THE CARBONIFEROUS LIMESTONE MARGIN BETWEEN CROWDECOTE AND HARTINGTON, DERBYSHIRE

by

A. Ludford, P. Madgett and Helen E. Sadler

Summary

The Carboniferous Limestone margin is well exposed east of the River Dove from Crowdecote to Hartington, Derbyshire. Three distinct limestone facies are present; (i) shelf facies forming a large part of the outcrop, (ii) marginal facies including shell beds and reefs, (iii) basin facies partly equivalent to the other two facies and partly unconformable on them. The limestones of these three facies are thought to range from high D_1 to low D_2 (P_1). Namurian shales are unconformable on the limestones, or are faulted against them.

Structurally the northern part is relatively simple with some NW - SE faults. However, immediately north of Hartington the limestones are folded into an asymmetric syncline with a steeper western limb, and faulting is well developed with the larger faults trending N - S. The syncline is cut off by a fault just north of Hartington.

History of previous work

The area described in this paper extends along the margin of the Carboniferous Limestone from Crowdecote (SK101652) in the north, south-eastwards for four and a half miles to Bullock Low (SK128601) immediately south of Hartington village. The Carboniferous Limestone near Hartington was first recorded by White Watson as far back as 1821 in a section from Bakewell to Hartington when he noted Aluminous Shales resting on Shell Limestone (Ford, 1960). In 1887, Green, Le Neve Foster and Dakyns described the area thus:- "At Crowdecote we found..... how complicated is the faulting along this line. At Ludwell is a very complicated bit. Opposite the mill the limestone was rising to the west steeply enough to carry it over the Yoredale shales on the opposite bank, unless a fault ran between. From Bank Top to Hartington there runs a clear line of crags of white limestone, dipping east at 25°, and with black shales abutting against them to the west; the boundary, therefore, for two reasons, must be a fault. This clear and undoubted line of faulted boundary ends at Narrow Dale." The interpretation of this description is seen on the Old Series Geological Survey Sheet 81 E.

Parkinson (1950), Prentice (1951), Parkinson and Ludford (1964) and Ludford (1970) all demonstrated that Namurian shales rest unconformably on the Carboniferous Limestone (Viséan) in the area immediately south of Hartington. To the north of Crowdecote a similar unconformity has been described by Hudson (1932), Holdsworth (1963) and Holdsworth and Trewin (1968).

The limestones to the south have been described by Parkinson (1950), Parkinson and Ludford (1964) and Ludford (1970). They indicated that three different facies i.e. basin, reef and shelf are present. To the north, Wolfenden (1958) mapped the area as far south as Pilsbury (SK118634), but concentrated his description on the shelf and reef (marginal) facies which crop out north of Crowdecote.

Sadler and Wyatt (1966) mapped an S_2 inlier within the shelf facies one mile east of Hartington and extended the area to include the Upper Limestones of D_1 age which crop out on the eastern edge of the region now described.

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Stratigraphy

The three facies present within the area are shelf facies, basin facies and marginal facies including reef limestones, shell beds and dark-grey, bedded limestones.

The Shelf Facies

These are a westward extension of those described by Sadler and Wyatt (1966) and Sadler (1966), and are typically well bedded, generally massive, pale-grey bioclastic limestones. They are calcarenites whose composition varies from highly crinoidal limestones with a few fragmented brachiopods, bryozoa and foraminifera, to rocks in which intraclasts predominate. Sorting is generally poor. Sparite is the usual cement and recrystallisation is common. Partial dolomitisation occurs near the fault zones.

The Basin Facies

As Ludford (1970) found further south, the limestones belonging to this group are much more variable. They are thinly-bedded, dark grey limestones, usually associated with black, calcareous shales. They range from biosparites of calcarenite grade to bituminous micrites. Cherts were noted at one locality near the ford (SK 126620). Limestones of the basin facies (sensu stricto) are limited in their outcrop to fringe areas north and south of Ludwell and to somewhat larger areas around Banktop and Hartington village.

The unstable nature of the marginal area led to the interdigitation of shelf and basin facies. Steady downsinking helped the growth of reefs but periodic uplift and penecontemporaneous erosion of the reef limestone produced limestone conglomerates on the back-reef (leeward) side, as at Parks Barn (SK 121632). Thickly bedded, pale-grey limestones between the conglomerates were produced by biochemical deposition during the times of downsinking.

Marginal facies

These are thought to have developed in a region of fluctuating conditions.

Reef limestones occur in the north and south of the area where they pass on the eastern side into shelf limestones. In the north they are typical apron reefs with dips away from the shelf (Wolfenden 1958). Judging by the cavity infillings of the shells, these dips are original, hence the term "apron reefs". South of Hartington, Bullock Low covers a belt some two hundred metres wide between the shelf facies and the overlying Namurian shales. The reefs here are similar to the Waulsortian 'reefs' of West-Central Eire described by Lees (1964). Petrographically both apron reefs and Waulsortian 'reefs' are calcite mudstones with varying amounts of recrystallisation. Shells and crinoid debris often occur in pockets. Laminae are common and probably result from recrystallisation of algae (Ludford 1970).

The bedded dark-grey limestones are seen to penetrate the reef limestone, as at Bridge End Crowdecote (SK 102650), or into the shelf facies as in the roadside exposure east of Pilsbury (SK 119634). In the Moat Hall syncline, dark-grey, fine or coarse grained crinoidal limestones are interbedded with pale-grey typical shelf facies and with shell beds. The shell beds are up to ten metres thick and are packed with brachiopods, mainly gigantoproductids of the latissimoid type. The fossils show varying degrees of attrition and the larger brachiopods rest predominantly with their concave side uppermost. Thin sections of the limestones indicate that they are fossiliferous micrites. Lack of sorting of the shells coupled with the presence of a micrite matrix signifies relatively quiet depositional conditions.

Details of the stratigraphy are best provided by subdividing the region as follows:

(i) From just north of Crowdecote (SK 101653) to immediately south of Pilsbury Castle Hills (SK 115639).

The junction between the reef limestones of High Wheeldon (SK 100660) and the Namurian shale to the west produces a strong topographic feature running NW - SE. In the vicinity of Crowdecote this line of contact continues but reef limestones are exposed west of it. This repitition of the reef limestone could be due to faulting, although there is no evidence, or it may signify a stratigraphically higher reef with an embayment of shale between the two reef zones. Green *et al.* (1887) proposed faulting to account for this extended outcrop of limestone, but did not then suspect a sub-Namurian unconformity. This feature is probably due to the exhumation of a pre-Namurian topography.

The bulk of the reef facies near Crowdecote consists of pale-grey, finely crystalline, unbedded limestone, but occasional bands of black, very fine grained limestone up to one metre thick penetrate the reef on the western flank. East of Crowdecote there is a rapid change from reef to shelf facies within a distance of a few metres. The shelf limestones here are pale-grey, massively bedded, poorly fossiliferous calcarenites dipping at 15° SW. The only fossil found in these bedded limestones which indicates a D_1 age is *Dibunophyllum bipartitum* (McCoy).

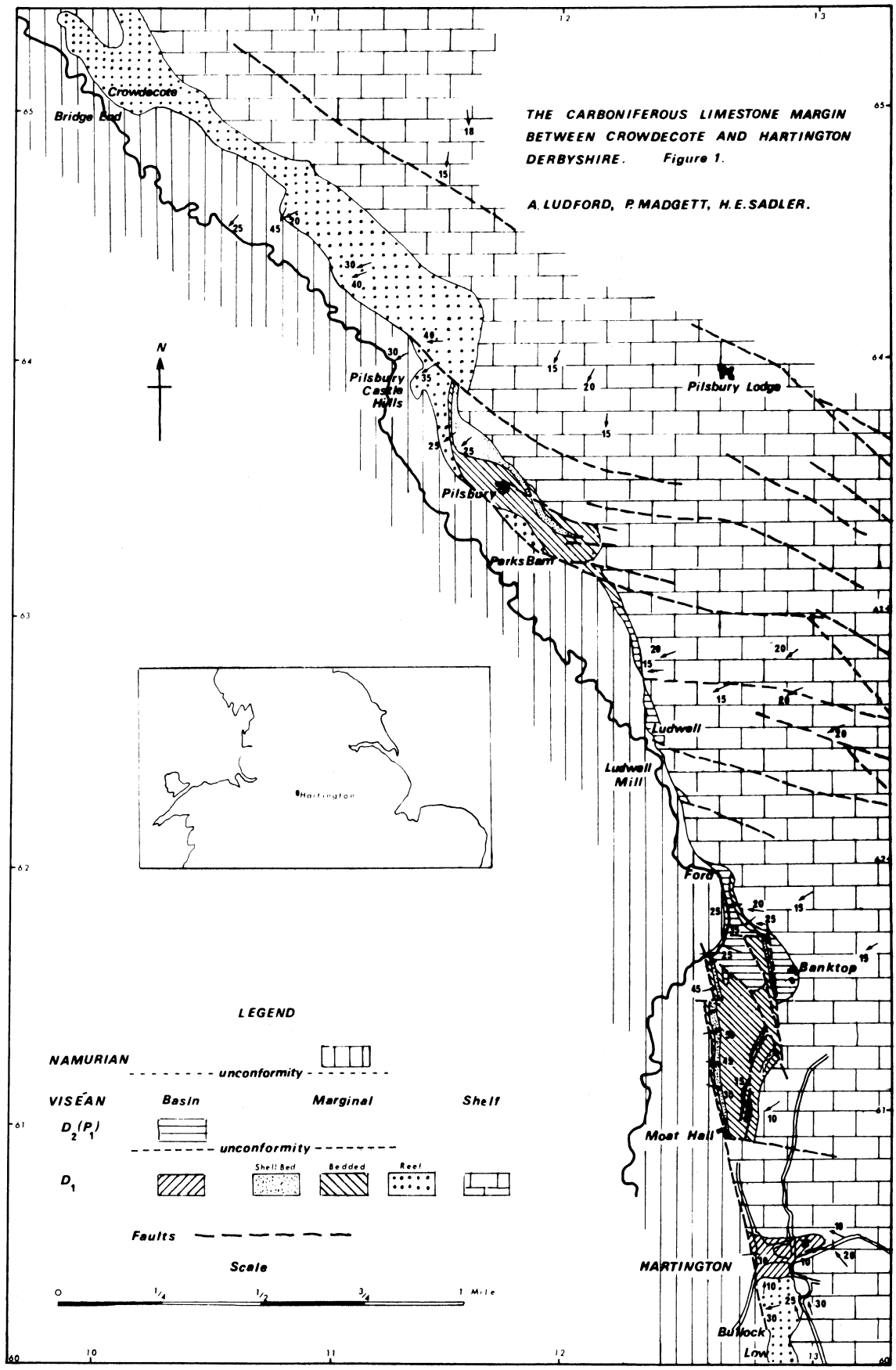
South of Crowdecote the shale/limestone junction again gives a marked break in slope. At one point (SK119645) along this feature purple-black shales dipping at 45° SSW are very close to fine-grained, grey and brown reef limestone dipping at 20° SW. This evidence suggest an unconformable junction. Further south at Pilsbury Castle Hills the limestone margin lies in front of the main reef belt, thus resembling Crowdecote. Evidence at the Hills suggests that they are natural extension of the main reef rather than faulted-off masses. Dips are approximately 30 - 35 degrees SSW. The reef limestones here contain a rich fauna of brachiopods, gastropods, lamellibranchs and occasional goniatites. *Davidsonina septosa* (Phillips), *Palaeosmilia murchisoni* (Edwards & Haime), *Dictyclostus semireticulatus* (Martin), *Giganto-productus latissimus* (J. Sowerby), *Echinoconchus* sp., *Eomarginifera* sp. and a nautiloid were found at Pilsbury Castle whilst further north (SK111643) *Bollandoceras* sp. and *Bollandites* cf. *castletonensis* (identified by Dr. W.H.C. Ramsbottom) were collected from loose blocks.

(ii) Pilsbury Castle Hills to Parks Barn (SK 121632).

In the north of this area the reef limestone outcrop gradually narrows, although it occurs along the line of the bridle path almost as far south as Pilsbury Farm. Everywhere the dip is to the SSW. Concomitantly with the decrease in the reef outcrop a shell bed develops and increases in thickness to the southeast. It is terminated on its northern side by a NW - SE fault. Due north of Pilsbury Farm the westward dip of this shell-bed would carry it below the apron reef. Just east of Pilsbury Farm (SK119634) two metres of black crinoidal limestone separate the shell bed from the overlying shelf facies. At Parks Barn the shell bed is partially silicified where it crops out on the crest of the hill north of a large gully. From this point eastwards the bed rapidly thins and disappears.

At the foot of the slope opposite Parks Barn, unfossiliferous limestone of reef aspect dips at 25° W. Between this reef and the shell bed, thickly-bedded, fine-grained, pale-grey limestones are interbedded with four bands of limestone conglomerate. The well-rounded pebbles have diameters of 20 - 50 mm, but one subangular block measured 250 m by 70 mm. Petrographically the pebbles are essentially micrites, and it is most likely that they were eroded from the reefs lying to the west and incorporated in deposits on the leeward side of the reefs. The intervening beds are fine-grained calcarenites with much recrystallisation. The absence of much reef at the surface is explained by the presence of a NW - SE fault which downthrows to the southwest. Breaks in the sequence are indicated by the fact that the conglomerates invariably rest on irregular surfaces, also at one point thinly bedded limestone dips at 20° W above a horizontal bed of massive limestone. The thicknesses of the conglomerates vary as they are traced along the sides of the gully but one measured section showed:-

Conglomerate	1 m
Massive limestone	3 m
Conglomerate	1.5 m
Massive limestone	4 m
Conglomerate	0.3 - 0.5 m
Massive limestone	2 m


THE CARBONIFEROUS LIMESTONE MARGIN BETWEEN CROWDECOTE AND HARTINGTON DERBYSHIRE. Figure 1.
A. LUDFORD, P. MADGETT, H.E. SADLER.
Crowdecote
Bridge End
Pilsbury Castle Hills
Pilsbury Lodge
Pilsbury
Parks Barn
Ludwell
Ludwell Mill
Ford
Banktop
Moat Hall
HARTINGTON
Bunlock Low
N
Hartington
LEGEND
NAMURIAN
unconformity
VISEAN
Basin
Marginal
Shelf
$D_2(P_1)$
unconformity
D_1
Shell Bed
Bedded
Reef
Faults
Scale
0
1/4
1/2
3/4
1 Mile

(iii) Parks Barn south to the ford ¼ mile NNW of Banktop Farm (SK126619)

There is no reef limestone in this section, and, although two thin shell beds have been found, their lateral extent is extremely limited. Usually pale-grey limestones of the shelf facies are overlain unconformably by black limestones belonging to the upper part of the basin facies. Even the latter are cut out in several places by the sub-Namurian unconformity.

The relationship between the basin facies and the shelf is best demonstrated at Ludwell (SK 124625). Here unfossiliferous, well-bedded black limestones are seen to rest unconformably on very fossiliferous greybrown limestones from which a fauna of high D_1 age has been collected, including *Dictyoclostus semireticularis* (Martin), *Gigantoproductus* cf. *latissimus* (J. Sowerby), *Gigantoproductus* sp., *Productus productus* (Martin), *Rugosochonetes hardrensis* (Phillips), and *Spirifer bisulcatus* (J. de C. Sowerby). Along the banks of the River Dove similar black limestones are interbedded with black calcareous shales. Chert lenses occur adjacent to the spring (SK 126620) immediately north of a small anticline at the ford (SK126619). Occasional small productids and one specimen of a zaphrentid coral are the only fossils to have been noted. No microfossils have been seen in thin sections. East of the road sparsely fossiliferous limestones of the shelf facies dip 20° - 35° SW. They are probably equivalent to the Upper Limestone of Sadler and Wyatt (1966).

All dips measured in this section are westwards and at no point have any limestones been seen dipping eastwards as indicated by Green *et al* (1887).

(iv) Banktop Farm to Moat Hall (SK 126609).

This is an area of marginal facies complicated by faulting and north-south folding. The main structural feature is an asymmetric syncline with dips up to 55° on the western limb and up to 25° on the eastern limb. A NW - SE fault terminates the structure to the north and an E - W fault limits it to the south. It is also cut off on both east and west sides by faulting. Instability is demonstrated by changes in the thicknesses of individual beds illustrated in a measured section just north of Moat Hall (Table 1).

Western Limb	Eastern Limb
Dark grey, thinly-bedded, slightly bituminous limestone with thin argillaceous bands. 4 m.	Dark-grey, thinly bedded bituminous limestone and dark-grey coarsely crinoidal beds. 2 m
	Shell bed 3 m
Pale-grey, fine grained limestone with some darker bands 5 m.	Grey, crinoidal crystalline limestone 1 m. Hard, splintery, fine-grained limestone. 2.5 m. Grey, fine-grained limestone 1.25 m. Ostracod bed 0.15 - 0.25 m. Pinkish, crystalline limestone 2 m. Dark-grey, fine-grained limestone 0.6 m.
Shell bed 10 m.	Shell bed 1.5 m.
Pale-grey, fine-grained limestone with some crinoidal debris. seen to 6 m.	Dark-grey, fine-grained limestone with crinoidal and shell debris. seen to 0.25 m.

Table 1

This relationship is shown diagrammatically in fig. 3.

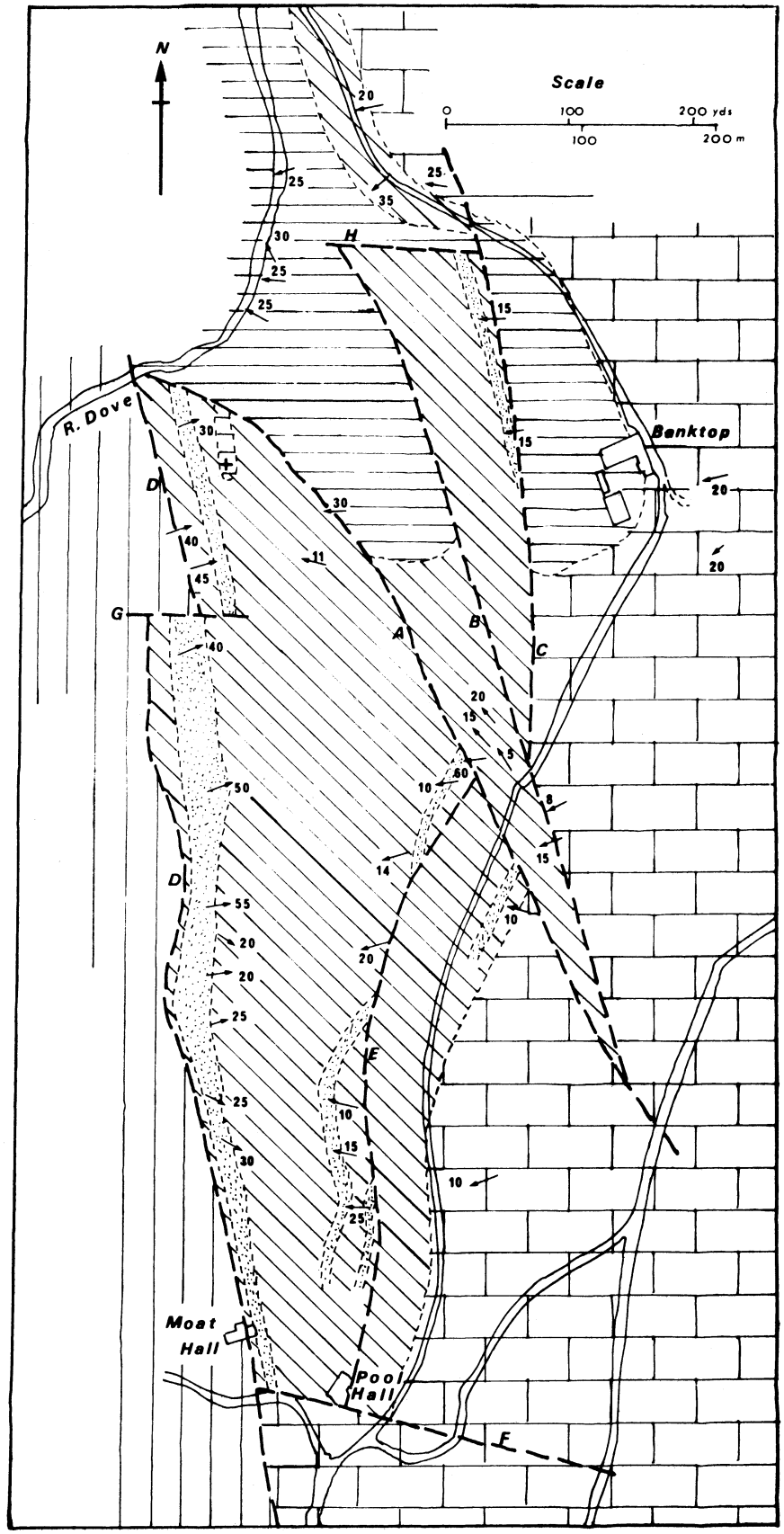


Figure 2. Geology of the Moat Hall Syncline.
Key as Figure 1. A- H Faults - see text.

The shell bed is packed with brachiopod valves, mainly productids, and include the following:- *Antiquatonia* sp., *Argentiproductus* sp., *Dictyoclostus semireticularis* (Martin), *Dictyoclostus* sp., *Eomarginifera setosus* (Phillips), *Gigantoproductus edelburgensis* (Phillips), *G. latissimus* (J. Sowerby), *G. praemoderatus* (Sarytcheva), *Linoproductus* cf. *corrugatus* (McCoy), *L.* cf. *hemisphaericus* (J. Sowerby), *Martinia glabra* (J. Sowerby), *Productus productus* (Martin), *P. productus* var. *hispidus* Muir-Wood, *Spirifer bisulcatus* (J. de C. Sowerby), *S. grandicostatus* McCoy, *S. trigonalis* (Martin) and *Spirifer* sp. *Carcinophyllum* sp. is the only coral found.

The centre of the syncline is occupied at the northern end by about one metre of black shales of upper basin facies. On the east the syncline is faulted against marginal facies exposed in a roadside quarry (SK 128612) where a thin shell bed is overlain by a thin band of black limestone.

Within the complex of three faults between Banktop and the northern end ot the syncline there are pale-grey limestones with some darker, fine-grained beds. Occasional shell pockets with *Lithostrotion irregulare* (Phillips) occur. These limestones dip between 5° and 20° NW and pass westwards under a series of black limestones and calcareous shales dipping at 30° NW exposed in the banks of the River Dove. North of Banktop shales probably occur at the surface and form an impervious cover to any limestone, thus producing boggy ground. East of the Hartington - Pilsbury road the normal sequence of shelf limestones reappears with the massively-bedded rocks dipping 10° - 25° in a general southwesterly direction.

(iv) Moat Hall to Hartington village.

The Moat Hall syncline is faulted off in the south by an east-west fault, and from here southwards there are very few outcrops. Shelf limestones crop out along the valley sides east of the village and also in Hide Lane north of the church. Dark greyish-brown limestones of the basin facies are exposed in the stream culvert in the village square. Below the southern side of the churchyard massive, pale-grey shelf limestones dip 10° WSW; these pass laterally into darker, fine-grained basin facies at the north gateway and below the west wall of the church. Stones taken from graves dug at the eastern end of the churchyard reveal specimens of both pale-grey limestones and dark-grey limestones with black shales suggesting intercalations of the shelf and basin facies just here. The presence of basin limestones as far as four hundred metres from the margin suggests a large embayment at Hartington at the time of deposition.

(vi) Hartington to Bullock Low.

From the start of the footpath southwards to Dovedale the exposures indicate a facies change to one of reef limestone. The first hill, north of Bullock Low, is made up of a series of lenses, each with quaquaversal dips, and built one on top of the other to produce a small knoll. Bullock Low is similarly built but the two knolls are clearly separated, thereby indicating that they were discrete growths. Dips usually vary between 10° and 30° although one of 50° has been recorded; their original nature can be demonstrated in several places by the geopetal infillings. The following fossils have been recorded:- *Dibunophyllum bipartitum* (McCoy), *Lithostrotion maccoyannum* Edwards and Haime, *Gigantoproductus* sp., *Martinia glabra* (J. Sowerby), *Productus productus* (Martin), *Striatfera striata* (Fischer), *Endolobus* sp. and occasional fenestellid bryozoa. The reef limestones pass with gradual transition eastwards into the shelf facies near Reynards Lane.

Age of the beds

The shelf limestones in the eastern part of the area are a continuation of the Upper Limestones of D_1 age (Sadler and Wyatt 1966), and the Alsop Moor Limestone (Parkinson 1950), to which Parkinson and Ludford (1964) subsequently assigned an upper D_1 age. The diagnostic D_1 forms collected in this survey include *Palaeosmilia murchisoni* (Edwards and Haime), *Dibunophyllum* cf. *bourtonense* Garwood and Goodyear, and *Gigantoproductus latissimus* (J. Sowerby).

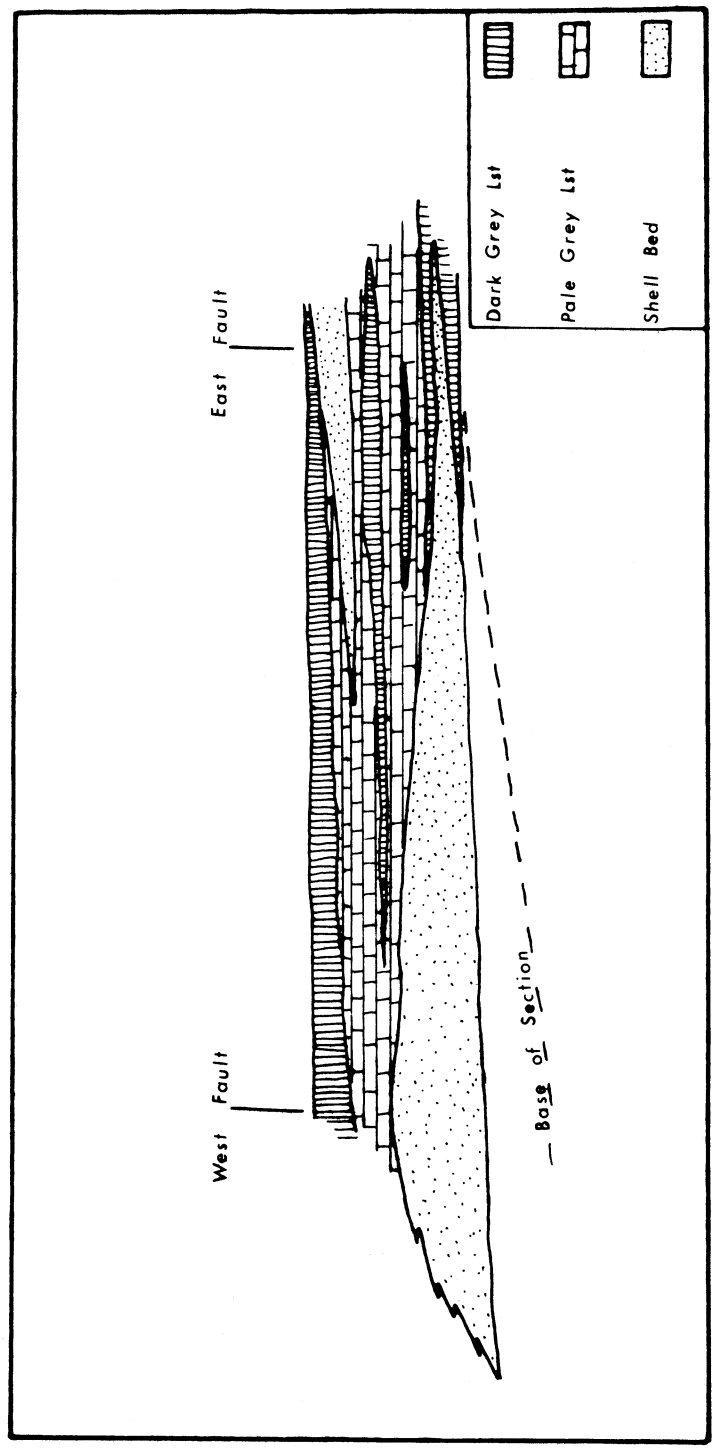


Figure 3.

Diagrammatic representation of the lithologies within the Moat Hall syncline

The marginal facies are of upper D_1 age. The general fauna of the shell bed is almost identical with that of a shell bed at Waterhouses which lies at the top of a richly fossiliferous high D_1 sequence (Ludford 1951). The reef limestones south of Hartington contain *Striatifera striata* which is rarely found much below D_2. Parkinson and Ludford (1964) showed that Pennilow is late D_1 in age, and as Bullock Low is separated from it by only a small gully, it is probably of the same age. The reefs at Pilsbury and Crowdecote include *Davidsonina septosa* and *Bollandites* cf. *castletonensis* thus equating them with the Upper B_2 reefs of Wolfenden (1958).

Beds of the basin facies are of two different ages. The larger outcrop at Hartington extends into and interdigitates with the shelf limestones and is therefore D_1 in age. Similarly, minor intercalations on the eastern side of the Moat Hall syncline are associated with the shell beds (see Fig. 3 and table 1). However, the higher beds consist of black limestones interbedded with calcareous shales and occasional cherts, which lie unconformably on fossiliferous shelf limestones (see Ludwell Section). Thus these latter beds cannot be older than Upper D_1 and are regarded as D_2 (P_1) in age.

The fissile black shales which crop out at various points along the River Dove are probably Namurian in view of their unconformable nature, although there is no palaeontological evidence. Holdsworth and Trewin (1968) note that the lowest Namurian beds in the vicinity of Dowel Dale to the north are of E_2 a.ii age.

Structure

Over much of the area the limestones dip westwards from the Hartington S_2 inlier and only in the Moat Hall syncline is there any appreciable folding. Faults noted by Sadler and Wyatt (1966) can often be traced into the present area; these are normal faults which trend NW - SE in the northern part of the area and WNW - ESE in the central part. The Moat Hall syncline has a north-south axis in its southern part swinging to NNW - SSE at the northern end. Dips on the western limb range from 20° to 55° on bearings of 85 - 110, whereas on the eastern side the dips are lower, ranging from 10° bearing 260 at its northern end to 25° bearing 250 at the south. The northern end of the syncline is cut off obliquely by a NW - SE fault (fault 'A' fig. 2).

West of Banktop two sub-parallel NNW - SSE faults occur ('B' and 'C' fig. 2). They merge south of the farm and pass through a crag where they are reperesented by a calcite vein about 0.3 m thick. The main fault of the area ('D' fig. 2) is on the western edge of the syncline where it throws Viséan limestones against Namurian shales. Another fault ('F' fig. 2) running just north of west terminates the syncline to the south, but cannot be traced far eastwards; its throw is not less than twenty metres to the north. There are also two small faults in the area; one displaces the shell bed on the western side of the syncline ('G' fig. 2) whilst the other ('H' fig. 2) terminates the outcrop of the thin shell bed north of Banktop. Gentle folding may be seen in Hartington village whilst small scale folding in the black limestones occurs at the ford (SK 126619) where a small anticline has limbs dipping at 20° SW and 25° NW.

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A. Ludford, M.Sc., Ph.D.,
Luton College of Technology,
Park Square,
Luton, Beds.

P. Madgett, B.Sc.,
Rothamsted Experimental Station,
Harpenden, Herts.

Helen E. Boynston (née Sadler), B.Sc., Ph.D.,
61 Corps Close,
Oadby, Leics.

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