Malham, North Yorkshire

[SD 884 654]–[SD 927 654]–[SD 904 628]

Introduction

The Malham GCR site (formerly referred to as the 'Malham, Gordale and Cawden Wedber Burns' GCR site) covers several square kilometres to the north of Malham village [SD 902 630]. This site is one of the classic British Dinantian localities, with superb exposures of limestone cliffs and pavements. The site embraces a significant part of the Middle Craven Fault, and is bordered on its northern side by the North Craven Fault (Figure 5.18). It Includes the gorge at Gordale Scar, a spectacular glacial meltwater feature that is terminated by the fault-scarp of the Middle Craven Fault. Numerous NW–SE-trending faults also cross the area ((Figure 5.18)a). The site lies in the transition zone between the shallow-water shelf area of the Askrigg Block to the north and the deeper-water area of the Craven Basin to the south. Strata range from Holkerian to Brigantian age and include the massive cyclic shelf limestones of the block as well as the reef complex of the transition zone. The area along the Craven Faults, including the Malham area, was first described in detail by Garwood and Goodyear (1924). More recently, the stratigraphy has been revised and the successions described In detail by British Geological Survey geologists working on the 1:50 000 map and memoir for the Settle district (Arthurton *et al.,* 1988; British Geological Survey, 1989).

Description

Most of the exposures within this site are of the Malham Formation ((Figure 5.3); and (Figure 5.21), see Settle GCR site report) and the type sections of its two members, the Cove Limestone Member and the Gordale Limestone Member, are within its boundaries. The type section of the Cove Limestone Member is at Malham Cove [SD 898 641] (Figure 5.19) where it is 72 m thick (Arthurton *et al.,* 1988). Its base is taken at the bottom of the cliff face, with crags of the underlying and darker-coloured Kilnsey Limestone Member cropping out in the narrow valley immediately south of the cove. The Cove Limestone Member is a massive, rather homogeneous pale-grey limestone, lacking obvious macrofossil remains apart from crinoids through much of its thickness. Petrographically, it consists of peloidal and bioclastic packstones, the bioclasts comprising foraminifera, *Koninckopora,* palaeoberesellids and brachiopod fragments, in addition to crinoids (Arthurton *et al.,* 1988). The Cove Limestone Member can also be seen in Gordale [SD 914 640] where the macrofossils *Axophyllum vaughani, Lithostrotion sociale, Linoprotonia* and *Megachonetes* and the foraminifera *Archaediscus* and *Koskinotextularia cribriformis* have been recorded (Arthurton *et al.,* 1988).

The Gordale Limestone Member is the major scar-forming limestone in the Settle area and is typically between 70 m and 75 m thick. In its type section at Gordale Scar [SD 913 640], however, it is 94 m thick (Arthurton *et al.,* 1988). The contact with the Cove Limestone Member was defined at the conspicuous bedding plane at the top of the lowest scar (Arthurton *et al.,* 1988). The Gordale Limestone Member is more variable than the Cove Limestone Member below. It is thickly bedded, pale- to medium-grey in colour, and weathers to form a series of scars that are well seen on the valley sides in the northern part of the site. In the area between the Craven Faults, it is the occurrence of muddier limestone lithologies (e.g. wackestones) that appears to be controlling the stepped topography, rather than the occurrence of shales as it is elsewhere in the Pennines (Arthurton *et al.,* 1988). Typical features of the Gordale Limestone Member are burrow-mottled beds and pseudobreccias, palaeokarstic surfaces and local cross-stratified grainstones. Macrofossils are concentrated in bands and include *Davidsonina septosa, Gigantoproductus maximus, Dibunophyllum bourtonense* and *Siphonodendron martini* (Arthurton *et al.,* 1988).

Arthurton *et al.* (1988) note that the Gordale Limestone Member consists of bioclastic wackestones, packstones and grainstones in which the dominant bioclasts are foraminifera, calcispheres, palaeoberesellids, crinoid fragments and ostracodes. One feature of the Gordale Limestone Member in the transition zone is the presence of coarse lithoclastic grainstone units. For example, a conglomerate a few metres above the base of the member is seen near Strideout Edge [SD 906 637] and contains lithoclasts up to 10 cm across (Arthurton *et al.,* 1988).

Much of the northern part of this site consists of Gordale Limestone Member, which forms the classic limestone pavements of the hill tops and the scars of the valley sides. However, locally, the overlying Wensleydale Group is exposed, although only the Lower Hawes Limestone at the base of the group occurs in this area. It consists of bioclastic packstones darker in colour than the Gordale Limestone Member and contains thin oncoid-bearing horizons (Arthurton *et al.,* 1988). It can be seen in a small quarry next to the road at [SD 907 649].

In the southern part of the site, south of the Middle Craven Fault, the shelf-margin reef-belt occurs (Figure 5.18). This area is described by Mundy (1980a) as well as by Arthurton *et al.* (1988). On Cawden [SD 905 632], the transition between the bedded Gordale Limestone Member, which here dips northwards at up to 20°, and the massive reef limestones can be seen. Near the summit of the hill [SD 905 631], stromatolitic boundstone is present with lithistid sponges including *Scheiia* '*Microspongia*' *castletonense* (Rigby and Mundy, 2000), bryozoans (*Tabulipora* and fenestrates) plus a 'reef' brachiopod fauna that includes *Proboscidella proboscidea, Rugicostella nystiana, Stipulina deshayesiana, Streptorhynchus anomalus, Undaria erminea* (Arthurton *et al.,* 1988), and *Parmephrix eileenarum* and *Limbifera grelthiana* (D. Mundy, pers. comm., 2000). This is a particularly interesting fauna with many specialized taxa (Mundy, 1980b). Quarries at the foot of the hill on the south side of Cawden [SD 904 630] expose reef limestones dipping southwards at up to 30°. These quarries have yielded goniatites of B_2b age, including *Bollandoceras micronotum, B.* sp. (tumid form), *Goniatites globostriatus* (*formerly* '*moorei*' and '*maximus*')and *G.* aff *crenistra* (early form) (Arthurton *et al.,* 1988). B_2, goniatites have been found on the western flank of Cawden and also in the adjacent reefs just outside the site boundary (Arthurton *et al.,* 1988).

Interpretation

The lithostratigraphical scheme applied at this site was adopted by Mundy and Arthurton (1980) and Arthurton *et al.* (1988) as a result of the resurvey of the area (1:50 000 map of the Settle district, British Geological Survey, 1989) and the acquisition of new borehole information. The term 'Great Scar Limestone', originating from the work of Phillips (1836), and applied to Askrigg Block limestones resting on Lower Palaeozoic rocks and overlain by Yoredale facies, was dropped by Arthurton *et al.* (1988), as were the subdivisions proposed by Ramsbottom (1974) and followed by George *et al.* (1976). This revision was adopted partly because marker bands used to divide the succession farther north are not recognizable in the Settle district. Recently, however, Mundy (2000) re-introduced the term as a 'group' name for the Kilnsey and Malham formations.

The Cove Limestone Member at this site contains a more restricted Holkerian foraminiferal assemblage than that found farther north on the Askrigg Block and this has been interpreted as a sign of deeper-water conditions at the northern edge of the block (Arthurton *et al.,* 1988). The Gordale Limestone Member contains a typical Asbian fauna. The marginal reef limestones also contain an Asbian fauna and are the same age as the Gordale Limestone Member. The Lower Hawes Limestone is of Brigantian age in the Settle area (Arthurton *et al.,* 1988).

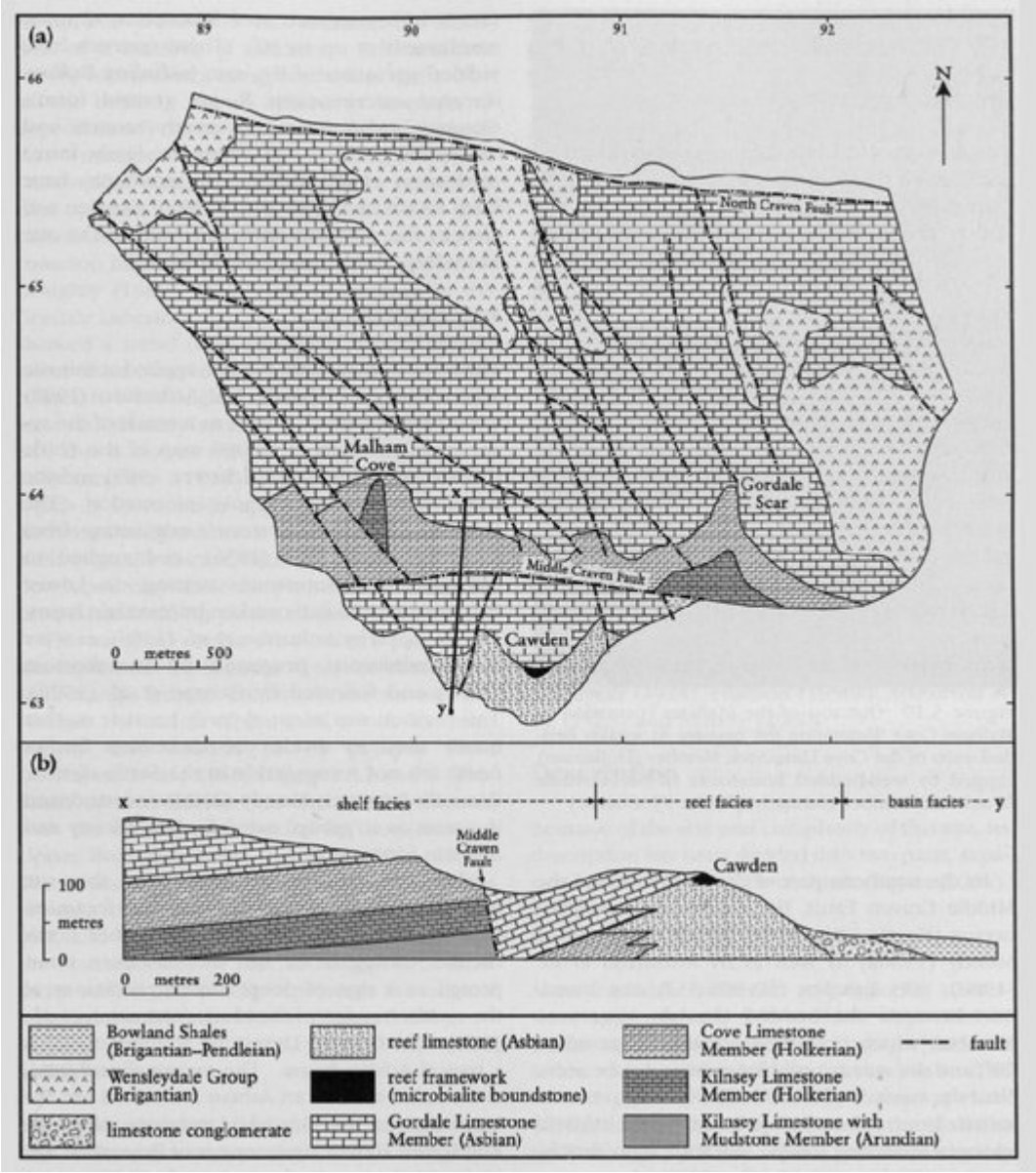
The exposed shelf limestone succession at the Malham site records deposition more-or-less continuously from late Holkerian to early Brigantian times. The succession is thicker than that in the immediate area to the north, away from the block margin, and palaeokarstic surfaces are less well developed (Arthurton *et al.,* 1988), suggesting that subsidence rates were more rapid to the north where periods of emergence were less significant. Cyclicity in the 'Great Scar Limestone' has attracted the attention of a number of workers. Schwarzacher (1958) recognized a number of cycles divided by master bedding planes spaced at intervals of approximately 10 m, each cycle being a major scar-forming unit traceable over long distances. Lithological variation appeared to be related to this cyclicity, with fossil concentrations and current features such as cross-stratification more common adjacent to the master bedding planes. Doughty (1968), in a study of jointing in the Gordale Limestone Member, noted that each cycle showed a trend from closely to widely spaced joints from base to top, and that this was also related to a lithological variation. In the Gordale area sedimentary cyclicity is undoubtedly present, but is not as simple as that suggested by Schwarzacher (1958) and Doughty (1968), which is more easily applicable to successions farther north (Arthurton *et al.,* 1988). At the shelf edge the thicker succession lacks the well-developed clay-shale intervals that characterize the master bedding planes of the block interior.

The marginal reef in the southern part of the site represents the remains of a once-continuous shelf-margin feature, contemporaneous with the Malham Formation of the shelf which has been faulted and eroded to its present form (Arthurton *et al.,* 1988) (Figure 5.2) and(Figure 5.18)b. Much of this erosion was intra-Carboniferous, with the eroded reefs buried by the Namurian Upper Howland Shales (Hudson, 1930a, 1932). The boundstone near the summit of Cawden is thought to represent the framework facies of the reef and the southerly dipping limestones on the southern side of the hill, fore-reef or flank facies whose present dip represents the original palaeoslope (Mundy, 1980b) (Figure 5.18)b.

Conclusions

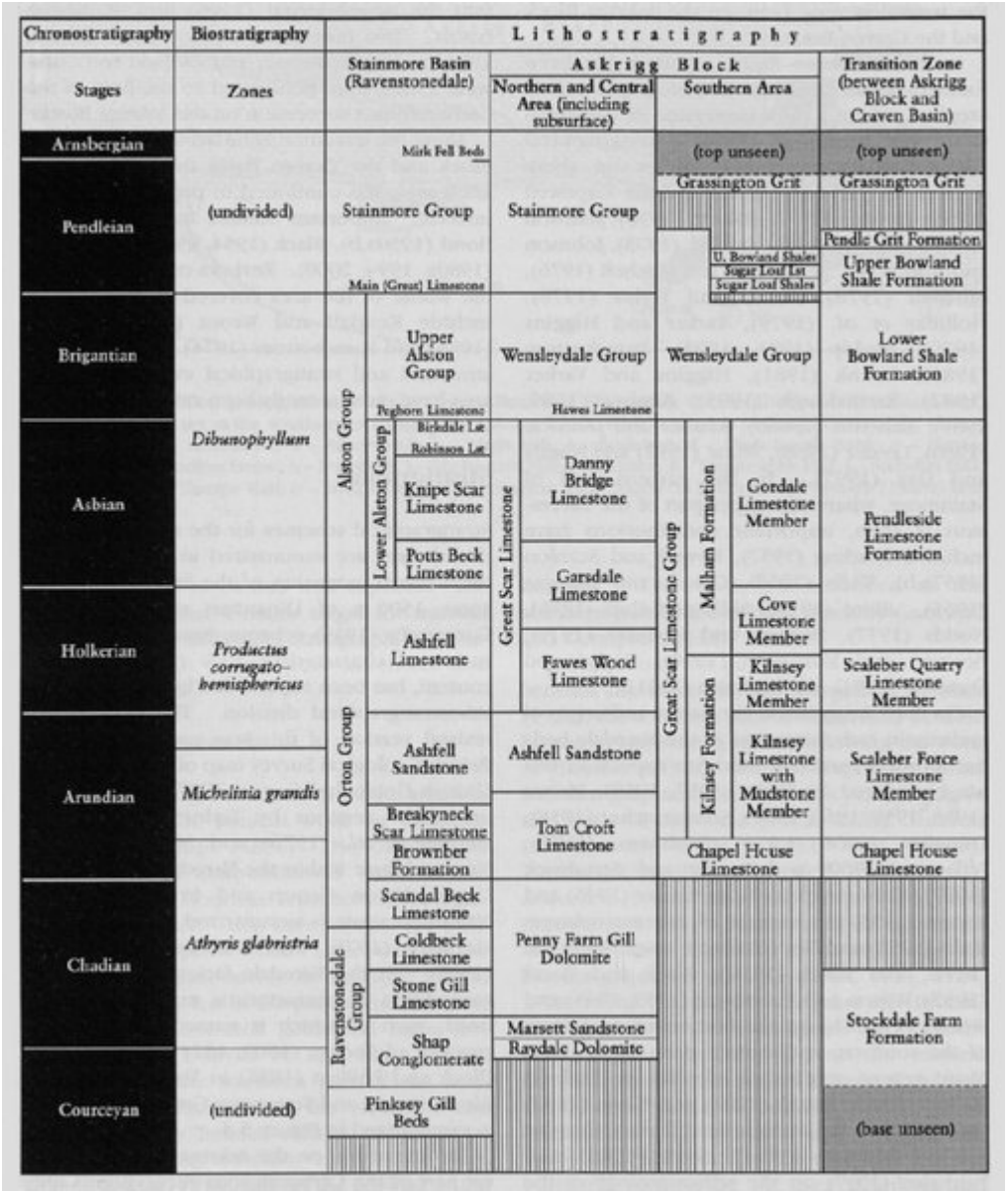
This classic locality offers the best exposures of the Malham Formation close to the margin of the Askrigg Block. The type sections for both members of the formation, the Cove Limestone Member and the Gordale Limestone Member, are within the site. The cyclicity of the limestones is of great interest here and requires further work to understand its relationship to the simple cyclicity described from the interior of the block. The site also contains excellent exposures of part of the marginal reef complex, including an exposure of the buildup framework from which many rare fossils have been recovered.

References

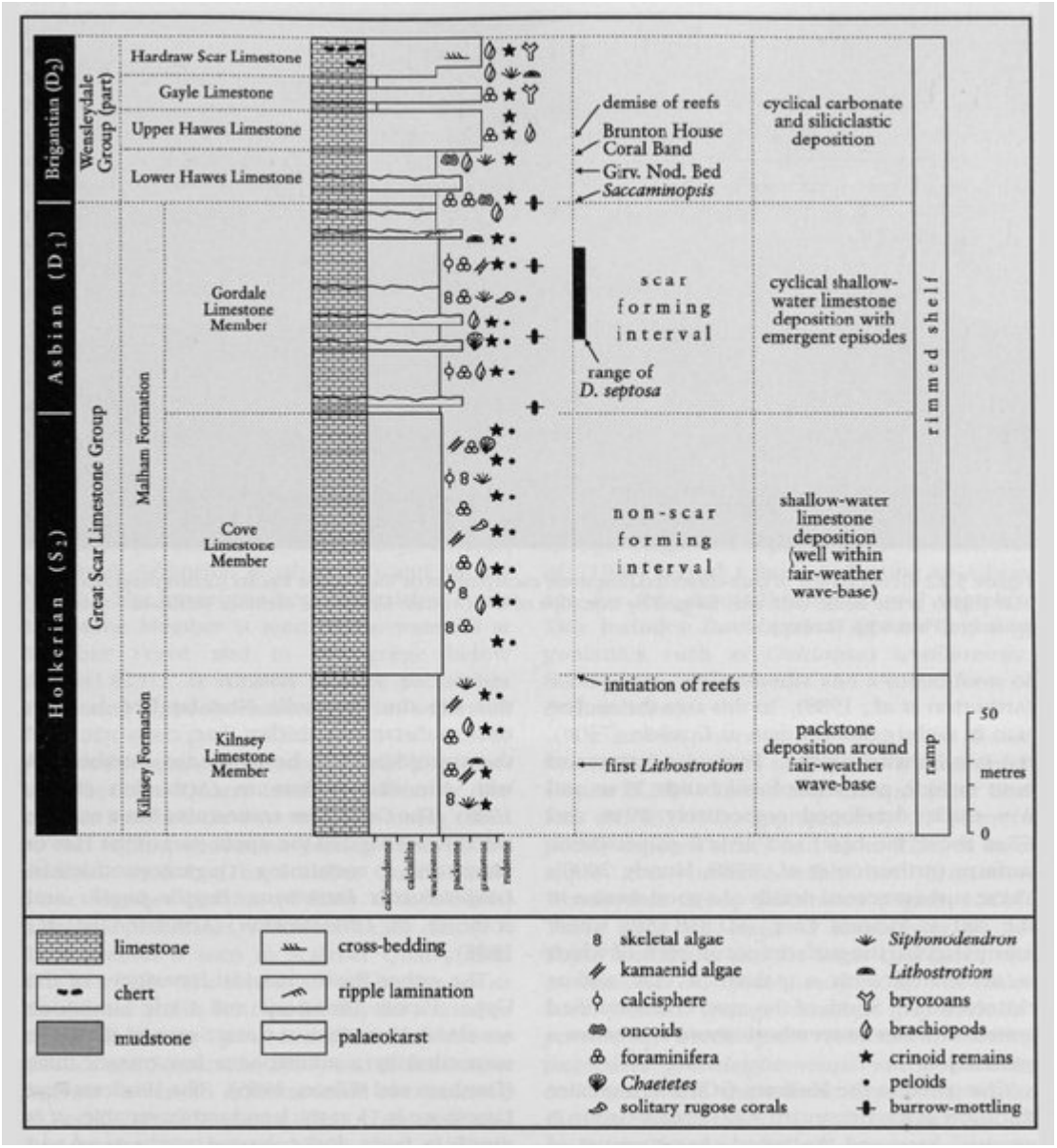


(Figure 5.18) (a) Geological map of the GCR site at Malham with details north of the North Craven Fault omitted. After British Geological Survey (1989). Points x and y mark the approximate line of the section illustrated in (b). (b) Section

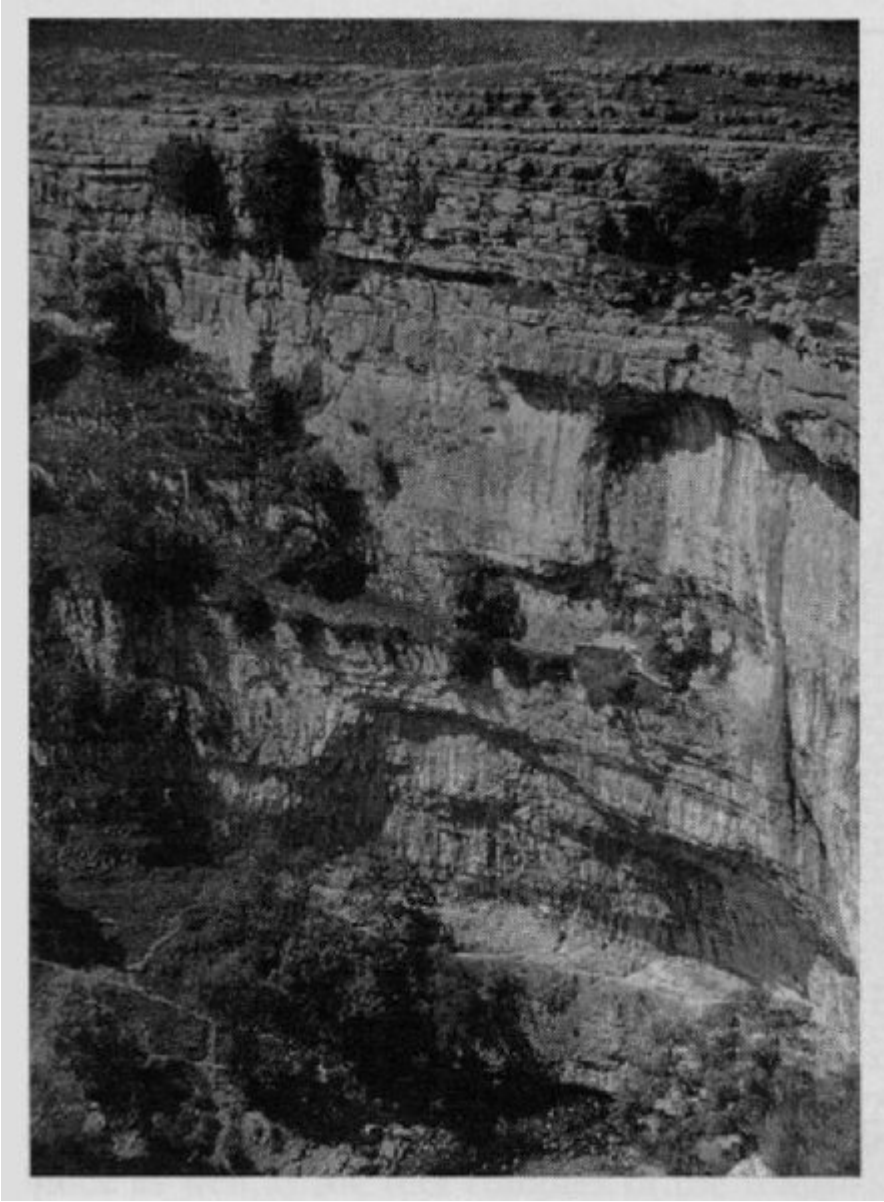
across the Middle Craven Fault showing the relationship between shelf and basin-margin facies. Based on Mundy (1980b) and Mundy and Arthurton (1980).



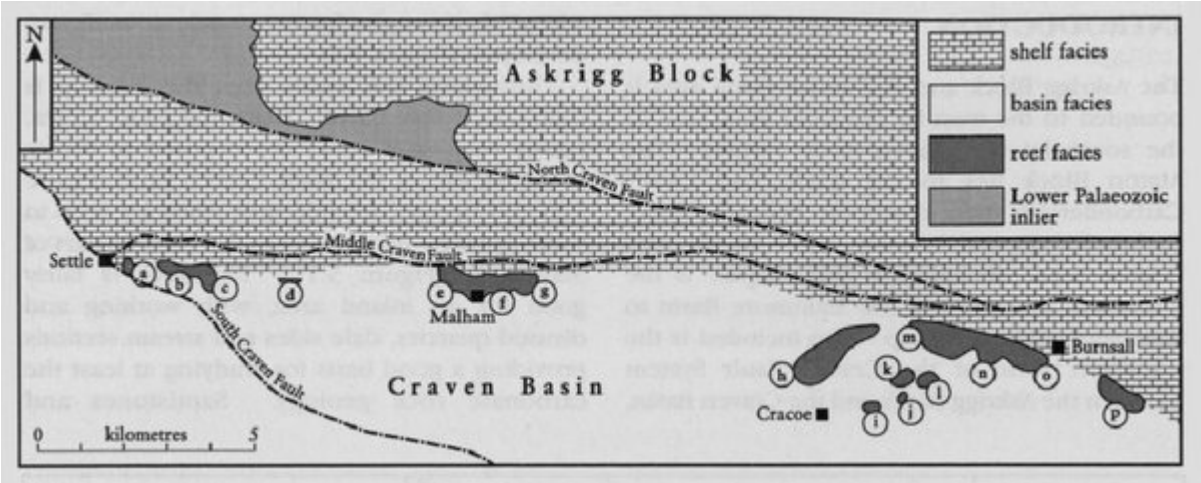
(Figure 5.3) Simplified stratigraphical chart for the Lower Carboniferous sequence of the Askrigg Block and Stainmore Basin. Compilation based upon and modified after George et al. (1976), Dunham and Wilson (1985), Arthurton et al. (1988), British Geological Survey (1997b,c), and Mundy (2000). Zonal biostratigraphy (Chadian–Brigantian only) after Garwood (1913). For further details of the Wensleydale Group, Upper Alston Group and Stainmore Group successions, see (Figure 5.4). Areas of vertical ruling indicate non-sequences. Not to scale.



(Figure 5.21) Composite log of the Lower Carboniferous succession between the North and Middle Craven faults at the southern end of the Askrigg Block close to Settle. After Mundy (2000), and including information from Arthurton et al. (1982, 1988). (Girv. Nod. Bed — Girvanella Nodular Bed.)



(Figure 5.19) Outcrop of the Malham Formation at Malham Cove illustrating the massive to weakly bedded units of the Cove limestone Member (Holkerian) capped by well-bedded limestones of the Gordale Limestone Member (Asbian). (Photo: P.J. Cossey.)



(Figure 5.2) Simplified geological map of the Craven Reef-Belt, illustrating the distribution of Dinantian reef, shelf and basin facies at the southern margin of the Askrigg Block, with Namurian outcrops omitted for clarity. Reef outcrops are as follows: a — Albert Hill; b — High Hill; c — Scaleber; d — High South Bank; e — Burns; f — Cawden; g — Wedber Brow; h — Swinden; i — Skelterton Hill; j — Carden; k — Butter Haw Hill; 1- Stebden Hill; m — Elbolton; n — Thorpe Kail; o —

Byra Bank; p — Hartlington Kail. Based on Brunton and Mundy (1988a) and Mundy (2000).