
Chapter 8 North Wales Shelf

A.E. Adams and P.J. Cossey

Introduction

Up to 900 m of Dinantian strata, mostly shallow marine limestone, occur in North Wales, deposited on the North Wales Shelf on the southern side of the Irish Sea Basin and bordering the Wales–Brabant Massif. The Lower Carboniferous succession also includes the lower part of the Namurian sandstone–shale succession which heralded the terrigenous clastic deposition of the Upper Carboniferous sequence.

Lower Carboniferous strata outcrop in a number of separate areas (Figure 8.1). These include a strip running southwards from Prestatyn, along the east side of the Clwydian Mountains to Llandegla, then offset eastwards by faulting to continue from Minera to Llangollen, and offset eastwards again, terminating at Llanymynech north of the Mon Vyrnwy. A second outcrop runs south-eastwards up the west side of the Vale of Clwyd from Llanddulas to Denbigh and Ruthin. The Little Orme and Great Orme, to the east and west of Llandudno respectively, are composed of Carboniferous Limestone, and on Anglesey there are outcrops in three areas, known as the Principal, Penmon and Straitside areas. There are also small outcrops in Arfon on the mainland opposite the Straitside area of Anglesey, and in an inlier near Corwen.

There are good coastal exposures of Lower Carboniferous strata in Anglesey and on the Little Orme and Great Orme, but these are not always easily accessible. Natural inland exposures occur where there are steep hillsides, such as on the Great Orme and on Eglwyseg Mountain, but many important exposures are in the numerous, mainly disused, quarries.

History of research

The first detailed descriptions of the Carboniferous Limestone in North Wales are contained in a series of papers by G.H. Morton (1870, 1878, 1886, 1897, 1898, 1901). Morton proposed a basic three-fold classification of the limestones, with more locally developed units at the base and top. At around the same time, the area was being mapped by the [British] Geological Survey and the first memoirs were published (Strahan, 1885, 1890). Vaughan's (1905) faunal zones were applied to the mainland area by Hind and Stobbs (1906) and to Anglesey by Greenly (1919). Jones (1921) was the first to describe the petrography of the limestones, using thin-sections, and he also made some environmental interpretations. Sargent (1923, 1927) reviewed the stratigraphy of the uppermost part of the succession in the east of the area, and Smyth (1925a) described the succession on the Great Orme. Papers of this period devoted to the Lower Carboniferous fauna and flora include those of Jackson (1925b), Smyth (1925b) and Walton (1928, 1931).

Further [British] Geological Survey memoirs with descriptions of Lower Carboniferous rocks include Wedd and King (1924) and Wedd *et al.* (1927, 1929). Neaverson authored a series of papers on the Carboniferous Limestone of mainland North Wales (Neaverson, 1929, 1930, 1935, 1937, 1943, 1945, 1946) and was the first to provide a general interpretation of depositional environments. Floras from parts of the succession were described by Lacey (1952a,b, 1962), Hibbert and Lacey (1969) and Pettitt and Lacey (1972), and palaeobotanical GCR sites of Lower Carboniferous age in North Wales have been described by Cleal and Thomas (1995). Banerjee (1959, 1969), Nichols (1965) and Oldershaw (1969) all studied aspects of the microfacies of the Lower Carboniferous strata of North Wales, with Orme and Brown (1963) and Oldershaw and Scoffin (1967) contributing to our knowledge of their diagenesis.

Renewed interest in the Carboniferous Limestone in the 1960s and 1970s also led to the completion of several PhD theses, including four mostly devoted to Anglesey (Nichols, 1962; Mitchell, 1964; Power, 1977; Davies, 1982). The theses of Somerville (1977) and Gray (1981) concentrated on the mainland successions, and Al-Fadel (1983) studied the diagenesis of the successions in north-east Clwyd. Solomon (1986) presented a Masters thesis on the diagenesis of late Asbian limestones at Llangollen.

An overview of the Lower Carboniferous geology of the area was presented by George (1974). The cyclicity of the Dinantian limestones has generated particular interest and was the focus of work by Somerville (1979a,b,c) in north-east Wales and by Davies (1984) in the Anglesey and Llandudno areas. In 1984, the [British] Geological Survey published the memoir for the area around Rhyl and Denbigh, which also includes the Lower Carboniferous rocks of the Little Orme and Great Orme (Warren *et al.*, 1984). A succession of fossil discoveries and some re-mapping of the outcrop between Prestatyn and Llandegla and in the Vale of Clwyd has led to major revision of the stratigraphy in these areas (Somerville and Strank, 1984a,b,c; Davies *et al.*, 1989; Somerville *et al.*, 1989).

Papers interpreting aspects of detailed local sedimentology include those of Walkden and Davies (1983) on the sandstone pipes of Anglesey, Solomon and Walkden (1985) on calcrete fabrics at Llangollen, Bancroft *et al.* (1988) on some unusual bryozoan buildups near Llandudno, Solomon (1989) on early cementation in cyclic limestones, and Davies (1991) on karstification and soil formation in the Anglesey succession.

Stratigraphy

In his series of papers on the Lower Carboniferous rocks of North Wales, Morton (1870, 1878, 1886, 1897, 1898, 1901) applied a simple lithostratigraphy based on the colour of the limestones. Thus the major part of the succession was divided into the Lower Brown Limestone, the Middle White Limestone and the Upper Grey Limestone (Figure 8.2). The lowest strata, the largely detrital Basement Beds, Morton originally classified as 'Old Red Sandstone'; however, this was revised after Strahan and Walker (1879) showed them to be Lower Carboniferous. The uppermost units are rather more variable. Morton's lithostratigraphy proved remarkably successful although it was applied more easily in some areas than others. Revisions and alternative names were suggested by Neaverson during his work of the 1930s and 1940s (e.g. Neaverson, 1935), but essentially Morton's classification remained in use until the 1970s when a plethora of local formation names began to appear to replace the outdated scheme.

Following the work of Hind and Stobbs (1906) on the mainland and Greenly (1919) on Anglesey, the whole of the limestone succession was attributed to the *Dibunophyllum* Zone and, after erection of the regional stages by George *et al.* (1976), to the Asbian and Brigantian stages. Although the possibility that the Basement Beds were S₂ (Holkerian) was raised, older Dinantian strata were not generally recognized with certainty, despite the record of S₂ (Holkerian) foraminifera from near Llanddulas by Simpson (1961), until detailed work on the outcrop between Prestatyn and Llandegla and in the Vale of Clwyd revealed the presence of beds of Chadian, Arundian and Holkerian age (Somerville and Strank, 1984b,c; Davies *et al.*, 1989; Somerville *et al.*, 1989). The current knowledge of the stratigraphical status of the various outcrops is summarized below.

Prestatyn to Llandegla

It is in this area that the most up-to-date stratigraphical work has been completed. Morton's classification stood until formal lithostratigraphical names were introduced in the Mold area by Somerville (1979c). However, these had to be modified in the light of the discovery of pre-Asbian faunas by Somerville and Strank (1984b,c) and Davies *et al.* (1989). The latter authors provided the most recent version of the stratigraphy for the southern part of the Clwydian range (Figure 8.2). To the north, around Prestatyn and Dyserth, Morton's classification was replaced by a formal lithostratigraphy in the [British] Geological Survey memoir of Warren *et al.* (1984). This was modified by Somerville *et al.* (1986) and is detailed in (Figure 8.2).

It was this area that was originally thought to contain the thickest succession of Asbian shelf deposits in the British Isles (e.g. George, 1974), but the discoveries of older successions outlined above bring the thicknesses closer into line with those of other similar areas.

Llangollen area

Morton's three-fold classification of the main part of the succession was superseded by the formal divisions of Somerville (1979a), shown in (Figure 8.2). The Cefn-y-fedw Sandstone is retained as the lowest part of the Namurian succession and is, at least in part, within the Lower Carboniferous succession as used here.

Llandudno and the area west of the Vale of Clwyd

A formal lithostratigraphy for these areas was set up by Warren *et al.* (1984) at the same time as they proposed divisions for the succession in the Prestatyn area. While these latter divisions have been modified in the light of the more recent work described above, those for the Great Orme and Little Orme represent the most recent stratigraphical work in these areas and are shown in (Figure 8.2). Somerville and Strank (1984c) recorded Arundian faunas from near the base of the succession at a number of localities between Llanddulas and Ruthin, so requiring updating of the nomenclature in this area.

Anglesey

It was on Anglesey that Morton's classification proved most difficult to apply (George, 1974). However, it has never been formally superseded in the published literature. All four PhD theses of the period 1962–1982 attempted to define an improved lithostratigraphy (Nichols, 1962; Mitchell, 1964; Power, 1977; Davies, 1982), the most workable and comprehensive schemes being those of Power (1977) and Davies (1982). Davies' scheme has been used in his publications on Anglesey (Walkden and Davies, 1983; Davies, 1991). The major divisions used by both Power (1977) and Davies (1982) are shown on (Figure 8.2).

Geological setting

The Lower Carboniferous succession in North Wales records the encroachment of the sea onto the northern margin of the Wales–Brabant Massif bordering the Irish Sea Basin. Comprising entirely shallow marine and marginal marine environments, the area is known as the 'North Wales Shelf'. Initially, during Chadian times, only the eastern part of the area was inundated, the sea perhaps reaching southeastwards to the Bryneglwys Fault (Figure 8.3)a. In common with other shallow shelf areas of the British Isles at this time, Somerville *et al.* (1989) suggested that there was probably a gently dipping carbonate ramp, with the outcropping rocks representing the proximal end. They proposed that Waulsortian buildups might lie under the Irish Sea. Their reconstructions of the ensuing ramp to rimmed platform transition for north-east Wales are shown in (Figure 8.4).

During Arundian and Holkerian times, the sea spread to the central areas, reaching at least as far as Llanddulas. To the west, the whole of the area remained land until Asbian times, when an open platform was established. As with Asbian shelf sequences elsewhere in Britain, a strong cyclicity is developed, defined by episodes of subaerial exposure. Probably the area was exposed, with previously deposited shelf carbonates undergoing meteoric diagenesis, for as much of late Dinantian time as it was covered with shallow sea. (Figure 8.3)b shows the likely maximum extent of the carbonate shelf across North Wales in late Dinantian times. Greenly (1919) recognized that much of Anglesey was land during early Carboniferous times and that the strata recorded the partial drowning of a landscape with a highly irregular topography. The proximity of land meant that during relative sea-level fall there was an influx of clastics from the adjacent elevated areas. This resulted in the progradation of alluvial fans across the emergent carbonates and the incision of fluvial channel complexes (Davies, 1982).

GCR site coverage

The choice of sites attempts to portray the stratigraphical and sedimentary evolution of the North Wales Shelf during Early Carboniferous times. Sites with Asbian and Brigantian successions are particularly well represented, reflecting the greater knowledge, broader outcrop width and better exposure of these stage intervals than those either higher or lower in the sequence. Restricted outcrop and poor exposure have so far prevented the selection of conservable Pendleian and Arnsbergian sites. In recent years the discovery of Chadian–Holkerian successions east of the Clwydian Mountains and in the Vale of Clwyd has prompted the search for new GCR sites in these areas and, although one new site has been identified and described in this chapter (Pentre-bach Quarries, Chadian, Foel Formation), gaps in the coverage still remain. However, the discovery of Chadian–Holkerian faunas in beds previously regarded as belonging to the Asbian Stage raises the possibility that some of these stage intervals may already be represented at other GCR sites, where thick Lower Carboniferous successions extending to the base of the Asbian Stage are reported (e.g. the poorly researched Great Orme GCR site). From the foregoing discussion it is clear that there is still some potential for change to

the site coverage in this area.

Oscillating sea levels across the North Wales Shelf during Early Carboniferous times produced cyclic successions that were either carbonate dominated or characterized by a clastic–carbonate mix. The GCR sites can be placed into either one of these groupings.

1. Carbonate-dominated successions:

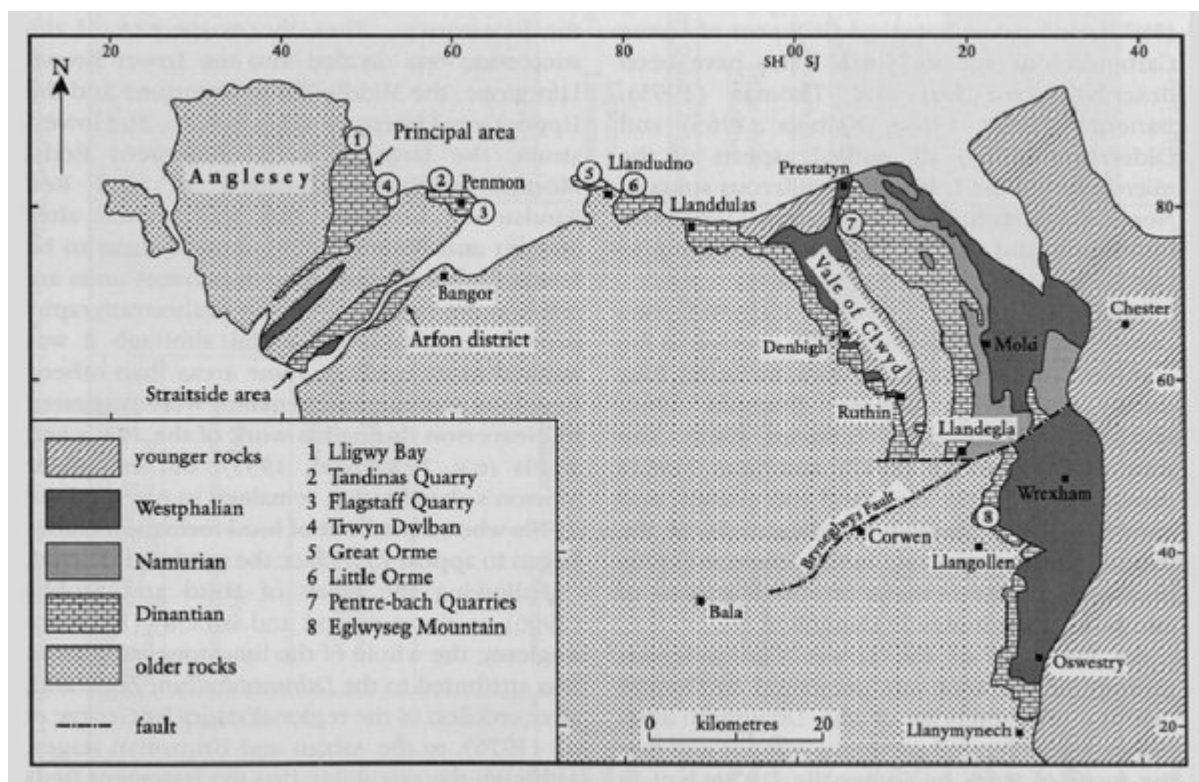
1. Pentre-bach Quarries (Chadian, subtidal facies)
2. Eglwyseg Mountain (thick Asbian–Brigantian succession, lateral facies changes, minor cycles, emergence, teaching resource)
3. Tandinas Quarry (early Asbian, subtidal and peritidal facies, palaeokarsts)
4. Flagstaff Quarry (late Asbian, carbonate sand shoals, palaeosols)
5. Great Orme (thick Asbian–Brigantian succession, largely unresearched)

2. Mixed clastic–carbonate successions:

1. Trwyn Dwlban (Brigantian potholes and sandstone pipes)
2. Lligwy Bay (Asbian collapsed cavern feature and Lligwy Bay Conglomerate)

A further site selected specifically for its sedimentological and palaeontological interest is the Little Orme in which rocks of reef facies are developed in the Great Orme Limestone (Asbian).

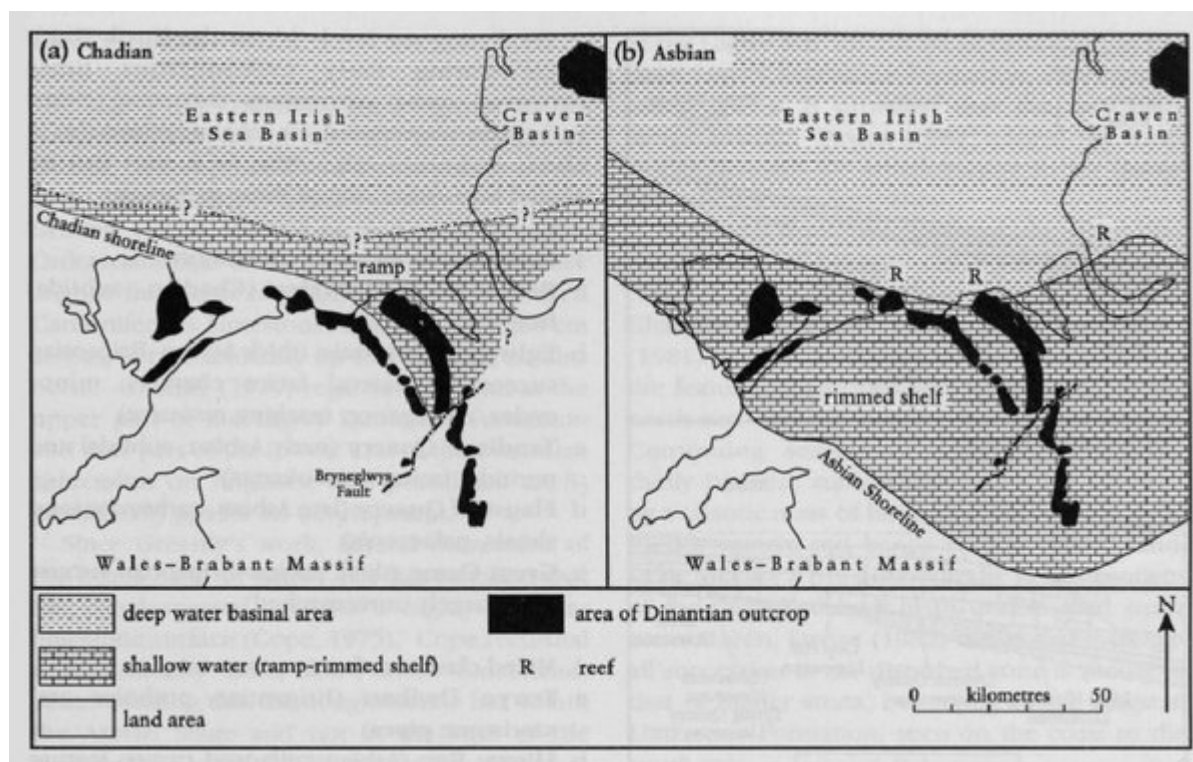
References



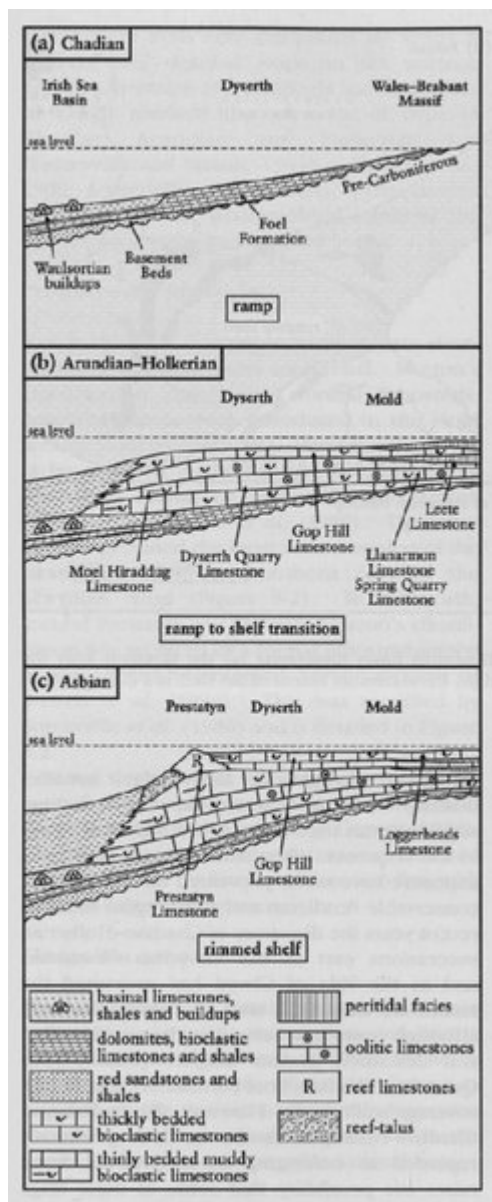
(Figure 8.1) Geological map of North Wales illustrating the distribution of Carboniferous rocks and the locations of GCR sites described in the text. Based on [British] Geological Survey maps of the area (principally institute of Geological Sciences, 1979b).

Chrono-stratigraphy	Lithostratigraphy								
	North Wales (general)	Anglesey (Principal and Penmon areas)		Great Orme	Little Orme	Llanddulas-Denbigh	Prestatyn	South Chwyd	Llangollen
	Morton (1870, 1878, 1886)	Power (1977)	Davies (1982)						
Namurian (part)	Cefn-y-fedw Sandstone			(top unseen)	(top unseen)	(top unseen)	Holywell Shales	Holywell Shales	Cefn-y-fedw Sandstone
Brigantian	Bedded Chert	Benllech Formation	Red Wharf Cherty Limestone Formation					Pentre Chert	Minera Formation
	Sandy Lst/Black Lst		Traeth Bychan Limestone Formation	Gronant Gp					
	Upper Grey Limestone				Summit Limestone	Treila Formation	Cefn Mawr Limestone	Trefor Limestone Formation	
Asbian		Penmon Limestone Formation	Moelfre Limestone Formation	Great Orme Limestone	Gloddaeth Purple Sl	Llanddulas Limestone	Prestatyn Limestone	Loggerheads Limestone	Egwyseg Limestone Formation
	Middle White Limestone		Flagstaff Limestone Formation						
				Tollhouse Mt	Dulas Limestone	Dulas Limestone			
	Lower Brown Limestone		Tandinas Limestone Formation	Careg-Onen Limestone Formation					
		Lligwy Sandstone Formation	Lligwy Sandstone Formation	Dyserth Limestone Group	Llandudno Pier Dolomite	Llysfaen Limestone	Gop Hill Limestone	Leete Limestone	Ty-nant Limestone Formation
	Basement Beds					Llysfaen Limestone			
Holkerian									Basement Beds
Arundian						Basement Beds	Moel Hiraddug Limestone	Llanarmon Limestone	
							Dyserth Quarry Limestone		
late Chadian							Foel Formation	Foel Formation	
early Chadian-Corsevian							Basement Beds	Basement Beds	

(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 8.3) Palaeogeography of North Wales during Dinantian times illustrating (a) the situation after the Chadian transgression (after Somerville et al., 1989), and (b) the maximum extent of the shelf sea during Asbian times. After Warren et al. (1984).



(Figure 8.4) A north to south section across north-east Wales showing the transition from carbonate ramp to reef-rimmed carbonate shelf during Dinantian times, with inferred facies for the Irish Sea Basin area: (a) Chadian, (b) Arundian-Holkerian, (c) Asbian. After Somerville et al. (1989). The approximate length of the sections is 50 km.