

## Chapter 21

### Dublin Basin

I.D. Somerville & C. N. Waters

The Carboniferous rocks of the Dublin Basin extend from the east coast of north Co. Dublin westwards to the River Shannon at Athlone and northwards to the Lower Palaeozoic rocks of the Longford-Down Massif (see Strogon *et al.* 1996, fig. 5; Sevastopulo & Wyse Jackson 2001, fig. 10.12; Fig. 21.1). They occur in counties Longford, Westmeath, Meath, north Co. Dublin, north Co. Offaly, north Co. Kildare and south Co. Dublin. Most of the rocks in the region belong to the Mississippian Subsystem, with Pennsylvanian strata preserved only in boreholes at Kingscourt (Fig. 21.2, Col. 1). The marine Tournaisian strata present above a basal continental siliciclastic facies are represented by three contrasting lithological successions referred to as the North Midlands, Kildare and Limerick provinces (see Philcox 1984; Strogon & Somerville 1984; Sevastopulo & Wyse Jackson 2001).

During the Tournaisian there was a gradual northward advance across Ireland of the marine transgression with associated deepening. In the Dublin Basin the arrival of marine sedimentation did not take place until the late Tournaisian (*Pseudopolygnathus multistriatus* conodont Biozone and PC miospore Biozone; Jones *et al.* 1988; Sevastopulo & Wyse Jackson 2001). Diachroneity of lithological units can be recognised when traced from south to north across the basin (see Sevastopulo & Wyse Jackson 2001). In the northern part of the Dublin Basin, above the basal red-beds facies, the marine Tournaisian succession forming the North Midlands Province (Philcox 1984) has been divided into two groups, the Navan and Cruicetown groups (Strogon *et al.* 1990). The overall sequence records a change from the initial nearshore tidally influenced, mixed carbonate-siliciclastic environments, with evaporitic sabkha intertidal-supratidal mudflats in the northwest, passing laterally into a more open marine carbonate shelf with periodic siliciclastic input (Navan Group). This was followed by an overall deepening trend with formation of deeper shelf/ramp carbonate rocks (Cruicetown Group), culminating in deep-water distal ramp Waulsortian mud-mounds in the latest Tournaisian.

From the latest Tournaisian time and throughout the Visean and into the Namurian, the Dublin Basin showed a distinct division into deeper water basinal facies (Fingal and Knockbrack groups), flanked to the north and northeast by shallow water marine carbonate platform sediments with local siliciclastic input (Milverton Group) (Nolan 1989; Somerville *et al.* 1992a; Strogon *et al.* 1996; McConnell *et al.* 2001). Similar shallow-water marine platform facies occur on the Kildare Block on the south side of the Dublin Basin (McConnell & Philcox 1994; Somerville *et al.* 1996). Within the greater Dublin Basin smaller sub-basins have been recognised, e.g. Moynalty Basin south of the Ardagh Platform at Kingscourt, and the Ballinalee Basin south of the Longford-Down Massif in Co. Longford (McConnell *et al.* 2001; Morris *et al.* 2003).

The lithostratigraphy used here is based on a synthesis of existing published nomenclature. Although a few groups have been defined formally, the formation is the primary stratigraphic unit used by the Geological Survey of Ireland (GSI) in their recent compilation of 1:100,000-scale map series. The groups combine related formations in similar depositional settings (e.g. shelf, ramp and basin).

### Tournaisian

The lowermost Tournaisian strata comprise siliciclastic (red-bed) non-marine fluvial rocks. These include the Baronstown Formation (Fig. 21.2, Cols. 1, 2 & 7), comprising red conglomerate, sandstone, siltstone and pedogenic carbonate rocks, resting unconformably upon Lower Palaeozoic rocks (Rees 1992). In the Roosky Borehole (2664/1) the basal clastic succession resting unconformably on Lower Palaeozoic rocks is assigned to the Fearnagh Formation (Morris *et al.* 2003) and comprises sandstone, red mudstone, black shale and gypsum evaporate rocks (Philcox 1984; Morris *et al.* 2003; Fig. 21.2, Col. 9). In the nearby Rinn River borehole the PC/CM miospore Biozone boundary is located in mudstone from the middle of this formation <sup>1</sup> (Polgar 1980; Higgs *et al.* 1988; Sevastopulo & Wyse Jackson 2001). In the Donabate area of north Co. Dublin (Fig. 21.2, Col. 4), this facies comprises pebble conglomerate of the Donabate Formation (Jones *et al.* 1988; Nolan 1989).

In the southwestern part of the Dublin Basin in the Cloghan-Ferbane-Moate area (Fig. 21.2, Col. 6) the oldest marine Tournaisian rocks are represented by the Ferbane Mudstone and Cloghan Sandstone formations. Both formations are also present in the Kildare Inlier at Boston Hill farther to the east (Fig. 21.2, Col. 5). The formations are only developed in the southern part of the North Midlands Province (McConnell *et al.* 2001; Morris *et al.* 2003). The Ferbane Mudstone Formation (Philcox 1984; McConnell & Philcox 1994) is present in the Cloghan borehole (BR-1), where it rests conformably on the Old Red Sandstone (Philcox 1984). The formation is composed predominantly of dark grey to black, weakly calcareous mudstone, with thin intercalations of calcareous siltstone and sporadic sandstone and limestone. The Ferbane Mudstone Formation is correlated with the Ringmoyle Shale, Ballyvergin Shale formations and the lower part of the Ballymartin Formation of the Limerick Province to the southwest (Philcox 1984; Sevastopulo & Wyse-Jackson 2001- see Chapter 22). The Ferbane Mudstone Formation thickens to the east, and in the Donabate area of north Co. Dublin, the equivalent 'Lower Limestone Shale' is present (Jones *et al.* 1988; Nolan 1989; Fig. 21.2, Col. 4). The top of the formation is sharp and marked by the incoming of thick sandstone bodies of the overlying Cloghan Sandstone Formation (Philcox 1984; McConnell & Philcox 1994). The latter is heterolithic with interbedded calcareous siltstone, shale and thin beds of calcarenite, but composed mostly of flaser bedded, fine- to medium-grained calcareous sandstone with sporadic thin beds of shelly limestone. The formation thickens to the east in the Kildare Inlier, where miospores of PC Biozone age have been obtained (McConnell & Philcox, 1994; Fig. 21.2, Col. 5 <sup>1</sup>). The Cloghan Sandstone Formation can also be recognised in the Moate Inlier (Philcox 1984), and as far north as Moyvoughly (Poustie & Kucha 1986; Morris *et al.* 2003). It has a sharp top contact with limestone of the succeeding Meath Formation.

The Navan Group, 300-400 m thick, includes three marine formations. The Liscartan Formation at Navan comprises a lower Portanclough Member of laminated and burrowed siltstones, linsen-bedded mudstone, flaser-bedded sandstone, micrite and a silicified anhydrite bed, succeeded by an upper Bishopscourt Member of nodular argillaceous bioclastic limestone containing corals and brachiopods (Strogen *et al.* 1990; Ashton *et al.* 1986; McConnell *et al.* 2001; Fig. 21.2, Col. 7). The Portanclough Member contains miospores of PC Biozone age <sup>1</sup> (McNestry & Rees 1992). The Liscartan Formation extends north to Kingscourt (Strogen *et al.*, 1995; Fig. 21.2, Col. 1). The overlying Meath Formation at Navan (Fig. 21.2, Col. 7) is composed of bioclastic limestone, sandy limestone, ooidal limestone, siltstone, thin beds of shale and a basal micrite unit (Stackallan Member) (Andrew & Ashton 1985; Strogen *et al.* 1990). The last unit is thickest in the Moynalty Basin (Fig. 21.2, Col. 1), where it is close to the Kingscourt Fault (Strogen *et al.* 1995). The PC/CM miospore boundary occurs in the middle of the Stackallan Member in the Moate-Moyvoughly area, Co.

Westmeath (Higgs *et al.*, 1988; Sevastopulo & Wyse Jackson, 2001; Fig. 21.2, Col. 6 <sup>1</sup>). In the Boston Hill area (Fig. 21.2, Col. 5) the equivalent shallow water facies of the Meath Formation (skeletal grainstone, ooidal limestone and fenestral micrite) with minor intercalations of shale and sandstone are referred to the Feighcullen Formation (McConnell & Philcox 1994). In the North Midlands Province, the Moathill Formation (Strogen *et al.* 1990) comprises a mixed unit of burrowed calcareous siltstone, bioclastic limestone rich in bryozoans, sandstone and, near the top, thick unfossiliferous shale with silty bands (Philcox 1984; McConnell *et al.* 2001). The formation thins westwards into counties Westmeath and Longford and shows lateral facies changes. The lower member is dominated by a thick sandstone in the North Midlands area (Rockfield Sandstone Member of Strogen *et al.* 1995 in the Kingscourt Outlier; Fig. 21.2, Col. 1). At Ballinalack miospores of CM Biozone age are recorded above the Rockfield Sandstone Member (Higgs *et al.* 1988; Fig. 21.2, Col. 8 <sup>1</sup>). The *Pseudopolygnathus multistriatus*/*Polygnathus mehli* conodont biozone boundary occurs in the upper part of the Meath Formation at Walterstown (Pickard *et al.* 1992; Fig. 21.2, Col. 2 <sup>01</sup>) and in the Navan-Slane area (Sevastopulo & Wyse Jackson 2001; Fig. 21.2, Col. 7 <sup>02</sup>), but occurs above the Rockfield Sandstone Member in the Moyvoughly area (Sevastopulo & Wyse Jackson 2001; Fig. 21.2, Col. 6 <sup>02</sup>).

The Cruicetown Group includes the Ballysteen Formation, Feltrim Limestone Formation (= Waulsortian Limestone facies) and the overlying Argillaceous Limestones (Strogen *et al.* 1990; McConnell *et al.* 2001; Morris *et al.* 2003). The Cruicetown Group was defined for the North Dublin Basin (Moate, Navan, Ballinalack and Longford areas; Fig. 21.2, cols. 6-9) and Kingscourt (col. 1) where the underlying Moathill and Navan formations belonging to the Navan Group can be distinguished. The latter formations are not recognised in South Dublin Basin (i.e. Kildare and Malahide; cols. 4 and 5). The group is between 400-1000 m thick depending upon lateral variation in the thickness of Waulsortian mud-mound facies. The Ballysteen Formation comprises irregularly bedded, nodular argillaceous bioclastic limestone interbedded with fossiliferous calcareous shale and represents a widespread development of open-marine carbonate rocks throughout counties Meath, Westmeath, Longford and Offaly. The Ballysteen Formation is characteristic of the Limerick Province further to the southwest (see Chapter 22). Throughout the North Midlands Province, the Ballysteen Formation has been informally referred to as the Argillaceous Bioclastic Limestone (Philcox 1984), and the Slane Castle Formation of the Boyne area, Co. Meath (Strogen *et al.* 1990). The lower part of the formation is mud-dominated and rich in fenestellid bryozoans and has been defined as the Woodtown Member, from the Woodtown Borehole (91-3347-1) in Co. Meath (Strogen *et al.* 1996; Fleming 1999; Fig. 21.2, Col. 7). At Ballinalack CM Biozone miospores have been recorded near the base of this formation (Higgs *et al.* 1988; Fig. 21.2, Col. 8 <sup>2</sup>). *Tetrataxis* of Cf3 foraminifer Biozone has been recorded from the Woodtown Member in Woodtown Borehole and in the Athboy Borehole (Fig. 21.2, Col. 7 <sup>03</sup>) near the base of the formation (Strogen *et al.* 1990; 1996). The same taxon is recorded in the upper part of the formation in the Pallasboy Borehole (PB-2), north Co. Offaly (Gatley *et al.* 2005; Fig. 21.2, Col. 5 <sup>02</sup>).

In the Kildare Province, at Malahide on the east coast and in the Swords boreholes, north Co. Dublin, the equivalent unit to the Ballysteen Formation is named the Malahide Limestone Formation (Jones *et al.* 1988; Strogen *et al.* 1990, 1996; Sevastopulo & Wyse Jackson 2001; Fig. 21.2, Col. 4) and at Boston Hill, Co. Kildare, it is referred to as the Boston Hill Formation (McConnell & Philcox 1994; Fig. 21.2, Col. 5). Both formations are characterised by the presence of a lower cyclic member and an upper laminated, cross-bedded grainstone interval, passing up near the top into nodular fine grained bioclastic limestone with thin shale interbeds. There is clear indication of repeated shallowing events marginal to the Leinster

Massif, with minor influx of siliciclastic detritus from the massif (Strogen & Somerville 1984). However, this limestone-dominated interval lacks the thick sandstone units typical of the Moathill Formation in the North Midlands Province. There is a marked thickening of the Malahide Limestone Formation in the eastern part of the basin coinciding with the development of the East Midlands depocentre (Jones *et al.* 1988; Strogen *et al.* 1996). This rapid subsidence event occurred mainly within the *Polygnathus mehli* conodont Biozone<sup>01</sup> (Fig. 21.2, Col. 4). The upper part of this formation contains *Polygnathus bischoffi*<sup>02</sup> (Jones *et al.* 1988).

The succeeding Feltrim Limestone Formation is composed of massive, pale grey fine-grained limestone (Waulsortian mud-mound facies with stromatactid cavities), which has a sharp basal contact with the underlying Ballysteen Formation (Fig. 21.1, Col. 5). This is well exposed in the Boyne Valley, Co. Meath and in Huntstown Quarry, north Co. Dublin (Jones *et al.* 1988; Strogen *et al.* 1990; Somerville *et al.* 1992b). The Waulsortian facies extends throughout much of the Central Irish Midlands, and can locally be over 800 m thick (Sevastopulo 1982; Lees & Miller 1995; Hitzman 1995; Somerville 2003; Fig. 21.1, Col. 5). In general, the Waulsortian facies forms coalesced and stacked mudbanks with few interbedded shale and crinoidal limestone intervals, but in the northern Irish Midlands, more isolated mounds developed, surrounded by argillaceous bioclastic limestone of the Ballysteen Formation or succeeding Argillaceous Limestones, as at Ballinalack Co. Westmeath and in Co. Longford (Morris *et al.* 2003) (Fig. 21.2, Cols. 8 & 9). In the Kingscourt Outlier, the Feltrim Limestone Formation passes laterally into a unit of shallow-water crinoidal sandy grainstone of the Kilbride Formation (Strogen *et al.* 1995; Fig. 21.2, Col. 1). A latest Tournaisian age has been established for the Kilbride Formation, with the presence of *Mestognathus praebeckmanni* and *M. beckmanni*<sup>01</sup> (Johnston 1976; von Bitter *et al.* 1986). The base of the Waulsortian in the Dublin Basin lies substantially above the base of the *Scaliognathus anchoralis* conodont Biozone (Sevastopulo & Wyse Jackson 2001).

The uppermost Argillaceous Limestones (Morris *et al.* 2003) represents an informally defined unit, previously referred to as the 'Post-reef Argillaceous Bioclastic Limestone' (Philcox 1984), and at Ballinalack the 'Upper Argillaceous Bioclastic limestone' (Jones & Brand 1986; Fig. 21.2, Col. 8), and is equivalent to the upper part of the 'Slane Castle Formation' (Strogen *et al.* 1996; McConnell *et al.* 2001). Lithologically, the Argillaceous Limestones are closely comparable with the bioclastic limestone and shale of the Ballysteen Formation ('Lower Argillaceous Bioclastic Limestone' of Jones & Brand 1986). However, it includes thin green and pale grey tuff bands, which are virtually absent in the Ballysteen Formation, and has an abundance of cherty limestone beds.

On the northeastern margin of the Dublin Basin, the basal unit of the Milverton Group (see below), rests unconformably on folded Lower Palaeozoic rocks of the Balbriggan Block (Nolan, 1986, 1989; Somerville *et al.* 1992a; Pickard *et al.* 1994). The McGuinness Formation comprises thick-bedded feldspathic sandstone, dolomite and shale with thin beds of micrite, known only from the Lane Borehole (Nolan 1989). The CM/Pu miospore zonal boundary lies within the lower part of the formation (Higgs *et al.*, 1988; Sevastopulo & Wyse Jackson, 2001) indicating a latest Tournaisian age (Fig. 21.2, Col. 3<sup>^1</sup>).

### Visean

Visean rocks of shallow-water marine platform and siliciclastic non-marine facies are present to the north, and northeast of the Dublin Basin (Milverton Group) and on the Kildare Block on the south side of the Dublin Basin (McConnell & Philcox 1994; Somerville *et al.* 1996).

The Milverton Group is about 900 m thick and comprises in ascending order, the McGuinness (of late Tournaisian age- see above), Lane/Crufty, Smuggler's Cave, Holmpatrick, Mullaghfin and Deer Park formations. This succession contrasts with mostly deeper water basinal facies (Fingal Group) in the centre and eastern part of the Dublin Basin (Strogen *et al.* 1996). The Fingal Group is c. 1300-1500 m thick, extends from the east coast in north Co. Dublin westwards to the River Shannon and comprises the Tober Colleen, Rush, Lucan, Naul and Loughshinny formations (Nolan 1989; Strogen *et al.* 1990, 1996; Pickard *et al.* 1992; McConnell *et al.* 2001).

The Chadian age part of the Milverton Group succession is represented by the Lane and Smuggler's Cave formations. The Lane Formation (Fig. 21.2, Col. 3) comprises nodular, slightly argillaceous packstone and wackestone in the lower part passing up into thick-bedded skeletal limestone, and sandy ooidal limestone containing bands of quartz pebbles, with thin interbeds of shale (Nolan 1989). At the southern margin of the Balbriggan shelf, shallow-water buildups have been recorded at Curkeen Hill and Popeshall, containing the foraminifer *Eoparastaffella simplex* of Chadian (early Viséan) age <sup>02</sup> (Somerville *et al.* 1992a). The upper part of the formation contains solitary rugose corals of early Viséan age \*<sup>3</sup> (Somerville 1994). The overlying Smuggler's Cave Formation consists of an unfossiliferous non-marine unit of lithic sandstone and conglomerate. An unconformity is evident at the base of the Smuggler's Cave Formation, which rests on a slightly tilted, karstified surface at the top of the Lane Formation (Nolan 1986, 1989). The Crufty Formation is developed on the western margin (Kentstown Platform; Fig. 21.2, Col. 2) and northern margin (Drogheda Platform) of the Balbriggan Block, and is the lateral equivalent of the Lane Formation (Pickard *et al.* 1994; Strogen *et al.* 1996). The Crufty Formation comprises fine-grained peloidal ooidal packstone, grainstone, fenestral micrite, argillaceous wackestone and thin beds of shale. At Walterstown on the Kentstown Platform, buildups are recorded in boreholes (Pickard *et al.* 1992). An early Viséan (Cf4a2) Subzone foraminiferal assemblage has been recovered from the Crufty Formation including *Eoparastaffella simplex* <sup>02</sup> (Rees 1987; Pickard *et al.* 1992). The equivalent-aged unit on the Kildare Block (Edenderry and Kildare Shelves), in the southern part of the Dublin Basin, is the lower part of the Allenwood Formation (Fig. 21.2, Col. 5). This comprises pale grey massive shelf limestone (peloidal skeletal grainstone and ooidal limestone, commonly dolomitized). At Ballykane Hill (at the northern end of the Edenderry Shelf) and in Pallasboy Borehole (PB-2) (Birr Shelf), the Allenwood Formation rests directly on Waulsortian limestones (Fig. 21.2, Col. 5). Also in the PB-2 borehole the limestone of the Allenwood Formation contains interbedded tuff, derived from the nearby Croghan Hill volcanic centre in north Co. Offaly (McConnell & Philcox 1994; Gatley *et al.* 2005). Chadian (early Viséan) microfossils (*Eoparastaffella simplex*, *Eostaffella*, and *Pseudolituotubella*) first appear in PB-2 core at a depth of 267.5 m (Fig. 21.2, Col. 5 <sup>03</sup>).

The Allenwood Formation interfingers with basinal mudstone of the Tober Colleen Formation (Fingal Group) north of the Kildare Block (Somerville *et al.* 1996; McConnell *et al.* 2001). The Tober Colleen Formation (Nolan 1986; 1989) comprises mostly cleaved grey mudstone at Rush (Fig. 21.2, Col. 4), with nodular and graded beds of calcisiltite and micrite near the top. In boreholes, the bulk of the formation is characterised by monotonous, bioturbated, slightly calcareous mudstone, interbedded with thin fine-grained argillaceous limestone and spiculitic micrite, with diffuse lower and upper bed boundaries. Fauna is very sparse. The upper part of the formation is marked by the incoming of thin cleaner limestone beds (skeletal packstone and grainstone), which are weakly graded and laminated with sharper boundaries. In this upper part of the formation, an early Viséan foraminiferal/algal assemblage (Cf4a2 Subzone) has been identified (Strogen *et al.* 1996; Fleming 1999), as well

as early Visean ammonoids (Smyth 1951; Fig. 21.2, Col. 4<sup>O+3</sup>). At the northern margin of the Dublin Basin coarse-grained debris-flow sediments of the succeeding Rush Formation were deposited locally against the Balbriggan Block (Fig. 21.2, Col. 4). The formation comprises a varied suite of lithologies including polymict conglomerate, graded lithic sandstone, bioclastic limestone, with clasts of Ordovician volcanic rock and shale (Nolan 1986, 1989). Ooidal intraclastic grainstone of the overlying Carylan Limestone have now been included in the Lucan Formation (McConnell *et al.* 2001). Foraminifers recorded from this part of the Lucan Formation (Mamet 1969) indicate an early Visean (Chadian–early Arundian) age (Fig. 21.2, Col. 4<sup>O4</sup>). This formation thins rapidly to the south, away from the Balbriggan shelf, where it interfingers with the Lucan Formation (Nolan 1989; Somerville *et al.* 1992a).

The Lucan Formation (Nolan 1986, 1989) forms the bulk of the basinal rocks (Fingal Group) throughout the Dublin Basin, and is characterised by graded, intraclastic skeletal packstone/grainstone interbedded with shale, laminated calcisiltite and argillaceous micrite. Its base is defined by the first appearance of thick graded beds of limestone, and a marked decrease in the proportion of interbedded shale, compared with the underlying Tober Colleen Formation. Chert can be locally abundant as nodules and bands. Occasionally, thin beds of tuff have been recorded in boreholes in Co. Westmeath. The thickest recorded interval of the Lucan Formation is in the Athboy Borehole and in the Navan Mine area, Co. Meath (Strogen *et al.* 1990; Somerville *et al.* 1996; McConnell *et al.* 2001; Fig. 21.2, Col. 7). Rich and diverse foraminiferal assemblages have been recorded from this formation in the Athboy Borehole, ranging in age from late Chadian to Asbian age (Cf4α2<sup>O4</sup> to Cf6α<sup>O5</sup> subzones) (Strogen *et al.* 1990, 1996; Somerville *et al.* 1996; Morris *et al.* 2003).

The Arundian–lower Holkerian part of the Milverton Group is represented by the Holmpatrick Formation, which comprises thick-bedded to massive bioclastic intraclastic grainstone, occasionally ooidal near the base. It rests disconformably on the non-marine Smuggler's Cave Formation between Lane and Skerries (Fig. 21.2, Col. 3), but conformably succeeds the Crufty Formation on the western and northern margins of the Balbriggan Block (Nolan 1989; Rees 1987; Pickard *et al.* 1992, 1994; Fig. 21.2, Col. 2). The Holmpatrick Formation contains Arundian corals (*Clisiophyllum multiseptatum*, *Siphonodendron martini*, *Haplolasma subibicinum*) and foraminifers (*Uralodiscus settlensis*) of the Cf4 γ–δ subzones (Fig. 21.2, Col. 2<sup>\*O3</sup> & Col. 3<sup>\*O4</sup>). Within the laterally equivalent upper part of the Allenwood Formation, an Arundian fauna is first recorded in the PB-2 borehole at 167.8 m with *Uralodiscus*, *Paraarchaediscus* at *involutus* stage and *Koninckopora tenuiramosa* (Gatley *et al.* 2005; Fig. 21.2, Col. 5<sup>O4</sup>). A thick volcanic sequence (>100 m thick) is recorded in the basinal rocks of the Lucan Formation at Croghan Hill in north Co. Offaly within the Tullamore Trough (Sevastopulo & Wyse Jackson 2001; Gatley *et al.* 2005; Fig. 21.1; Fig. 21.2, Col. 6). It comprises vitric tuff, tuff-breccia and thin ankaramite and basalt lava flows mostly of Arundian age (Strogen *et al.* 1996; Gatley *et al.* 2005).

The upper Holkerian–Asbian strata of the Milverton Group are represented by the Mullaghfin Formation, which consists of varied limestones: graded packstone, argillaceous wackestone, crinoidal packstone and grainstone, thin beds of dark shale, mud-mound micrite and lithostrotionid biostromes (Rees 1987; Pickard *et al.* 1992, 1994). The formation is well exposed around Brownstown (Kentstown Platform; Fig. 21.2, Col. 2<sup>\*O4</sup>) and contains corals (*Siphonodendron pauciradiale*, *S. intermedium*, *S. scaleberense* and *Solenodendron furcatum*), conodonts (*Gnathodus girtyi*) and foraminifers (*Vissariotaxis compressa* and *Archaediscus* at *angulatus* stage) of mostly Asbian age (Pickard *et al.* 1992). The Naul Formation, of Asbian age, consists of mainly pale grey, laminated, graded, fine-grained

limestone with thin shale seams, developed on the northern margin of the Dublin Basin at Loughshinny, adjacent to the Balbriggan Block (Fig. 21.2, Col. 4), where to the south it succeeds and passes laterally into the Lucan Formation (Nolan 1989). In the upper part of the Lucan Formation (Fingal Group), a distinctive marine sandstone and shale interval (Athboy Sandstone Member) of Asbian age has been identified in the Athboy Borehole (Strogen *et al.* 1996; Fig. 21.2, Col. 7<sup>O5</sup>), and is also present in the Skreen Borehole immediately to the west of the Kentstown Platform (Pickard *et al.* 1992).

The youngest sedimentary rocks of the Milverton Group, the Deer Park Formation, are present only on the Ardagh Platform at Kingscourt (Strogen *et al.* 1995; Fig. 21.2, Col. 1). They comprise dark grey to black thin-bedded fine-grained cherty argillaceous limestone, very coarse-grained crinoidal grainstone and rudite, and pale grey thick-bedded packstone. The lower part of the formation contains the conodonts *Gnathodus bilineatus* and *Mestognathus bipluti* of early Brigantian age<sup>O2</sup>, but in the uppermost beds at Poulmore Scarp are recorded *Lochriea mononodosa*, *L. nodosa* and the alga *Calcifolium okense* indicating a late Brigantian age<sup>O3</sup> (Somerville 1999; Somerville & Somerville 1999; Cózar *et al.* 2005). The laterally equivalent basinal Loughshinny Formation (Nolan 1989) comprises thin-bedded laminated graded limestone interbedded with shale and a basal massive polymict breccia, locally dolomitized (Drumanagh Member), and well-exposed at Loughshinny (Fig. 21.2, Col. 4). Rich and diverse Brigantian foraminiferal assemblages (Cf6δ subzone) have been recorded from this formation in boreholes in the Kentstown area (Fig. 21.2, Col. 2<sup>O5</sup>), Loughshinny coastal sections (Fig. 21.2, Col. 4<sup>O5</sup>) and in the Kingscourt area (Fig. 21.2, Col. 1<sup>O3</sup>) (Nolan, 1986; Pickard *et al.*, 1992; Strogen *et al.*, 1995;). The basinal limestone and shale sequence of the Loughshinny Formation transgressed onto the platform areas at Kentstown and Ardagh (Pickard *et al.* 1992, 1994; Strogen *et al.* 1995; Fig. 21.2, Cols. 1 & 2). Locally, north of Loughshinny, at the Balbriggan shelf margin, the Loughshinny Formation rests unconformably on the lower Viséan Lane Formation (Somerville *et al.* 1992a; Pickard *et al.* 1994).

### Namurian

In the Dublin Basin, the Knockbrack Group (400-600 m) comprises the Donore Shale, Balrickard Sandstone and Walshestown Shale formations (Nolan 1989; McConnell *et al.* 2001). Further to the northwest in the Kingscourt Outlier a complete c. 600 m-thick Namurian succession is present at outcrop (Jackson 1965). This stratigraphic succession has recently been revised (McConnell *et al.* 2001).

Black shales of the Pendleian Donore Shale Formation in the Summerhill Outlier, NW Dublin (Fig. 21.2, Col. 4) have yielded the important ammonoid *Cravenoceras* (= *Emstites*) *leion* (E<sub>1a</sub>)<sup>+6</sup> (Nevill 1957). Similar strata with thin beds of limestone at the base and sandstone at the top, of late Brigantian-Pendleian age, are known from the Boyne Valley (Rees 1987). The succeeding Balrickard Sandstone Formation, south of the Balbriggan Massif and west of Loughshinny, is a deltaic sandstone (Smyth 1950; Nolan 1989). This in turn is overlain by the argillaceous Walshestown Shale Formation, containing the ammonoids *Eumorphoceras malhamense* (E<sub>1c</sub>) at the base<sup>+7</sup> and *Eumorphoceras bisulcatum* (E<sub>2a</sub>)<sup>+8</sup> and *Cravenoceratoides nitidus* (E<sub>2b</sub>) near the top<sup>+9</sup> (Smyth 1950; Ramsbottom *et al.* 1978; Sevastopulo & Wyse Jackson 2001).

In the Kingscourt outlier (Fig. 21.2, Col. 1), the base of the Namurian succession is marked by the presence of *Cravenoceras* (= *Emstites*) *leion* at the base of the Ardagh Shale Formation<sup>+4</sup>, which is conformable with the underlying late Brigantian Altmush Shale Member of the

Loughshinny Formation (Jackson 1955, 1965; Strogon *et al.*, 1995; Somerville & Somerville 1999). The upper part of the Ardagh Shale Formation includes Jackson's (1965) Ardagh Sandstone (McConnell *et al.* 2001). The overlying Carrickleck Formation includes the Arnsbergian Carrickleck Sandstone Member near the base, followed by the Carrickleck Shale. Jackson's (1965) Barley Hill Grit, of probable Chokierian–Alportian age, forms the top of the formation (McConnell *et al.* 2001). The Carrickleck Sandstone is cross-bedded, pebbly and locally includes thin coals, thinning rapidly northwards and rests directly on upper Brigantian limestone of the Deer Park Formation (Ardagh Platform) at Poulmore Scarp (Somerville & Somerville 1999). The ammonoid *Eumorphoceras bisulcatum* (E<sub>2a</sub>) is recorded in shales immediately below the Carrickleck Sandstone <sup>+5</sup> and *Cravenoceratoides nitidus* (E<sub>2b</sub>) at the base of the overlying Carrickleck Shale <sup>+6</sup> (Jackson 1965).

In the Kingscourt Outlier (Fig. 21.2, Col. 1) the Kinderscoutian Clontrain Formation includes Jackson's (1965) Rathe Sandstone (McConnell *et al.* 2001). It is composed mostly of shale and siltstone, and contains three prominent sandstones units. Shale in this formation above the Rathe Sandstone contains the ammonoid *Reticuloceras reticulatum* (R<sub>1c</sub>) <sup>+7</sup>. The succeeding Corratober Bridge Formation, of Marsdenian age, includes Jackson's (1965) Corratober Grit, Corratober Brick Shale and Corrybracken Sandstone. This formation contains cyclothemic sequences with marine shale at the base containing, in turn, the zonal goniatites *Bilinguites gracilis* (R<sub>2a</sub>) <sup>+8</sup>, *B. bilinguis* (R<sub>2b</sub>) <sup>+9</sup> and *B. superbilinguis* (R<sub>2c</sub>) <sup>+10</sup> (Jackson 1965). The overlying Cabra Formation, of Yeadonian age, includes in the lower part Jackson's (1965) Cabra Shale and the overlying fine-grained Cabra Sandstone, with a predominantly shaly interval forming the upper part of the formation. At the base of the Cabra Shale is recorded *Cancelloceras cancellatum* (G<sub>1a</sub>) <sup>+11</sup> and shale above the Cabra Sandstone contains *Cancelloceras cumbriense* (G<sub>1b</sub>) <sup>+12</sup> (Jackson 1965; Sevastopulo & Wyse Jackson 2001).

## Westphalian

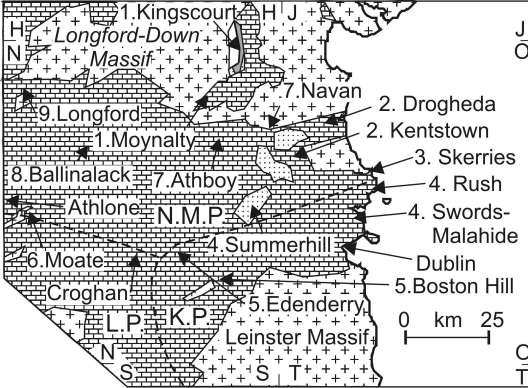
Unnamed Langsettian beds are known from boreholes in the Kingscourt Outlier (Jackson, 1965) and have been assigned to the non-marine bivalve *Lenisulcata* Chronozone <sup>~14</sup> (Fig. 21.2, Col. 1; Fig. 18.3). This succession consists mainly of micaceous shale, thin siltstone beds, laminated sandstone and rare thin coal seams. A marine band at the base contains the ammonoid *Gastrioceras subcrenatum* <sup>+13</sup> (Jackson 1965). A higher marine band containing brachiopods may correlate with the *Gastrioceras listeri* Marine Band of the Leinster coalfield succession (Sevastopulo & Wyse Jackson 2001; Fig. 18.3). The upper part of the sequence at Kingscourt is reddened close to the unconformable contact with the overlying Permian rocks. This reddening probably resulted from weathering prior to deposition of the Permian strata (McConnell *et al.* 2001).

Fig. 21.1 Geological map showing the distribution of Carboniferous strata from east Central Ireland (Dublin Basin), adapted from GSI (1972).

Fig. 21.2. Correlation of successions of Tournaisian and Visean age in the Dublin Basin region. Col. 1 from Strogon *et al.* (1995); Somerville (1999); Somerville & Somerville (1999); Col. 2 from Pickard *et al.* (1992); Somerville *et al.* (1992a); Col. 3 from Nolan (1986, 1989); Pickard *et al.* (1994); Col. 4 from Nolan (1986, 1989); Jones *et al.* (1988); Pickard *et al.* (1994); Col. 5 from Philcox (1984); McConnell & Philcox (1994); Col. 6 from Philcox (1984); Sevastopulo & Wyse Jackson (2001); Gatley *et al.* (2005); Col. 7 from Strogon *et al.* (1990, 1996); McNestry & Rees (1992); McConnell *et al.* (2001); Sevastopulo & Wyse



Jackson (2001); Col. 8 from Philcox (1984); Morris *et al.* (2003); Col. 9 from Philcox (1984); Sevastopulo & Wyse Jackson (2001); Morris *et al.* (2003).



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