P. Gutteridge

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Dinantian sedimentation and the basement structure of the Derbyshire Dome

Peter Gutteridge

City of London Polytechnic, Department of Geology, Walburgh House, Bigland Street,
London E1 2NG, U.K.

The depositional history of the Dinantian on the Derbyshire Dome can be divided into three phases: (1) pre-Holkerian: onlap of an irregular basement surface by evaporite and carbonate sediments, (2) Holkerian to Asbian: sedimentation on a carbonate shelf formed by the merging of early Dinantian depocentres following burial of the basement topography, and (3) Brigantian: formation of intrashelf basins and the development of a carbonate ramp on part of the pre-existing shelf.

A model of the basement structure underlying the Derbyshire Dome is presented to explain the location of the Brigantian intrashelf basins and carbonate ramp. The basement consists of two main tilted fault blocks separated by a smaller tilt block. Movement on faults bounding the tilt blocks caused the development of intrashelf basins. The basin margins were controlled by structures which developed in the cover sediments. The carbonate ramp present during the late Brigantian developed in response to an eastward tilting of the basement.

KEY WORDS Basement tilt-blocks Carbonate shelf Carbonate ramp Derbyshire Dinantian Intrashelf basins

1. Introduction

The structure of the pre-Dinantian basement is regarded as a major influence on Dinantian sedimentation in northern England. For example, Bott (1967) and Johnson (1967) explained thickness and facies variation in the Dinantian in terms of a basement structure consisting of blocks and basins (see also review by Anderton *et al.* 1979). However, discrepancies between observed facies and thickness variations in the Dinantian and in the Namurian with those predicted by the block and basin hypothesis (e.g. Dunham 1973) led Leeder (1982), Miller and Grayson (1982), and Grayson and Oldham (in press) to question its validity. They proposed an alternative basement structure composed of tilted fault blocks to account for the pattern of Dinantian sedimentation in northern England. Gawthorpe (in press) studied the sedimentary and tectonic development of the Bowland Basin during the Dinantian and showed that tilt block hypothesis is valid on a local scale.

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The aim of this paper is to review the history of Dinantian sedimentation on the Derbyshire Dome and to examine its relationship with models of the basement structure proposed by Maroof (1976), Rogers (1983), and Smith *et al.* (1985) and to re-interpret the history of Dinantian sedimentation on the Derbyshire Dome in terms of the tilt block hypothesis.

The term 'Derbyshire Dome' refers to the area of predominantly shallow-water Dinantian carbonate sedimentation which occupied much of the Derbyshire outcrop of the Carboniferous Limestone. It was connected through the eastern part of the outcrop to the extensive East Midland carbonate platform (Leeder 1982, Figure 3). The Derbyshire Dome was bounded on the west and south by the Widmerpool Gulf and to the north by the Edale Basin.

2. Pre-Asbian sedimentation

2a. Evidence from deep boreholes

Early Dinantian sediments deposited on the Derbyshire Dome occur in the Woo Dale and Eyam boreholes (Table 1). The Woo Dale borehole encountered carbonates of Arundian age resting on volcanics of pre-Dinantian age (Cope

Table 1. Dinantian stratigraphy of the Derbyshire Dome

OUTCROP

Brigantian	LONGSTONE MUDSTONES		
	EYAM LIMESTONES		
	MONSAL DALE LIMESTONES	Light - coloured facies	Dark- coloured facies
		Station Quarry Beds	
Asbian	BEE LOW LIMESTONES		
Holkerian	WOO DALE LIMESTONES		

SUBCROP

	Eyam Borehole	Woo Dale Borehole
Holkerian	WOO DALE LIMESTONES	WOO DALE LIMESTONES
Arundian		
Chadian		
Upper Tournaisian	MIDDLETON DALE ANHYDRITE SERIES	

1973, 1979; Strank 1986) and the Eyam borehole encountered evaporites of late Tournaisian age resting on mudstones of Llanvirn/Arenig age (Dunham 1973; Strank 1985). The Dinantian sequences found by each borehole contain no significant stratigraphic break; however, the age of the sediments resting on basement in each case is different.

On the basis of a thin Arundian sequence present in the Woo Dale borehole, Strank (1985, 1986) suggested that subsidence not only started much earlier in the Eyam area but proceeded at a different rate than in the Woo Dale area. However, the Arundian rests unconformably on basement in the Woo Dale borehole and it is not known how much of the early Arundian is represented. A comparison of the thickness of the Holkerian strata in both areas can indicate the amount of differential subsidence. The thickness of the Holkerian in the Eyam borehole is 257·38 m (Strank 1985). In the Woo Dale area the Holkerian has a total thickness of approximately 246 m (Aitkenhead *et al.* 1985; Strank 1986).

The similarity between the thickness of Holkerian sediments in each area suggests that there was little differential subsidence during the Holkerian. Therefore, the different ages of sediments at the base of each sequence is likely to be due to sedimentary onlap of an irregular basement surface.

2b. Holkerian sedimentation

Limestones and dolomites of Holkerian age exposed on the Derbyshire Dome form part of the Woo Dale Limestones Formation (Table 1). The stratigraphy and sedimentology of the Woo Dale Limestones have been described by Schofield and Adams (1985) who interpreted the environment of deposition as a shallow, subtidal carbonate shelf which experienced varying degrees of restriction from open marine conditions. Uplift in the northern part of the Derbyshire Dome resulted in shallowing causing the development of tidal flats which subsequently prograded southwards. Shelf carbonates of the Woo Dale Limestones do not show the repeated shallowing-up cycles which are present in shelf carbonates of the overlying Bee Low Limestones and Monsal Dale Limestones.

3. Asbian sedimentation

The Bee Low Limestones Formation, defined by Aitkenhead and Chisholm (1982) includes carbonates and minor volcanics of Asbian age (Table 1). Figure 1 shows the palaeogeography of the Derbyshire Dome during the deposition of the Bee Low Limestones.

The Bee Low Limestones, which have been described by Stevenson and Gaunt (1971), Walkden (1974, 1982) and Aitkenhead *et al.* (1985) comprise thickly-bedded bioclastic packstones and grainstones with rare wackestones. They contain finely-comminuted bioclasts and peloids. Cross-bedding is occasionally preserved but most depositional texture has been obliterated by bioturbation. The limestones are cyclic: each bed displays evidence of progressive shallowing. The lower parts of each bed comprise skeletal carbonate sands deposited in a subtidal environment, the upper parts of beds show evidence of emergence including calcrete textures and palaeokarstic surfaces (Walkden 1974). Stevenson and Gaunt (1971), Walkden (1982), and Aitkenhead *et al.* (1985) interpreted the depositional environment of the Bee Low Limestones to be a shallow carbonate shelf which was subject to minor eustatic sea-level changes which produced the repeated shallowing-up cycles.

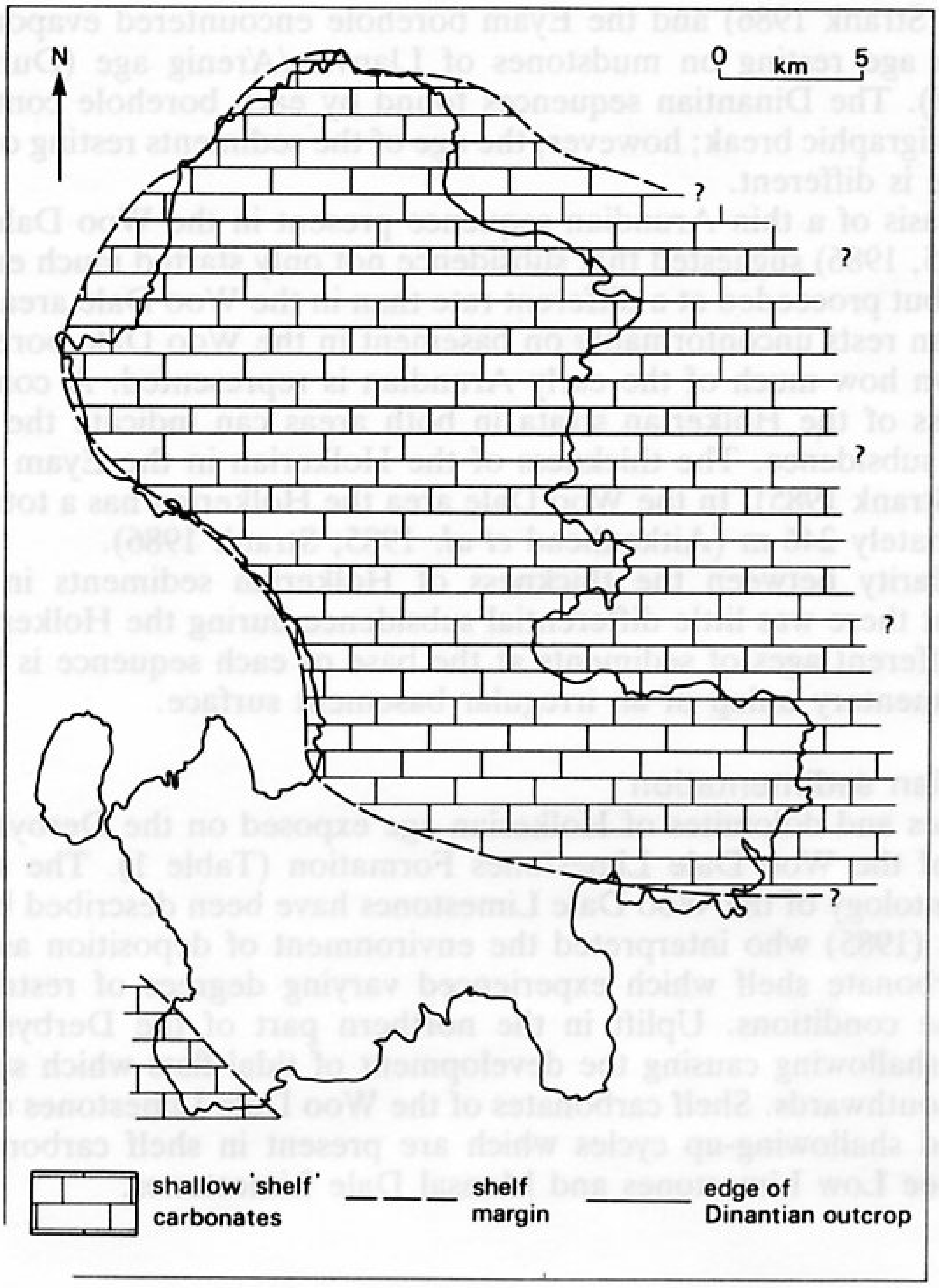

Figure 1. Palaeogeography of the Derbyshire Dome during deposition of the Bee Low Limestones (Asbian).

4. Early Brigantian sedimentation

4a. Deposition of the Station Quarry Beds

The earliest episode of Brigantian sedimentation was the deposition of the Station Quarry Beds (Table 1) which have been discussed by Cope (1937), Walkden (1977), and Pazdzierski (1982). The Station Quarry Beds are thin- to medium-bedded bioturbated packstones and wackestones which were deposited after a period of uplift and karstic erosion of the top of the Bee Low Limestones in the Miller's Dale region. After deposition of the Station Quarry Beds another period of uplift, accompanied by folding, took place and the Station Quarry Beds were removed from the crests of anticlines resulting in further karstic erosion of the Bee Low Limestones.

Walkden (1977) interpreted the Station Quarry Beds to have been deposited in a sheltered environment marginal to an intrashelf basin which was present to the

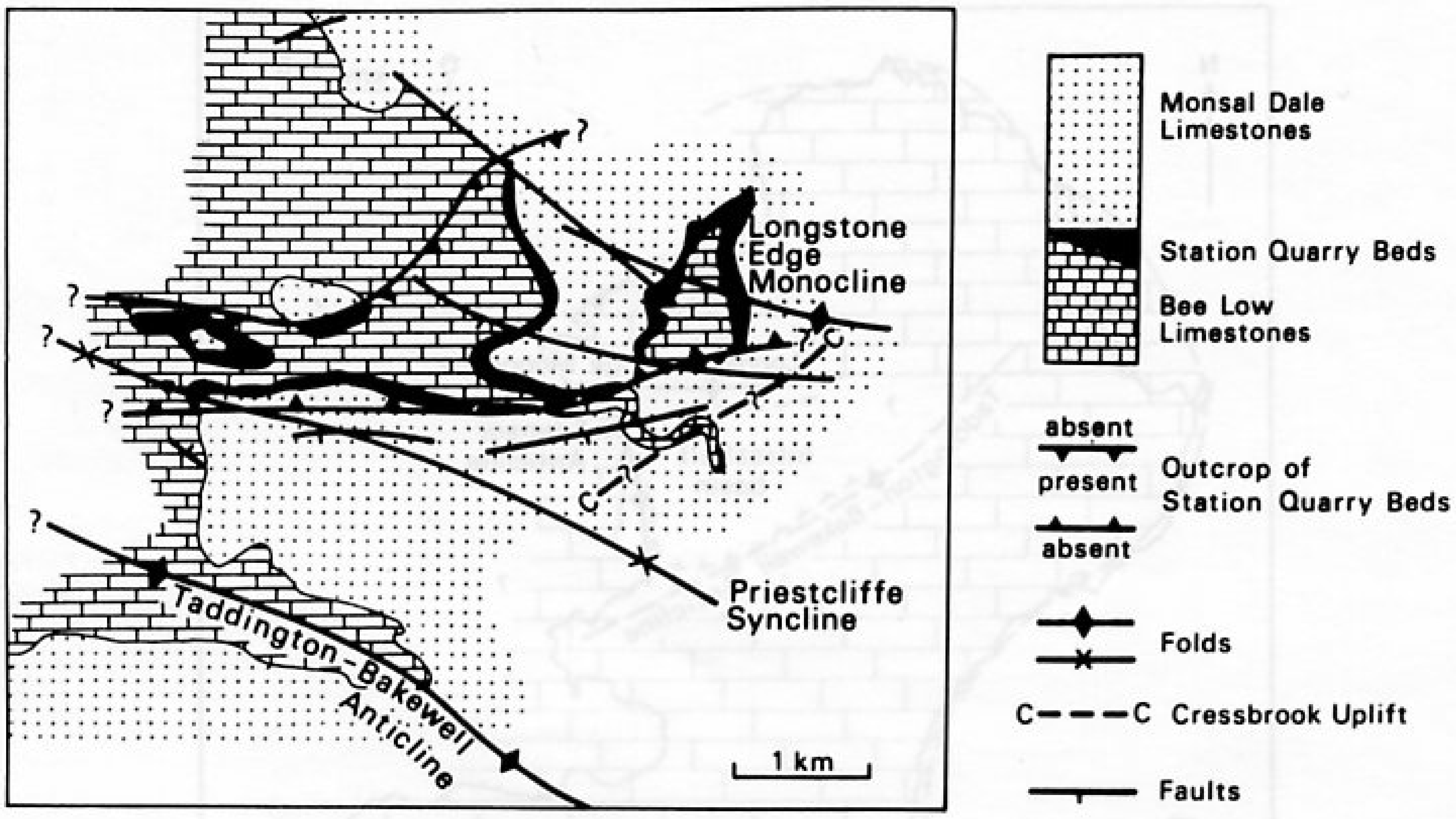

Figure 2. Distribution of the Station Quarry Beds (early Brigantian). Outcrop data from Aitkenhead *et al.* (1978) and data on occurrence of Station Quarry Beds from Walkden (1977).

east in the Monsal Dale area.

The distribution of the Station Quarry Beds is shown in Figure 2 and is controlled by two factors:

1. The original limits of deposition, which Walkden (1977) suggested was within an incipient syncline between the Taddington–Bakewell Anticline and a westward extension of the Longstone Edge Monocline.
2. The extent of erosion following uplift prior to further deposition of the Monsal Dale Limestones. Walkden (1977) shows that the eastern limit of the Station Quarry Beds is formed by a NE–SW trending monocline. This feature is probably the Cressbrook Uplift described by Pazdzierski (1982) who suggested that it later influenced deposition of the Monsal Dale Limestones.

4b. Deposition of the Monsal Dale Limestones

Figure 3 shows the palaeogeography of the Derbyshire Dome during deposition of the Monsal Dale Limestones. Structural features which are thought to have influenced sedimentation are shown.

The Monsal Dale Limestones have been divided into two facies (Table 1) by Stevenson and Gaunt (1971), Aitkenhead and Chisholm (1982), and Aitkenhead *et al.* (1985): the light-coloured (or 'normal') facies and the dark-coloured facies.

The light-coloured facies, has been described by Stevenson and Gaunt (1971), Bridges (1982), Walkden (1982), and Aitkenhead *et al.* (1985) and comprises thickly-bedded, pale-coloured limestones which display cyclicity. Each bed typically consists of bioturbated bioclastic wackestones and packstones at the base grading up into bioturbated bioclastic grainstones with occasional cross-bedding. The tops of the beds often contain evidence of emergence such as calcrete textures and fenestrae. The limestones are often interbedded with clay horizons which rest on a palaeokarstic surface (Walkden 1974). These clay horizons were interpreted by Walkden (1972) as weathered volcanic ashes.

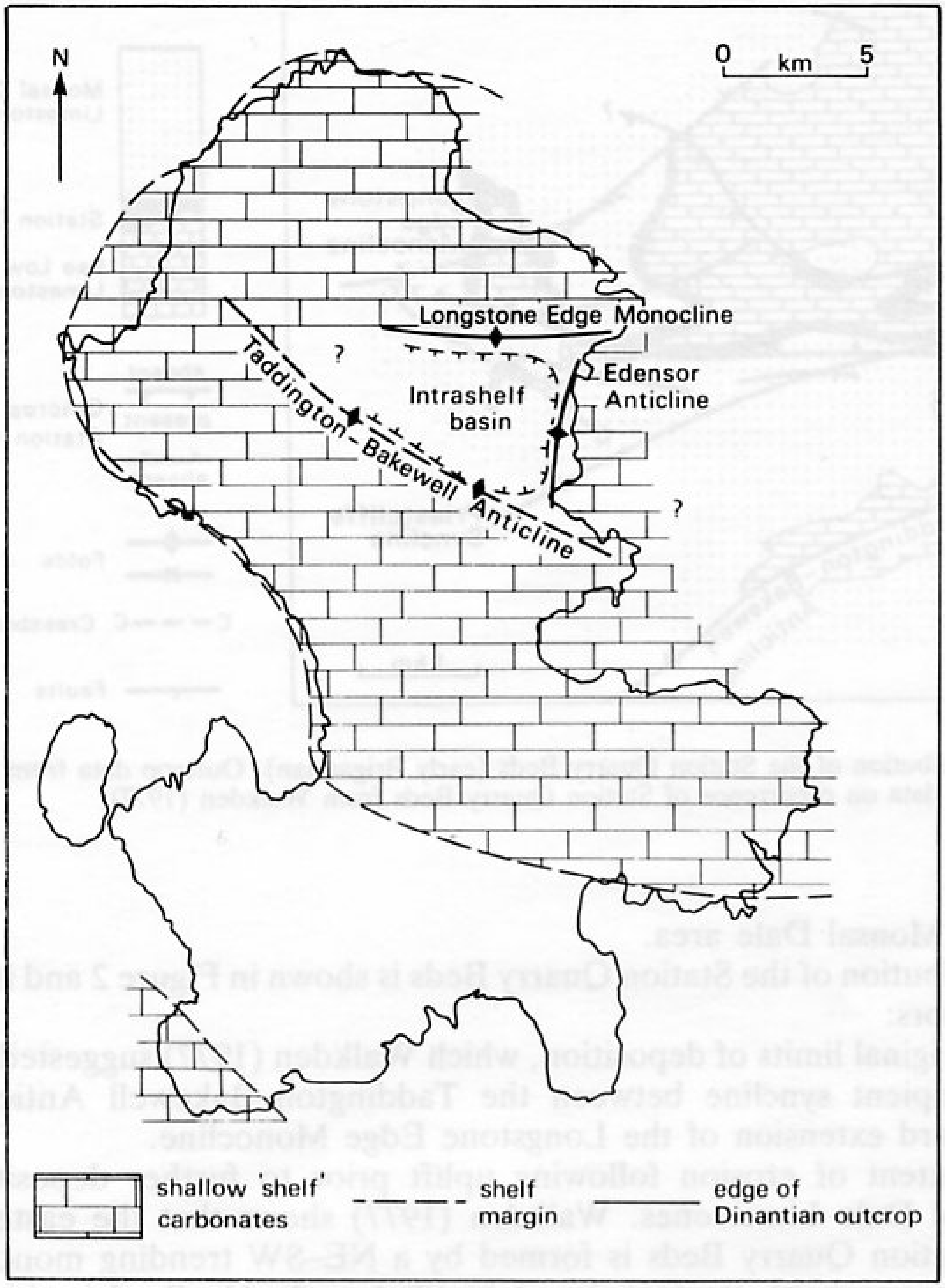

Figure 3. Palaeogeography of the Derbyshire Dome during deposition of the Monsal Dale Limestones (early Brigantian) indicating structural features which influenced sedimentation.

The depositional environment of the light-coloured facies was interpreted by Stevenson and Gaunt (1971) and Aitkenhead *et al.* (1985) to have been a carbonate shelf. Deposition of each bed took place initially in a subtidal environment followed by deposition in intertidal and supratidal environments. The repeated shallowing-up cycles are thought to result from repeated minor eustatic changes (e.g. Bridges 1982; Walkden 1982).

The dark-coloured facies has been described by Walkden (1970), Stevenson and Gaunt (1971), Brown (1973), Butcher and Ford (1973), Ford (1977), Pazdzierski (1982), and Aitkenhead *et al.* (1985) and comprises the following sediment types:

1. Thinly-bedded dark grey organic-rich wackestones and very fine grained packstones which have a strong organic smell when broken. They contain no *in situ* fauna, very few whole fossils and their trace fossil assemblage is very sparse. The absence of reworking suggests deposition in a very quiet

environment probably below storm wave base. The very limited body fossil and trace fossil assemblage and preservation of organic matter suggests deposition in conditions of very low oxygenation.

2. Medium-bedded, bioturbated packstones, which contain a diverse bioclast assemblage. The majority of bioclasts are disarticulated and abraded, but some brachiopods and corals may be preserved *in situ*. These limestones are interpreted to have been deposited above storm wave base but below normal wave base in conditions of near normal salinity and oxygenation.
3. Thickly-bedded grainstones containing abundant crinoid stems, stacked gigantoproductoid brachiopods and rolled, abraded solitary corals with occasional *in situ* colonial corals. These limestones were subject to a high degree of reworking and were probably deposited above normal wave base. These limestones pass laterally into the two limestone types described above.
4. Thickly-bedded, bioclast grainstones and packstones containing reworked and fragmented shallow-water fossils. The beds often display well-developed grading. These limestones are interpreted as proximal turbidites. Finer grained and more thinly-bedded distal turbidites contain *Zoophycus* and *Chondrites* burrows. The absence of any reworking suggests deposition below storm wave base in a deep-water or sheltered environment. The dominance of *Chondrites* over other trace fossils suggests that the level of oxygenation of the sediment was low (Bromley and Ekdale 1984). Slumped masses are present and are commonly overlain by channel-like scours infilled with transported but whole gigantoproductoid brachiopods and other whole bioclasts of shallow water origin. These were interpreted by Pazdzierksi 1982) to be former intertidal channels, but, because of their common association with slumped masses in a turbiditic sequence they are interpreted here as the product of progressive slope failure after a slump has occurred.
5. A slumped, laminated dolomitized limestone unit known informally as the 'Rosewood Marble' consisting of alternating carbonate mudstone and grainstone laminae. The depositional environment of this unit is problematical: it has been interpreted as an outershelf storm laminite by Adams and Cossey (1978), a deep-water seasonally-varved deposit by Walkden (1970) and a peritidal deposit by Pazdzierski (1982).

The dark-coloured facies is interpreted as an intrashelf basin deposit. Orientation of slump structures suggests that palaeoslopes within the basin were controlled by structural features (Figure 4). Butcher and Ford (1973) recorded eastward slumping into the Priestcliffe Syncline. Adams and Cossey (1978) and Pazdzierski (1982) recorded slumping in a southeasterly direction in the Rosewood Marble directed away from the Putwell Hill Fault, palaeostrike in this case being parallel to the Putwell Hill Fault. This suggests that the Putwell Hill Fault is a later expression of a structural feature within the basin. The reworked bioclastic limestones were probably deposited on top of such topographic features.

The significance of the Rosewood Marble is unclear owing to the uncertainty about its depositional environment. It could represent either a phase of low sea level stand, or of extreme environmental restriction which caused stratification of the water column to develop within the basin.

The site of the intrashelf basin was probably marked by a greater rate of subsidence rather than any great difference of water depth from the shelf area on which the light-coloured facies were deposited. Features of deep-water deposition were probably produced by the sheltered situation of an intrashelf basin rather than by great water depth.

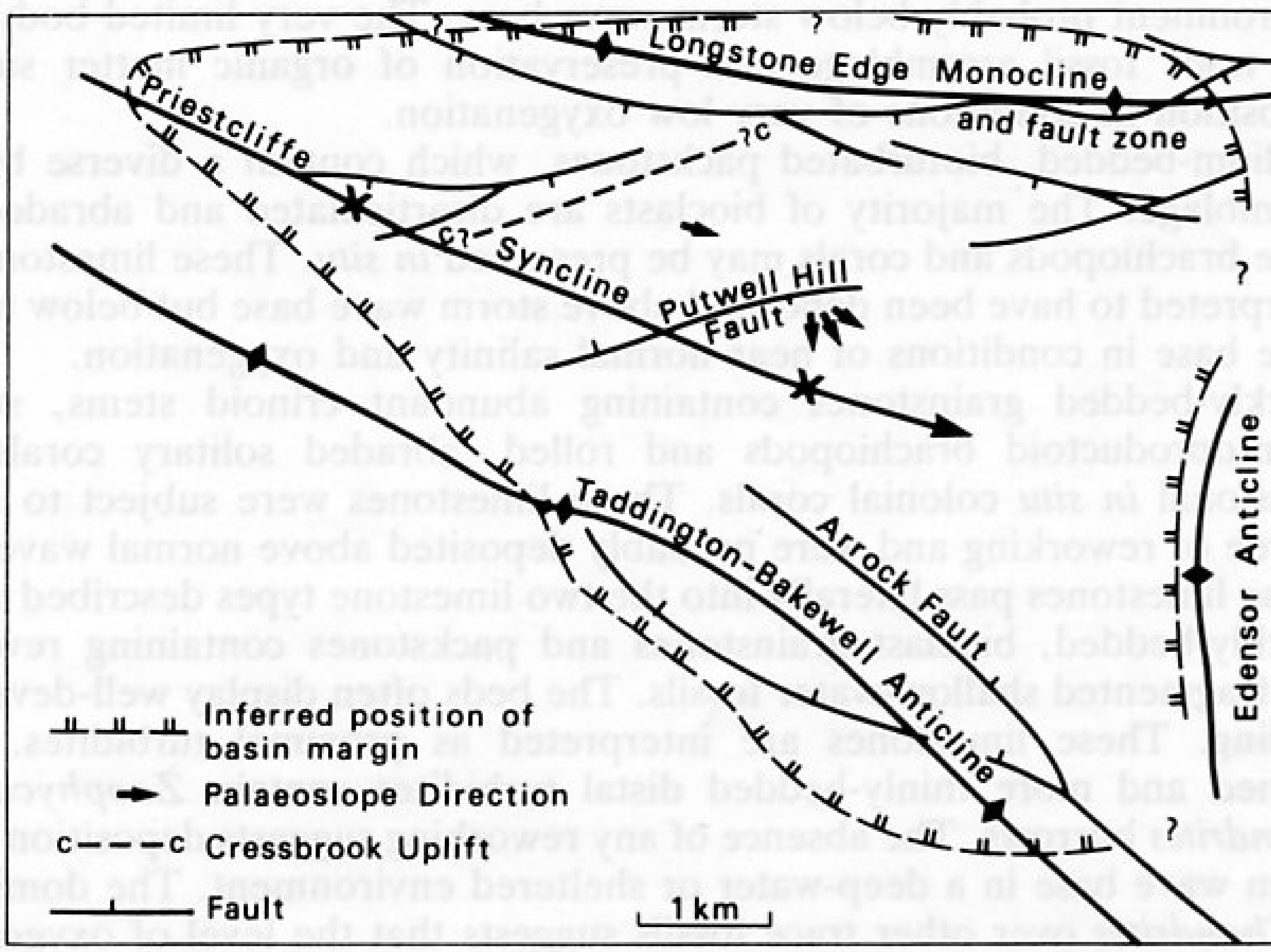

Figure 4. Structural setting of the early Brigantian intrashelf basin. Palaeoslope data from Adams and Cossey (1978), Pazdzierski (1982) and the authors's unpublished data.

The structural setting of this intrashelf basin is shown by Figure 4. The south-western margin was formed by the Taddington–Bakewell Anticline. The northern margin coincides with the Longstone Edge Monocline, although there is conflicting evidence as to the timing of its development. Walkden (1977) and Pazdzierski (1982) showed that it formed the northern deposition limit of the Station Quarry Beds and Butcher and Ford (1973) recorded upwarping of the Longstone Edge Monocline during the early Brigantian. However, Aitkenhead *et al.* (1985, Figure 10), show that the thickest development of the Monsal Dale Limestones underlies the Longstone Edge Monocline. In addition, Stevenson and Gaunt (1971) recorded the presence of the Monsal Dale Limestones dark-coloured facies to the north of the Longstone Edge Monocline. This suggests that the Longstone Edge Monocline may only have been active sporadically during the early Brigantian. At times when the Longstone Edge Monocline was inactive, basinal sedimentation spread northwards. The occurrence of the dark-coloured facies of the Monsal Dale Limestones south of the Taddington–Bakewell anticline mapped by Aitkenhead *et al.* (1978) may indicate that there was some movement on the Cronkston–Bonsall fault during the early Brigantian.

5. Late Brigantian sedimentation: deposition of the Eyam Limestones Formation

The Eyam Limestones Formation is the youngest carbonate formation of Dinantian age to have been deposited on the Derbyshire Dome (Table 1). Figure 5 shows the palaeogeography of the Derbyshire Dome during its deposition. Structural

Figure 5. Palaeogeography of the Derbyshire Dome during deposition of the Eyam Limestones (late Brigantian) indicating structural features which influenced sedimentation.

features which are thought to have influenced sedimentation are indicated.

An area of deeper water sedimentation, described by Walkden (1970), Brown (1973), Butcher and Ford (1973), and Gutteridge (1983) was present in the Ashford area (referred to here as the Ashford Basin) which continued the deeper water sedimentation established in the early Brigantian. The Eyam Limestones in the Ashford Basin rest conformably on the dark-coloured facies of the Monsal Dale Limestones. At the base of the Eyam Limestones there is a slumped and laminated dolomitic limestone unit. This unit was described by Walkden (1970), Brown (1973), Butcher and Ford (1973), and Gutteridge (1983). The latter found calcrete textures, fenestrae, early-formed evaporites and a coal seam with a seat earth and interpreted this unit as a peritidal deposit. This laminite was probably deposited during an episode of low sea level stand at the beginning of the deposition of the Eyam Limestones (Gutteridge 1983). Overlying the laminated

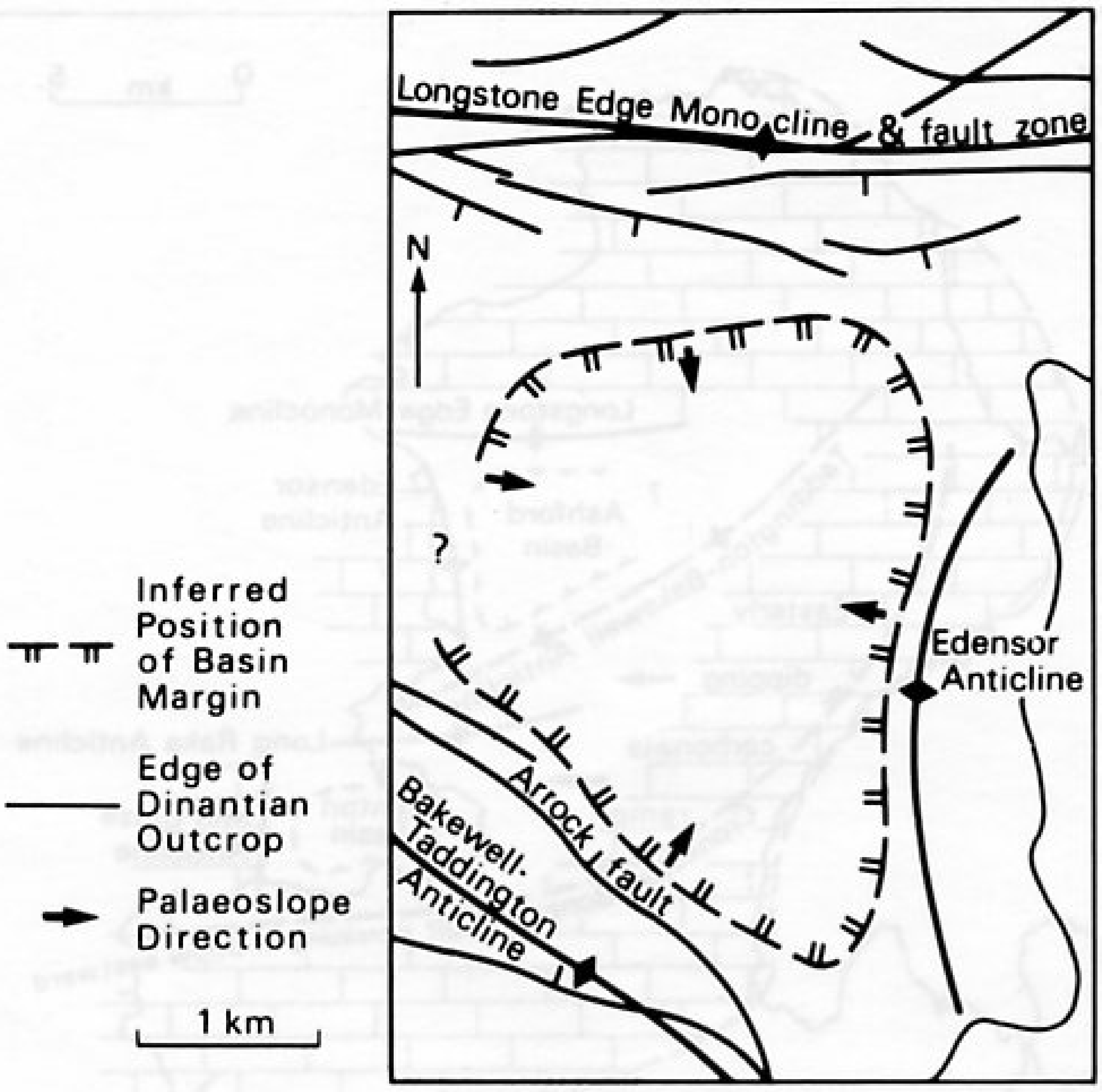

Figure 6. Structural setting of the Ashford Basin. Palaeoslope data from Gutteridge (1983).

dolomitic limestone is 10–15 m of bioclastic turbidites which become more thinly-bedded towards the top of the Eyam Limestones. The proportion of shale between limestones beds increases towards the top of the sequence. The Eyam Limestones are overlain conformably by the Longstone Mudstone Formation whose base was defined by Aitkenhead and Chisholm (1982) as the point at which shale forms the larger proportion of the sequence (Table 1).

Slump structures present in the Eyam Limestones demonstrate the orientation of the palaeoslopes which formed the margins of the Ashford Basin (Figure 6). The northern margin is formed by the Longstone Edge Monocline, and the southwestern margin is formed by the Taddington–Bakewell Anticline which is associated with the Arrock Fault. The Arrock Fault is a NW–SE trending normal fault zone with a northeasterly downthrow towards the former Ashford Basin. The eastern margin of the Ashford Basin is formed by the N–S trending Edensor Anticline across which there is a facies change to shallow-water carbonates (Brown 1973; Gutteridge 1983). The easterly directed slumping at the western part of the outcrop may represent slumping along the western margin of the basin or off an active topographic feature within the basin.

The early Brigantian carbonate shelf between the Taddington–Bakewell Anticline and the Cronkston–Bonsall Fault later developed into an easterly-dipping carbonate ramp. Sedimentation on this carbonate ramp consisted of high energy bioclastic shoals at the shallow western part of the ramp passing eastwards down the depositional slope into shallow subtidal packstones and wackestones and then into dark limestones deposited by storm activity below wave base (Gutteridge

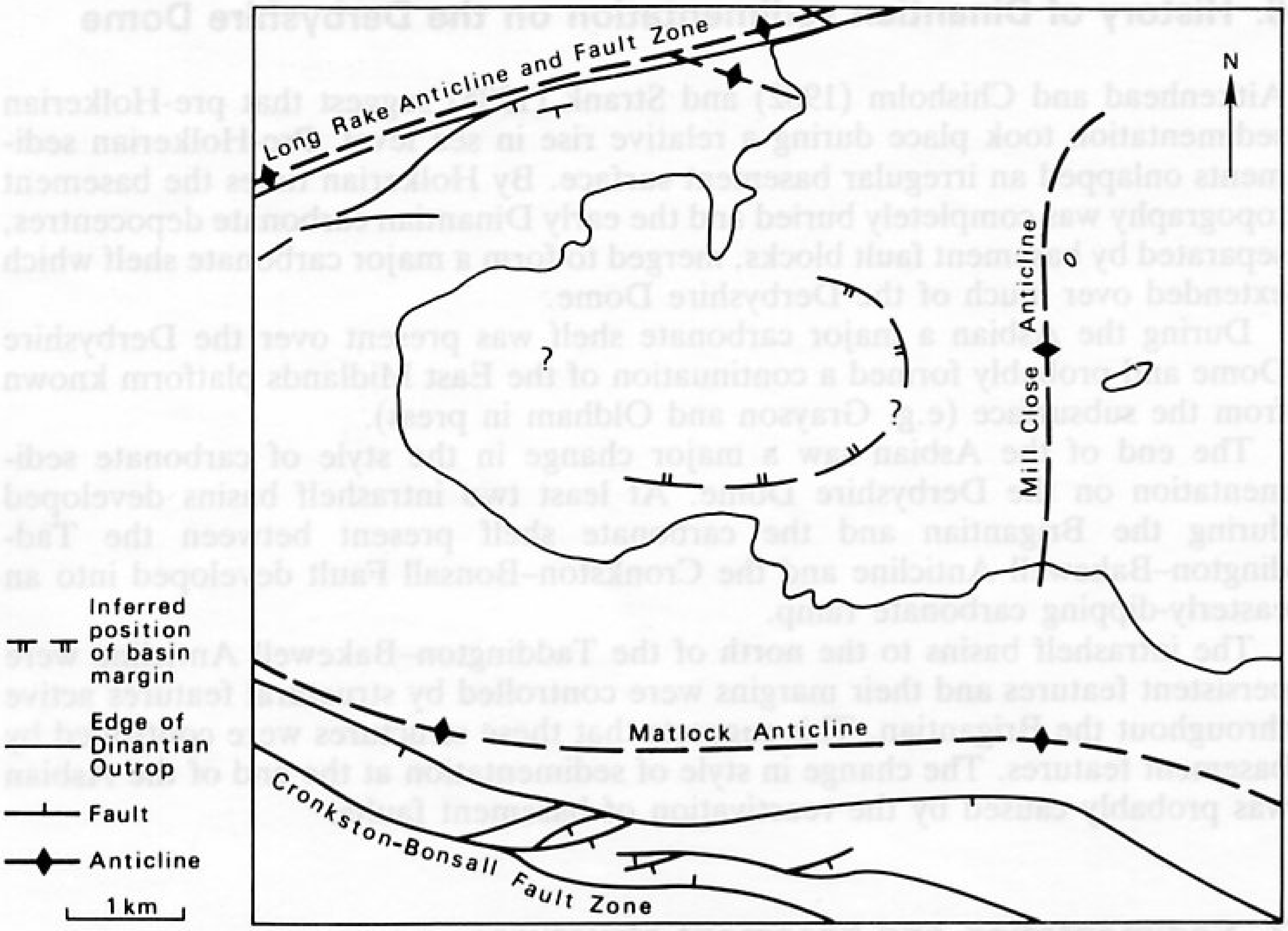

Figure 7. Structural setting of the Stanton Basin (adapted from Butcher and Ford 1977).

1984). South of the Cronkston–Bonsall Fault deposition of the Eyam Limestones appears to have taken place on a stable carbonate shelf (Shirley 1958; Walkden 1982).

A second basin (referred to as the Stanton Basin) developed in the east–central part of the Derbyshire Dome during the late Brigantian. This basin is mainly concealed beneath Namurian strata in the Stanton Syncline, but exposures of Eyam Limestones around the margins of the Stanton Syncline described by Brown (1973) and boreholes drilled near Birchover indicate that it contains a similar sequence to that present in the Ashford Basin, but overlies the Monsal Dale Limestones light-coloured facies (Butcher personal communication, 1982; Aitkenhead *et al.* 1985). Trail (1939, 1940) and Butcher (personal communication, 1982) suggest that the eastern margin of the Stanton Basin corresponds with the Mill Close Anticline, across which there is a facies change from basinal to shallow-water carbonates. The Stanton Basin does not appear to have a well-defined western margin but it probably passes into the deep, eastern part of the carbonate ramp described above. The structural setting of the Stanton Basin is similar to that of the Ashford Basin in that it is bounded on the north by an E–W trending anticline associated with a fault zone, to the southwest by a NW–SE trending anticline and associated fault zone and to the east by a N–S trending anticline (Figure 7).

6. History of Dinantian sedimentation on the Derbyshire Dome

Aitkenhead and Chisholm (1982) and Strank (1985) suggest that pre-Holkerian sedimentation took place during a relative rise in sea level. Pre-Holkerian sediments onlapped an irregular basement surface. By Holkerian times the basement topography was completely buried and the early Dinantian carbonate depocentres, separated by basement fault blocks, merged to form a major carbonate shelf which extended over much of the Derbyshire Dome.

During the Asbian a major carbonate shelf was present over the Derbyshire Dome and probably formed a continuation of the East Midlands platform known from the subsurface (e.g. Grayson and Oldham in press).

The end of the Asbian saw a major change in the style of carbonate sedimentation on the Derbyshire Dome. At least two intrashelf basins developed during the Brigantian and the carbonate shelf present between the Taddington–Bakewell Anticline and the Cronkston–Bonsall Fault developed into an easterly-dipping carbonate ramp.

The intrashelf basins to the north of the Taddington–Bakewell Anticline were persistent features and their margins were controlled by structural features active throughout the Brigantian. This suggests that these structures were controlled by basement features. The change in style of sedimentation at the end of the Asbian was probably caused by the reactivation of basement faults.

7. Sedimentation and basement structure

7a. Basement structure

The term basement refers here to the rocks which underlie carbonates and evaporites of Dinantian age. The known stratigraphy of the basement is shown by Table 2.

Maroof (1976) inferred a positive basement feature underlying the Derbyshire Dome from gravity data. He modelled the presence of Ordovician sediments but did not explicitly identify any other component of the basement.

Rogers (1983) studied the basement using gravity, aeromagnetic, and seismic

Table 2. Known stratigraphy of the basement

AGE	Southern Province	Northern Province
Devonian / early Dinantian	REDHOUSE SANDSTONES	
Ordovician		Volcanics in Woo Dale Borehole. Llanvirn/Arenig mudstones in Eyam Borehole.
Cambrian		?
Precambrian	CHARNIAN	CHARNIAN

refraction techniques. He recognized the presence of Charnian sediments on the basis of the NW–SE trend of gravity and aeromagnetic contours and on the correlation of a seismic reflector with the top Charnian reflector identified to the southeast of the Derbyshire Dome by Whitcombe and Maguire (1981). Rogers recognized two basement provinces which are separated by a fault having a northward downthrow and whose position corresponds to that of the Cronkston–Bonsall Fault. This fault has a minimal throw near the western margin of the Derbyshire Dome, but increases to the east.

To the south of the Cronkston–Bonsall Fault the Charnian basement is overlain by the Redhouse Sandstones which are up to 1 km in thickness and thin northwards to zero at the Cronkston–Bonsall Fault. The Redhouse Sandstones are late Devonian to early Dinantian in age (Aitkenhead and Chisholm 1982). The basement surface in the southern province is relatively flat and corresponds to the area of carbonate shelf deposition present throughout the Asbian and Brigantian. To the north of the Cronkston–Bonsall Fault the basement surface dips eastward. Charnian rocks are overlain by rocks of Lower Palaeozoic age including mudstones of Llanvirn or Arenig age encountered by the Eyam borehole (Dunham 1973). Rogers (1983) correlated the top Ordovician reflector at Eyam with the top basement reflector at Woo Dale implying that the volcanics encountered by the Woo Dale borehole may be of Ordovician age.

Smith *et al.* (1985) suggested that the basement structure of the Derbyshire Dome consists of two tilted fault blocks whose surfaces dip to the south. The northern tilt block was called the Eyam Tilt Block and the southern tilt block the Woo Dale Tilt Block. The fault blocks are separated by the Bakewell Fault whose position corresponds to the Taddington–Bakewell Anticline. Smith *et al.* (1985) suggested that the Taddington–Bakewell Anticline was formed by drape over the northern margin of the Woo Dale Tilt Block.

The basement model of Smith *et al.* (1985) can explain the position of the intrashelf basin which developed at the beginning of the Brigantian. However, it cannot explain the development of the Stanton Basin and the easterly-dipping carbonate ramp later in the Brigantian. Smith *et al.* (1985) did not consider the Cronkston–Bonsall Fault to be a major influence on sedimentation during the Brigantian.

The basement between the Cronkston–Bonsall Fault and the Bakewell Fault may either be a small tilt block or a fault terrace at the northern margin of the Woo Dale Tilt Block. The easterly dip of the basement surface was probably acquired during the late Brigantian causing the development of the easterly-dipping carbonate ramp. Figure 8 shows a modified interpretation of this area.

The similar structural settings of the Stanton Basin and the Ashford Basin can be explained by postulating that they were formed on the downthrown side of a major basement fault. Reactivation of these faults during the Brigantian caused downwarp in the Monsal Dale and Stanton areas forming the depositional basins. The southern margin of the Ashford Basin was controlled by the Bakewell Fault and the southern margin of the Stanton Basin was controlled by the Cronkston–Bonsall Fault. The northern margin of the Ashford and Stanton Basins may have been controlled by roll-over anticlines (the Longstone Edge Monocline and the Long Rake Anticline respectively) associated with faults developed in the cover sediment which have an antithetic relationship to the main basement fault (see N–S section on Figure 8). These antithetic faults later propagated through the cover sediments to form the E–W trending fault zones associated with the folds.

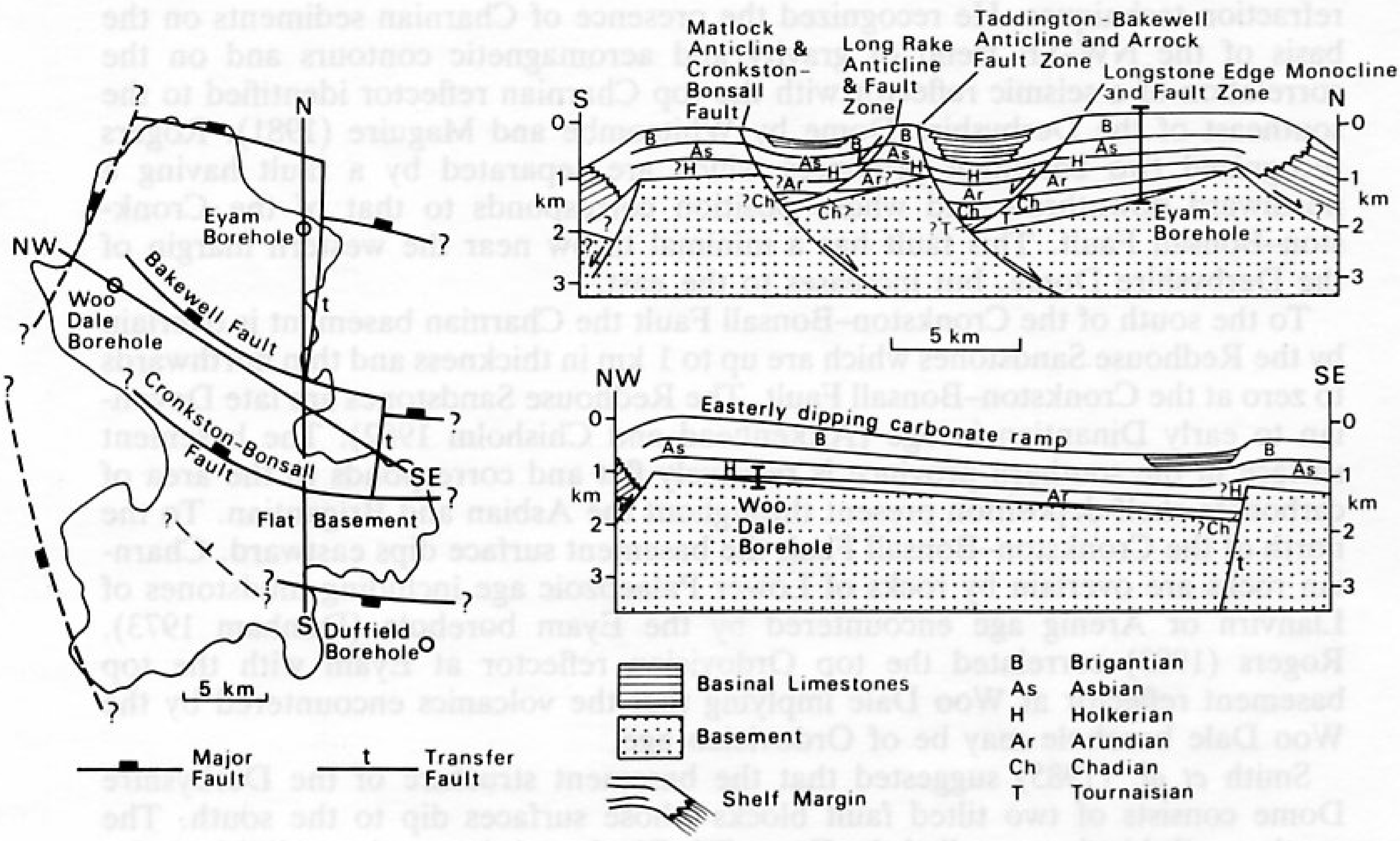

Figure 8. Proposed tilt block structure of the basement to the Derbyshire Dome. The horizontal scale of the sections is 1·5 times the horizontal scale of the map. The vertical scale of the sections is approximate and is taken from the results of seismic refraction studies obtained by Rogers (1983).

Accounting for the eastern margins of the intrashelf basins is more difficult. In both cases, the basins pass eastwards into shallow water facies across N–S trending anticlines. One possible solution is to postulate a second set of tilt blocks to the east of the present Dinantian outcrop, but displaced from the Eyam and Woo Dale tilt blocks by a series of N–S trending transfer faults which have a westward downthrow. Drape over these transfer faults may have formed a contemporaneous flexure which controlled the eastern margins of these basins. However, Lee (personal communication 1986) identified a series of N–S trending lineaments in residual gravity data, which he interpreted to be the expression of N–S trending faults having an eastward downthrow. Further research is necessary to resolve the sedimentological and geophysical evidence.

This model of basement structure, taking into account the conditions of Brigantian sedimentation is shown in Figure 8.

7b. Basement structure at the southern and western margins of the Derbyshire Dome

During the Dinantian an area of deeper water, called the Widmerpool Gulf, was present to the south and the west of the Derbyshire Dome (Aitkenhead 1977; Frost and Smart 1979; Bridges 1984; Aitkenhead *et al.* 1985). The Duffield borehole, 15 km southeast of the Derbyshire Dome, proved a Viséan sequence at least 641·77 m thick which is at least four times thicker than that deposited on the southeastern part of the Derbyshire Dome (Frost and Smart 1979). This sequence consists of clastic mudstones containing a goniatite/bivalve fauna interbedded with siliciclastic and bioclastic turbidites (Aitkenhead 1977).

Whitcombe and Maguire (1981) identified a down-step of the top basement reflector (interpreted by them to be the top of the Charnian) to the south of the present Dinantian outcrop. They suggested that the Charnian is at a depth of approximately 2 km to the south of the Derbyshire Dome. Lee (1986) identified an E–W trending residual gravity high stretching across the southern margin of the Derbyshire Dome. The southern margin of this high corresponds with the position of the down-step of the Charnian basement. The coincidence of these features identified by geophysical techniques with the facies and thickness change in the Viséan, suggests that the northern margin of the Widmerpool Gulf is marked by a major basement fault.

Bridges (1984) examined the nature of the southwest margin of the Derbyshire Dome during the Chadian and interpreted the transition to the Widmerpool Gulf as a westward-dipping carbonate ramp. Studies by Ludford *et al.* (1973) and Aitkenhead *et al.* (1985) show that during the Asbian the western margin of the Derbyshire Dome was marked by a distinct shelf margin of a similar type to that described from the Castleton area by Broadhurst and Simpson (1973). These studies support the ramp to rimmed shelf model of sedimentation at the western margin of the Derbyshire Dome proposed by Miller and Grayson (1982) and Grayson and Oldham (in press). However, gravity data does not support the basement structure proposed by Miller and Grayson (1982) and Grayson and Oldham (in press) who show a major basement fault with westward downthrow coinciding with the western margin of the Derbyshire Dome. Rogers (1983) noted that there is no fault apparent from the gravity data and Maroof (1976) showed that the sub-Dinantian basement dips uniformly to the west. Rogers (1983) and Lee (personal communication 1986) suggest this transition may be marked by a series of small NW–SE trending fault bounded basins. An interpretation of the basement structure at the margins of the Derbyshire Dome is shown by Figure 8.

8. Conclusions

Sedimentation on the Derbyshire Dome during the Dinantian can be divided into three episodes:

Pre-Holkerian: characterized by sedimentary onlap of an irregular basement topography.

Holkerian to Asbian: merging of early-Dinantian depocentres initially separated by basement topography to form a major carbonate shelf present over the Derbyshire Dome.

Brigantian: development of intrashelf basins and an easterly-dipping carbonate ramp, controlled by contemporaneous structural features.

The tectonic features which influenced Brigantian sedimentation are probably basement-controlled and the change in style of carbonate sedimentation at the end of the Asbian was probably caused by reactivation of basement faults. It is perhaps significant that Gawthorpe (1986, in press) also records a tectonic event which caused an episode of extension affecting the Bowland Basin during the late Asbian/early Brigantian.

The basement structure of the Derbyshire Dome consists of two main tilt blocks separated by a smaller tilt block. The bounding faults of the tilt blocks have a northward downthrow. The surface expressions of these faults are the Taddington–Bakewell Anticline with the associated Arrock Fault and the Cronkston–Bonsall Fault. These features were active during the Brigantian and formed the southwestern margins of the two intrashelf basins. The northern margins of the intrashelf basins were formed by roll-over anticlines associated with antithetic faulting in the Dinantian cover developed in response to movement on the basement faults. The eastern margins of the intrashelf basins were probably formed by drape of the Dinantian cover over N–S trending transfer faults separating the tilt blocks underlying the Derbyshire Dome from a postulated set of tilt blocks further to the east.

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