Woodeaton, Oxfordshire

[SP 533 123]

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Introduction

The quarry at Woodeaton, Oxfordshire, provides one of the best and most complete exposures of Bathonian rocks in the south Midlands, showing a continuous section from the top of the Taynton Limestone Formation up to the lower part of the Forest Marble Formation (Figure 4.5). The quarry is situated near the top of Noke Hill, which is formed by a periclinal inlier of Great Oolite Group surrounded by the outcrop of the Callovian–Oxfordian Kellaways and Oxford Clay formations. The hill lies at the point of intersection of the Wheatley Fault Zone and the Charlton Anticline (Arkell, 1947b; Horton *et al.,* 1995). Beds dip away from the crest of the pericline, progressively from about 3° to a maximum of 10°, as seen in the south-west face of the quarry, which provides the most complete section (18–20 m thick).

The section was first described in detail by Palmer (1973), whose record is thought to lack the uppermost 3.5 m of the White Limestone Formation, including the whole of the Bladon Member, because these beds are cut out by channelling at the base of the Forest Marble Formation in much of the quarry. Additionally, a minor fault probably accounts for the absence in his record of some beds lower in the succession. A more recent record of the complete succession was presented by Horton *et al.* (1995), following considerable extension of the quarry faces (see below). Graphic logs of the section were provided by Bradshaw (1978) and Cripps (1986) in unpublished theses. Lateral variations in lithology and thickness of beds, which occur throughout the quarry, probably account for differences between the various recorded sections.

Description

The basal 0.6 m of the succession, hidden by talus or backfill for many years, represents the topmost beds of the Taynton Limestone Formation. It consists of shell-fragmental, sparry, ooidal limestone. Complete fossils are uncommon but *Kallirhynchia?* has been recorded (Palmer, 1973). The following section through the overlying beds is taken, with minor amendments, from Horton *et al.* (1995); Bed 3 and Bed 5 of the Rutland Formation were not recorded by Palmer (1973), and Bed 4 is much thicker than his 'Monster Bed' with which it equates.

	Thickness (m)
White Limestone Formation	
Bladon Member (*Upper Epithyris Bed*)	
25: Limestone, cream and buff, finely detrital or micritic, with greenish-grey clay-filled burrows, brown wood-fragments; poorly preserved bivalves including *Anisocardia?, Eomiodon* cf. *fimbriatus* (Lycett), *Lucina?, Modiolus, Protocardia, Quenstedtia?, Vaugonia* cf. *angulata* (J. de C. Sowerby); and gastropods including *Sphaeriola oolithica* (Rollier) and *Fibula* cf. *phasanioides* (Morris and Lycett)	0–0.12
***Bladon Member* (*Fimbriata–Waltoni Bed*)**	
24: Clay, bluish-green, with calcareous nodules near base	0.40–0.60
23: Marl, brown, with sand-grade carbonate detritus; carbonaceous debris and, near base, shell fragments	0.10–0.20
22: Marl, fawn-grey, rusty mottled; abundant *Praeexogyra hebridica* (Forbes), also *Bakevillia waltoni* (Lycett) and much carbonaceous plant-debris	0.20–0.40
Ardley Member	

21: Limestone, fawn, soft, marly, shell-detrital, slightly ooidal	0.20
20: Limestone, cream, micritic, ooidal, bioturbated	0.70
19: Limestone, cream, soft, marly, micritic, slightly ooidal, bioturbated	0.45
18: Limestone, fawn, hard, bedded, ooidal, detrital, sparry	0.50–0.70
17: Marl, brown; abundant *P. hebridica*	0.50–1.00
16: Limestone, cream and brown, hard, shell-fragmental, micritic; in two beds with a marl parting; very fossiliferous with brachiopods (*Digonella digonoides* S.S. Buckman, *Epithyris bathonica S.*S. Buckman, *E. oxonica* Arkell); bivalves (*Anisocardia* cf. *islipensis* (Lycett), *Coelastarte?, Costigervillia crassicosta* (Morris and Lycett), *Falcimytilus sublaevis* (J. de C. Sowerby), *Homomya, Isocyprina, Liostrea* cf. *undosa* (Phillips), *Modiolus imbricatus* (J. Sowerby), *Parallelodon, Plagiostoma subcardiiformis* (Greppin), *Protocardia?, Thracia?*)*;* gastropods (*Globularia morrisi* Cox and Arkell, *Sphaeriola oolithica*)*;* echinoids (*Clypeus?*)	0.65–0.75
15: Limestone, creamy-white, micritic, patchily shell-detrital, with *Falcimytilus*	0–1.00
14: Limestone, creamy-white, micritic, very fossiliferous, with abundant *Epithyris oxonica* and *Modiolus;* also *Anisocardia* cf. *islipensis, Falcimytilus sublaevis, Pholadomya* cf. *ovalis* (J. Sowerby) and *Sphaeriola oolithica;* at southern end of quarry face, passing into 0.40 m of buff or fawn, finely ooidal, fine-grained, detrital limestone with laminae of creamy-white micrite; *Digonella digonoides* and various bivalves	0.20–0.50
13: Limestone, creamy-white, micritic, bioturbated in lower part; *Anisocardia, Bakevellia waltoni, Costigervillia?, Cuspidaria ibbetsoni* (Morris), *Lucina, Modiolus, Protocardia, Globularia*	0.30–0.50
12: Limestone, creamy-brown, fine- to medium-grained, detrital, cross-bedded	0.60–1.50
11: Limestone, brown, fine grained, marly, slightly sandy, with bivalve casts	0.20–0.25
10: Marl to marly limestone, rusty-brown	0.03–0.08
Shipton Member	
9: Limestone, cream, finely detrital, slightly ooidal, with poorly preserved bivalves; top locally brown, hard, recrystallized, with marl-filled burrows; thickest in north-west corner of quarry where four beds are separated by thin marly limestone bands; *?Epithyris oxonica, Unicardium?, Cossmannea*	0.40–1.10
8: Marl to marly limestone, fawn and rusty-brown, soft, shell-detrital, ooidal	0.12
7: Oolite, cream, fine grained, well sorted	0.60–0.70

6: Limestone, creamy-white, finely detrital, rubbly weathering; bivalves including *Camptonectes laminatus* (J. Sowerby), *Ceratomya concentrica* (J. de C. Sowerby), *Coelastarte* cf. *compressiuscula* (Morris and Lycett), *Costigervillia crassicosta, Isognomon isognomonoides* (Stahl), *Lucina, Pleuromya, Protocardia buckmani* (Morris and Lycett); gastropods (*Trochotoma*)*;* brachiopods (*Kallirhynchia* cf. *deliciosa* S.S. Buckman)	0.65–0.80
5: Limestone, pale-buff, massive, finely detrital, slightly ooidal; *Tbalassinoides* on top surface	0.65–0.80
4: Silt to siltstone, fawn, shaly weathering	0.15–0.20
3: Limestone, fawn, finely detrital; bivalves (*Ceratomya concentrica, Isognomon, Myoconcha, Myophorella, Protocardia?*)*;* gastropods (*Ampullospira*)	1.2
2: Limestone, creamy-white, finely detrital; bivalves (*Antiquicyprina loweana?* (Morris and Lycett), *Ceratomya concentrica, Isognomon* cf. *isognomonoides, Pholadomya lirata* (J. Sowerby), *Plagiostoma cardiiformis* (J. Sowerby), *P. subcardiiformis*)*;* gastropods (*Ampullospira*)	0.40–0.45
1: Marl, rusty-brown, finely shell-detrital; *Praeexogyra hebridica*	0.15
Rutland Formation	
8: Mudstone, pale greenish-grey, silty, with dark-green burrow-mottling in top 0.14 m; passing laterally into calcareous siltstone with shell-debris filled burrows at top; scattered thin-shelled bivalves and oyster-shell debris; carbonaceous rootlets truncated at top surface	0.42–0.70
7: Mudstone, dark-grey and brownish-grey, bioturbated with shell debris and many bivalves	0.17
6: Marl, dark-grey, sandy with much shell-debris; passing laterally into nodular, sandy, shell-fragmental limestone with fine plant-detritus; *Ampullospira?;* and bivalves (*Mactromya, Placunopsis socialis, Praeexogyra hebridica*)*;* sharp base	0.90
5: Mudstone, dark brownish-grey, wispy bedded, intensely bioturbated and with distinct, green, clay-filled burrows; pockets of bivalve shells; sharp, uneven burrowed base	0–0.10
4: Mudstone, pale greenish-grey, silty; in places at top passing laterally into marl with siltstone; rare bivalves; scattered calcareous nodules; well-defined rootlets marked by grey clay traces in upper part	0.65
3: Mudstone, dark-grey, shell-debris rich with many oysters; sharp base	0.03–0.06
2: Marl, pale-green, silty; rare shells and scattered rootlets	1.36
1: Mudstone, medium-grey with silt wisps, some ripple-laminated; green clay-filled burrows	seen to 0.15

Up to 3.5 m of Forest Marble Formation are present above the White Limestone Formation in the western face of the quarry. Grey and brown mottled clay with calcareous race nodules, overlie fawn, cross-bedded, shell-fragmental oolite containing angular fragments of derived white micritic limestone at the base. Ripple marks, clay drapes and clay flakes characterize these limestones.

Within the White Limestone Formation, the Shipton, Ardley and Bladon members are readily recognizable. The limestones of the basal Shipton Member are less well-cemented, softer and more easily weathered than those of the Ardley Member, which enables the two units to be readily differentiated in the quarry face. A shelly marl at the base of the Shipton Member (Bed 1) sharply truncates the uppermost rootlet bed of the Rutland Formation. As well as the fauna listed in the above section and in Palmer (1973), colonial corals such as *Cyathophora, Isastrea* and *Thamnasteria,* and the red alga *Solenopora jurassica* Brown, rare in the White Limestone Formation, have been recorded in the upper half of the member (Palmer, 1979). Sporadic nerineid gastropods are also present. Rootlets have been noted at the top of Bed 2 and also beneath Bed 4 (Bradshaw, 1978). The fine-grained, well-sorted oolite of Bed 7 is a useful marker. The locally hard and recrystallized top of Bed 9 is an incipient hardground of Dagham Stone type. Bed 11, near the base of the overlying Ardley Member, may be compared with the 'Roach Bed' (see Ardley Cuttings and Quarries GCR site report, this volume). Two very fossiliferous beds higher up in the member are noted for an abundance of well-preserved bivalves and brachiopods. The lower of the two (Bed 14) is the *Modiolus–Epithyris* Bed of Palmer (1973), which is characterized by an abundance of well-preserved *Modiolus imbricatus* (J. Sowerby) and *Epithyris oxonica* Arkell, the latter representing all life stages of the brachiopod. A facies change occurs at the southern end of the quarry, where this shelly, creamy-white micrite passes into buff, finely ooidal, detrital limestone with micrite laminae, in which *Digonella digonoides* S.S. Buckman is common, to the exclusion of *Epithyris.* However, these brachiopods are both present in the higher fossiliferous bed (Bed 16), which is overlain by a conspicuous shelly marl containing abundant *Praeexogyra hebridica.* The overlying Bladon Member is present only in the north-west corner of the quarry; all but the top limestone bed constitutes the so-called 'Fimbriata–Waltoni Bed'. Its basal marl (beds 22 and 23) contains much carbonate sand and carbonaceous plant-debris, large lignitic logs, and, in the lowest part, abundant oyster-shells. Bed 25 occurs along only a short section of the face and is all that is preserved of the Upper Epithyris Bed beneath the Forest Marble Formation. The basal erosion surface of the latter channels up to 4.7 m into the underlying White Limestone Formation, cutting out the Bladon Member and the top of the Ardley Member.

Minor faults are seen to displace strata in the north-west part of the quarry; the one with the greatest downthrow (*c.* 5 m) is associated with well-formed terminal bending ((Figure 4.6) and (Figure 4.7)).

Interpretation

The Taynton Limestone Formation was deposited in the turbulent waters of a shallow shelf-sea, and constitutes the marine phase and lower part of the Wellingborough Rhythm of Bradshaw (1978).

The beds traditionally assigned to the dominantly marine Hampen Formation were referred to the Rutland Formation by Horton *et al.* (1995) because occurrences of brackish-water bivalves and ostracods, seatearth lithologies and well-developed rootlet beds resemble the characteristic facies of the latter formation. The bivalves include marine forms such as *Mactromya* and *Praeexogyra hebridica* (Forbes), and others, such as '*Corbula*', *Cuspidaria, Neomiodon* and *Placunopsis socialis* Morris and Lycett, which tolerated brackish-water conditions. However, the distribution of these various forms may have had as much to do with substrate as with salinity (J.D. Hudson, pers. comm., 1998). Three rootlet beds define the tops of three rhythmic, shallowing-up depositional units (Horton *et al.,* 1995; Wyatt, 1996a,b). These are, in ascending order, the Wellingborough, Cranford and Finedon rhythms of Bradshaw (1978) (Figure 4.5). The top of the Finedon Rhythm (the top of Bed 8) is marked by a particularly distinctive pale greenish-grey clay with long, vertical rootlets infilled with dark-green clay. The rootlet beds indicate the establishment of coastal saltmarshes at the termination of the regressive rhythms. Marine bivalves, notably *P. hebridica,* characterize the basal parts of the Cranford and Finedon rhythms, whilst a mixed brackish-water to marine bivalve fauna occurs in the remaining sediments. The 'Monster Bed' of Palmer (1973) (= Bed 4 above), which forms the bulk of the Cranford Rhythm in Horton *et al.* (1995), has yielded two mid-dorsal vertebrae of the dinosaur *Cetiosaurus,* numerous bone fragments and a large quartzite pebble, interpreted to be a gastrolith (stomach stone). The freshwater gastropods *Valvata* and *Viviparus* also occur in this bed, together with a dominantly brackish-water ostracod microfauna. The calcified oogonia (egg cells) of charophytes form another freshwater element. Some rootlets in this bed have been assigned to the genus *Equisetites,* colonization by which suggests emergent conditions; higher-order plants are present as fragmentary material only. This mixed brackish-water fauna, together with its freshwater elements, suggests rapidly changing salinity levels, probably caused by influxes into a nearshore brackish-water lagoon of freshwater from streams draining the London Landmass. The streams transported the freshwater gastropods and charophytes, and the terrestial plant-debris.

The dominant micritic or finely detrital, pelletal, bioturbated limestones in the Shipton and Ardley members of the White Limestone Formation are inferred to have been deposited in the marine, shallow, quiet waters of a lagoon that formed the proximal part of an extensive shelf-sea marginal to the London Landmass. The coarser, cross-bedded limestone in the lower part of the Ardley Member denotes more turbulent depositional conditions. An abundance of burrowing bivalves throughout accounts for the common occurrence of bioturbation. Beds of mudstone, marl and silt represent periodic influxes of terrigenous sediment that generally form the bases of the regressive depositional units. Only the basal oyster-rich bed of the Bladon Member is marine; the occurrence of the eponymous bivalve *Bakevellia waltoni* (Lycett) above suggests brackish-water conditions. An abundance of coarse, carbonaceous, terrestrial plant-debris throughout indicates proximity to the shoreline. The calcareous nodules in the uppermost clay unit of the Fimbriphenotoni Bed may represent a caliche, suggesting sub-aerial exposure. The strata of the White Limestone Formation can be interpreted in terms of shallowing-up, rhythmic, depositional units (Palmer, 1979; Wyatt, 1996a,b), some capped by rootlet beds, some clearly separated by depositional breaks. Thus, in the Shipton Member, there are three rhythms, the lower two capped by rootlet beds, the uppermost by a burrowed hardground (the top of Bed 9) that may be correlated with the regionally persistent Excavata Bed (Sumbler, 1984; Wyatt, 1996a,b). Three rhythms are evident in the Ardley Member, the lower two capped by the highly fossiliferous beds 14 and 16, which contain abundant epifaunal elements in addition to the ubiquitous burrowing bivalve fauna. The higher of these fossiliferous units (Bed 16), which comprises two distinct beds with a marl parting, probably corresponds to the Ardleyensis Bed hardground elsewhere, another regionally persistent marker (Sumbler, 1984); its double character suggests the presence of a fourth minor rhythm (Wyatt, 1996a,b). Unlike some other exposures in Oxfordshire, no hardground is developed at the top of the Ardley Member at Woodeaton. The Fimbriphenotoni Bed (the lower and greater part of the Bladon Member) represents a rhythm in the brackish-water facies.

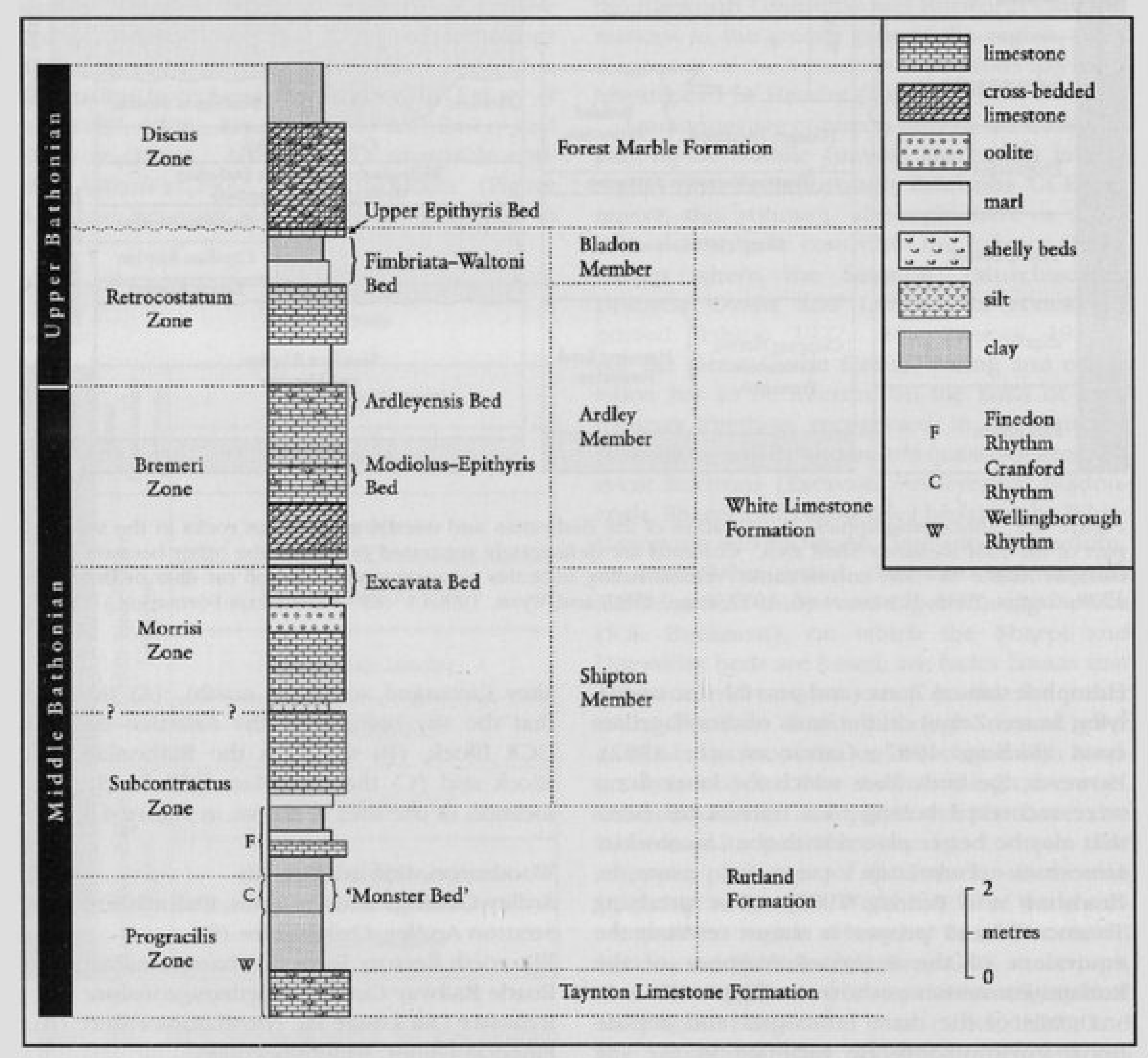
The succeeding cross-bedded ooidal limestones of the Forest Marble Formation were laid down in conditions similar to those of the Taynton Limestone Formation. The uppermost clay represents a return to deposition of quiet-water terrigenous sediment.

No ammonites have been collected from the quarry, but a zonal interpretation (Progracilis to Discus zones) is made possible by regional correlation of the rhythmic depositional units (Figure 4.5).

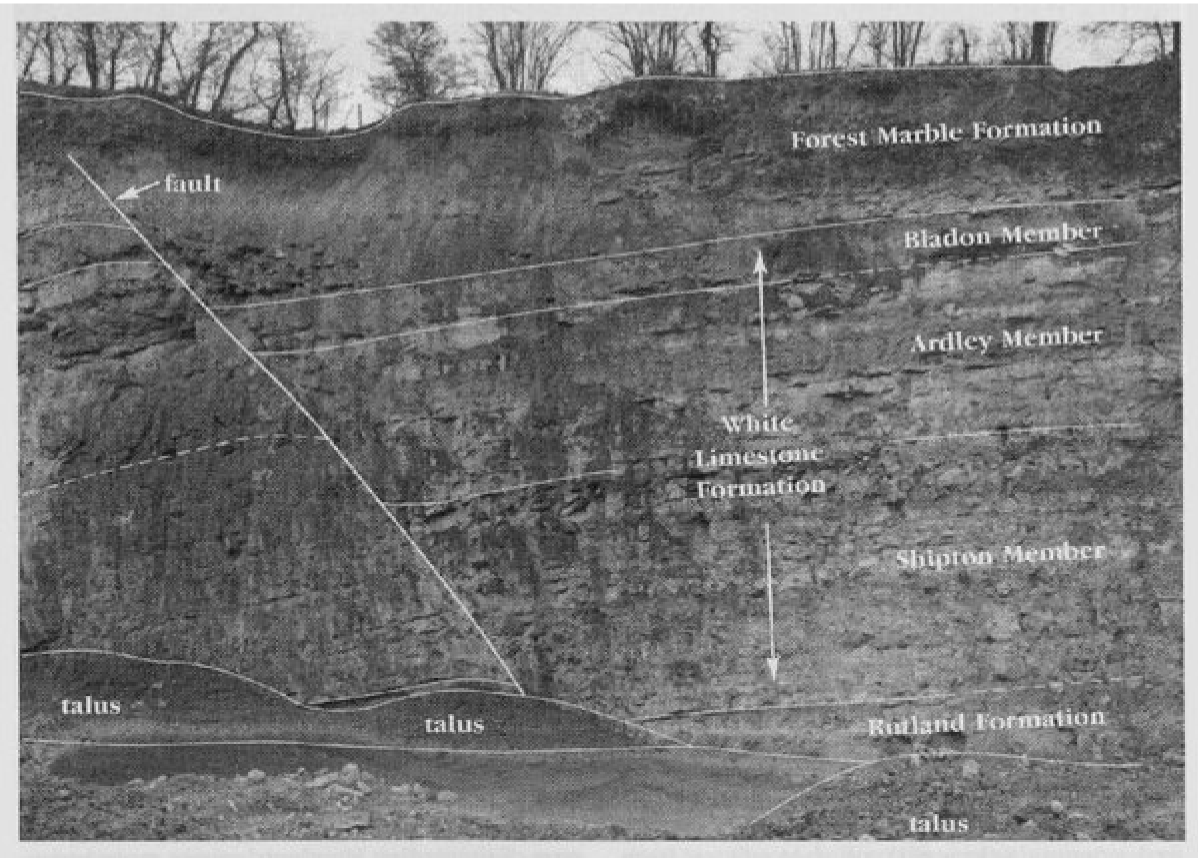
Conclusions

The quarry at Woodeaton exposes the complete White Limestone Formation, and offers one of the more accessible exposures of the Rutland Formation in the south Midlands. The rocks include representatives of a brackish-water, nearshore saltmarsh (Rutland Formation); a marine, high-energy, open shelf-sea (Taynton Limestone and Forest Marble formations); and a marine, quiet-water, protected lagoon (White Limestone Formation). Of special interest are highly fossiliferous beds yielding well-preserved fossils in the White Limestone Formation, and the 'Monster Bed' with its vertebrate remains and mixed brackish-water–freshwater fauna and flora in the Rutland Formation. The succession is characterized by several shallowing-up, rhythmic, depositional units, some capped by distinctive rootlet beds. The quarry exhibits the increasingly inclined strata on the south-western flank of the Noke Hill Pericline, in part disrupted by minor faults associated with terminal bending.

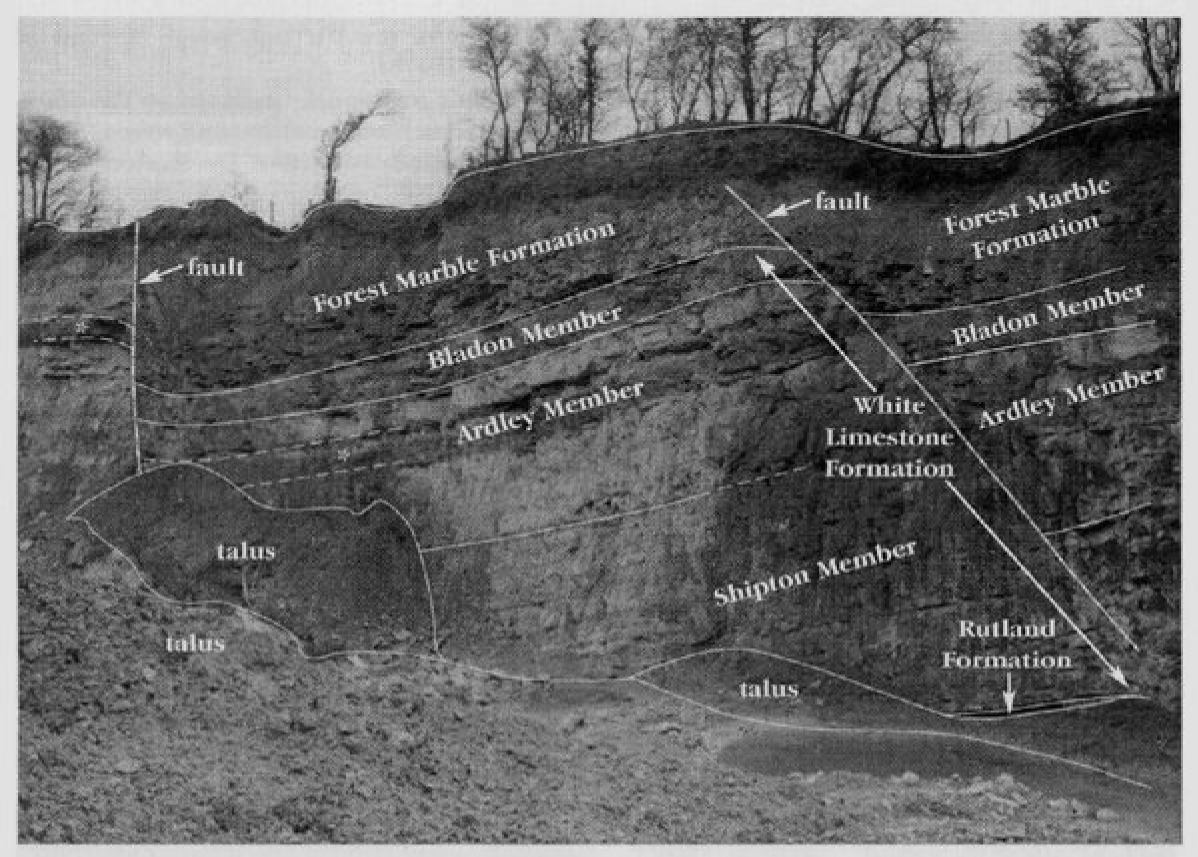
References



(Figure 4.5) Graphic section of the Bathonian succession in the quarry at Woodeaton. (After Horton et al., 1995, fig. 9.))



(Figure 4.6) The quarry at Woodeaton; flaggy limestones of the Forest Marble Formation overlie a complete White Limestone Formation, with a fault of c. 3 m downthrow. (Photo: British Geological Survey, No. A15356; reproduced with the permission of the Director, British Geological Survey, © NERC, 1991.))



(Figure 4.7) The quarry at Woodeaton; west face showing faults with terminal bending of beds. (Photo: British Geological Survey, No. A15358; reproduced with the permission of the Director, British Geological Survey, © NERC, 1991.))