Eglwyseg Mountain, Clwyd

[SJ 235 478]–[SJ 240 428]

Introduction

The Eglwyseg Mountain GCR site runs in an arc up to 0.8 km wide for 7.5 km from World's End [SJ 235 478] to Bron Heulog Quarry [SJ 240 428] near the Sun Inn at Trefor, 3 km east of Llangollen (Figure 8.14). It includes the W-facing scarp of Creigiau Eglwyseg and the SW-facing Trefor Rocks. The main scarp rises in a series of steps to a height of over 450 m and includes the finest continuous inland exposures of late Dinantian limestones on the North Wales Shelf. In addition to those of the scarp face, there are exposures in the sides of steep ravines and in disused quarries. The extent of the site is of particular importance in that it allows the lateral variation in the limestones to be studied as well as the vertical succession.

Morton (1878) applied his earlier (Morton, 1870) division of the Carboniferous Limestone in North Wales to the Eglwyseg scarp. He recognized three major divisions based on the colour of the limestones: the Lower Brown Limestone, Middle White Limestone and Upper Grey Limestone (Figure 8.2). Hind and Stobbs (1906) recognized that all three units lay within the D Zone of the zonal scheme set up by Vaughan (1905) for the succession in the Avon Gorge (see GCR site report, Chapter 9). They also established that the boundary between the D_1 and D_2 subzones lay at the contact of the Middle White Limestone with the Upper Grey Limestone, a position confirmed by the further palaeontological work of Neaverson (1929, 1946), despite Wedd *et al.* (1927) having placed the boundary lower, within the Lower Brown Limestone.

Early reference to the site was made by Wills (1920) and Power and Somerville (1975) but the most important general sedimentological work in the area has been that of Somerville (1979a,b) and Gray (1981). Much of the description here is based on their work. In addition to studying the lithologies in detail and establishing the nature of the cyclicity in the succession, Somerville (1979a) proposed a formal stratigraphical scheme to replace Morton's original divisions. This stratigraphical framework and the earlier divisions, plus the assignment to the stages of George *et al.* (1976), are shown in (Figure 8.2).

Description

Basement Beds

The Basement Beds, consisting of red and yellow sandstones and conglomerates, are very poorly exposed, but according to Morton (1878) reach their thickest development at the foot of the Eglwyseg escarpment. His estimate of their maximum thickness was 90 m (300 ft), but this was regarded as excessive by Wedd *et al.* (1927). In the absence of any firm palaeontological evidence the Basement Beds are tentatively assigned to the Holkerian Stage (Figure 8.2).

Ty-nant Limestone Formation

The thickest development of the Ty-nant Limestone Formation (early Asbian) is in the type section seen in two old quarries ([SJ 219 454] and [SJ 219 457]) north of Ty-nant farmhouse. Here some 60 m are exposed up to the contact with the overlying Eglwyseg Limestone Formation (Somerville. 1979b). The lower part of the Ty-nant Limestone and the contact with the Basement Beds are not exposed and Somerville (1979b) estimates the unexposed limestone thickness to be approximately 55 m.

Sedimentary cyclicity was recognized in the ly-nant Limestone by Somerville (1979b). The cyclicity involves the alternation of two principal lithologies — a lower muddy bioclastic packstone or wackestone and an upper fenestrate carbonate mudstone or wackestone. These alternations make up 15 exposed cycles (Figure 8.15), the lower group (cycles 1–8) only being seen in the more northerly of the two quarries at Ty-nant [SJ 219 457]. Here these cycles are 2–3 m thick and consist of brownish-weathering, dark-grey dolomitic bioclastic limestones with thin shaly partings, alternating with bluish-weathering carbonate mudstones. The bioclastic limestones commonly contain abundant *Daviesiella llangollenensis* (see Cope, 1940), usually in life position.

The upper group of cycles (9–15) vary in thickness from 1.5 m to 11 m, with generally thicker developments of bioclastic limestones and shales. At the top of cycle 10 there is a prominent hummocky surface overlain by an orange-weathering bentonite clay and a thin coal seam. In the uppermost three cycles the carbonate mudstones are thicker and the bioclastic limestones are purer carbonate with less shale. *D. llangollensis* is present throughout the upper cycles. Other notable fossils in the Ty-nant Limestone include *Linoprotonia, Syringopora* and *Siphonodendron sociale,* and the type specimen of *Chaetetes* (*Boswellia*) *mortoni* containing spicule pseudomorphs which Gray (1980) used to demonstrate the spongioid nature of Palaeozoic chaetetids.

It is clear that there is significant variation in the thickness of the Ty-nant Limestone and of individual cycles when traced along the outcrop. (Figure 8.15) shows the sedimentary logs of Somerville (1979b) and his proposed correlations.

Egiwyseg Limestone Formation

The Eglwyseg Limestone Formation is up to 150 m thick and consists predominantly of massive, pale-coloured bioclastic limestones. Details of the succession are presented in (Figure 8.16). As with the Ty-nant Limestone beneath, a cyclicity can be recognized, but the cycles in the Eglwyseg Limestone are much thicker, ranging from 7 m to more than 20 m in thickness. Somerville (1979a) recognized 10 cycles, the lower cycles being better exposed than the upper ones (see (Figure 8.17)).

Although there is some variation in lithology between cycles, Somerville (1979a) was able to demonstrate an idealized succession, representing a 'typical' cycle. This consists of a thin unit of shale or rubbly limestone at the base, followed by at most a few metres of fairly well-bedded or wavy-bedded, dark-grey bioclastic packstone or grainstone and succeeded by a thick unit of massive pale-coloured bioclastic packstone or grainstone ((Figure 8.18)a). Some of these massive units show a colour mottling. These 'spotted' rocks or 'pseudobreccias' are similar to those found in limestones of this age elsewhere in Britain, such as north-west England (Garwood, 1913) (see Chapter 4) and South Wales (Dixon and Vaughan, 1911) (see Chapter 9).

The boundaries between the cycles are characterized by hummocky surfaces, interpreted as palaeokarsts, overlain by bentonite clays. Coating some of the palaeokarsts are laminar calcite crusts, and features indicative of root activity such as rhizocretions and alveolar-septal fabric can sometimes be found in the limestones immediately beneath. One well-exposed palaeo-karstic surface is that at the top of the fourth cycle, and this is clearly seen in Trefor Rocks Quarry [SJ 231 433]. Exposure phenomena in the limestones at the top of cycle 7 were studied in detail by Solomon and Walkden (1985).

The cyclicity is responsible for the development of the stepped topography of the main crags of the Eglwyseg escarpment (Figure 8.17). The steep faces of the step are predominantly the massive limestones, and the bentonites overlying the hummocky surfaces plus lower well-bedded limestones at the base of the next cycle form the slope break where natural exposures are generally covered by grass and scree. The hummocky surfaces and associated features are well seen at Bron Heulog Quarry.

The Eglwyseg Limestone contains a rich coral–brachiopod fauna characteristic of late Asbian times, including *Dibunophyllum bipartitum, D. bourtonense, Lithostrotion portlocki, L. vorticale, Palaeosmilia murchisoni, Siphonodendron junceum, S. martini, S. sociale, S. pauciradiale, Delepinea* aff. *comoides* and *Linoprotonia hemisphaerica.* Towards the top, in the poorly exposed uppermost cycles, *Gigantoproductus giganteus* makes its first appearance.

Trefor Limestone Formation

The Trefor Limestone Formation comprises about 90 m of thinly bedded dark-grey crinoidal packstones and wackestones. The formation is best seen in the area around Trefor Rocks [SJ 250 455]. Cyclicity is again present, with cycles intermediate in thickness between those of the Ty-nant Limestone and those of the Eglwyseg Limestone. The most important sedimentological study of the Trefor Limestone is that of Gray (1981), also reported by Tucker (1985). Gray (1981) identified a typical cycle consisting of a basal unit of microfossil (algal) packstone and wackestone with brachiopods and corals often abundant and preserved in life position. This is overlain by algal grainstone with a more fragmented fauna and capped by calcisphere wackestone ((Figure 8.18)b). Boundaries between cycles are marked by palaeokarstic surfaces and bentonite clays or by sutured discontinuity surfaces.

The Trefor Limestone contains a typical Brigantian coral assemblage, including *Actinocyathus floriformis* and *Palastraea regia.* Other fossils present include the corals *Aulophyllum pachyendothecum, Diphyphyllum lateseptatum* and *Lithostrotion maccoyanum,* and the brachiopod *Semiplanus latissimus.* The problematic organism *Saccaminopsis,* which has been assigned to both the foraminifera and to the green algae by different workers, is also present at some levels.

Sandy Passage Beds

The Sandy Passage Beds record the beginnings of the change from the dominantly calcareous deposition of late Dinantian times to the terrigenous clastic deposition of Late Carboniferous times (Taylor, 1973). According to Morton (1878) their thickness is less than 25 m (75 ft), but Wedd *et al.* (1927) suggest that it must be greater, at least 50 m (170 ft). Wedd *et al.* (1927) record alternating limestones, sandstones, shales and 'mixed' rocks including sandy limestones and calcareous grits in this unit.

The best exposure of the Sandy Passage Beds is in old quarries at the south-east end of the exposure, north of the road above Bron Heulog Quarry [SJ 241 429]. In these quarries several metres of sandy limestone with large-scale cross-stratification occur. The dune foresets are defined by an alternation of brown-weathering and grey-weathering bands, each 1–2 cm in thickness. The brown-weathering layers consist of fine sand-sized angular quartz grains cemented by calcite. The calcite contains some iron (ferroan calcite) which results in the brbwn colour on weathering. The grey layers consist of small ooids and superficial ooids with quartz grain nuclei set in a calcite cement containing much less iron than that in the quartz sand layers.

Interpretation

Each of the three limestone formations is characterized by cyclicity. Cycle boundaries are either defined by palaeokarstic surfaces with attendant bentonite days, and sometimes with calcretization features in the limestone beneath the palaeokarstic surfaces, or by 'sutured discontinuity surfaces' interpreted by Gray (1981) as the products of intertidal solution and erosion. In either case a degree of subaerial exposure is involved, more profound and prolonged in the case of the palaeokarsts than in the case of the discontinuity surfaces.

The cycles are interpreted in terms of shallowing-upwards successions culminating in subaerial exposure. Somerville (1979b) interpreted the muddy bioclastic limestones of the Ty-nant Limestone as the deposits of sheltered lagoons or subtidal mudflats. The abundance of *Daviesiella llangollensis* in life position supports the idea of a quiet environment below wave-base. The mudstones and wackestones have a restricted fauna and are interpreted as the deposits of back-lagoons and tidal flats. The presence of fenestrae at some levels is diagnostic. Both laminar fenestrae elongate parallel with bedding and more rounded structures ('bird's-eyes') are present; the former may represent decayed cyanobacterial mats, characteristic of high intertidal and supratidal environments, and the latter entrapped gas bubbles, also characteristic of supratidal flats. The absence of any evidence for evaporites suggests that the climate was relatively wet, and more akin to that of the Bahamas today than that of the Arabian Gulf.

The cycles of the Eglwyseg Limestone are quite different in character, being much thicker than those of the Ty-nant Limestone, but with less evidence for well-developed tidal flats ((Figure 8.18)a). Somerville (1979a) interpreted the basal rubbly limestones as shallow subtidal deposits, with the deepest water represented by the dark-grey well-bedded bioclastic limestones. Shallowing is recorded by the massive pale-coloured packstones and grainstones with their rich faunas. Evidence of shoaling within this unit is occasionally provided by increased burrowing activity and the presence of cross-stratification towards the top of cycles. Finally, with lowering of relative sea level, each cycle was exposed to meteoric waters and underwent solution, probably beneath a bentonite soil formed from weathered volcanic ash.

Limestones beneath these surfaces suffered from intense early diagenesis with multiple generations of solution and cementation (Solomon and Walkden, 1985).

The colour mottling ('pseudobrecciation') in the massive limestones was the subject of detailed investigation by Solomon (1989). He interpreted the mottles as being early cemented areas formed in the meteoric–marine mixing zone during the repeated episodes of deposition followed by regression and emergence.

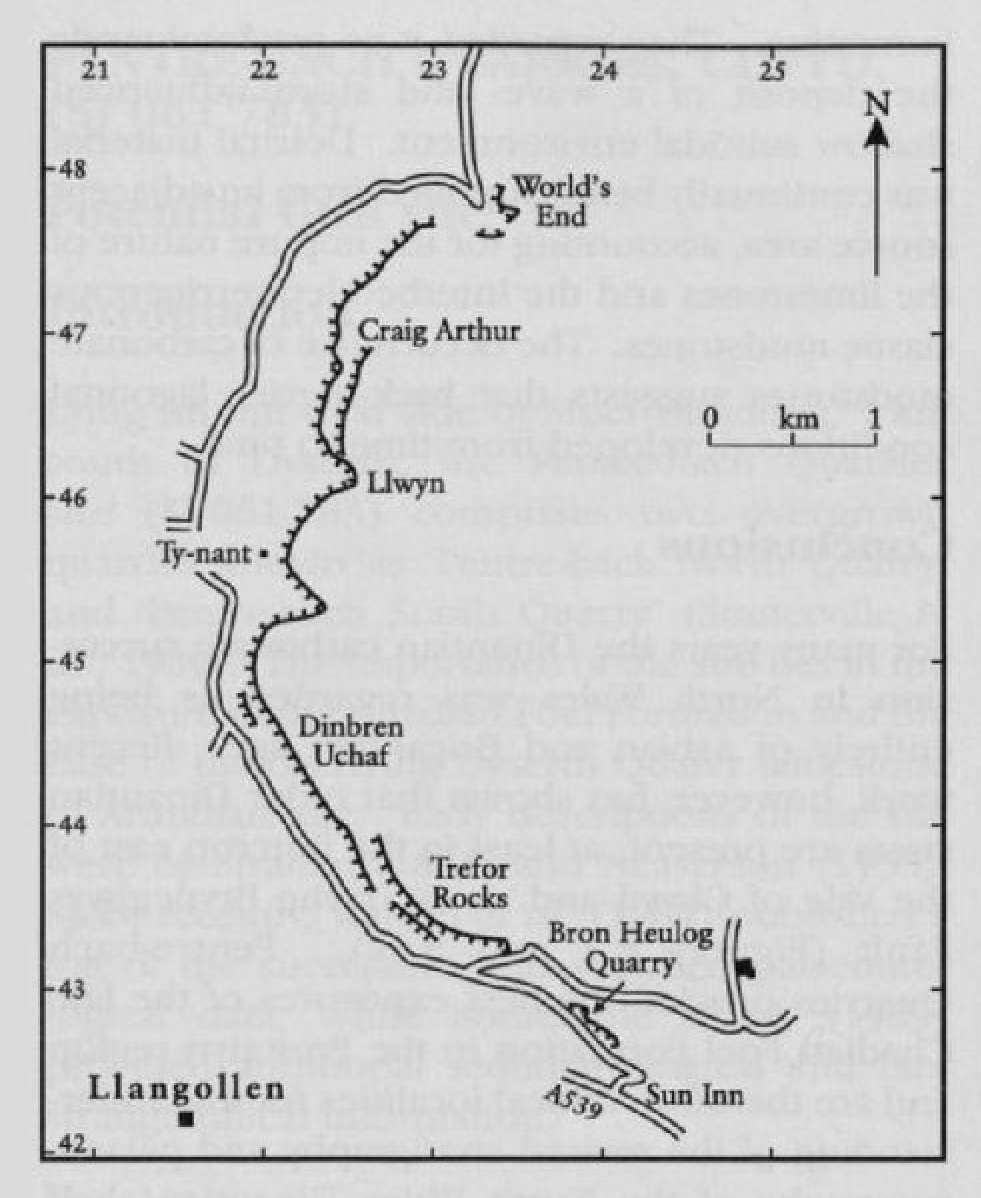
The Trefor Limestone shows a cyclicity that is closer in style to that of the Ty-nant Limestone than that of the Eglwyseg Limestone ((Figure 8.18)b). Gray (1981) interpreted the Trefor Limestone cyclicity in terms of different depths of shelf flooding and regarded the microfossil packstones and wackestones as subtidal below-wave-base deposits, the algal grainstones as shoreface deposits, and the calcisphere wackestones as tidal-flat deposits. The Trefor Limestone cycles, with a greater subtidal component, may represent cycles developed farther from the contemporary shoreline or under a regime of greater relative sea-level change compared to the thinner cycles of the Ty-nant Limestone with a more poorly developed subtidal facies.

It is generally accepted that eustatic variations were at least partly responsible for late Dinantian cyclicity (see, for example, Walkden, 1987). As Somerville (1979b) pointed out, in the area represented by this site, eustatic fluctuations could account for the cyclicity, but the variations in cycle thickness, particularly evident in the Ty-nant Limestone, suggest the involvement of local tectonism.

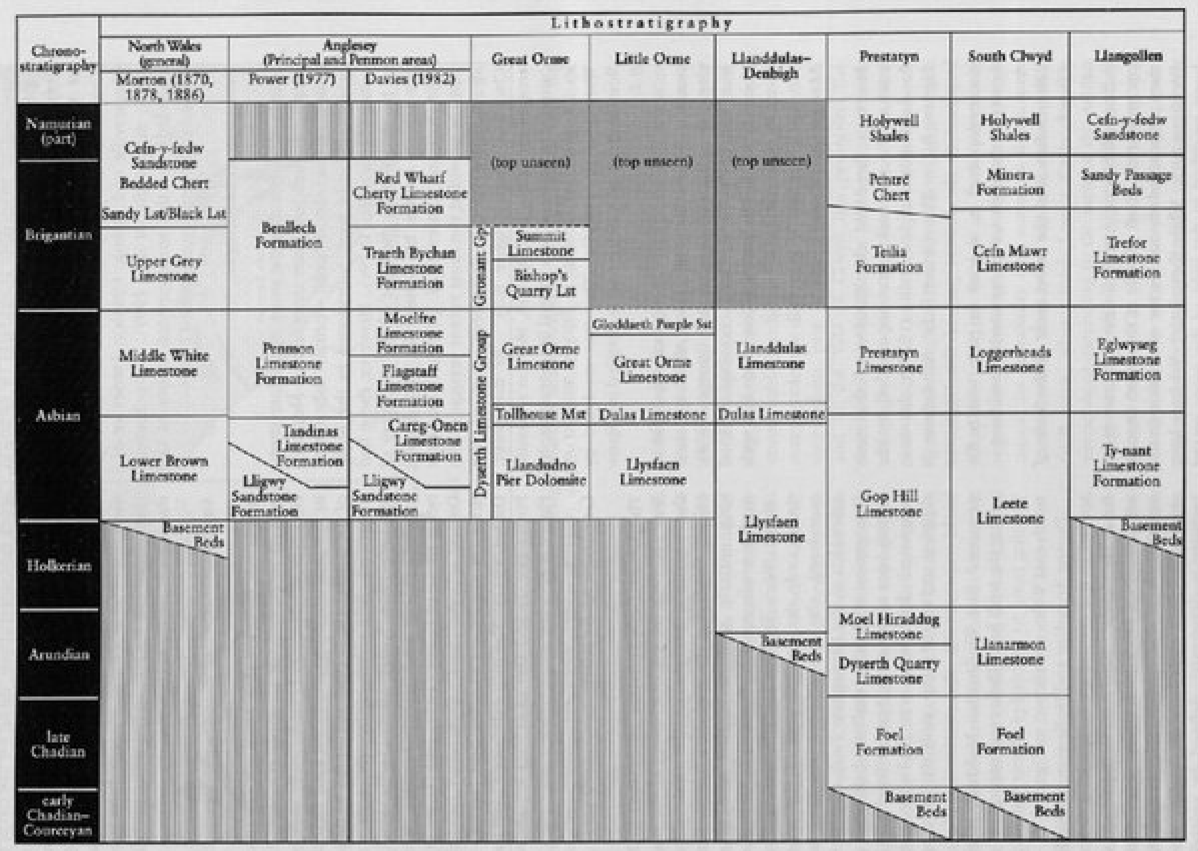
Conclusions

The superbly displayed succession at Eglwyseg Mountain shows the different styles of late Dinantian cyclicity developed in entirely carbonate facies better than at any other site in Britain. A unique feature of the site is the geographical area covered, which allows study of lateral variation in cycles and in cycle bounding surfaces. These features make Eglwyseg Mountain an essential resource for teaching and for further research.

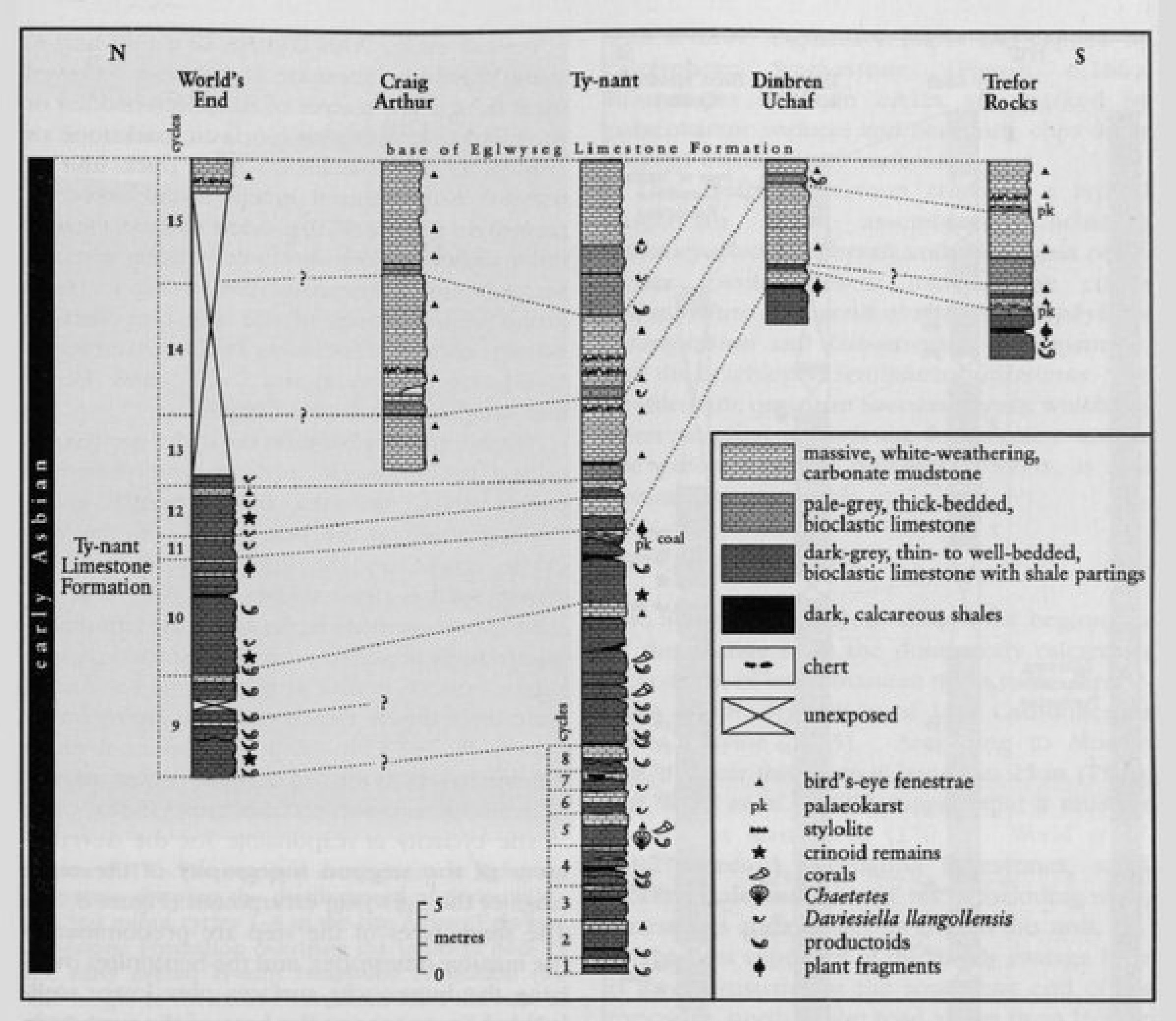
References



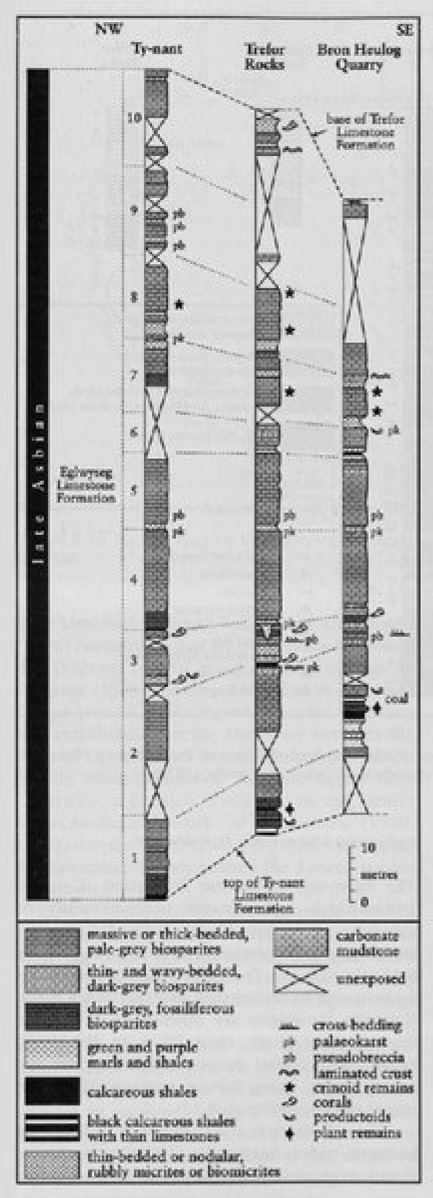
(Figure 8.14) Locality map for the Eglwyseg Mountain GCR site.



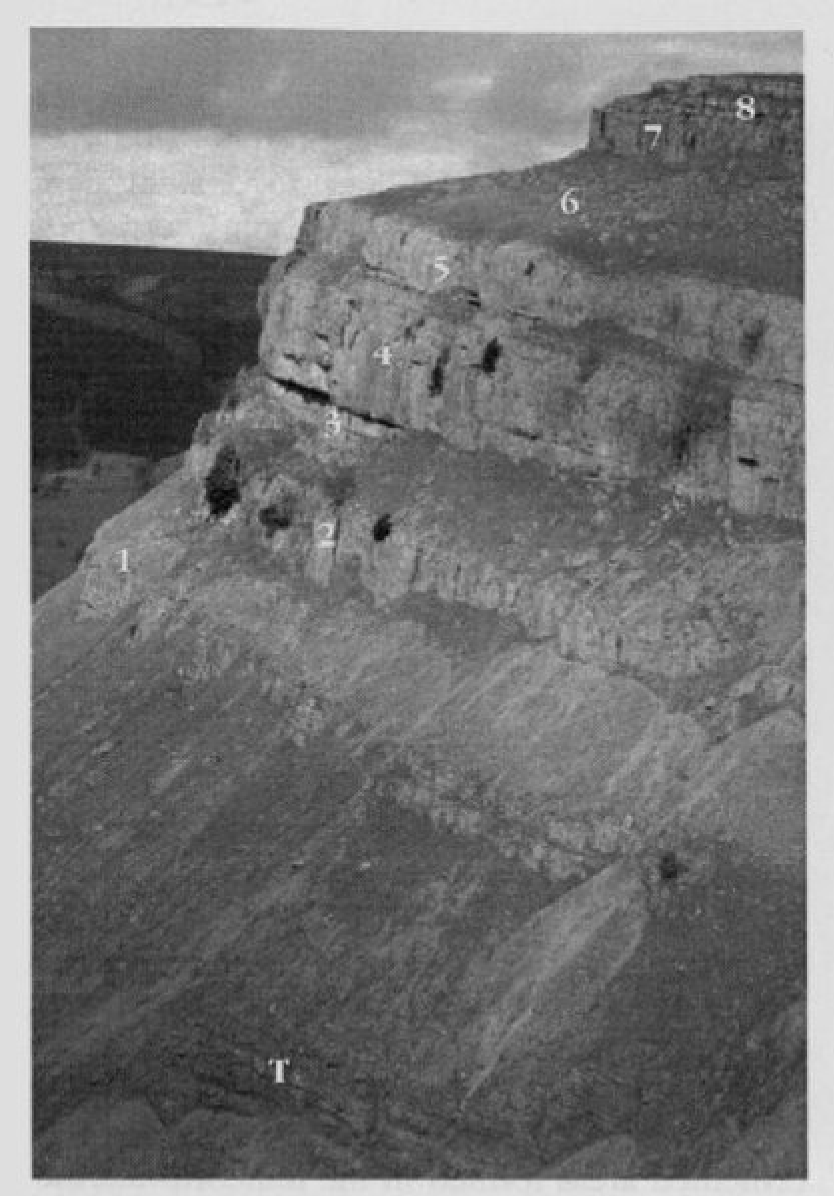
(Figure 8.2) Simplified stratigraphical chart for the Lower Carboniferous succession of North Wales. In the central areas of the Great Orme, the Little Orme and Llanddulas to Denbigh, Warren et al. (1984) placed Brigantian strata in the Gronant Group and Asbian strata in the Dyserth Limestone Group. Compilation based on information from Power (1977), Somerville (1979a), Davies (1982), Somerville and Strank (1984c), Warren et al. (1984), Somerville et al. (1986) and Davies et al. (1989). Areas of vertical ruling indicate non-sequences. Not to scale.



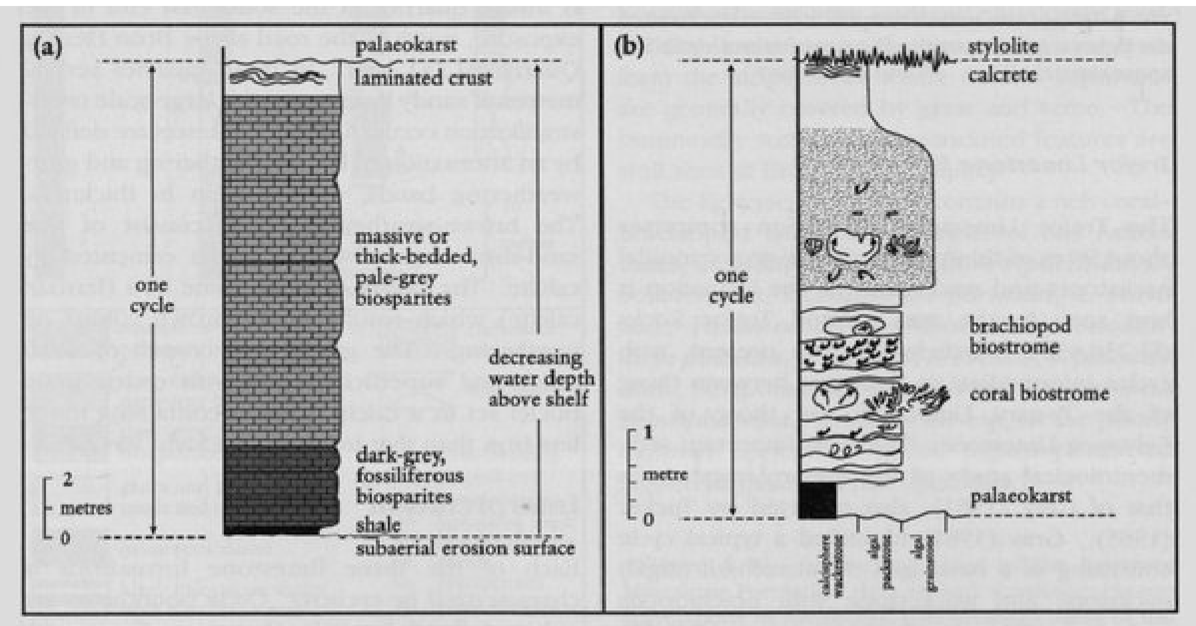
(Figure 8.15) Sedimentary logs of the Ty-nant Limestone Formation (early Asbian) at the Eglwyseg Mountain GCR site showing lateral facies variations and cycle-top correlations. After Somerville (1979b).



(Figure 8.16) Sedimentary logs of the Eglwyseg Limestone Formation (late Asbian) showing cycle-top correlations in the central and southern areas of the Eglwyseg Mountain GCR site. After Somerville (1979a).



(Figure 8.17) The stepped escarpment at Eglwyseg Mountain showing the development of Somerville's (1979a) minor cycles 1–8 in the late Asbian Eglwyseg Limestone Formation overlying the topmost beds of the early Asbian Ty-nant Limestone Formation (T). The height of the main escarpment from the base of the Eglwyseg Limestone to the top of minor cycle 5 is approximately 80 m. (Photo: P.J. Cossey.)



(Figure 8.18) Styles of cyclicity in late Dinantian limestones at Eglwyseg Mountain. (a) A typical Eglwyseg Limestone (late Asbian) cycle. After Somerville (1979a). (b) An ideal Trefor Limestone (Brigantian) cycle. Based on Gray (1981) and Tucker (1985).