

Chapter 20

Carboniferous of western Ireland I.D. Somerville & C.N. Waters

The Carboniferous rocks of western Ireland extend from the Ox Mountains in south Co. Mayo, south to Galway Bay, east to the western margin of the Dublin Basin Co. Roscommon (Chapter 21) and west to Clew Bay and Clare Island (Figure 19.1). Tournaisian rocks of mostly continental or marginal marine facies, Visean rocks of mostly marine limestone, and Namurian predominantly marine and fluviodeltaic siliciclastic rocks crop out in the region, the entire succession belonging to the Mississippian Subsystem. In western Ireland, late Tournaisian and Visean (Chadian-Asbian) aged shelf limestones occur within structurally controlled basins, many of which are extensions of structures in the adjacent northwest region (see Chapter 19). In the Castlebar area of south Co. Mayo, the Castlebar Syncline represents a southwest extension of the Ballymote Syncline, bounded to the north by the Ox Mountains Inlier and to the south by the Belhavel Fault (Long *et al.* 2004).

Across most of the region the Tournaisian succession rests unconformably upon Devonian and older strata. However, in the east Galway area, the Tournaisian succession is thicker and contains more marine rocks representing an earlier arrival of the transgression from the south and rests conformably upon Devonian strata. The rocks below the Waulsortian Limestone in the south and east of the area (Fig. 20.1) are transitional with those further to the east belonging to the North Midlands Province (Chapter 21), and those to the south forming the northern margin of the Limerick province (Chapter 22) (see Philcox 1984; Sevastopulo & Wyse Jackson 2001). From latest Tournaisian time and throughout the Visean, the western region developed a mainly limestone succession. The Namurian rocks are very isolated in their distribution and are restricted to the Slieve Carna Outlier.

The lithostratigraphy used here is based on a compilation and synthesis of existing published nomenclature. The formations are those defined by the Geological Survey of Ireland (GSI) in their recently published 1:100,000-scale map series. Many are named from borehole sections in areas of poor exposure and lack a defined group hierarchy.

Tournaisian

In west Ireland strata of early Tournaisian age are restricted to the Tynagh area of east Co. Galway (Fig. 20.1, Col. 4). These Tournaisian rocks represent a thinned sequence of a much thicker succession typical of the Limerick Province further to the south (Chapter 22), towards the Shannon estuary (Philcox 1984). At Tynagh, Borehole T-415 penetrated a 'Basal Sandstone' present above red-beds of the Old Red Sandstone. Two skeletal siltstone units within the top 45 m of the 'Basal Sandstone' have been interpreted as possible traces of the Mellon House Formation (Philcox 1984). A direct transition to the overlying Ringmoylan Shale Formation is seen in borehole T-178 at Tynagh, where thin-bedded black shale and limestone interbedded with thinly laminated calcareous siltstone is present. This is overlain by the Ballyvergin Shale Formation, which consists of greenish-grey non-calcareous blocky mudstone with fine siltstone and shale. It is sparsely fossiliferous, with rare horizons of brachiopods, but

does contain spores of PC Biozone age ^{^1} and an assemblage of Lower Palaeozoic acritarchs. This formation acts as a good regional marker (Clayton *et al.* 1980; Philcox 1984).

The Ballymartin Formation of the Tynagh area (Fig. 20.1, Col. 4) comprises interbedded pale-grey argillaceous bioclastic limestone and dark calcareous shale in roughly equal proportions. It is highly fossiliferous with brachiopods, crinoids, bryozoans, molluscs and corals (usually tabulates - *Michelinia* and *Syringopora*). At Tynagh its base is taken at the top of the Ballyvergin Shale and the top placed at a distinct lithological change marked by a 1.2 m thick black shale in borehole T-178 (Philcox 1984). In the Pallaskenry Borehole the top of the Ballymartin Formation is taken below the equivalent Pallaskenry Member (Somerville & Jones 1985). The lower part of the Ballymartin Formation is replaced by Ringmoylan Shale facies (Philcox 1984) at Tynagh, due to diachronism. In Tynagh borehole T-178, 16.7 m of Ringmoylan Shale facies is seen above the Ballyvergin Shale Formation, and a distinct correlatable 3.6 m black shale bed, occurs at the top of the facies. In the Tynagh area, an important marker bed, the Tynagh Sandy Bed lies within the upper part of the Ballymartin Formation. It consists of laminated, fine to medium-grained sandstone alternating with dark, burrowed, silty, fine-grained sandstone.

The Tynagh Sandy Bed was deposited at about the same time as extensive sedimentation of sandstone-dominated formations, e.g. the basal Moy Sandstone Formation of the Castlebar area (Fig. 20.1, Col. 1). In the northeast part of Clare Island (Fig. 20.1, Col. 2) the lower part of a predominantly siliciclastic succession is formed by the Maam Formation red-bed sequence, which rests unconformably on Dalradian rocks. It is composed of cross-bedded coarse-grained sandstone and conglomerate in the lower part, and finer grained lithologies in the upper part (Phillips & Clayton 1980; Graham 2001). Palaeocurrents suggest a northwesterly provenance. The overlying Capnagower Formation is composed of fine-grained sandstone and mudstone with palaeosols in the lower part. It is distinguished from the underlying Maam Formation by the incoming of dark grey mudstone and the rarity of red-beds (Phillips & Clayton 1980; Graham 2001). In the upper part of the formation are interbedded dark mudstone and sandstone containing poorly preserved ostracods, bivalves, gastropods and plants, indicating a brackish water environment. Six productive spore samples were obtained from this formation. The lower 4 samples contained a CM Biozone spore assemblage of late Tournaisian age ^{^1}, whereas the upper 2 samples from near the top of the formation contained small numbers of *Lycospora pusilla*, indicating the incoming of the Pu Biozone ^{^2} (Phillips & Clayton 1980; Higgs *et al.* 1988; Graham 2001).

In the Oughterard area (Fig. 20.1, Col. 3) the basal clastic rocks of the Tonweeroe Formation rest on the Oughterard Granite. The formation, drilled in two GSI boreholes (92-9 and 92-10), comprises a lower red-bed unit 34 m thick, a transitional unit 9 m thick and an upper grey sandstone and mudstone unit 62 m thick (Long *et al.* 2004). The red-bed unit consists mainly of red, trough cross-bedded feldspathic sandstone, siltstone and mudstone with sporadic graded coarse-grained sandstone and thin beds of conglomerate. The upper part of the lower unit contains caliche carbonate nodules. The upper unit is composed mainly of light grey, fine-grained sandstone and dark grey siltstone and mudstone. However, the upper part of this unit contains quartz pebble conglomerate and near the top, a thin sandy dolomitized calcarenite containing

brachiopods and gastropods, marking the transition into the marine limestone of the succeeding Oughterard Limestone Formation. Spores of CM Biozone age have been recorded from near the base and top of the Tonweeroe Formation ^{^1} (Long *et al.* 2004).

In the Mount Bellew area (Fig. 20.1, Col. 5) the basal clastic rocks are assigned to the Boyle Sandstone Formation. The red-bed Boyle Sandstone Formation grades up into a transitional sequence (Meath Formation of the Navan Group) characterised by burrowed fine-grained siliciclastic rocks, and scattered limestone beds. In the Mount Bellew Borehole AG.MB-1 the Meath Formation represents a much thinner and more marginal marine facies of the thicker sequence at Navan more typical of the North Midlands Province (Philcox 1984; McConnell *et al.* 2001; Long *et al.* 2004). It is dominated by sandstone and siltstone with subordinate limestone and thin fossiliferous mudstone. However, at the base of the formation, is an abundance of micrite which suggests equivalence with the Stackallan Member at Navan (Long *et al.* 2004). Above the Meath Formation in the Mt Bellew borehole AG.MB-1 is a 4 m thick fine-grained skeletal sandstone with subordinate biosparite and sandy limestone, which is correlated with the Rockfield Sandstone Member ('Upper Sandstone' of Philcox 1984) at the base of the Moathill Formation at Navan and Kingscourt (Strogen *et al.* 1995; McConnell *et al.* 2001).

In North and East Galway and Mount Bellew areas (Fig. 20.1, Cols. 3, 4 & 5), the upper Tournaisian succession is dominated by carbonate deposition. The Oughterard Limestone Formation of the Oughterard area (Fig. 20.1, Col. 3) consists mainly of argillaceous limestone divided into two members, a lower Waterfall Member and an upper Owenriff Member, both of which are present at outcrop in the Owenriff River near Oughterard. The Waterfall Member in GSI borehole 92-9 consists of interbedded light and dark grey argillaceous crinoidal limestone, bioturbated silty limestone and subordinate calcareous siltstone (Long *et al.* 2004). The top of the member is marked by a distinctive 4.5 m-thick brachiopod-rich unit. The Owenriff Member in GSI 92-9 consists of dark grey argillaceous limestone, with subordinate interbeds of fossiliferous shale and nodular bioturbated silty shale (Long *et al.* 2004). The formation is probably of late Tournaisian to early Viséan age ⁰² as suggested by the record of the foraminifer *Eblanaia michoti* in the lowest samples of the Waterfall Member, and *Eoparastaffella* Morphotype 2 in the middle of the Owenriff Member (A. Lees, personal communication).

In Tynagh borehole T-178 (Fig. 20.1, Col. 4), the lowest 125 m of the Ballysteen Formation consist of thick, uniform, argillaceous crinoidal limestone with thin shale interbeds. It contains a distinctive marker, the 6 m-thick 'Fine Calcarene Marker' (FCM) (6 m above the base). The overlying 50 m of the formation are shalier, with siltstone, indicating lower energy conditions, and is more varied, with a gradational upper contact at the base of the Waulsortian Limestones. In borehole T-178 burrowed siltstone is overlain by coarse crinoidal calcarenite and nodular micrite with shale. Unlike most of the Limerick Province (Chapter 22), there is no sub-Waulsortian chert sequence in borehole T-178. This succession is equivalent to the lower part of the Kilbryan Limestone Formation in the Mount Bellew area (Fig. 20.1, Col. 5), which comprises interbedded fossiliferous shale and thin irregularly bedded nodular limestone generally with a rich coral fauna.

The Waulsortian Limestone attains an average thickness of 200 – 350 m over the area in east Co. Galway (Fig. 20.1, Col. 4), but it reaches over 700 m in the Ballinasloe area (borehole 96-3459-5; Wilkinson & Earls 2000) on the northern margin of the Tynagh Basin. These limestone units also occur within the middle part of the Kilbryan Limestone Formation in the Mount Bellew area (Fig. 20.1, Col. 5).

Visean

The mainly Chadian succession of the Castlebar area (Fig. 20.1, Col. 1) comprises a lower Lough Akeel Oolite Formation, which consists of sandy, cross-bedded, fine-grained ooidal limestone. Pebbly limestone and chert are present locally (Long *et al.* 2004). The overlying Castlebar River Limestone Formation comprises interbedded dark grey fine-grained argillaceous limestone containing fenestral micrite with calcareous shales (Long *et al.* 2004). The Clare Island succession is similar to that developed around the northern shore of Clew Bay (Fig. 20.1, Col. 2). The Rockfleet Bay Limestone Formation is composed of dark grey, fine-grained limestone and calcareous shale of unknown thickness (Long *et al.* 2004). It is similar to the Castlebar River Limestone and may be its lateral equivalent.

The Cregg Limestone Formation of the Oughterard area in the GSI (Laghtgannon) Borehole 02-3 (Pracht *et al.* 2004; Long *et al.* 2004) (Fig. 20.1, Col. 3) consists of massive pale grey, commonly sandy or pebbly limestone with occasional coarse-grained sandstone and conglomeratic beds. The limestone is fine to medium-grained sandy grainstone and packstone, with local cross-bedded ooidal limestone and fenestral micrite. Rare tabulate corals include *Michelinia* and *Syringopora*. The formation has *Koninckopora* algae and foraminifers of early Visean age. The overlying Oldchapel Limestone Formation consists mainly of dark grey, very fine-grained limestone with micrite and minor calcareous shale. The Cregg Limestone Formation passes east into the Oakport Limestone Formation (Pracht *et al.* 2004; Long *et al.* 2004). In east Co. Galway, borehole T-178 (Fig. 20.1, Col. 4) includes a 0.3 m tuff which lies 12 m above the Waulsortian Limestones within the basal limestones of the Lucan Formation of early Visean age (Philcox 1984).

In the Ballinasloe area of east Co. Galway and in deep boreholes drilled in the Galway-Roscommon shelf (Fig. 20.1, Col. 5) a thick shelf sequence succeeds the Waulsortian limestones (Gatley *et al.* 2005). These include the Kilbryan and Oakport Limestone formations that were first defined further to the north in the Carrick Syncline (Chapter 19) by Caldwell (1959). In the Clonbrock Borehole GSI-00-206, 3 km northwest of Ahascragh, the Kilbryan Limestone Formation directly succeeds the Waulsortian Limestone. It is composed of dark-grey argillaceous, fine-grained limestone and calcarenite, which become increasingly coarse grained and more crinoidal towards the base. The finer grained limestone in the upper part of the formation contains scattered crinoid debris and the large solitary coral *Siphonophyllia*. To the northwest, in the Slieve Dart Borehole (02-3471-01), over 100 m of Kilbryan Limestone Formation are present with *Siphonophyllia* and *Michelinia megastoma* corals of Chadian age *¹ (Gatley *et al.* 2005). The upper part of the Kilbryan Limestone Formation in the Mount Bellew area (Fig. 20.1, Col. 5), above the level of tuffs, is early Visean in age and comprises very fine-grained calcarenite with local chert (Long *et al.* 2004). The overlying Oakport Limestone Formation in the Clonbrock Borehole is characterised by massive, medium-grey, fine-grained limestone and rare calcarenites (locally dolomitized), containing crinoids, occasional

large *Siphonophyllia*, brachiopods and gastropods. It shows the same informal tripartite division as in the type section defined by Caldwell (1959). The basal unit comprises massive pale-grey crinoidal calcarenite overlain by a variable unit of fine to coarse-grained ooidal limestone and micrite, with an upper unit of massive pale-grey, fine to medium-grained calcarenite with sporadic chert and birdseye micrite. In the Slieve Dart Borehole, the formation includes *Siphonophyllia cylindrica* and *Michelinia megastoma* corals of Chadian age ^{*2} (Gatley *et al.* 2005).

The Aille Limestone Formation of the Castlebar area (Fig. 20.1, Col. 1) is composed of dark grey, fine to medium-grained calcarenite with thin beds of shale. The lower part of the formation contains a thin tuff band and an horizon of quartz pebbles in paler coarser grained calcarenite beds. The upper part of the formation is more argillaceous. *Siphonodendron* corals are recorded along with Arundian foraminifers in the lower part of the formation ^{O1} but the upper part is probably Holkerian (Long *et al.* 2004). In the Laghtgannon Borehole 02-3, of the Oughterard area (Fig. 20.1, Col. 3), the Illaunagappul Formation consists mainly of medium to dark grey, fine- to medium-grained bioclastic calcarenite with thin shale partings and abundant corals (*Siphonodendron*, *Syringopora*, *Michelinia*) and brachiopods. Chert nodules occur throughout, but are particularly common in the middle part of the formation. The basal unit, 1-2 m thick, comprises a distinctive shelly pebbly coarse-grained sandy grainstone rich in brachiopods and quartz granules. Foraminifers of the Cf4δ Subzone have been recorded including the first archaeadiscids, indicating an Arundian age for the formation ^{O3} (Pracht *et al.* 2004; Long *et al.* 2004). The succeeding Ardnasillagh Formation in the Laghtgannon Borehole 02-3 consists mainly of dark grey very fine-grained limestone with abundant chert. A subordinate component is pale grey crinoidal calcarenite. The formation contains foraminifers of Cf4δ Subzone and in the upper part Cf5 Zone of Arundian to Holkerian age ^{O4} (Pracht *et al.* 2004; Long *et al.* 2004). The Ballymore Limestone Formation in the Clonbrock Borehole (Fig. 20.1, Col. 5) is typified near the base by 24 m of medium to dark-grey, very argillaceous micrite, containing scattered fine-grained crinoid debris and occasional larger skeletal material, interbedded with dark-grey calcareous shale or rare thin black shale. These beds grade upwards into 37 m of fine-grained calcarenite interbedded with calcareous, commonly crinoidal, shale. The uppermost 190 m of the formation are mostly heavily dolomitised, skeletal and crinoidal limestone, apart from the top 25 m of dark grey, fine-grained calcarenite and calcareous shale with *Caninia* and solitary corals, which may still be assignable to the Ballymore Limestone Formation (Gatley *et al.* 2005). In the Slieve Dart Borehole (02-3471-01) more than 40 m of Ballymore Limestone Formation are present with *Siphonodendron sociale* colonies of Arundian age near the base (Fig. 20.1, Col. 5 ^{*3}; Gatley *et al.*, 2005).

The Blarney Limestone Formation (Fig. 20.1, Col. 1) is composed of thick-bedded pale grey, coarse-grained crinoidal calcarenite with brachiopod bands and colonial corals (*Siphonodendron* and *Lithostrotion*). It is mainly equivalent and similar to the Burren Formation in Co. Clare (see Chapter 22) (Long *et al.* 2004). Two members have been distinguished: Kinturk Member exposed near Kinturk Castle, comprising pale grey cross-bedded ooidal limestone, underlain by dark grey fine-grained limestone and shale. The Bohoge Member is the highest unit in the formation and consists of dark grey fine-grained cherty limestone, with chert making up 50% of the section. The higher part of the member is more thin bedded, contains darker limestone and shale interbeds are present. *Siphonodendron junceum* and *Dibunophyllum* are

recorded *² suggesting that this member, together with the high chert content, may correlate with the Slievenaglasha Formation of Co. Clare of Brigantian age (Long *et al.* 2004).

In north Co. Galway (Fig. 20.1, Col. 3), the equivalent Holkerian to Asbian succession to the Blarney Limestone Formation is represented by three formations. The lowermost, the Aughnacore Oolite Formation, has its type section around Aughnacore Castle. In the Laghtgannon Borehole 02-3, it is c. 33.5 m thick and consists mainly of cross-bedded ooidal skeletal and coated grainstone. Foraminifers of the Cf5 Zone have been recorded, indicating a Holkerian age for the formation (Pracht *et al.* 2004; Long *et al.* 2004). The overlying Corranellistrum Formation consists of thick-bedded, medium grey, clean, fine- to medium-grained calcarenite. The formation contains a few local markers (chert bands and dolomitised beds), and *Siphonodendron* colonies are locally abundant. Foraminifers of the Cf5 Zone have been recorded indicating a Holkerian age for the formation ^{O5}, although the uppermost beds may be of Cf6 zone suggesting an early Asbian age ^{O6} (Pracht *et al.* 2004; Long *et al.* 2004). The youngest Visean rocks in the Lough Corrib area (Fig. 20.1, Col. 3) belong to the Knockma Formation and consist of thick-bedded pale grey clean limestone similar to those of the underlying Corranellistrum Formation. The base is marked by the first appearance of cerioid *Lithostrotion* colonies. The Knockma Formation is mostly Asbian in age and is equivalent to the Burren Formation, in south Co. Galway and Co. Clare (Pracht *et al.* 2004; Sleeman & Pracht 1999). The highest beds of the formation are differentiated from the rest of the formation as the Two Mile Ditch Member (Long *et al.* 2004). This member, named after a quarry near Galway city, contains distinctive clay wayboards similar to the Ailwee ('Terraced Limestones') Member of the Burren Formation (Sleeman & Pracht 1999).

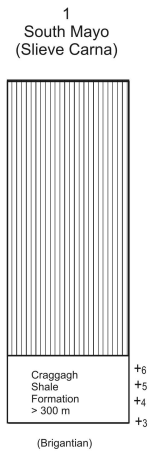
The Tooromin Shale Formation represents an isolated outcrop on the east side of the Slieve Carna Outlier (Fig. 20.1, Col. 1) (Long *et al.* 2004). It is composed of dark grey limestone with black shale interbeds. A Brigantian (P₂) age has been reported for this formation (Ramsbottom *et al.* 1978).

Namurian

Namurian shale and sandstone of the Craggagh Shale Formation are poorly exposed in the Slieve Carna Outlier, south Co. Mayo (Fig. 20.1, Col. 1), but are considered to be conformable on the Tooromin Shale Formation (Long *et al.* 2004). Ammonoids recorded by Ramsbottom *et al.* (1978) from shale in the lower part of the formation include *Cravenoceras* (= *Emstites*) *leion* (E_{1a}) ⁺³, *Tumulites pseudobilinguis* (E_{1b}) ⁺⁴, *Cravenoceras malhamense* (Zone E_{1c}) ⁺⁵, of early to late Pendleian age. Shale from the upper part of the formation has yielded *Eumorphoceras bisulcatum* (Zone E_{2a}) of early Arnsbergian age ⁺⁶.

Fig. 20.1. Correlation of successions of Tournaisian and Visean age in the Western Ireland region. Col. 1 from Long *et al.* (1992); Graham (1996); Col. 2 from Phillips & Clayton (1980); Long *et al.* (1992); Graham (2001); Col. 3 from Long *et al.* (2004); Ramsbottom *et al.* (1978); Col. 4 from Pracht *et al.* (2004); Long *et al.* (2004); Col. 5 from Philcox (1984); Gatley *et al.* (2005); Col. 5 from Philcox (1984); Gatley *et al.* (2005); Long *et al.* (2004).

| Subsystem | International Stage | Regional Substage | Ammonoids | Palynomorphs |
|----------------------|---------------------|-------------------|-----------|--------------|
| PENNSYLVANIAN (pars) | NAMURIAN | Yeadonian | G1b | FR |
| | | | G1a | |
| | | Marsdenian | R2c | |
| | | | R2b | |
| | | Kinderscoutian | R2a | KV |
| | | | R1c | |
| | | Alportian | R1b | |
| | | | R1a | |
| | | Chokierian | H2c | SO |
| | | | H2b | |
| MISSISSIPPIAN (pars) | | | H2a | |
| | | Arnsbergian | H1b | |
| | | | H1a | |
| | | Pendleian | E2c | TK |
| | | | E2b | |
| | | | E2a | |
| | | | E1c | NC (pars) |
| | | | E1b | |
| | | | E1a | |
| | | | | |



- Biostratigraphical symbols
- + Ammonoids
 - o Conodonts & foraminifers
 - ^ Palynomorphs & macroflora
 - * Corals & brachiopods

| Subsystem | International Stage | Regional Substage | Ammonoids | Palynomorphs |
|----------------------|---------------------|-------------------|-----------|--------------|
| MISSISSIPPIAN (pars) | VISEAN | Brigantian | P2c | NC (pars) |
| | | | P2b | |
| | | | P2a | VF |
| | | | P1d | |
| | | Asbian | P1c | |
| | | | P1b | |
| | | | P1a | NM |
| | | | B2b | |
| | | | B2a | |
| | | | | TC |
| TOURNAISIAN | | Holkerian | B1 | TS |
| | | Arundian | | |
| | | | BB | |
| | | Chadian | | Pu |
| | | | FA | |
| | | Courceyan | | CM |
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