THE GEOLOGY OF 1:50,000 SCALE BEDROCK MAP SHEET 77, WEXFORD

Edited by

A.G.Sleeman

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Department of Communications, Marine and Natural Resources

THE GEOLOGY OF 1:50,000 SCALE BEDROCK (GIS) MAP SHEET 77, WEXFORD

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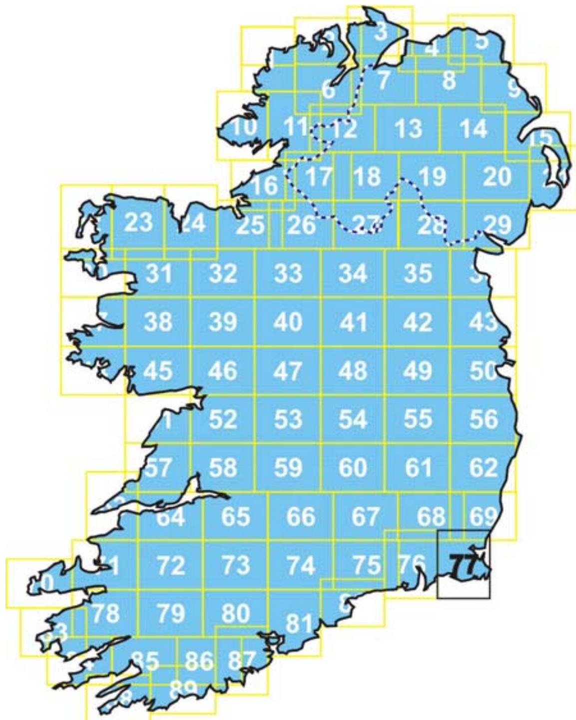
Report to accompany the 1:50,000 scale GIS Bedrock Geology map Sheet 77, Wexford

Based on D. Tietzsch-Tyler and A.G.Sleeman, 1994. *Geology of South Wexford. A geological description of South Wexford and adjoining parts of Waterford, Kilkenny and Carlow to accompany the Bedrock geology, 1:100,000 scale map series, Sheet 23, South Wexford.* Geological Survey of Ireland, 62pp.

Geological Survey of Ireland
Suirbhéireacht Gheolaíochta Éireann

Published under the authority of the Director of the Geological Survey of Ireland



Index to 1:50,000 scale Bedrock Geology (GIS) Map Series

Bibliographic reference:-

Report
Sleeman, A.G. (ed.) 2006. *The Geology of Wexford; report to accompany the 1:50,000 scale Bedrock (GIS) map Sheet 77*. Geological Survey of Ireland, 44pp.
Map
Scanlon, R. and Sleeman, A.G. (compilers) 2006. *The Geology of 1:50,000 scale Bedrock (GIS) map Sheet 77, Wexford.* Geological Survey of Ireland.

ISBN

Cover picture: The engine house of the former lead mine at Barrystown, alongside Bannow Bay, near Wellington Bridge, Co. Wexford (photo by Patrick O'Connor)

PREFACE

This report on the geology for 1:50,000 Sheet 77, Wexford, is prepared from the Booklet to accompany 1:100,000 scale map sheet 23 (South Wexford). It is intended to give an overview of the geology of the map area primarily for geologists and related professionals.

There has been only a minimal attempt to update the geological interpretation, despite work that has been published since the 1:100,000 scale map was published, due to time constraints. In the author's opinion, in particular, the complexities of the Lower Palaeozoic stratigraphy and structure would require a considerable field time input to justify any significant changes to the map that might be envisaged from recent publications. Some simplification of the overall stratigraphic terminology might be justified if this were to be done. The reference list has been updated.

With regard to the map, only minor changes to the geological linework and polygons have been made since 1:100,000 Sheet 23 was published in 1994, although additional point datasets have been added in the GIS map such as boreholes and outcrops. An appendix is included that identifies those lines and polygons on the map which have been changed from those depicted on Sheet 23. The Stratigraphic lexicon entries hot-linked to the stratigraphic polygons on the map take into account the latest interpretations of the stratigraphy, correlations and dating. The original Sheet 23 line-work and polygons have also been fitted to the 1:50,000 base with reference to the coastline, outcrops and boreholes.

CONTENTS

FIGURES

TABLES

PRECAMBRIAN ROCKS

Some of the oldest rocks in Ireland are found in South Wexford. These rocks are Precambrian in age (Table 1). They form an area of 120 square kilometres of low-lying, flat country projecting into the Irish Sea south of Wexford Town (Fig. 1). These are the highly and repeatedly deformed and metamorphosed rocks of the Rosslare Complex.

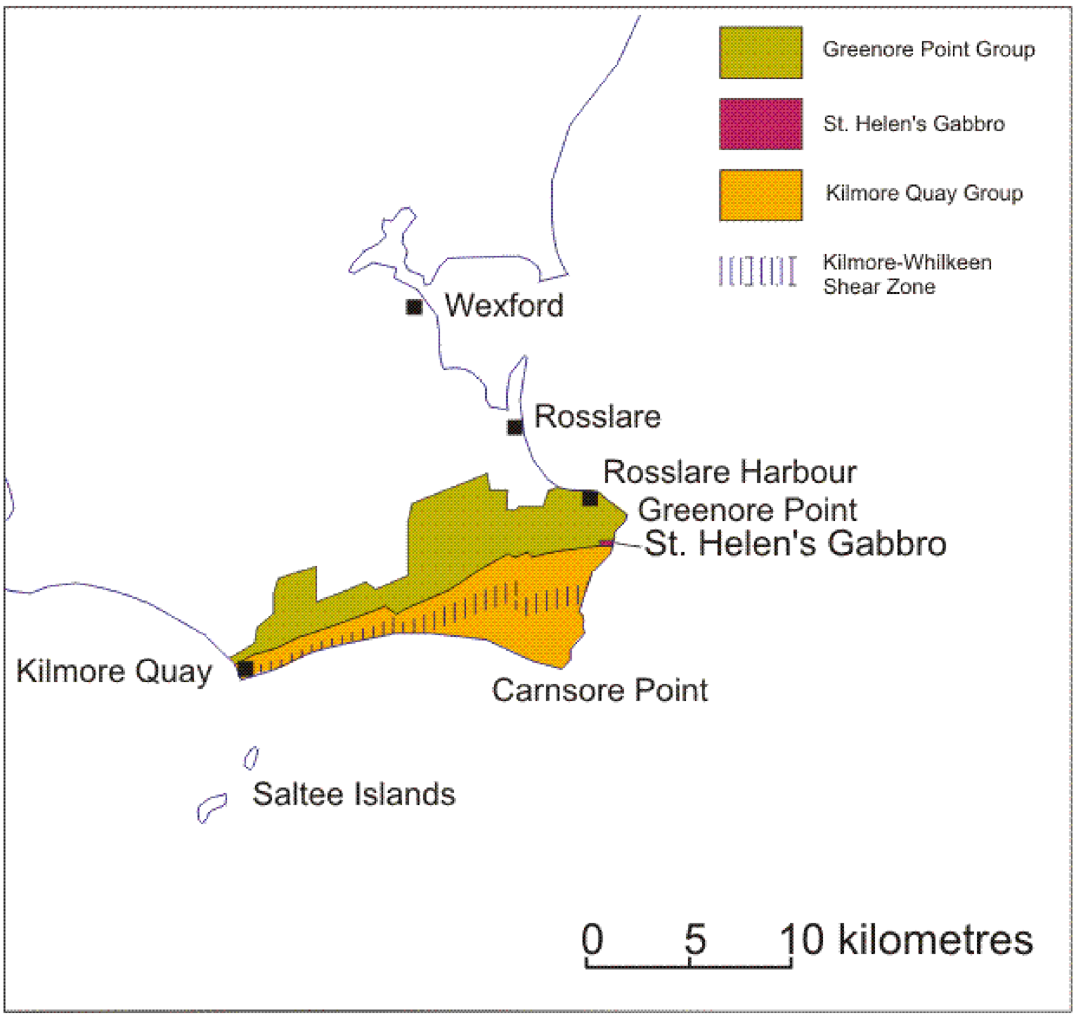


Figure 1. Precambrian rocks in southeast Wexford

AGE (date in million years)	GEOLOGICAL EVENTS
1800	Formation of ancestral crust in the region
?	Deposition of greywackes of the Kilmore Quay Group, derived by erosion from ancestral crust
?	Intrusion of gabbro and diorite to form the Greenore Point Group, possible eruption of basaltic volcanics
?	Formation of gneisses and amphibolites, partial melting produces migmatites during first metamorphism (D1).
620	Possible emplacement of the St. Helen's Gabbro during 2nd metamorphism (D2).
Precambrian ---- 570 ---- Cambrian	Intrusion and deformation (D3) of granodiorite sheets
480	Intrusion of earlier basaltic dykes
436	Shearing and metamorphism (D4).
?	Shearing, metamorphism (D5) and intrusion of Saltees Granite
430	Intrusion of later basaltic dykes
	Intrusion of the Carnsore Granite

Table 1. Events affecting the Precambrian Rosslare Complex

THE ROSSLARE COMPLEX

The Rosslare Complex can be divided into two major units, the Kilmore Quay Group of grey gneisses and the Greenore Point Group of dark green amphibolites and metagabbro (Fig. 1).

The complex is not well exposed, except in a number of coastal sections, because of a thick cover of unconsolidated Quaternary sediments. The grey gneisses can be examined at Kilmore Quay, the amphibolites along the beaches around Rosslare Harbour and between the harbour and just south of Greenore Point, and the metagabbro around St Helen's Harbour.

Paragneisses, schists and migmatites

The Kilmore Quay Group principally comprises a sequence of thinly banded gneisses, in which pale grey granular bands, chiefly composed of quartz and plagioclase, are separated by darker, mica-rich schist bands. Thicker bands of mica schist are sometimes also present. In places, thin sheets of granitic composition were injected parallel to the banding in the gneisses to produce migmatites.

Because of the extreme deformation and metamorphism that affected them, it is not possible to tell by simple observation what these rocks were originally. However, the chemical composition of the gneisses shows them to be paragneisses - i.e. they originated as sediments. They were first deposited as a succession of greywacke sandstones and interbedded mudstones (very similar to the Cambrian rocks described in the next section). The thicker schist bands may have originated as thicker mudstone beds, though some were produced from the gneisses by extreme deformation.

Metamorphism under high temperature and pressure conditions, following deep burial, produced the present-day gneisses and schists. The presence of migmatites suggests that particularly high temperatures were operative, causing partial melting of the sediments and re-injection of the melted rock elsewhere into the succession as thin granite sheets. Some of this granitic melt was also injected into the amphibolites and metagabbro described below.

Amphibolites and metagabbro

The Greenore Point Group is made up largely of a thick sequence of dark green amphibolites comprising varied proportions of the minerals amphibole and plagioclase. Commonly these amphibolites are finely foliated and in most localities all directly observable evidence of their origin is lost. The chemistry of the more deformed, foliated amphibolites, however, indicates that most of them also originated as gabbros.

At St Helen's the amphibolites have not been completely foliated but retain the texture of a coarsely crystalline gabbro (they are still altered, and should be called metagabbros). It has been suggested, however, that the metagabbros at St. Helen's are somewhat younger than the rest of the amphibolites and represent a separate intrusive body. Some amphibolites found south of Greenore Point were originally diorites. The amphibolites, as gabbros and diorites, must have been first emplaced as magma at some considerable depth below the Earth's surface. Some geologists have suggested that a proportion of the foliated amphibolites might have had a slightly different origin, the magma reaching the surface of the Earth as lavas and tuffs.

The age of the Rosslare Complex

No precise age has been determined for the formation of the Rosslare Complex. Several periods of metamorphic alteration have been identified as a result of microscopic examination of the minerals in the gneisses and the amphibolites. Minerals which grew in the rocks during the second metamorphism have been dated, so that it is known that the gneisses and the amphibolites were both in existence more than 620 million years ago. This is just a minimum age, and radioactive decay of elements in the gneisses indicates that they first became part of the Earth's crust about 1,800 million years ago. However, it must be emphasised that the sediments which underwent change to produce the gneisses need not be that old, simply being the product of reworking of much older rocks through one or more cycles of erosion and sedimentary deposition.

The age relationship between the amphibolites of the Greenore Point Group and the gneisses of the Kilmore Quay Group is not known. If most of the amphibolites originated as gabbro (and some diorite), it is likely that they were actually emplaced into the gneisses (which were then greywackes) with which they are now in contact. In this case, the amphibolites must be younger than the gneisses they intrude. Alternatively if the amphibolites were originally volcanic rocks, they could be either older or younger than the gneisses since no evidence now remains for the younging direction of the original sediments. Thin bands of foliated amphibolite in the paragneisses might also have originated as occasional volcanic lavas, punctuating sedimentation. Yet again, they might have been basaltic dykes which passed through older, pre-existing sediments to feed volcanics in the Greenore Point Group.

DEFORMATION OF THE ROSSLARE COMPLEX

Rocks as old as those of the Rosslare Complex have usually been affected by several important events in the Earth's history. This is particularly true of the regions bordering the North Atlantic, where the Earth's crust has been extremely active over the last 3 billion years with relatively frequent collisions between continental plates drifting across the face of the earth.

Folding and refolding

The amphibolites, gneisses and schists of the Rosslare Complex have been foliated by several episodes of compressive deformation. Several generations of small folds were produced during these events. Sometimes individual folds are re-folded by younger folds. Careful study of such relationships permits a sequence of fold and foliation producing events to be identified.

Additional evidence for significant events may be provided by intrusive igneous rocks such as basaltic and granitic dykes. These may be intruded after one or more episodes of folding, cutting across folds and foliations generated by those events (Table 1). The dykes themselves may then have been folded or foliated by later periods of deformation.

The Cadomian Orogeny (Late Precambrian)

Three periods of deformation affected the Rosslare Complex prior to injection of basaltic dykes during the Cambrian Period (Table 1). Though the first event, which produced gneisses and amphibolites from the original sediments and gabbros, might be much older, all of these happenings were probably caused by late Precambrian continental collision across what is now southern England and northwestern France during the Cadomian Orogeny. The first (D_1) and second (D_2) deformations produced foliations (usually difficult to tell apart) and rare folds. Metamorphic recrystallisation during the first event produced amphiboles, garnets and rare kyanite at the highest temperatures and pressures these rocks were ever to reach. Kyanite is first completely altered to fine clay minerals by the effects of later metamorphism. Garnets are partly or wholly altered to chlorite. The Rosslare Complex attained Amphibolite Facies metamorphic grade during the first deformation event.

Metamorphism associated with the second event took place about 620 million years ago. Successive events saw retrogressive metamorphism through the lower Amphibolite Facies (second event) and the Greenschist Facies (subsequent events). This sequence probably reflects initial deep burial of the complex, followed by gradual uplift over many millions of years.

The third event saw the injection of a swarm of granodiorite dykes into the Rosslare Complex, and their subsequent alteration to gneisses.

Lower Palaeozoic events affecting the Rosslare Complex

Two sets of basaltic dykes cut across the Rosslare Complex. The first of these was intruded during the Cambrian, and the second was intruded during the late Ordovician and early Silurian. The dykes of both sets are metamorphosed and foliated, and those of the older set are folded too.

The gneisses were deformed and metamorphosed during both the Monian Orogeny (Upper Cambrian to early Ordovician) and the Caledonian Orogeny (latest Ordovician to Silurian). Much of this alteration is confined to ductile faults (shear zones) which cut across the gneisses and amphibolites. Within these, the gneisses have been altered to mylonitic schists and the amphibolites have been altered to chlorite schists. The latter may be seen around the site of the ruined castle southeast of Tomhaggard. Pervasive folding is also associated with some of these shear zones.

Most of the shear zones suggest that a sinistral wrench movement took place across them, and they were repeatedly active. A mineral date of about 480 million years, obtained from the rocks at Kilmore Quay, reflects such an early event.

Sinistral wrenching at Kilmore Quay (in the Kilmore - Whilkeen Shear Zone) was the last major event that can be demonstrated to have affected the Rosslare Complex. The Saltees Granite was emplaced during this deformation, so the granite is deformed. The second set of basaltic dykes was intruded towards the end of the deformation, and the Carnsore Granite was intruded after deformation had concluded. Radiometric dating of the granites has placed the deformation during late Ordovician and early Silurian times.

METAMORPHISM

The Rosslare Complex sustained high amphibolite facies metamorphism during the earliest deformational event (D_1). Mineralogical evidence for this is not well documented, and the presence of kyanite in pelitic gneisses of the Kilmore Quay Group is not alone sufficient to recognise high amphibolite facies. However, it has also been recorded that these gneisses have been partially melted and migmatised by injection of many granitic veins and that grain size has been coarsened: these features better support the interpretation that high amphibolite facies conditions were indeed attained. Subsequent shearing has retrogressed the high grade metamorphism of much of the Rosslare Complex to much lower grade, greenschist facies grade and mylonites.

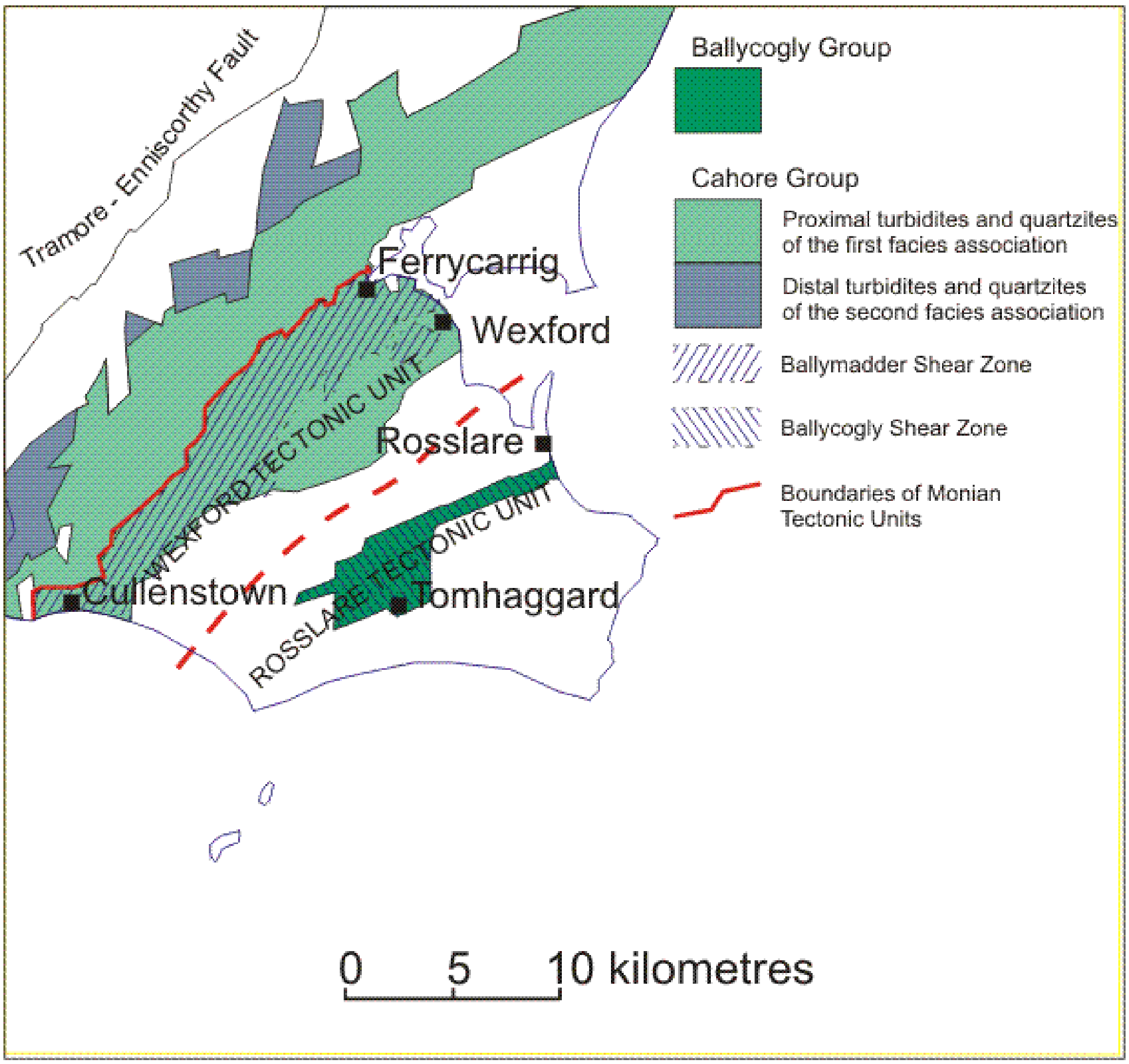


Figure 2. Cambrian rocks in south Wexford

LOWER PALAEOZOIC ROCKS

Most of South Wexford is underlain by Ordovician and Cambrian rocks, the latter in a band up to 25 kilometres wide along the southeastern margin of the Ordovician outcrop. Rocks of Silurian age are not found in the map area. The Cambrian to Ordovician succession is cut by the Enniscorthy - Tramore Fault which extends from 9 kilometres northeast of Enniscorthy to just north of Tramore (Fig. 2). The fault is divided along its length, into short segments offset by more recent faults that have a nearly north-south trend (Fig. 2).

The succession is subdivided into six groups. Rocks which are undoubtedly Cambrian are only found southeast of the Enniscorthy - Tramore Fault where they fall into two groups, the Cahore Group and the Ballycogly Group. The age of the Cahore Group is not particularly well constrained because of a general absence of fossils. Microscopic plant spores (acritarchs) and the feeding traces of a minute, worm-like creature (Oldhamia) suggest a Lower to Middle Cambrian age (Fig. 5). Recent dating of acritarchs from the Cullenstown Formation (Fig. 5) suggests that the group extends into the late middle to early late Cambrian. The Ballycogly Group is only recognised southeast of the Upper Palaeozoic rocks near Wexford Town.

The Cahore Group is succeeded by lower Ordovician rocks assigned to the Ribband Group in the northwest and to the Tagoat and Tuskar Groups in the southeast. The broad outcrop of the Ribband Group is split into two by the Enniscorthy - Tramore Fault and, on the northwest side of the fault, by a relatively narrow outcrop of overlying Duncannon Group rocks (Upper Ordovician - Caradoc) which are inclined to the southeast, towards the fault (Fig. 6).

IAPETUS - A VANISHED OCEAN

During the early part of the Cambrian Period faults cutting through the gneissic crystalline basement facilitated crustal extension and contemporaneous crustal thinning. Basaltic magma was injected into narrow fissures created by this extension in the Precambrian gneisses of the Rosslare Complex. As crustal thinning progressed, the land surface sank below sea-level and a deep basin formed; this was the beginning of the Iapetus Ocean. The Iapetus Ocean existed for several hundred million years along much the same axis as the present-day North Atlantic. It reached its widest extent during the early Ordovician, after which it began to shrink as the ocean-floor was subducted beneath chains of volcanic islands along the ocean margins - comparable to the present day Pacific Ocean margins. The Cambrian and Ordovician rocks of South Wexford formed along the southeast margin of this ancient ocean. Whether Iapetus existed before the Cambrian began, and whether it continued to exist into the Silurian and Devonian Periods is the subject of a continuing debate.

THE CAMBRIAN SUCCESSION

THE CAHORE GROUP

Two distinctive associations of sedimentary facies make up the Cahore Group in South Wexford (see Figures 2 and 5 and Table 2). In the first facies association, found east of Bannow, the group is divided into a number of formations, most of which are dominated by grey-green and occasionally purple or buff-coloured greywacke sandstones. The greywackes of these formations are interbedded with varying proportions of similarly coloured mudstones. These greywackes are the Kiln Bay, Ardenagh, Newtown, Cullentra, and Cullenstown Formations.

The Cahore Group greywacke succession can be examined along the south coast. On Clammers Point, it is relatively thinly-bedded, and fine sandstones are interbedded with mudstones in a ratio of 1:2. Further east, on Cullenstown Strand, less than a quarter of the succession is mudstone, and the sandstones are coarser grained and form much thicker beds.

The second distinctive facies association is found west of Bannow and along the River Slaney (the Booley Bay Formation) and comprises a finer grained association dominated by mudstones and siltstones with subordinate greywacke sandstones. Similar rocks to the Booley Bay Formation (mapped as the Polldarig Formation) are found along the River Slaney.

Cambrian earthquakes and turbidity currents

Sedimentary structures contained in the greywackes of the Cahore Group tell us that they were deposited by turbidity currents in a marine basin - they are turbidites. These, earthquake-triggered currents carried large volumes of mixed sand and mud, at great speed, into the new Cambrian basin. Once on the basin floor, the currents reduced speed and were no longer able to carry their sediment load, depositing the mixture of sand and mud (as greywackes) in fan-shaped sheets along the margin of the basin. Between earthquake events, clays settled out of suspension to form the interbedded mudstones. The greywackes of this first facies association were deposited relatively close to the basin margin and are called proximal turbidites. Finer mud-dominated material was much further out into the basin as distal turbidites (the second facies association, described below).

Catastrophic earthquakes during the Cambrian also led to slumping of the newly deposited sediments into the basin. Sheets of bedded sediments, up to 85 m thick, broke away from the margin of the basin during major earthquakes and slid down toward the basin floor under the influence of gravity.

The power of such slumps is attested by much more recent earthquakes. An earthquake in the Grand Banks area of Newfoundland in 1929, generated a slump sheet measuring 100 km in each direction and 400 m thick. Altogether, about 4000 km^3 of sediment was carried out onto the abyssal plain of the Atlantic Ocean. Travelling at speeds of up to 70 kilometres per hour, the slump sheet and slump-generated turbidity currents tore through telegraph cables connecting Europe with North America as they went, signalling their passage.

Metagreywackes and regional tectonic units

On Cullenstown Strand and along the length of Forth Mountain, the Cahore Group is much more deformed than is usually the case. In general, only the mudstones of the Cahore Group are cleaved. Along Cullenstown Strand, however, the greywackes also have a pronounced cleavage (they are metagreywackes). Metagreywackes can be seen at Cullenstown and also on the outside of the west wall of the disused quarry on Shelmaliere Commons (Forth Mountain); beneath Ferrycarrig Tower; and in several nearby road-cuttings and in places in Wexford Town where they have been extensively used as building stones.

Figure 3. Third phase (D_3) kink folding of the first phase (D_1) cleavage in the Cullenstown Formation metagreywackes alongside the stream which cuts across Cullenstown Strand (photo by Daniel Tietzsch-Tyler).

Figure 4. Giant flute casts deformed by sedimentary loading on the base of the lowest quartzite bed in the Shelmaliere Formation at the disused Shelmaliere Commons Quarry, Forth Mountain, Co. Wexford (photo by Daniel Tietzsch-Tyler).

The metagreywackes occur within a major ductile shear zone, the Ballymadder Shear Zone, which divides the Cahore Group into two tectonic units (Figure 2, Table 2). The succession northwest of this zone (Kiln Bay, Ardenagh and Newtown Formations, in the Clammers Point Tectonic Unit) is often finer grained and more thinly bedded (gradational to facies association 2), and has been thrust towards the southeast over the rest of the Group (Cullentra and Cullenstown Formations) in the Wexford Tectonic Unit.

Booley Bay - Duncannon - Bannow Bay	River Slaney - Oilgate	Clammers Point - Cross Lake - Taghmon	Cullenstown Strand - Ferrycarrig
CLAMMERS POINT TECTONIC UNIT (NW)			**WEXFORD TECTONIC UNIT (SE)**
	POLLDARRIG FORMATION (upper)	ARDENAGH FORMATION	CULLENSTOWN FORMATION
BOOLEY BAY FORMATION	Ballynacarrig Member	CROSS LAKE FORMATION	SHELMALIERE FORMATION
	POLLDARRIG FORMATION (lower)	KILN BAY FORMATION	NEWTOWN FORMATION

Table 2: Correlation of Cambrian Cahore Group sub-successions.

Quartzites - an unusual association with greywackes

Deposition of the greywacke succession was interrupted mid-way by deposition of pure quartz sands which had been cleaned of muddy material by the winnowing action of currents on a shallow marine shelf. This interruption may have been brought about by a change in sea-level. The character of sediments which were carried into the basin by turbidity currents also changed as a consequence of the source sediments being cleaner. These formed the white and locally purple quartzites of the Cross Lake and laterally equivalent Shelmaliere Formations. This intimate association of quartzites with turbidites is very rare.

The quartzites have generally proved resistant to erosion between the numerous minor faults which cut them, and they are exposed along the length of their outcrops. Frequently they have been quarried, and disused quarries are the best place to find the quartzites inland. On Forth Mountain, the contact between the first quartzite of the Shelmaliere Formation and the underlying greywackes is exposed in the west wall of Shelmaliere Commons Quarry. Of particular interest are large flute casts on the base of the quartzite which indicate that the turbidity currents carried the quartzite into the basin from the southeast (Figure 4). The quartzites and an impressive thickness of red mudstones are exposed on the south coast, immediately west of Blackhall. Like the greywacke successions, the quartzites are locally slumped and at Cross Lake, 1300 m east of Clammers Point, they form an olistostrome. The quartzites may also be seen in the older walls of Wexford Town.

Between the deposition of individual quartzites, reddish purple, green and occasionally grey mudstones with thin greywacke siltstones were deposited. Overall, the quartzites are massive and undeformed internally, while the interbedded mudstones have a slaty cleavage. On Ballymadder Point, at the western end of Cullenstown Strand, and on Forth Mountain, the quartzites fall within the shear zone between the Clammers Point and Wexford Tectonic Units. There, they too are cleaved and locally, at Ballymadder, they have become mylonites.

Into the abyss

The second sedimentary facies association within the Cahore Group occurs mostly west of Bannow, in the Booley Bay Formation. Inland exposure is negligible, but the formation is well exposed around Bannow Island and forms striking cliffs between Fethard-on-Sea and Baginbun Head, and between the southern end of Duncannon Strand and Stonewall Bay located on the adjacent Sheet 76.

The Booley Bay Formation comprises dark grey to black mudstones which are commonly interbedded with subordinate, pale grey siltstones. The siltstones may be only a millimetre or two thick and closely spaced, giving the rocks a pin-striped appearance. The catastrophic instability of the basin during deposition has given rise to widespread slump deformation here too.

The preponderance of thinly bedded dark mudstones (70% or more) tell us that they were deposited at the furthest edge of turbidite sheets on the abyssal floor of the Cambrian basin. Deep basins, like that in which the Cahore Group was deposited, occur today off the southwest coast of Ireland (e.g. the Porcupine Sea-Bight and Biscay Abyssal Plain). Whereas the proximal turbidites were derived from the southeast, currents depositing the Booley Bay Formation had a northeast-southwest flow. They indicate that the outer parts of the turbidite sheets were affected by contour currents parallel to the margin of the basin. Occasional black mudstones up to two metres thick, which occur throughout the succession, represent long quiescent intervals between periods of frequent (geologically speaking) earthquake activity.

Microfossils in the Booley Bay Formation show that it has an age-range which encompasses the greywacke successions already described (Fig. 5). The greywackes of the Kiln Bay and Ardenagh Formations appear to pass laterally westwards into the distal turbidites. The latest microfossil dating suggests that the quartzites (Cross Lake Formation) may be slightly older (Fig. 5).

Similar distal turbidites found along the Slaney River (Polldarrig Formation), differ from the Booley Bay Formation in that they include a 500 m thick member (Ballynacarrig Member) comprising quartzites mid-way through the succession. These quartzites are the basinal equivalent of the Cross Lake and Shelmaliere Formations.

THE BALLYCOGLY GROUP

This group of rocks is isolated at the southeastern margin of the Cambrian outcrop, near Tomhaggard. The relationship of the Ballycogly Group to the Cahore Group is obscured by Carboniferous rocks. A similar succession on Anglesey (Wales), and the presence of quartz mylonite xenoliths in dykes, suggests that the Ballycogly Group is younger than and overlies the Cahore Group, albeit within a third (Rosslare) tectonic unit. At the centre of their outcrop area, the rocks can still be recognised as cleaved, grey-green greywackes and conglomerates. Most of the group, however, comprises pale green, thinly laminated mylonites produced over a long period by repeated crushing and milling of the sediments in a broad shear zone, the Ballycogly Shear Zone.

The deformation which produced the mylonites must have occurred after the sediments were deposited, during the Upper Cambrian. Unmylonitised Lower Ordovician sediments are deposited across the mylonites, telling us that later movements on the shear zone uplifted the mylonites at least 10 km in only a few million years.

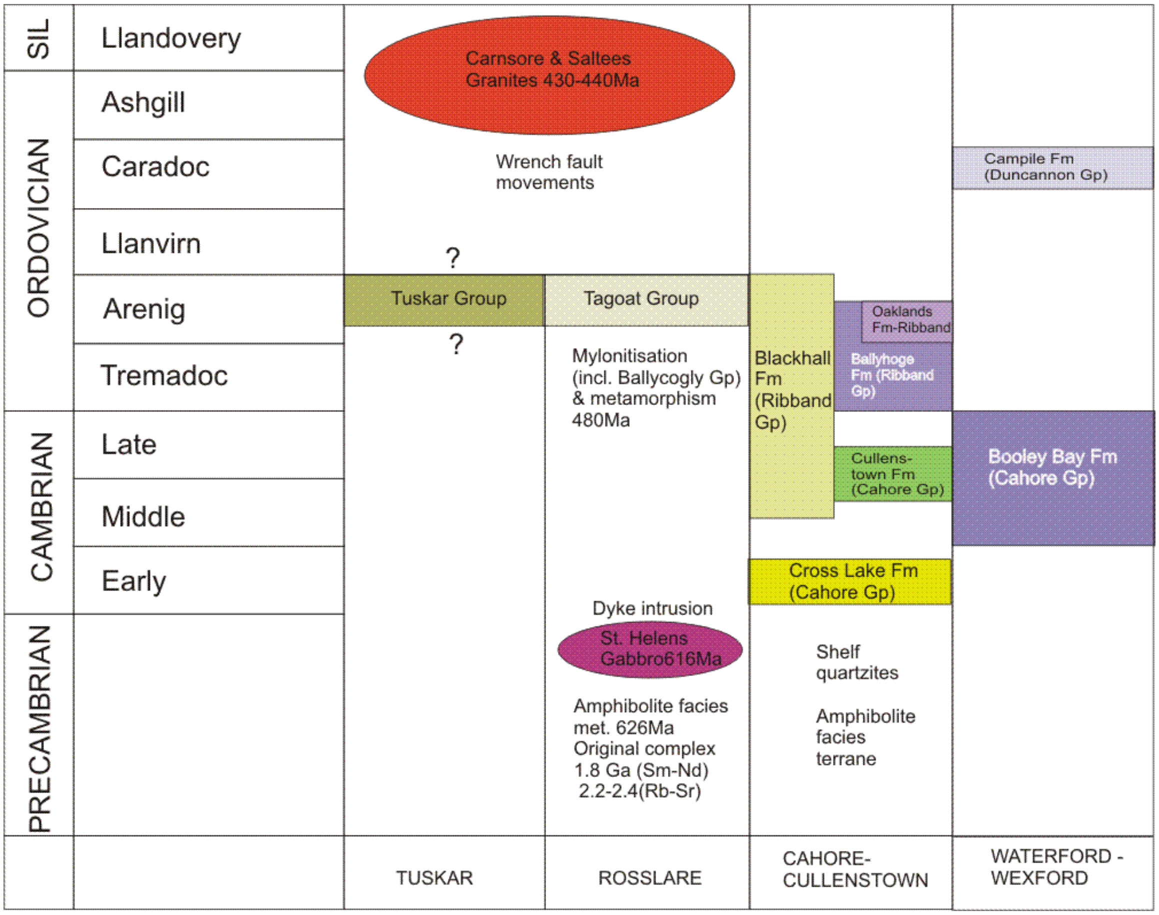


Figure 5. Correlations of Precambrian and Lower Palaeozoic rocks in the Wexford area, modified after Max et al. (1990). The age relationships of the different formations and groups are sourced as follows:- Carnsore and Saltees Granites – Max et al. (1990); Tuskar Group – Tietzsch-Tyler and Sleeman (1994); Tagoat Group – Baker (1966) and Brenchley et al. (1967)Harper and Parkes (2000); Ballycogly Group – Max et al. (1990); St. Helen's Gabbro – Max et al. (1990) ; Amphibolite complex – Max et al. (1990) ; Blackhall, Cross Lake and Cullenstown Formations – Brück and Vanguestaine (2004); Oaklands Formation – Rushton (1996); Ballyhoge Formation – Tietzsch-Tyler and Sleeman (1994); Campile Formation – Harper and Parkes (2000); Booley Bay Formation – Madlowska and Crimes (2004).

ORDOVICIAN SUCCESSIONS

Sedimentation continued without interruption into the Ribband Group (Lower Ordovician) southeast of the Enniscorthy - Tramore Fault. This fault was an active structure throughout the Ordovician, leading to significant differences in the timing and the nature of events on either side of it. Northwest of the fault, the base of the Ribband Group is not seen. At its lowest level, it may extend down into the Cambrian and be partly equivalent to the Cahore Group (see Figure 5 – Blackhall Formation). Further southeast, the Rosslare Complex is unconformably overlain by the Tagoat Group and the

Tuskar Group (probably equivalent to each other), both also of Lower Ordovician age (Fig. 5).

At the end of the Lower Ordovician, there was a hiatus in sedimentation across the whole region. Sedimentation, accompanied by active volcanism, resumed during the Upper Ordovician (Duncannon Group) in a radically different palaeogeographical environment.

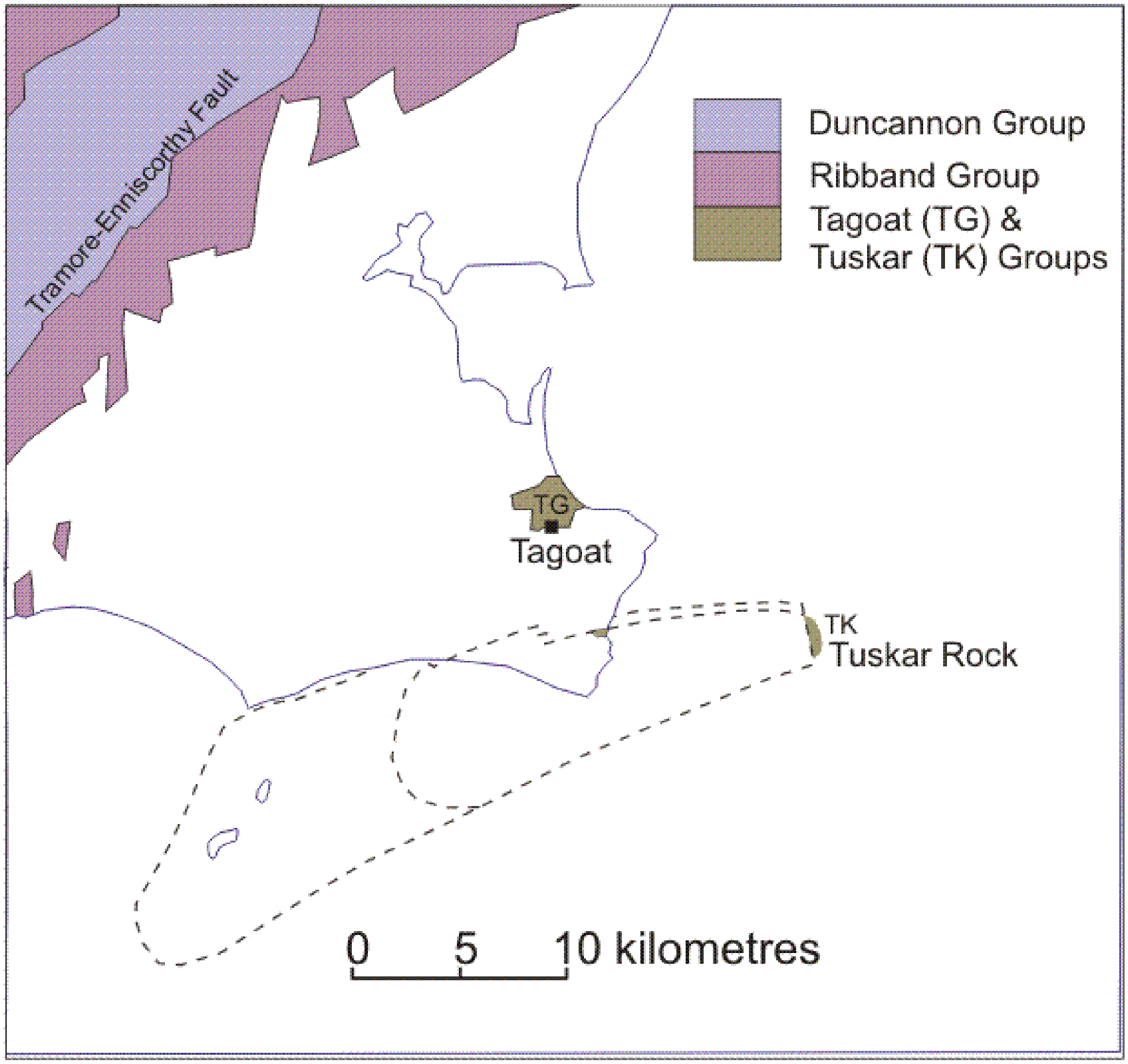


Figure 6. Ordovician rocks in south Wexford

THE RIBBAND GROUP

The Ribband Group is characterised by a thick succession of variously coloured slaty mudstones. In the general absence of fossils (which would provide us with relative ages for different parts of the succession), it is only the systematic change of colour that provides us with a stratigraphy. The colour variations reflect changes in the conditions under which deposition took place, and these appear to have occurred progressively later during the Lower Ordovician towards the west. Frequently the mudstones are thinly laminated with pale grey siltstones only a millimetre or two thick, giving them a pin-striped or "ribband" appearance, giving rise to the Ribband Group's name. The mudstones are very soft and in consequence are usually poorly exposed.

The Ribband Group is represented by two formations on the southeastern side of the Enniscorthy - Tramore Fault (Figs 5 and 6), the Ballyhoge and Blackhall Formations. Like the Maulin Formation (not on this map), with which it can be correlated, the Ballyhoge Formation comprises dark blue-grey, sometimes graphitic, slaty mudstones which are frequently pinstriped with pale siltstone laminae.

Fossils found in the upper part of this formation along the County Wexford coast a few miles north of the Wexford map boundary place deposition of the Ballyhoge Formation, and by inference deposition of the Maulin Formation, within the Tremadoc and lower part of the Arenig Series.

The Blackhall Formation on this map was shown as the Loftusacre Member of the Campile Formation (Duncannon Group) on the 1:100,000 Map sheet 23. Recent dating of acritarchs (Fig. 5) has suggested that this unit was erroneously attributed to the Caradoc aged Campile Formation and is in fact no younger than Arenig. A record of Caradoc aged graptolites (since lost) was previously used as evidence for a correlation with the Campile Formation. It is now thought more likely that the locality where the graptolites were found is an isolated small fault bounded block and that the gross characteristics and age of the previously named Loftusacre Member better fit the description of the Ribband Group – hence the use of Blackhall Formation here.

Enter greywackes - a new landmass nearby

The Maulin Formation (to the north and east of this map) is succeeded by two further mudstone-dominant formations. The lower, Ballylane Formation is characterised by thinly laminated green-grey mudstones and siltstones. It is succeeded by the Oaklands Formation (northwest corner of this map) which is characterised by the introduction of reddish-purple mudstones interbedded with green-grey mudstones and siltstones indistinguishable from those of the Ballylane Formation.

Deposition of Oaklands Formation mudstones was interrupted, approximately mid-way, by the entry of greywacke sandstones (the Palace Member). Their presence indicates that a shallow source of sediment had reappeared to the southeast. Structures within the sediments of both the Ballylane and Oaklands Formations indicate that the basin as a whole was getting shallower. Both the influx of greywackes and the overall shallowing reflect Monian orogenic uplift (see below).

Fossils, of upper Arenig to lower Llanvirn age, have been found in a series of small disused quarries in the Oaklands Formation near Kiltrea Bridge, six kilometres west of

Enniscorthy (to the north of this map).

THE TAGOAT GROUP AND THE TUSKAR GROUP

Two isolated successions form small outcrops overlying the late Cambrian – Tremadoc Ballycogly Group and the Rosslare Complex in the southeast of the area. The age of the Tagoat Group is constrained by fossils, but the age of the Tuskar Group is not well defined so the group could be anything from late Precambrian to Upper Ordovician in age. Its composition suggests that it is an extension of the Tagoat Group.

The Tagoat Group

This group was deposited unconformably across the Rosslare Complex gneisses and the Ballycogly Group mylonites at about the same time as the Oaklands Formation was deposited further to the northwest.

The succession begins with grey-green and purple conglomerates of the Grahormack Formation, followed by dark grey to black mudstones with subordinate thin siltstones (probably distal turbidites) of the Milltown Formation. The uppermost Ballybro Formation is made up of fossiliferous buff-coloured and olive green greywacke sandstones and siltstones, interbedded with slaty mudstones. The junction between the Milltown and Ballybro Formations is not seen. The fossils have an upper Arenig age (Fig. 5).

The Tuskar Group

The Tuskar Group has been drilled about 4 km north of Carnsore Point, and examined by divers on the Whilkeen Rocks just offshore and beneath the Tuskar Rock lighthouse. The group was completely metamorphosed during emplacement of the Carnsore Granite.

The group includes a lower succession of black mudstones, thinly interbedded with sandstones and siltstones, and an upper succession of greywacke sandstones. These successions may correspond to the Milltown and Ballybro Formations of the Tagoat Group. On Tuskar Rock, however, the transition between the two successions includes basaltic volcanics.

THE MONIAN OROGENY

The Cahore and Ballycogly Groups were first subjected to compressional stresses shortly after deposition, during the Monian Orogeny. This deformation caused large scale crumpling in the thinly bedded turbidites of the Booley Bay Formation, producing cliff-sized folds which may be seen along the shore north of Booley Bay (Sheet 76) at low tide. Smaller folds can be seen at the southern end of Bannow Island, and in the greywackes on Clammers Point and Cullenstown Strand.

While these folds and numerous small thrust faults were forming, the whole succession was dismembered and, as the Clammers Point Tectonic Unit, was thrust up and over the succession to the southeast (the Wexford Tectonic Unit). The thrust between the units (actually the broad Ballymadder Shear Zone) cuts through beds which were tipped into a vertical attitude (and even overturned) between a major anticline in the Clammers Point Unit and a major syncline in the Wexford Unit. Deformation of the Cullenstown Strand metagreywackes is related to development of this shear zone.

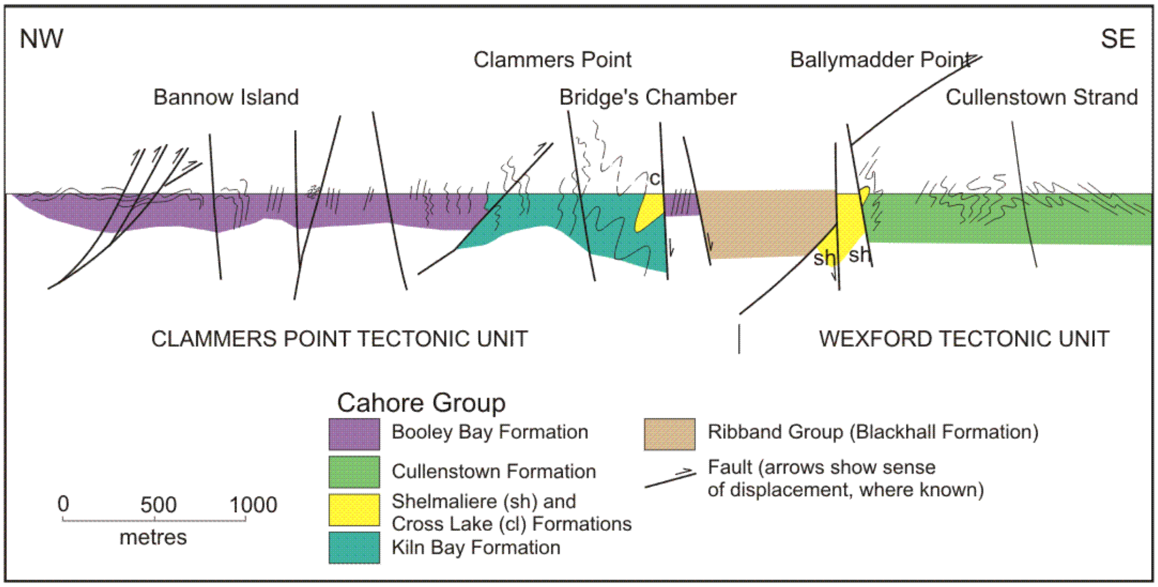


Figure 7. Cross-section of the Monian orogenic belt between Bannow Island and Cullenstown strand.

The Wexford Tectonic Unit was itself compressed against, and must have been thrust over the Ballycogly Group (this relationship is now concealed beneath Upper Palaeozoic rocks). The Ballycogly Group was itself thrust over the Precambrian rocks of the Rosslare Complex, which acted as a rigid buffer. Relationships within the Monian Orogenic belt are illustrated in Figure 7.

When, and how widespread?

Monian deformation, responsible for the burial of the Ballycogly Group to depths of 10 or 15 km was over, and the Rosslare Tectonic Unit had collapsed again, before deposition of the Tagoat Group began in the upper Arenig. Further north in County Wexford, but southeast of the Enniscorthy - Tramore Fault, the lower Arenig rocks of the Ribband Group were also deformed at this time, placing the Monian Orogeny in that region within middle Arenig times.

On the northwestern side of the Enniscorthy - Tramore Fault, Ribband Group sedimentation continued unabated into the Llanvirn (Figure 5). The only evidence for the deformation taking place to the southeast is the shallowing of the basin and the occasional input of greywackes coming off the uplifted Cambrian rocks. Eventually, deformation spread to the northwest, causing uplift and the cessation of sedimentation across the whole region for a short period. In Ireland, the Monian Orogeny appears to have been a localised event, restricted to the edge of the Leinster Basin, which was pushed upwards and outwards (i.e. inverted). Significant mountains were not formed at this time, but a narrow offshore landmass was created along the southeastern margin of Iapetus, extending at least from southeastern County Wexford into the north of England.

THE DUNCANNON GROUP
Collapse of the Monian landmass

By late Llanvirn times the whole of the uplifted Monian belt had once more subsided to below sea-level. A new deep basin resulted into which the sediments, which became the shales and occasional siltstones and sandstones of the Tramore Shale Formation (Sheet 76), were deposited. Sedimentation was interrupted just west of this area by andesitic and basaltic volcanism and intrusion.

A volcanic island arc in South Wexford

The extrusion (and intrusion into unconsolidated sediments at the surface) of great thicknesses of volcanic lavas and tuffs formed the Campile Formation. The volcanics are mostly pale coloured rhyolites which originated as viscous, gassy magmas that erupted explosively and were deposited as fragmentary tuffs and, more especially, as very coarsely fragmental agglomerates. The volcanic rocks include thinly flow-banded, rhyolitic lavas, with occasional basaltic and andesitic lavas and tuffs.
Many of the volcanic rocks were erupted below sea-level, but the volcanic pile periodically built up above sea-level to form an island arc. The chemistry of the volcanic rocks suggests that Leinster occupied a transitional position, between a volcanic island arc which extended from County Waterford to the English Lake District (formed above a subduction zone), and a back-arc basin in County Wexford. Back-arc basins commonly form behind ocean-margin island arcs. They are sites of tensional stress, where the arc is pulled away from the continental margin. Such paired island arcs and back-arc basins occur widely along the western rim of the Pacific Ocean. The most obvious example is Japan, its many islands dominated by the classical volcanic cone of Mount Fuji (among many others), and the Sea of Japan which separates the islands from the Asian mainland. Grey mudstones with subordinate siltstones and sandstones, continued to be deposited between eruptive events. The grey mudstones are frequently weathered to a buff colour. Locally their primary colour varies to dark blue-grey, reddish purple or green. They are commonly tuffaceous. The Leinster Basin was not particularly deep during this period.

THE CALEDONIAN MOUNTAINS

In the northern part of Ireland, parts of the Midlands and in Leinster, we see the eroded remnants of what was once a great mountain chain; one that rivalled the Alps and the Himalayas of today. The Caledonian Mountains extended from arctic Norway and east Greenland into the southern states of North America. Except in Scandinavia, they have been mostly worn down by erosion and weathering which have been active over the last 400 million years.

Caledonian Mountain building

The Caledonian Orogeny came about with the final closure of the Iapetus Ocean, brought on by the last oceanic lithosphere disappearing beneath the two approaching continental margins. When the continents met, the sediments and volcanics at the continental margins were subjected to enormous pressures similar to those which affected the rocks of the Rosslare Complex at an earlier time. Whereas the Cambrian and Ordovician rocks in North America and Scandinavia were pushed down to great depths and subjected to extreme temperatures and pressures, Britain and Ireland appear to have escaped such extremes. Despite deep erosion of the mountains here, no great degree of metamorphic alteration or intensity of deformation has become apparent.

It was originally thought that all the structures seen in Leinster were caused by Caledonian collision. Recognition in the last few years of the effects of the Monian Orogeny now suggests that only late folds, small-scale kink bands and crenulations locally, and faults may be Caledonian. These formed during late Ordovician to Silurian times. Some geologists see the termination of major volcanic activity in Leinster, Wales and the Lake District as marking the end of subduction and therefore ocean closure. Others see continued subduction indicated by the Silurian and Devonian lavas of Northern Ireland and Scotland. Silurian rocks across the Irish Midlands were certainly deformed during the Caledonian Orogeny. There was probably a protracted period of intermittent deformation extending from the latest Ordovician to the Devonian, while remnants of the ocean floor continued to be subducted. The Mediterranean Sea is a modern analogue for this situation.

METAMORPHISM

The lack of an adequate geographical spread of reliable modern data makes it almost impossible to give a clear picture of the pattern of regional metamorphism in the Cambrian and Ordovician rocks of the area. Preliminary studies of illite crystallinity in samples collected along a few traverses indicate a very low grade of metamorphism in both the zeolite facies and prehnite-pumpellyite facies, with additional northeasterly trending zones of low greenschist facies grade rocks within the three major shear zones which traverse them with a northeasterly trend: the Ballycogly Zone; the Ballymadder Zone; and the Graiguenamanagh - Inistioge Zone. The regional metamorphic grade of the latter is difficult to gauge because of higher grade thermal alteration caused by intrusion of the Blackstairs, Tullow and other granites into it.

CALEDONIAN INTRUSIONS

Most of the Lower Palaeozoic rocks considered up to this point started as sediments that were discontinuously deposited, at first, in a deep oceanic basin, but later becoming shallower. During the upper Ordovician, the basin became the site of violently erupting volcanoes, producing great thicknesses of extrusive igneous rocks. Other kinds of igneous rocks, however, intruded this sedimentary sequence.

GRANITES

The Caledonian Mountains were cored in many areas by large intrusive igneous bodies, commonly composed of pale coloured granite (Fig. 8). The Leinster Massif is intruded by several such bodies, including the largest exposed granite batholith in Britain and Ireland - the Leinster Granite. The southern end of this batholith appears in South Wexford as the Blackstairs Granite and its satellites. Other major granites in South Wexford on this map (Fig. 8) include the Saltees and Carnsore Granites, and the Ballynamuddagh Granite.

Sheared granite on the Saltee Islands

The typically pink, Saltees Granite forms the two Saltee Islands (Fig. 8) and is well exposed in the cliffs. It is also exposed, at low tide, along the outer foreshore south of Kilmore Quay. Compositionally, the Saltees Granite is a granodiorite. The granite is foliated because it was intruded into a shear zone while shearing was actively taking place. The southern margin of the Rosslare Complex became active again at about the same time as volcanic activity ceased in Leinster, developing into a sinistral shear zone towards the end of the Ordovician (Table 1). Xenoliths of the rocks into which the granite was emplaced fell into the granite magma during intrusion, and these were also cleaved and folded during the shearing. Intrusion of the Saltees Granite has been dated to about 436 million years ago.

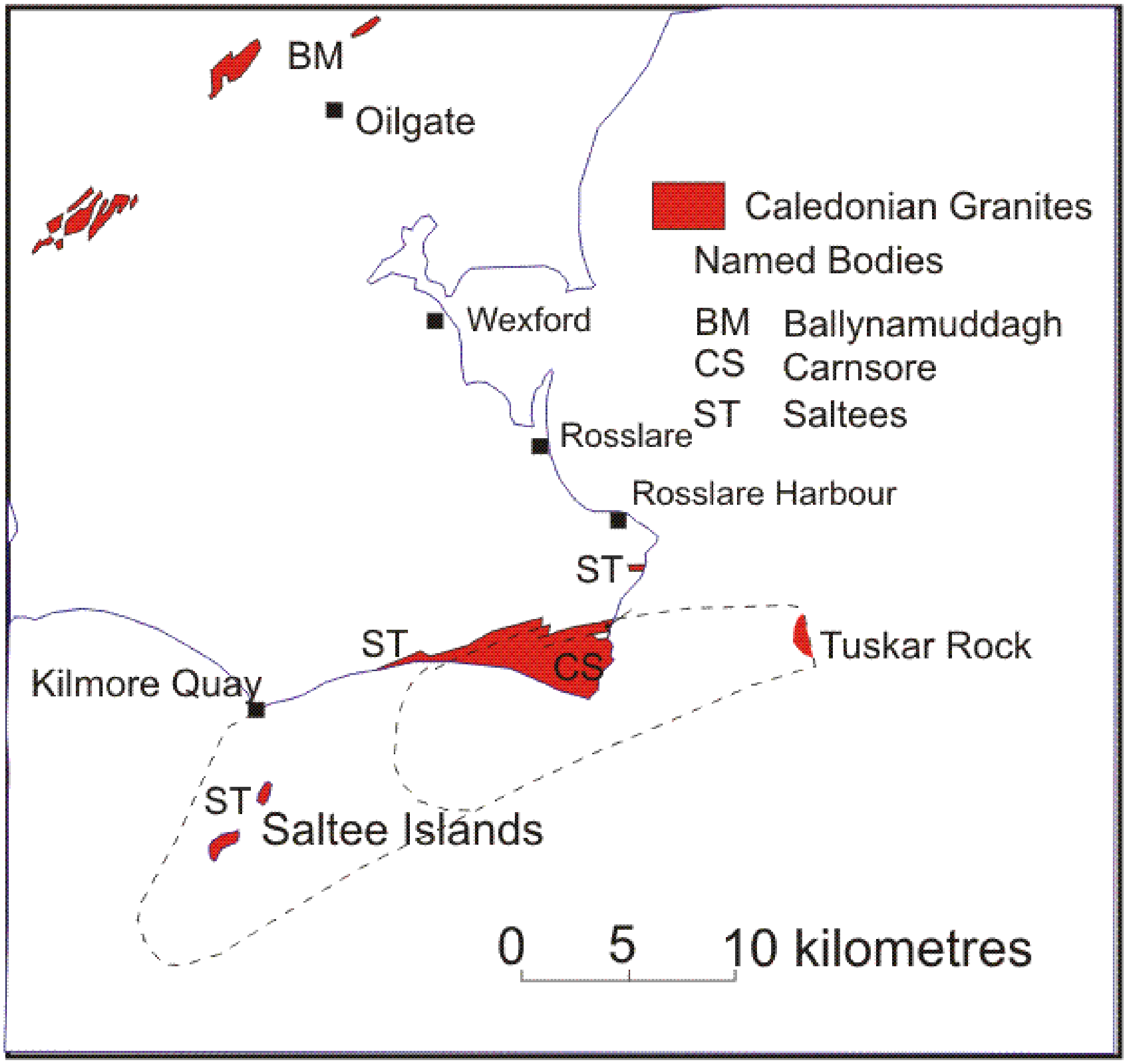


Figure 8. Caledonian Granites in south Wexford

Undeformed granite at Carnsore Point

Once shearing had ended along the southern margin of the Rosslare Complex, the Carnsore Granite was intruded across the shear zone about 430 million years ago. This undeformed, pink granite contains larger, 1 - 2 centimetres long crystals (megacrysts or phenocrysts) in a finer-grained matrix. It is only well exposed around Carnsore Point. The later basaltic dykes in the Rosslare Complex were also intruded during shearing, but after emplacement of the Saltees Granite, which they penetrate.

Little can be written about the contact metamorphic aureole of the composite Saltees-Carnsore Granite body because of the pre-existing medium to high regional metamorphic grade of the rocks they intruded. The presence of cordierite in metasediments and the chemistry of amphiboles in metabasalts from the Tuskar Group on offshore Tuskar Rocks suggest that temperatures of over 500 degrees Celsius were reached immediately adjacent to the Carnsore Granite. Onshore dolerite dykes in the Rosslare Complex which post-date the Saltees Granite but pre-date the Carnsore Granite are metamorphosed except along the shore around Rosslare Harbour. This suggests, though rather tentatively, that the Carnsore aureole extends towards but not much beyond Greenore Point.

The Ballynamuddagh Granite

The Ballynamuddagh Granite, which intrudes the Ballyhoge Formation east of Enniscorthy, is represented by several small granite bodies. Metamorphism around these granites also has produced shiny, micaceous phyllites in which andalusite and garnet have crystallised. These are surrounded by a swarm of rhyolitic dykes. Geophysical evidence suggests that, like the Blackstairs Granite, there is a much larger granite below the surface.

Granite bodies within the Duncannon Formation, south and south southeast of Enniscorthy, may be part of the Ballynamuddagh Granite too. These, and the presence of andalusite schists in the Cambrian Polldarrig Formation at Oilgate, suggest the existence of a granite up to 30 km long and 12 km wide below this area.

DYKES AND SILLS

A variety of mainly basaltic dykes and sills intrude the Precambrian to Ordovician rocks of the area.

Metadolerites

These represent metamorphosed dolerite dykes of two distinct ages - Cambrian and Ordovician (the earlier and later basaltic dykes of Table 1), which also generally have a northeasterly trend. They are best exposed on the coast and can be seen in the sections between Rosslare Harbour and St. Margaret’s House (near St. Iberius' Bridge). Larger sheets of gabbro and dolerite were injected into the Duncannon Group rocks as sills and they also have been metamorphosed, becoming metagabbros and metadolerites.

Appinites and Lamprophyres

A swarm of appinite and lamprophyre dykes at Kilmore Quay has been referred to in the literature, but its affiliation has been questioned and the dykes there may be metadolerites derived from dolerites now in various states of metamorphism and deformation.

Other dykes

Here are included acid and intermediate dykes, many of which probably relate to granite intrusion, as for example the swarm of rhyolitic dykes surrounding the Ballynamuddagh Granite.

UPPER PALAEOZOIC ROCKS

OLD RED SANDSTONES

Following the Caledonian mountain building episode at the end of the Silurian Period, when most of Leinster became land and the Lower Palaeozoic rocks were intruded by the Saltees and Carnsore Granites, the area was eroded rapidly under semi-desert conditions. Where there had once been an ocean (Iapetus) there was now a continental landmass covering much of northwest Europe. Fluviatile sediments, now identified as the Old Red Sandstone Facies, were deposited across the arid landscape The continent remained throughout the Devonian Period, from about 410 to 355 million years ago.

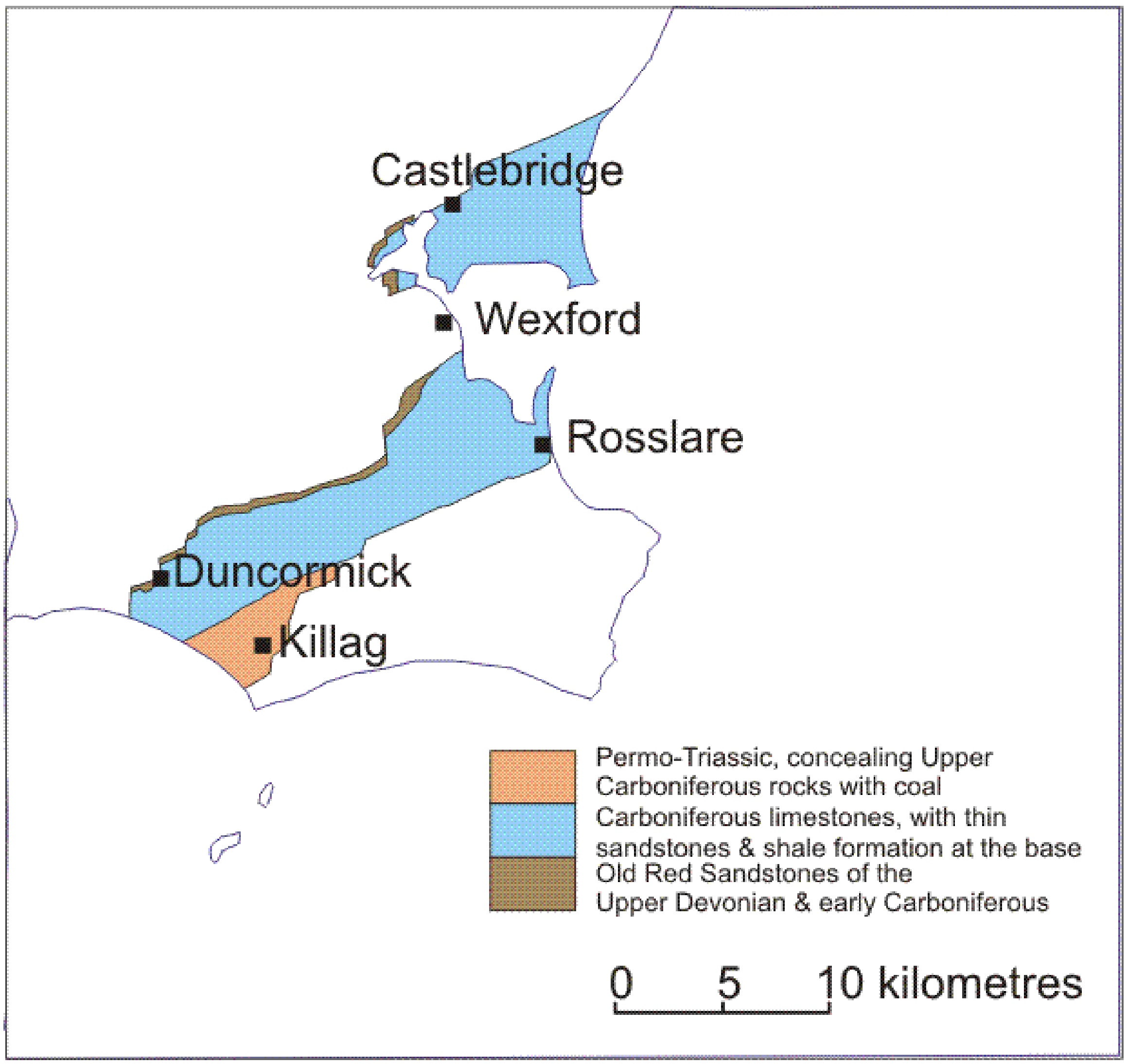


Figure 9. The outcrop of Upper Palaeozoic and post Palaeozoic rocks in south Wexford

On Sheet 77 only the uppermost part of the Upper Devonian Old Red Sandstone succession is preserved in a narrow strip between Duncormick and Wexford Town (Fig. 9).

Duncormick - Wexford Town

Rocks of Old Red Sandstone facies are found in a narrow strip along the north side of the Upper Palaeozoic outlier (Fig. 9). Fossil spores contained in them show that all of these rocks are of earliest Carboniferous age, unlike those at Hook Head (Sheet 76) where the Devonian-Carboniferous boundary is found close to the top of the Harrylock Formation. The Duncormick Formation is composed mostly of conglomerates with subsidiary siltstones, sandstones and mudstones. The base of the formation is seen to rest unconformably on rocks of Cambrian age at Milltown (Grid Ref. 10220 31600) (Cullenstown Formation). The formation however is poorly exposed and information is mostly derived from boreholes.

LOWER CARBONIFEROUS SANDSTONES AND SHALES

We have already noted that the earliest Carboniferous rocks in the southeast are of non-marine Old Red Sandstone fluviatile origin. Further southwest, however, in County Cork, marine sandstones and shales were being deposited in latest Devonian times. This marine incursion moved in a generally northerly direction to reach south County Wexford at a somewhat later time, demonstrated by both fossil spores and conodonts.

The first marine deposits in the area belong to the Porter's Gate Formation (about 40 m thick). This formation records a sequence of shallow water beach sandstones, tidally influenced sandstones and mudstones and the first shallow water limestones followed by sub-tidal mudstones. With increasing depth of water, and consequently less extreme conditions, came various shellfish (brachiopods, bivalves), other invertebrates (crinoids, corals) and fish.

It is clear from fossil dating that the sea moved relatively rapidly northwards during this first Carboniferous influx to cover much of the midlands.

CARBONIFEROUS LIMESTONES (Fig. 9)

As the early Carboniferous sea gradually advanced further northwards, so successive depth related sediments were deposited. At Hook Head (Sheet 76) and in the Duncormick-Wexford area, the predominantly clastic sediments of the Porter's Gate Formation were succeeded by an inter-bedded limestone and shale sequence deposited in deeper sub-tidal conditions.

Ballymartin Formation

The Ballymartin Formation comprises a succession of interbedded dark-grey muddy limestones and calcareous shaly mudstones. The formation is 70 m thick at Hook Head and thins to about 25 m near Wexford Town. The presence of so much mud indicates that a terrigenous source was still being eroded to supply the non-carbonate material. This source can probably be identified in the residual Leinster Massif, which had been a significant mountain chain in Devonian times, but which in Carboniferous times was gradually inundated by the sea.

Ballysteen Formation

The lower part of the Ballysteen Formation consists of well bedded relatively clean calcarenitic (sand grade) limestones. It passes gradationally up into finer grained and more muddy limestones. Some of the dolomitised limestones were originally oolitic, as the Bullockpark Bay Member at Hook Head, but they are difficult to identify except in thin section. The formation represents carbonate sands and gravels produced primarily from the disarticulated remains of crinoids and fragments of other calcareous shellfish and corals which lived in the warm tropical shallow sea. The Ballysteen Formation in the Duncormick - Wexford outlier is almost totally dolomitised.

Wexford Formation

The succession in the Duncormick - Wexford Outlier is quite different from any other part of the country. To begin with, deposition of the Ballysteen Formation (dolomitised) continued for a longer period of time, in place of the Waulsortian Limestones found to the northwest of Waterford City (Sheet 76).

In the Wexford area the Ballysteen Formation is gradationally overlain by fine-grained limestones (micrites) and dolomites and limestone breccias. For the most part these rocks are almost devoid of fossils except for the topmost beds seen, which are rich in corals and foraminifera. These limestones however, reveal abundant evidence of very shallow water conditions. Evidence of former evaporites in the succession indicates an environment not unlike the present day Persian Gulf. The formation is poorly exposed under a thick mantle of drift; most knowledge has been gleaned from the many exploration company boreholes drilled across the outlier by Pennaroya and Munster Base Metals (MBM) in the past forty years.

UPPER CARBONIFEROUS

Upper Carboniferous rocks are not exposed within the confines of the map sheet, but boreholes have encountered probable Namurian and definite Westphalian age rocks at considerable depth. These Upper Carboniferous rocks were found beneath a thick cover of Quaternary sediments blanketing a thick Permo-Triassic succession.

The "Namurian" Park Formation rests unconformably on the limestones of the Wexford Formation and comprises mostly fissile laminated dark-grey mudstones, commonly pyritic.

The Westphalian Richfield Formation comprises carbonaceous mudrock, thin sandstones and siltstones, grey mudrocks and near the lowest level encountered, a thin bituminous coal. Reworked fossil spores of Devonian and early Carboniferous age have been found, as well as fossil bivalves and conchostrachans, which show that these are the youngest coal measures found on land in Ireland (Westphalian C/D). The base of the formation was not reached, however, though it seems probable that the formation rests unconformably on older rocks with the likelihood that older coal measures are missing, by analogy with the Shrewsbury and Oxfordshire Coalfields of England.

THE VARISCAN OROGENY

Evidence for the Variscan Orogeny, which produced the striking fold mountains of West Cork and Kerry, is limited within the confines of Sheet 77. To the south of a line drawn between Dingle and Dungarvan, cleavage and large scale folds are developed; their axes trend approximately east northeast but swing to lie approximately east-west in the northeast. The Wexford sheet lies in a transitional zone where close folding gives way to gentle folding.

Later structural events

The most notable structural feature in South Wexford is the east northeast Caledonide trending Rosslare Fault. This strike parallel fault throws the Carboniferous Limestone succession against the Precambrian Rosslare Complex. Here some 2 km of vertical throw can be demonstrated. Movement on the fault, however, was probably mainly post Variscan, during the Permian Period and later, resulting in the fault bounded preservation of the Permo-Triassic Killag Formation

METAMORPHISM

These rocks are essentially unmetamorphosed with absence of recrystallisation, though changes due to heating have been recorded during studies of kerogen maturation using determinations of mean random reflectance of vitrinite, conodont and spore colour alteration, and spore fluorescence characteristics. Measurements have been made at only a few localities, but to the northwest of the map a greater degree of maturation (zone 4) contrasts with lower levels to the southeast (zone 2, Dunmore East, Hook Head (Sheet 76) and Wexford areas, and zone 1 (borehole into the hidden Richfield Formation southwest of Bridgetown). The maturation zones are based on a correlation of the various kerogen maturation indices, with the boundary between zones 1 and 2 representing the floor of the oil window: only rocks of zone 1 being possible oil source areas.

POST CARBONIFEROUS ROCKS

PERMO-TRIASSIC ROCKS

Although there are no Permo-Triassic rocks exposed on the map sheet, the same boreholes in which the Upper Carboniferous succession was discovered in the Duncormick area, also penetrated a 240 m thick succession of Permo-Triassic sandstones and conglomerates (Killag Formation). The Killag Formation is believed to be of Permo-Triassic age because of its continental origin and unconformable relationship with the underlying Carboniferous. It is most likely to be Triassic in age, as Triassic, but not Permian rocks, are known from offshore in the Celtic Sea Basin. The formation comprises a succession of red conglomerates, derived largely from the local Carboniferous Limestone and Precambrian Rosslare Complex, underlain by red sandstones and siltstones deposited in semi-arid conditions similar to those described for the Devonian Old Red Sandstone succession.

MESOZOIC AND TERTIARY ROCKS

There are no Mesozoic and Tertiary rocks found in the area covered by the map sheet (other than the Permo-Triassic Killag Formation). The majority of Ireland remained above sea-level from the beginning of the Permian Period until late Cretaceous times when most of the country was flooded by the chalk sea. This is demonstrated by the chalk, present in County Antrim, and at one small locality preserved near Killarney in County Kerry. Mesozoic and Tertiary rocks, however, are known to occur in basins off the south coast of Ireland where they have been encountered in drilling for oil and gas. Evidence in the extreme south of County Wexford suggests that the Upper Carboniferous Richfield Formation was buried beneath at least 2.5 km of cover, implying that Triassic and possibly younger rocks have since been removed by erosion.

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APPENDIX 1

Key Localities

It should be remembered that there is no right of access to examine rock outcrops on private land. Permission to cross private land or to enter a quarry should be obtained from the landowner.

PRECAMBRIAN AND LOWER PALAEOZOIC

Kilmore Quay (29650 10320)

This is the only extensive outcrop of the Precambrian Kilmore Quay Group, but is set within a late Caledonian shear zone. Quartzo-feldpathic gneisses alternate with thin semi-pelitic schist bands and occasional foliated amphibolite bands. Intruded granodiorite sheets give them a migmatitic appearance locally. The pervasive foliation is a mylonitic successor (end-Ordovician) to several earlier foliations: associated folds deform both the gneisses and the earlier (Cambrian) of two sets of metadolerite dykes. Some of the granodiorite sheets may be related to the Saltees Granite which was intruded during mylonitisation (visible at low tide east of the harbour).

Rosslare Harbour to Greenore Point (31280 11240 to 31530 11120)

Here, a near continuous section (interrupted by the harbour itself) of the foliated and banded amphibolites of the Greenore Point Group which show a variety of textures and structures are seen. Occasionally there are minor semi-pelitic schists.

Fault blocks of Tagoat Group sediments may be seen at low tide at two localities east of the harbour (31400 11200; 31440 11170). These include purple conglomerates of the lowermost Grahormack Formation and dark grey to black mudstones of the succeeding Milltown Formation.

St Helen's Harbour (31460 11970)

A near-continuous section across the 150 m thick, St Helen's metagabbro which occurs along the junction between the Greenore Point Group (exposed 100 m to the north) and the Kilmore Quay Group (exposed along the beach to the south) is seen. The gabbroic textures are cut at frequent intervals by ductile shear zones. Originally thought to be an undeformed relict of the gabbros from which the amphibolite was formed, some geologists now believe that it is a more recent intrusion (though neither margin has been seen in recent years).

Clammers Point to Cross Lake (28300 10650 to 28440 10680)

Grey-green, buff or purple greywacke sandstones & siltstones and interbedded grey-green or buff slates on Clammers Point (west of the entry into Kiln Bay) define the Kiln Bay Formation at its type locality. Downward-facing (in S_1 cleavage) greywackes & slates in the cliff (note flute casts on a greywacke bed in the cliff) mark an 85 m thick slump-inverted zone. An uppermost slump zone of folded and boudinaged greywackes in a slate matrix occurs on the outer wave-cut platform.

The Cross Lake Formation can be seen at the end of the wave-cut platform at low tide. A thinly interbanded, red and green slate unit at the base is succeeded by the lowermost of the quartzites which define the formation. Tight folding of the contact between the Kiln Bay Formation and the Cross Lake Formation can be seen from 400 m east of Kiln Bay to Cross Lake from which point the Cross lake Formation becomes severely disrupted by slumping (giving rise to lenses of quartzite in a slate matrix).

Cullenstown Strand to Ballymadder Point (28750 10780 to 28600 10740)

Green and occasionally purple metagreywackes of the Cullenstown Formation, exhibiting coarse to fine grading and occasional flute casts, are interbedded with laminated slates and siltstones. These lower greenschist facies metasediments are penetratively cleaved (S_1) and this cleavage is axial planar to tight or isoclinal F_1 folds. Rare F_2 folds with an associated S_2 cleavage as well as ubiquitous large-scale F_3 kink-folds are also present.

At the western end of the strand (Ballymadder Point) penetratively cleaved pale quartzitic and purple and grey pelitic schists containing a large lens of undeformed, massive quartzite represent the Shelmaliere Formation. The extreme deformation reflects their location at the centre of the Ballymadder Shear Zone.

Ferrycarrig Tower (30160 12330)

Tight F_1 folds are exposed in the Cullenstown Formation metagreywackes and pale green fine-grained quartzites (typical of the more proximal Cahore Group). Pale, highly cleaved quartzitic schists of the Shelmaliere Formation are visible in the north bank of the River Slaney just west of the bridge. South of the bridge a relatively new roadcut exposes a long section through metagreywackes of the Cullentra Formation. Two dolerite dykes (probably Ordovician) cut the deformed metagreywackes at the northern end of the west wall of the roadcut.

Shelmaliere Commons quarry (29860 12030)

The floor of the disused quarry is now flooded and the east side has been landscaped, though the red and green slates which formed its former east face (tightly folded with the quartzite on a large scale) may still be seen as float. The west face of the quarry stands as a thick wall, excavated on both sides. The west side of this wall is formed by the base of the lowest quartzite of the Shelmaliere Formation, which is steeply overturned here, and displays large-scale loaded flute casts. A quarry pool run-off channel at the southern end of the west wall shows the loaded base of this quartzite passing down through a purple phyllite (at the base of the Shelmaliere Formation) into penetratively cleaved metagreywackes of the Cullentra Formation.

APPENDIX 2

Corrections and new interpretation of the geology made to the map from 1:100,000 Sheet 23.

Object ID	
132	Loftusacre Mbr to Blackhall Formation (see Brück & Vanguestaine (2004)
187	Loftusacre Mbr to Blackhall Formation (see Brück & Vanguestaine (2004)
33	Correction - Unconformity dots changed to other side of line
340	Correction - Ballysteen Fm changed to Duncormick Fm
343	Correction - Duncormick Fm changed to Porter's Gate Fm
345	Correction - Porter's Gate Formation changed to Ballymartin Fm
321	Correction - Ballysteen Fm dolomitise changed to Ballysteen Fm
330	Correction - Ballysteen Fm changed to Ballysteen Fm dolomitise
339	
349	
253	Correction - Ballysteen Fm dolomitise changed to Ballysteen Fm
248	Correction - Ballysteen Fm changed to Ballysteen Fm dolomitised
94	Ballysteen Fm polygon split by two new faults interpolated due to rotary borehole WX-P-61 being interpreted as Wexford Fm (micrite breccia)