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The stratigraphy of new sections in the Ludlow Series of the type area, Ludlow, Salop, England

D. E. White and J. D. Lawson

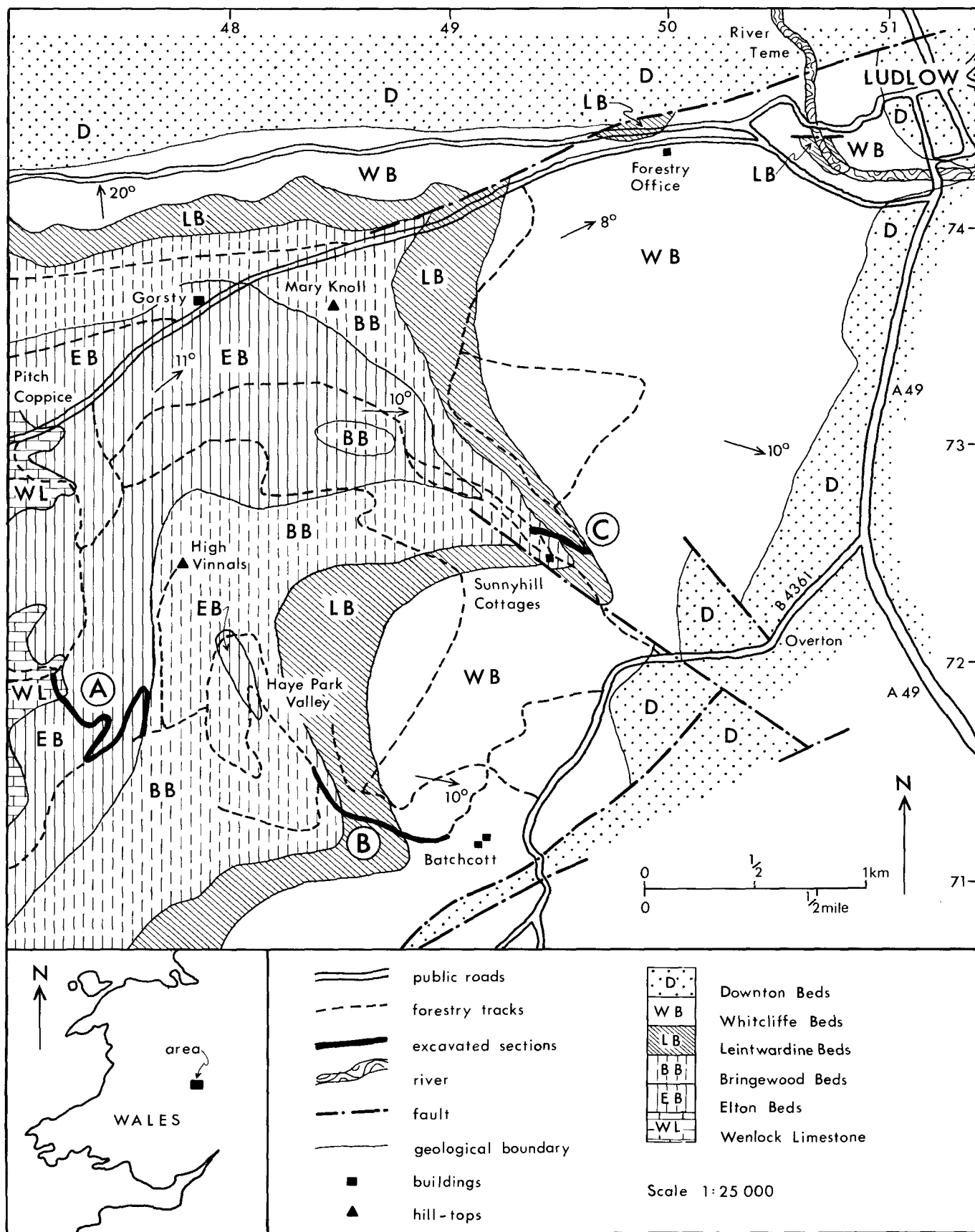


Figure 1 Geological sketch-map showing the location of Sections A, B and C

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INTRODUCTION

Since 1975 the Nature Conservancy Council has been able to provide money for projects aimed at excavating new, and improving old, exposures in areas of high geological interest. The first area chosen was the Ludlow district because of its international importance as the type area for the Ludlow Series of the Silurian System and because of the educational pressures it experiences. This selection was particularly appropriate in view of the current interest in Project Ecostratigraphy of the International Geological Correlation Programme, which is an international investigation of the palaeobiogeography of the time interval from the base of the Wenlock Series to the top of the Gedinian, the basal stage of the Devonian System.

On the recommendation of one of us (Lawson), many of the overgrown quarries along the road west-south-west from Ludlow (towards Wigmore) were cleared to provide good sample exposures of the main divisions of the Ludlow Series. These are intended primarily for use by the numerous school and student parties which frequently visit the area, and are described (by Lawson) in the Mortimer Forest Geological Trail guide, published by the Nature Conservancy Council (1977).

In addition, advice was given on the selection of sites for excavation and clearance within the forest which would be suitable for study by research workers and which would provide as near complete a sequence as possible through the Ludlow Series. On the grounds of economy three existing forest tracks were selected (Sections A, B and C of Figure 1).

During detailed examination of these three sections, fossil collections were made (by White) to provide the basis for a national reference collection of the fauna of the Ludlow Series to be kept at the Institute of Geological Sciences, London. It is hoped that this collection will become more comprehensive as a result of donations of specimens by research workers investigating these sections.

The purpose of this paper is to describe the newly excavated sections and provide details of their location, stratigraphic relationships, biostratigraphy and classification. This information will enable collectors to record locality and horizon details in a way that will facilitate assimilation of their material into the reference collection. The paper is a contribution to Project Ecostratigraphy of the International Geological Correlation Programme.

Already a considerable amount of work is being carried out on the new sections. For example, Dr P. Toghiani is investigating the graptolite faunas of the Elton Beds (Section A); the palaeoecology of the Lower Brington Beds (Sections A, B), Lower Leintwardine Beds (Sections B, C), Upper Leintwardine Beds (Sections B, C) and Whitcliffe Beds (Sections B, C) is being studied by Mr D. Atkins, Dr L. Cherns (research completed), Dr J. D. Lawson and Mr D. D. J. Antia

Bibliographic reference

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Table 1 Classification of the Ludlow Series in the Ludlow district

Murchison, 1834	Elles and Slater, 1906		Holland, Lawson and Walmsley, 1959, 1963		Graptolite zones
Upper Ludlow rock	Upper Ludlow Group	Upper Whitcliffe or <i>Chonetes</i> Flags	Upper Whitcliffe Beds	Whitcliffian Stage	— — — —
		Lower Whitcliffe or <i>Rhynchonella</i> Flags	Lower Whitcliffe Beds		<i>bohemicus</i>
Aymestry and Sedgeley limestone	Aymestry Group	Mocktree or <i>Dayia</i> Shales	Upper Leintwardine Beds	Leintwardinian Stage	<i>leintwardinensis</i>
		Aymestry or <i>Conchidium</i> Limestone	Lower Leintwardine Beds		
			Upper Bringewood Beds	Bringewoodian Stage	<i>tumescens/incipiens</i>
			Lower Bringewood Beds		
Lower Ludlow rock	[Lower Ludlow rocks]		Upper Elton Beds	Eltonian Stage	
			Middle Elton Beds		<i>scanicus</i>
					<i>nilssoni</i>
			Lower Elton Beds		?

respectively. We gratefully acknowledge information received from them and incorporated in this account. Their collections (or representative selections) will be deposited with IGS for assimilation in the national reference collection of Ludlow Series faunas.

Excavations and clearances of sites were carried out by the Forestry Commission on behalf of the Nature Conservancy Council and all who investigate these sections owe a debt of gratitude to Mr M. MacPherson, District Officer and Mr J. W. Waite, Chief Forester at Ludlow, both of the Forestry Commission, and to Dr G. P. Black and Dr K. L. Duff, Geology and Physiography Section, Nature Conservancy Council, for the successful completion of this project.

The diagrams were drawn by Mrs M. Leeper, University of Glasgow.

Detailed maps of the sections (Figures 2, 4, 6) are based upon Ordnance Survey Plans SO 4671-4771, SO 4871-4971 and SO 4872-4972, revised in 1972 and published in 1975. We are grateful to Mr and Mrs P. Cross for help with detailed surveying along parts of Section A.

A brief history of geological research on the rocks of the Ludlow Series in the Ludlow district has been given by Holland, Lawson and Walmsley (1963, pp.96-98). These authors (1959, 1963) proposed a new classification which has since been widely adopted in Britain. This, and earlier classifications, are summarised in Table 1.

Since the publication of the modern classification of the Ludlow Series in 1963, several new, long sections of Ludlow rocks have been exposed in Mortimer Forest, south-west of Ludlow, during road construction by the Forestry Commission. These have been briefly described elsewhere (Lawson, 1973).

The three sections described in this account (A, B and C of Figure 1) consist of new cuttings, re-excavations of deteriorated cuttings and earlier cuttings still well-exposed along existing forestry roads, but an important part of Section C is the large Sunnyhill Quarry, part of which has been cleared of vegetation to facilitate access and improve the exposure.

SECTION A (Figures 2, 3)

This section is on the south-western slopes of High Vinnals Hill and exposes rocks ranging from Wenlock Limestone, through basal Lower Elton Beds to Lower Bringewood Beds. The junction between the Wenlock and Ludlow series is taken near the base of the section at Locality A1-5, at the level where mudstone predominates over nodular limestone and above which there are no layers of limestone. There is a rapid transition but it is not as sharp as at the boundary stratotype of Pitch Coppice, 1.5 km to the north, with which no exact time equivalence is implied. There is an excellent section through the Elton Beds with long stretches of continuous exposure, particularly in the middle and upper parts of the sequence; the softer, lower part could be improved by trenching. The Lower Elton Beds are estimated to be 45 m thick and six bentonites have been recorded (see Details, below). The junction between the Lower and Middle Elton beds is not visible. The Middle Elton Beds have an estimated thickness of 85 m, including 10 bentonite horizons, but the highest beds are probably missing as the junction with the Upper Elton Beds is almost certainly faulted, the thickness of the Upper Elton Beds being only about 19 m. Their junction with the Lower Bringewood Beds is exposed and is marked by a slight change of slope. The basal 17 m of the Lower Bringewood Beds are exposed, before their outcrop is terminated by a fault which repeats the outcrop of Upper Elton Beds.

DETAILS

Lower Elton Beds At Locality A1-5 the following section in the basal Lower Elton Beds is exposed:

	m	collection numbers
Mudstone, pale olive, silty, calcareous, with limestone nodules common in lower part	1.55	A5
Bentonite	0.02	
Mudstone, pale olive, silty, calcareous; limestone nodules common	0.40	

Bentonite	0.03	
Mudstone, as for A1	1.00	A4
Bentonite (mica-rich)	0.03	
Mudstone, as for A1	1.40	A3
Bentonite	0.01	
Mudstone, as for A1	1.74	
Bentonite	0.02	
Mudstone, as for A1, with prominent limestone nodules at base	0.30	A2
Mudstone, pale olive, silty, calcareous, with scattered limestone nodules	1.00	A1

Base of Ludlow Series

Higher Lower Elton Beds are exposed at Locality A6 where the following section in the middle part of the sequence can be examined:

Mudstone, pale olive, calcareous, with scattered limestone nodules and 3 cm of decalcified siltstone	m	collection numbers
2.10 m from base	6.50	
Bentonite	0.05	
Mudstone, pale olive, calcareous, with scattered limestone nodules and 4 cm of decalcified siltstone		A6
0.39 m from base	0.45	

FAUNA The mudstone and limestone nodules contain an abundant and varied fauna, typical of these beds as described by Holland, Lawson and Walmsley (1963, pp.105–106) Brachiopods are particularly common, including *Amphistrophia* (A.) *funiculata* (McCoy), *Atrypa reticularis* (Linnaeus), *Craniops implicatus* (J. de C. Sowerby), *Dalejina hybrida* (J. de C. Sowerby), *Gypidula galeata* (Dalman) and *Protochonetes minimus* (J. de C. Sowerby). Tabulate and solitary rugose corals are also well represented. No graptolites have so far been recorded.

Middle Elton Beds The junction between the Lower and Middle Elton Beds lies within the gap separating Localities A6 and A7–9. At Locality A7–9 the following section was measured:

Siltstone, light olive-grey, rather flaggy	m	collection numbers
Bentonite	1.00	A9
Siltstone, light olive-grey, argillaceous	up to 0.08	
Mudstone, light olive-grey, silty	1.00	A8
	1.00	A7

The mudstone at the base of this section resembles the Lower Elton Beds but it is more silty and darker in colour; it contains a rich graptolite fauna. Higher beds are slightly more flaggy and silty and are therefore more characteristic of the Middle Elton Beds.

At Locality A10–11, 3.7 m of argillaceous siltstones are exposed with a prominent bedding plane 2.2 m above the base of the section, separating collections A10 and A11.

Higher beds are well exposed in a deep cutting (Locality A12–14) where the following section can be examined.

Siltstone, light olive-grey, flaggy	m	collection numbers
Bentonite	2.60	A14
Siltstone, light olive-grey, flaggy, with 2 cm bentonite at 1.13 m above base	0.06	
Bentonite	1.65	A13
Siltstone, light olive-grey, flaggy, with two 2 cm bentonites at 1.40 m and 1.80 m above base	0.03	
	2.50	A12

Approximately 1.5 m of flaggy siltstones are imperfectly exposed at Locality 15, but from Locality A16 to Locality A23 (inclusive) there is an almost continuous section of approximately 21.5 m of high Middle Elton Beds, with new excavations at Localities A16–18, A19–20, A21, A22, and A23. The ascent of the succession is due to the increase in ground height. At the base of this section, at Locality A16–18, 4 bentonites were recorded as follows:

Siltstone, light olive-grey, flaggy with 8 cm bentonite at 1.30 m above base	m	collection numbers
Bentonite	1.68	A18
Siltstone, flaggy	0.02	
Bentonite	1.18	A17
Siltstone, flaggy	0.03	
Bentonite	1.40	A16
	0.02	

A little higher in the sequence, at Locality A19–20, the following section was measured:

Siltstone, more massive and more sandy than lower beds	m	collection numbers
Siltstone, flaggy	1.00	A20
	0.10	A19

At Locality A21 (Figure 2) about 1 m of siltstones are poorly exposed, representing an horizon approximately equivalent to that of Locality A19–20. A 3-cm bentonite is present 0.20 m above the base of the section at Locality A22 where the flaggy siltstone contains thin sandy beds. The highest Middle Elton Beds visible (Locality A23) include thin coarser beds of fine-grained sandstone and, in addition, thin beds (up to 7 cm) of calcareous siltstone, possibly indicative of a transition to typical Upper Elton Beds lithology.

FAUNA Graptolites are common throughout the sequence. *Saetograptus* (*Colonograptus*) *varians varians* (Wood) and *Spinograptus spinosus* (Wood) are present in the lower beds (for example, Collection A7), and *Saetograptus* (S.) *chimaera chimaera* (Barrande), *S.* (S.) *chimaera semispinosus* (Elles and Wood) and *Pristiograptus dubius* (Suess) in higher beds (Locality A15 and above). Shells are numerous in the basal beds at Locality A7–9, including *Aegiria grayi* (Davidson), *Acidaspis coronata* Salter, *Dalmanites* sp. and *Raphiophorus* sp. but generally the shelly fauna becomes sparse and is represented mainly by small brachiopods (especially *Glassia* sp.) and orthocones, although locally fragments of *Dalmanites* sp. are common (for example, Locality A12–14). However, scattered horizons with numerous examples of *A. grayi* are present in the higher part of the sequence (for example, Locality A21).

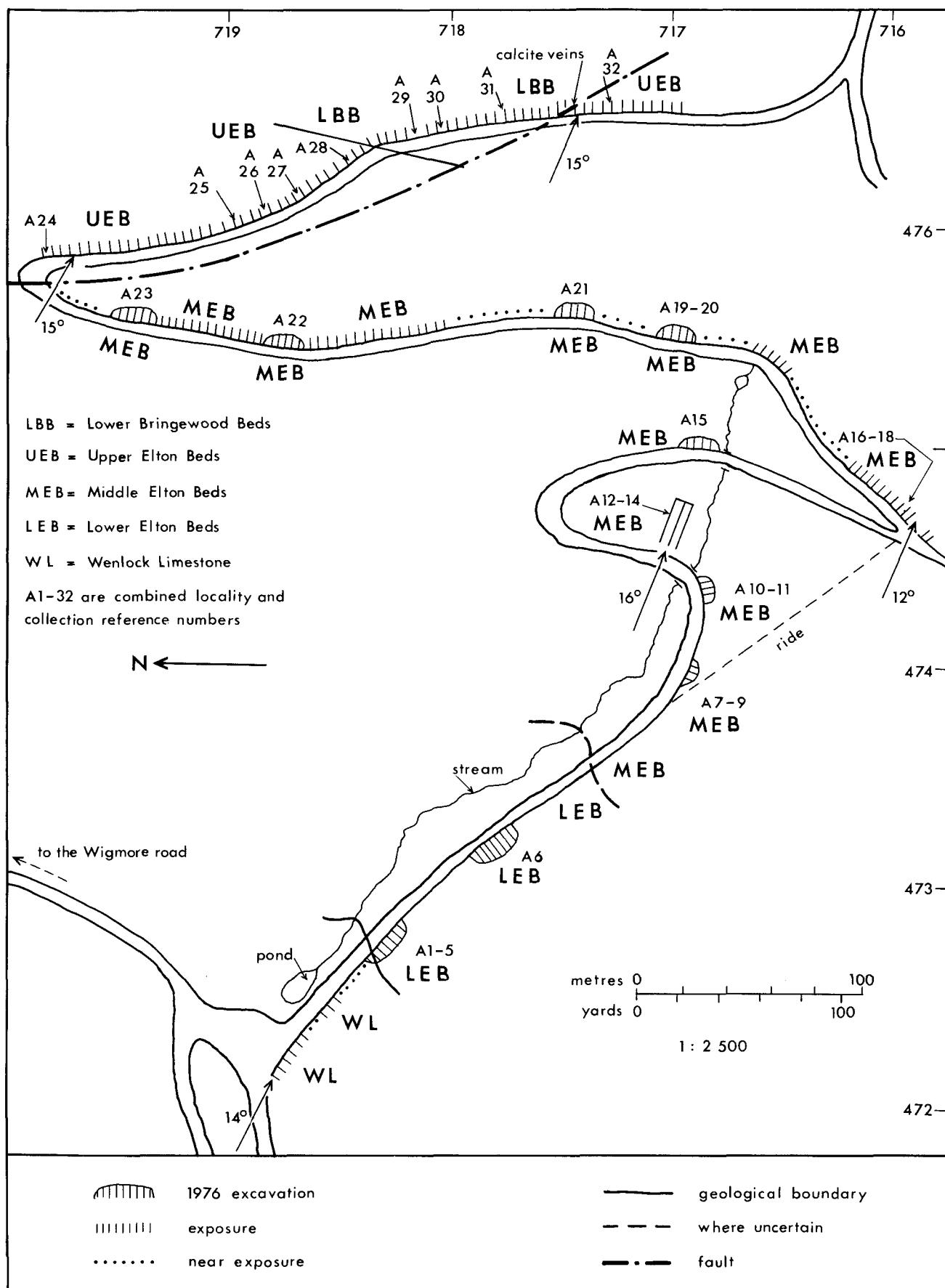


Figure 2 Location map of Section A, below High Vinnals

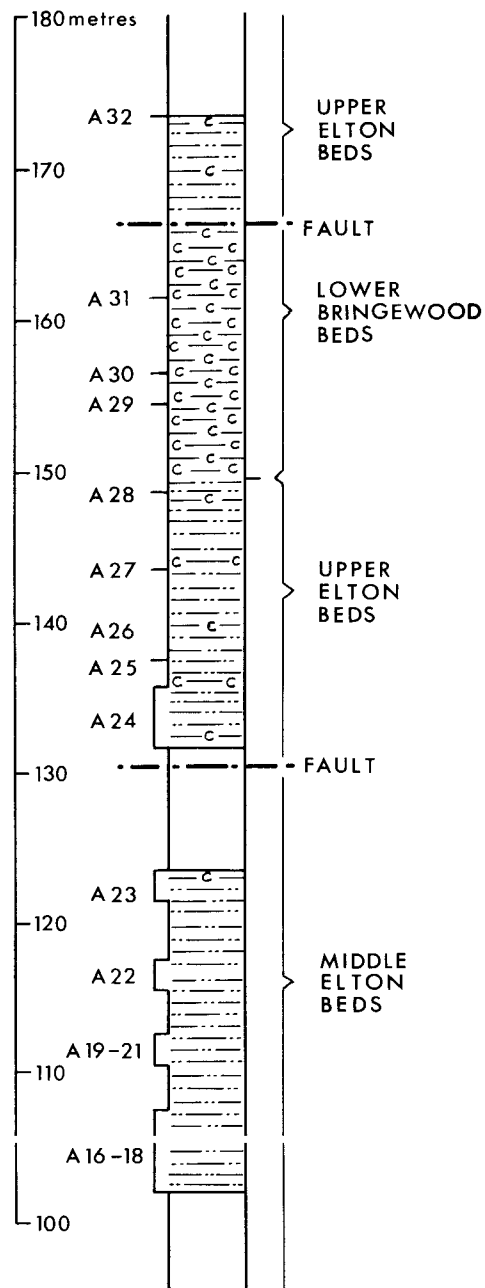
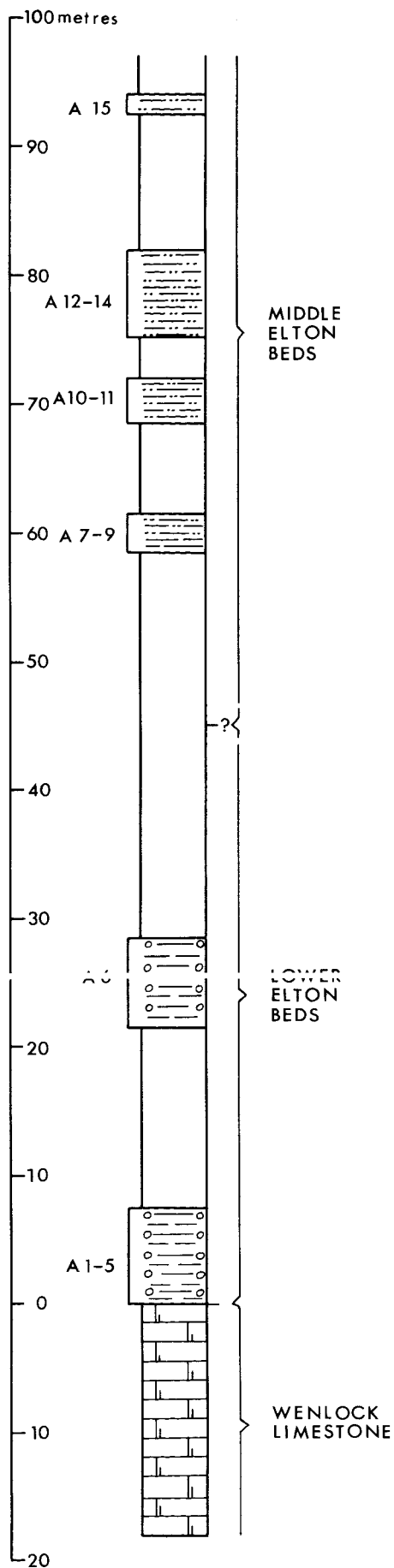
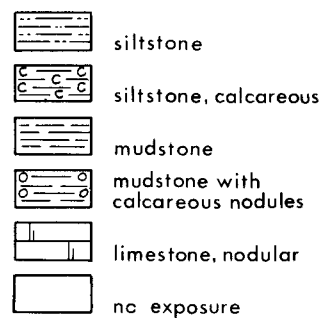


Figure 3 Section A — vertical column. Combined locality and collection reference numbers are shown on the left of the section. Lateral extension of the left side of the vertical column indicates the stratigraphic extent of the collection



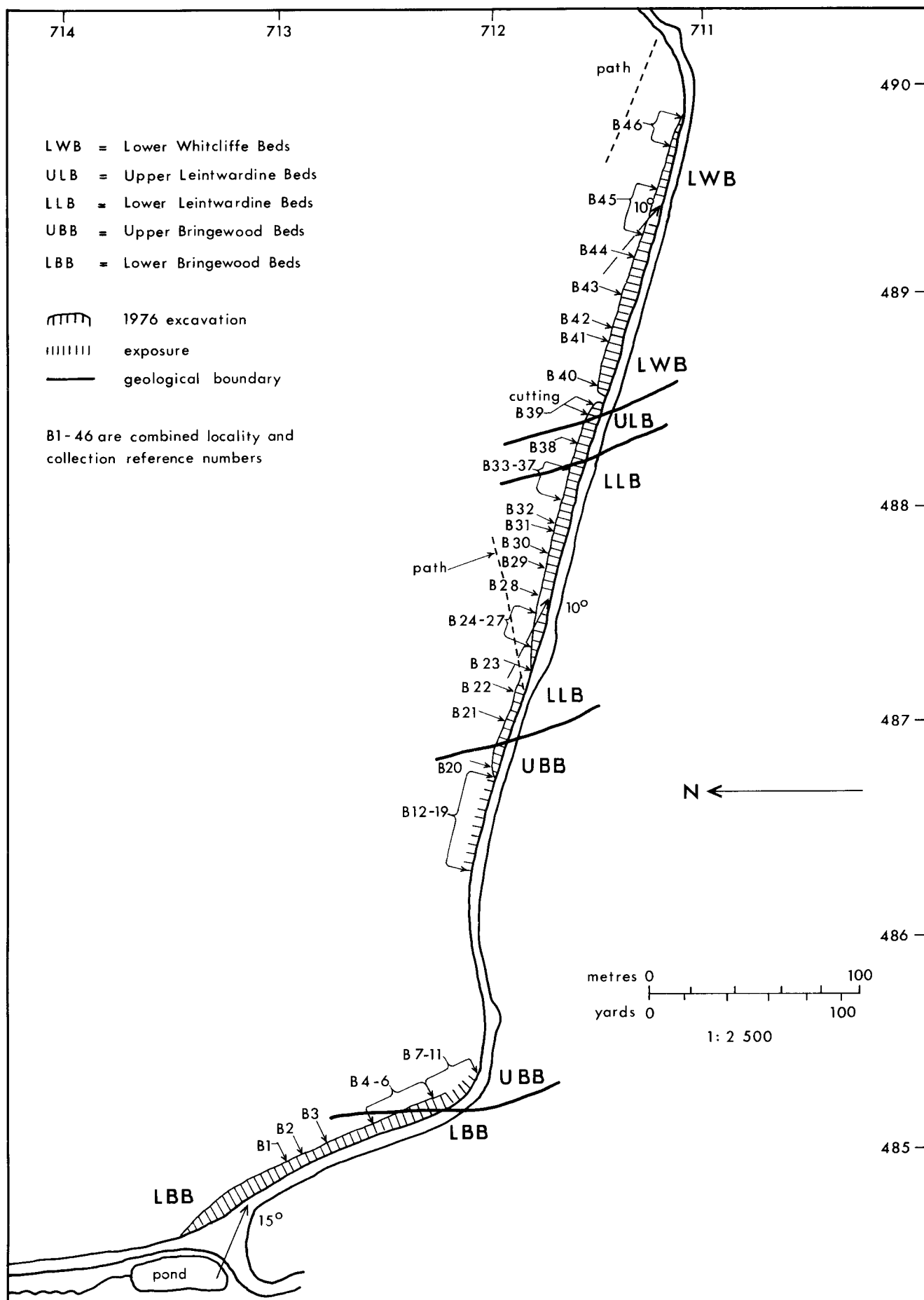


Figure 4 Location map of Section B, along Deer Park and Haye Park

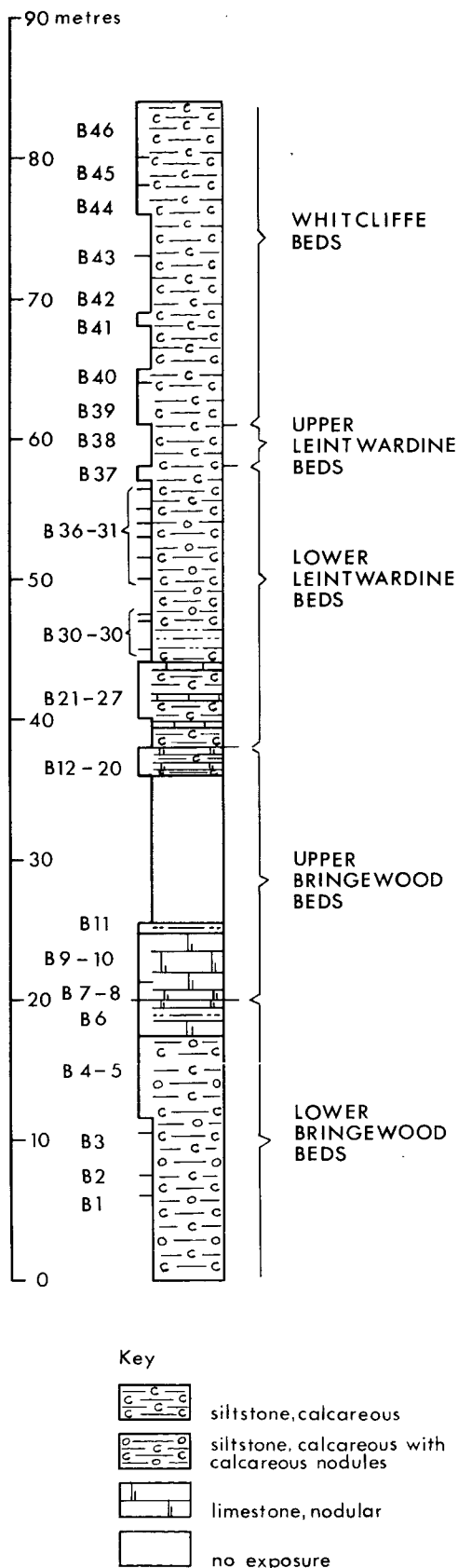


Figure 5 Section B — vertical column. Combined locality and collection reference numbers are shown on the left of the section. Lateral extension of the left side of the vertical column indicates the stratigraphic extent of the collection.

Upper Elton Beds The lower part of the sequence is faulted out but the highest 19 m of beds are continuously exposed below the Eltonian–Bringewoodian boundary, and consist of hard, light olive-grey, sandy siltstones, less flaggy than the underlying Middle Elton Beds, interbedded with hard calcareous siltstones up to 8 cm thick.

FAUNA Graptolites are fairly common, mainly *Pristiograptus tumescens* (Wood). At scattered horizons *P. minimus* is common and near the top of the sequence (Collection A28) rare examples of *Pholidostrophia* (*Mesopholidostrophia*) *lepisma* (J. de C. Sowerby) occur.

Lower Bringewood Beds Within about 2 m stratigraphically there is a transition from the flaggy siltstones with calcareous bands of the Upper Elton Beds into the harder, light olive-grey, more massive calcareous siltstones of the Lower Bringewood Beds. The basal 17 m are exposed, in the upper part of which silty limestones are present. Higher beds are faulted out, Upper Elton Beds occurring on the southern (upthrow) side of the fault (Figure 2).

FAUNA In contrast to the Upper Elton Beds, graptolites are rare or absent but large brachiopods are present, including *A. (A.) funiculata*, *A. reticularis* and *P. (M.) lepisma* [common].

SECTION B (Figures 4, 5)

This section along the Deer Park Road of Mortimer Forest, ranges from high Lower Bringewood Beds into the Lower Whitcliffe Beds, and spans a total thickness of 84 m.

A continuous section of the uppermost 21.0 m of the Lower Bringewood Beds underlies 5.5 m of Upper Bringewood Beds (Localities B1–11). The upper part of the Upper Bringewood Beds is not well exposed but the highest beds (2 m) can be examined, underlying the Lower Leintwardine Beds (Localities B20–21). This junction is marked by a sharp faunal as well as a lithological change. The estimated thickness of the Upper Bringewood Beds is 17.5 m.

There is a complete section of the Lower and Upper Leintwardine beds and the lower part of the Whitcliffe Beds. The Lower Leintwardine Beds are 20 m thick, and are lithologically similar to, but faunally distinct from, the Upper Leintwardine Beds (see Details, below). The latter have an estimated thickness of only 3.5 m and are succeeded (Localities B38–39) by approximately 23 m of the Lower Whitcliffe Beds.

DETAILS

Lower Bringewood Beds These consist of irregularly bedded, light olive-grey, calcareous siltstones in which limestone nodules are common, becoming particularly abundant in the upper part of the sequence. About 4 m from the top, there is a bentonite, up to 10 cm thick.

FAUNA Large brachiopods and corals are common particularly in the limestone nodule horizons. Of the brachiopods, *Atrypa reticularis* (Linnaeus), *Sphaerirhynchia wilsoni* (J. Sowerby) and *Strophonella euglypha* (Hisinger) are common, while *Leptaena* cf. *depressa* (J. de C. Sowerby), *Pholidostrophia* (*Mesopholidostrophia*) *lepisma* (J. de C. Sowerby) and *Shaleria* sp. are also

present. The corals include *Favosites* sp., *Phaulactis* sp. and *Rhabdocyclus* sp.

Upper Bringewood Beds The junction between the Lower and Upper Bringewood beds is taken where light olive-grey, calcareous siltstones containing abundant limestone nodules are sharply succeeded by hard, light olive-grey to medium grey, silty limestones (Locality B7). The basal 5.5 m are well exposed but above these there is a 10-m gap to the uppermost 2 m which can be examined at Localities B12–20 (Figure 4), where they consist of rubbly, nodular limestones with thin beds of shaly siltstones.

FAUNA *Kirkidium knightii* (J. Sowerby) is very common in a 0.10-m band (Collection B8) 1.20m from the base. *S. euglypha* is common in the lower part of the sequence (Localities B7–11) as are tabulate coral colonies including *Favosites* sp. and *Heliolites* sp. In the uppermost beds, *Shagamella ludloviensis* Boucot and Harper is fairly common while *Amphistrophia* (A.) *funiculata* (McCoy), *L. cf. depressa*, *Leptostrophia filosa* (J. de C. Sowerby), *P. (M.) lepisma*, *S. wilsoni* and the small 'button' coral *Rhabdocyclus* sp. are well represented. Other fossils recorded include *Shaleria* sp. and *Dalmanites myops* (König).

Lower Leintwardine Beds The junction with the Upper Bringewood Beds is marked by a sharp lithological change from light olive-grey, rubbly, nodular limestones with thin shaly siltstone beds to thinly flaggy, light olive-grey calcareous siltstones with irregularly bedded silty coquinas. These are succeeded by siltstones which are more thickly bedded and contain scattered calcareous nodules. The complete thickness of 20 m is exposed.

FAUNA In marked contrast with the underlying Upper Bringewood Beds, *Howelllella elegans* (Muir-Wood) and *Microsphaeridiorhynchus? nucula* (J. de C. Sowerby) are common throughout and *Dayia navicula* (J. de C. Sowerby) is very common in bands below Locality B33 but also occurs at higher levels. *Isorthis* (*Protocortezorthis*) *orbicularis* (J. de C. Sowerby) and *Salopina lunata* (J. de C. Sowerby) are well represented in the lower half of the sequence and *S. wilsoni* is confined to the basal few metres of beds (Localities B21–24). *S. ludloviensis* is well represented in the upper half of the sequence while *L. cf. depressa* and *Shaleria ornatella* (Davidson) become common at the top (Localities B34–37), where *Aegiria grayi* (Davidson), *A. reticularis*, *Calymene* sp., *Proetus* (*Lacunoporaspis*) *obconicus* Lindström and *Warburgella* (*Tetinia*) *ludlowensis* (Alberti) and *Saetograptus leintwardinensis* (Lapworth) also occur.

Upper Leintwardine Beds These are represented by only 3.5 m of flaggy, light olive-grey, calcareous siltstones (Locality B38).

FAUNA The large ostracod *Neobeyrichia lauensis* (Kiesow) is characteristically common, associated with a fauna which includes *Aegiria grayi* (Davidson) [common], *S. ornatella* var., *Calymene puellaris* [*neointermedia*] Reed, *Encrinurus stubblefieldi* Tripp and *Cytherellina siliqua* (Jones).

Lower Whitcliffe Beds The lowest 23 m of these beds are exposed, consisting of medium grey to greenish

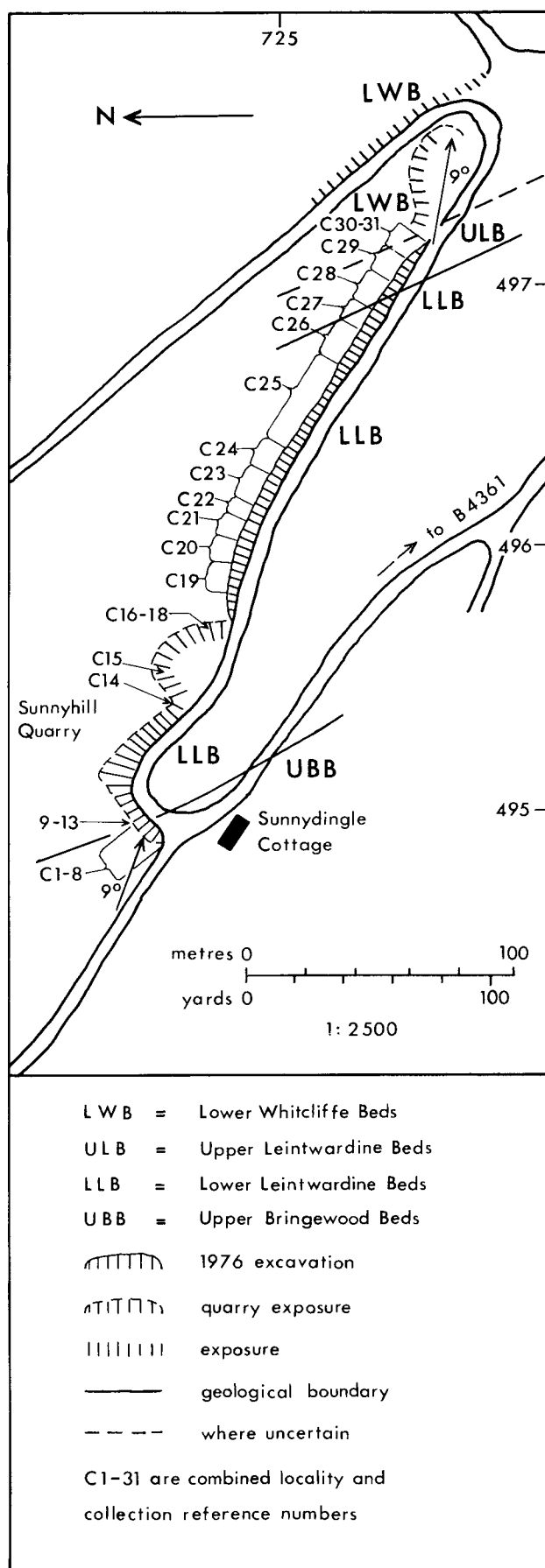


Figure 6 Location map of section C, Sunnyhill, Mary Knoll Valley

grey, thickly flaggy, calcareous siltstones, more thinly bedded higher in the sequence.

FAUNA This is markedly less varied than that of the underlying beds, and includes *M.?* *nucula* and *Protochonetes ludloviensis* Muir-Wood, both being abundant, associated with *D. navicula*, *Orbiculoidea rugata* (J. de C. Sowerby), *Fuchsella amygdalina* (J. de C. Sowerby) and '*Serpulites*' *longissimus* J. de C. Sowerby.

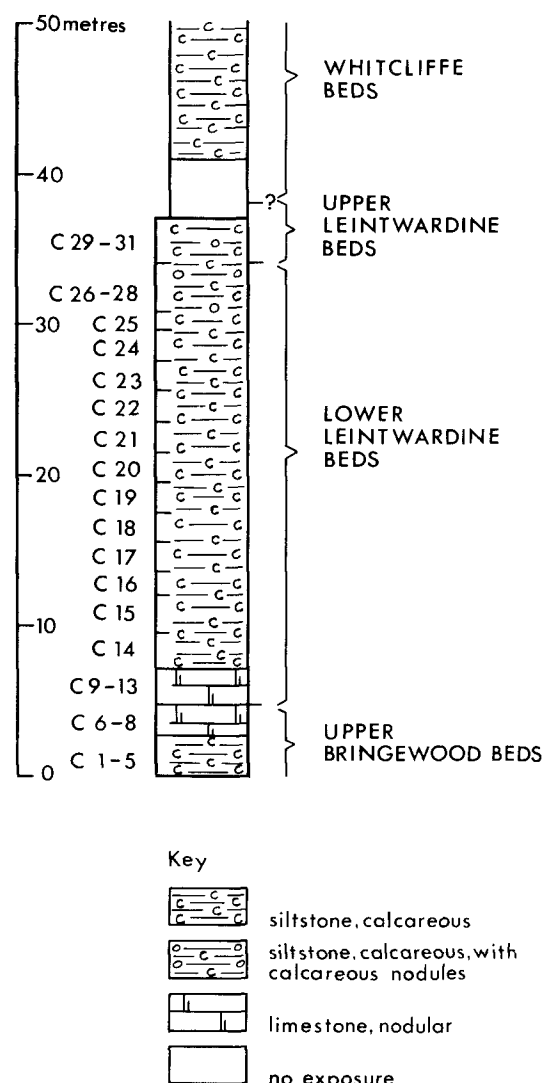


Figure 7 Section C — vertical column. Combined locality and collection reference numbers are shown on the left of the section. Lateral extension of the left side of the vertical column indicates the stratigraphic extent of the collection.

SECTION C (Figures 6, 7)

This section consists of the exposures in Sunnyhill Quarry and the overlying sequence of beds exposed along the track to the east-south-east. The succession is virtually complete and ranges in age from high Upper Bringewood Beds to high Lower Whitcliffe Beds, with a total thickness of approximately 50 m.

The exposure at the western end of Sunnyhill Quarry is the standard section for the base of the Leintwardinian Stage, designated by Holland, Lawson and Walmsley

(1963, pp.141-143). A thickness of 4.69 m of Upper Bringewood Beds is now exposed (Locality C1-8). The lower part of the overlying Lower Leintwardine Beds is well seen in the quarry (Localities C9-13, C15, C16-18) and higher beds are continuously exposed along the adjacent forestry track to the east-south-east (Localities C19-28); a total thickness of approximately 29 m for the Lower Leintwardine Beds has been measured. Their junction with the Upper Leintwardine Beds is exposed at Localities C28-29 (Figure 6), the boundary being at road level 20 m from the east-south-eastern limit of the track section. Only 3 m of Upper Leintwardine Beds are visible. Their upper boundary lies within the gap of 4 m to the Lower Whitcliffe Beds which are exposed in the adjacent roadside quarry (Figure 6). According to Mr David Antia (personal communication) approximately 17 m of Lower Whitcliffe Beds are exposed in this quarry and nearby road section, but these beds have not been examined in detail by us.

DETAILS

Upper Bringewood Beds The lowest beds available can be examined at the most westerly exposure of Sunnyhill Quarry (Locality C1-13), which was designated the standard section for the Bringewoodian-Leintwardinian junction by Holland, Lawson and Walmsley (1963, pp.141-143). Their symbols for these beds are shown in brackets alongside the collection numbers in the following section:

	m	collection numbers
<i>Lower Leintwardine Beds</i>		
Siltstone, light olive-grey, flaggy, calcareous	2.40	C14 (I)
Limestone, light olive-grey, silty, nodular	1.37	C13 (H)
Bentonite	0.08	C12 (G)
Limestone, light olive-grey to medium grey, massive, nodular	0.38	C11 (F)
Shale (?bentonite)	0.05	C10 (E)
Limestones, nodular and calcareous siltstones	0.48	C9 (D)
Shale	0.006	(C)
<i>Upper Bringewood Beds</i>		
Limestones, medium grey, nodular and siltstones, light olive-grey, calcareous	0.61	C8 (B)
Limestones, medium grey, nodular, and siltstones, light olive-grey, calcareous	0.61	C7 (A)
Limestone, medium grey, nodular, massive towards base	0.85	C6
Siltstone, light olive-grey, fairly massive with flaggy beds, calcareous	1.40	C5
Bentonite	0.20	C4
Siltstone, light olive-grey, fairly massive, argillaceous, calcareous	0.58	C3
Bentonite	0.02	C2
Siltstone, light olive-grey, fairly massive, argillaceous, calcareous (seen)	0.44	C1

Only 1.22 m of the uppermost Upper Bringewood Beds were exposed in 1963 but the sequence has since been extended to include 3.5 m of lower beds as a result of excavations by the Forestry Commission.

FAUNA The beds are generally poorly fossiliferous. Scattered specimens of *Atrypa reticularis* (Linnaeus), *Isorthis* sp., *Kirkidium knightii* (J. Sowerby) and *Sphaerirhynchia wilsoni* (J. Sowerby) together with *Favosites* sp., *Syringopora* sp. and *Rhabdocyclus* sp. are present and a thin bed in which *Strophonella euglypha* (Hisinger) is common occurs about 0.50 m from the base of Horizon C6 (see section, above).

Lower Leintwardine Beds The lowest 2.36 m of beds are light olive-grey, massive, nodular limestones and are well exposed at the standard section for the boundary between the Bringewoodian and Leintwardinian stages (for detailed section, see above, p.). The position of the junction was selected by Holland, Lawson and Walmsley (1963, p.143) because it is the first parting above a significant faunal change.

The basal nodular limestones are overlain by light olive-grey, flaggy, calcareous siltstones with thin silty limestone beds, which are exposed in the main part of Sunnyside Quarry and in the cutting along the adjacent forestry track. Horizons C16–18 form the lower part of the eastern face of the quarry. The top of C17 forms a prominent ledge which gives access to the forestry track. The top of C18 is a prominent bedding plane and beds above this are best examined in the track section. In the upper part of the sequence (Localities C19–25) the beds are less calcareous and limestone beds are absent. However, the uppermost 3.2 m (Localities C26–28) consist of hard, massive calcareous siltstones with scattered limestone nodules.

FAUNA The lowest beds at the standard section for the base of the Leintwardinian contain layers in which *A. reticularis*, *Dayia navicula* (J. de C. Sowerby) and *Isorthis* (*Protocortezorthis*) *orbicularis* (J. de C. Sowerby) are common. Higher beds, exposed in the main part of Sunnyside Quarry (Locality C16–18) contain numerous examples of *A. reticularis*, *I. (P.) orbicularis*, *S. wilsoni* and *Shagamella ludloviensis* Boucot and Harper, while *D. navicula* is also well represented. In the track section, *D. navicula* becomes common at Locality C19, where *I. (P.) orbicularis* and *S. wilsoni* are also numerous. At the top of the Lower Leintwardine Beds (Localities C24–28), *Aegiria grayi* (Davidson), *Microsphaeridiorhynchus? nucula* (J. de C. Sowerby), *Salopina lunata* (J. de C. Sowerby) *S. ludloviensis* and *Shaleria ornatella* (Davidson) are common and the varied fauna also includes *A. reticularis*, *Leptaena* cf. *depressa* (J. de C. Sowerby), *Proetus* (*Lacunoporaspis*) *obconicus* Lindström, *Warburgella* (*Tetinia*) *ludlowensis* (Alberti) and *Saetograptus leintwardinensis* (Lapworth).

Upper Leintwardine Beds The basal metre of these beds (Locality C29) consists of hard, light olive-grey, massive calcareous siltstone with scattered limestone nodules, a lithology similar to that of the highest strata of the Lower Leintwardine Beds. This is followed by 2 m of light olive-grey, sandy, mainly flaggy siltstone (Localities C30, 31) to the end of the cutting along the forestry track. Higher beds are contained within the 4 m gap to the Whitcliffe Beds exposed in the old quarry situated near the termination of the forestry track section (Figure 7).

FAUNA Two important forms are present which were not recorded from the Lower Leintwardine Beds — *Neobeyrichia lauensis* (Kiesow) and *Calymene puellaris*

[*neointermedia*] Reed. The fauna also includes *S. ornatella* var. and many forms present in the underlying beds such as *M.? nucula* and *Cytherellina siliqua* (Jones) both of which are particularly common, and *L. cf. depressa*, *Encrinurus stubblefieldi* Tripp and *S. leintwardinensis*.

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