Wye Valley and Cressbrook Dale, Derbyshire

[SK 100 724]–[SK 192 713] and [SK 172 740]–[SK 178 755]

Introduction

The Wye Valley and Cressbrook Dale GCR site report considers the geology at two GCR sites in central Derbyshire, the Midland Railway to Wye Valley site and the Cressbrook Dale site, together. Thus, it includes details of the extended section [SK 100 724]–[SK 192 713] of Lower Carboniferous strata exposed along the line of the disused Midland Railway cutting and in the valley-side crags and quarries of the River Wye between Buxton and Bakewell, together with details of the exposures in the A6 road cutting at Topley Pike [SK 108 724]–[SK 114 724] and valley-side crags of Cressbrook Dale [SK 172 730]–[SK 173 728] and [SK 172 740]–[SK 178 755]; these localities are shown on (Figure 7.5).

The Wye Valley component of this composite site is unique as it provides an extensive and almost continuous section (> 9 km in length) of the exposed Dinantian beds of the Derbyshire carbonate platform ranging from the Woo Dale Limestones (Holkerian) through to the Eyam Limestones (Brigantian) (Figure 7.3). The succession demonstrates many features, including dolomitization, changing depositional environments, the response of carbonate sedimentation to sea-level changes, contemporaneous volcanism, the influence of syn-depositional uplift and subsidence, the development of an intra-platform basin and the final abandonment of carbonate sedimentation on the Derbyshire Platform in late Brigantian–early Namurian times.

The basic lithostratigraphy and biostratigraphy of the central part of the platform was first established by Sibly (1908) and Cope (1933, 1937) in this area. The latter author also recognized the complex stratigraphical relationships around the Asbian–Brigantian boundary in the Millers Dale area, which was further elaborated by Butcher and Ford (1973), Walkden (1977), Pazdzierski (1982), Aitkenhead *et al.* (1985) and Gutteridge (1989a, 1990b).

The Monsal Dale Limestones were divided into a 'dark' and 'pale facies' by Cope (1933). These facies, recorded on [British] Geological Survey maps of the area (Institute of Geological Sciences, 1976b, 1978), were described in detail by Stevenson and Gaunt (1971), Butcher and Ford (1973) and Aitkenhead *et al.* (1985). Later work by Pazdzierski (1982) and Gutteridge (1989a) showed that the dark facies of the Monsal Dale Limestones accumulated in an intra-shelf basin, while the pale facies accumulated over surrounding shelf areas. Aitkenhead and Chisholm (1982) refined the lithostratigraphy with the establishment of type sections for the Woo Dale Limestones, Bee Low Limestones, Station Quarry Beds, Monsal Dale Limestones and the Longstone Mudstones in this area (Figure 7.3).

Description

Wye Dale to Chee Dale [SK 100 724]–[SK 123 734]

In this region, the upper 72 m of the Woo Dale Limestones is exposed. The basal part of the sequence has been partly replaced by dolomite in the form of massive to stratiform bodies that locally cross-cut bedding (Aitkenhead *et al.,* 1985; Schofield and Adams, 1986). The Woo Dale Limestones comprise lenticular-bedded wackestone-packstone beds 0.5–1.0 m thick with fenestrae, gastropods, bivalves and *Daviesiella* valves (see Cope, 1940). Sharp, erosively based, beds of fine-grained bioclastic grainstone are also present. Some unusually thick (1–2 cm) bituminous stylolite residues that resemble thin coal seams are also present (Schofield, 1982). A Holkerian age for this formation is indicated by the presence of *Davidsonina carbonaria, Composita* cf. *ficoides* and foraminifera listed by Strank (1986).

The contact between the Woo Dale Limestones and the Bee Low Limestones is marked by a transition from medium-grey lenticular-bedded limestones to thick and planar-bedded pale-grey limestones. The whole of the Bee Low Limestones (130–150 m), including the Lower Millers Dale Lava, is exposed between Blackwell Cottages [SK 1135 7265] and Millers Dale (Aitkenhead *et al.,* 1985). The formation consists of thickly bedded, pale bioclastic peloidal packstone-grainstone with minor wackestone and calcrete features associated with palaeokarstic surfaces. Scattered coral–brachiopod bands typically contain *Daviesiella, Linoprotonia hemisphaerica, Davidsonina septosa* and *Dibunophyllum bourtonenese* (Mitchell and Strank in Aitkenhead *et al.,* 1985), the last two taxa confirming an Asbian age for these beds.

Millers Dale Station Quarry to Cressbrook Dale (SK 132 734–[SK 172 729]

The type section of the Station Quarry Beds (Cope, 1937) is at Millers Dale Station Quarry (Figure 7.6) where they are 14 m thick and overlie a palaeokarstic surface developed on top of the Bee Low Limestones (Section 1 on (Figure 7.7)). Some palaeokarstic pits up to 3 m deep are present but are now obscured (Cope, 1937; Walkden, 1977; Pazdzierski, 1982). The basal 1 m of the Station Quarry Beds comprises interbedded shale and packstone, and contains *Koninckopora,* intraclasts, fenestrae and rhizocretions. These beds are overlain by dark-grey bioclastic wackestone–packstone (Gutteridge, 1990b). Cope (1937), Stevenson and Gaunt (1971), Butcher and Ford (1973) and Pazdzierski (1982) showed that the Station Quarry Beds pinch out to the south and north against the Taddington-Bakewell Anticline and the Long-stone Edge Anticline respectively.

Millers Dale Quarry [SK 141 730] exposes a 30 m section (Section 2 on (Figure 7.7)) of the 'pale facies' of the Monsal Dale Limestones, made up of minor cycles 0.5–3 m thick, comprising bioclastic packstone and grainstone, with some evidence of cross-bedding, passing up to bioclastic wackestone or packstone with calcrete textures.

Relationships between the Bee Low Limestones and the Monsal Dale Limestones can be seen along the railway cutting from the front of the Upper Millers Dale Lava (see Stephenson *et al.,* 2003) at [SK 1560 7300] to the western entrance of Cressbrook Tunnel [SK 1675 7255] (Section 3 on (Figure 7.7)). The front of the Upper Millers Dale Lava is draped by beds of the Monsal Dale Limestones, forming a wedge-shaped unit of bioclastic limestone overlain by parallel-bedded dark-grey calcisiltite with tabular chert. The latter contain a sparse fauna of thin-shelled bivalves and *Chondrites* burrows. A lateral facies change to wackestone with a diverse bioclast suite including large in-situ colonial corals takes place over a distance of 250 m to the east. Cope (1937) recorded gigantoproductids, numerous lithostrotionid corals and *Saccaminopsis* from these beds. A thickly bedded sequence of the Bee Low Limestones topped by a prominent palaeokarst with deep-brown to bluish-grey clay-filled pits containing pebbles of the Station Quarry Beds is exposed at the western end of Litton Tunnel [SK 1620 7280] and between the Litton and Cressbrook tunnels ([SK 1665 7270]–[SK 1675 7255]) (Butcher and Ford, 1973; Walkden, 1977; Pazdzierski, 1982). The overlying Monsal Dale Limestones here comprise bioclastic grainstones with reworked gigantoproductids, crinoids and solitary corals.

A section in the lower part of the Monsal Dale Limestones in the cutting east of Cressbrook Tunnel [SK 1725 7255] (Section 4 on (Figure 7.7)) comprises some 8 m of cherry calcisiltite with two slumped units of recumbently folded bioclastic packstone–wackestone. Some thin graded beds of grainstone–packstone with reworked bioclasts also occur here. Butcher and Ford (1973) record the Upper Dale Coral Bed (1 m) halfway up this section; the corals include *Siphonodendron junceum* with *S. martini* and *Diphyphyllum lateseptatum* (Butcher and Ford, 1973; Aitkenhead *et al.,* 1985) and some show evidence of having been reworked (toppled and inverted colony fragments and re-orientated growth forms, etc).

An excellent section of the 'pale facies' of the Monsal Dale Limestones, incorporating numerous lithostratigraphical marker bands, is developed in north Cressbrook Dale. The section here (Figure 7.8) extends from the top of the Bee Low Limestones, through the entire thickness of the Monsal Dale Limestones (*c.* 155 m), to the base of the Eyam Limestones and includes the poorly exposed Cressbrook Dale Lava and the Litton Tuff (Stevenson and Gaunt, 1971). A notable development, some 15 m above the Litton Tug is that recognized by Shirley and Horsfleld (1945), Taylor (1957) and Stevenson and Gaunt (1971) as the Hobs House Coral Bed, and which Cossey (1983) referred to as the 'Cressbrook Dale Coral Band'. A typical Brigantian coral assemblage from this band includes *Aulophyllum pachyendothecum, Dibunophyllum bipartitum, Slimoniphyllum slimonianum, siphonodendron* spp., *Diphyphyllum lateseptatum, Palastraea regia, Lithostrotion maccoyanum* and *Actinocyathus floriformis* (Taylor, 1957; Stevenson and Gaunt, 1971; Cossey, 1983). Its structure, development and significance at the top of a shallowing-upward (regressive) cycle capped by a calcrete and a minor angular discordance has been described by Cossey (1983).

Monsal Dale to Headstone Cutting [SK 172 724]–[SK 190 713]

A 44 m section in the middle part of the Monsal Dale Limestones extending from the Hobs House Coral Bed (0.5 m) to just above the 'Rosewood Marble' (1.6 m) is exposed in Monsal Dale Viaduct Cutting between Monsal Dale Station and Monsal Head Viaduct (Section 5 on (Figure 7.7)). The Hobs House Coral Bed is best exposed at Hobs House [SK 1760 7122] where it is up to 5 m thick and contains spectacular examples of both solitary corals and large in-situ colonial corals including *D. bipartitum, Koninckophyllum magnificum, Slimoniphyllum slimonianum, Clisiophyllum keyserlingi, Siphonodendron* spp., *Diphyphyllum* spp., *Lithostrotion decipiens* and *Nemistium edmondsi* (Cossey, 1983). This fauna, together with other coral assemblages in the Monsal Dale Limestones (see below), confirms the Brigantian age assigned to this formation by Aitkenhead and Chisholm (1982). The Hobs House Coral Bed also occurs at Crossdale Head [SK 1825 7310].

The majority of the section in Monsal Dale consists of thickly bedded, fine-grained, dark packstone with comminuted bioclasts and *Chondrites* and *Zoophycos* burrows. These are interbedded with thin shale beds and some K-bentonite beds. Both the extensional and compressional parts of slump sheets overlain erosively by metre-thick graded beds of coarse bioclastic grainstone are also exposed. The Rosewood Marble consists of millimetre- to centimetre-scale laminations of carbonate mudstone and dolomite replacing fine grainstone layers. The laminations show slumping and are cut by burrows infilled by dark calcisiltite. This unit is described in more detail by Adams and Cossey (1978).

A 19 m section in the Monsal Dale Limestones between the Rosewood Marble and the White Cliff Coral Bed is exposed at White Cliff [SK 1825 7200] (Section 6 on (Figure 7.7)). This records an upward transition from fine-grained cherty calcisiltite through bioturbated open marine bioclastic wackestone to bioclastic grainstone with reworked gigantoproductids and crinoids. The White Cliff Coral Bed, at the top of the section, contains *Lonsdaleia duplicata, Actinocyathus floriformis, Palastraea regia, Dipbyphyllum lateseptatum* and *Orionastraea placenta* (Butcher and Ford, 1973; Aitkenhead *et al.,* 1985). The White Cliff Coral Bed and underlying bioclastic limestones are also exposed around Monsal Head [SK 1845 7150].

Headstone Cutting (Section 7 on (Figure 7.7)) provides a complete section through the Eyam Limestones (19.5 m) and the overlying Longstone Mudstones (3.5 m). The base of the Eyam Limestones is taken at the base of a 7.5 m-thick sequence of laminated and dolomitized limestones (Aitkenhead and Chisholm, 1982). These consist of dolomitized grainstone and carbonate mudstone layers interlaminated at a millimetre-scale. Grainstone laminae contain ostracodes, possible green algae and calcareous encrusting organisms. Carbonate mudstone laminae contain early diagenetic evaporite pseudomorphs, desiccation curls, fenestrae, plant fragments and calcrete features (Gutteridge, 1983, 1989a). A millimetre-thick coal seam with associated seatearth is present 10.6 m above the base of the bed. At least three slump sheets are present below the coal; these slumps are erosively overlain by thickly bedded (up to 1 m) graded intraclast packstone. Intraclasts are derived from the laminated dolomitized limestones. The laminated dolomitized limestones are overlain by a 0.2 m-thick bioclastic packstone dominated by *Spirifer trigonalis* with minor *Martinia glabra* and *Productus productus* (Butcher and Ford, 1973). Above this are 12 m of interbedded bioclastic calcisiltite and shale. Limestone beds in this part of the sequence contain sparse reworked bioclasts.

Aitkenhead and Chisholm (1982) defined the base of the Longstone Mudstones at that point where the succession becomes mudstone dominated. Fauna in the Longstone Mudstones includes trilobites, ostracodcs, chonctoid brachiopods and the index goniatite *Lusitanoceras granosus* characteristic of the P_{2a} (late Brigantian) Subzone (Cope, 1937; Butcher and Ford, 1973; Riley, 1993).

Interpretation

The Woo Dale Limestones (Holkerian) accumulated on a shallow carbonate shelf as a mosaic of peritidal flats surrounded by tidal channels and areas of subtidal deposition (Schofield and Adams, 1985). The dolomitization was originally thought to be syn-depositional in origin; however, Schofield and Adams (1986) and Fowles (1989) produced detailed petrographical and geochemical evidence for dolomitization during burial.

The Bee Low Limestones (Asbian) developed as cyclic carbonates formed on a shallow platform prone to occasional episodes of emergence and extrusion of lava flows and pyroclastic deposits.

The Station Quarry Beds represent the first episode of Brigantian sedimentation on the Derbyshire Platform after a period of subaerial exposure at the Asbian–Brigantian boundary (Walkden, 1977; Aitkenhead and Chisholm, 1982; Aitkenhead *et al.,* 1985; Gutteridge, 1989a). They accumulated in an intra-platform basin that developed in response to the syn-sedimentary growth of the Taddington–Bakewell Anticline and the Longstone Edge Anticline. The conditions of deposition changed progressively from peritidal to restricted subtidal as the carbonate platform was flooded (Walkden, 1977; Gutteridge, 1989a, 1990b).

The Station Quarry Beds were removed over the crest of an intrabasinal structure in the Litton Mill area by an episode of intra-Brigantian erosion that also caused karstification of the underlying Bee Low Limestones (Butcher and Ford, 1973; Walkden, 1977; Pazdzierski, 1982). The intrabasinal high continued to influence sedimentation during early Brigantian times, with oxygenated, high-energy conditions over its crest passing down-dip into low-energy near-anoxic conditions down its flanks The slumps seen in the cutting east of Cressbrook Tunnel represent the down-slope transport of shallow-water limestones into the deeper waters flanking this 'high'.

The cyclic Brigantian shelf carbonates of Millers Dale Quarry and north Cressbrook Dale (the 'pale' facies of the Monsal Dale Limestones) represent the development of carbonate shelf conditions in areas surrounding the intra-platform basin. The 'dark' facies of the Monsal Dale Limestones seen at Monsal Dale represent intra-platform basin deposits formed in the central part of the Derbyshire Platform. Most of the succession comprises bioclastic carbonates deposited during highstands when the surrounding carbonate platform was flooded. The coarser bioclastic beds may have been deposited by storm events or were generated by slumping (Walkden, 1970; Butcher and Ford, 1973; Gutteridge, 1989a).

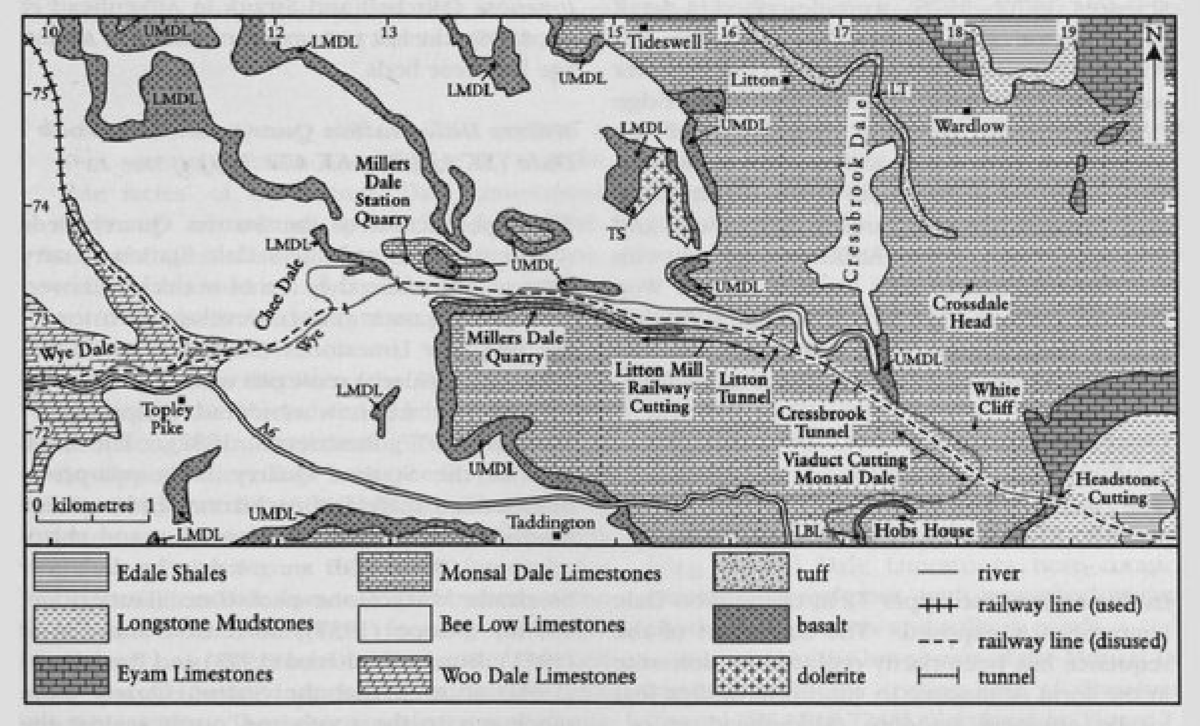
The Upper Dale, Hobs House and White Cliff coral beds form basin-wide stratigraphical markers (Butcher and Ford, 1973; Aitkenhead *et al.,* 1985; Gutteridge, 1989a). The Upper Dale Coral Bed is at least partially re-sedimented, whereas the Hobs House and White Cliff coral beds are largely *in situ* and were deposited in moderate- to high-energy subtidal conditions. The section at White Cliff is interpreted as a shallowing sequence that represents progradation of the northern margin of the intra-platform basin. Mapping by Butcher and Ford (1973) and Gutteridge (1989a) show that the coral beds occur at the top of shallowing sequences at the transition with overlying deeper-water carbonates. The coral beds may represent the base of transgressive sequences overlying earlier regressive units.

The significance of the finely laminated dolomitized units in the 'dark' facies of the Monsal Dale Limestones has been discussed by many authors. Adams and Cossey (1978) regarded the Rosewood Marble as a slumped offshore storm deposit, while Walkden (1970) and Brown (1973) proposed that the Headstone Laminite formed in a stratified basin and a lacustrine basin respectively. Gutteridge (1983, 1989a) and Fowles (1989), using evidence from both the Rosewood Marble and the Headstone Laminite interpreted them as slumped tidal-flat deposits that formed when the intra-platform basin was almost completely drained during sea-level lowstands. The Headstone Laminite at the Monsal Dale Limestones–Eyam Limestones boundary represents peritidal carbonates formed during a low-stand when surrounding parts of the Derbyshire Platform were exposed above sea level (Aitkenhead *et al.,* 1985; Gutteridge, 1989a). The Longstone Mudstones were deposited in deep-water subtidal conditions below wave-base; the diverse benthic fauna suggests that bottom conditions were oxygenated.

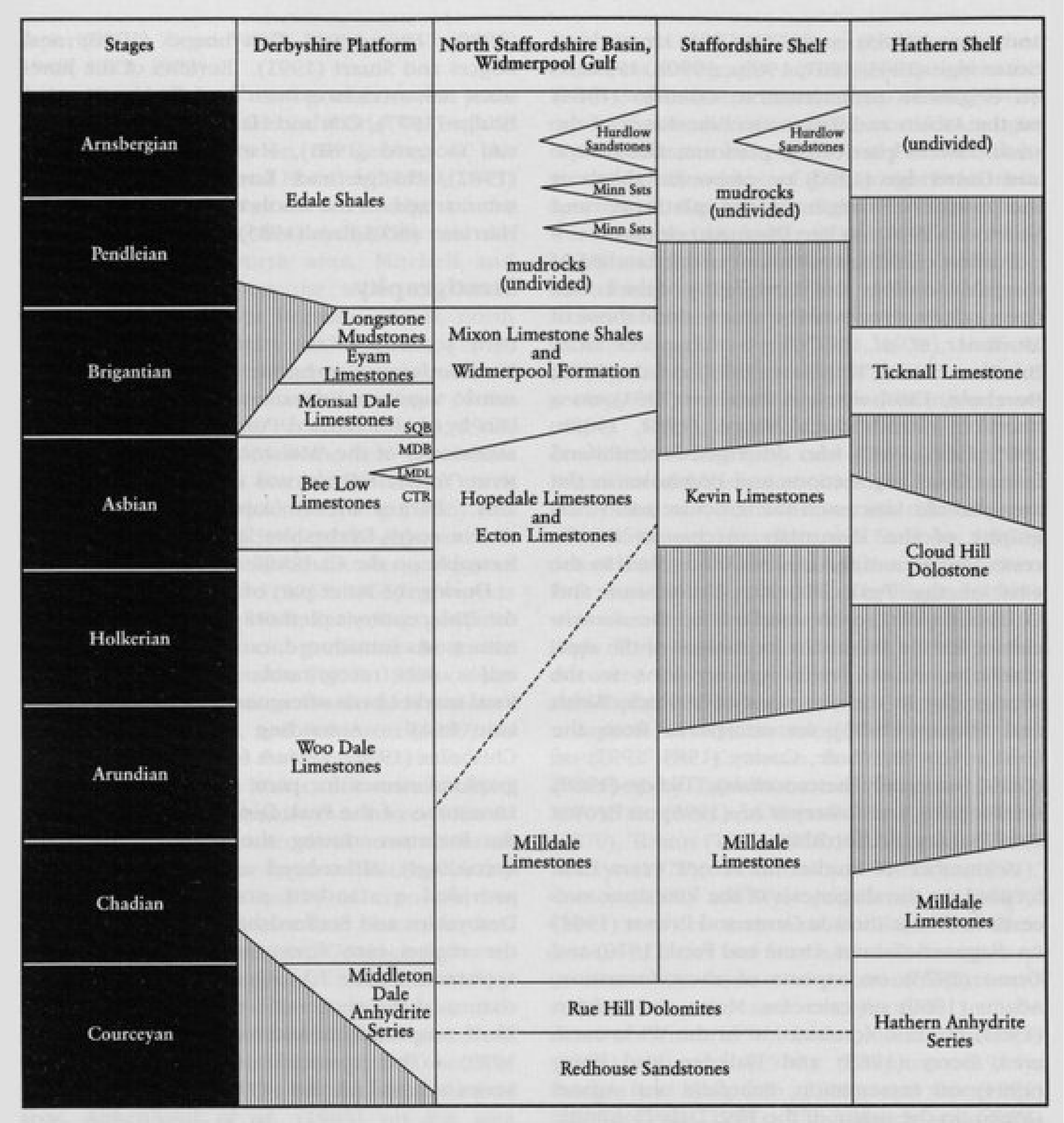
Conclusions

The sections at these extensive and important localities collectively provide a continuous record of the sedimentary evolution of the central part of the Derbyshire Platform from Holkerian through to Brigantian times when carbonate sedimentation was abandoned. Deposition during Holkerian and Asbian times took place on a flat-topped carbonate shelf, with the development of minor shallowing-up cycles becoming apparent during the Asbian Age. An episode of differential subsidence at the Asbian–Brigantian boundary caused the development of an intra-platform basin. Brigantian sedimentation took place by deposition of bioclastic carbonates reworked from surrounding shelf areas with minor carbonate production over an intrabasinal high within the intra-platform basin. The intra-platform basin responded to sea-level changes by the development of peritidal facies during high-magnitude lowstands and progradational episodes of the basin margin during low-magnitude lowstands. The coral beds formed during transgressions after progradation. The conformable transition from the Eyam Limestones to the overlying Longstone Mudstones represents the abandonment of carbonate sedimentation during mid-Brigantian times.

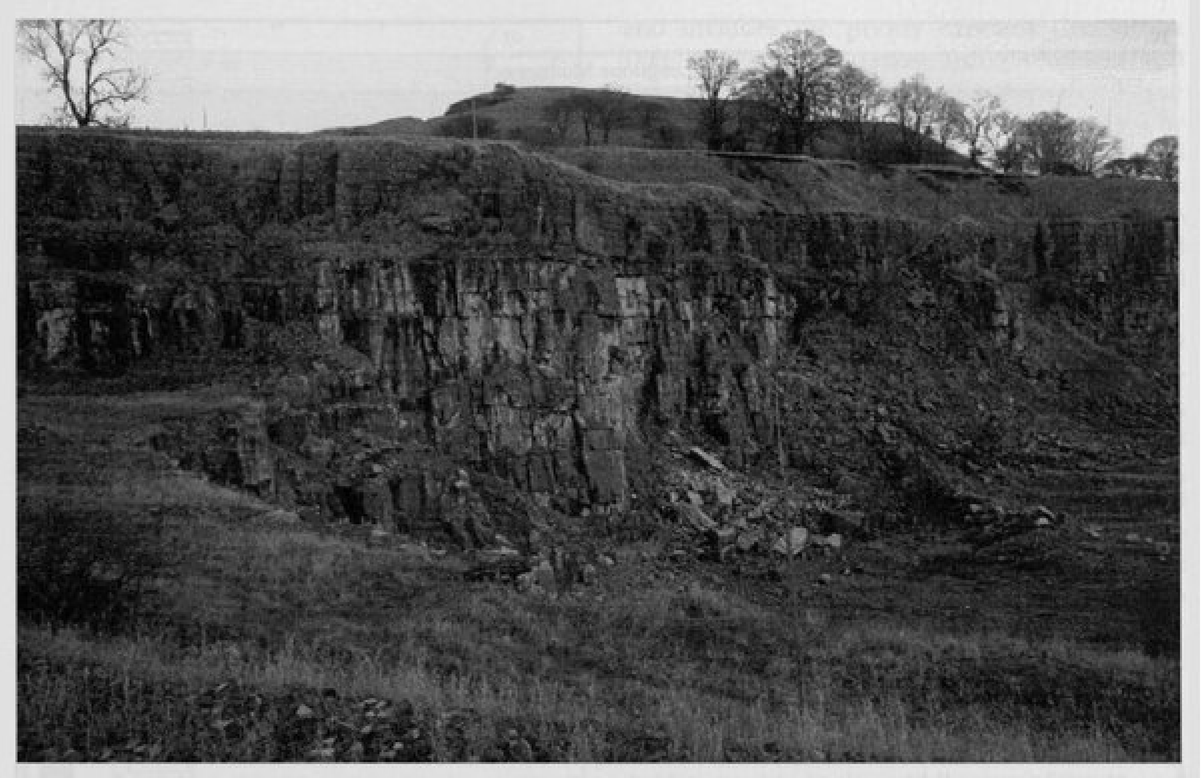
References



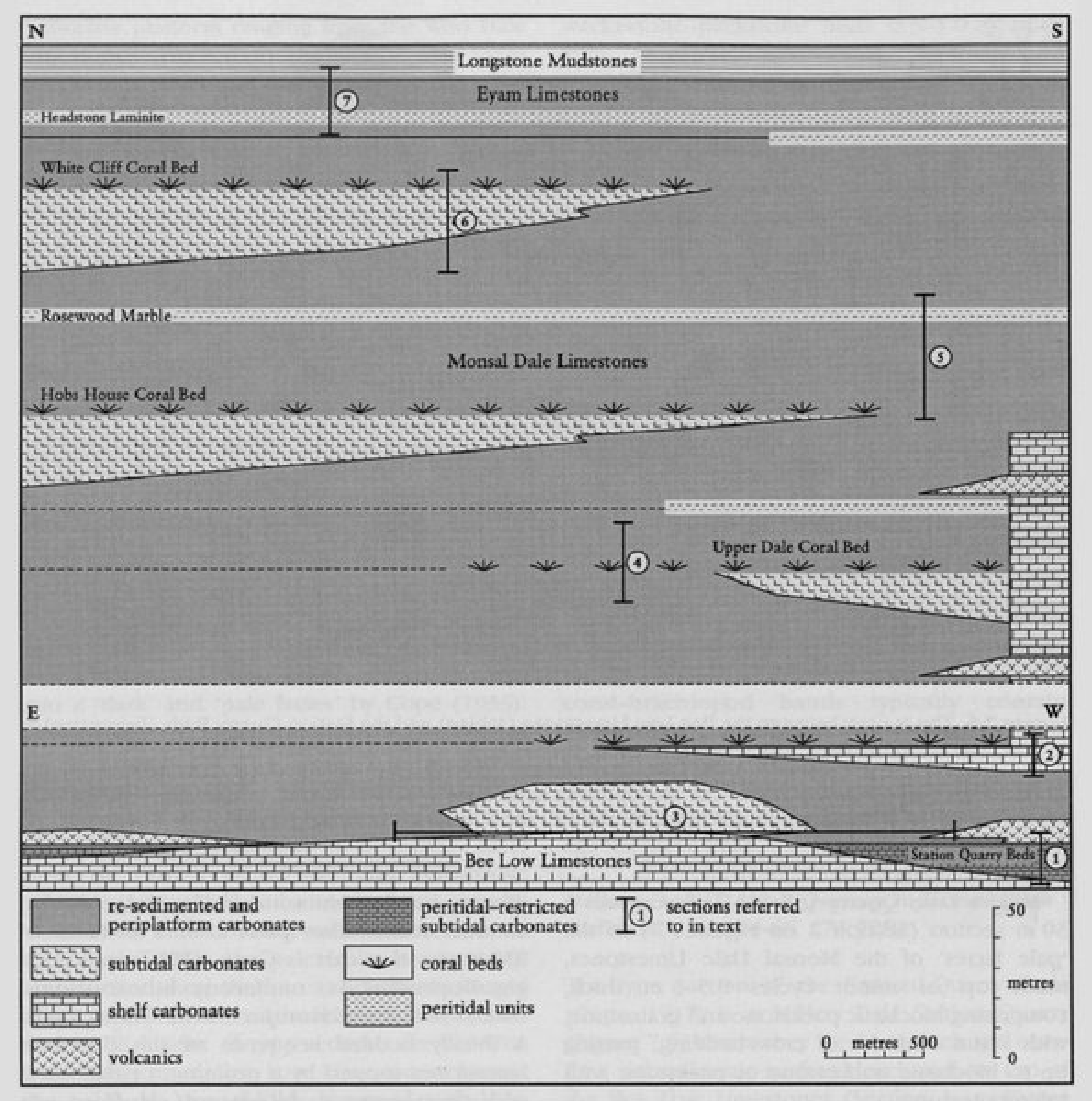
(Figure 7.5) Simplified geological map of Wye Valley and Cressbrook Dale area illustrating the position of localities referred to in the text. LMDL — Lower Millers Dale Lava; TS — Tideswell Sill; UMDL — Upper Millers Dale Lava; LBL — Lees Bottom Lava; LT — Litton Riff. Based on the [British] Geological Survey maps of the Chapel en le Frith and Buxton districts (Institute of Geological Sciences, 1975b, 1978).



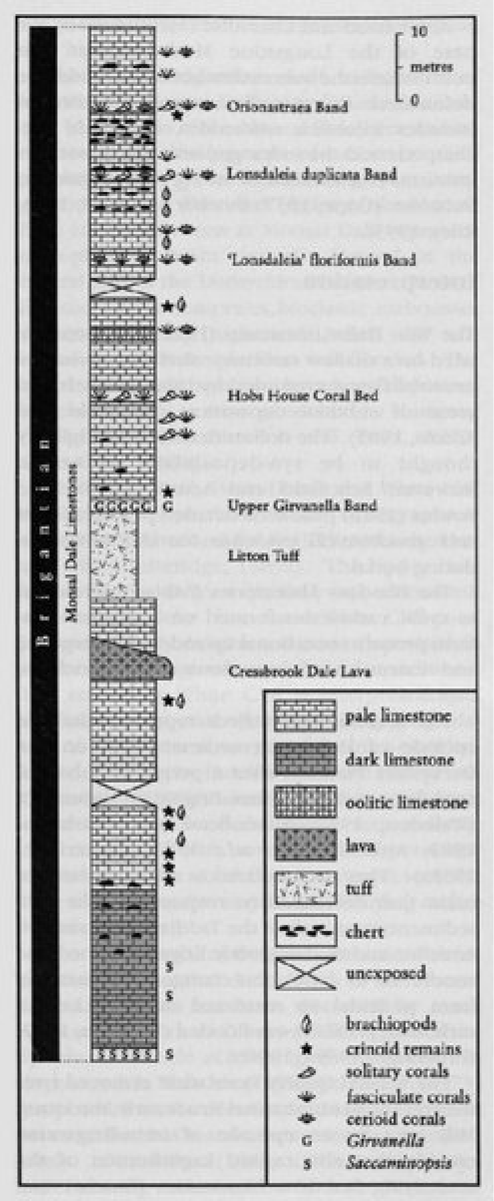
(Figure 7.3) Simplified stratigraphical chart for the Lower Carboniferous succession of Derbyshire, north Staffordshire and north-west Leicestershire. CTR — Chee Tor Rock; LMDL — Lower Millers Dale Lava; MDB — Millers Dale Beds; SQB Station Quarry Beds. Areas of vertical ruling indicate non-sequences. Not to scale. Note that, unless otherwise stated, all major lithostratigraphical units shown on this chart are recognized as formations. Compilation based on information from Aitkenhead and Chisholm (1982) with additional details from Smith et al. (1967), Aitkenhead et al. (1985), Chisholm et al. (1988), Ambrose and Carney (1997, 1999) and Ambrose (1999).



(Figure 7.6) The contact between the Bee Low Limestones (Asbian) and the Station Quarry Beds (Brigantian) at Millers Dale Station Quarry. The contact, which is marked by a significant palaeokarst, occurs towards the top of the quarry where thicker-bedded Bee Low Limestones are overlain by thinner-bedded, darker-coloured limestones of the Station Quarry Beds. The elevated area behind the quarry is formed by the Upper Millers Dale Lava. The height of the quarry face is approximately 20 m. (Photo: P.J. Cossey.)



(Figure 7.7) Summary of the late Asbian–Brigantian stratigraphy of the Millers Dale-Monsal Dale area. Note that the section is split in two: the lower part represents an east-west section through the Litton Mill-Millers Dale area; the upper part represents a north-south section across the Monsal Dale area. The sections described in the text are as follows: 1- Millers Dale Station Quarry; 2 — Millers Dale Quarry; 3 — Litton Mill Railway Cutting; 4 — Cressbrook Tunnel; 5 — Monsal Dale Viaduct Cutting; 6 — White Cliff; 7 — Headstone Cutting. After Butcher and Ford (1973) and Gutteridge (1989a).



(Figure 7.8) Simplified sedimentary log of the Monsal Dale Limestones (Brigantian) at Cressbrook Dale. After Stevenson and Gaunt, 1971.