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The Lithostratigraphy of the Tournaisian & Viséan of Ireland:Donegal Basin

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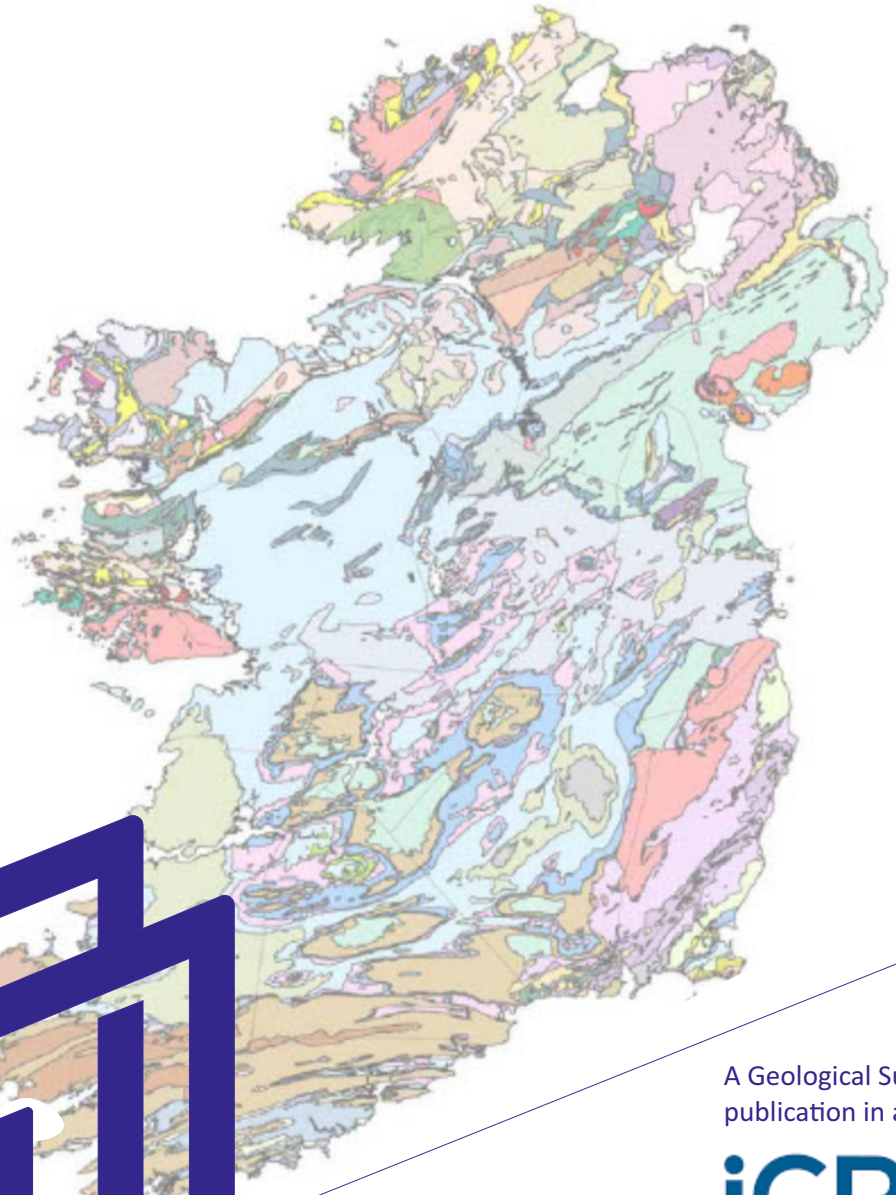
Editors: R Doyle, Dr M Pracht & Dr K Torremans



A Geological Survey Ireland
publication in association with:

iCRAG
SFI RESEARCH CENTRE
IN APPLIED GEOSCIENCES

Geological Survey Ireland is a division of the Department of the Environment, Climate and Communications

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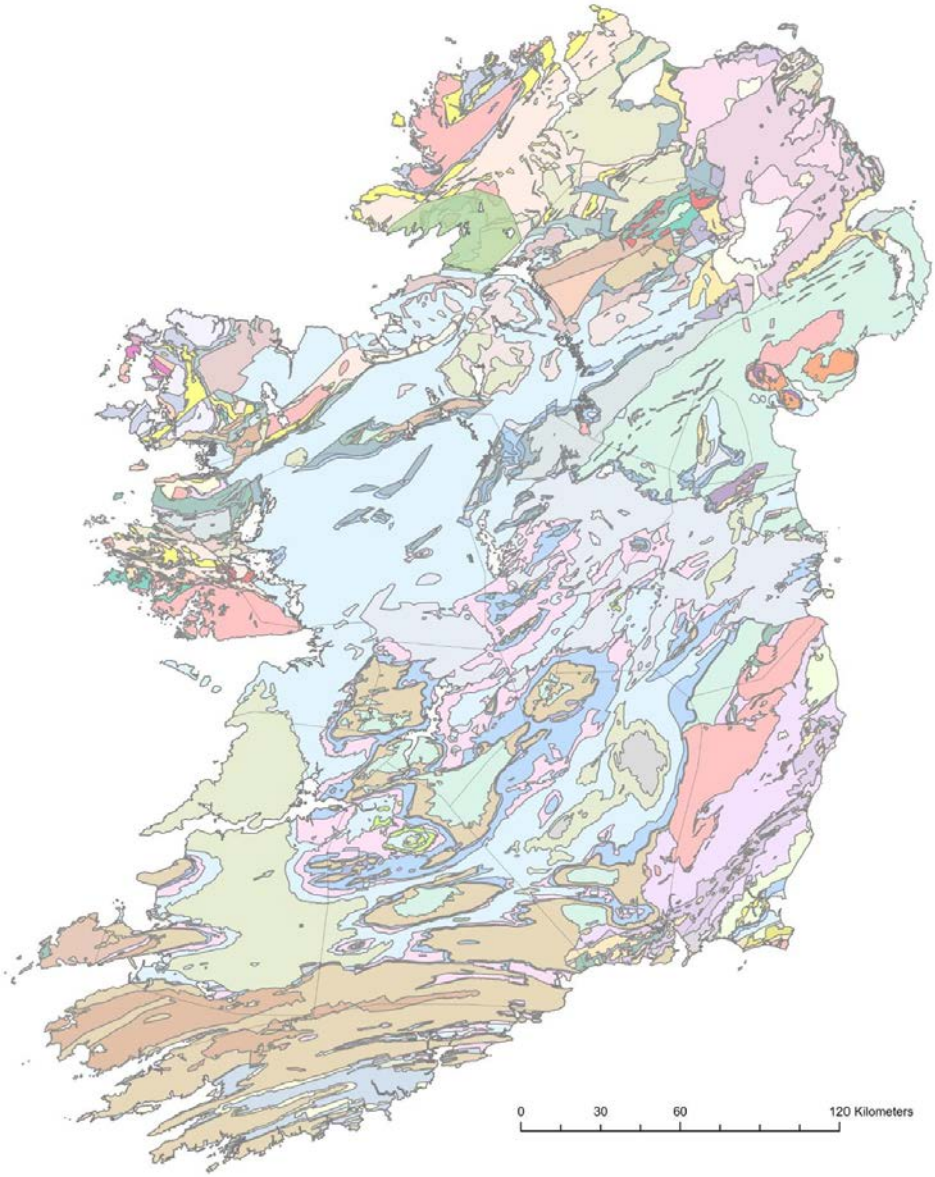

Table of Contents

Donegal Successions

Introduction

The Donegal Basin (Figure 1), much like the Kesh-Omagh and Newtownstewart areas lies at, or close to the northern margins of the Lower Carboniferous outcrop area in Ireland. The succession was first described by George and Oswald (1957). In subsequent work, the northern part of the Donegal Basin and minor adjacent areas is described in detail from outcrop mapping by Ní Bhroín (1999) and Graham et al. (2014) who subdivided the successions here (from west to east) into the Shalwy Succession, Northwestern Donegal Basin Succession and the Northeastern Donegal Basin Succession.

The succession in the southern part of the Donegal basin is well understood from an analysis of historical exploration drillholes drilled by Penarroya in the late 1960s and relogged and described by Philcox (1982).

Largymore - Shalwy Outlier Succession

The Shalwy Succession describes the rocks of the Largymore – Shalwy Outlier, comprising small Carboniferous outliers to the west of Killybegs (Figure 1). The basal unit of the succession is the Roelough Conglomerate Fm. (the Basal Conglomerate of George and Oswald), which rests unconformably on Dalradian metasediments, predominantly schists of the Termon Formation. The Roelough Conglomerate Fm. is composed of moderately-well sorted conglomerates dominated by psammites, quartzites and common small quartz clasts, with interbedded subordinate lenses of sandstones, siltstones and mudstones. The Formation reaches a thickness of approximately 30m. Although resting on schists, clasts of schist are almost completely absent. The formation has been interpreted as fluvial by Graham (1996).

The Roelough Conglomerate Fm. is succeeded by the Largysillagh Sandstone Fm., the base of this unit established by Graham et al. (2014) as the first >2m sandstone above which conglomerates become a subordinate element in the succession. The formation is sandstone-dominated but contains significant amounts of grey, red, green and variegated mudrock. The unit is interpreted as fluvial in origin (Graham, 1996) and is 66m in thickness at Shalwy (Figure 1).

The overlying Shalwy Fm. is marked by a sharp, but conformable basal contact, and is characterised by the presence of intense bioturbation in the mudstones and sandstones of the formation. The basal part of the formation is characterised by black mudstones with abundant plant debris and biomicrites with ostracods and gastropods. The formation is 63m thick at the type section at Shalwy and is interpreted as coastal to near-shore tidal channel and flats.

The Rinn Point Limestone Fm. overlies the Shalwy Fm. and is mainly composed of impure argillaceous limestones and shales, with thin to medium-bedded (0.3 – 1.0m) bioturbated argillaceous limestones interbedded with bioturbated calcareous shales of similar thickness. In the lower and upper parts of the formation, some beds of crinoidal limestone occur and

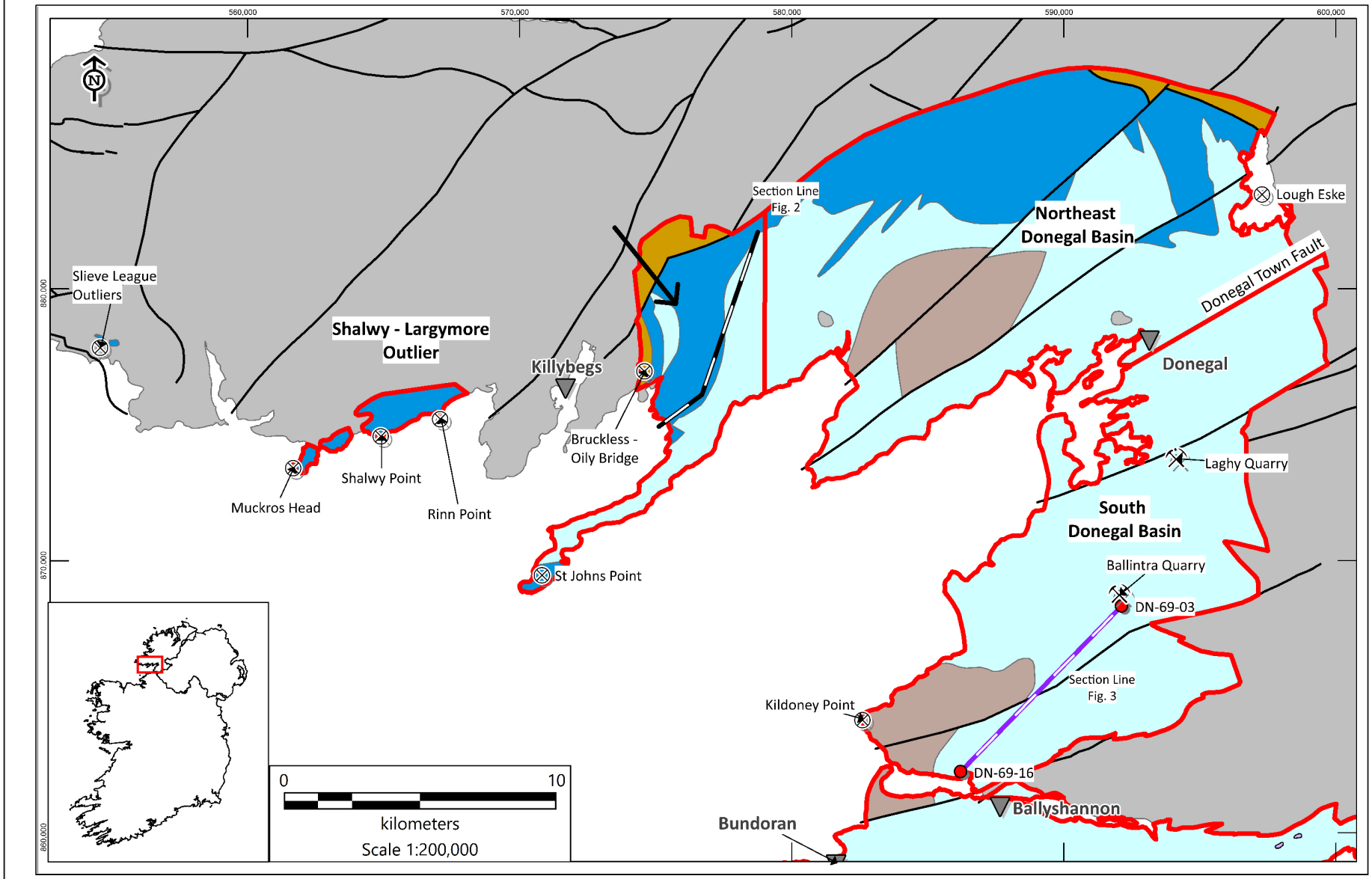

Figure 1: Geology map of the Donegal Basin with borehole and site locations

limestone / shale contacts are typically gradational rather than sharp. The fauna is a typical Carboniferous open-marine assemblage, macrofossils include brachiopods, bivalves, crinoids, corals, echinoderms and bryozoa and microfossils include algae, ostracods, foraminifera and calcispheres.

The youngest unit present in the Largymore Basin is the Muckros Head Sandstone Fm., best exposed in the west at the type section at Muckros Head (Figure 1) and also forming a limited exposure area in the centre of the syncline. The basal contact is marked by the first calcareous sandstone overlying the limestones and mudstones of the Rinn Point Fm., the transition between the two formations being gradational with a steady increase in clastic contact in the uppermost part of the Rinn Point Fm.

The lower part of the Muckros Head Sandstone Fm. is composed of coarse-grained to pebbly calcareous sandstones, non-calcareous sandstones and oolitic sandy limestones and micrites with subordinate mudstones. The beds are frequently bioturbated and a marine fauna is almost universally present through the succession. Graham et al. (2014) estimate a minimum thickness of 25m and George and Oswald (1957) estimated a thickness of 40m.

Main Donegal Basin

The northern part of the main Donegal Basin shows significant lateral variations between the western and eastern parts of the succession (see Figure 2) below the Bundoran Shale Fm., described in detail by Graham et al. (2014). The variation between the northern part of the basin and the southern part of the basin is outlined by a comparison between the successions outlined by Graham et al. and Philcox (1982).

Northwest Donegal Basin Succession

The West Donegal succession shows similarities to the Largymore Basin – Shalwy Succession. The basal unit is termed the Oily River Conglomerate Fm., resting on Dalradian metasediments and composed of conglomerates, sandstones and mudstones. The Oily River Fm. differs significantly, however, from the Roelough Conglomerate as it is distinctively red coloured throughout, the coarse clasts include significant amounts of schist, in addition to psammites, quartzites and vein quartz, cross-stratification is common and is much less well-sorted. Graham et al. (2014) estimate the thickness to be up to 150m, although it may be significantly lower.

The Oily River Conglomerate is overlain in this area by the Largysillagh Sandstone Fm., lithologically similar to the formation in the Largymore – Shalwy area, but much thicker, estimated at 220 – 280m in the Bruckless area (Figure 1).

The overlying Shalwy Fm. is again largely similar to the lithologies in the Largymore – Shalwy area, but with two recognisable differences in the main Donegal Basin. Firstly, the basal beds contain a distinctive bed (termed the *Syringopora* Bed) composed of a calcareous pebbly lag of angular quartz and quartzite clasts and shell debris overlying an erosion surface. This pebbly

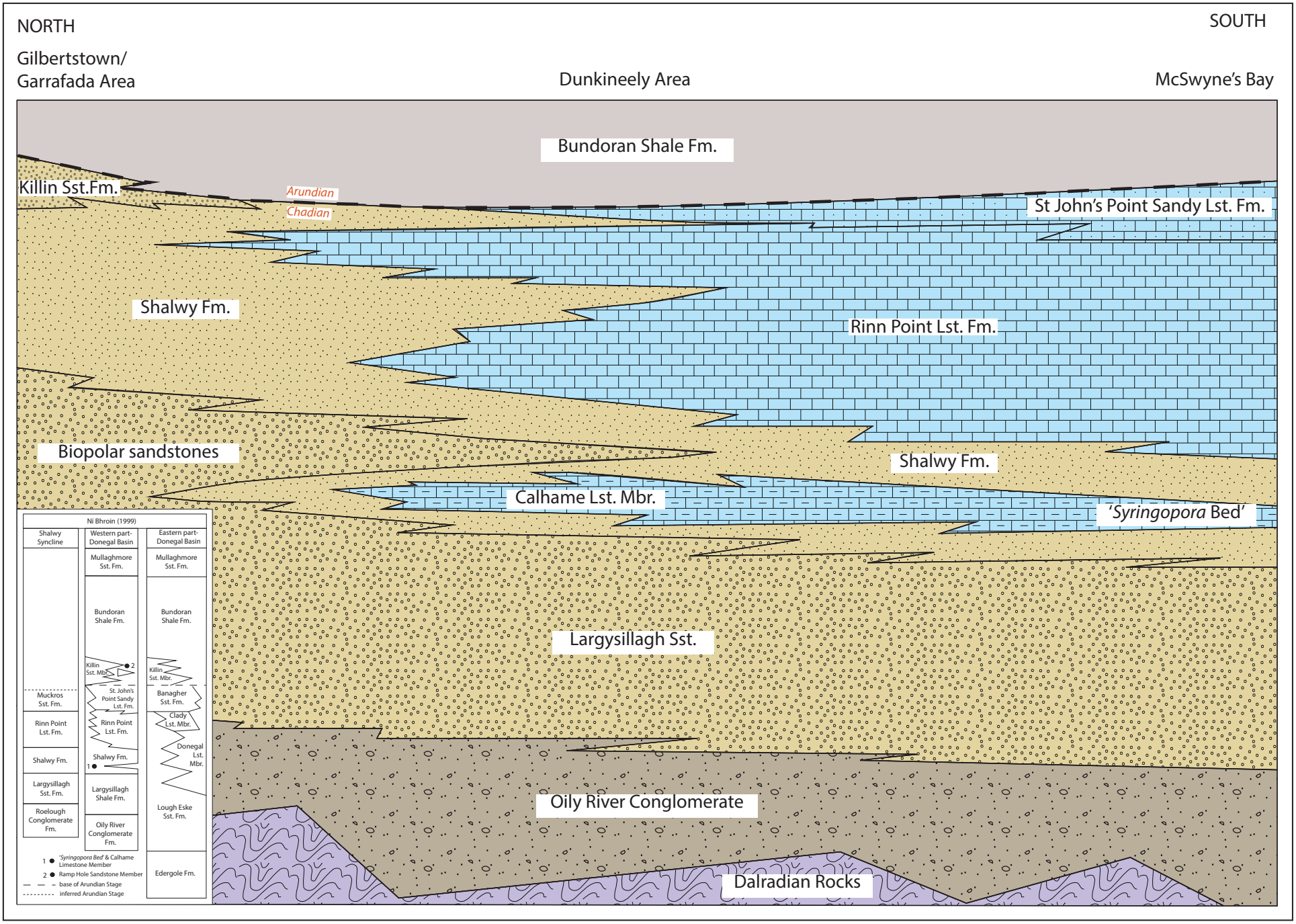

Figure 2. Schematic depiction of lateral variation in stratigraphy and facies, western limb, main Donegal Syncline. Approximately 600m of succession is represented at McSwyne's Bay.
(Modified from Graham et al. 2014)

unit is overlain by a calcareous sandstone, bioturbated in its upper part. There are numerous *Syringopora* corals, crinoids and gastropod debris within this bed and abundant *Syringopora* in the overlying bed as well. In addition to the above, a distinctive carbonate unit, termed the Calhame Limestone Member, has been identified north of Bruckless. This consists of approximately 30m of micaceous, silty limestone and calcareous siltstone. The Calhame Limestone Member is considered a lateral equivalent of the *Syringopora* Bed.

The Shalwy Formation is here also overlain by lithologies that can be assigned to the Rinn Point Limestone Fm., with only minor differences from the succession to the west, mainly the presence of beds dominated by *Delepinea carinata* and crinoidal grainstone beds. Due to the presence of numerous faults and limited exposure, an accurate thickness is difficult to determine but it is estimated at 130 – 180m, thicker than the succession at Largymore to the west.

Overlying the Rinn Point Limestone in the St. Johns Point area is a succession of limestones, sandy limestones and sandstones, termed the St. John's Point Sandy Limestone Fm. and sub-divided by Graham et al (2014). into three members, the Rabley Limestone Member, the Gullhuch Sandy Limestone Member and the Cavan Sandstone Member. The St. John's Point Sandy Limestone Fm. is considered to be a deeper marine lateral equivalent of the Muckros Head Sandstone Fm. to the west.

The Rabley Limestone Member comprises some 60m of thin "rubbly" beds of argillaceous limestone to sandy limestone separated by units of argillaceous limestones. This was previously assigned to the Rinn Point Limestone Fm. by George and Oswald (1957) but has been assigned as the lowermost unit of the St. John's Point Sandy Limestone Fm. by Graham et al. This member is succeeded by the Gullhuch Sandy Limestone Member, the basal contact is not exposed. As with the Muckros Head Sandstone Fm., this formation is directly overlain by the Bundoran Shale Formation.

Northeast Donegal Basin Succession

The basal unit in the northeastern part of the Donegal Basin is the Edergole Formation, only exposed to the north of Lough Eske (Figure 1). It is composed of some 275 – 400m of red sheet and channel conglomerates with interbedded wedges of sandstones, cross-bedded/lenticular sandstones, siltstones and minor conglomerates, grey lake fill rippled and lenticular sandstones and siltstones and flat-bedded valley-fill red sandstones and siltstones. The formation has been confirmed as Carboniferous (Tournaisian) by Graham and Clayton (1994).

The Lough Eske Sandstone Fm. outcrops along the northern edge of the eastern Donegal Basin northwest of Lough Eske and unconformably overlies the Edergole Formation. It is primarily composed of non-calcareous sandstones with minor calcareous sandstones (more common in the upper part of the formation), conglomerates and mudstones.

North of the Donegal Town Fault, two carbonate units have been mapped that are considered northward equivalents of the Ballyshannon Limestone *sensu stricto* south of the fault. The lower carbonate-dominated unit, the Donegal Limestone Mbr., is composed of bioturbated bioclastic argillaceous limestones, calcareous sandstones, sandy limestones and silty calcareous shales. The dominant bioclastic material is composed of crinoid debris and specimens of *Syringopora*. The member passes laterally into the Lough Eske Sandstone Fm. west of Lough Eske.

Also, west of Lough Eske, a relatively clean fossiliferous limestone is present above the Donegal Limestone Member, termed the Clady Limestone Mbr. and distinguished from the underlying Donegal Limestone by a marked decrease in argillaceous content.

The base of the Banagher Sandstone Fm. is marked by a change in sedimentation to light-grey, mainly coarse-grained arkosic sandstones and pebbly conglomerates. The conglomerate clasts are composed of quartzite, psammite and vein quartz, up to 40cm in size, in a sandy matrix or interbedded with rarer sandstones, frequently cross-bedded. Sedimentary evidence indicates a northern source for the clastic material and the formation fines overall to the south and west. Outcrop northwest of Donegal Town indicates an interdigitation of the Banagher Sandstone with the Ballyshannon Limestone in that area.

South Donegal Basin Succession

The south Donegal Basin succession is based on Philcox (1982) who established an informal succession below the thick-bedded, pale bioclastic grainstones and packstones of the Ballyshannon Limestone Fm. *sensu stricto* (see Figure 3).

The lowermost unit of Philcox (1982) is termed the “Basal Sandy Beds”, unconformably overlying Neoproterozoic psammitic paragneisses attributed by GSI to the Slishwood Division. These “Basal Sandy Beds” as intersected in Pennarroya boreholes DN-69-03, -06 and -16 are composed of 10 – 30m of medium to coarse-grained non-calcareous sandstones in the lower part of the unit, with a more mixed upper part composed of sandstones, sandy shales and subordinate argillaceous micrites.

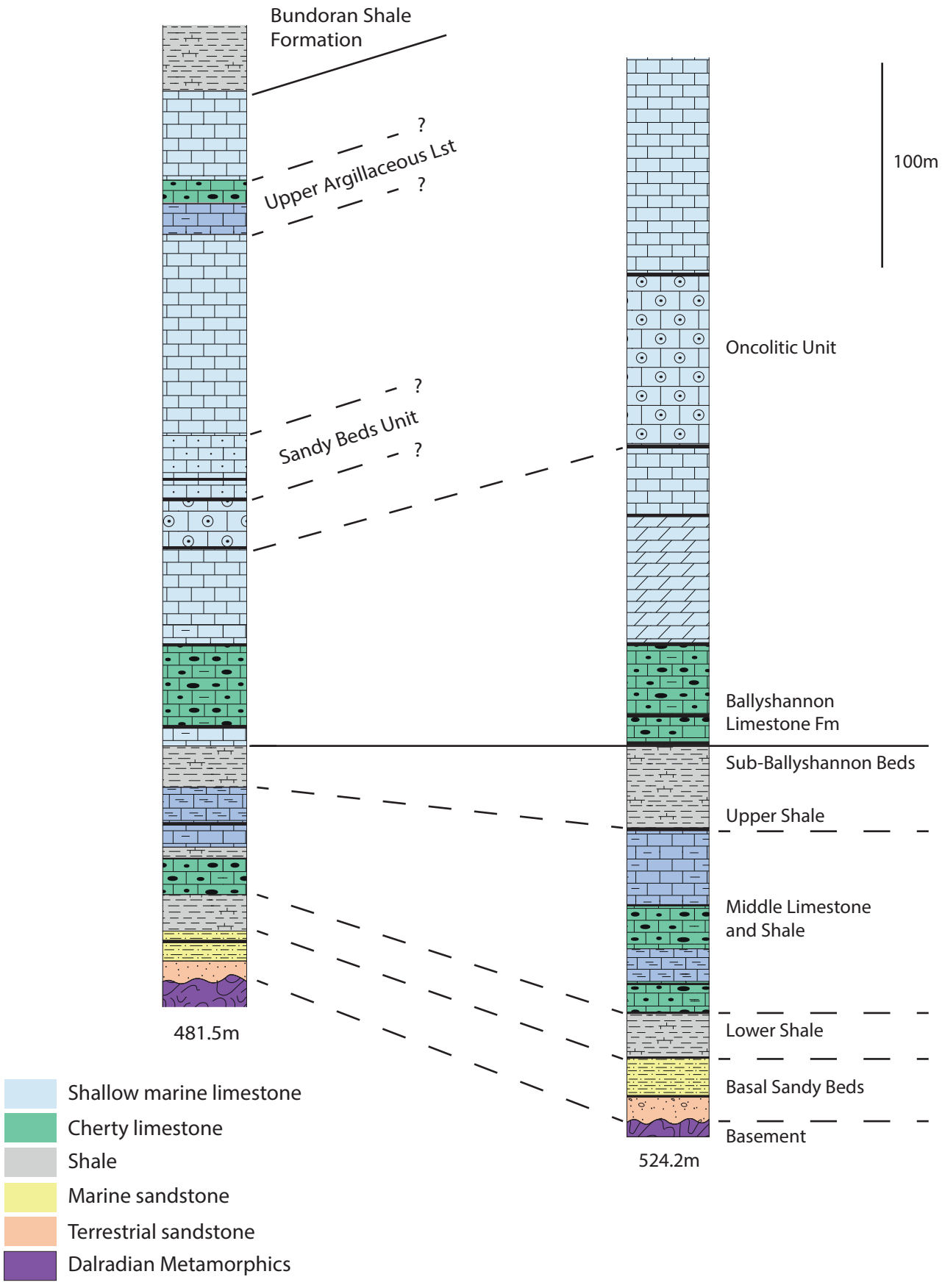

Figure 3. Correlation of Pennarroya Boreholes DN-69-03 and DN-69-16 South Donegal. (Based on Philcox 1983)

The “Basal Sandy Beds” are sharply overlain by the “Lower Shale”, comprising some 10 to 40m of non-calcareous or weakly calcareous poorly fossiliferous shales and rare beds of argillaceous micrite. The base of the unit is sharp, with mudstone/shale directly overlying a sandstone and the upper contact is also sharp, placed at the top of the thick shale-dominated succession. The shales vary gradationally from black, non-calcareous, unfossiliferous and pyritic, through calcareous shales to highly argillaceous micrites with gradational contacts.

Philcox (1982) divided the succession between the top of the “Lower Shale” and the Ballyshannon Limestone Fm. into a “Middle Limestone and Shale”, overlain by the “Upper Shale”, which were amalgamated by GSI (Long and McConnell 1999) into the informal “Argillaceous Limestones and Calcareous Shales Facies”, considered by them to be a lower sub-unit of the Ballyshannon Limestone Fm., although only the overlying pale limestones fully match the formal description of the Ballyshannon Limestone.

The “Middle Limestone and Shale” consists of pale to mid-grey non-argillaceous bioclastic limestones similar to the Ballyshannon Limestone, but interbedded with argillaceous limestones and shales. In the Pennarroya boreholes, this unit is some 30 to 60m in thickness. The “Upper Shale“ of Philcox (1982) is some 35 to 50m in thickness, it has a sharp basal contact with thick shales overlying a distinctive non-argillaceous grainstone/packstone which can be correlated across the Pennarroya boreholes. The upper contact is somewhat gradational from shales with subordinate limestone beds being succeeded by a unit of limestones with interbedded shales which is then overlain by thick-bedded cherty limestones. The “Upper Shale” is largely composed of calcareous, crinoidal shales and mudstones or argillaceous crinoidal limestones, it is highly laterally variable.

The argillaceous succession above the “Basal Sandy Beds” is overlain by a generally non-argillaceous succession of variable limestones assigned to the Ballyshannon Limestone Fmn. The type section for the Ballyshannon limestone is defined in Pennarroya borehole DN-69-16, collared some 1.5km northwest of Ballyshannon. Here a full succession of the Ballyshannon Limestone has been intersected, the formation here is 331m thick (Philcox 1982).

The main lithology of the Ballyshannon Limestone is a medium to light-grey, thick to massive-bedded crinoidal grainstone/packstone which can be sub-divided based on several distinctive interbedded horizons. The lowermost unit is the Cherty Basal Unit, which is approximately 50m in thickness, composed of dark, fine-grained calcarenites with cherts and thin silty, bioturbated shales, locally unbioturbated and laminated. The bioturbation and presence of shales is highest in the basal part of the unit.

The Ballyshannon Limestone above the Basal Cherty Unit is sub-divided by the presence of three interbedded units, the Oncolitic Unit, the Sandy Beds Unit and the Upper Argillaceous Limestone. These units are laterally variable in composition and thickness but provide some sub-division of the formation.

The Oncolitic Unit is lowest of these and consists of a similar lithology to the typical Ballyshannon, but also contains widely scattered oncolites, peloids or micrite “lumps”. In DN-

69-03 it is nearly 100m in thickness, but only 25m of oncolitic limestones were recognised in DN-69-16. In DN-69-04, a similar 75m thick fine-grained calcarenite is present but with only very rare oncolites. The unit was not recognised in DN-69-02 or -06.

Above the Oncolitic Unit, a number of sandy calcarenites up to 2m thick, have been recorded, these are correlatable across many of the Pennarroya boreholes. The final unit which varies from the typical lithologies of the formation is an interval of thinly- nodular bedded (up to 0.2m), slightly argillaceous calcarenite with interbedded argillaceous crinoidal limestones, solitary corals (Caniniids) are common. In the type section (DN-69-16), this unit is 15m in thickness, increasing to 42m in DN-69-06.

Donegal Basin - Bundoran Shale and Younger Formations

Overlying the highly laterally variable units in the lower Donegal Basin succession are a more uniformly distributed succession of units. The Bundoran Shale Fm. is the lowermost of these, overlying most of the identified units in the Donegal Basin. The base of the formation is taken at the point where calcareous shales become dominant in the succession. It is primarily composed of thick-bedded calcareous bioclastic shales with subordinate calcareous siltstones and thin limestones. The formation appears to become more fossiliferous to the south. On the western limb of the northern part of the basin it overlies the Cavan Sandstone member of the St. John's Point Sandy Limestone Fm., while in the east it overlies the Banagher Sandstone Fm., where the contact is gradational. The thickness of the formation is estimated at approximately 200m.

A thick development of sandstone, laterally equivalent to the lower part of the Bundoran Shale is termed the Killin Sandstone Fm. by Graham et al. (2014). This is composed sandstones and conglomerates that are seen to interfinger laterally with shales typical of the Bundoran Shale.

The Bundoran Shale Fm. is overlain by the Mullaghmore Sandstone Fm. which is the youngest unit preserved in the Donegal Basin. The contact with the underlying Bundoran Shale is gradational, the succession passing upwards into pale, coarse-grained arkose sandstones with common bioturbation and plant debris. Some beds with a sparse fauna suggest some deposition in a marine environment. Within the Donegal Basin (north of the Erne at Ballyshannon), the Mullaghmore Sandstone Formation is preserved in exposures in the core of the northern Donegal Basin syncline and in the Kildoney Point area, the upper contact is not preserved.

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