Lithological Groups within the Wenlock Limestone (Silurian) at Wren's Nest, Dudley

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Summary

Over 300 rock samples have been collected from the Wenlock Limestone of Wren's Nest and have been studied in thin section and hand specimen. The information accumulated shows that the majority of specimens can be termed biomicrites, but biomicrudites, skeletal micrites and biosparrudites are also common. The skeletal components of these limestones are mainly crinoids, brachiopods, algae, bryozoans and corals (Oliver 1971).

Using this and further lithological data it has been possible to define six groups of limestones (classes A to F). All were deposited in a shallow marine environment with considerable organic activity.

Folk's (1959) classification of limestone has been used, with a few modifications. It is easily applicable to the present study, is well tried and also takes into account recrystallisation. Some terms are derived from the work of Bathurst (1966). A glossary is included at the end of the paper.

Introduction

For many years now, the rocks of Wren's Nest have been of great significance to the geologist, but whilst the palaeontologist has paid them much attention, the petrologist has not. This paper attempts to redress the balance. In addition further evidence for palaeoenvironmental interpretations is provided, although these are mentioned only briefly in this particular paper.

It is hoped that the information will be of use to students of all ages who visit the locality. In particular it may encourage investigations where observations can be undertaken on rocks in situ and where collecting of samples can be confined to scree.

The limestones of Dudley were first described by Murchison (1839) and then by Jukes in 1859. Jukes gives the succession at Wren's Nest as:-

Upper Limestone	28'4"
Intermediate Shale	90'0"
Lower Limestone	42'3"

and mentions other occurrences of the Wenlock Limestone. The Wenlock limestone of the Dudley-Walsall area is characteristically in three divisions. Although there may be a certain amount of inaccuracy in these early records, it can be seen that the two limestone bands thicken, in general, to the S.W. while the Nodular Beds (Intermediate Shale) thicken to the east. Jukes describes the Wenlock and Dudley Limestone as

"... two bands of solid concretionary and flaggy limestone, with many calcareous nodules, concretions and small flaggy beds, both between, above and below them".

The Dudley Limestone was compared with the Wenlock Limestone by Crosfield and Johnston (1914). They note a distinct difference between the crog-balls of Dudley and the ballstones of Wenlock Edge when they conclude.

"... that ballstone as known in Shropshire is not present in the Dudley Limestone."

The crog-balls of the Nodular Beds were observed to be smaller than the ballstones of Wenlock Edge but similar in constitution and origin (Butler and Oakley, 1936). They describe the upper part of the Nodular Bends as thin, laterally impersistent bands of grey shales, with one or two thick beds of crinoidal limestone. The Lower Limestone is described as consisting of soft grey medium grained limestones, each bed up to 5" thick, with thin shale partings. Again the composition of the Lower Limestone crog-balls is described as being different to those of the Nodular beds, with few corals but abundant crinoid and polyzoan fragments. Mention is made of the dominant fossil types, the Upper Limestone and the occurrence of stromatoporoid beds. A general description is also given of the limestones at Daw End, Walsall. The blue-green matrix of many of the crog-balls is noted and a suggestion made as to the important role of algae in their formation.

The only detailed work that has been published on the Wenlock Limestone of Dudley is that of Butler (1939). This presents a stratigraphical framework and suggests the conditions of deposition. A type section is described in detail and a large part of the present study is concerned with this section. Many of the petrographical terms used by Butler are now outdated, but his descriptions of general bed forms are good. He divides the sequence into a number of units as shown below.

<table>
<tr><td>Lower Ludlow Shale</td><td colspan="2"></td></tr>
<tr><td rowspan="5">Wenlock Limestone</td><td rowspan="2">Upper Wenlock Limestone</td><td>Passage Beds</td></tr>
<tr><td>Upper Quarried Limestone</td></tr>
<tr><td colspan="2">Nodular Beds</td></tr>
<tr><td rowspan="2">Lower Wenlock Limestone</td><td>Lower Quarried Limestone</td></tr>
<tr><td>Basement Beds</td></tr>
<tr><td>Wenlock Shale</td><td colspan="2"></td></tr>
</table>

He shows that there are no appreciable changes in the thickness of the beds of the Wenlock Limestone in the Dudley area. He is also careful to point out the differences in faunal content of the crog-balls of the Nodular Beds and those of the Lower Limestone. He mentions that at the time of deposition the water was shallow. There were variations in the amount of terrigenous material being supplied and that the bioherms needed a small but solid base for initial growth. He also suggests that segregation of calcium carbonate took place, in the Nodular Beds, soon after deposition.

A short mention is made of the Wenlock Limestone of Dudley and Sedgley by Whitehead (1947) who describes it as two bands separated by rubbly and nodular limestones and calcareous flags.

Lithologies

In the present study samples were taken from ten different points (Fig. 1) mainly from the western outcrop of the Limestone. Approximately 300 hand specimens and 200 thin sections were examined.

From this visual analysis six basic types of lithology were recognised. They are here described in much the same manner as that used by Weiss and Norman (1960). Supporting evidence is provided from thin section analysis.

The divisions of a massive Lower Limestone, a series of alternating shales and limestones of the Nodular Beds, and a massive Upper Limestone, are very obvious.

The following units can be recognised within the divisions:-

(1) Lower Limestone

a) Bioherms of large size, up to 10' thick (Fig.2).

b) Biostromes approximately 1' thick.

c) Bedded limestone, 3" - 6" thick, but occasionally up to 1' thick, with intervening thin shales, 1" thick (Fig.3). Individual beds tend to vary slightly, in thickness, when traced laterally.

(2) Nodular Beds

a) Bioherms of variable size, but not as large as those of the lower Limestone.

b) Alternating thick limestone and shales (Fig.4).
The limestones vary in thickness between $\frac{1}{2}$" and 4".
The shales tend not to be as thick as the limestones.

c) Impersistent limestone nodules up to 6" thick and between 2" and 1' long, surrounded by shales up to 4" thick.

d) Occasional limestone bands up to 2'6" thick, and laterally persistent.

(3) Upper Limestone

a) Bedded limestones, 2" - 5" thick with intervening shales up to 2" thick.

b) Thicker limestones, up to 1' thick with thin shale partings (Fig.5).

c) Bioherms up to 3' thick (after Butler, 1939).

The above units indicate the basic rock types that can be seen in the field. Within these there are considerable numbers and varieties of limestones, but the following broad classes A to F can be recognised. It must be remembered that sorting and rounding features, are more likely to be the result of faunal characteristics and biological activity than of hydrological conditions.

Class A

Hand specimen (Fig.6)

The rocks are coloured light grey and light greyish-brown. In general, fossil fragments are less than 1 mm. in longest dimension and are not identifiable. Some specimens, however, contain whole brachiopods. Sorting is variable but in general is moderate to good. Micrite is the dominant fraction of all the specimens. There is only a slight development of lamination, in a few specimens. Bioturbation is present to various degrees. Some of the rocks show transitions to Classes B and C. The majority are classed as skeletal micrites (see Fig.2).

Fossil (identifiable) content is less than 10% (from a two dimensional analysis of a polished surface). Insoluble residue; 10-20% (powdered sample dissolved in 20% HCl solution).

Thin section

Fossil fragments are usually less than 100 microns and show a gradual transition of size, to micrite. The micritic fraction of the specimens is dominant. Algal lumps, circular or oval in shape, of approximately 60 microns, are locally abundant. There are occasional larger fossils, sometimes unbroken, of about 2 mm. Shell chambers and cavities are druse filled and grain growth is developed in the micritic areas.

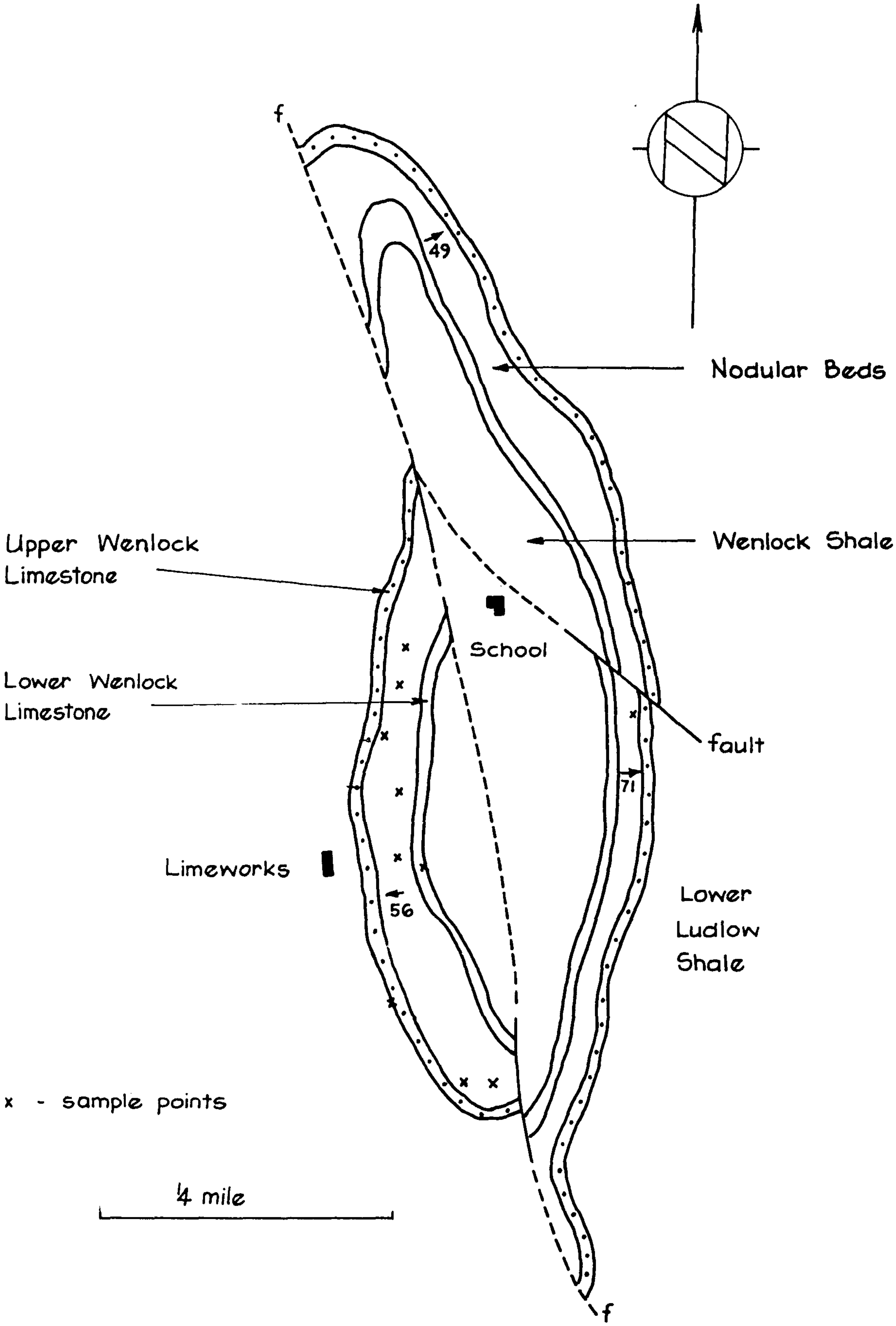
Class B.

Hand Specimen (Fig. 7)

The rocks are coloured light brown and light and medium grey. They are, in general, fine grained with fragments less than 1 mm. Sorting is moderate to good and most rocks are composed of either silt or sand sized grains. Laminations, cross bedding and graded bedding are all developed. Most fragments appear to be of organic origin but accurate identification is difficult. The micrite fraction is likely to be composed of fine skeletal material. Unbroken fossils are very rare. Bioturbation is locally developed.

Some rocks show transitions to Classes A and E. Rocky types are best termed micrites and biomicrites (calcilutites and calcarentites), (Fig. 3).

Fossil content is difficult to determine because of the small grain size. Insoluble residue; 15-40%.

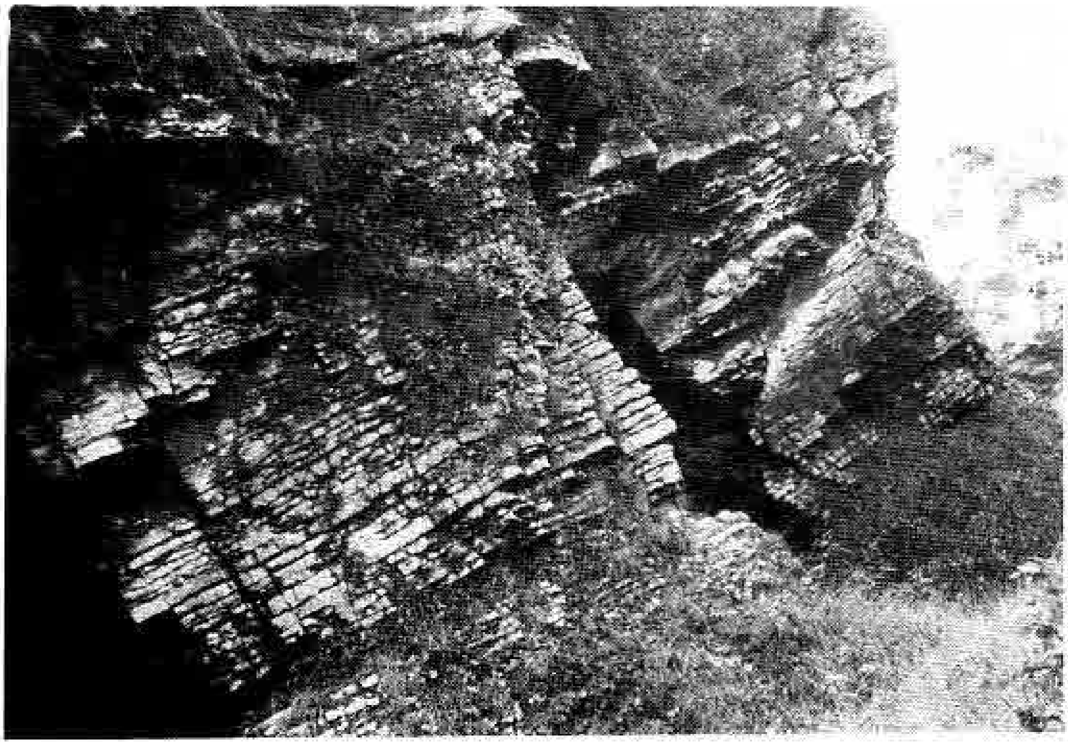


Geological map of Wren's Nest showing Sampling points.

Fig. 1.

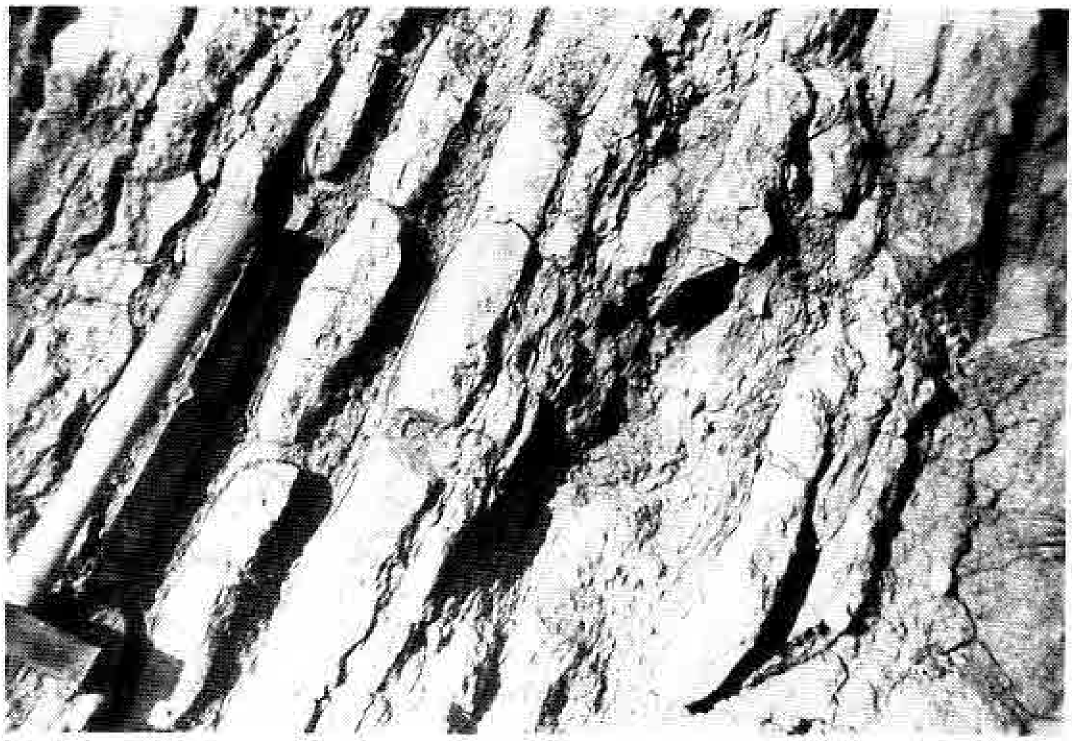
Lower Limestone bioherm

Fig. 2.



Lower Limestone showing limestone/shale sequence.

Fig. 3.



Alternating limestones and shales in
the Nodular Beds.

Fig. 4.

An exposure of the Upper Limestone

Fig. 5.

Thin section

Many specimens are cleanly washed biosparites, packed with fossil fragments which have undergone various degrees of rounding. Most specimens are well sorted, with the average grain size being approximately 400 microns. There are some larger fragments up to 1 cm. which commonly protect druse filled cavities below.

Some layers contain very little micrite and have calcite filled pores. There are some layers and specimens, however, that have a micrite matrix and contain algal lumps.

In general crinoid and brachipod fragments are abundant with lesser amounts of bryozoan and algal grains.

There are many examples of laminated micrites. These contain fossil fragments too small to identify and also variable amounts of argillaceous material. Some micrites contain abundant fine skeletal material, 50-100 microns in size.

Bioturbation is locally predominant with burrows tend to be well defined; the 'fill' being more opaque than the surrounding material. Burrows are between 600 microns and 5 mm. across.

There are a few mollusc shells (replaced by calcite) and also iron replacements of a few skeletal fragments. Grain growth is developed, especially near adjacent shale layers.

Class C.

Hand Specimen (Fig.8)

The rocks are coloured light brown and grey. Fossils are broken and the majority of fragments are less than 1 mm. This means that the fossils, generally, are unrecognisable. Sorting is between poor and moderate. A matrix of micrite is well developed. There are a few small masses of colonial organisms but an absence of lamination or alignment of fragments. Bioturbation is present and is locally very well developed.

Some of the specimens are transitional to Class A and most can be termed biomicrites.

Fossil content is greater than 10%. Insoluble residue; 10-40%.

Thin section

Most fragments are around 200 microns in their longest dimension, but coarse grains up to 2 or 3 mm. and fine grains down to 20 microns, also occur. Fragments range in size from large ones of 2 or 3 mm. down to the micrite. There are a few quartz grains. There is some alignment of fragments and poorly developed lamination, sorting shows a complete range of poor to good.

Grain growth is developed. Pore cement and druse filled cavities occur, but boundaries are not well defined and there is a merging with surrounding micrite and/or grain growth. Micritic envelopes are locally developed.

In general there appear to be two groups; a) rocks containing coarse fragments of approximately 200 microns in a micrite matrix; and, b) rocks with similar coarse fragments but grading down to the micrite, via all intermediate sizes.

Class D.

Hand specimen (Fig. 9)

Light and dark grey and light brown in colour. Fragmentation of fossils is developed but there are whole fossils and also fragments greater than 1 mm. Sorting is between very poor and moderate. Specimens show areas or pockets of fossil fragments. There are, large fossils up to 2 cm. and occasional bryozoans and encrusting algae. Micrite forms the predominant part of these rocks. Bioturbation is present and locally well developed.

Specimens show an alignment of fragments (especially brachiopods) and a development of lamination with layers between 1 mm. and 3 cm. in thickness. This indicates transitional types to Class E. Most specimens are coarse biomicrites, and biomicrudites.

Fossil content is great than 10%. Insoluble residue 10-45%.

Thin section

There is a wide range of fossil types including trilobites, brachiopods, crinoids and bryozoans, which occur whole and as broken fragments. Specimens are composed of large fragments of 1-2 mm. with only small amounts of finer fragments, all set in a fine micrite. There are variations on texture and percentages of fossils, but in general micrite is abundant and sorting is poor. There are examples of encrusting algae and a few brachiopods with outgrowths intact. Bioturbation has affected the original fabric.

Grain growth is developed in the micrite and locally dominant. There are a few developments of pore cement and stylolites.

A few specimens show alignment of fragments parallel to bedding.

Class E.

Hand Specimen (Fig. 10)

Rocks within this group are grey in colour. Fossil fragments are predominantly greater than 1 mm. and are mainly of brachiopod and crinoid origin. There are only a few intact shells which are up to 2 cm. across. Many of the specimens are laminated and the sorting within individual layers is moderate to good. Graded bedding is locally present with a micrite matrix throughout. Bioturbation is not well developed.

Some of the specimens are transitional to Class D. Most of the rocks within this group are biomicrudites.

Fossil content is greater than 30%. Insoluble residue; 10-30%.

Thin section

The smallest fragments are of the order of 100 microns and the larger ones 2-3 mm. There are a few brachiopod shells over 1 cm. The fragments are mainly of crinoid origin, but there are also frequent brachiopod, trilobite and bryozoan remains. A few specimens contain algal lumps. Sorting is between poor and moderate but the rocks are, in general, cleanly washed with calcite filled pore spaces. Micrite is locally absent in some cases due to fragment protection of pores. Lineation is locally developed.

Grain growth is well developed in the micritic areas.

It appears that there are two groups; a) those specimens formed under lower energy conditions, containing crinoids, brachiopods, bryozoans, trilobites, ostracods, echinoid spines and stromatoporoid masses, and, b) those showing better sorting, a less complex fossil assemblage and a lower amount of micrite; indicating higher energy conditions.

Class F.

Hand Specimen (Fig. 11)

The rocks are light greenish-brown and light and medium grey in colour. They are characterised by in-place organic growths, which form up to 90% of the rock; the lower limit being 40%. Stromatoporoids, corals, bryozoans and algae are all common. Fossil fragments are common ranging in size from 0.2 mm. (just visible to the naked eye) up to 2 cm.

There is a random distribution of both fragments and to a lesser extent, in-place organic growths. Sorting of fragments, in general, is poor but there are 'pockets' of well sorted fragments. This may possibly be due to sorting by algal mats or selective bioturbation.

The micritic fraction of the rock is important and is in places disturbed by bioturbation.

All rocks can be termed biolithites.

Insoluble residue; 10-25%.

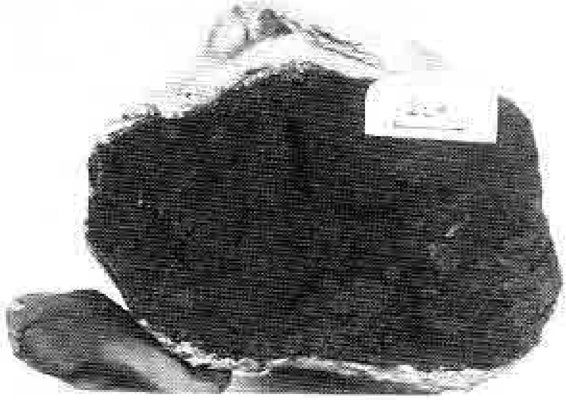
There is a minor group of rocks which marks transitions between Class F, and Classes C. & D. where in-place organic growths total 10-40% of the rock. These are called partial biolothites.

Thin section

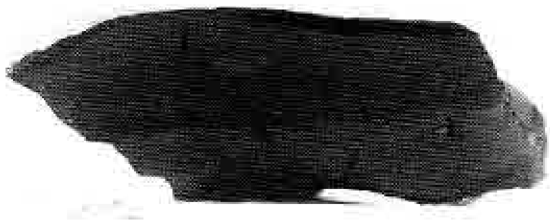
Reef building organisms are abundant, such as; stromatoporoids, bryozoans, algae and corals. Algal masses are sometimes up to 4 mm. across and there are also numerous encrusting developments. The corals Syringopora, Halysites, Heliolites, Favosites and Thecia are quite common. The rock surrounding the in-place organic growths has a dominant micrite fraction, but with fossil fragments between 40 and 400 microns. There are a few large brachiopods, with valves and outgrowths intact, up to 1 cm. across.

There are examples of druse filled cavities, shale injection and solution surfaces. Grain growth is well developed in the micrite and crystals up to 100 microns occur.

The specimens that are transitional to Classes C and D contain colonial organisms, similar to those already mentioned set in a matrix similar to either Class C or Class D. A number of the fossil fragments within the rock are derived from the larger organic masses.

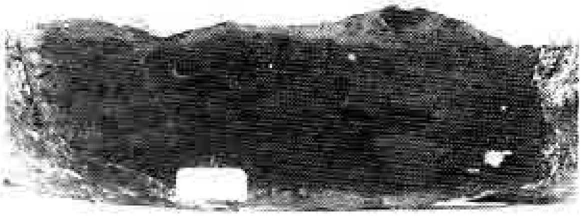


Class A hand specimen
Fig. 6.

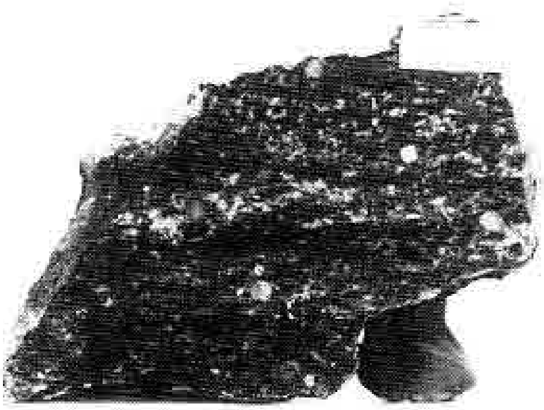


Class B hand specimen
Fig. 7.

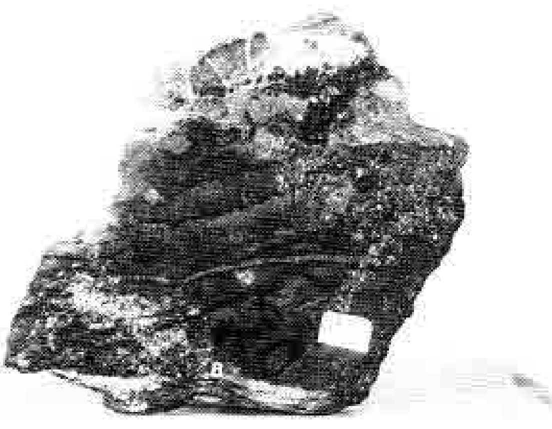
Class C hand specimen
Fig. 8.



Class D hand specimen
Fig. 9.



Class E hand specimen
Fig. 10.



Class F hand specimen
Fig. 11.

Conclusion

The limestones of Wren's Nest can be divided into six lithological groups. The principal distinguishing features (Fig.12) are here listed, together with simple palaeoenvironmental interpretations and places of occurrence. Most specimens are more accurately described by using the preceding term; argillaceous.

Class A:- Micrites, with only a minor percentage of the rock composed of fragments greater than 0-1mm. Occasional large, whole or slightly broken fossils.

Rocks in general from the Lower Limestone and the Nodular Beds.

Evidence suggests quiet conditions of deposition. Fine debris due to the upheaval and digestion of sediment by benthonic organisms, and/or transport from adjacent areas.

Class B:- Laminated micrites, biosparites and biomicrites, showing cross - bedding and graded bedding. In many cases well sorted and cleanly washed. Fragments are semi-rounded grains or organic origin.

Rocks are mainly from the Nodular Beds (platey type).

A relatively high energy environment in shallow water with possible current and wave sorting and transport. Sediment disturbed by organic activity.

Class C:- Biomicrites, in general without lineation or lamination, but variable grain size. Variable texture.

The majority of rocks are from the Nodular Beds but a few are from the Lower Limestone.

Quiet conditions of deposition but with energy high enough to disarticulate and break shells. Organic activity fairly high.

Class D:- Similar to Class C. but with larger fragments. Biomicrudites with wide range of fossils, including encrusting algae.

Rocks from the Lower Limestone and the Nodular beds.

Very quiet conditions of deposition with abundant organic life.

Class E:- Laminated biomicrudites and biosparrudites.

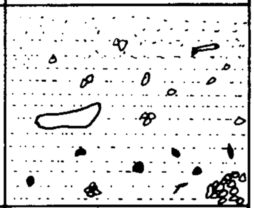
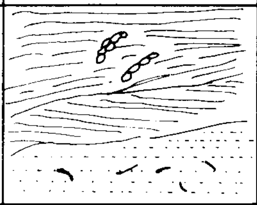
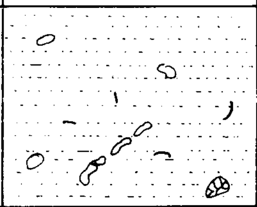
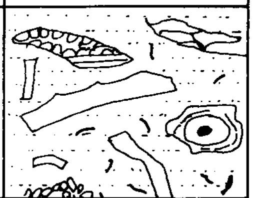
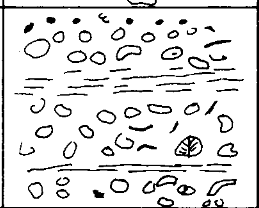
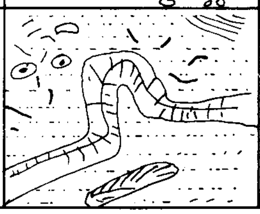
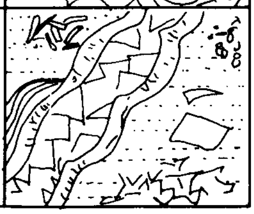
Rocks mainly from the upper Nodular Beds and the Upper Limestone.

A relatively high energy environment but with fluctations to quieter conditions. Current and wave action with transport to and from adjacent areas. Abundant organic life in the area or nearby.

Class F:- Biolithites. Variable texture of material surrounding the colonial organisms.

The majority of rocks are from bioherms within the Lower Limestone and Nodular Beds.

Variable conditions of deposition. Mostly quiet water, but others relatively high energy with currents and turbulence. Abundant organic activity, in form of small reef builders and life in and on surrounding sediment.

CLASS	MACRO-FEATURES		MICRO-FEATURES	
	Basic rock type	Lithology x ½ approx.	Character-istics	Lithology x 10 approx.
A	Micrites Skeletal micrites		Fragments < 100 microns Micrite dominant	
B	Micrites Skeletal micrites Biomicrudites		Laminated Micrite matrix and pore cement	
C	Biomicrudites		Most fragments about 200 microns	
D	Biomicrudites		Large varied fragments	
E	Biomicrudites		Laminated Cleanly washed	
F	Biolithites		Colonial organisms dominant	

The Principal Distinguishing Features
of the Lithological Classes A - F.

Fig. 12.

GLOSSARY

Allochems	Fragments of highly organised chemical and biochemical precipitates that have usually undergone some transport.
Argillaceous	Applied to those rocks containing a notable proportion of clay.
Authigenic	Applied to those constituents which originate in or with the rock.
Bioherm	Domelike, moundlike, lenslike or otherwise circumscribed mass; built exclusively or mainly by sedentary organisms and enclosed in a normal rock of different lithologic character.
Biostrome	Stratiform deposits, such as shell beds, crinoid beds and coral beds, consisting of and built mainly by organisms, and not welling into moundlike or lenslike forms.
Bioturbation	The movement and reworking of sediment by organisms, on or just below the depositional surface.
Calcarenite	Mechanically deposited carbonate rock consisting of sand sized fragments.
Calcilutite	A carbonate rock consisting of silt and clay sized fragments.
Dismicrite	A microcrystalline rock that has been disturbed either by burrowing organisms or soft sediment deformation and with resulting calcite filled "eyes".
Grain growth	The growth of grains at the expense of their neighbours by ionic replacement without solution.
Intraclast	Penecontemporaneous sediment fragment.
Limestone	A sedimentary rock composed of more than 50% calcite.
Micrite	Microcrystalline calcite having a crystal size less than 20 microns, and of chemical, biochemical or mechanical origin.
Recrystallization	The process of conversion of a mineral species to a different morphology.
Reef	A structure erected by framework building or sediment binding organisms and usually forming a topographical feature at the time of deposition.
Skeletal	Refers to debris derived from the remains of organic hard parts.

Sparite	Sparry calcite cement.
Stylolite	A zig-zag solution surface within a rock frequently associated with, and showing a transition to clay layers.

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REFERENCES

BATHURST, (1966) Boring algae, micritic envelopes and lithification of molluscan biosparites. L'pool- Manchr. geol. J., vol.5. pp 15-32.

BUTLER A.J. and OAKLEY K.P. (1936) Report of"coral reef" meeting: The Dudley district. Proc.Geol.Ass., Lond., vol. 25 pp.133-136.

BUTLER A.J. (1939) The stratigraphy of the Wenlock Limestone of Dudley. Q. Jl. geol. Soc. Lond., vol.95. pp.37-74.

CROSSFIELD, M.C., and JOHNSTON M.S. (1914) A study of Ballstone ands the associated beds in the Wenlock Limestone of Shropshire. Proc. geol. Ass. Lond., vol.25. pp 193-224.

FOLK R.L. (1959) Practical petrographic classification of limestones. Bull. Amer. Ass. Petrol. Geol., vol. 43. pp.1-38.

MURCHISON R.I. (1839) The Silurian System. John Murray, London.

OLIVER P.G. (1971) The Petrology of the Wenlock Limestone of Wren's Nest. Ph. D. Thesis. University of Birmingham. (unpublished).

WEISS M.P. and NORMAN C.E. (1960) The American Upper Ordovician Standard - IV Classification of the limestones of the type Cincinnatian. J. Sediment. Petrol., vol. 30. pp. 282-296.

WHITEHEAD T.H. and POCOCK R.W. (1947) Dudley and Bridgnorth, Mem. Geol. Surv. Eng, & Wales.