

Palaeogeographical and environmental reconstruction, Carboniferous, Northern Ireland

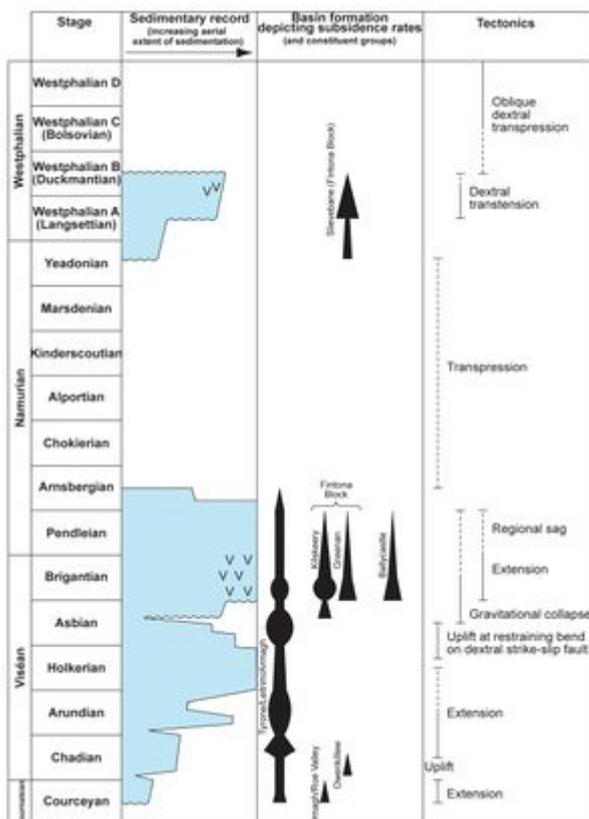
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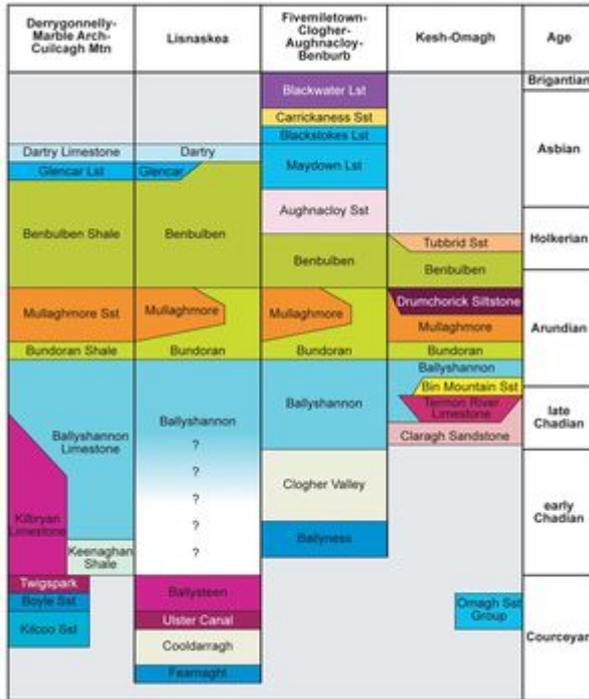
W I Mitchell

Introduction

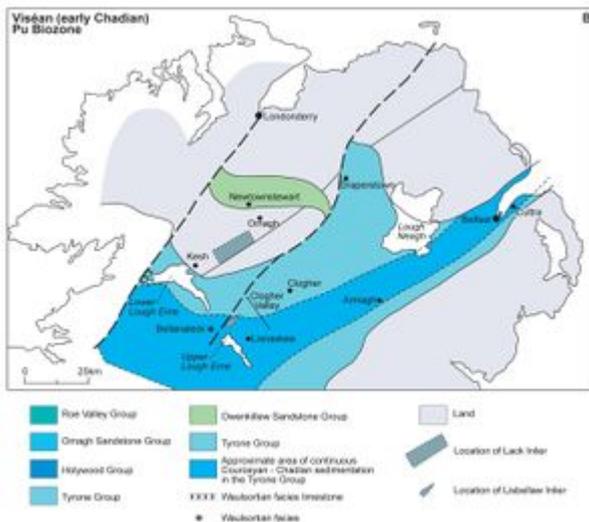


Summary of the principal events in the Carboniferous history of Northern Ireland. V - contemporaneous volcanism (P947824)

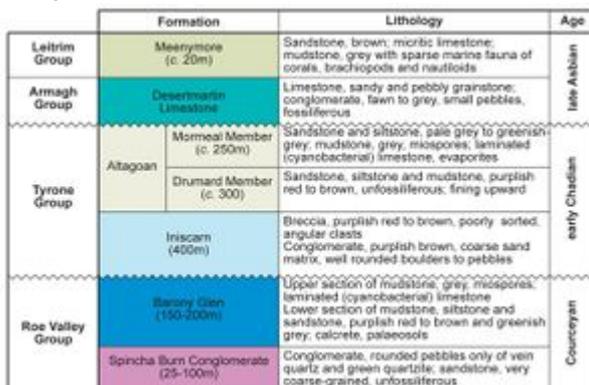
Palaeogeography of Northern Ireland in the late Courceyan. (P947826)



Lithostratigraphy of the Tyrone Group in the four regions of Co. Fermanagh-south Co. Tyrone. (P947933)



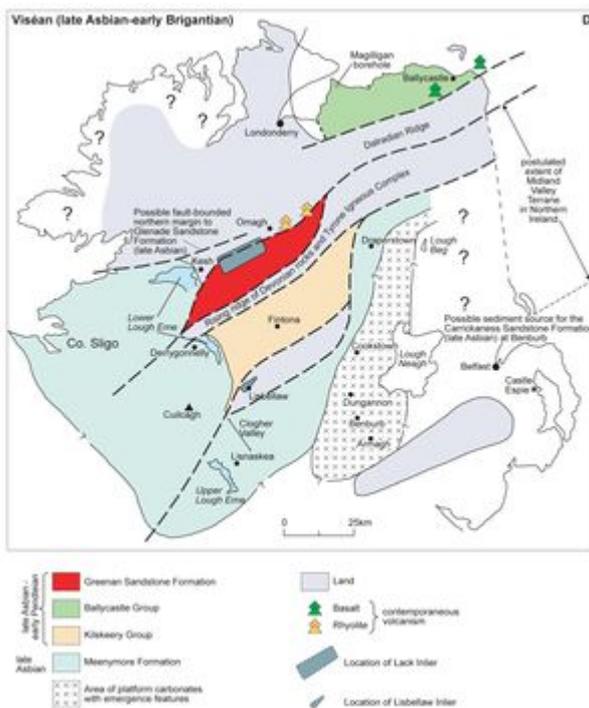
Palaeogeography of Northern Ireland in the early Chadian. (P947827)



Lithostratigraphy of the Carboniferous rocks in Co. Londonderry. (P947930)

Formation	Lithology
Dartry Limestone (130-280m)	Limestone, dark grey, spicular, bluish black chert, fine-grained, fossiliferous; thin mudstone
Glencar Limestone (18-170m)	Limestone and mudstone in equal proportions; black chert nodules
Benbulbin Shale (90-365m)	Mudstone, grey, calcareous, fossiliferous; thin lenticular limestone and sandstone
Mullaghmore Sandstone (200m)	Sandstone, pale grey, orange-weathering, calcareous, fine- to medium-grained, subarkose; thin siltstone and mudstone
Bundoran Shale (60-555m)	Mudstone, dark grey, calcareous; siltstone, thin limestone; fossiliferous; basal sandstone
Dowra Sandstone Member (0-53m)	Pebble conglomerate, sandstone, mudstone, micritic 'limestone'
Ballyshannon Limestone (200-345m)	Limestone, lower and upper members are dark grey packstone and thin mudstone; middle member is pale fawn grainstone; fossiliferous
Magherameena Limestone Member (0-15m)	Waulsortian limestone
Keenaghan Shale (20m)	Mudstone, black, silty, rare miospores; thin sandstone; stromatolitic and micritic limestone

Lithostratigraphy of the Tyrone Group in the Derrygonnelly - Marble Arch - Cuilcagh Mountain area. (P947934)



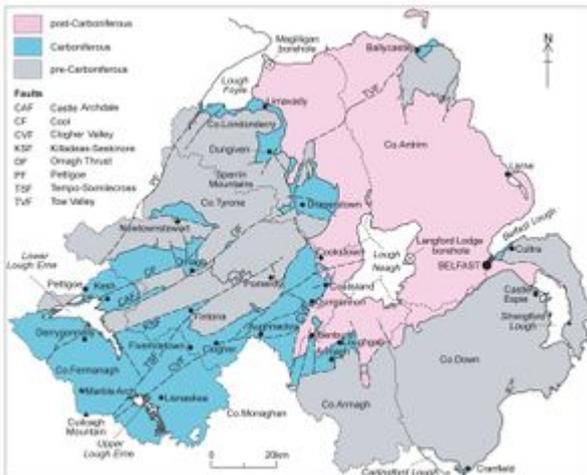
Palaeogeography of Northern Ireland in the late Asbian-early Brigantian. (P947829)

Formation	Lithology	Palynology	Zone	Stage
Ballinacallad Mudstone (1000m)	Mudstone and siltstone, greyish red, rarely greyish green, microspores. Corkill Sandstone, Errington and Coa Sandstone members consist mainly of sandstone	<i>Reticulatisporites carnosus</i>	NC	Penobscian
Ballymogh Conglomerate (350m)	Conglomerate, pebbly sandstone, sandstone, thin siltstone and mudstone; purplish brown to grey, fining upward; unfossiliferous; pebbles mainly of greywacke		VF	Brigantian
Topped Mountain Sandstone (1000m)	Sandstone, grey, weathering reddish brown, fine- to coarse-grained; mudstone, greyish red, purple and green with calcareous nodules and mud-flake conglomerates. Glen Mbr (20m) is unfossiliferous grey, calcareous siltstone, mudstone and thin sandstone. Coolcran Conglomerate Mbr (40m) is sandstone, pebbly sandstone and conglomerate with lamina of green mudstone with microspores	<i>Savatisporites nux</i> <i>Tripartites vetustus</i> <i>Knoxisporites stephanephorus</i> <i>Schulzospora</i> sp. cf. <i>elongata</i> <i>Vallatisporites ocellis</i>	NM	Asbian

Litho-, bio- and chronostratigraphy of the Kilskeery Group of the Fintona Block. (P947931)

Formation	Lithology	Age
Lackagh Sandstone (36m)	Sandstone, pebbly, coarse-grained, fawn to white	Ardsbergian (pars)
Coislaun Shale (55m)	Mudstone, calcareous, dark grey, fossiliferous	
Brisloonagh Sandstone (52m)	Sandstone, beds coarsening and thickening upwards; siltstone and mudstone	Penobscian
Dergvone Shale (130m)	Mudstone, dark grey to bluish black, fissile, ferruginous, siderite nodules, calcareous mudstone with ammonoids, sandstone in thin beds and dykes	
Carraun Shale (55m)	Mudstone, dark bluish grey, fossiliferous in lower half, five thin limestone members; sandstone dykes, bentonites, carbonate bullions	Brigantian
Bellavally (40m)	Cyclical sediments of mudstone, subordinate siltstone, sandstone and stromatolitic and fossiliferous marine limestone	
Glenade Sandstone (75-300m)	Sandstone, pebbly, fawn to white; thin siltstone	Asbian (pars)
Meenymore (100-240m)	Non-cyclical mudstone, siltstone, sandstone and limestone	

Lithostratigraphy of the Leitrim Group on Cuilcagh Mountain. (P947935)



Geological map of Northern Ireland showing the Carboniferous outcrop. (P947815)

Formation	Lithology	Palynology	Zone	Stage
Drumlish Conglomerate (c. 1000m)	Conglomerate, greyish purple, volcanoclastic clasts up to 0.5m of trachybasalt and trachyandesite, minor metamorphic content, sandstone, very coarse- to fine-grained, upward fining; mudstone, green, microspores	<i>Crassispora kosankai</i> <i>Laevigatisporites medius</i>	NJ	Westphalian B (Duckmantonian)
Drumgivery Limestone Mbr, 0.3-0.5m of pink calccrete				RA
Tullenagire Mudstone (c. 80m)	Mudstone, siltstone, sandy calcareous, mottled purplish brown and greenish grey, calcareous, calccrete nodules	<i>Endosporites globiformis</i> <i>Micronebulatisporites novilis</i> <i>Vestispora pseudoreticulata</i> <i>Doctyrietes breviculatus</i> <i>Schulzospora rara</i> <i>Laevigatisporites desmoinensis</i>		

Litho-, bio- and chronostratigraphy of the Slievebane Group of the Fintona Block. (P947932)

There is abundant evidence in the outcrop in Co. Fermanagh, south Co. Tyrone and Co. Armagh with which to reconstruct the palaeogeographical evolution of Northern Ireland during the early Carboniferous. This is not the case however, in the eastern part of Northern Ireland where isolated outliers hint at other events but provide little evidence. The recognition of Carboniferous rocks in the Fintona Block helped resolve aspects of the geological evolution of Northern Ireland ^[1]. It particularly revealed the importance of strike-slip faulting in the dismembering of the three non-marine basins (P947824). Deformation styles in the Carboniferous tectonic collage between the Castle Archdale Fault-Omagh Thrust Fault zone and the Clogher Valley Fault resulted from serial strike-slip overprinted by end-Variscan transpression and southeasterly-directed thrusting.

The detailed synthesis presented here of early Carboniferous transgression and regression is based on the Tyrone Group (Courceyan to late Asbian) succession in Co. Fermanagh-south Co. Tyrone (P947927) and in the Kesh-Omagh area (P947825).

Late Courceyan (CM Biozone)

The most extensive deposits in Northern Ireland associated with the late Courceyan (CM Biozone) transgression occupy a 25 km wide and more than 125 km long, northeast-southwest trending trough at the northern edge of the Southern Uplands-Down-Longford Terrane (P947826). They occur in the Holywood Group on Belfast Lough and as continental, peritidal and shallow marine sediments of the Tyrone Group in Co. Armagh (P947927) and at Lisnaskea (P947933). In the succession the early continental sediments which developed at fault scarps were buried by later peritidal sediments deposited during the earliest northwards transgression ^[2]. That transgression ultimately failed due to tectonic uplift but is recorded in the Omagh Sandstone Group in the Kesh-Omagh area. North of the Sperrin Mountains, the Roe Valley Group was deposited initially by rivers and as soil profiles in a late Courceyan inter-montane basin with marine sediments at the top. Courceyan sediments are absent north of the present position of the Clogher Valley.

Chadian (Pu Biozone)

Chadian time in Northern Ireland was a period when the marine transgression spread northwards and southeastwards from the early-formed trough (P947827). Tyrone Group sequences that contain evidence of the Courceyan-early Chadian boundary (CM to Pu biozones) occur in Co. Armagh and at Lisnaskea. In the Clogher Valley, both the continental Ballyness Formation and peritidal and shallow marine Clogher Valley Formation (P947933) are early Chadian. Contemporaneous rocks at Draperstown in Co. Londonderry (Altagoan Formation) were also deposited by this transgression (P947930). There, however, localised uplift halted the early Chadian transgression and the break in sedimentation extends into the late Asbian. Minor regression and deposition of the continental late Chadian Milford Mills Formation demonstrates the pulsed nature of the transgression in Co. Armagh (P947819).

There is no record of early Chadian deposits in the Kesh-Omagh area (P947825). The Claragh Sandstone Formation was largely deposited in a non-marine environment. Succeeding sediments deposited during the ensuing late Chadian transgression, the Bin Mountain Sandstone and Termon River Limestone formations, gradually submerged the wedge of clastic sediments of the Claragh Sandstone Formation. As the transgression progressed northwards and the sea deepened southwards, shallow marine sand and gravel gave way to peritidal carbonates of the Termon River Limestone and then, in the latest Chadian and early Arundian, to coral-rich, open marine platform carbonate and mudstone of the basal Ballyshannon Limestone Formation (P947825). The Owenkillew Sandstone Group at Newtownstewart was deposited in an intra-cratonic basin (P947927).

Arundian

During the early and mid-Arundian, the transgression continued and the sea expanded northwards onto the Dalradian and submerged more of the Southern Uplands-Down-Longford Terrane at Lisnaskea and Carlingford ([P947828](#)). Arundian sediments are 840 m thick at Derrygonnelly, 600 m at Kesh-Omagh and 30 m in Co. Armagh.

Evidence of regression is apparent in Arundian strata of the Tyrone Group across the southwest part of the Carboniferous outcrop. Shallow water sediments occur at the top of the Ballyshannon Limestone Formation ([P947936](#)). In the Kesh-Omagh area the Ederney Limestone Member is the product of emergence and micritisation of semi-consolidated carbonate of that formation by groundwater brine. At both Derrygonnelly and Lisnaskea the top of the formation was not exposed but the highest strata are represented by shallow water, oolitic grainstones. The base of the Bundoran Shale Formation is represented by a thin, possibly volcanoclastic, clay in the Kesh-Omagh area. The Skea Sandstone Member succeeds the clay. That detritus was eroded from Dalradian and Carboniferous rocks and funnelled southwards in a palaeovalley, incised into the top surface of the Ballyshannon Limestone. This episode corresponds to a localised period of emergence prior to the transgression in which mudstone of the Bundoran Shale Formation ([P947825](#)) was deposited. At Lisnaskea, the Mullynagowan Sandstone Member is the contemporary of the Skea Sandstone Member, and has a southerly provenance. Both sandstones formed as a result of regional eustatic sea-level fall.

The late Arundian Mullaghmore Sandstone Formation ([P947934](#)) was deposited at a time of marine regression and of increased erosion of land to the north of the Carboniferous basin. It is 220 m thick in the Kesh-Omagh area, at Derrygonnelly and in the Glennoo borehole but thins southwards and is absent at Lisnaskea and in Co. Armagh ([P947821](#)). In the former area, the basal Dromore Sandstone Member is a marine deposit that was followed by the formation of a sabkha. Succeeding shallow marine and intertidal sediments were deposited on a delta with periods of intermittent exposure leading to the formation of palaeosols and thin coals. The arrival of a renewed transgression in the late Arundian is evident in the brackish to marine sediments in the upper part of the Mullaghmore Sandstone Formation. By latest Arundian-early Holkerian times ([P947933](#)) the shoreline and sediment source lay far to the north. Water depths had increased from shallow marine with corals (Drumchorick Siltstone Formation), to a deeper shelf, slope setting with turbiditic limestone (Drumchorick Siltstone and Benbulbin Shale formations).

Holkerian

Throughout much of Northern Ireland, the Holkerian is represented by the Benbulbin Shale Formation. However, coarse detritus of the Carland Sandstone Formation at Dungannon, Drumman More Sandstone Formation ([P947819](#)) in Co. Armagh and Aughnacloy Sandstone Formation ([P947933](#)) at Aughnacloy accumulated at the eastern and southern margins of the rising basement block that included the Lack and Lisbellaw inliers. Almost 2000 m of older Dinantian strata were stripped from the basement block exposing the Dalradian and early Palaeozoic rocks respectively.

Early Asbian

Asbian time in the north of Ireland was a period of syn-sedimentary fault movement, of basin formation ^[3], ^[4] and of continued uplift of the Lisbellaw Inlier and erosion of early Dinantian cover rocks.

While early Asbian basins were fault-controlled, there is no evidence of transgression onto either the

Central Highlands (Grampian) or Southern Uplands-Down-Longford terranes or of near-shore depositional environments in the Benbulbin Shale, Glencar Limestone or Dartry Limestone formations ([P947934](#)). The absence of the Glencar Limestone Formation, for example at Lisnaskea, is believed to indicate deep water conditions. While cherty limestones are a major part of the Dartry Limestone Formation they are impoverished in faunal and floral remains and are deep water facies. Near the top of the Dartry Limestone Formation shallow water grainstones of the Ballagh Limestone ^[5] (Lisnaskea) and Carrickmacsparrow Limestone ^[6] (Derrygonnelly) members show evidence of slumping and channels and represent shallow water sediments that moved downslope to deeper water. Carbonate 'buildups' of the Knockmore Limestone Member ^[6] accumulated on the southwesterly inclined ramp in Co. Fermanagh in shallower water than the cherty limestones. In Co. Armagh ([P947819](#)) the early Asbian was a period of non-deposition.

Late Asbian

The late Asbian was a time of uplift and marine regression and subsidence of the non-marine Kilskeery Group basin (Fintona Block). Over much of Co. Fermanagh and Co. Sligo the erosional gap between the Dartry Limestone Formation (Tyrone Group) and Meenymore Formation (Leitrim Group) was the result of regional uplift. It separates deep-water marine carbonates from shallow marine, intertidal, sabkha and fluvial sediments respectively. The Meenymore Formation accumulated on tidal flats some 40 km wide that stretched for 120 km from Draperstown to Co. Sligo, but is replaced in the Armagh-Cookstown area by the Armagh Group ([P947829](#)).

At the southern margin of the subsiding Kilskeery Group basin, the Lisbellaw Inlier was the source of greywacke pebbles in the Ballyreagh Conglomerate Formation ([P947931](#)). Subsidence probably resulted from gravitational collapse in the centre of an uplifted and arched orogenic belt ([P947829](#)).

Deposition of the Glenade Sandstone Formation ([P947935](#)) occurred in a half-graben with the northern faulted margin defining a clastic source area that included Courceyan-Chadian strata. Minor faulting continued during deposition of the lowest two members of the Bellavally Formation which were overlapped southwards by younger members onto the top surface of the Glenade Sandstone Formation. Deposition of the Doobally Sandstone Member coincides with the early Brigantian subsidence event.

Between Co. Armagh and Draperstown the Armagh Group developed on a north-south orientated carbonate platform ([P947829](#)). Deposition was affected by oscillating sea levels, exposure and by pedogenesis and resulted in the formation of solution features filled with red clay of continental origin. The development of Asbian emergence surfaces is believed to indicate a glacio-eustatic control on sea levels and on emergence ^[7].

Brigantian-Arnsbergian

During the Brigantian, Northern Ireland experienced bimodal volcanism, development of new, non-marine basins and marine sedimentation in quiet basinal settings.

Extensional faulting in the early Brigantian at the margins of the Central Highlands (Grampian) Terrane led to the development of two new sedimentary basins ([P947829](#)). At Ballycastle the Ballycastle Group was deposited in a fault-controlled basin associated with basalt volcanism. Similar sediments occur in the Magilligan borehole and were deposited in shallow marine, fluviodeltaic and coal swamp environments with limestones only developed during brief transgression. Deposition of the Greenan Sandstone Formation ([P947927](#)) in a new basin was associated with rhyolitic volcanism. Sandstone composition is constant and indicates a low topographic contrast between the basin and

sediment source areas. Subsidence of the Kilskeery Group basin continued from Brigantian into Pendleian times when alluvium of the Ballinamallard Mudstone Formation was deposited in axial parts of the basin and in playa lakes.

Early Brigantian sediments at Armagh-Cookstown, Benburb and Castle Espie were deposited in shallow marine, lagoonal and carbonate platform environments and all contain evidence of shallowing upwards cycles, emergence, palaeokarsts and fluvial channels. Their occurrence at Benburb and Cookstown may be related to the proximity of a shoreline to the east, marking the edge of a basement block beneath Lough Neagh that is now concealed by Mesozoic and Cenozoic rocks ([P947815](#)).

In Co. Fermanagh, basinal mudstone and deltaic sandstone with a northerly provenance succeed the Bellavally Formation ([P947935](#)). In the late Brigantian, anaerobic bottom conditions prevailed and the rich benthic community of the lower Carraun Shale Formation disappeared in the upper part and in the Pendleian Dergvone Shale Formation. The K-bentonites in the Carraun Shale Formation represent distal ashfall deposits of volcanic eruptions. The relative tectonic quiescence of late Brigantian and early Pendleian times is ascribed to regional thermal subsidence. ^{[1][3]}

The late Pendleian and Arnsbergian was a time of marine transgression and delta progradation. In the Dergvone Shale Formation the Lagoon Sandstone Member ^[6] is a forerunner of the Briscloonagh Sandstone delta with its upward coarsening and increasingly proximal succession. Marine transgression at the base of the Arnsbergian drowned the delta and deposited the Gowlaun Shale Formation. Thin coals in the succeeding Lackagh Sandstone Formation testify to intermittent exposure of the delta top. Across Northern Ireland, Carboniferous sedimentation ceased in the mid-Arnsbergian and renewed uplift created the mid-Carboniferous hiatus.

In east Co. Tyrone, the Leitrim Group comprises the Rossmore Mudstone Formation which was deposited during the mid-Brigantian transgression and faunally resembles the Carraun Shale Formation. The lower part of the Millstone Grit was deposited in times of fluctuating sea-levels and subaerial exposure and of deposition in shallow marine, deltaic, fluvial and coal swamp environments.

Late Namurian-Westphalian A/B

Coal Measures in east Co. Tyrone accumulated in poorly drained swamps as alluvium and peat of the alluvial plain facies association. In the Fintona Block the Tullanaglare Mudstone Formation was also deposited on this alluvial plain but at a higher topographic level with improved drainage ([P947932](#)). The bed of calcrete (Drumgivery Limestone Member) at the top of the formation indicates a period of sediment starvation in early Westphalian B times corresponding to the onset of dextral strike-slip, uplift of Dalradian basement and rapid subsidence of a pull-apart basin to the south. The upwards-fining, volcanoclastic, alluvial fan sediments of the Drumlish Conglomerate Formation reflect either decreasing rate of subsidence and gradual lowering of the clastic source area or of depocentre migration to the southwest.

Late Carboniferous-Early Permian

In Northern Ireland the late Carboniferous and early Permian was a time of maximum Variscan deformation in a zone of convergent dextral strike-slip faulting and orogenic shortening along the Omagh Thrust Fault. The severity of strike-slip faulting and southeasterly-directed thrusting may be gauged from the virtual destruction of the original sedimentary basin of the early Westphalian Slievebane Group.

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