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The litho- and biostratigraphy of the Lias Group of the Glastonbury-Shepton Mallet area, Somerset

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Bristow, C.R. and Donovan, D.T. 2015. The litho- and biostratigraphy of the Lias Group of the Glastonbury-Shepton Mallet area, Somerset. *Geoscience in South-West England*, **13**, 377-391.

This paper synthesises recent geological mapping by CRB, formerly of the British Geological Survey, with palaeontological data collected primarily by DTD over many years. In addition, it incorporates a wealth of data, both published and unpublished, to provide the first comprehensive overview of Lias stratigraphy and biostratigraphy across an area of rapidly changing thicknesses and lithologies.

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Keywords: Glastonbury, Shepton Mallet, Somerset, Lias Group.

Introduction

The area is dominantly rural with only a few scattered hamlets. Except in the north and north-east, where Triassic Mercia Mudstone and Penarth Group rocks crop out, the area is everywhere underlain by strata of the Lias Group, although in the west there are extensive tracts of Alluvium, Peat, River Terrace Deposits and Head deposits which obscure the bedrock geology. The northern area lies on the southern flank of the Mendip Hills, with the southern part dominated by the east-west trending Pennard Hill capped with strata of the Dyrham and Beacon Limestone formations, and Glastonbury Tor rising to 158 m capped by the Bridport Sand Formation. Drainage is essentially to the west and north-west into the Somerset levels. Agriculture is the main industry of the area, with a predominance of dairy farming. There is little woodland, apart from on the steeper slopes of Pennard Hill. There are several newly planted apple orchards in the area.

The Glastonbury-Shepton Mallet area of this account comprises 1:10,000 sheets ST44SE (part), 54SW AND SE (parts), 64SW (part), 43NE, 53NW and NE and 63NW. Figures in square brackets are National Grid references and fall within 100-km square ST.

Previous work

The Glastonbury-Shepton Mallet area was first surveyed at the 1:63,360 scale and included on Old Series sheets 18 (published in 1850) and 19 (first published in 1845; third edition published 1899). There was no specific Old Series Memoir which covered the Glastonbury-Shepton Mallet area, but some details were included in the East Somerset and Bristol coalfields memoir (Woodward, 1876) and the regional Jurassic stratigraphic memoirs (Woodward, 1893, 1894). The area included in this paper falls on the New Series Glastonbury (296) Sheet which was first published at the 1:63,360 scale in 1969 as a provisional edition. This sheet was largely based on the Old Series Sheets 18 and 19, but also incorporated information from Sheet 296 of the Soil Survey of England and Wales published in 1955. The Glastonbury Sheet was republished without revision at the 1:50,000 scale in 1973. The whole sheet was resurveyed by the British Geological Survey at the 1:10,000 scale mainly between 2001 and 2008. However, there will be no published 1:50,000 map, memoir and no more open-file reports. This paper is an attempt to rectify the lost opportunity for at least part of the Glastonbury area to produce a synthesis of the recent mapping. It combines this with notes and observations, usually on specific locations, by the many geologists who have visited this area, some of which are published in several journals.

The current area was surveyed by one of us (CRB) in 1982 and 2001-2008. The notes, observations and biostratigraphical data gathered by DTD over many years are incorporated in this account. In addition, valuable material seen, recorded and collected by the late Hugh Prudden and Kevin Page has kindly been made available to us. Some additional fossils from the Beacon Limestone have been identified by Dr. M.K. Howarth.

Geological terminology

In recent years, where possible, geological stratigraphical terminology has been rationalised and unified across the British Isles. Consequently, some generalised, older, terminology (i.e. 'Lower, Middle and Upper Lias') or even more recent names (i.e. Pylle Clay) have been replaced by formally defined units of regional or UK-wide extent. Both the old and new terminology is shown in Figure 1.

Stratigraphy of the Lias Group

Strata of the Lias Group underlie much of the area except in the north, north-east and extreme south-west. The group comprises a variety of lithologies including mudstones, alternating thin mudstones and limestones, limestones, sandy and silty mudstones, siltstones and very fine-grained sandstones. These characteristics are used to divide the Lias into lithostratigraphical units (Figure 1). The base of the Jurassic System is taken at the lowest occurrence of the ammonite *Psiloceras planorbis* in the lower part of the Blue Lias Formation. The Blue Lias thus spans the Triassic/Jurassic System boundary, but for convenience, it is treated in its entirety in this chapter.

The Lias of the north Somerset region can be divided into three palaeogeographical domains: the *Radstock Shelf*, north of the Mendip Hills (and not considered further in this account), the *Mendips Littoral Area*, and the *Central Somerset Basin* lying south of the Mendips (Kellaway and Wilson, 1941). The group shows marked facies changes across the area, particularly in the Blue Lias, from the thin, limestone-dominated, Mendips Littoral Area (see Figure 3), to the thicker, mudstone dominant, basinal sequence of the Central Somerset Basin to the south (Figure 4). The thickness of the group in the area is not known with certainty, but varies from 30 m on the littoral area to over 300 m in the basin area. In the present districts, all the Lower Jurassic ammonite zones and many of the subzones have been proved (Figure 1). Whilst some subzones are unproven due to non-exposure, others may be absent due to non-sequences.

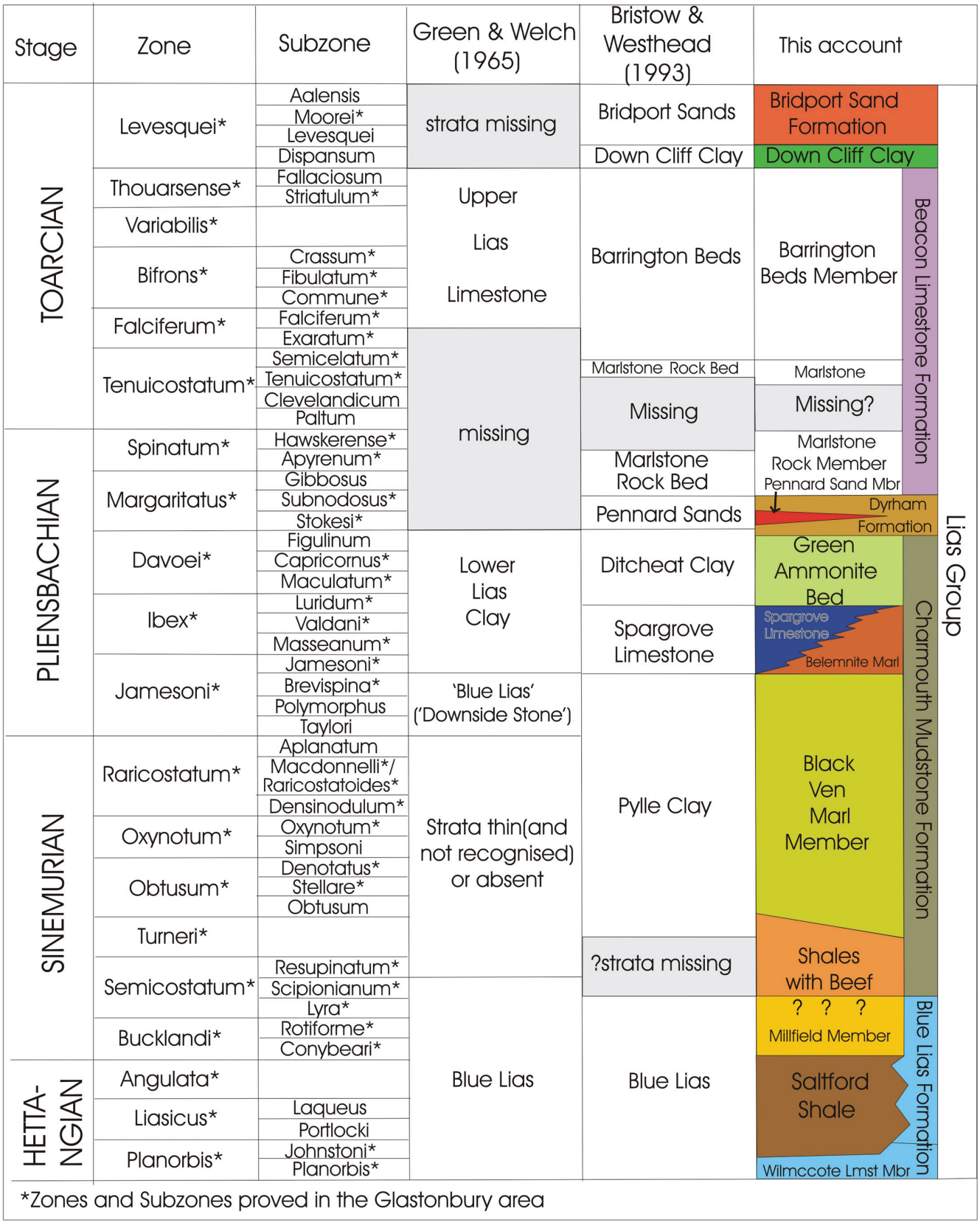

Figure 1. *Correlation of Hettangian, Sinemurian, Pliensbachian and Toarcian Strata in the Glastonbury area.*

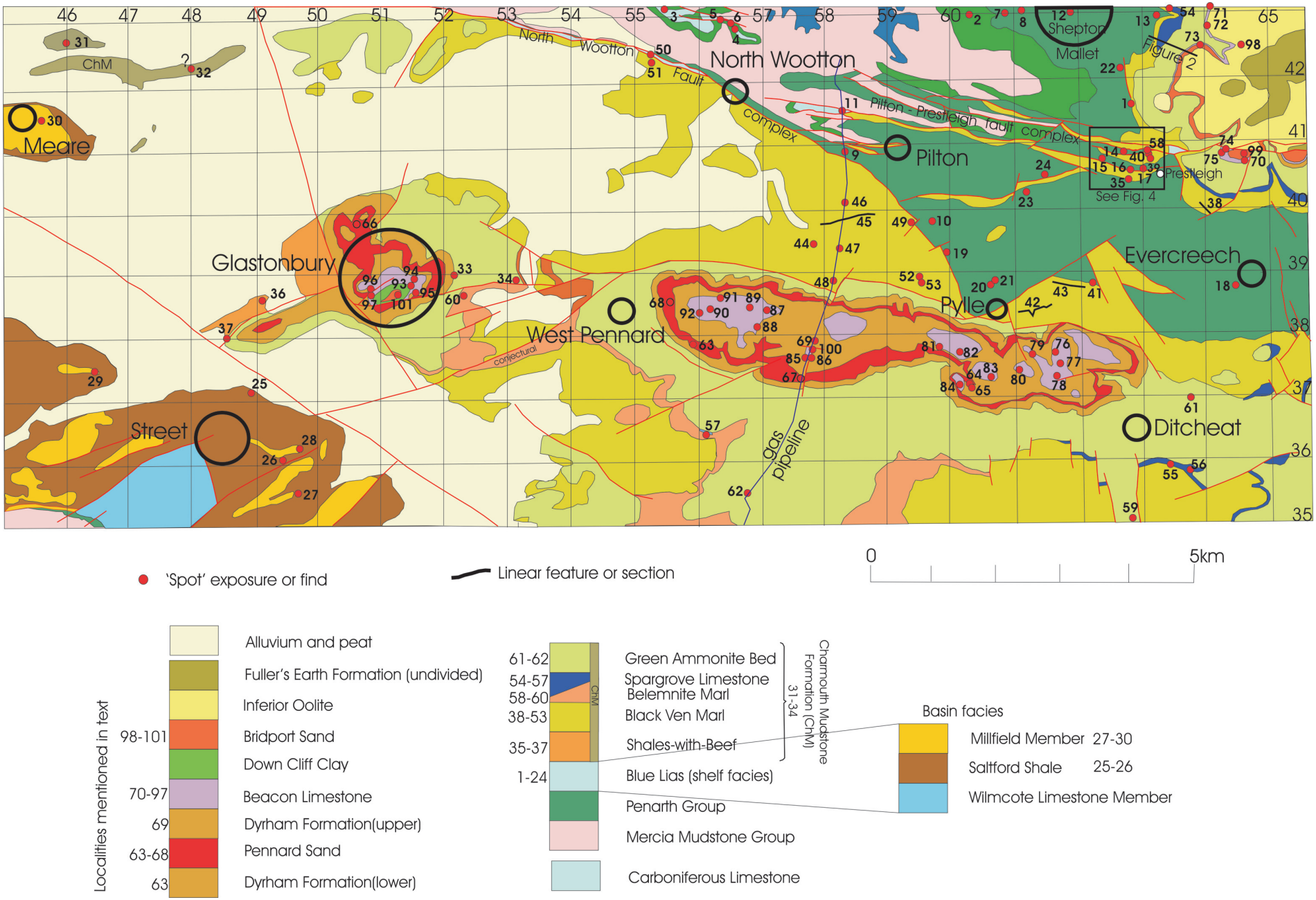

Figure 2. *Geological map of the Glastonbury-Shepton Mallet area. Based upon 1:10,000 scale geological mapping, British Geological Survey © NERC. All rights reserved CP14/018.*

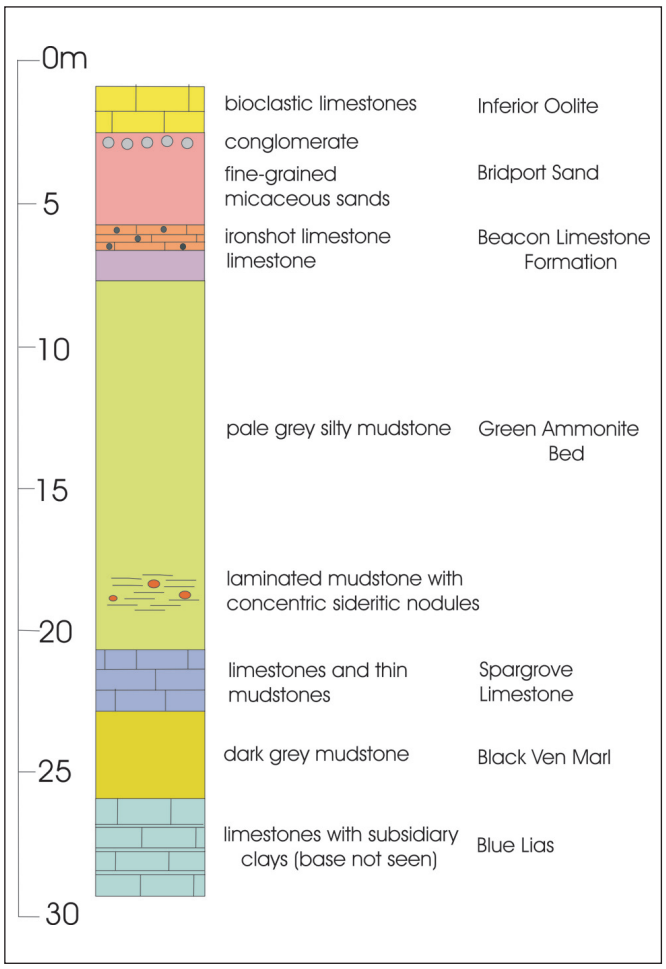

Figure 3. *Schematic section through the Lias Group of the Littoral Area.*

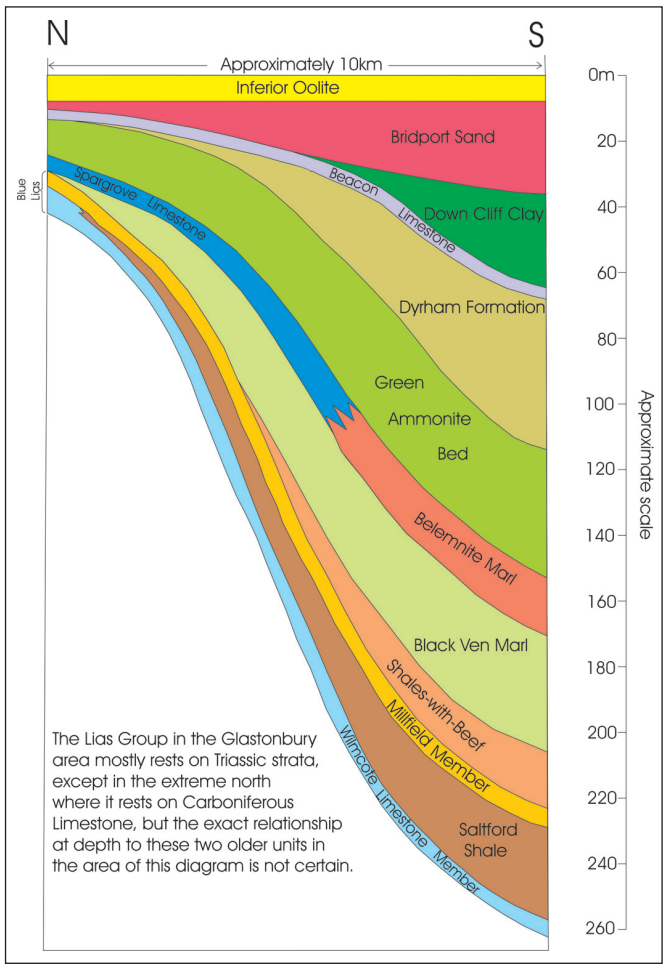

Figure 4. *Schematic N-S cross section of the Lias Group from 'shelf' to 'basin'.*

Blue Lias Formation

In the south-western, basinal area, the Blue Lias Formation is tripartite and up to about 40 m thick. We extend Ambrose's (2001, fig. 3) use of the name Wilmcote Limestone Formation (which stops at Saltford cutting) south of the Mendips, in applying this name to the lowest group of limestones and shales of the Blue Lias in the Street area. This member consists of up to 5 m dominantly of micritic limestones with thin interbeds of mudstone (i.e. typical Blue Lias facies) of latest Triassic and Planorbis Zone age; a median unit, the Saltford Shale Member, comprises up to 30 m dominantly of silty mudstones, but with a few thin micritic limestones, ranging in age from Liasicus to Angulata zones, and the uppermost unit, the newly named Millfield Member of early Bucklandi Zone, Conybeari Subzone age (upper age limit not known as the top is nowhere exposed in the present area) consists of mudstones with some micritic limestone beds up to 3 m thick.

On the littoral area of north Somerset, the Blue Lias consists of three contrasting facies. Around Shepton Mallet [619 444 and 635 448] is a 'littoral' facies, the *Downside Stone* (Richardson, 1911). It comprises up to 20 m of massive, coarse-grained, detrital, locally conglomeratic, limestone, but with no argillaceous beds. It is fossiliferous with abundant bivalves and gastropods, but only rare ammonites of Hettangian (Planorbis, Liasicus and Angulata zones) and earliest Sinemurian (Bucklandi Zone) age. It represents shallow-water deposition on the south flank of the Mendips high. The southern boundary of this facies is more-or-less the line of the Bodden Fault on the 1:50,000 Wells (280) Sheet and its eastwards continuation, the Cranmore Fault on the 1:50,000 Frome (281) Sheet. This facies is not considered further in this account (but see Bristow and Donovan, 2003).

South of the Bodden/Cranmore faults, the Blue Lias consists of coarsely crystalline to fine-grained and argillaceous, bedded limestones, in beds usually less than 0.3 m thick, interbedded with thin mudstones. This typical 'Bowlish' facies was formerly exposed at Bowlish [6118 4392] just beyond the northern boundary of the Glastonbury district (but see Figure 5). In the old railway cutting [602 429] west of Shepton Mallet (Figure 2; Locality 2[1]) only the strata of Angulata and Bucklandi zones are typical Bowlish facies. The Cannard's Grave section [629 416 (**1**)] (Donovan, 1958; Green and Welch, 1965), which is also of Hettangian and earliest Sinemurian (Bucklandi Zone) age, has a slightly higher percentage of mudstone throughout. The 'Bowlish' facies passes rapidly southwards into the more 'normal', thicker, basinal facies of the Blue Lias, either gradually or perhaps abruptly across the Warminster Fault and its westward continuation through Maes Down (see localities **74** and **75** for location) and the fault complex passing through Prestleigh, Beard Hill (see Figure 6) and North Wootton. It ranges in age from the Planorbis Zone to the Semicostatum Zone, Lyra Subzone.

The thickness of the Blue Lias varies from 6.5 possibly up to 25 m on the littoral area, but an accurate calculation of the thickness is not possible in the absence of dip measurements or good biostratigraphical control. The only complete section through the Blue Lias on the shelf area is the section in the former railway cutting [629 416 (**1**)], now filled, at Cannard's Grave where the formation is 7.3 m thick (Donovan, 1958). A somewhat thicker (8 m), but incomplete, sequence was seen at Bowlish just north of the district (Figure 5). Farther west, another incomplete section (6.75 m) was seen in the old railway

[1] Location numbers in bold are shown on Figure 2.

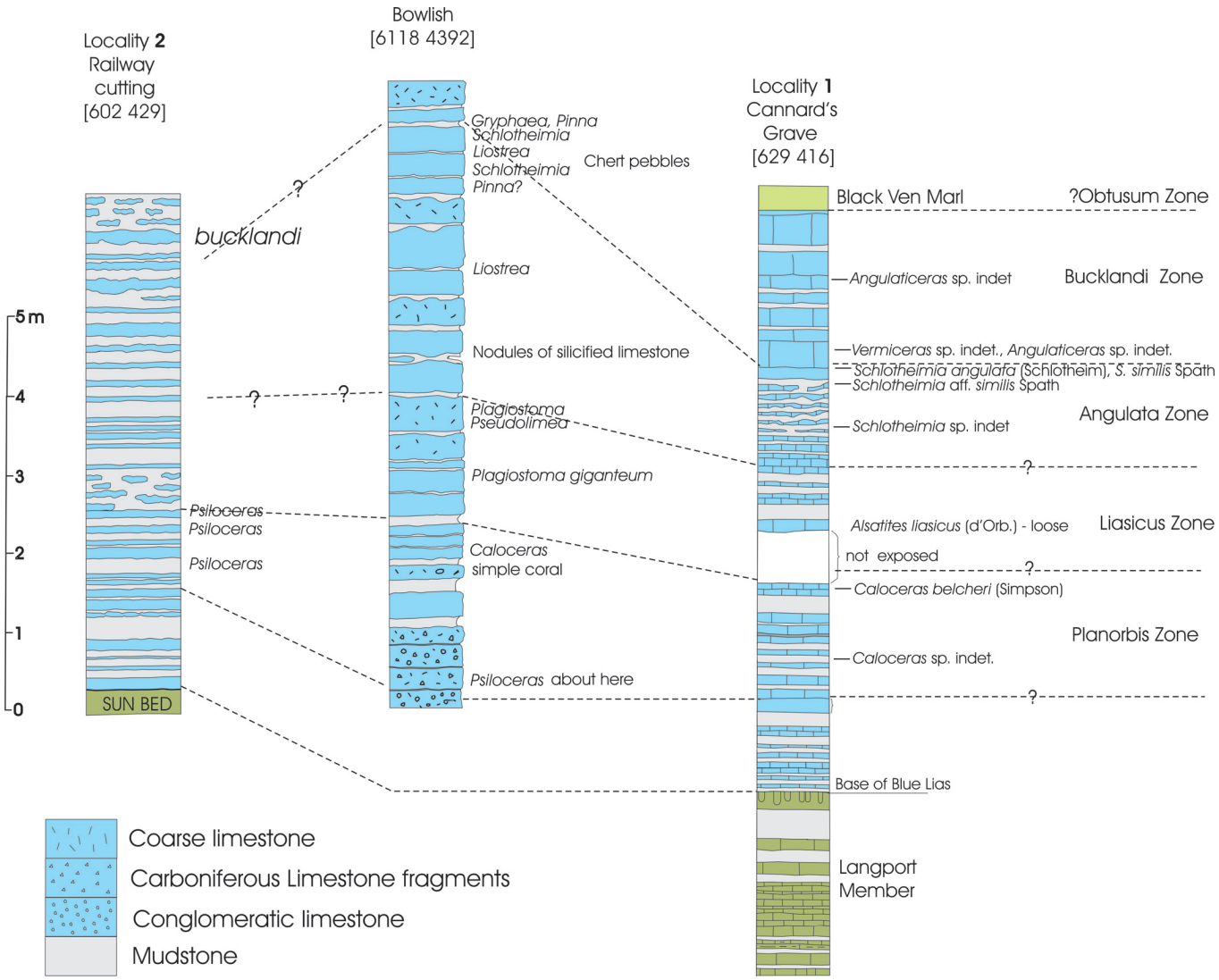

Figure 5. *Comparative sections in the Blue Lias Formation of the Shepton Mallet-Cannard's Grave area.*

cutting [*c.* 602 429 (**2**)] west of Shepton Mallet (Figure 5). Boreholes east [626 436] and south-east [628 431] of Shepton Mallet church, presumably sited on limestones of Bucklandi Zone age, proved respectively 19.8 and 21.3 m of Blue Lias above the Penarth Group (Green and Welch, 1965).

The suburb of West Shepton is largely built on the upper surface of Bowlish facies limestones. Excavations have yielded fossils indicating the Hettangian-Sinemurian boundary, as in a housing estate at Bowlish [6118 4392], just beyond the northern boundary of the area considered in this paper, where ammonites included *Caloceras* sp. and *Schlotheimia* indicating mid- to late Hettangian, but also *Vermiceras, Coroniceras schloenbachi* and *Arietities bucklandi* indicating the Sinemurian Bucklandi Zone, Rotiforme Subzone (Figure 5). Indications of several successive horizons in a small flat area seem to indicate that the ammonite subzones are thin in the upper part of the Bowlish facies here.

The base of the Blue Lias resting on the Triassic Langport Member in the Glastonbury area is known with certainty only in the Cannard's Grave [629 416 (**1**)] railway cutting (Donovan, 1958), the old railway cutting [602 429 (**2**)] west of Shepton Mallet, and from brash on Launcherley Hill [5550 4307 (**3**)] and near Wormington Cross [5660 4278 (**4**)] where *Psiloceras sampsoni* indicative of the Planorbis Subzone has been found. Elsewhere, the formation is in fault contact with the Black Ven Marl. In the Worminster Cross area, a probable *Macrogrammites* sp. from brash in a fault sliver [5643 4290 (**5**)] is indicative of the Liasicus Zone. At Cannard's Grave [629 416 (**1**)], the Liasicus Zone was proved by a loose specimen of *Alsatites liasicus*. Strata of Angulata Zone age were proven near Worminster Cross [5656 4285 (**6**)] where *Schlotheimia* sp. was found in brash low down in the sequence; in brash at the Shepton Mallet Cricket Ground [609 431 (**7**)] (*Schlotheimia postangulata* Lang); *Schlotheima* sp. in a nearby trench [6102 4335 (**8**)], and near Pilton [5816 4085 (**9**) and 5965 3972 (**10**)] (stratigraphical positions uncertain because of faulting).

Most of the other dated finds in the Blue Lias of the littoral area indicate the Bucklandi Zone, with just a few of confirmed Semicostatum Zone, Lyra Subzone age. In one of the fault slivers of the gas pipeline trench near Pilton, interbedded limestone and mudstones yielded Bucklandi Zone fossils [5818 4146 (**11**)] (Donovan *et al.*, 1989, p. 304). A section in the old railway cutting [619 432 (**12**)], Shepton Mallet is described by (Duff *et al.*, 1985, p. 93). There, a 2.6 m section showed some twelve to fifteen beds of pale grey sandy and shelly limestones with thin interbedded mudstones, 2 m thick, overlain by 0.6 m of disturbed mudstone and stone. Fossils include *Arietites bucklandi, Cenoceras, Pleurotomaria anglica, Pleuromya, Chlamys, Pecten* and *Plagiostoma* indicative of the Bucklandi Zone. The limestones are of a type intermediate between the Downside Stone and Blue Lias. A temporary exposure [6320 4284 (**13**)] south of Charlton exposed about 1 m of bedded limestone in beds 0.1 to 0.15 m thick, and with no interbedded mudstone; fossils included common *Gryphaea* and an impression of *Vermiceras conybeari* (J. Sowerby) indicative of the Bucklandi Zone, Conybeari Subzone.

On Beard Hill, there are several old quarries (see Figure 6). One of these [6275 4078 to 6296 4077 (**14**)] was figured and described by Duff *et al.* (1985, p. 94, photo 4). At the western end of the section, some 6.5 m of planar bedded, but with undulating tops and bottoms, limestones in units up to 0.3 m thick, separated by thin (5 mm thick) mudstones could be seen (Figure 7). Large specimens of *Arietites* indicate that most of this section falls in the Bucklandi Zone, but the occurrence of *Arnioceras* towards the top of the section shows that it extends up into the Semicostatum Zone. The presence of nautiloids (presumably *Cenoceras*) is unusual in such a shallow-water facies. On the south side of Beard Hill, an old quarry [6243 4064 (**15**)] in a different fault block exposes a 3-m section dominantly of thin-bedded, dark grey, limestones in beds 0.1 to 0.3 m thick interbedded with thin (1 to 10 cm thick) grey silty mudstone. In a small gully [6286 4049 (**16**)] to the ESE, an 8-m section in the beds of the Beard Hill section were seen. Near the top, *Coroniceras* indicates a horizon high in the Bucklandi Zone. At the southern end of the section, the beds dip steeply, up to about 45°, at 10°, but the dip decreases northwards. Farther east, in the same fault block, another quarry [6298 4049 to 6312 4050 (**17**)] exposes a 4.5 m section [6298 4050] dipping 10°NNE (Table 1). All the limestones in this section are argillaceous and dark grey on fresh fractures, with scattered brachiopods and bivalves (including *Gryphaea*). The *Coroniceras* indicates the late Bucklandi/basal Semicostatum Zone. At the eastern end, a slightly different section [6304 4050] in the same part of the sequence showed a slightly higher proportion of mudstone to limestone than Beard Hill Quarry (**14**), indicating the transition, gradual or across growth faults, from the mudstone-starved Bowlish facies to the basinal Blue Lias south of the present area.

There are several old quarries at Evercreech, now built over. One south of Leighton Lane is still open, and a 2-m section [6430 3856 (**18**)] in interbedded limestone and grey silty mudstone was cleaned up by the (then) Nature Conservancy. Duff *et al.* (1985) noted that fossils were plentiful and could be easily picked out of the mudstones. They include the brachiopods *Lobothyris, Spiriferina* and *rhynchonellids*, bivalves, including *Liostrea, Gryphaea, Oxytoma* and *Entolium*, gastropods, belemnites, crinoid columnals and ostracods. The limestones contain ammonites indicative of the Bucklandi Zone and *Plagiostoma giganteum*; fragments of carbonised wood are common. The section has been designated a RIGS site.

South-east [5995 3917 (**19**)] of Pilton, a 2-m exposure of interbedded limestone and grey silty mudstone yielded *Metophioceras* sp. indicative of the Bucklandi Zone, Conybeari Subzone. Farther south-east, near Pylle, ammonites from an old quarry [6068 3865 (**20**)] included *Charmasseieras, Coroniceras kridion* (Zieten) and *Vermiceras scylla* (Reynès) indicative of the Bucklandi Zone. *C.* cf *charmassei* was also found in the nearby railway cutting [6085 3880 (**21**)] where beds of limestone up to 0.15 m thick are interbedded with grey mudstone. Roadworks near Cannard's Grave [around 627 421 (**22**)] exposed a pale grey and crystalline limestone weathering to a yellowish brown, bedding surface beneath topsoil. It contained disarticulated bivalves, gastropods and ammonites, including small *Arnioceras* and *Coroniceras* indicative of the lower part of the Semicostatum Zone. The Black Ven Marl crops out as a small outlier in one area [626 420] on the south-west of the site, and as part of the main outcrop on the east of the site. Near Whitecroft Farm, limestone brash [6130 4022 (**23**)] yielded *Piarorhynchia* sp., *Coroniceras (Paracoroniceras)* cf. *charlesi* (Donovan), echinoid spines and a ichthyosaur vertebrum, indicative of the Semicostatum Zone, ?Lyra Subzone (Ivimey-Cook, 1993a, p. 5). To the north-east, in a different fault block, brash [6156 4048 (**24**)] included *Coroniceras* cf. *lyra* and *C.* cf. *quadratum* Donovan, indicative of the Semicostatum Zone, Lyra Subzone (Ivimey-Cook, 1993a, p. 5). Just south of the present area, strata of probable Semicostatum Zone age were exposed in a brickpit at Hornblotton Mill [ST 593 322] (Woodward 1893, p. 85; Kellaway and Wilson, 1941, p. 141).

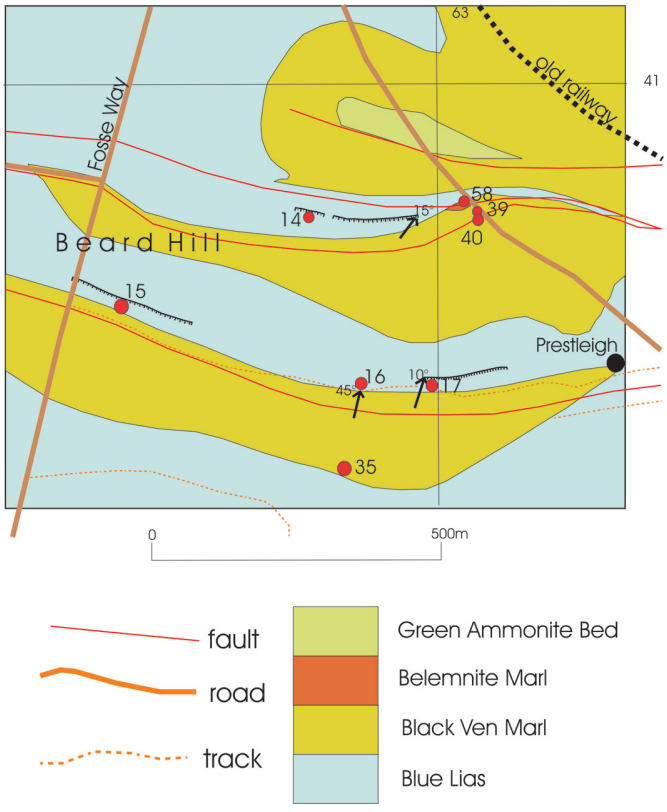

Figure 6. *Detailed map of the Beard Hill-Prestleigh area (see Figure 2 for location).*

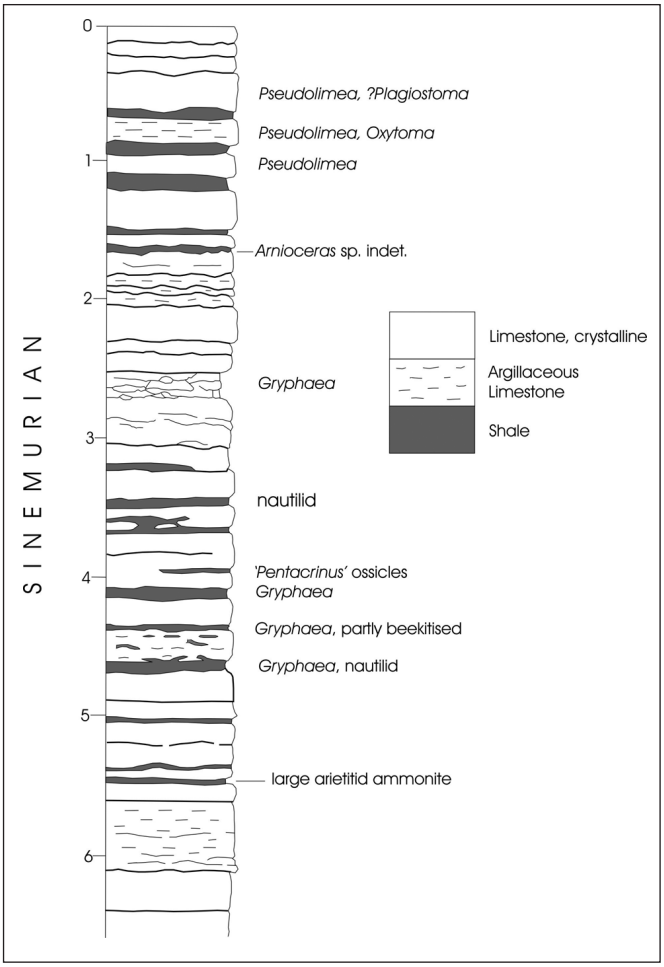

Figure 7. *Beard Hill Quarry section [628 408].*

Unit	Thickness (m)
Limestone, thinly bedded in beds 0.1 to 0.3 m thick, with thin (up to 10 cm) beds of grey silty mudstone or clayey silt	2.00
Limestone, nodular, with irregular (?rippled) tops and bottoms; mudstone irregularly present and thickest in troughs; in the basal limestone with *Coroniceras (Arietites)* cf. *bucklandi*	1.00
Limestone, planar-bedded	0.16
Mudstone, silty, dark grey	0.12
Limestone, planar-bedded	0.30
Limestone, nodular with irregular tops and bottoms in beds 7 to 15 cm thick, alternating with thin (up to 10 cm thick) grey, silty mudstone	0.95

Table 1. *Quarry section [6298 4050] in Blue Lias Formation.*

Basinal area

The Blue Lias, as described by William Smith (in Townsend, 1813) in the Bath area, consists of two groups of the characteristic alternating thin limestones and mudstones, separated by the Saltford Shale Member (Donovan, 1956), the thickest development being about 18 m (Donovan and Kellaway, 1984). The equivalent beds on the Dorset coast section are similar, but a little thicker, about 26 m. Long regarded as the basal formation of the Jurassic System, the lowest part of the Lias Group was pushed into the Triassic System by the international decision to fix the base of the Jurassic at the earliest appearance of ammonite fossils. The basinal depositional area of central Somerset has a similar tripartite subdivision. The numerous quarries at Street, famous for fossil reptiles, exposed the equivalent only of Division A of Donovan and Kellaway (1984, p. 6).

Wilmcote Limstone Member: The name Wilmcote Limestone Member (Ambrose, 2001) is a formal replacement name for the 'Passage beds' (Woodward, 1893, p. 76) and 'basement-beds of the Lower Lias' (Woodward, 1893, p. 79). It is equivalent to Division A [Basal Blue Lias limestone] of the Bristol area (Donovan and Kellaway, 1984); the St Mary's Well Bay Member of South Wales, and the Barnstone Member of the East Midlands. The dominant lithology is an alternating sequence of thin (maximum of 0.3 m thick), bluish grey, shelly, micritic, limestones and dominantly medium grey mudstones (maximum of 0.4 m thick). Fossils, dominantly bivalves, include: *Modiolus, Lima* spp., *Psiloceras planorbis*, cidarids, and reptilian bones. The lower boundary, which was not exposed in any of the recorded Street quarries, is taken at the top of the Sun Bed (a bored, porcellanous, limestone at the top of the Langport Member [=White Lias Formation]). The upper boundary is not exposed, but is taken at the upward change from a dominantly limestone sequence to the dominantly mudstone sequence of the Saltford Shale. There is no mappable subdivision, but many local terms were used for individual beds (Clogs, Yellow Bed, Corn-size Building-Stone, Bunch Back, Clay Bat, etc.) (see Figure 8). Only a partial thickness of about 6 m is known. *Ammonites planorbis* (i.e. *Psiloceras* sp.) was recorded from the upper part of the quarry sections. The age of the Wilmcote Limestone Member is thus latest Trias and earliest Jurassic (Planorbis Subzone), as is Division A in the Bath area.

Saltford Shale Member: Because of extensive superficial cover and faulting, the outcrop of the Saltford Shale is uncertain. Woodward (1893, p. 81) recorded "*beds of clay with bands of limestone*" at Mead's Batch [probably about ST 489371 (**25**)] just north of Street church, which yielded *Am. Johnstoni*

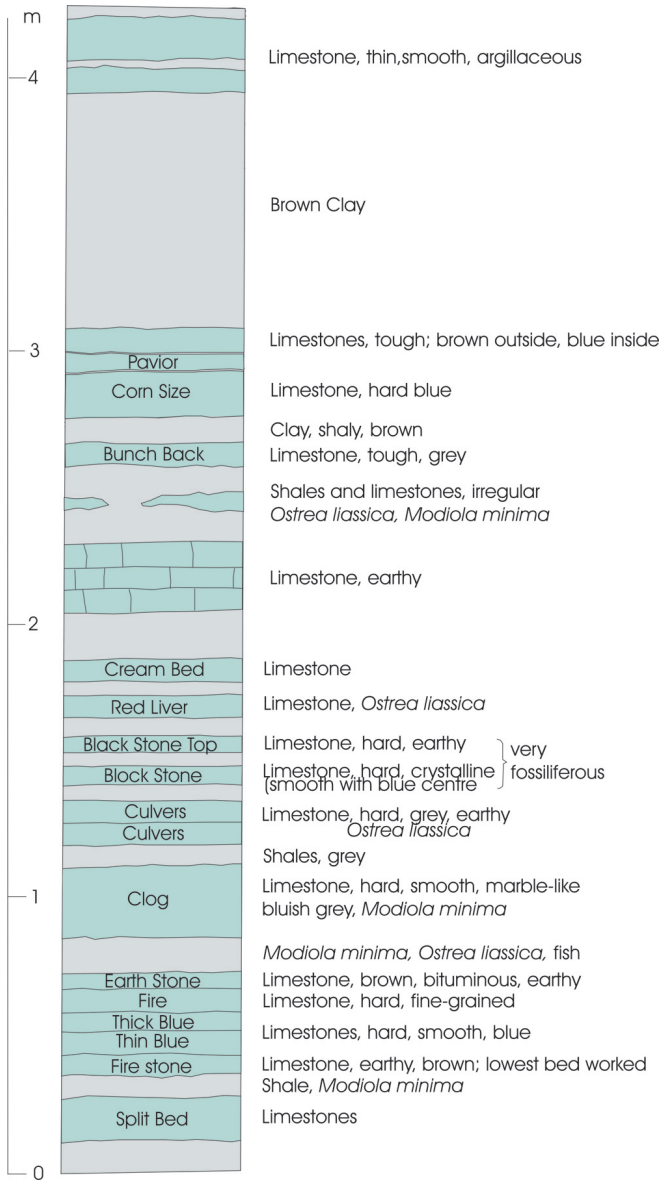

Figure 8. *Section through the Wilmcote Limestone Member of the Blue Lias Formation, Pym Quarry, Street (after Bristow and Etheridge, 1873).*

(i.e. *Caloceras* sp.) and *Am. angulatus* (i.e. *Schlotheimia* sp.) along with *Gryphaea* and other bivalves indicative of the Angulata Zone and possibly Liasicus Zone. The Saltford Shale here would be the equivalent of Divisions B (Saltford Shale) and C at Saltford cutting (Donovan and Kellaway, 1984, fig. 10) where they are about 10 m thick. The member spans the Liasicus and Angulata zones. The thickness of the member in the Street area is 30 m as proved in a borehole [4937 3606 (**26**)] in the grounds of Millfield School which started just below the base of the Millfield Member and reached limestone with *Caloceras johnstoni* at a depth of 30 m at the top of the presumed Wilmcote Limestone Member.

Millfield Member: The Millfield Member in the present area was mapped from just west of Walton [450 360] to Burleigh Wootton on the south side of the River Brue [505 355]. In this area, micritic limestone, up to 3 m thick, appears to be the basal bed of the member and caps low hills. North of Walton, the Millfield Member caps the hill at Sharpham Park [460 375] and underlies much of Meare [450 410]. Levelling of a sports field of Millfield School resulted in large blocks of limestone being dumped on the south side of the playing fields [4935 3546 (**27**)] on the bank of a stream. The limestone carries large (>30 cm) ammonites and brachiopods. There may be a single bedding plane with ammonites. They are all crushed flat, but the many narrow whorls and close ribbing indicate *Vermiceras longidomus* (Quenstedt) or a closely related species of Bucklandi Zone, Conybeari Subzone age, at or close to the base of the Sinemurian Stage. The situation compares with the Calcaria Bed of sections of the Blue Lias in the Bristol Avon valley (Donovan and Kellaway, 1984, p. 29) where similar large *Vermiceras* on the upper surface of the bed, probably a condensed deposit, mark the earliest Sinemurian fauna. In the present area, we suggest that the Millfield Member marks a temporary cessation of muddy sedimentation which allowed limestone to be deposited and the accumulation of ammonite fossils. Ammonites indicative of the Bucklandi Zone, Conybeari Subzone include *Vermiceras* sp. indet. from brash close to the base of the member east of Street [4971 3622 (**28**)]; loose ammonites at Sharpham Park House [4650 3745 (**29**)] include *Vermiceras* cf. *longidomus*; in the Cemetery at Meare [456 466 (**30**)], blocks of fine-grained argillaceous limestone yielded two specimens of *Vermiceras*. Both are close-ribbed species identified in the Weston-super-Mare memoir (Whittaker and Green, 1983) as *V. solaroides* (Costa) and similar to, or identical with, the better known *V. spiratissimum* (Quenstedt).

Charmouth Mudstone Formation

The Charmouth Mudstone Formation has a fault-bounded outcrop on the north side of Pennard Hill, covered by superficial deposits, and a broader (>2 km), outcrop on the south side of the hill. The formation comprises five members, not all of which are present in the same area: in ascending sequence, Shales-with-Beef (only locally developed or recognised), Black Ven Marl, Belemnite Marl (mainly in the west and south), Spargrove Limestone (locally developed in the east) and Green Ammonite Bed, but over much of the area, only the Black Ven Marl and Green Ammonite Bed are present. The formation is rarely exposed.

In the extensively drift-covered area in the north-west between Meare and Godney, there is insufficient exposure or biostratigraphical control to subdivide the Charmouth Mudstone Formation. The lithology of pale to medium grey silty mudstones suggests the Green Ammonite Bed, but the only fossils found is a ribbed ammonite with smooth venter at 30 mm diameter (*Angulaticeras?* sp.) [4599 4273 (**31**)] in a fine-grained pale grey limestone on one of the 'islands' west of Lower Godney, and an echioceratid ammonite indicative of the Raricostatum Zone from a ditch [grid ref. uncertain - either 480 413 or 480 423 (**32**)], in fine-grained limestone. The thickness of the formation on the shelf area in the north-east is between 30 to 40 m. In the Norwood No. 1 [5215 3900 (**33**)] and No. 2 boreholes [5315 3878 (34)] in the basinal area, the thickness is at least 100 m (see Figure 9).

The age of the base of the formation is diachronous. In the area between North Wootton and Prestleigh [635 405], black mudstones of the Black Ven Marl have yielded Turneri Zone fossils (see below) equivalent to the Shales-with-Beef of the Dorset Coast (Wilson *et al.*, 1958), but further north, in the Cannard's Grave area [629 416 (**1**)] strata of Turneri Zone age are absent (Donovan, 1958).

Shales-with-Beef Member: The lowest 43 m in the Norwood No. 2 Borehole [5315 3878 (**34**)] were silty mudstones of Semicostatum Zone, Scipionianum Subzone age. The base was not proved (see Figure 9), but on the Dorset coast, strata of this age fall within the Shales-with-Beef and overlie limestones of the Blue Lias. On the south facing slope below Beard Hill quarry (see locality **16** above), a trench [6284 4035 (*35*)] in mudstone with pieces of 'beef' up to 5 mm thick, yielded a small fauna with *Arnioceras* indicating an age not later than Obtusum Zone, more probably the Turneri Zone. The fauna from two localities near Glastonbury in the basinal area suggests a level within the Black Ven Marls (Obtusum Zone), but the lithology of mottled grey and orange-brown (as opposed to dark grey or black), silty mudstone is not characteristic of that member. They are regarded therefore as the youngest part of the diachronous top of the Shales-with-Beef. At Beckery, west-south-west of Glastonbury [4915 3865

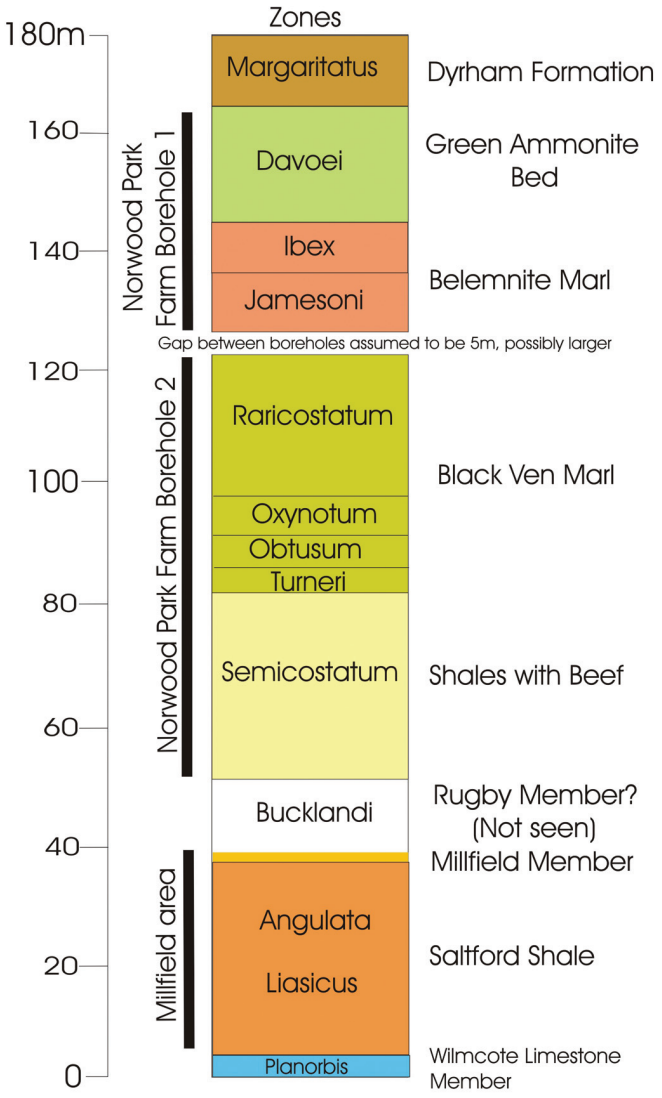

Figure 9. *Composite section through the lower part of the Lias Group of the Glastonbury-Street area.*

(**36**)], an excavation in stiff, mottled orange and grey, silty mudstone with the ammonites *Promicroceras, Asteroceras smithi?* and *Xipheroceras* also indicative of the Obtusum Zone was seen. At Northover [*c.* 485 380 (**37**)], Woodward (1893, p. 84) found "Ammonites [Xipheroceras] Dudressieri" (an old form of *A. planicosta*) in a limestone nodule. On the Dorset coast, *dudressieri* occurs in the Obtusum Zone, Stellare Subzone, in the middle of the Black Ven Marl.

Black Ven Marl Member: The Black Ven Marl (the Pylle Clay of Bristow and Westhead, 1993) is equivalent to the Lower Lias Shales of Duff *et al*. (1985), and the lower part of the Lower Lias Marls of Kellaway and Wilson (1941). It corresponds more-or-less to the Charlton Bank Series of the Soil Survey (Avery and Osmond, 1955). The member consists of very dark grey, almost black, mudstone and usually has a very thin (<1 m) weathered profile compared to the mudstones of the Green Ammonite Bed. Scattered, thick (up to 0.6 m), micritic limestones occur in the lower part of the member, with only a few thin muddy limestones higher in the sequence. Although poorly exposed, temporary sections show that the Black Ven Marl is richly fossiliferous with common ammonites and, less commonly, belemnites [6314 3752, 6330 4308]. The ammonites indicate that the Black Ven Marl ranges from the Turneri Zone to at least the Raricostatum Zone, Macdonnelli Subzone, but may range up into the Jamesoni zone.

The member thickens southwards from the Mendips. There is a narrow outcrop around the lower slopes of Ingsdons Hill [636 435]. At the western end of the hill [632 434], just north of the present district, about 2 m of dark grey calcareous mudstone, resting on Bowlish facies limestone, is succeeded by pale grey silty mudstone, presumably the Belemnite Marl Member (not mapped separately, but included with the succeeding Spargrove Limestone). There is a slightly wider, but fault-bounded, outcrop farther south around Whitstone Hill [634 415], where the member is about 8 m thick. In a borehole [6286 4181] nearby, 11 m of stiff, dark grey silty mudstone was proved. In the fault slivers at Beard Hill [624 405] (see Figure 6), the member is at least 15 m thick. To the west, there are more fault-bounded slivers. Just east of Pylle [615 384], the Black Ven Marl is about 30 m thick, and it is probably a similar thickness near North Wootton [566 416]. There is an extensive, fault-bounded, outcrop, on the north side of the Glastonbury-Pennard Hill ridge. South of this ridge, south of West Pennard, and south-west and south-east of Ditcheat [615 355 and 635 355] it is also estimated to be about 30 m thick.

On the north side of Shepton Mallet, just beyond the district in the present study, there is a small, partially fault-bounded, crop of Black Ven Marl. Some 3 m were proved in an excavation for a gas holder [6185 4403] and yielded *Furcirhynchia* sp., *Pseudopecten priscus* and belemnites. Dark grey, non-calcareous, stiff mudstone exposed in the cemetery nearby [*c.* 6170 4406] yielded *Gleviceras* sp. aff. *guibalianum* S. S. Buckman indicative of the Raricostatum or early Jamesoni Zone (Green and Welch, 1965, p. 104). In the Cannard's Grave section [629 416 (**1**)] (Donovan, 1958), the Black Ven Marl was exposed at the top of the east side of the cutting [6290 4170]. Woodward (1893) recorded 9 m of clay at this locality. Ammonites recorded by Donovan (1958) indicate a range from the Oxynotum Zone and Subzone to the Raricostatum Zone, Macdonnelli Subzone, and that the Turneri Zone is absent. Woodward (1876, p. 101) recorded "*blue clay, with impersistent beds of earthy limestone, with* 'Am. oxynotus' [Oxynoticeras]" overlying Blue Lias in the railway cuttings between Evercreech and Prestleigh [641 398? to 637 405? (**38**)], again suggesting strata of Turneri Zone age [Shales-with-Beef] are absent. Above the clays, he noted "*about six feet of grey earthy limestones and clays containing Belemnites*". To the north-west, blocks of shelly grey limestone in a predominantly mudstone sequence on one of the fault slivers near Prestleigh (see Figure 6), yielded a probable *Oxynoticeras* [6314 4074 (**39**)] indicative of the Oxynotum Zone as well as Raricostatum Zone fossils [6311 4076] (**40**).

A thin limestone forms a low southward-dipping feature about 15 m above the base of the Black Ven Marl east of Pylle [6105 3825 to 6160 3833 (**42**)]. A similar southward-dipping feature, but only about 2 to 3 m above the base of the mudstone occurs south of Street on the Fosse [6157 3873 to 6224 3865 (**43**)]. Some 2 m of the basal beds of the Black Ven Marl are exposed at the top of the old railway cutting [6225 3875 (**41**)] at Street on the Fosse. Around Holt Farm [578 394 (**44**)], dark grey mudstones several metres thick with common interbedded limestones 0.2 to 0.6 m thick occur. Limestone is common in the soil brash [5782 3949]. Along the Whitelake Stream, beds of limestone up to 25 cm thick floor the stream over a 700 m tract [5808 3970 to 5877 3986 (**45**)]. Close by, thin beds (*c.* 10 cm) of limestone interbedded with dark grey mudstone can be seen in the stream bed [5885 3969 and 5891 3955]. A little farther north, dark grey mudstone, also with limestone interbeds, yielded [5820 4015 (**46**)] *Arnioceras* sp. indicative of an age not younger than mid-Obtusum Zone. Thus, these mudstones with thin limestone beds appear to occur in the lower part of the member. Strata no younger than the mid-Obtusum Zone were proved by *Arnioceras* on the northern slope of Pennard Hill [5808 3890 (**48**)], and *?Arnioceras* in dark mudstones south of Pilton [5932 3970 (**49**)].

The brachiopod *Piarorbynchia radstockiensis* found in limestones [5815 3940 (**47**)] in the gas pipeline trench (Donovan *et al.*, 1989) would suggest an occurrence higher in the sequence as it is thought to indicate the Jamesoni Zone (Ager, 1962) at a level close to the Black Ven Marl/Green Ammonite Bed boundary and equivalent to part of the Spargrove Limestone of areas to the east and north-east. However, south of Pennard Hill, the only limestone found close to the Black Ven Marl/Green Ammonite Bed boundary [between 5600 3648 to5625 3643], differed from the above by containing common belemnites.

Strata of Turneri Zone age were proved in the North Wootton fault sliver [5543 4229 (**50**)] where a calcareous nodule in steeply dipping dark grey mudstones at least 25 m thick yielded *Caenisites* sp., probably *C. turneri*; a loose specimen 100 m to the south [5540 4214 (**51**)] on the main crop of the Black Ven Marl is *C. turneri*. Limestone nodules 20 to 25 cm across in medium grey mudstones south of Pilton yielded *?Caenisites* sp. [5950 3895 (**52**)] and *Caenisites* grp. *turneri* [5954 3894 (**53**)]. Just south of the present area, *Caenisites* indicating the Turneri Zone was found in finely laminated mudstones at the junction of the Rivers Alham and Brue [607 329] (Hollingworth *et al.*, 1990, fig. 90). Further east along the Brue, the Obtusum Zone with *Asteroceras* (i.e. probably the Obtusum or Stellare Subzone) [612 328], and the Oxynotum Zone with *Oxynoticeras oxynotum, Bifericeras bifer* and *Angulaticeras* at [616 333] was proved. A well at Sutton [*c.* 622 335] yielded fossils which showed that it penetrated the Raricostatum Zone into the Oxynotum Zone (Kellaway and Wilson, 1941, p. 142). A little farther south, the Turneri Zone is indicated in the Wheat Hill railway cutting [585 310] by '*Am. brookei*', presumably *Caenisites* (Woodward 1905, p. 103, p. 104; Kellaway and Wilson, 1941, p. 141). The cutting is about 10.5 km south-east of Glastonbury. In the Norwood No. 2 Borehole [5315 3878 (**34**)], strata equivalent to the Black Ven Marl is at least 40 m thick (see Figure 9).

Spargrove Limestone Member: The Spargrove Limestone (Bristow and Westhead, 1993) comprises up to 2.5 m of interbedded muddy limestones, in beds up to 0.1 m thick, and thin silty mudstones, that crop out in the east of the district. To the north on the adjacent Wells (280) Sheet, an outlier [615 448] of Spargrove Limestone on the south side of Windsor Hill is erroneously included as part of the Downside Stone facies of the Blue Lias (Green and Welch, 1965, p. 103). In its type area [672 380] east of the present district, it forms well-featured ground and an outcrop width of over 300 m. In the Alham Borehole [6793 4118] east of the district, 7.6 m of massive limestones overlie the Blue Lias (the Black Ven Marl is missing). The Jamesoni and Valdani limestones of the Radstock area,

north of the Mendips, are equivalent to the Spargrove Limestone, but of a different lithology (hard, massive limestones forming a lenticular body, several metres thick, and representing the whole of the Jamesoni + Ibex zones (Tutcher and Trueman, 1925; Green, 1992). A rich ammonite fauna, detailed in Bristow and Westhead (1993) Westhead (1994) and Ivimey-Cook (1993a), indicates all subzones between the Jamesoni Zone, Jamesoni Subzone, and Ibex Zone, Luridum Subzone, with most of the member falling in the latter Zone (Figure 1).

Just north of the area on the adjacent Wells Sheet, an overgrown section [6169 4484] in about 1.5 m of thin-bedded limestone along the lane north of the old railway line has yielded *Platypleuroceras* aff. *brevispina* (J de C Sowerby) (from near top of section), *Uptonia jamesoni* (J de C Sowerby) (not *in situ*, but probably from the upper half of section), *U? (Metadoceras?) submuticus* (Oppel) (from upper surface of second limestone bed from bottom of section, i.e. about 0.75 m above road level), *U. sp., Tragophylloceras undulatum* (Wm Smith) and *Liparoceras* sp. Collectively, the Jamesoni Zone is indicated, but the fauna could range up into the basal Ibex Zone. North of the River Sheppey, also on the adjacent Wells Sheet, the outcrop is about 100 m wide on the west and south-west side of Ingsdons Hill, but the thickness is no more than 2 m. Limestone with belemnites can be followed over a distance of 900 m on the west and south-west side of Ingsdons Hill. Within this tract, large body chamber fragments of *Uptonia* are common [6327 4346 to 6340 4306 (**54**)]. They include *U. lata* Quenstedt at the latter locality, whilst nearby [635 430], *Platypleuroceras* aff. *brevispina* is indicative of the Jamesoni Zone, Brevispina Subzone (Ivimey-Cook, 1993b, p. 12). In addition, poorly preserved fragments of *?Platypleuroceras* were found in the northern part [6327 4346]. The northernmost record of fossils in this tract include *Acanthopleuroceras maugenesti* (d'Orbigny) and *Tragophylloceras ibex* found in brash [6322 4360] of coarse, thin-bedded limestone. South of the River Sheppey, the Spargrove Limestone can be readily traced by augering as far as Bullimore Farm [633 423]. There, the outcrop width is up to 200 m. Southwards as far as Prestleigh, no trace of the Spargrove Limestone could be found over a 2 km-tract.

In Ditcheat Park, the Spargrove Limestone is seen as a calcareous mudstone or marly limestone [around 6215 3600]. South-east of Ditcheat, the limestone is well developed and forms well-featured ground [6300 3587 to 6345 3590 (**55**)]. In the bed of the River Alham, there are several exposures [637 358, 6376 3586, 6387 3579 and 6395 3578 (**56**)] of flaggy, calcareous siltstone with belemnites, in beds up to 0.3 m thick, interbedded with dark grey silty mudstone. Just south-east of West Bradley, a feature forming, belemnite-rich, limestone extends over a 250-m tract [5600 3648 to5625 3643 (**57**)] before passing under the Alluvium. In addition to the common belemnites, one fragmentary ammonite was found. Dr. M.K. Howarth (pers. comm., 2004) comments "*that it is probably an* Uptonia *from the upper part of the Jamesoni Zone. The whorl shape and the ribbing that is visible are those of an* Uptonia *rather than anything from the Ibex Zone*". This diagnosis suggests a unit equivalent to the lower part of the Spargrove Limestone.

Belemnite Marl Member: The presence of the member at Ingsdons Hill [632 434] has been mentioned above. Further south, a small faulted outcrop (too small to show on Figure 2; exaggerated on Figure 6) of the member was proved in a corner of the large arable field east of the A371 at Prestleigh [6305 4078 (**58**)] where abundant debris of pale grey, fine-grained limestone contained two kinds of belemnite, the ammonite *Apoderoceras* and a possible *Uptonia*. In the central south of the area, south of Huxham Farm [593 359], a unit of very pale grey, almost white, silty mudstone, 150 to 200 m wide, but partially covered by superficial deposits, caps the Black Ven Marl and occupies the same position as the Spargrove Limestone of areas to the east and north. It is regarded as Belemnite Marl. Donovan *et al*. (1989, p. 298) noted similar pale grey mudstones at the same stratigraphical level just south of the district. A small, not separately delimited, outcrop of pale grey mudstone with belemnites, and grey calcareous siltstone nodules and layers occurs in the stream bed [6277 3508 (**59**)] south-east of Highbridge Farm in the extreme south.

Farther west, from west of Lottisham [555 350], northwards to Parbrook [565 365] and then westwards to West Bradley [558 368], auger holes were fairly consistent in proving pale grey silty mudstones above dark grey mudstones of the Black Ven Marl and a tentative boundary delimiting the Belemnite Marl has been drawn. Elsewhere, the Belemnite Marl has been included as the basal part of the Green Ammonite Bed. In the Glastonbury area, a ploughed field [5215 3860 (**60**)] on the south-eastern slope of Stone Down showed pale grey silty clay soil. The lower two-thirds of the field had abundant belemnite fragments; small pieces of pale grey fine grained limestone also contained belemnites. Two specimens of the *Uptonia* were found (Wells and Mendip Museum nos. 4448, 4449). On the basis of lithology and fossils, this part of the field was identified as part of the Belemnite Marl. The upper part of the member forms a terrace or platform on the hillside, about 75 m wide, and traceable for several hundred metres. The feature is possibly due to a local equivalent of the Belemnite Stone (bed 121) of the coastal section. In the upper third of the field, belemnites were rare or absent so this area is regarded as the lower part of the Green Ammonite Bed, the basal boundary of which lies close to the 30 m contour. On this evidence, and from auger holes proving pale grey silty mudstone, the outcrop of the Belemnite Marl has been tentatively drawn in this area and to the west of West Pennard [around 540 385].

Green Ammonite Bed Member: The Green Ammonite Bed (the Ditcheat Clay of Bristow and Westhead, 1993) equates with the upper part of the Lower Lias Marls of Kellaway and Wilson (1941, p. 337), the Belemnitiferous and Micaceous Marls of Wilson *et al*. (1958, p. 414), and the Long Load Series of the Soil Survey (Avery and Osmond, 1955). Much of the outcrop of the member is pasture covered and consequently there are few exposures. The dominant lithology is of pale to medium grey, silty mudstone (well seen in the stream bed between Ditcheat and Wraxall [6135 3660 to 6137 3648]) that commonly has a deep (up to 2 m) weathering profile of mottled pale grey and orange clay. The parent material of the soil was described as a "*micaceous, silty clay loam*" with 36 per cent clay (<2 μm) and 54 per cent silt (2-50 μm) (Findlay, 1965, p. 97, p. 142). A few siltstone and ironstone nodules, and silty limestones, up to 0.15 m thick, occur. The outcrop is prone to landslides, both large [637 415] and small [6409 4077]. The member has an extensive outcrop, up to 2 km wide, on the south and east side of Pennard Hill, where it is about 45 m thick, but thins northwards to about 35 m on Whitstone Hill, to 30 m on the west side of Doulting Sheep Sleight, and to 25 m on the west side of Ingsdons Hill, north of which it is cut out by the Bodden Fault. An erosional remnant occurs north of the present area near Thrupe (Green and Welch, 1965, 103). The member has only a narrow (150 to 400 m wide), fault bounded outcrop on the north side of Pennard Hill.

Fossils are scarce, but include *Androgynoceras* sp. indicative of the Davoei Zone. *Androgynoceras* cf. *maculatum* and other liparoceratid ammonites were recorded from brown ferruginous nodules in "*bluish micaceous clays*" in the old brick pit [638 370 (**61**)] at Evercreech Junction (Kellaway and Wilson, 1941, p. 143), and *Androgynoceras* sp. was found in stiff pale grey silty mudstone on the south side of Pennard Hill [5665 3549 (**62**)] (Donovan *et al*., 1989). Just south of the district, ammonites (now in Wells Museum) of the Capricornus Zone were found in excavations at the Castle Cary Sewerage works [ST 630 317]. Just east of the district, a section [6657 3926] with *Beaniceras crassum* and *Lytoceras fimbriatum* show the basal beds of the Green Ammonite Bed to belong to the Ibex Zone, middle Luridum Subzone (Donovan in Bristow and Westhead, 1993).

As the top of the Spargrove Limestone also falls in the Luridum Subzone, the junction between these two units is there dated fairly precisely, but elsewhere, the top of the Spargrove Limestone may range up into the Davoei Zone.

Dyrham Formation

Dyrham Silts were mapped on the One-Inch Bath (265) sheet published 1965, becoming Dyrham Formation on the 1:50,000 version of 1990. The name Pennard Sands was proposed by Kellaway and Wilson (1941, p. 144) for the "*sandy strata below the Marlstone*". In fact, most of the beds that they included are siltstones, only a few beds in the middle of the unit achieving the grain size of fine sand. It is synonymous with, and replaced by, Dyrham Formation. In the present area, the more sandy middle part is mapped separately as the Pennard Sand Member.

The Dyrham Formation, the Martock Series of the Soil Survey (Avery and Osmond, 1955), has a wide outcrop on Pennard Hill. In the north-east, the Dyrham Formation is apparently absent, either being cut out beneath the Marlstone, or by facies change. Because the upper, very silty, part of the Green Ammonite Bed has not yielded any fossils, it is impossible to say whether the Dyrham Formation is represented by silty mudstone at the top of that member, or to determine the extent of an unconformity below the Beacon Limestone Formation. The formation has a maximum thickness of about 65 m and consists of fissile, micaceous, silty and very fine-grained sandy mudstones, with a median unit of micaceous, coarse siltstone to very fine-grained sandstone - the Pennard Sand Member. On the south side of Pennard Hill, the boundary with the underlying Green Ammonite Bed is taken at a marked negative feature break. On the north side, the boundary is commonly obscured by landslides. The lower unit of fine-grained silty and sandy mudstones varies from about 10 to 25 m thick. A silage pit at [5979 3717] at East Pennard exposed micaceous very fine-grained sand. In Glastonbury, a trench [5038 3907] along Rowley Road exposed about 18 m of pale grey, fissile, silty mudstones.

The Pennard Sand Member is best developed in the west where it is about 25 to 30 m thick. It is well exposed in the many sunken lanes that cross the outcrop. The base of the member is commonly marked by springs which give rise to extensive landslides. Eastwards, the member thins steadily to about 10 m near East Pennard and continues to thin eastwards to about 5 m on Ditcheat Hill. One of the best sections in the Pennard Sand is in the road cutting [559 379 (**63**)] north-east of Knapp Farm (Table 2). To the north-west, a section [5545 3861 to 5564 3857] along Cottles Lane has exposures up to 3 m high of massive and flaggy siltstone and very fine-grained sandstone. There are also poor exposures in the cuttings on Sticklinch Hill [5648 3878 to 5640 3865], Castle Lane [5726 3876 5718 3860], Stickleball Lane [5762 3858 to 5761 3843] and Cockmill Lane [5935 3831 to 5943 3814]. North of Wraxall, ribs of calcareous sandstone in a fine-grained sandy mudstone [6035 3715 (**64**)] in a stream bed, and blocks of ferruginous-weathered, shelly limestone in a nearby ditch [6043 3712(65)], are part of the Pennard Sand. At the latter locality, the blocks yielded '*Turbo' latilabrus, Amauroceras?* and *?Hastites microstylus* (Phillips), other belemnites and a crinoid fragment. In Glastonbury, the Pennard Sand is well seen in Wick Hollow [508 392], a sunken lane up to 9 m or 10 m deep where it is a sparsely micaceous clayey fine-grained sand, grain size about 100 µm. The upper unit of silty and fine-grained sandy mudstones is about 10 to 25 m thick, but it has an eroded top beneath the Beacon Limestone Formation.

Fossils are scarce, but include *Beaniceras* sp. from the silty mudstones of the lower part of the Dyrham Formation [5586 3880 (**63**)], indicative of the upper part of the Ibex Zone; *Amaltheus stokesi* from the Pennard Sand Member on the south side of Pennard Hill [5757 3727 (**67**)] (Donovan *et al.*, 1989) a small *Amaltheus* sp. from blocks of sandstone [5555 3852 (**68**)] on the west side of Pennard Hill, and in an old pit [506 397 (**66**)] on the north side of Glastonbury are indicative of the Margaritatus Zone, Stokesi Subzone; an *Amaltheus* sp. indet., together with belemnites and bivalves, was found [5787 3793 (**69**)] in cementstone nodules in the bluish grey silty and fine-grained sandy mudstones of the upper part of the Dyrham Formation.

Beacon Limestone Formation

The Beacon Limestone Formation, better known as the Junction Bed (the Pennard Series of the Soil Survey), is a thin, but widespread, condensed deposit, 1 to 3 m thick, that spans the Pliensbachian/Toarcian Stage boundary and encompasses six ammonite biozones (Figure 1). It forms well-featured ground below Glastonbury Tor [515 388], and crops out as large outliers on Pennard Hill [around 565 384, 583 380, 600 378], and partially fault-bounded south-south-west of Hill Farm [578 377]. In places, such as north-west of Maes Down, it is appears to be cut out beneath the Bridport Sand. Except locally on Pennard Hill, the Beacon Limestone is mapped as an undivided unit.

Unit	**Thickness (m)**
Pennard Sand Member	
Siltstone	1.00
Siltstone, flaggy forming prominent feature in lane	1.00
Siltstone, poorly exposed	4.00
Siltstone, flaggy forming prominent rock bed in lane	0.90
Siltstone, massive, but thinly bedded, well cemented	6.00
Total	**12.90**
Unnamed lower part of the Dyrham Formation	
Not exposed, presumed mudstone	1.50
Mudstone, silty, pale grey, fissile	0.90
Siltstone, clayey with two bands of hard calcareous nodules with crinoid ossicles; bivalves and the ammonite *Beaniceras*	0.61
Mudstone, silty, poorly exposed	*c.* 8.00

Table 2. *Section in road cutting north-east of Knapp Farm [559 379].*

The Beacon Limestone is divisible into a lower Marlstone Rock Formation [formerly Rock Bed] and an upper Barrington Beds (Bristow and Westhead, 1993) – equivalent to the Upper Lias Limestone of Kellaway and Wilson (1941). The Marlstone comprises belemnitiferous, grey, commonly ferruginous-weathering calcarenite, with mudstone clasts and pebbles. The thickness varies from about 0.4 to 1.0 m, although 3 m were recorded at Maes Down [*c.* 646 406 (**70**)] (Richardson, 1906). Fossils are common and include brachiopods, gastropods, bivalves, ammonites, especially species of *Pleuroceras*, and conspicuous belemnites. The fauna from the eastern part of Pennard Hill indicates that the Marlstone there ranges from the Margaritatus Zone up into the Toarcian Tenuicostatum Zone, Semicelatum Subzone. The Barrington Beds comprise up to 3 m of sparsely oolitic micrites and calcarenites with common ammonites, including species of *Dactylioceras, Harpoceras* and *Hildaites*; belemnites are much scarcer than in the Marlstone. The Barrington Beds range from the latest Tenuicostatum Zone or early Falciferum Zone to the Thouarsense Zone.

Just north of the district, the base of the formation can be readily traced around Ingsdons Hill by a line of springs. Marlstone is proved by finds of *Amaltheus margaritatus* (de Montfort) (now in Bristol City Museum) at [645 434 and 6423 4340]. Ammonites from other exposures [6393 4336, 6421 4340, 6445 4336] in the Barrington Beds indicate that they range from the Falciferum Zone (Exaratum Subzone), to the Thouarsense Zone (Striatulum Subzone) (Bristow and Donovan, 2003, pp. 38-39). On Doulting Hill, springs also mark the base of the formation. Fragments of probable *Grammoceras toarcense* (d'Orbigny) were found by Richardson (his locality 12c) in a roadside section [*c.* 6423 4311 (**71**)] west of Doulting. Farther south-south-west, Richardson (1916, 491, locality 12b) saw a section [*c.* 6405 4277 (**72**)] in which, beneath the Inferior Oolite, he saw beds 3, 4 and 5 of the section detailed in Table 3. On the north side of Doulting Sheep Sleight, the base of the formation can also be traced by a line of springs. There, Richardson (1916, p. 490, locality 12a) recorded a section [*c.* 6390 4242 (**73**)] beneath Inferior Oolite (Table 3). Richardson attributed the beds to the Falciferum Zone (Bed 6) to Thouarsense Zone, Striatulum Subzone (Bed 4).

At Maes Down, Richardson (1906, pp. 368-369) recorded a 3.7 m section [6467 4062 (**70**)] in the Beacon Limestone. Some 2 m of strata were still exposed in 1982, including the Marlstone at the base. Specimens collected include *Pleuroceras hawskerense* (Young and Bird) and *P.* cf. *solare* (Phillips) from the Marlstone, indicating the Hawskerense and Apyrenum subzones. A small D*actylioceras* sp. indet. at the top of the Marlstone may indicate that this extends in age into the Toarcian, as on Pennard Hill to the west. The Marlstone also yielded the brachiopods *Gibbirhynchia micra* Ager and *Tetrarhynchia quadrata* (S. S. Buckman); large belemnites, probably *Passaloteuthis bisulcata* (Blainville), are conspicuous. At the western end of Maes Down, there is much micritic limestone debris with *Harpoceras* [6428 4078 (**74**)], with oolitic, belemnitic limestone a little lower down the slope [6426 4076 (**75**)].

On Pennard Hill and Glastonbury Tor, there are numerous small exposures and abundant fossiliferous brash on ploughed fields. Most of these occurrences are summarised in Table 4, but a few are detailed below. Stone Down, east and north of Glastonbury Tor, is a prominent feature formed by the Beacon Limestone Formation. In medieval times, Marlstone was quarried here for the wall cores of Glastonbury Abbey, faced with Doulting Stone ashlar. Old quarries on Stone Down Hill referred to by Day (in Guise, 1863, pp. 121-122) are probably those at [*c.* 5146 3887 (**93**)]. There, he noted two beds of Marlstone 1.2 m thick, capped by 'Upper Lias' clays and ragstones (Barrington Beds) more than 4m thick. The ammonites recorded by him from the Marlstone are given in Table 4 (modern genera in square brackets). On the south side of the Tor, Barrington Beds fossils may be found in a field known as The Lynches. They are dumped overburden from a former Marlstone quarry at [5160 3862].

Down Cliff Clay Formation

The Down Cliff Clay crops out all around Glastonbury Tor. It consists of some 30 m of pale to medium grey silty mudstone, similar in lithology to the Green Ammonite Bed. No fauna has been found in the Down Cliff Clay at Glastonbury, but it probably is of Levesquei Zone, Dispansum Subzone age.

Unit	**Thickness (m)**
Bridport Sand	
2. Sands, yellow, incoherent above and indurated below	4.5 to 6.0
3. Clay, blue, crowded with belemnites	0.15
Beacon Limestone Formation	
Barrington Beds	
4. 'The Blue Ironshot Beds'. *Grammoceras* sp., *Rhynchonella moorei* Davidson and *Cincta lycetti* (Davidson) found loose	not given
5. Limestone, blue, richly ironshot but weathering brown and full of ammonites *Haugia navis* (Dumortier), *Dactylioceras* cf. *braunianum* (d'Orbigny), *Hildoceras bifrons* (Brugière), *H.* aff. *hildense* (Young and Bird), *Harpoceras* sp. etc.	0.60
6. 'The Pink Bed'. Limestone, very hard, sparsely ironshot, and of a pinkish tinge	not given
Marlstone?	
7. Yellowish brown rock	0.60
8. Clay, fawn coloured	0.60

Table 3. *Section recorded by Richardson (1916) below Inferior Oolite on north side of Doulting Sheep Sleight [c. 6390 4242].*

EAST PENNARD HILL				
Locality	Grid ref.	Ammonites	ZONE	SUBZONE
76	6168 3768	*Pleuroceras* cf. *salebrosum, P. solare*	Spinatum	Apyrenum
77	6175 3745	*Pleuroceras solare*	Spinatum	Apyrenum
78	6155 3727	*Harpoceras falciferum*	Falciferum	
79	6130 3766	*Harpoceras falciferum, Hildaites subserpentinus, Dactylioceras* sp.	Falciferum	mid-Falciferum
80	61023742	*Pleuroceras solare, P.* cf. *spinatum*	Spinatum	Apyrenum
81	6015 3715	*Cenoceras* sp. juv., *Dactylioceras* cf. *anguiforme, D. toxophorum, Harpoceras falciferum, H. serpentinum, Hildaites murleyi, Nodicoeloceras crassoides, Youngibelus* sp.	Falciferum	Exaratum and Falciferum
82	602 378	*Amaltheus* cf. *subnodosus, Pleuroceras solare, Dactylioceras (Orthodactylites) semicelatum*	Margaritatus Tenuicostatum	Semicelatum
83	606 373	*Dactylioceras (O.) semicelatum, Pleuroceras solare, P. spinatum*	Spinatum	Apyrenum and possible Hawskerense
84	5980 3772	Old flooded quarry, no ammonite found		
WEST PENNARD HILL				
85	5782 3777		Exaratum-Variabilis	
86	5776 3760	*Dactylioceras tenuicostatum, D. semicelatum, Hildaites murleyi, Harpoceras falciferum, Hildoceras lusitanicum, H. bifrons*	Tenuicostatum to Bifrons	Semicelatum Fibulatum and/or Crassum
87	5705 3800	*Harpoceras falciferum, Hildaites subserpentinus, H.* cf. *forte, Polyplectus* cf. *pleuricostata, Dactylioceras toxophorum, Nodicoeloceras multum*	Bifrons	Crassum and/or Fibulatum
88	5690 3820	*Hildoceras lusitanicum, Harpoceras falciferum, Dactylioceras toxophorum*	Falciferum	Falciferum
89	5622 3836	*Harpoceras falciferum*	Falciferum	Falciferum
90	5622 3836	*Pleuroceras solare* var. *solitarium*	Spinatum	
91	5632 3858	*Harpoceras* cf. *falciferum, Catacoeloceras*	Falciferum	
92	5600 3838	*Hildoceras ?lusitanicum, Harpoceras falciferum,* and *Dactylioceras (Orthodactylites) semiannulatum*	Falciferum	Falciferum and Exaratum
GLASTONBURY TOR				
93	5146 3887	*'Ammonites* [*Amaltheus*] *margaritatus'* '*Ammonites* [*Dactylioceras*] *communis, A.* [*Catacoeloceras*] *crassus, A.* [*Catacoeloceras*] *Raquinianus, A.* [*Hildoceras*] *bifrons, A.* [*Harpoceras*] *serpentinus* and *A. radians'* [probably *Protogrammoceras paltum*]	Margaritatus Tenuicostatum, Falciferum Bifrons	
94	5153 3897	*Amaltheus, Pleuroceras*	Spinatum	Apyrenum
95	5156 3864	*Dactylioceras,* harpoceratid	Tenuicostatum	
96	5085 3870	*Harpoceras, Hildoceras bifrons, Mercaticeras* sp. , *Dactylioceras* spp.	Bifrons	
97	5084 3864	*Pleuroceras solare, Dactylioceras tenuicostatum, Harpoceras falciferum,*	Spinatum Falciferum	Apyrenum

Table 4. *Ammonite finds in the Beacon Limestone Formation on Pennard Hill and Glastonbury Tor.*

Bridport Sand Formation

Fine-grained silty sands and calcareous sandstones, principally of late Toarcian age, with some of earliest Aalenian age, crop out in an arc through western Dorset and south Somerset. Within this tract, they have been variously named the Midford Sands, Yeovil Sands and Bridport Sands (Arkell, 1933), but the term Bridport Sand has now been adopted for this diachronous formation. Characteristically, the Bridport Sand consists of yellow and orange-weathering, friable, silty, fine- and very fine-grained sandstones in rhythmic alternation with calcareous sandstone doggers. The base of the Bridport Sand in the north-east is probably locally unconformable, cutting out the Down Cliff Clay and Beacon Limestone in places. Locally, some or all of the formation has been removed by erosion prior to the deposition of the Upper Inferior Oolite, which is strongly unconformable in this area, although some of this apparent erosion may be due to cambering.

Around Ingsdons Hill just north of the district, no Bridport Sand has been mapped, although it has been proved in trial pits [*c*. 642 436 and 644 436] on top of the hill where it was described as greenish-yellow, fine-grained, micaceous sands with an indurated top beneath Upper Inferior Oolite (Richardson, 1916, p. 489). Possibly the Inferior Oolite here has cambered over the Bridport Sand, as it appears to have done on Whitstone Hill [633 415] farther south. In the railway cutting [*c*. 6440 4245 (**98**)] south of Doulting, Richardson (1916, p. 490) saw "*Upper Inferior Oolite resting on blue arenaceous shaly clay*", which in turn rested on "*grey, more micaceous sandy clay*" - ?Green Ammonite Bed. Some 200 m south-west, Richardson (1916, p.490, locality 12a) [6390 4240 (**73**)] recorded between 5.4 and 6.0 m of Bridport Sand between the Inferior Oolite and Beacon Limestone Formation (see above).

The outcrop of the Bridport Sand widens as it is traced around Doulting Sheep Sleight and fine-grained orange and yellow sand can readily be augered, or seen thrown out from badger setts [6367 4202]. The outcrop narrows on the steeper slopes on either side of the valley through Farncombe [641 410 to 646 413 to 6140 4093], but nevertheless, fine-grained sand can be augered along the crop. There are small, partially fault-bounded outcrops to the north-west [646 407 (**99**)] and north-east [654 407)] of Maes Down Farm. In the former area, the Bridport Sand is about 7 m thick The formation was seen as a very small, fault-bounded outlier [5784 3778 (**100**)] on Pennard Hill where about 3 m of orange-brown, fine-grained sand with *Grammoceras* overlies the Beacon Limestone and which is faulted on the north against the upper part of the Dyrham Formation. Glastonbury Tor is capped by an incomplete thickness of 30 m of Bridport Sand. The *Grammoceras* mentioned above, and a specimen of *Dumortieria moorei* found on the south side of Glastonbury Tor [*c*. 5118 3854 (**101**)] indicate the Levesquei Zone, Moorei Subzone.

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