EXPOSURES OF THE WIDMERPOOL FORMATION (DINANTIAN) IN SOUTH DERBYSHIRE

by

J.D. Weaver and M.F. Stanley

Summary

Detailed investigation of the surface exposures of the Widmerpool Formation north-west of Derby has revealed that these upper Visean sediments are mainly composed of thin limestone, sandstones and shales. Detrital fragments in the sandstones indicate derivation from an area composed of igneous and metamorphic rocks. Sole structures on some of the sandstone units suggest a south-easterly source, possibly the Charnwood Forest area.

Introduction

The Widmerpool Formation is a local facies of the Upper Visean developed in the area between the southern margin of the Derbyshire Limestone massif and Charnwood Forest. The age of the Formation ranges from B_2 - P_2 (goniatite zones). The rocks have been described as a "basin" or "gulf" facies (Lees & Taitt 1945, Falcon & Kent 1960, George 1963) deposited in a deep trough, trending E-W, situated to the south of the Derbyshire massif, extending from Grantham in the east and opening westwards into the North Staffordshire Gulf (Falcon & Kent 1960, Sylvester-Bradley & Ford 1968). It has been stated by these authors that this trough was present throughout Dinantian and Namurian times. The Widmerpool Formation is characterised by substantial thicknesses of shales siltstones, and thin sandstones and limestones, being proved in boreholes to be 645 m thick at Duffield (SK 343422) and at least 799 m thick at Widmerpool (SK 632280) (I.G.S. 1967, 1968, Edwards 1951). At the surface, exposure is poor but seven small outcrops of the formation have been studied between Turnditch and Mackworth (text-fig.1). This paper gives, for the first time, an account of these exposures.

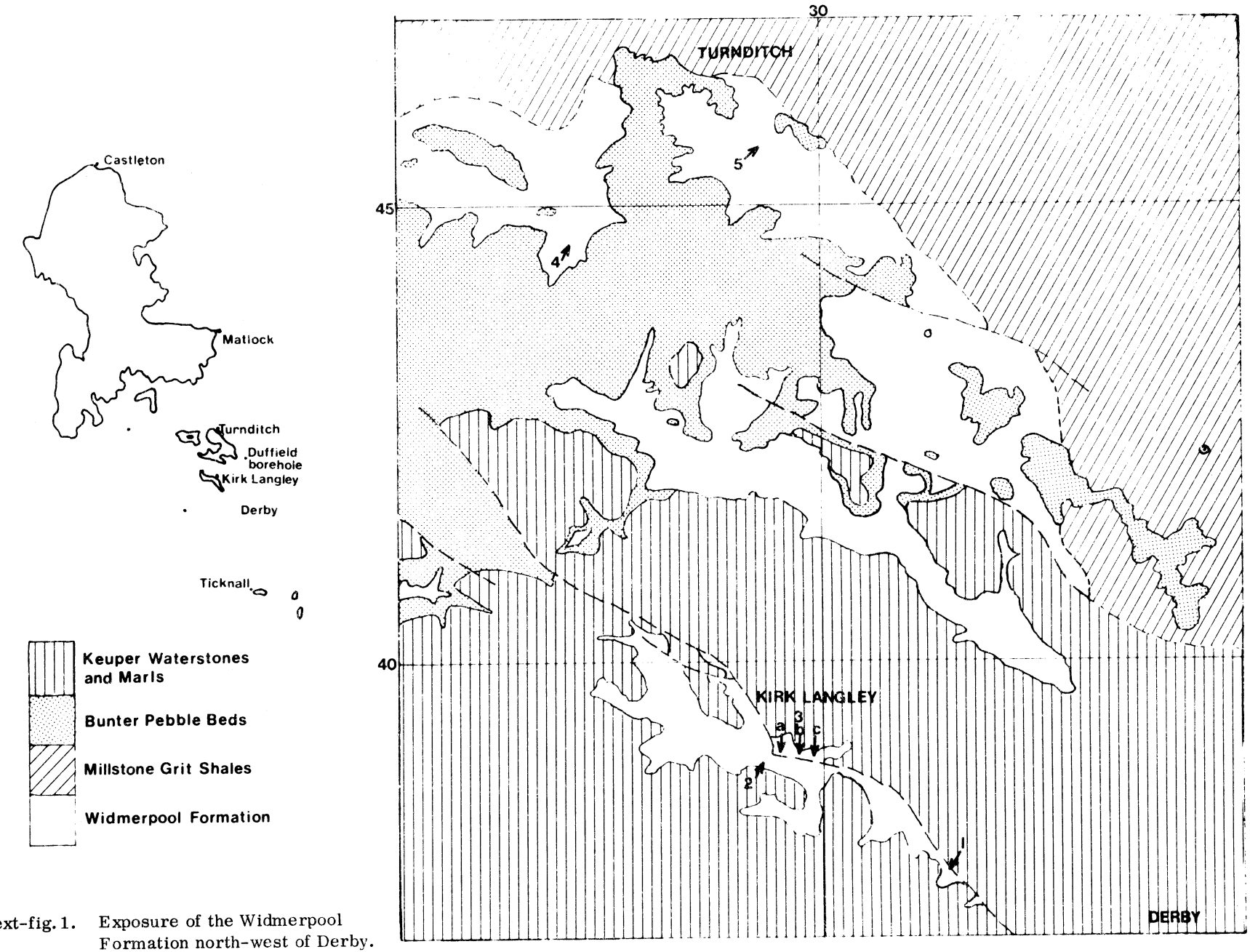
Description of Exposures

(i) Cold Lane, Mackworth (SK 31363770) Here the Widmerpool Formation is seen faulted against the Keuper Waterstones, as shown in text-fig.2. About 1.6 m of sandstones and siltstones with thin grey clays are exposed at the south-western end of Cold Lane (text-fig.3). The sequence starts with 0.15 m of finely laminated siltstones and mudstones bearing plant remains; the main constituent of the siltstones is angular and sub-hedral quartz showing strained extinction. Above these siltstones a very fine, fawn sandstone 0.095 m thick, exhibits a scoured base. In this sandstone the grains (50 - 100μm) are angular to sub-hedral and are mainly composed of strained quartz associated with small amounts of microcline and haematite. The grains are cemented by calcite with some haematite. The base of the sandstone shows prod marks, groove marks, and incipient flute marks. The orientation of these indicates that the underlying silt was scoured by a northward flowing current. The mean direction of palaeoflow towards 329°, (Table 1, p.108).

(ii) Kirk Langley, Old Quarry (SK 29163888) A[1] The sequence, 2.4 m thick, comprises fawn, pink, buff and grey sandstones interbedded with thin grey clays. The upper part is also exposed in the field on the west side of the quarry. Some 0.5 m below the top of the succession a buff and pinkish grey sandstone 0.61 m thick is developed. This fine to medium grained (100 - 300μm) sandstone is composed of strained quartz (70% - 80%), associated with grains of

[1] A. For details of the measured sections, see appendix p.114 et. seq.

Mercian Geol. vol.6, No.2, 1977, pp.103-117, 5 text-figs. Appendix.



Text-fig. 1. Exposure of the Widmerpool Formation north-west of Derby.

microcline, and fragments of quartzite and schist. Biogenic clasts, mainly crinoid columnals are also present. The sandstone has a calcite cement and is stained by haematite.

(iii) Flagshaw Brook, Kirk Langley A. Along the stream section three exposures of the Widmerpool Formation were noted.

(a) SK 29453900 Some 0.6 m of clays and sandstones are exposed in the bank of the stream. In the middle of the sequence there is a fine grained (100-200 μm) yellow-grey flaggy sandstone (0.14 m) thick with a scoured base, composed of angular, strained quartz (80% - 90%) and grains of labradorite, microcline and fragments of quartzite and volcanic rocks. The base of the sandstone shows prod and groove casts, which indicate a mean direction of palaeoflow (current) towards 342°.

(b) SK 29613896 A small exposure, (0.18 m) in the stream bed reveals 0.13 m of grey clay interbedded with a friable, fine-grained (100 - 150 μm) yellow-brown sandstone 0.05 m thick. This sandstone is composed of angular strained quartz (90%) with fragments of quartzite and volcanic rocks and grains of labradorite. Its scoured base shows prod and groove marks, which indicate a mean direction of palaeoflow towards 315°.

(c) SK 29813892 In the bank at this locality some 1.2 m of sandstones, siltstones and mudstones are exposed. Generally at least 50 - 60% of the sandstones are composed of angular quartz grains showing strained extinction. Fragments of quartzite are common; grains of microcline and labradorite and volcanic rock fragments are also present. Some of the units, between 0.02 and 0.065 m thick, fine upwards with fine to medium grained sands (150 - 300 μm) near the base and silts (20 - 50 μm) at the top. These sandstones are stained with haematite and have a calcite cement. The lowermost sandstone shows calcisiltite laminae (grain size 20-50 μm and quartz content 40%), alternating with fine grained quartz sand laminae (grain size 100 - 150 μm and quartz content 80%). This lowermost sandstone has a scoured base with prod, groove, bounce and brush marks which indicate a mean direction of palaeoflow towards 327°.

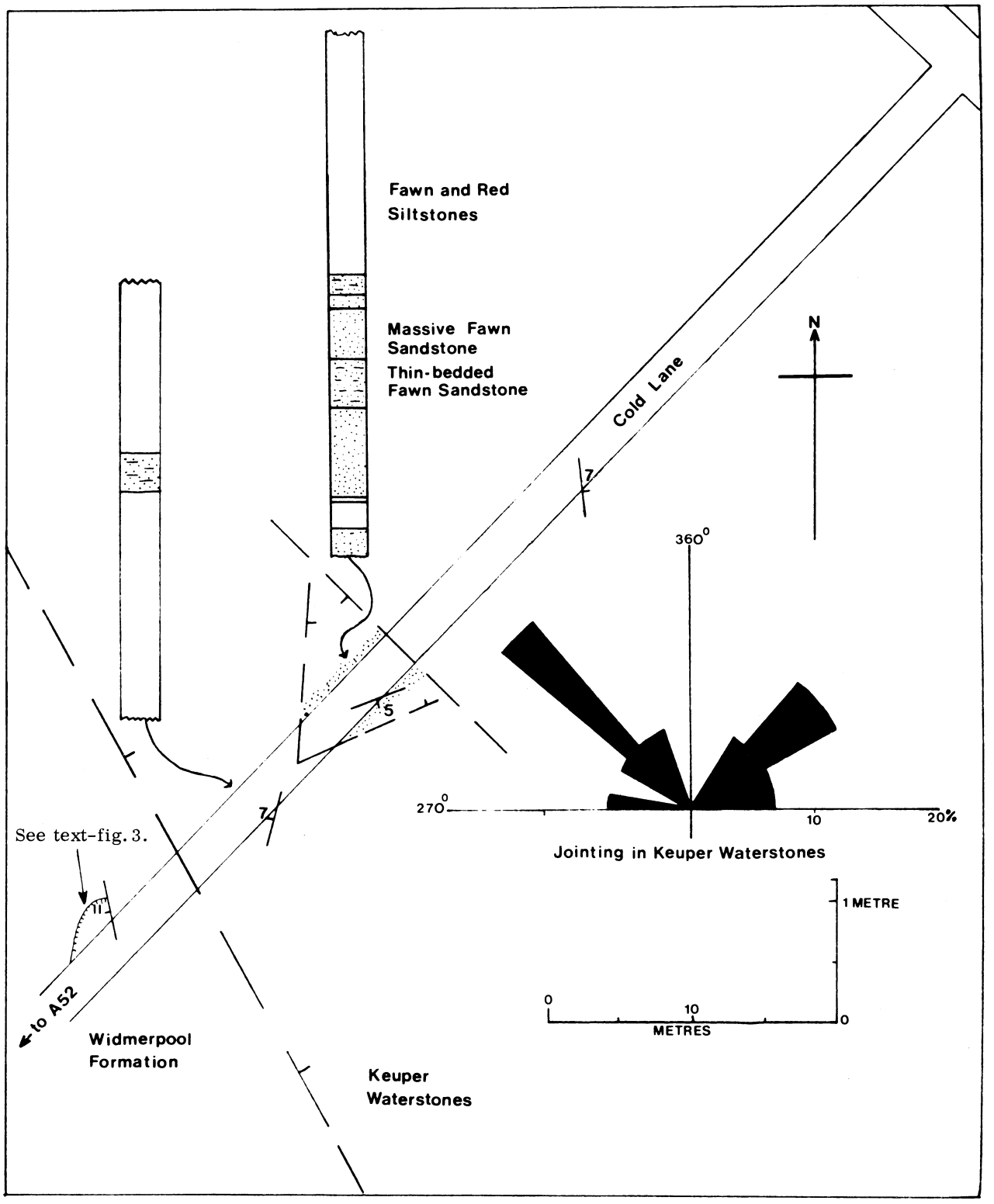
(iv) Black Brook, Hulland (SK 27304458) The stream exposure here shows about 1.9 m of black shales and mudstones. Some of the shales contain plant debris and calcareous concretions. Generally the mudstones contain thin layers (75 - 110 μm thick) of biogenic clasts, micrite and carbonaceous material. A small amount (up to 15%) of detrital quartz silt (10 - 25 μm) is present. These are angular and show strained extinction.

(v) Cow Lane Quarry, Turnditch (SK 29314551) A. This is the most extensive sequence of the Widmerpool Formation exposed in the area totalling some 6.5 m. Unfortunately the quarry is considerably overgrown and at least a further 7 m of the succession is now covered over. The best exposure is the north face of the quarry and shows an alternating sequence of thin limestones, calcareous shales and clays.

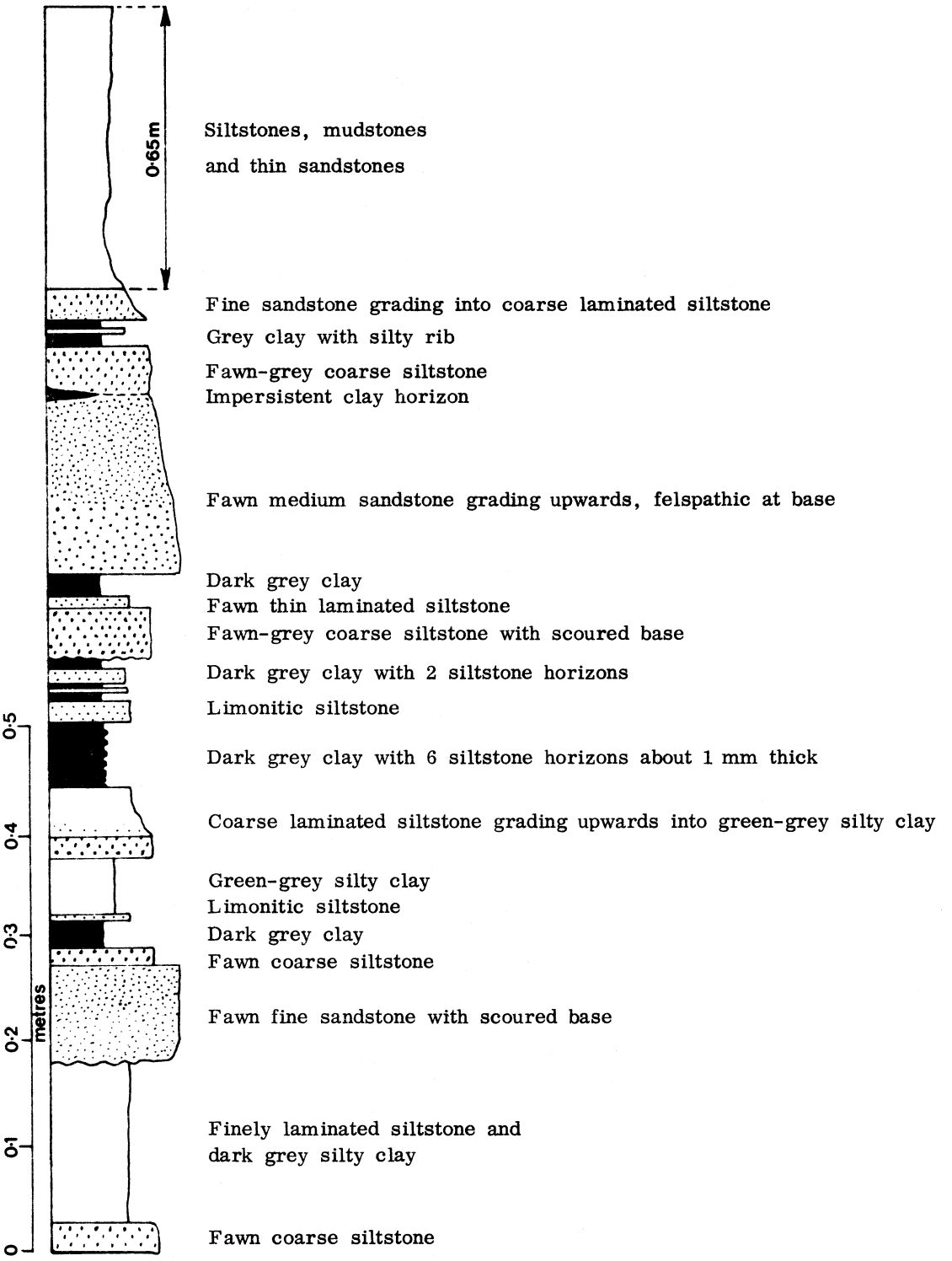
The sequence becomes more shaley towards the top. The limestones in the lower part of the succession are predominantly composed of crystalline calcite.

All the limestones have planar bases and tops and appear as distinct lithological units. Generally the limestones in the upper part of the succession contain a greater amount of detrital quartz. Some show a banding which gives the impression of grading (text-fig. 5b). Coarser layers containing large amounts of shell debris give way upwards to finer layers with detrital grains of quartz. Most of the limestones contain fragments of macro-fossils together with abundant microfossils. These include echinoderm plates and spines, shell fragments, platform conondonts, foraminifera and calcispheres. Detrital grains of quartz in these limestones rarely amount to more than 5% of the rock, they are angular, show strained extinction and are generally 50 - 150 μm in size, although some attain 300 μm.

On the east side of the quarry (SK 29484547) a small exposure some 0.72 m in thickness shows 0.5 m of mudstones underlain by over 0.22 m of a coarse sparite (300 - 500 μm). This limestone contains fragments of crinoids, brachiopods and echinoderm plates. Also present are angular grains of strained quartz, 50 - 100 μm is size together with quartzite fragments.



Text-fig. 2. Geological sketch map of Cold Lane, Mackworth, (SK 31363770)



Text-fig. 3. Detailed section of the Widmerpool Formation, Cold Lane, Mackworth

Sediment Transport

At all the localities the sandstones and detrital limestones contain grains of quartz showing strained extinction, microcline and labradorite and fragments of quartzite, schist and volcanic rocks. The grains and fragments would suggest that the sediments were derived from an igneous and metamorphic terrain exposed during Upper Visean times. The nearest area would nave been the Charnwood Forest region to the south-east. The orientation of current markings support this suggestion. The vector mean for all the current marks observed (Table 1) is 331° with a range from 309° to 354° (text-fig. 4).

Table 1

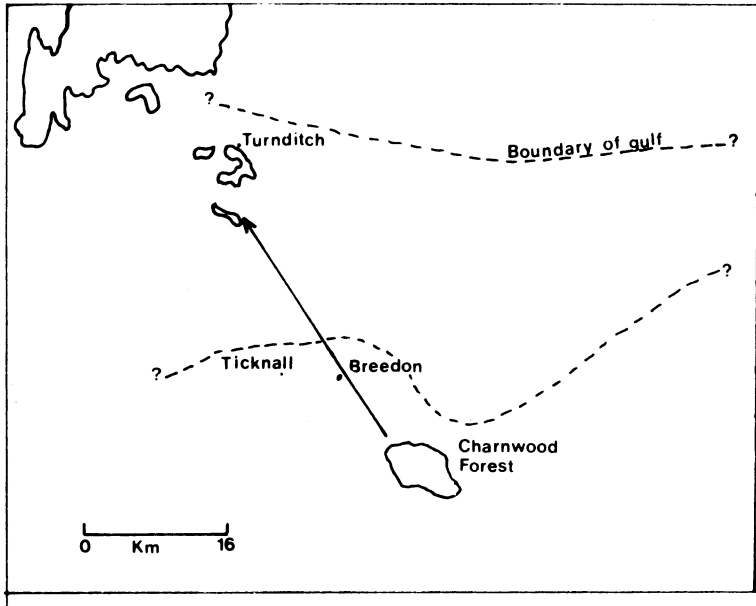
Locality	Grid. Ref.	Sediment transport directions (in degrees).
Mackworth	SK 31363770	332. 333. 325. 323. 328. 327. 338. 339. 340. 310. 328. 331. 338. 309. 338. 310. 328. 332. 329. 330.
Kirk Langley	SK 29453900	345. 354. 343. 338. 342. 351. 345. 340. 331. 325.
Kirk Langley	SK 29613896	320. 318. 311.
Kirk Langley	SK 29813892	338. 336. 322. 328. 330. 328. 318. 311. 329. 331.

Synthesis

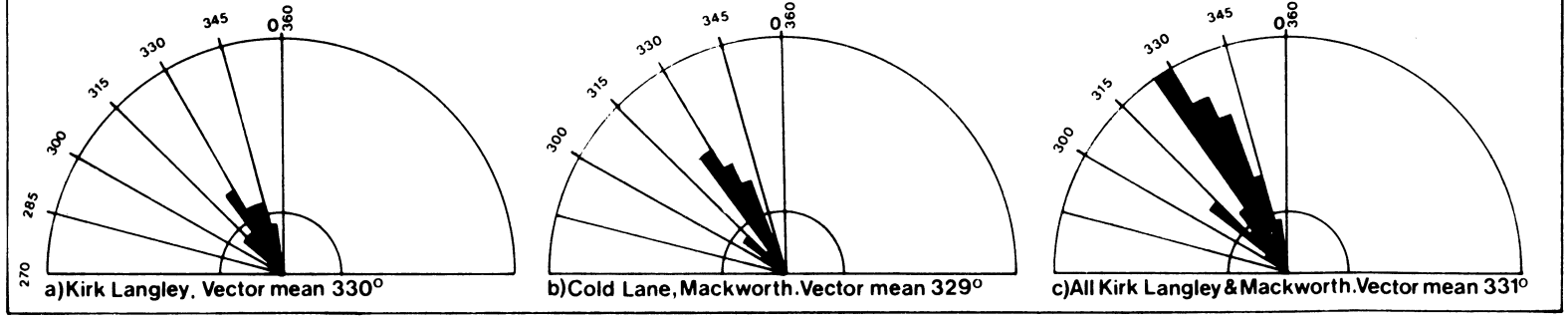
Although the Widmerpool Formation as recorded in the Duffield Borehole (I. G. S. 1967, 1968) ranges in age from the upper part of B_2 to the top of P_2, it is not possible to date the small surface exposures described or to correlate them with each other or with the borehole logs. However it seems reasonable to suggest that they may lie within the uppermost 120 m of the Duffield borehole sequence as no surface exposures of the Upper Dolerite Sill a prominent lithological unit found in the upper part of the Duffield bore-hole, have been observed. This would imply a P_2 age for all the surface exposures.

Other rock exposures of probable P_2 age are found on either side of the Widmerpool Formation outcrop, near Matlock (A) to the north and at Ticknall (A) to the south. Near Matlock the Cawdor limestones and shales are exposed at Cromford Station (SK 302574) and at the western end of Cawdor Quarry (SK 384606) (A).

At Cromford some 5 m of black calcareous shales are exposed and at Cawdor Quarry there is a sequence of cherty limestones and shales passing upwards into black calcareous shales totalling 16 m. Little or no detrital quartz was found in the limestones at Cawdor quarry but a fauna of crinoid columnals, brachiopod and bivalve shells, echinoderm plates and calcispheres was noted. At Ticknall (SK 362239) some 7 m of nodular grey limestones interbedded with shales are seen passing upwards into 4 m of buff sandy limestones. The latter consist of up to 50% angular quartz grains, (50 - 300μm) showing strained extinction. In addition to the grains of quartz, orthoclase and andesine, fragments of quartzite, schist and volcanic rocks are present. The beds of limestone comprise quartz rich and calcite rich layers. The composition of the detrital grains in these limestones is similar to that found in the Widmerpool Formation sequences, and may suggest a similar derivation, from the southern margin of the basin.

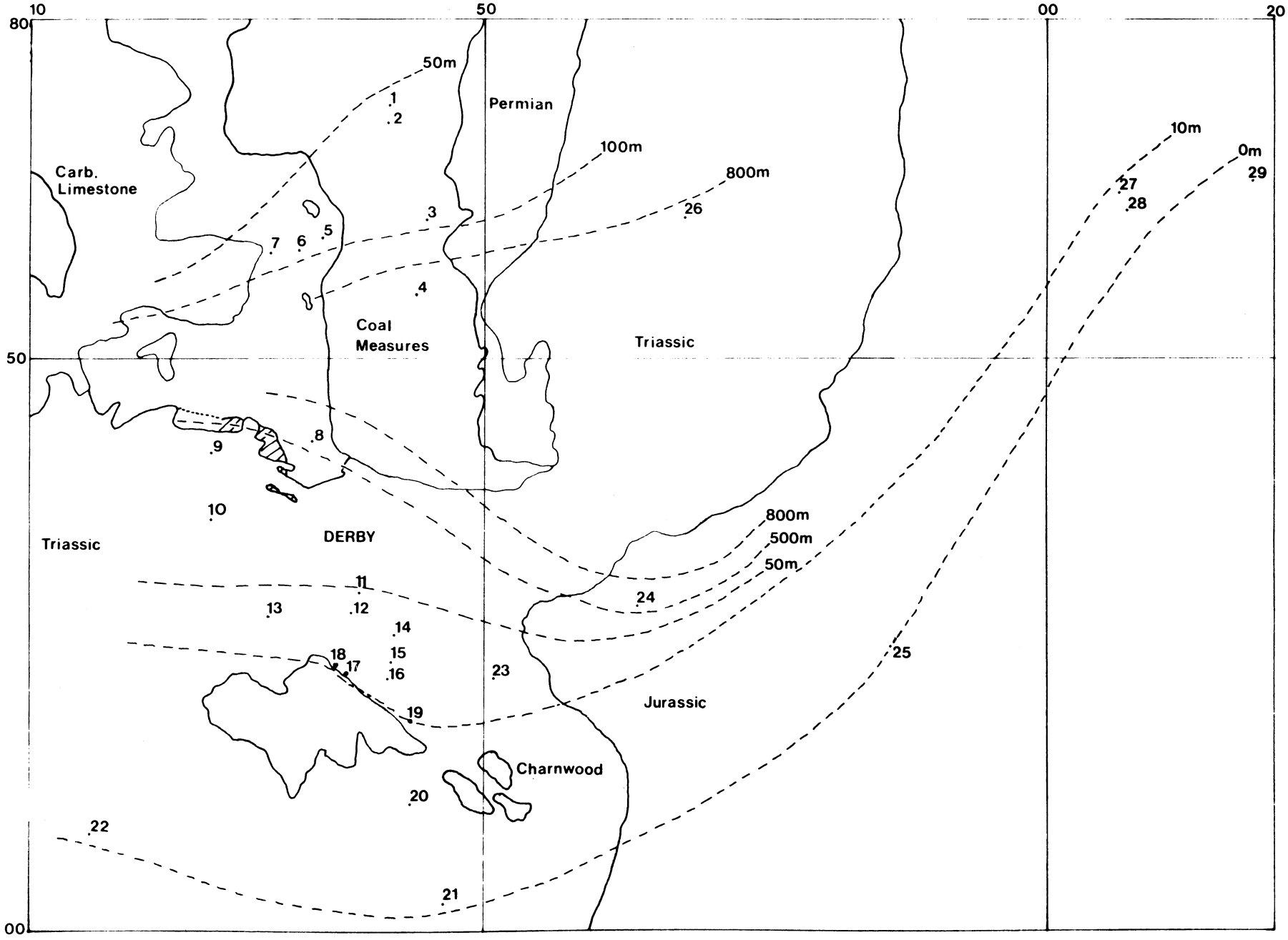


Class Interval	298 389		2961 3896		2945 3900		Kirk Langley All a		314 377 b		ALL c	
	No	%	No	%	No	%	No	%	No	%	No	%
350-54	–	–	–	–	2	20	2	8·7	–	–	2	4·7
345-49	–	–	–	–	2	20	2	8·7	–	–	2	4·7
340-44	–	–	–	–	3	30	3	13·0	1	5	4	9·3
335-39	2	20	–	–	1	10	3	13·0	4	20	7	16·3
330-34	3	30	–	–	1	10	3	13·0	5	25	8	18·6
325-29	3	30	–	–	1	10	4	17·4	6	30	10	23·2
320-24	1	10	1	33	–	–	2	8·7	1	5	8	7·0
315-19	1	10	1	33	–	–	2	8·7	–	–	2	4·7
310-14	1	10	1	33	–	–	2	8·7	2	10	4	9·3
305-09	–	–	–	–	–	–	–	–	1	5	1	2·3
TOTALS	10	100	3	99	10	100	23	99·9	20	100	43	100·1



Text-fig. 4. Palaeoflow directions for Kirk Langley and Mackworth

	Borehole	Thickness in metres of probable $P_1 - P_2$ age	Lithology
1.	Brimington	53	Limestone
2.	Calow No. 1	29	Limestone & mudstone
3.	Hardstoft No. 1.	37	Limestone
4.	Ironville No. 2.	11+	Limestone
5.	Highoredish	90	Shale on limestone
6.	Tansley	14+	Shale on limestone
7.	Johannesburg No. 9	18+	Shale on limestone
8.	Duffield	525	Mudstones, sandstones & thin limestones
9.	Brailsford	47+	Shale & thin limestones
10.	Trusley	54+	Shale & thin limestones
11.	Chellaston No. 6	34	Sandy limestone & shale
12.	Stanton	15+	Shale & thin limestones
13.	Repton Lawn Bridge	2+	Shale & thin limestones
14.	Castle Donington	10+	Shale & thin limestones
15.	Tonge	25	Shale & limestone
16.	Breedon Cloud	24	Dolomite
17.	Dimminsdale	12	Shale
18.	Calke	10	Shale
19.	Grace Dieu	10	Shale
20.	Ellistown Colliery	8	Dolomite, sandstone & shale
21.	Stockhouse Farm	8	Conglomerate & sandstone
22.	Whittington Heath	1	Limestone
23.	Hathern	30+	Shale & sandstones & thin limestones
24.	Widmerpool	799	Mudstones & thin limestones
25.	Sproxton	0	- - -
26.	Eakring No. 146	898	Limestone & shale
27.	Nocton No. 1.	0	- - -
28.	Dunston No. 1.	9+	Mudstones
29.	Stixwould	0	- - -



Text-fig. 5. Isopachytes for P_1 - P_2 zones within the East Midlands

Using borehole data compiled from Boulton (1934), Edwards (1951), Falcon & Kent (1960), Fox-Strangways (1905), I. G. S. (1967, 1968) Lees & Taitt (1945), Mitchell (1954), Mitchell & Stubblefield (1941), Parsons (1917) and Smith *et al* (1967) an attempt (text-fig. 5), has been made to draw isopachytes for the P_1 and P_2 zones and to consider the broad palaeogeography of the area. It appears that the Upper Visean shoreline in the south ran along the northern edge of Charnwood Forest, which George (1958) suggested was part of a more extensive land-mass running E - W across the Midlands and central Wales, referred to as the "Mercian Highlands". Adjacent to the land area there appears to be a narrow carbonate shelf border which passes northwards into the basin of the Widmerpool Gulf. To the north the Derbyshire Massif rises gently within the sea to form a broad carbonate platform. The borehole information points to uplift of the Mercian Highlands with detritus being carried northwards into a subsiding basin, which is bordered to the north by a more stable platform area.

It is expected that further studies of cores from the Duffield and Trusley boreholes together with examination of the surface exposures around Ashbourne and Kniveton will refine the palaeogeographic picture. Finally spores obtained from a number of localities will help in the dating and possible correlation of the surface exposures.

Acknowledgements

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Michael F. Stanley, A.M.A.,
Derby Museums & Art Gallery,
The Strand,
Derby, DE1 1BS.

John D. Weaver, B.Sc., Ph.D., F.G.S.,
Division of Geology,
Derby College of Art & Technology,
Kedleston Road,
Derby, DE3 1GB.

(ii) KIRK LANGLEY (old Quarry SK 29163888)

	m
Drift	-
Yellow-fawn-grey sandstone, medium grained, planar base	0.42
Yellow-fawn clay	0.06
Brown sandstone	0.015
Sandy red-brown clay	0.035
Yellow and pink-grey sandstone, beds 0.05m. thick	0.61
Silty grey and pink clay with thin fine-grey sandstone layers	0.06
Massive buff-grey sandstone	0.36
Pink-grey clay with siltstone layers	0.07
Pink-grey sandstone	0.025
Pale-grey clay	0.035
Yellow-grey sandstone	0.115
Pale-grey clay	0.02
Grey and pink-grey sandstones, poorly developed scours at base	0.035
Pale-grey clay	0.015
Fawn-grey sandstone	0.08
Grey clay	0.02
Yellow-grey sandstone	0.085
Grey clay	0.01
Grey and fawn-grey flaggy sandstones	0.30+
Total:	2.37

(iiia) KIRK LANGLEY Flagshaw Brook (SK 29453900)

Drift	-
Grey clay	0.16
Yellow and grey silty clay	0.05
Yellow-brown silts	0.01
Yellow-grey sandstone with scoured base, flaggy & plant fragments	0.14
Grey plastic clay with silty bands	0.19
Grey fine grained sandstone	0.03+
Total:	0.58

(iiic) KIRK LANGLEY FLAGSHAW BROOK (SK 298389

Finely laminated brown-grey siltstone	0.10
Alternating laminae of grey and fawn sandstone with mica?	0.025
Green-grey sandstone, irregular base	0.12 - 0.17
More rubbly fawn sandstone	0.05
Grey silty clay with darker grey bands	0.02
Fawn-grey silty clay with small iron nodules	0.02
Grey silty clay with darker grey bands	0.03
Grey sandstone with planar base	0.06 - 0.065
Brown-grey silty mudstone	0.02
Dark grey-brown sandstone	0.015 - 0.025
Dark-grey shaly silty mudstone, calcareous	0.17
Grey sandstone with planar base	0.02 - 0.025
Dark-grey silty mudstone	0.07

		m
Fawn laminated siltstone		0.04
Fawn-grey silty mudstone		0.03
Dark-grey sandstone with planar base		0.05 - 0.055
Dark-grey and light-grey laminated silty mudstone		0.13
Sandstone with scoured base, calcareous		0.03 - 0.035
Grey silty mudstone		0.10 +
	Total:	1.18

(v) COW LANE QUARRY TURNDITCH (SK 29314551)

Brownish-grey muddy shale - paper shale	0.05
Brown mudstone	0.02
Yellow-brown limestone, planar base	0.03
Brownish-grey muddy shale	0.165
Grey limestone, planar base	0.065
Brown-grey muddy shale	0.02
Siltstone band	0.002
Brown-grey muddy shale	0.04
Grey limestone, irregular base	0.01 - 0.025
Brown silty mudstone	0.015
Brownish-grey muddy shale	0.015
Brown mudstone	0.01
Brownish-grey laminated muddy shale	0.13
Grey-brown calcarous mudstone	0.025
Grey-brown, iron stained muddy shale	0.21
Grey limestone, planar base	0.08
Grey muddy calcareous shale	0.07
Grey limestone	0.01
Grey muddy shale	0.28
Grey mudstone	0.01
Brownish-grey limestone, planar base	0.165 - 0.18
Brownish-grey muddy calcareous shale	0.115
Greyish-fawn siltstone	0.01
Brownish-grey calcareous shale	0.42
Grey muddy limestone, planar base, laminated	0.04
Grey muddy shale	0.07
Beef calcite	0.01
Grey limestone, planar base	0.03
Calcareous mudstone	0.03
Grey muddy shale	0.11
Grey muddy limestone, planar base	0.07
Grey-brown muddy shale, laminated	0.205
Grey limestone, planar base	0.32
Grey brown limy muddy shale	0.125
Calcite band	0.004
Grey-brown calcareous shale	0.12
Grey-brown limestone (0.15 m thick) thickening locally	0.10 - 0.34
Grey-brown calcareous shale	0.22
Limonitic horizon	0.01
Grey-brown calcareous shale	0.04
Hard grey calcareous shale	0.13
Grey and grey-brown limestones, planar top and base	0.05

	m
Dark-grey muddy shale	0.20
Dark-grey muddy limestone, planar top and base	0.08
Dark-grey platy limestone	0.03
Dark-grey muddy shales	0.13
Hard dark-grey limestone	0.03
Dark-grey soft muddy shales	0.11
Grey limestone with planar base grading upwards into shales	0.205
Thin platy limestones with shale partings (5 mm thick)	0.04
Dark-grey calcareous shale-soft	0.14
Dark-grey harder calcareous shale	0.36
Iron-rich horizon	0.01
Dark-grey clay	0.10
Grey limestone	0.025
Grey clay	0.12
Grey limestone, planar base	0.135
Grey muddy shale	0.05
Hard grey calcareous shale	0.035
Grey shale	0.26
Light grey limestone, planar base	0.035
Grey shale	0.08
Light-grey limestone	0.21
Grey shale	0.03 +
Total:	6.426

Cawdor Quarry (W. end) (SK 284606)

Black calcareous shales, some paper shales, brachiopods and bi-valves	4.0
Massive black limestones	1.0
Black limestone	0.2
Black calcareous shales	2.5
Black limestone	0.4
Black shales	0.25
Dark-grey-black limestone	1.0
Black shales	0.25
Dark grey and black limestones, cherty with thin shaly partings	6.0 +
Total:	15.60

TICKNALL SUCCESSION (Combined localities SK 362239)

Thin bedded yellow-brown sandy limestone	1.75
Silty grey and pink-grey clay	0.04
Buff sandy limestone with grey clay partings	0.06
Silty grey and pink-grey clay	0.05
More massive buff sandy limestone	2.10
Light-grey limestone	0.18
Shell band	0.075
Grey and pink-grey limestones	0.46
Shell band-giganto productids	0.10 - 0.18
Fawn-grey and grey limestones	0.53

Buff and pink shale	0.04
Medium grey limestone	0.70
Dark-grey muddy shale	0.15
Dirty grey limestone	0.15 - 0.20
Grey-brown shale	0.10
Medium grey knobbly limestone	0.055
Grey-brown shale	0.04
Medium grey limestone	0.27
Thin dark-grey clay and shaly limestone	0.03
Medium-grey limestone	0.10
Dark-grey shaly limestone and grey clay	0.09
Medium-grey limestone crystalline	0.15 - 0.17
Grey clay with thin dark-grey shaly limestone	0.20
Massive lighter-grey limestone, more regular base	0.64
Grey shale	0.03 - 0.06
Nodular grey limestone	0.07 - 0.14
Grey brown shale	0.04 - 0.08
Nodular light-grey limestone	0.21
Dark-grey-brown shale	0.08 - 0.10
Medium grey, more well bedded limestone impersistent shaly parting in middle	0.47
Grey brown shale	0.11
Nodular, light-grey limestone with thin shaly parting in middle	0.16
Dark grey and grey-brown shale with thin impersistent limestone in middle	0.14
Thin rubbly limestone and grey-brown shale horizons - units 0.10 - 0.15 m in thickness	1.25 m+
Total	10.93