polished thin-section showing the anhedral nature of the siderite and the presence of relatively abundant porosity (black). Note apatite is poorly resolved on this image.

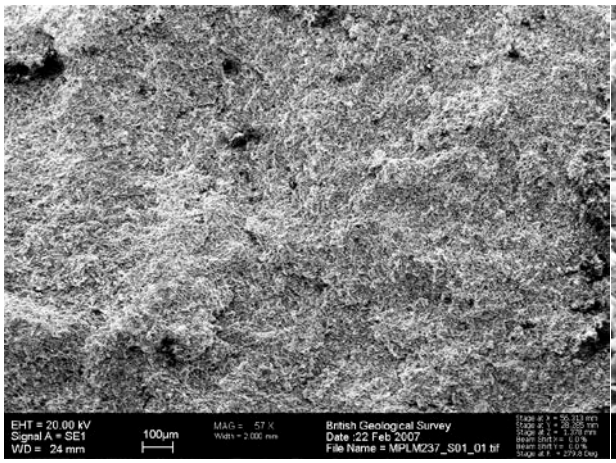


EDXA spectrum of siderite showing appreciable concentrations of Mn and Ca in addition to Fe.

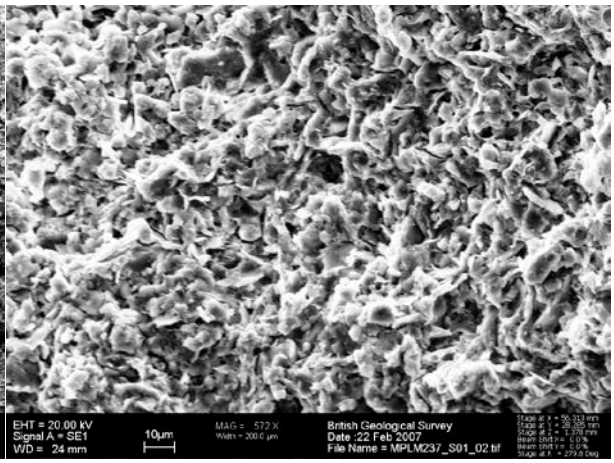
Site:	**Smokejacks**	Sample ID:	**Smokejacks S4**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Blue Clay)*
MPL Sample Code(s):	**MPLM237_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Silty horizon within laminated pale yellowish brown/brown mudstone. Sample taken approximately 1m below MPLM234 in the lower blue clay.

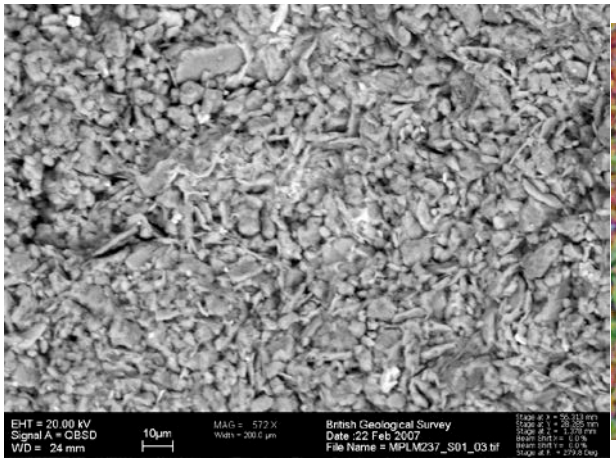
Description: This sample is a more granular, silty version of that sampled by MPLM234. It has a more massive fabric. The matrix clays return the same Fe-K-Al-Si-bearing composition.



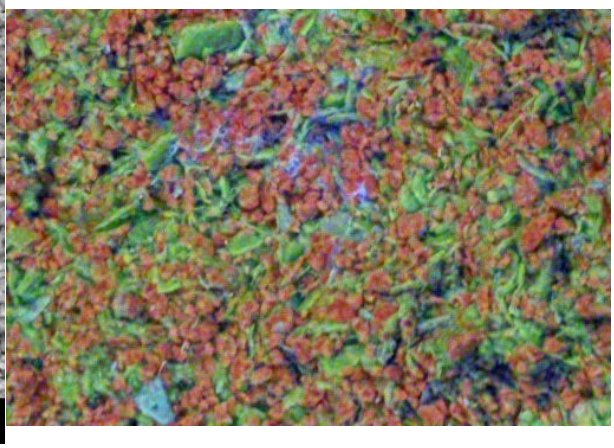
Low magnification SEM image of the rough fracture surface showing the more massive nature of this material.



Detailed SEM image of the rough fracture surface showing the relatively massive fabric with abundant fine-silt grade grains of quartz.



BSEM image of the same field of view as shown to the top right. In this image the granular nature of the sample is more apparent.



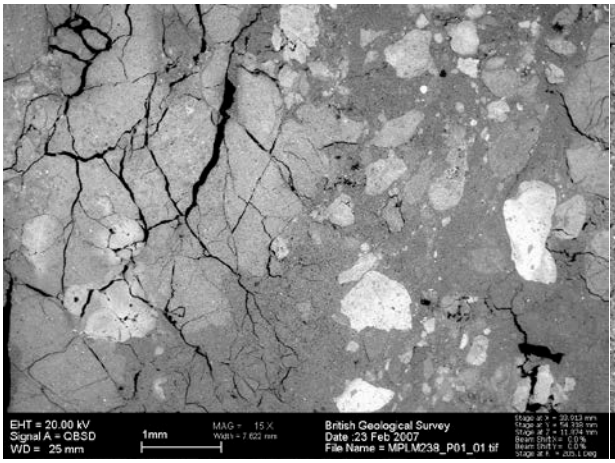
False-colour colour SEM-EDXA image of the field of view shown to the left and above. Quartz grains appear red, micas and clays are green. A relatively Fe-rich patch of fine-grained material (?chlorite) appears blue.

Site:	**Laybrook**	Sample ID:	**Laybrook S1**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Mottled Red-Green Clay)*
MPL Sample Code(s):	**MPLM238_S01** **MPLM238_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

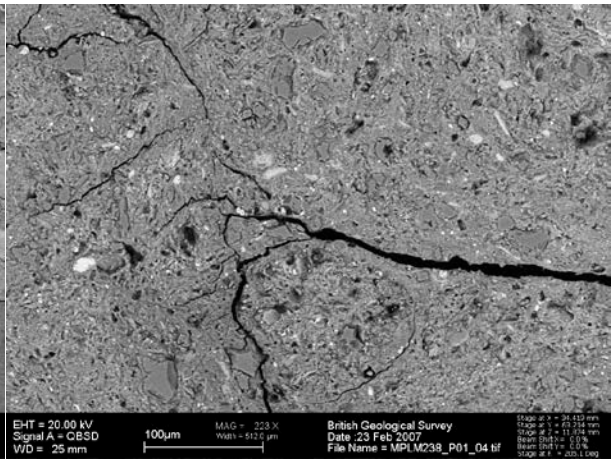
Sampling Comment: Mottled red-green, massive plastic mudstone.

Description: This mudstone has a heterogeneous chemistry and mineralogy related to the mm- to cm-scale mottling observed in hand specimen. At low magnification it is apparent that in the areas which appear red in hand specimen the clays have brighter BSEM responses and higher Fe-contents than the green areas. The clays are possibly of illitic composition based on their EDXA chemistry which indicates Fe+K+Al+Si-bearing compositions. In detail the mudstone is relatively silty, and has a massive or irregular fabric with variably aligned clay particles, which locally occur in domains with a preferred alignment. Randomly oriented shrinkage cracks are well-developed throughout the sample, but are best developed within the red mottles.

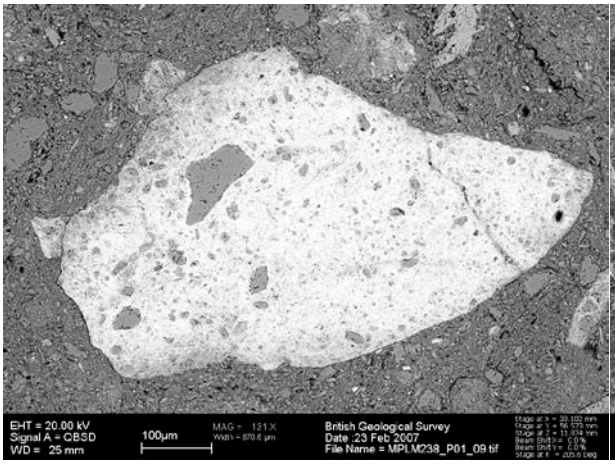
In addition to the variations observed in BSEM response of the clay matrix, the sample also contains mm-scale concretions in which the matrix clay has been completely replaced by hematite. These appear to occur along planar feature approximately 3mm wide.



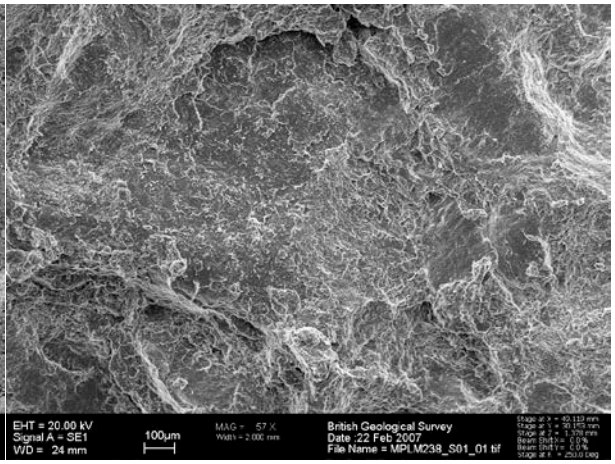
Low magnification BSEM image of the polished thin-section showing the variations in Fe-content within the matrix clay (brighter=higher Fe-content). Also note the very bright Fe-oxide-cemented concretion.



Detailed BSEM image of the polished thin-section showing the darker clay (green in hand specimen) showing the random/massive fabric.



Detailed BSEM image of the polished thin-section showing an Fe-oxide cemented concretion, within which the matrix clay has been replaced.

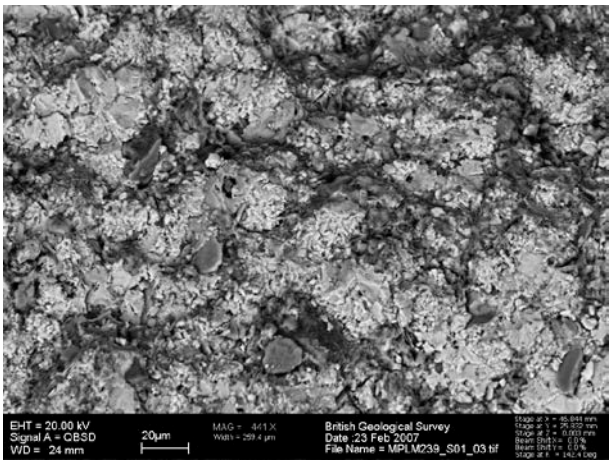


Low magnification SEM image of the rough fracture surface showing the massive nature of the sample.

Site:	**Laybrook**	Sample ID:	**Laybrook S2**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Upper Grey Clay)*
MPL Sample Code(s):	**MPLM239_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Ironstone band.

Description: This sample is an ironstone band dominated by tiny anhedral siderite crystals with minor apatite cement. Minor quartz and ?illitic clay sediment is present but this represents a small proportion of the rock.

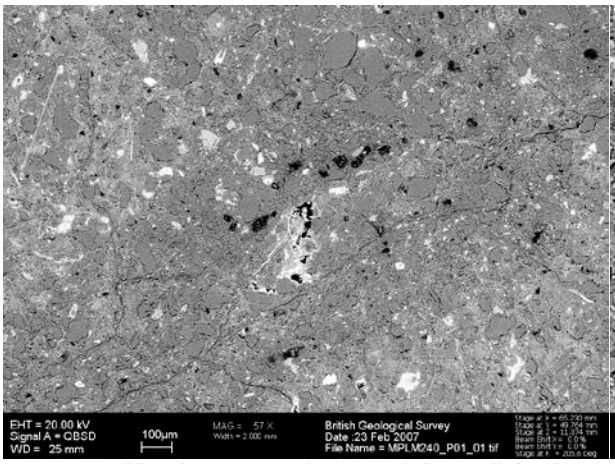


BSEM image of the rough fracture surface showing very fine grained (c.20µm) anhedral siderite (light grey) and apatite (darker grey). Minor amounts of sedimentary quartz and clay particles are also evident.

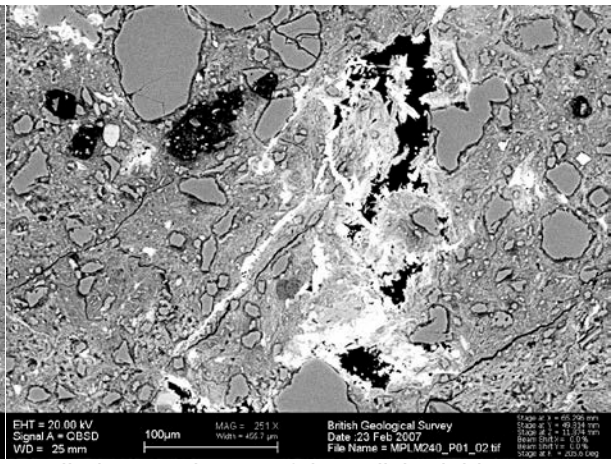
Site:	**South Chailey**	Sample ID:	**South Chailey S1**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Mottled Red-Green Clay)*
MPL Sample Code(s):	**MPLM240_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM240_S02		**Air dried, cut surface, c-coated.**
	MPLM240_P01		**Polished thin-section, uncoated.**

Sampling Comment: Green-grey massive mudstone, with minor red mottling. This sample was taken from the face of the pit, just above the pit floor. In the floor of the pit, where this horizon has been exposed for longer, the red mottling is more pronounced.

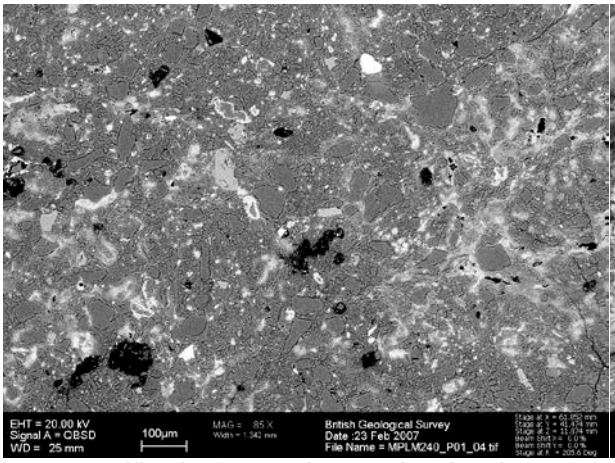
Description: This is a relatively silty mudstone with abundant silt and very fine sand grade grains of detrital quartz in a densely packed, clay matrix. It also contains patches of dark material (black in hand specimen), which are probably organic matter. The red-mottles seen in hand specimen are relatively Fe-rich compared with the green areas of the sample. Rare authigenic apatite is locally developed. EDXA suggests that the clay is illitic in composition (K-Al-Si-bearing, with variable Fe- probably reflecting the presence of finely disseminated hematite in the red mottled areas, although as noted elsewhere, the Al:Si ratios are comparable to those expected of kaolinite).



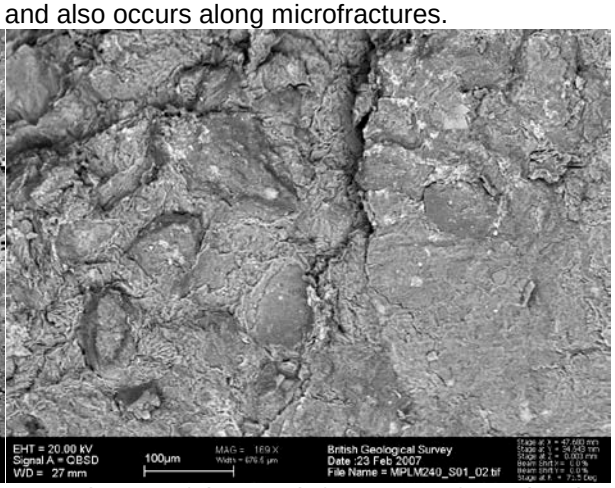
Low magnification BSEM image of the polished thin-section showing the variations in BSEM response between the red (more Fe-rich and appear brighter) and green mottled areas.



Detailed BSEM image of the polished thin-section showing a small patch of the sample, which is cemented by apatite (appears bright). Note the apatite fills an open macropore – possibly a relict after removal of organic matter and also occurs along microfractures.



Low magnification BSEM image showing the brighter (more Fe-rich) nature of the clayey matrix within one of the red mottles. Also note the presence of grains with halos of bright hematite.

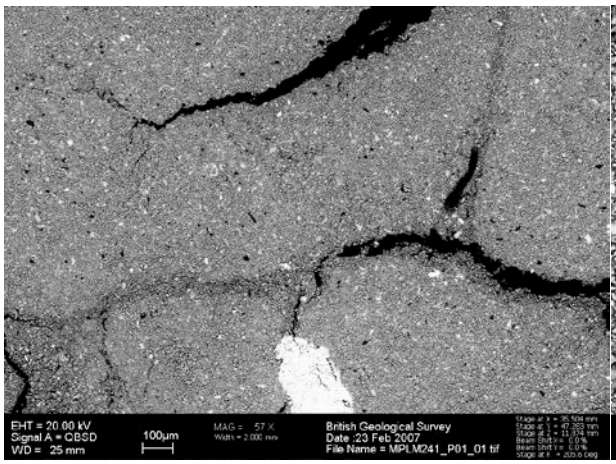


BSEM image of the rough fracture surface showing fine-sand grade grains of quartz embedded in a clayey matrix. The bright flecks seen on the surfaces of some grains are authigenic apatite.

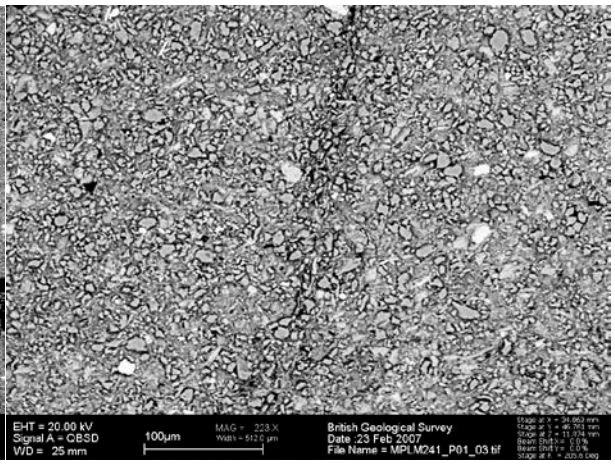
Site:	**South Chailey**	Sample ID:	**South Chailey S2**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Grey Clay)*
MPL Sample Code(s):	**MPLM241_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM241_S02		**Air dried, cut surface, c-coated.**
	MPLM241_P01		**Polished thin-section, uncoated.**

Sampling Comment: Faintly laminated, dark-grey plastic mudstone adjacent to groundwater seep, approximately 4m above sample MPLM240.

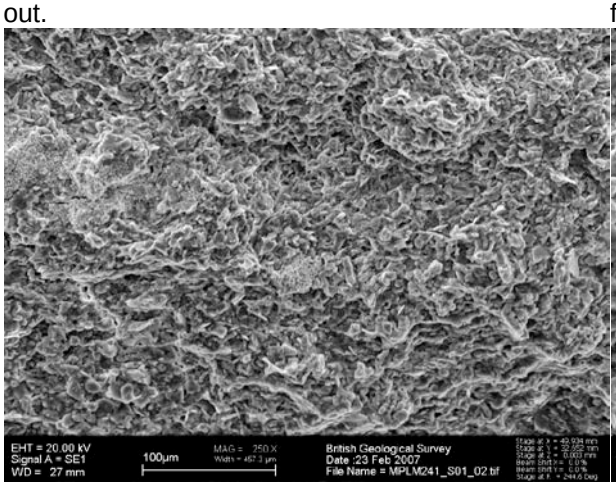
Description: This is a massive silty mudstone which is cross-cut by numerous, randomly oriented microfractures. Adjacent to these fractures, fine-grained material appears to have been washed out of the mudstone resulting in the sample containing areas which are dominated by silt to very fine sand grade grains of quartz with low matrix clay contents and high porosities. Away from the microfractures, the sample has a massive fabric with abundant silt grade quartz grains in matrix of probably illitic clay (as described in sample MPLM240).



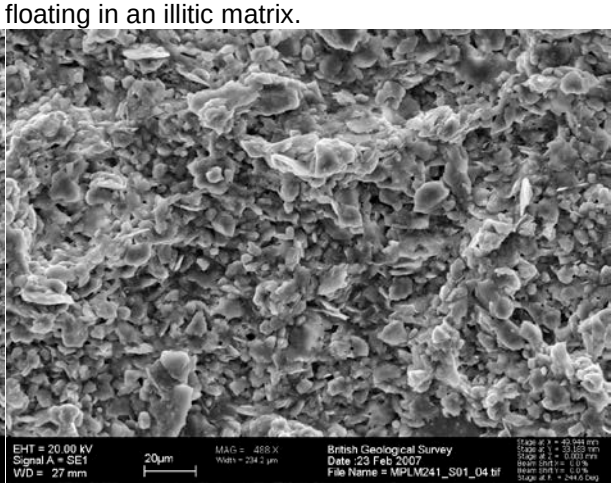
Low magnification BSEM image of the polished thin-section showing the massive nature of the mudstone, and the fact that it is cut by microfractures, adjacent to which the fine-grained matrix appears to have been washed out.



Detail BSEM image of the polished thin-section showing the nature of the fabric away from the microfractures (although an incipiently developed fracture runs approximately N-S down the centre of the image). Abundant quarzt grains are floating in an illitic matrix.



Low magnification SEM image of the rough fracture surface showing a relatively silt-poor area with a massive fabric.

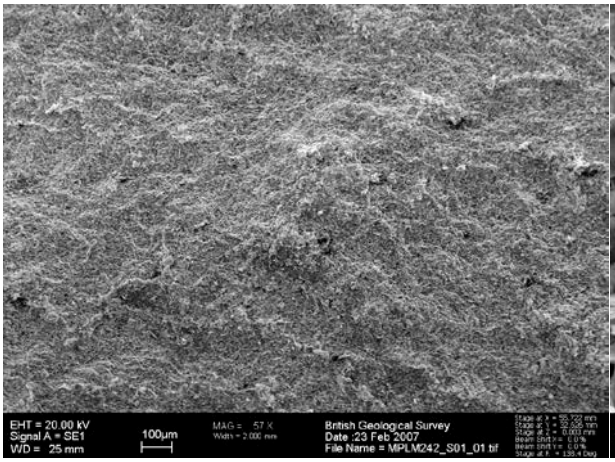


Detailed SEM image of the rough fracture surface showing the relatively granular nature of the mudstone when viewed at high magnification.

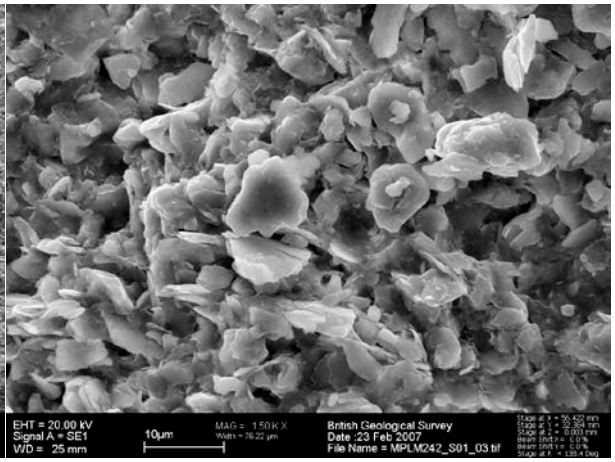
Site: **South Chailey** Sample ID: **South Chailey S3**
Basin: **Weald** Division: **Weald Clay Fm** *(Lower Grey Clay)*
MPL Sample Code(s): **MPLM242_S01** Preparation: **Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Dark grey mudstone with thin silty laminae.

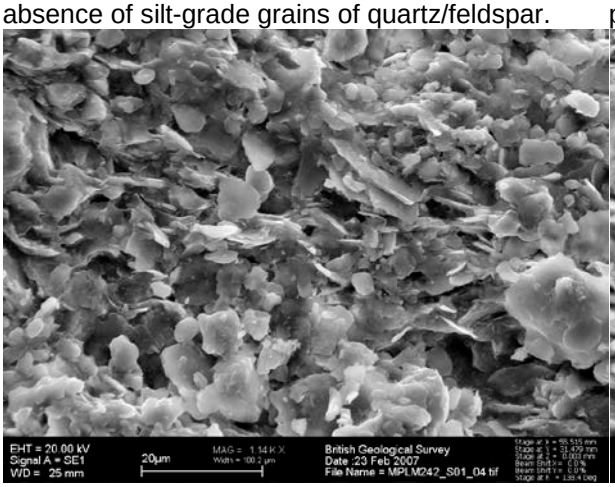
Description: A fine grained mudstone, which in the SEM stub investigated has a low content of detrital quartz/feldspar silt grains. The fabric is relatively massive, and in detail, the mudstone has a relatively granular character with thin clay platelets having random orientations. As elsewhere, EDXA of the clay indicates K-Fe-Al-Si-bearing compositions suggestive of illite.



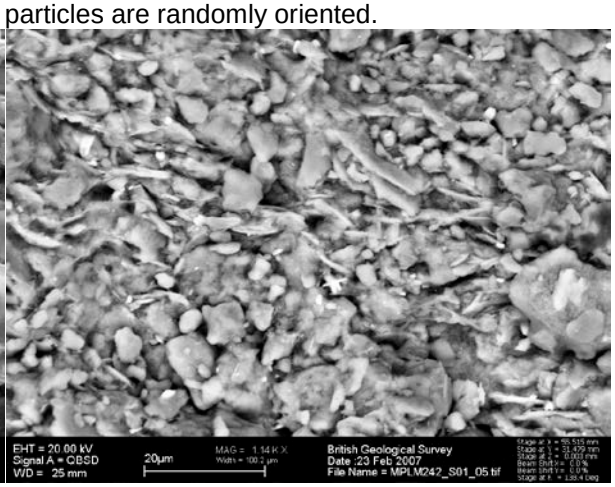
Low magnification SEM image showing the massive nature of the sample, and the general absence of silt-grade grains of quartz/feldspar.



Detailed SEM image showing a patch in which the relatively coarse (up to 10µm) platy clay particles are randomly oriented.



Detailed SEM image showing a patch in which the relatively coarse (up to 10µm) platy clay particles display a weak lamination.

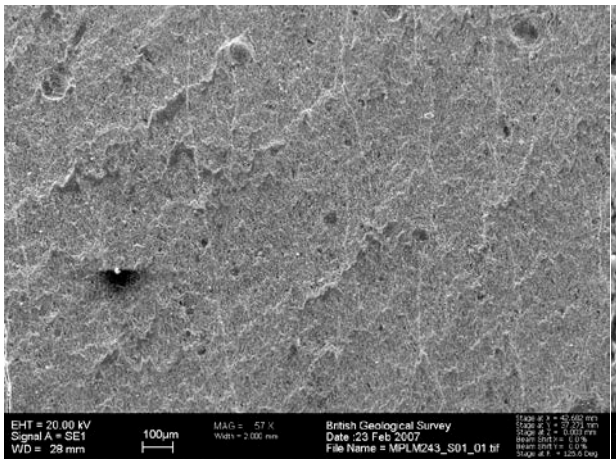


BSEM image of the field of view shown to the left, showing the presence of very fine-silt grade grains of granular material whose thin clay coatings prevent them being imaged using SEM.

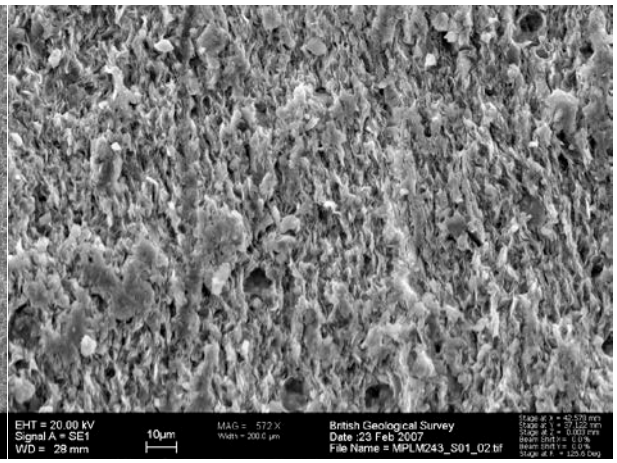
Site:	**South Chailey**	Sample ID:	**South Chailey S4**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Grey Clay)*
MPL Sample Code(s):	**MPLM243_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Brown (weathered) clay with silty laminae. This sample was taken within a weathered zone close to the top of exposed quarry face (a few cm above sample MPLM242).

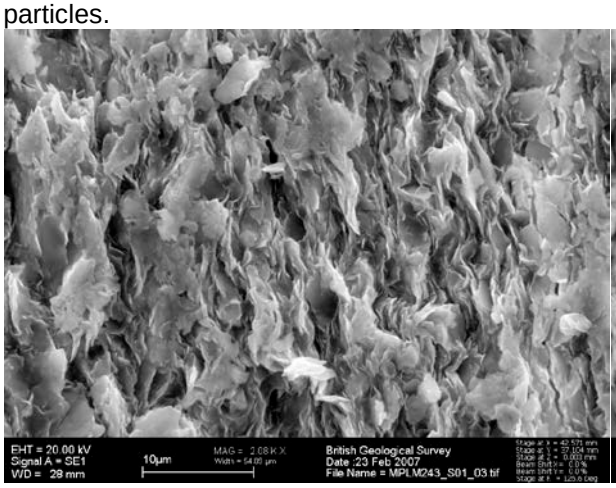
Description: This is a very fine-grained, very well-laminated mudstone with no significant amounts of silt-grade material observed. The clays here appear to be more Fe-rich than seen in MPLM242, and are less platy and more sheet-like in character. The sample is cut by a number of lamination-parallel microfractures.



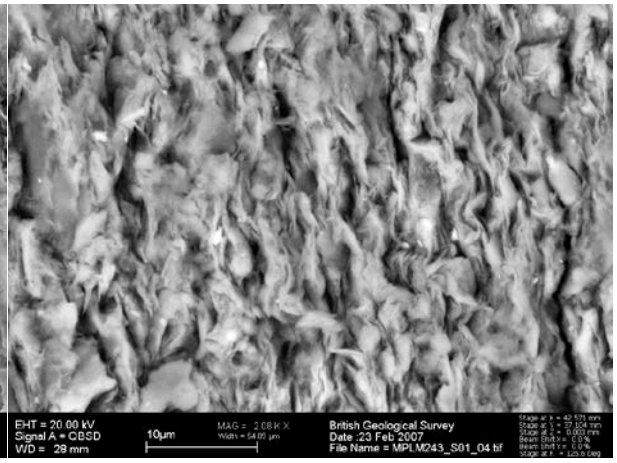
SEM image of the rough fracture surface showing the presence of very thin-microfractures. The lamination, which is so apparent at high magnification is not well-resolved due to the very fine nature of the clay particles.



Detailed SEM image showing the well-laminated and fine-grained nature of the clay particles.



Even higher magnification SEM image showing the fine-grained and more sheet-like nature of the individual clay plates.

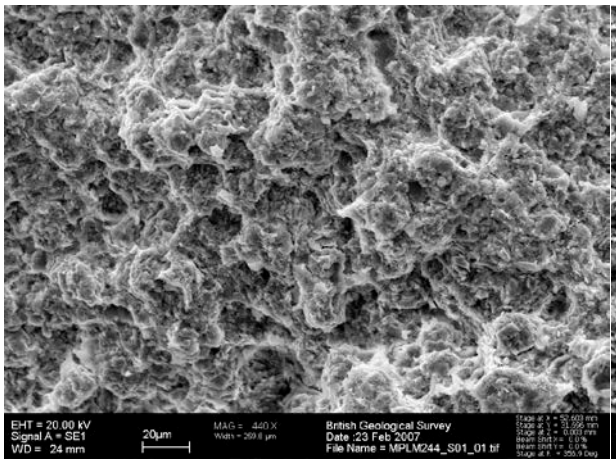


BSEM image of the same field of view as seen to the left. Note the absence of granular material.

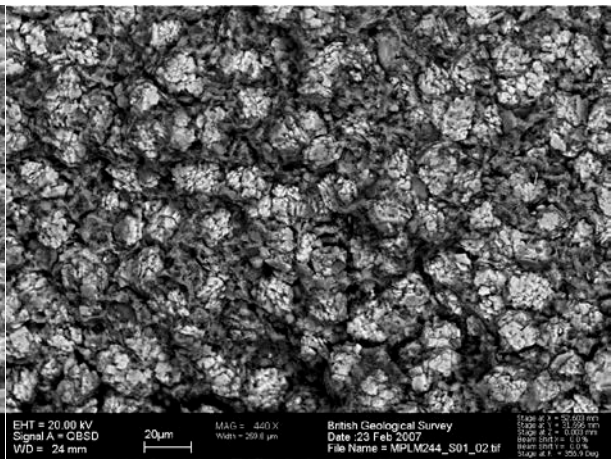
Site:	**South Chailey**	Sample ID:	**South Chailey S5**
Basin:	**Weald**	Division:	**Weald Clay Fm** *(Lower Grey Clay)*
MPL Sample Code(s):	**MPLM244_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**

Sampling Comment: Ironstone band.

Description: This sample is an ironstone band dominated by tiny anhedral siderite crystals with minor apatite cement. Minor quartz and ?illitic clay sediment is present but this represents a small proportion of the rock.



SEM image of the rough fracture surface showing the rough topography of the sample surface. The true nature of this sample is obscured by the coatings of clay which obscure the underlying microcrystalline siderite.



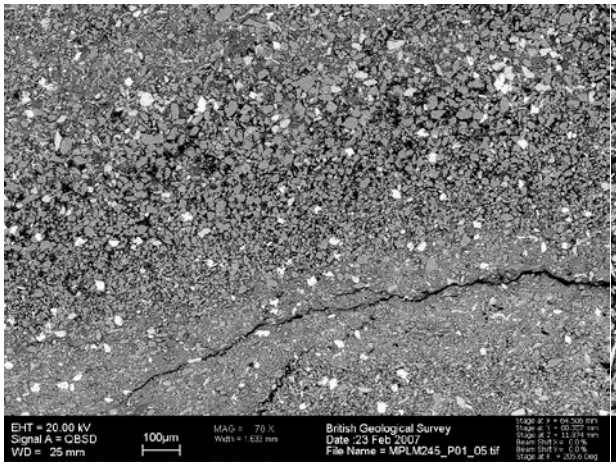
BSEM image of the same field of view shown to the left. Irregular, anhedral, very finely crystalline siderite appears bright and sits in a matrix of apatite and clay.

WESSEX BASIN – WESSEX FORMATION

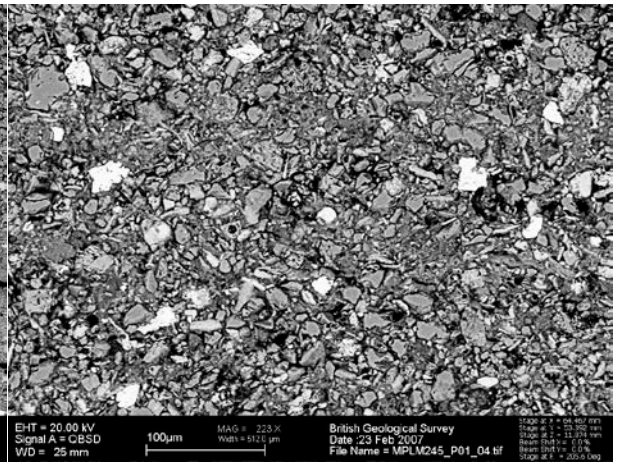
Site:	**Lulworth Cove**	Sample ID:	**Lulworth Cove S1**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM245_S01** **MPLM245_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

Sampling Comment: Laminated silty mudstone with sandy horizons.

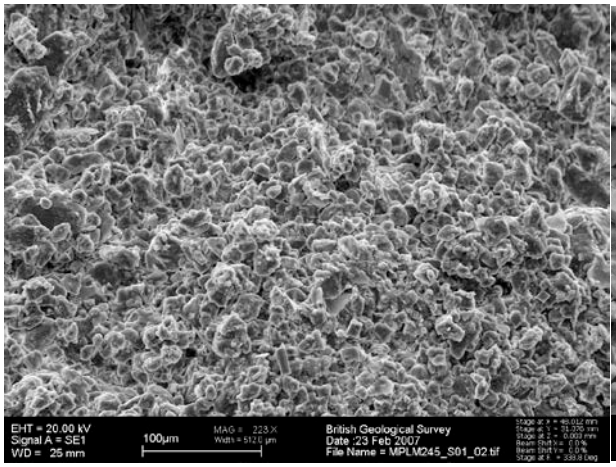
Description: Some areas/laminae of this well-laminated mudstone have been polished away during polished thin-section preparation. However, BSEM analysis of the polished thin-section reveals a well-laminated silty mudstone, with alternating bands of relatively clay-rich/silt-poor and silt-rich/clay-poor sediment. The sample contains relatively abundant grains of Fe- and Ti-oxides. Minor amounts of authigenic siderite, dolomite, apatite and gypsum/anhydrite are observed.



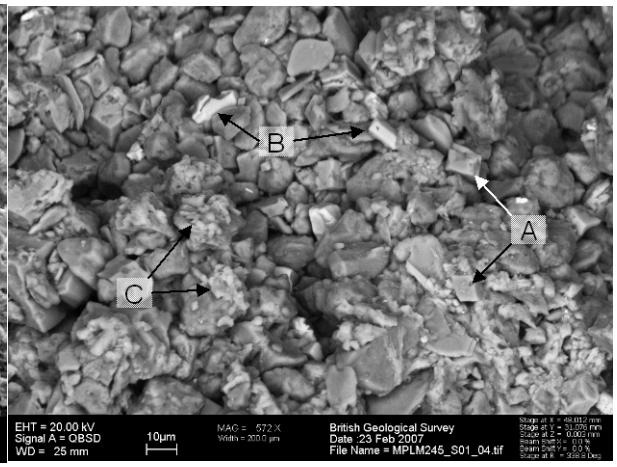
Low magnification BSEM image of the polished thin-section showing alternating clay-rich/silt-poor and clay-poor/silt-rich laminae.



Detailed BSEM image of the polished thin-section showing a silty lamina. Within this lamina, abundant silt-grade grains of quartz (and lesser amounts of rounded Fe- and Ti-oxides which appear white) sit in a clay matrix. The bright white, rhombic phase is authigenic siderite.



Low magnification SEM image of the rough fracture surface showing the relatively granular, silt-rich nature of this sample.



Detailed BSEM image of the rough fracture surface showing the relatively granular, silt-rich nature of this sample. Also evident are small rhombs of authigenic dolomite (A), authigenic apatite (B) and gypsum/anhydrite (C).

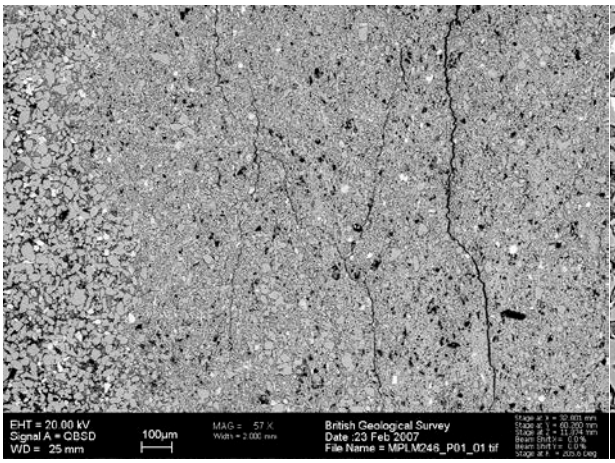
Site:	**Hanover Point**	Sample ID:	**Hanover Point S1**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM246_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM246_P01		**Polished thin-section, uncoated.**

Sampling Comment: Faintly laminated, dark grey mudstone.

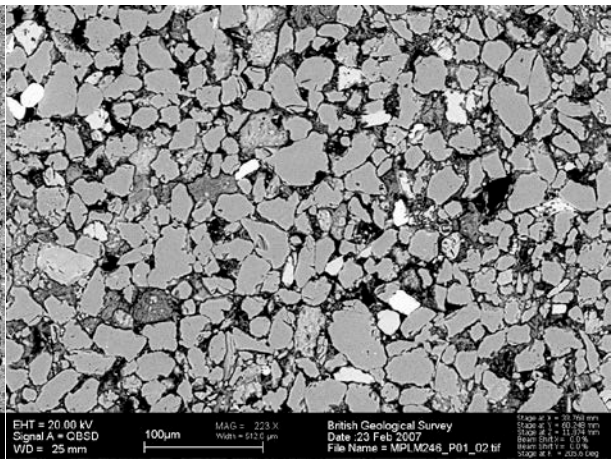
Description: A laminated mudstone with layers of different grain sizes comprising a mixture of coarser, clay-poor laminae and finer-grained clay-rich laminae.

Within the sandier lamina the fabric tends to be relatively massive and grains are relatively tightly packed with elongate grain contacts, along which detrital clay is locally compressed. The mineralogy is dominated by quartz with minor feldspar and detrital Fe- and Ti-oxide grains. The pores are lined with clay of comparable, probably illtic, composition to that seen in the more clay-rich laminae.

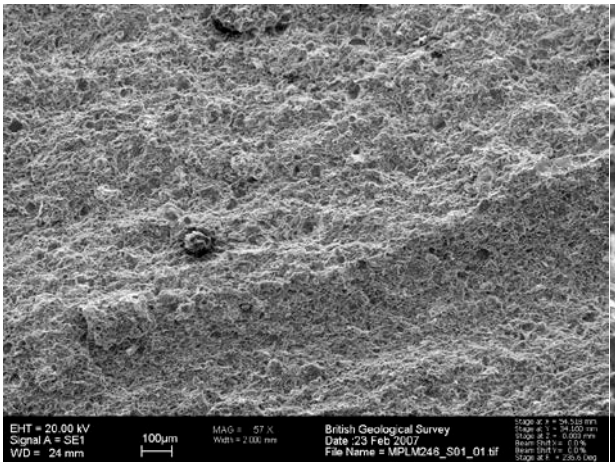
Within the clay-rich lamina, silt grains are still present, but not as abundant. The fabric is moderately well-laminated, and microfractures have developed parallel to this lamination.



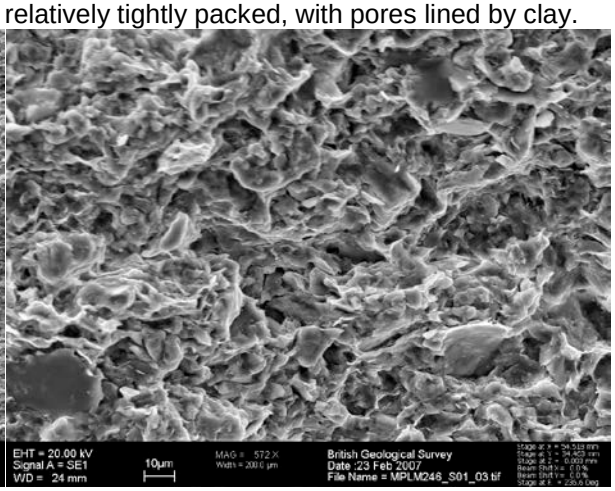
Low magnification BSEM image of the polished thin-section showing the laminated nature of the sample.



Detailed BSEM image of one of the coarser-grained laminae, in which abundant silt-grade particles of quartz, feldspar and Fe-Ti-oxides are relatively tightly packed, with pores lined by clay.



Low magnification SEM image of the rough fracture surface showing a relatively weakly laminated fabric.

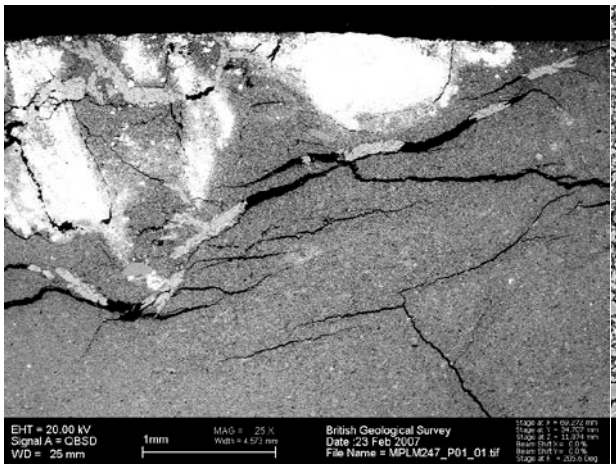


Detailed SEM image of the rough fracture surface showing silt grade quartz grains in a clayey matrix.

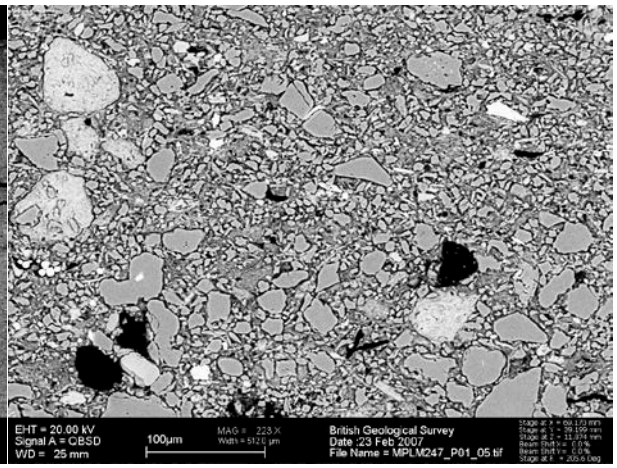
Site:	**Hanover Point**	Sample ID:	**Hanover Point S2**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM247_S01** **MPLM247_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

Sampling Comment: Faintly laminated, dark grey mudstone.

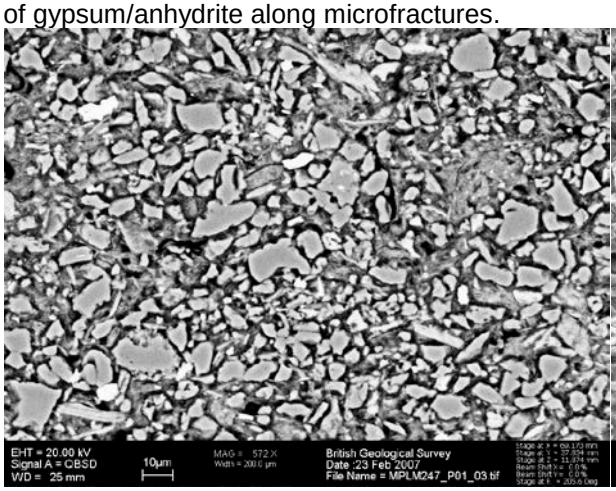
Description: One margin of this sample contains an array of microfractures which are cemented by gypsum/anhydrite. Also developed, are mm-scale nodules of pyrite. In detailed the mudstone contains abundant silt and very fine sand grade grains of detrital quartz although there are some variations in both silt/sand content and also their prevailing grain size between different laminae.



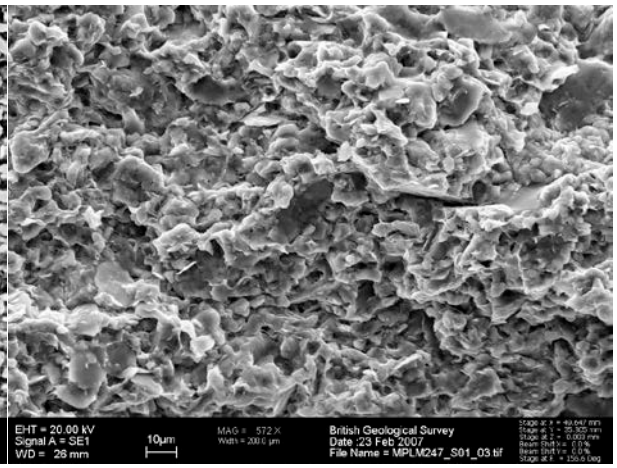
Low magnification BSEM image of the polished thin-section showing the development of coarse (mm-scale) pyrite at the margin of the sample, and the development of coarse, bladed crystals of gypsum/anhydrite along microfractures.



Intermediate magnification BSEM image of the polished thin-section showing the presence of coarse-silt/very fine sand grade grains of quartz and feldspar.



Detailed BSEM image of the polished thin-section showing the fine-silty, granular nature of the mudstone.

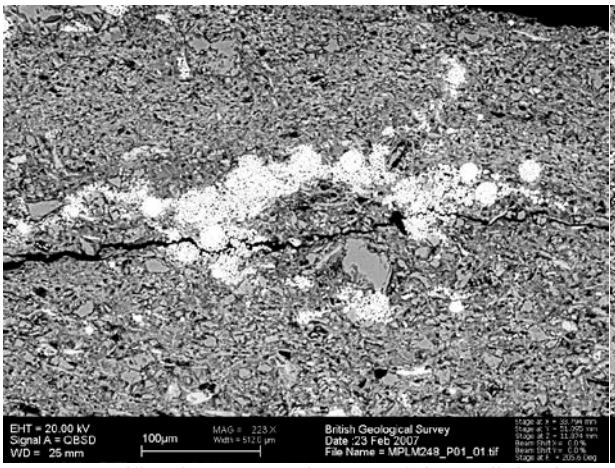


Detailed SEM image of the rough fracture surface showing the relatively granular nature of this material.

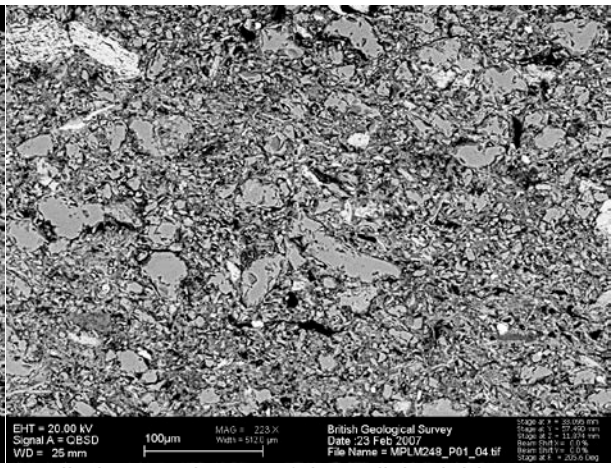
Site:	**Holiday Park**	Sample ID:	**Holiday Park S1**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM248_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM248_P01		**Polished thin-section, uncoated.**

Sampling Comment: Dark grey mudstone.

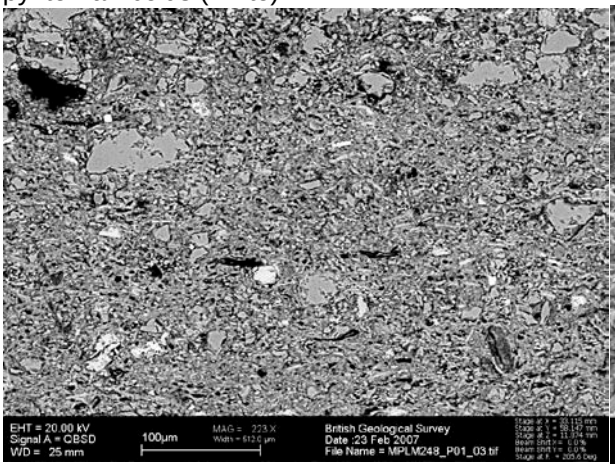
Description: In many respects this sample is similar to sample MPLM247, being a laminated silty mudstone, with variations in grain-size. Displaying mm-scale variations in the amount of silt grade quartz material between laminae/lenses. Framboidal pyrite occurs in elongate clusters of framboids up to c.0.5mm long, possibly replacing organic matter. Within the more clay-rich laminae, a clear lamination is defined by the clay particles.



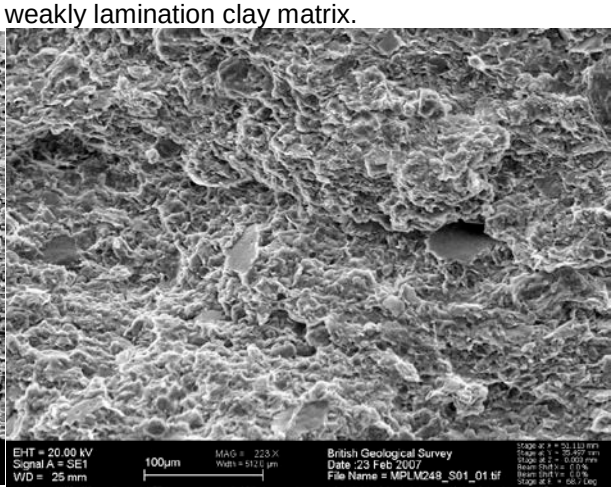
Low magnification BSEM image of the polished thin-section showing the laminated fabric in the more clay-rich laminae, and a large cluster of pyrite framboids (white).



Detailed BSEM image of the polished thin-section showing one of the siltier areas of the sample with angular grains of quartz in an only weakly lamination clay matrix.



Detailed BSEM image of the polished thin-section showing one of the more clay areas of the sample. A faint horizontal lamination is evident.

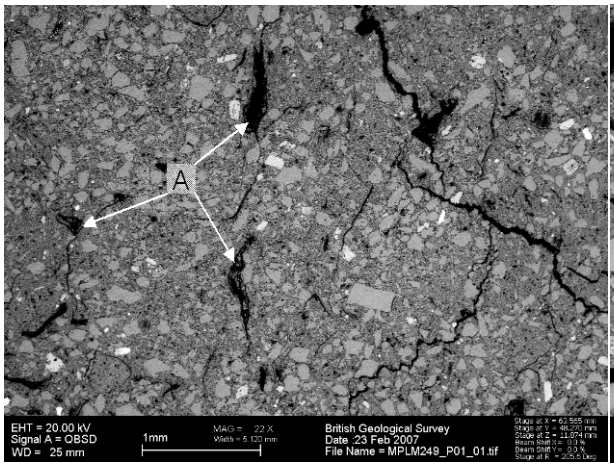


Detailed SEM image of the rough fracture surface showing the weakly laminated nature of the clay particles.

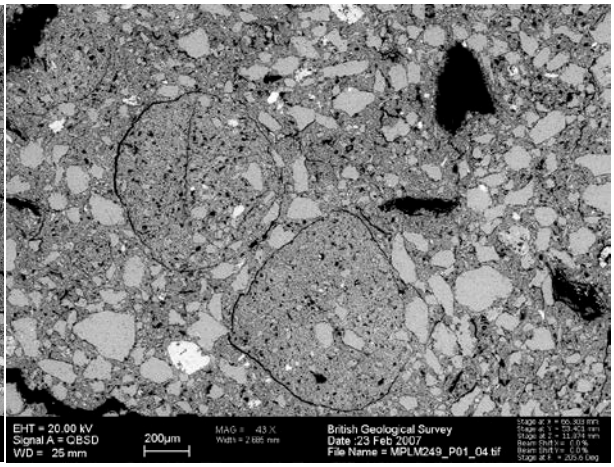
Site:	**Swanage**	Sample ID:	**Swanage S1**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM249_S01** **MPLM249_P01**	Preparation:	**Air dried, fresh fracture surface, c-coated.** **Polished thin-section, uncoated.**

Sampling Comment: Dark grey, massive, silty mudstone.

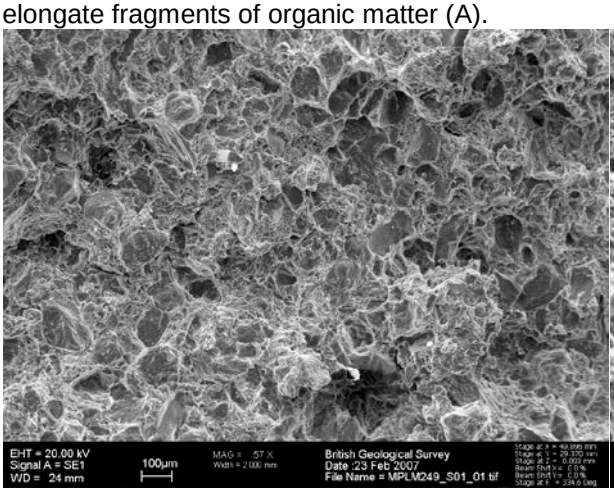
Description: This sample has a massive fabric and is particularly sand-rich, with abundant grains of detrital quartz up to fine sand (Upper) grade in an ?illtic clay matrix. In addition, the sample also contains some relatively large (close to 1mm-scale) fragments of organic matter. These fragments share a preferred horizontal alignment and are the only evidence for lamination in this sample. Whilst the fabric is typically massive, some mm-scale burrow-like features are observed. These have thin coatings of organic matter and are filled predominantly with clay, although minor amounts of silt grade quartz grains are also present.



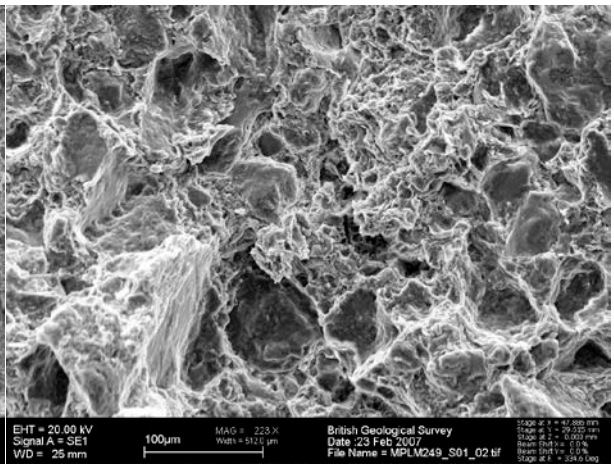
Low magnification BSEM image of the polished thin-section showing the massive, sand-rich nature of this sample. The sample is cut by a number of microfractures (appear black), but also contains coarse (up to c.1mm long) elongate fragments of organic matter (A).



Low magnification BSEM image of the polished thin-section showing mm-scale organic-lined, clay filled ?burrows.



Low magnification SEM image of the rough fracture surface showing the sand-rich nature of the sample with abundant grains of quartz in a clay-rich matrix.



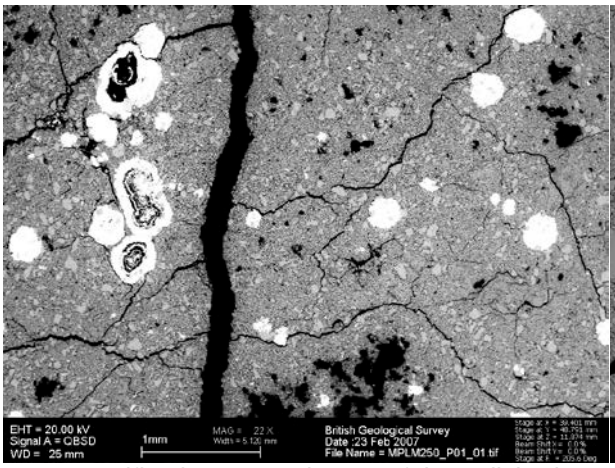
Detailed SEM image of the rough fracture surface showing the sand-rich nature of the sample with abundant grains of quartz in a clay-rich matrix.

Site:	**Swanage**	Sample ID:	**Swanage S2**
Basin:	**Wessex**	Division:	**Wessex Fm**
MPL Sample Code(s):	**MPLM250_S01**	Preparation:	**Air dried, fresh fracture surface, c-coated.**
	MPLM250_P01		**Polished thin-section, uncoated.**

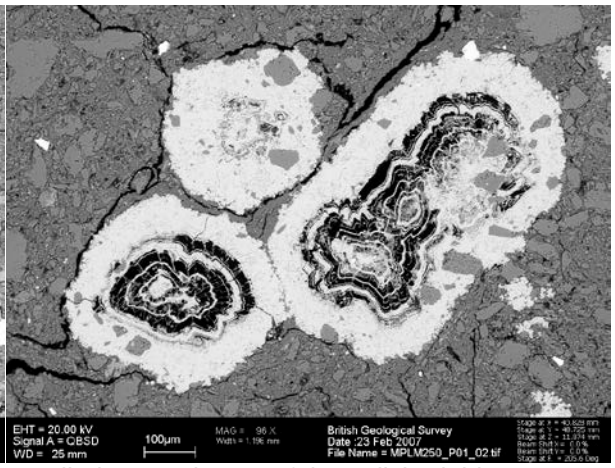
Sampling Comment: Light grey, massive, silty mudstone.

Description: This sample is similar to MPLM249, in that it is a massive mudstone with abundant detrital quartz grains. However, the detrital quartz is marginally finer-grained.

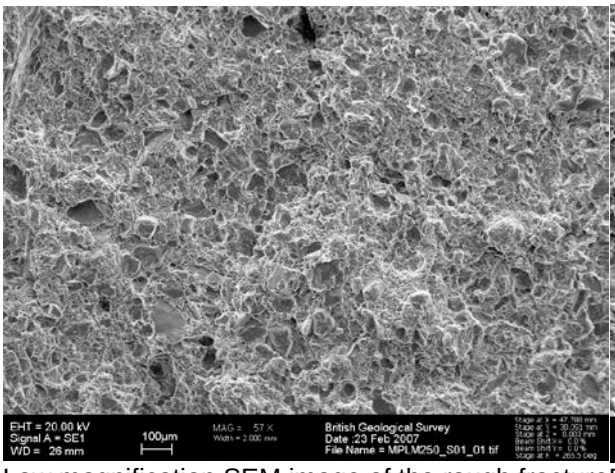
The sample contains abundant, dispersed concretions/nodules of siderite of between 100-1000µm diameter. These have clearly developed with a radial fibrous habit. The earlier generations tend to be dark brown, with later generations tending towards lighter-brown colours. Growth zoning is clearly developed and includes thin, opaque (?organic-rich) bands and also bands where an unknown phase has been removed. These "empty" growth bands are locally bridged by thin blades of siderite cement and contain minor amounts of brown, spongy, non-birefringent (?smectitic) clay. The outer margins of the nodules engulf/enclose grains of quartz, suggesting that the later generations of siderite replace detrital clay. Only rare grains of quartz are included in the earlier siderite generations, which suggests that the siderite is nucleated within and is replacing a detrital component (?faecal pellets).



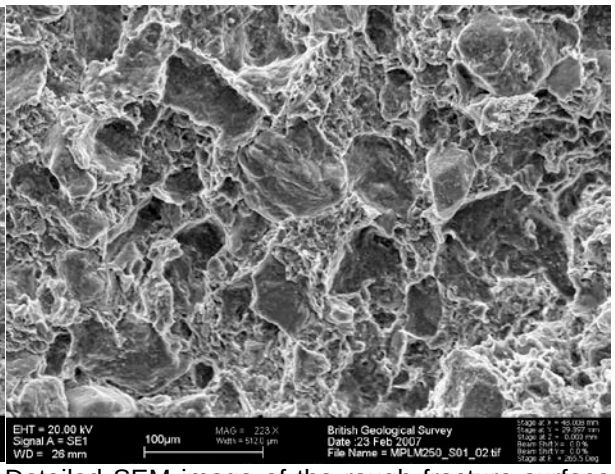
Low magnification BSEM image of the polished thin-section showing the massive, sand-rich nature of this sample. The sample is cut by numerous randomly oriented microfractures and contains abundant siderite nodules.



Detailed BSEM image of the polished thin-section showing the internal structure of the siderite concretions.



Low magnification SEM image of the rough fracture surface showing the silty/sandy nature of the sample.



Detailed SEM image of the rough fracture surface showing the silty/sandy nature of the sample, with grains of quartz sitting in a clayey matrix.