THE GEOLOGY OF WESTINGTON HILL QUARRY GLOUCESTERSHIRE

by

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Summary

The quarry described, shows the finest remaining exposure of the Oolite Marl (Middle Jurassic) in the Cotswolds. It is equally important palaeontologically as the only recorded source of early juvenile zeilleriid brachiopods, the discovery of which, has enabled the fact to be finally demonstrated, that during early development, the anterior elements of the zeilleriid loop, arise from an outgrowth from the floor of the brachial valve. The carbonate succession in the quarry is interesting in that it shows a rhythmic alternation of oomicrite and oosparite.

Introduction

The most comprehensive accounts of the geology of the Cotswolds are to be found in Buckman (1895, 1897, 1901) and Richardson (1904a, 1910, 1929, 1933) although these two very active workers have made numerous other important contributions to Cotswold geology (Buckman 1910) (Richardson 1903, 1904b, 1906, 1908, 1925). The earliest record of Westington Hill Quarry (Woodward, 1894) antedates these however and differs in detail from the better-known account prepared by Richardson (1929). In 1894 the quarry must have been somewhat less than half its present size, although, even then, the presently exposed lithological units were represented.

Situated to the South of Chipping Campden (text-fig. 1) at the northern end of the Main Hill Mass (SP 142368) the quarry seems to have escaped attention since 1929 until quite recently, when bulk sampling of the Oolite Marl revealed the presence (Baker 1972) of very young juveniles of *Zeilleria leckenbyi* (Davidson). Immature zeilleriid brachiopods have been recognised by Richardson (1929) and as ontogenetic stages of zeilleriid genera had been eagerly sought by brachiopod workers for a number of years, their failure to investigate Richardson's record, before Baker's (1972) study, seems somewhat strange.

The strata exposed in the quarry (text-fig. 2) fall entirely within the lower Inferior Oolite (Upper Aalenian Stage) of the Middle Jurassic and represent deposits of upper *murchisonae* zone and lower *concava* zone age.

Structures

The area is structurally uncomplicated. The rocks are more or less uniformly bedded, with a low regional dip to the S.W. Locally the pattern is disturbed by small normal oblique faults (plate 4. fig. 1). On a smaller scale, interesting diagenetic effects in the form of pressure-solution structures (plate 5, fig. 2, arrowed) affecting ooliths, may be seen at certain horizons within the Lower Freestone.

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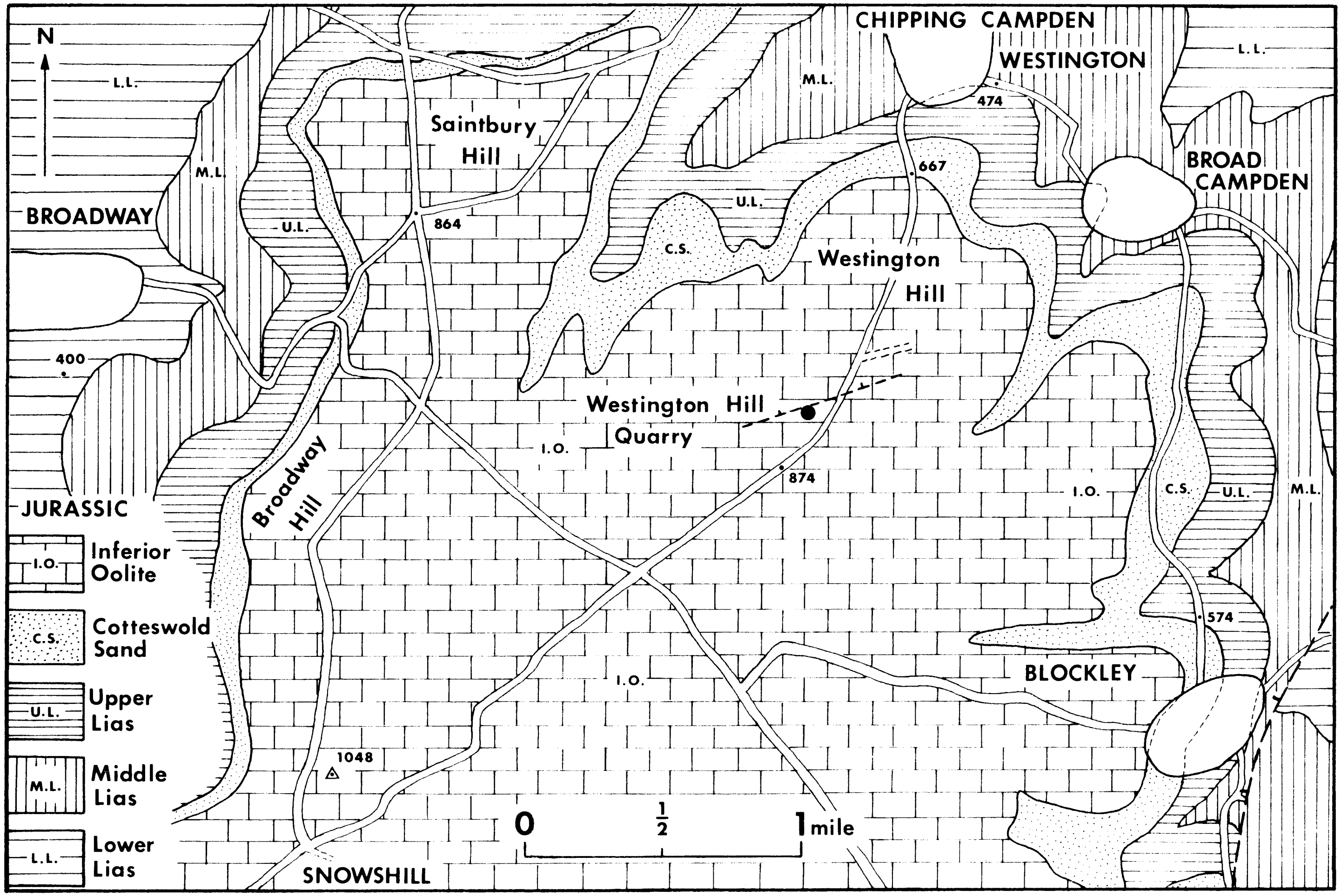
4 text-figs. 2 plates.



Geological Map of the area around Westington Hill Quarry showing the general outcrop of the Inferior Oolite and adjacent strata.

The Lithostratigraphical Divisions

The formations are described in ascending stratigraphical order and their outcrop is shown in text-fig. 3. The terminology applied to the lithological units follows that proposed by Folk (1959). For explanation of the terms see appendix.

Lower Freestone

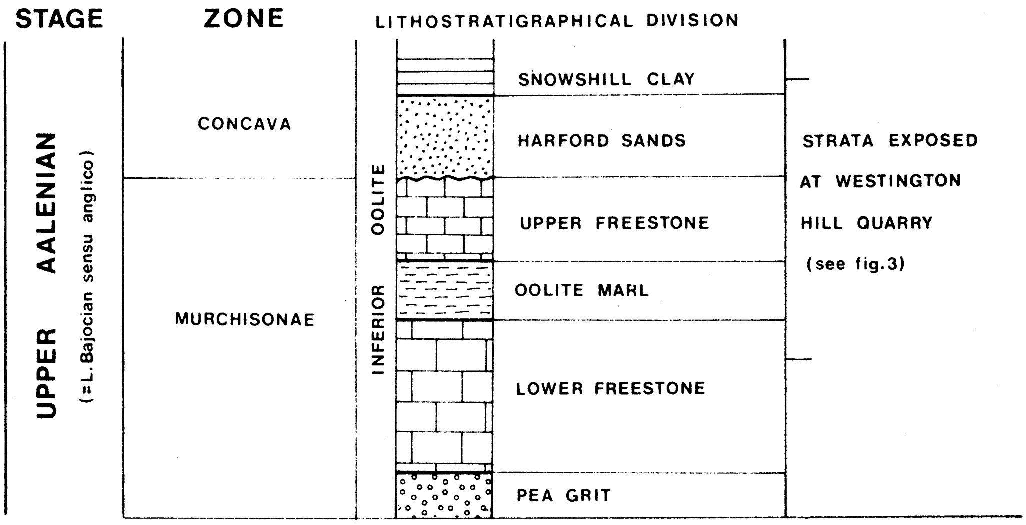
The Lower Freestone is represented by some 8·2 m of oolitic limestones and the main lithological units are apparently very uniform, being easily traced all round the quarry face (text-fig. 3). Many authors describe the Lower Freestone as unfossiliferous. This term is misapplied, unless it relates specifically to the absence of macrofossils, as much organo-detrital debris occurs at certain horizons (plate 5, fig. 4, 5).

Closer examination of the main lithological units visible in the Lower Freestone (text-fig. 4, B) shows that they are by no means as uniform as they appear at outcrop. They display a general cyclic sequence of biomicrite and oomicrite (plate 5, fig. 1, 4) followed by an oosparite horizon (plate 5, fig. 2, 3).

It is evident that the "local" names recorded by Richardson (1929) are derived from the way in which the varying lithologies of the units influence their surface characteristics. The "White Post" (text-fig. 4, A) is an oosparite in which the white-weathering ooliths are cemented by crystalline calcite, which sparkles as light is reflected from the cleavage planes; this cement appears glassy on polished surfaces. The "Ironstone" is really an oolite-bearing biomicrite which consists of small faecal pellets, foraminifera and shell fragments, together with occasional ooliths, set in a fine-grained calcite mud matrix. Many of the pellets are coated with limonite and this mineral is also found as an infilling in some of the chambers of foraminifera, so that, on weathering, a "rusty" appearance is imparted to the rock. This weathering apparently takes some time, as the horizon is only clearly visible in older faces of the quarry (text-fig. 3, locality 2). The main fossiliferous horizons occur near the top of the Lower Freestone and are represented by masses of comminuted brachiopod and bivalve shell debris, bryozoan fragments, echinoid plates and spines, mud pellets and scattered ooliths set in a cement of calcite spar (plate 5, fig. 5). Diagenesis has affected the shell fragments selectively; soon after deposition a micrite envelope developed round each shell fragment. The fabric of the brachiopod shells remained subsequently unaffected but the aragonite of the bivalve shell fragments was dissolved away so that only the micrite envelope remained. Later, calcite spar cement was precipitated, so that the bivalve remains are now represented only by these micrite "ghosts" (plate 5, fig. 5). The top of the Lower Freestone is marked by a well-defined erosion surface, sparsely colonised by encrusting *Ostrea* and rock boring *Lithophaga*. The main lithological succession displayed in the Lower Freestone, together with useful marker horizons, may conveniently be illustrated in diagrammatic form as outlined in text-fig. 4, B.

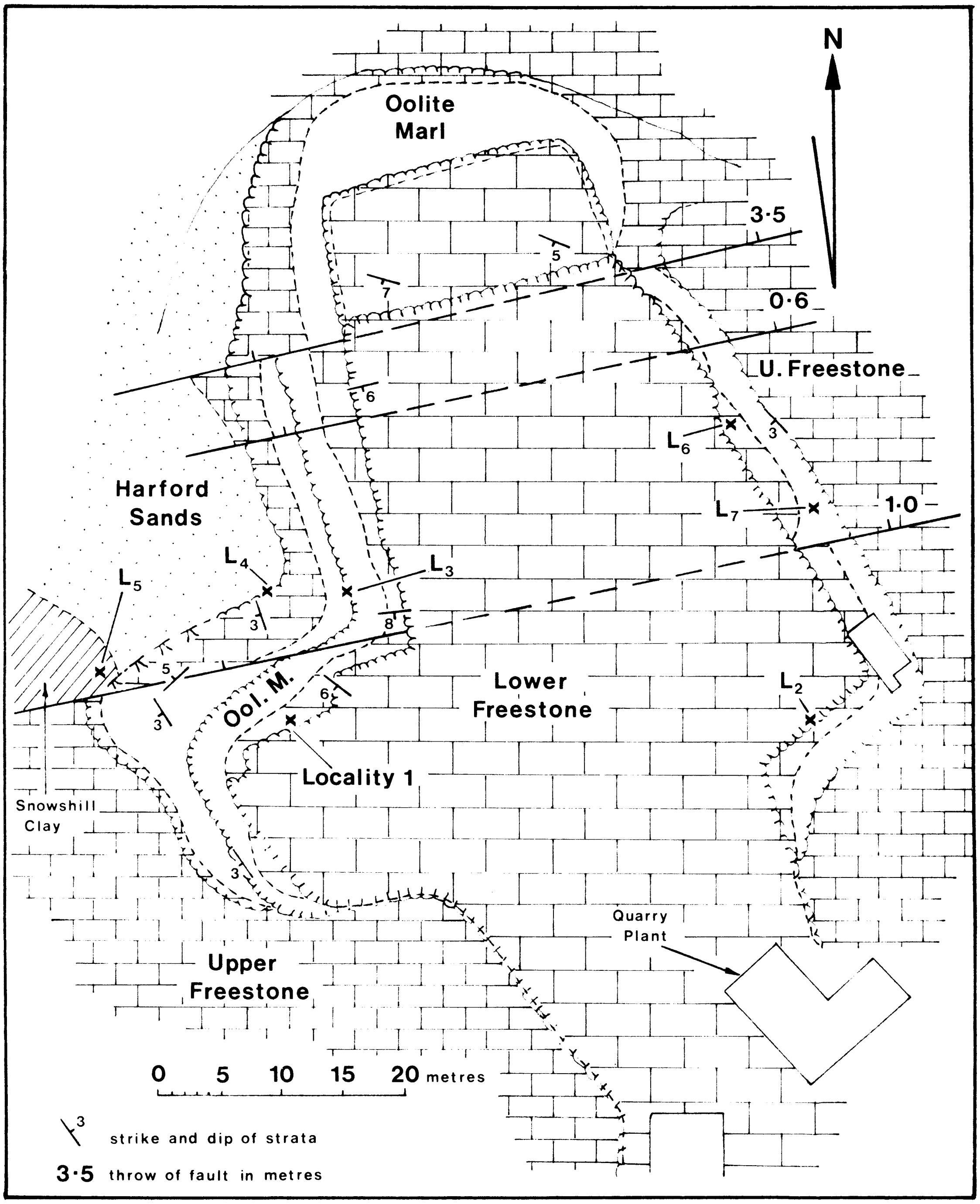
Oolite Marl

This is by far the most fossiliferous horizon in the quarry and has a thickness of 3·5 m. The deposit is typically a pale, cream-coloured marl, relatively harder and more oolitic in the upper layers, softer and with the ooliths more scattered towards the base (plate 4, fig. 2). Immediately above the Lower Freestone erosion surface (text-fig. 4, C) is a thin development of marly orange clay, containing micromorphic brachiopods assigned to the genera *Moorellina*, *Zellania* and *Nannirhynchia* also very early juveniles of *Zeilleria*, *Globirhynchia* and *Flabellirhynchia*. The clay at the base is overlain by about 1 m of marls and soft biomicrites, which yield a rich brachiopod fauna, especially *Epithyris submaxillata* (Morris), *Flabellirhynchia lycettii* (Davidson) *Globirhynchia subobsoleta* (Davidson) *Plectothyris fimbria* (Sowerby), *Zeilleria leckenbyi* (Davidson ex Walker Ms). Other fossils which are common, are the bivalves *Ostrea* and *Lopha* and the gastropods *Natica* and *Pleurotomaria*. Sieved samples of the marl yield bryozoan fragments, echinoderm spines and plates, crinoid columnals,



Text-figure 2. Diagram showing the lithostratigraphical divisions exposed in Westington Hill Quarry.

Text-figure 3. (opposite p.137) Geological map of the enlarged quarry at Westington Hill including recent excavations up to July 1973. L1 - 6, composite section fig. 4B. L2, hard brown-weathering band 0·35 m. thick developed below the grey marl, corresponds to the "ironstone" of Richardson. L6, fresh face, grey marl not well marked, L7 patch reef development. Throw of faults in metres.



N
Oolite Marl
3·5
0·6
U. Freestone
Harford Sands
L6
L7
1·0
L4
L3
L5
Ool. M.
Lower Freestone
L2
Locality 1
Snowshill Clay
Upper Freestone
Quarry Plant
0 5 10 15 20 metres
strike and dip of strata
3·5 throw of fault in metres

serpulids, foraminifera and ostracods. In the eastern part of the quarry (text-fig. 3, locality 7) small, poorly preserved coral reef mounds or patch reefs may be seen weathering out from the Oolite Marl. These yield *Zeilleria* and *Globirhynchia*, together with the coral *Goniocora* and occasional shark's teeth of *Psammodus* type. The highest bed is a prominent (plate 4, fig. 1) very hard, pale brown, sparry oomicrite which weathers to dark brown. This bed had been included in the Upper Freestone by Richardson but it contains occasional large specimens of *Plectothyris* and should therefore, on faunal grounds be included in the Oolite Marl. This view is substantiated by a marked change in lithology also, in the overlying beds.

Upper Freestone

This is not a very apt name in the Westington Hill area, as freestones are only very thinly developed. Of the 4·35 m of strata exposed, the lower 2·72 m (text-fig. 4, B) is not, in fact, oolitic limestone but interbedded marl, micrite and biomicrite. The lowest beds are pale-cream, very fine-grained uniform micrites, devoid of organo-detrital remains. These are overlain by pale-cream biomicrites (text-fig. 4, B) containing numerous internal casts of the bivalves *Isocardia* and *Anisocardia*. In thin section (plate 5, fig. 6) they are seen to consist of scattered faecal pellets and shell fragments set in a matrix of fine-grained calcite mud. The upper, oolitic member of the Upper Freestone forms a small feature, set back a short distance from the quarry face, on the western side of the quarry (text-fig. 3, locality 4). Here 1·63 m of thinly bedded oomicrite and sparry oomicrite are exposed, showing ripple marking and occasional marl bands. A somewhat weathered specimen of the zonal ammonite *Ludwigia murchisonae* (J. de. C. Sowerby) has been recovered from the oomicrite at this locality.

Harford Sands

In this area, the Harford Sands are represented by sparsely exposed bright yellow, fine-grained, unconsolidated quartz sands, having a total thickness of about 0·6 m. They have become relatively more well exposed recently where trees and soil have been removed for extension of the quarry but have so far yielded no fauna.

Snowshill Clay

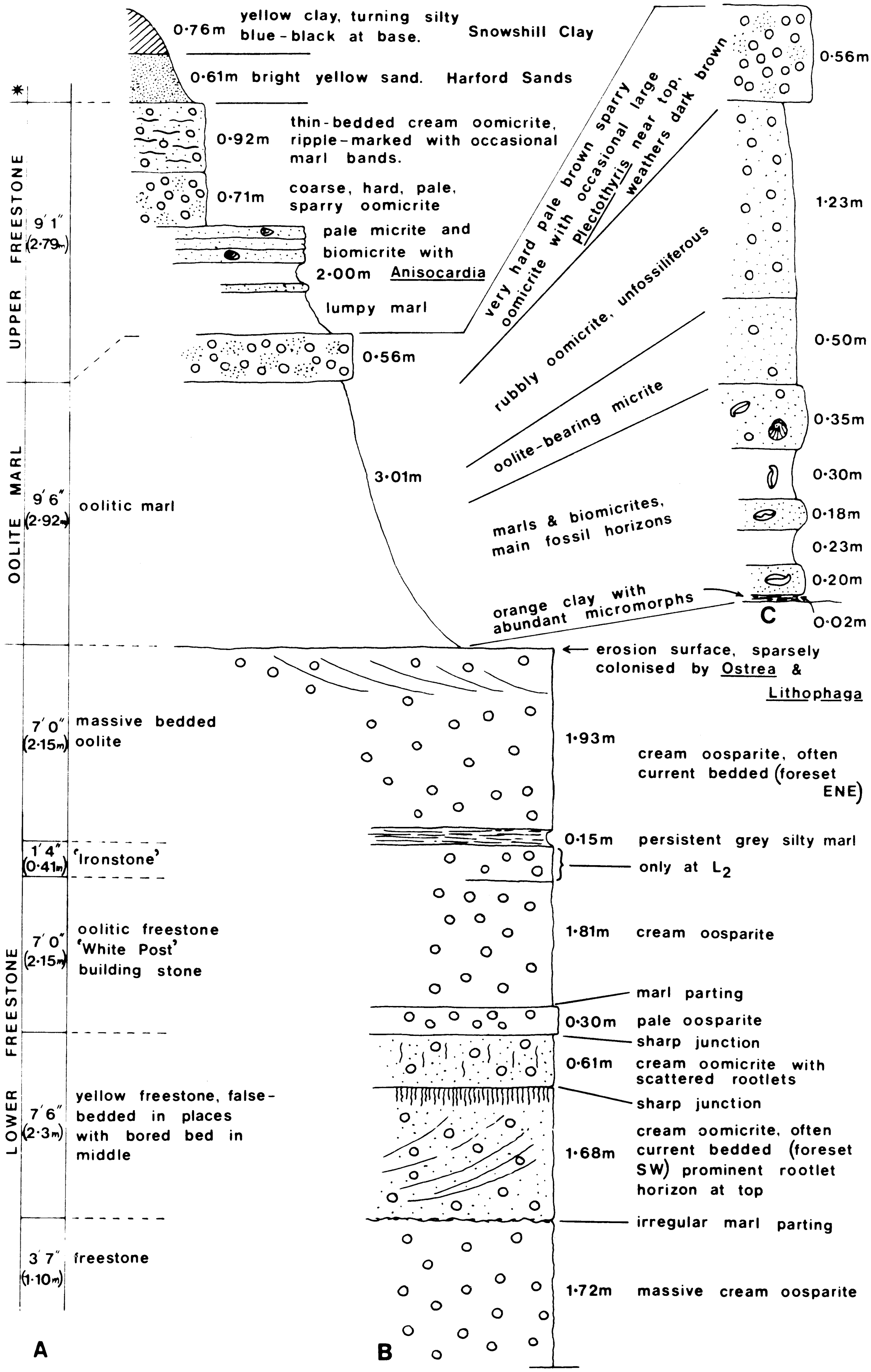
The Snowshill Clay was recorded by Woodward (1894) but the exposure had not been seen subsequently. At present the deposit is poorly exposed in a recent excavation in one corner of the quarry (text-fig. 3, locality 5) where it is represented by approximately 0·7 m of stiff clay, yellow at the top but becoming silty and blue-black towards the base. It exists as a small pocket on the downthrown side of the small fault visible in plate 4, fig. 1.

Text-figure 4. (opposite p.139)

A. Succession in Westington Hill Quarry described by Richardson (1929) * Harford Sands described by Woodward (1894) mentioned but not seen by Richardson.

B. Measured succession, July 1973, A composite section (based on locality numbers 1 - 6, text-figure 3) to show the various lithological units depicted in plate 1.

C. Enlarged succession to show the Oolite Marl in greater detail. The highest bed, included in the Upper Freestone by Richardson, is here, on lithological and faunal grounds, correlated with the Oolite Marl.



0·76m yellow clay, turning silty blue-black at base. Snowshill Clay
0·61m bright yellow sand. Harford Sands
0·92m thin-bedded cream oomicrite, ripple-marked with occasional marl bands.
0·71m coarse, hard, pale, sparry oomicrite
pale micrite and biomicrite with
2·00m Anisocardia
lumpy marl
0·56m
3·01m
UPPER FREESTONE
9' 1" (2·79m)
OOLITE MARL
9' 6" (2·92m)
oolitic marl
very hard pale brown sparry oomicrite with occasional large Plectothyris near top, weathers dark brown
rubbly oomicrite, unfossiliferous
oolite-bearing micrite
marls & biomicrites, main fossil horizons
orange clay with abundant micromorphs
0·56m
1·23m
0·50m
0·35m
0·30m
0·18m
0·23m
0·20m
0·02m
C
erosion surface, sparsely colonised by Ostrea & Lithophaga
7' 0" (2·15m) massive bedded oolite
1·93m cream oosparite, often current bedded (foreset ENE)
0·15m persistent grey silty marl
1' 4" (0·41m) 'Ironstone'
only at L2
7' 0" (2·15m) oolitic freestone 'White Post' building stone
1·81m cream oosparite
marl parting
0·30m pale oosparite
sharp junction
0·61m cream oomicrite with scattered rootlets
sharp junction
LOWER FREESTONE
7' 6" (2·3m) yellow freestone, false-bedded in places with bored bed in middle
1·68m cream oomicrite, often current bedded (foreset SW) prominent rootlet horizon at top
irregular marl parting
3' 7" (1·10m) freestone
1·72m massive cream oosparite
A
B

Conclusions

It has been argued (Ager, personal communication) that the Oolite Marl simply represents the unindurated lower portion of the Upper Freestone. It is certainly true that, from Painswick southwards, the lithology changes until, in the vicinity of Stroud, the Oolite Marl becomes virtually indistinguishable from the overlying limestone. However, the author considers that, in Westington Hill Quarry, the faunal and lithological difference between the Oolite Marl and the Upper Freestone provide sufficient justification for their continued separation. The oomicrite - oosparite sequences in the Lower Freestone show considerable similarity with the oolitic (oomicrite) and oolite (oosparite) lithofacies described by Bathurst (1971) in the Great Bahama Bank. The micrites at the base of the Upper Freestone also have a bahaman counterpart in the form of the pellet mud and mud lithofacies of the most sheltered reef environment. This similarity indicates that during Middle Jurassic time the mid-Cotswold environment may have been similar to that which exists in the Bahamas at the present time. Finally, the relative abundance of previously unnoticed micromorphic brachiopods in sieved Oolite Marl residues indicates that they are more common than is generally realised but, owing to their small size, remain largely overlooked.

Acknowledgements

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APPENDIX

Glossary of sedimentological terms not defined in the text.

Biomicrite — A limestone composed of skeletal grains in a matrix of micrite (Folk, 1959).

Biosparite — A limestone composed of skeletal grains in spar cement (Folk, 1959).

Micrite — A normal precipitate, formed within the basin of deposition and showing little or no evidence of significant transport; forming crystals of 1 - 4μ in diameter (Folk, 1959) i.e. a "calcite mud".

Oomicrite — A limestone composed of ooids (ooliths) in a matrix of micrite (Folk, 1959).

Oosparite — A limestone composed of ooids (ooliths) in spar cement (Folk, 1959).

Spar — A mosaic of crystals larger than those in micrite, formed either as cement or as neomorphic spar (Folk, 1959).

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EXPLANATION OF PLATE 4

Figure 1 — A section of the west face (centred on locality 3, fig. 3) of Westington Hill Quarry showing the persistent sparry oomicrite at the top of the Oolite Marl and the effect that the small fault has on its outcrop. The face shown in the extreme right foreground has now been removed during recent excavation.

Figure 2 — A fresh section (now removed) through the Oolite Marl exposed in the N.W. face of the quarry in 1971. For explanation of the horizons marked see fig. 4C.

EXPLANATION OF PLATE 5

Photomicrographs, taken in plane polarised light, of thin sections showing the variation in lithology of the Lower and Upper Freestone exposed in Westington Hill Quarry. All are magnification. X40.

Figure 1 — Oomicrite, collected from the west face (map locality 1) approximately 2 m. above the floor of the quarry. The moderately well-formed ooliths are set in a matrix of fine-grained calcite mud. In the majority of cases the oolith nuclei (n) are composed of angular quartz grains.

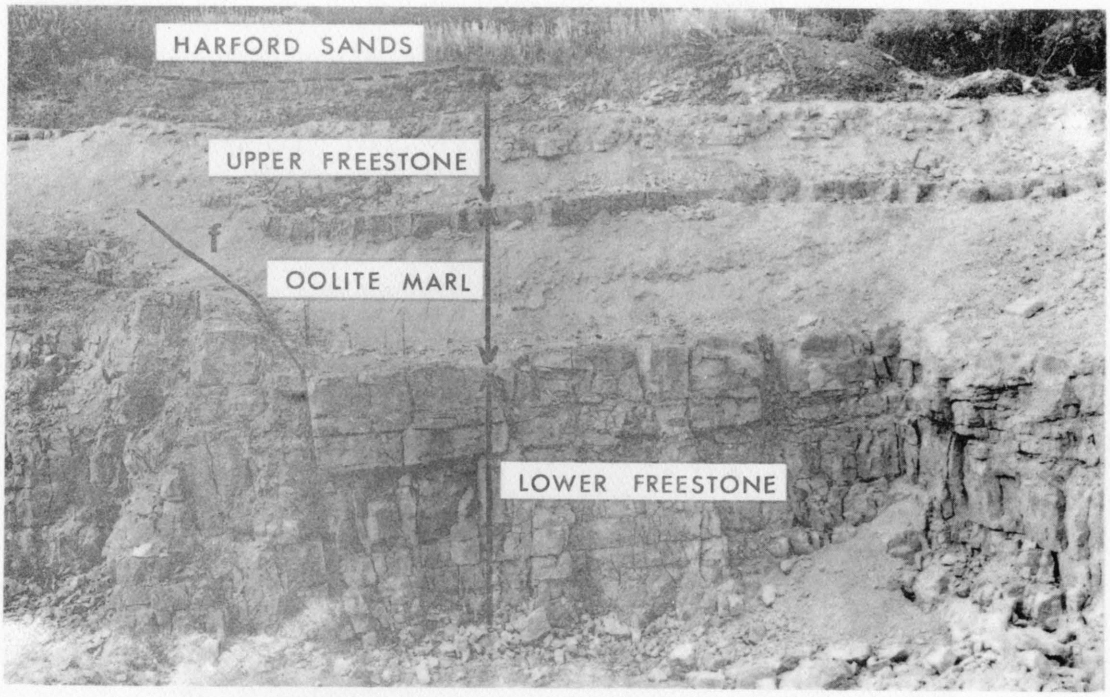
Figure 2 — Oosparite, collected from the same locality as the previous specimen but at a height of 5·3 m above the quarry floor. Many of the ooliths show pressure-solution interfaces (arrowed).

Figure 3 — Oosparite, collected from the "White Post" building stone and showing beautifully formed ooliths, many with clear growth rings, set in a cement of calcite spar.

Figure 4 — Oolite-bearing biomicrite, collected from map locality 2, showing faecal pellets (p) and organo-detrital remains set in a fine-grained calcite mud matrix.

Figure 5 — Biosparite from the top of the Lower Freestone (Map locality 6) showing a mass of comminuted shell debris set in a calcite spar cement.

Figure 6 — Typical fine-grained biomicrite, representative of the lower part of the Upper Freestone in the vicinity of Westington Hill.



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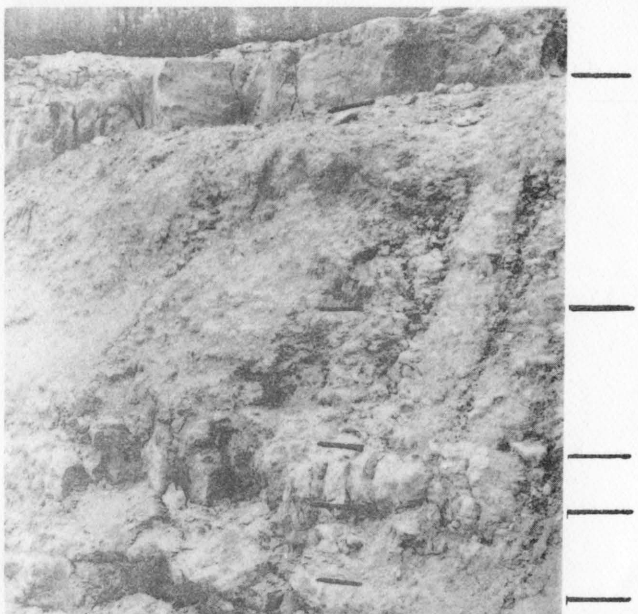
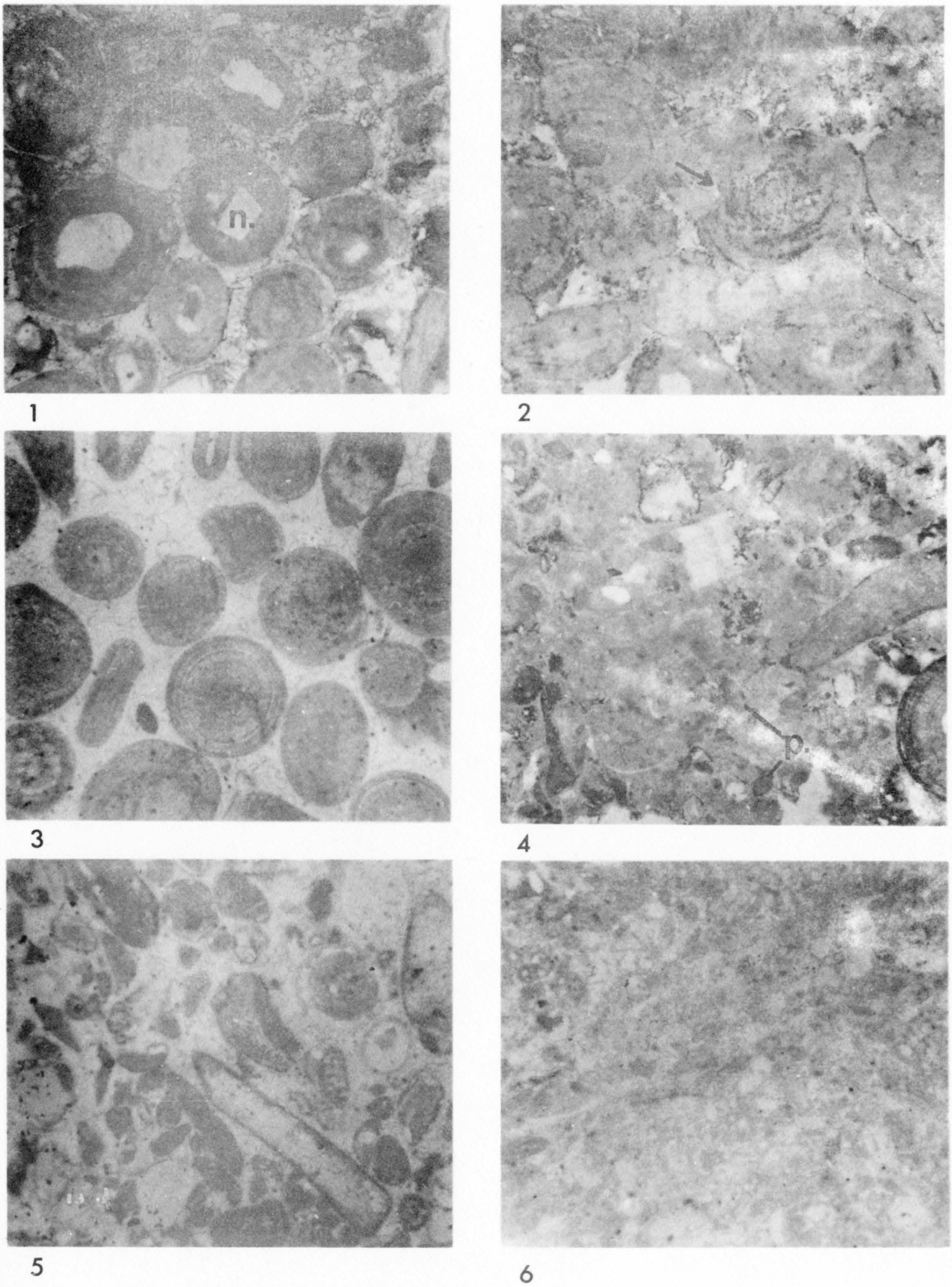


2

BAKER, P.G. Westington Quarry.



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