

FURTHER EVIDENCE FOR DEVONO-CARBONIFEROUS RIFTING IN CENTRAL IRELAND¹

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ABSTRACT

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Based on the body of available data it is argued that the Irish midland Devono-Carboniferous developed as a graben structure of the type currently exhibited at the Red Sea/African and Rhine upwarp systems. Evidence, both data-based and inferential, is drawn from studies of basement framework, regional Devono-Carboniferous stratigraphy and inferred palaeogeography, igneous geology, geophysical (gravity) patterns and known Irish Devono-Carboniferous fault systems. Examples of two of the latter are presented. This Irish central graben is argued to have developed in Late Devonian times along the axis of a crustal upwarp inferred to have resulted from plate collision during Late Ordovician to Early Devonian times. It is hypothesized that rifting may have been preceded by possible deepseated carbonatite intrusion along the upwarp axis, possibly coeval with and/or following intrusion of the Late Caledonian Irish granites. Carbonatite evidence may have been subsequently destroyed by intrusion of 'embryonic spreading centre' magmas, so providing a possible explanation for present day regional Irish gravity values. For reasons presently unknown this 'foetal' spreading centre failed, the rift filled and subsequent (Hercynian) overthrusting and crustal shortening has resulted in Irish regional geology as it is today.

INTRODUCTION

This note is intended to develop in more detail the evidence supporting the Early Carboniferous Irish rift previously postulated (DEENY, 1981-a,b). The evidence is drawn from regional studies of Devono-Carboniferous stratigraphy (and consequent palaeogeographic interpretation), geophysical (gravity) interpretation, igneous occurrences and inferences concerning known Irish fault systems.

PHILLIPS ET AL. (1976) have presented a synthesis of pre-Devonian Irish geology. In this the Iapetus suture (represented today by a weak regional gravity 'ridge') represents the junction between two continental crustal plates whose oblique collision occurred during Late Ordovician to Early Devonian times.

This collision probably produced a gross northeast to southwest trending zone of crustal upwarp (along the 'Iapetus upwarp axis', Fig. 1) whose southwestern extremity would

have 'followed' the collision point as it migrated southwestward. In this model the 'impact' of the plate collision would presumably have been decreasing as the collision phase drew to a close, so that gentle upwarp might be expected to become more evident with progression southwestwards along the upwarp axis. In the present view this might explain the general absence of sediments of Early to Middle Devonian age in the Irish central region (NAYLOR & SEVASTOPULO, 1980); i.e. along the 'Iapetus upwarp axis' (Fig. 1) and also, perhaps, the locally conformable Silurian-Devonian succession on the Dingle Peninsula (HORNE, 1974) at the southwestern extremity of the 'upwarp zone'.

It should be noted that crustal upwarps are among the features typically associated with plate edges in both the 'dying' (collisional) phases and 'embryonic' (intra continental rifting) phases of their existence (DEWEY & BURKE, 1974).

Irish Devono-Carboniferous stratigraphy has been summarised in terms of three areas, the Munster Basin Region, the Central Region and the Northern Region (NAYLOR & SEVASTOPULO, 1980). Until recently (DEENY, 1981-a,b; GARDINER & MC.CARTHY, 1981) the Central and Northern Regions had been considered palaeogeographically distinctive and

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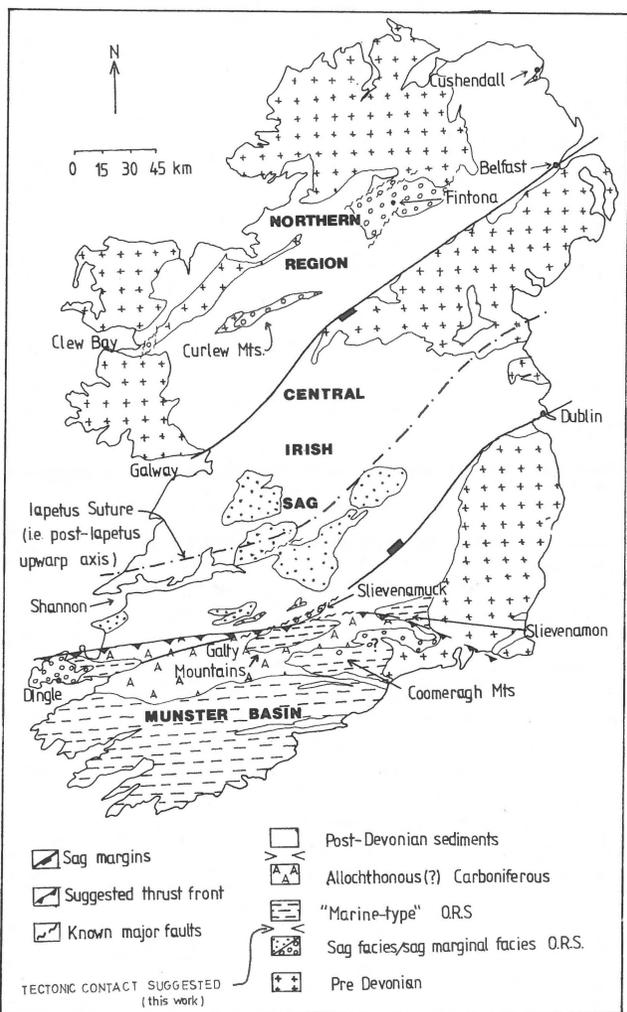


Fig. 1
An interpretation of Irish Devonian sedimentation. The Late Devonian 'central Irish sag' developed along the 'Post-Iapetus upward axis', i.e., the Iapetus suture of Phillips et al (1976). This sag was the first manifestation of rifting. Marine-type O.R.S. on the Dingle Peninsula is interpreted as a southerly derived thrust sheet resting upon in-place O.R.S. of the Dingle/ Caherbla Groups. See text for facies interpretation.

reasonably understood, whereas palaeogeographic interpretation and synthesis had long been uncertain and problematical for the Munster Basin Region (see below).

The northern margin of the Munster Basin (Fig. 1) is a zone of general geological discontinuity which stretches east-northeast from the Dingle Peninsula. South of this zone Devonian-Carboniferous geology differs markedly from the regime to the north. The south Munster Basin sediments are comparable with their European marine Devonian-Carboniferous equivalents. This, combined with their relatively intense deformation history suggests that they might be allochthonous, translated an unknown distance northward in the Hercynian orogeny. The Munster Basin region might then be a zone of considerable crustal shortening.

These considerations prompted me to review Irish

Devono-Carboniferous geology in terms of presumed separate basinal development for the northern and southern regions. Such new views have just recently been published (DEENY, 1981-a; GARDINER & MCCARTHY, 1981).

In the present synthesis the south Munster Basin is considered a separate geological province. Palaeogeographic evidence for the Carboniferous graben is thus derived from the Northern and Central Regions (NAYLOR & Sevastopulo, 1980) and from the northern margin of the Munster Basin Region.

A DEVONO-CARBONIFEROUS CENTRAL IRISH SAG

Evidence for a Devonian-Carboniferous central Irish sag (DEENY, 1981-a) is most clearly exhibited by early Carboniferous sediments but a review of Irish Devonian stratigraphy does provide some evidence that a terrestrial 'sag' may have existed in late Devonian times in the area where the Carboniferous graben is argued to have subsequently developed.

Fault controlled, coarse-grained intramontane (fan type) deposits prevailed during Middle to Late Devonian times in the area north of the Belfast-Galway line in Fig. 1 (CLAYTON ET AL., 1980). Outcrop areas are Clew Bay, Curlew Mountains, Fintona Block, Ballymaddock and Cushendall (GRAHAM, 1981). The Upper O.R.S.³, which in these areas generally consists of fluvial units, passes conformably into marine sediments of Dinantian age, suggesting that by end-Devonian times the rugged topography had been considerably eroded and that gentle submergence was occurring (NAYLOR & SEVASTOPULO, 1980).

Scree-type deposits are very much less evident in the Devonian of the Central region, suggesting that the topography was not nearly so rugged. COLTHURST (1978, p.101), in discussing the Devonian north of the Munster Basin has stated 'There is no evidence for local high ground and scree-type deposits are absent, suggesting that the area north of the Munster Basin was a virtually flat plain'.

This contrasts with evidence from the northern margin of the Munster Basin (GARDINER & HORNE, 1972; JACKSON, 1972; CAPEWELL, 1957) where piedmont fan and scree conglomerate occurrences at Dingle (the problematical Dingle/Caherbla Groups, see below), the Galty Mountains and the Coomeragh Mountains have fed considerable discussion as to their mechanism of formation (HORNE, 1977; GARDINER, 1975; DORAN ET AL., 1973; NAYLOR & JONES, 1967). What seems certain is that there was considerable topographic relief along parts, at least, of the northern margin of the Munster Basin during late Devonian times.

³ O.R.S.:—Old Red Sandstone, a continental facies of the Devonian which constitutes the bulk of Devonian stratigraphy in the central and northern British Isles.

Thus the present review suggests that in Late Devonian times the Irish Central Region was a flat, low-lying terrestrial plain, 'sandwiched' between zones of higher elevation and rugged relief ('sag marginal facies', Fig. 1) lying to the north and south respectively. This central Irish Late Devonian sag may have been the forerunner of the proposed Irish graben. Much further to the south (due to probable crustal shortening the distance may be much greater than present day outcrop locations indicate) lay a Devonian sea in which sediments of European marine-type character were being deposited.

In the southern and central regions the Irish Carboniferous is conformable with the Upper Devonian (NAYLOR & SEVASTOPULO, 1980). Prior to DEENY (1981-a,b) and GARDINER & MCCARTHY (1981) palaeogeographic interpretations (NAYLOR & SEVASTOPULO, 1980; MACDERMOT & SEVASTOPULO, 1972; SEVASTOPULO, 1979) were agreed that the Early Carboniferous marine 'transgression' progressed relatively smoothly and quickly from the southern province onto the 'shelf' area of the Central Region where a shoreline (the Dublin-Galway line of SEVASTOPULO, 1979) developed in Middle Tournaisian times. The southern shelf edge at this time was considered to have lain in the vicinity of the Dingle - Galty Mountains zone where there occurs a sudden northward thinning of sediments deposited in pre-Middle Tournaisian times (MACDERMOT & SEVASTOPULO, 1972, SEVASTOPULO, 1979).

Other interpretations are possible. The Irish Carboniferous may have developed in two separate basins (GARDINER & MCCARTHY, 1981) separated by a positive 'ridge' which may have existed in the Dingle - Galty Mountains - southwestern Leinster massif zone in Late Devonian and early Tournaisian times. The cited authors (*ibid.*) suggested submergence of this ridge to explain Late Devonian facies and conformable transition to marine Carboniferous evidenced by sediments in the area. I like to argue that the ridge was not submerged during the Devonian-Carboniferous time interval. A prediction of the latter hypothesis is that any exposures of marine Devonian which might occur in the area must be allochthonous. Devonian exposures at Dingle and at the Galty Mountains - Slievenamuck range are important in this respect.

On the Dingle Peninsula the much investigated but still enigmatic Dingle/Caherbla Groups (CAPEWELL, 1965; 1975; NAYLOR & JONES, 1967; HORNE, 1970; GARDINER & HORNE, 1972; HORNE, 1974; GARDINER, 1975) are overlain, apparently unconformably, by a typical Munster Basin O.R.S. succession. However, the Dingle Group is locally conformable with Ludlow strata and commonly shows typical O.R.S. facies characteristics. Palynological evidence (VAN DER ZWAN, 1980) suggests that part of it is of Devonian age. In view of their combined thickness (2300m), conformability (of the Dingle Group) with Upper Silurian, and general stratigraphic properties, the Dingle/Caherbla Groups could represent a reasonably full record of sedimentation at the southern margin of the previously postulated central Irish sag. Their lithostratigraphic correlation with the O.R.S. of the northern Region has been the subject of considerable investigation (C.H. HOLLAND, pers. comm. 1982). The middle and upper parts of the

Dingle Group and the succeeding Caherbla Group indicate conditions similar to those which prevailed at the northern margin of the sag during late Devonian times; i.e. topographically positive and syntectonically active volcanic regions with (probably) an abundance of active fault scarps/cliff faces. This description would fit practically any present day site of active intra-continental rifting and such is the terrestrial environment envisaged here for central Ireland in Late Devonian times.

The typical Munster Basin O.R.S. succession which overlies the Dingle/Caherbla Groups constitutes a serious problem in this interpretation. 'Standard' interpretations consider this stratigraphic contact 'a classic angular unconformity of text book type' (R.R. HORNE, pers. comm. 1982). No evidence for low angle thrusting has been recorded and such should exist if the overlying O.R.S. is allochthonous (as required in the present interpretation). I am forced to consider *this* an enigma rather than accept the 'standard' interpretations which, because of the absence of a credible correlation between the Dingle/Caherbla Groups and any part of the (presently) adjacent Munster Basin succession, tend to relegate this considerable stratigraphic thickness (i.e. of the Dingle/Caherbla Groups) to the domain of the enigmatic.

GARDINER & MCCARTHY (1981) have drawn attention to a geological situation in the Slievenamuck range which I consider analogous to that described above for the Dingle Peninsula. A palaeogeographic interpretation similar to that just described for the Dingle Peninsula is possible here also.

Further to the northeast the Devonian geology is buried beneath younger sediments.

The concept of separate basinal development is attractive when applied to the Irish Carboniferous. It provides a satisfying explanation for at least one major regional facies peculiarity which developed in the Tournaisian and continued through the Visean. The wide late Tournaisian Irish 'shelf' sea was dominated by a basinal feature highlighted now by facies distribution and sediment thickness and bordering the positive Leinster 'high' to the southeast (MACDERMOT & SEVASTOPULO, 1972; SEVASTOPULO, 1979) (Fig. 2). This negative element coincides with the late Devonian central Irish sag and could represent a rift-controlled sedimentary trough which developed by rifting in the late Devonian (thus explaining the Middle and Late Devonian tectonism of the north Munster Basin and northern Regions as noted in NAYLOR & SEVASTOPULO, (1980)). Later, in the Early Carboniferous, a period of minor regional tectonism (MACDERMOT & SEVASTOPULO, 1972) coincided with the commencement of a Visean overstep, progressing northwestward and southeastward from this central basinal region (DEENY, 1981-a,b). The latter author has suggested that this tectonism could be ascribed to Tournaisian rifting in the Irish graben (*ibid.*) and its coincidence with the onset of the Visean 'transgression' is significant. The graben sea may have 'overflowed', due possibly, to a stepback in the position of one or both graben margins beginning at that time.

IGNEOUS EVIDENCE

The marked association of alkaline basic igneous rocks with both 'embryonic' (intra-continental rifting) and 'dying' (continental collisional) plate edges has been noted (DEWEY & BURKE, 1974). Their occurrence in the Northumberland (LEEDER, 1974) and Shannon (MACDERMOT & SEVASTOPULO, 1972) Basins have been invoked to support the postulated position of the Iapetus suture (PHILLIPS ET AL., 1976). The present synthesis envisages the Devonian-Carboniferous central Irish rift as a possible manifestation of 'attempted separation' of two crustal plates along the Iapetus suture line of weakness. Thus, the Shannon Basin volcanics (MACDERMOT & SEVASTOPULO, 1972) are associated, in the present interpretation, with the end-Tournaisian rifting episode previously discussed. It is possible (see below) that plate edge igneous activity continued until at least end-Tournaisian times along the Iapetus suture. (It should be noted in the context of postulated rifting that endemicity of volcanic or plutonic

evidence is not a pre-requisite for indicating rift tectonism; e.g. in the upper Rhine rift the paucity of volcanics has been related to possible tightness of seal on rift marginal faults during periods of fault inactivity (HOLMES, 1965, p.1051)).

The Shannon Basin volcanics constitute extrusives located principally in the Limerick area (Fig. 2). Olivine basalts, trachybasalts, trachyandesites and trachytes were extruded in early Viséan times from a large number of small vents (ASHBY, 1939). At one of these centres STROGEN (1973) noted that hydromagmatic and gaseous explosive activity occurred. He also noted an occurrence of primary calcite in vesicles and as post-pyroxene pseudomorphs in a basalt from the uppermost flow in the area in question. WILLIAMS (1956) has shown that such igneous lithologies can result from differentiation in a nephelinitic magma (derived by segregation of pyroxenes and plagioclase in an original 'basaltic' primary magma), if the differentiation process results in the removal of iron-rich alvikitic carbonatite from the nephelinitic magma. Such a process he argued, would be favoured in the more stable inter-rift blocks of a given rift system.

In HOLMES (1965) much significance is attached to the occurrence of warm, CO₂-rich springs at the Rhine and African rift-upwarp systems. These springs are ascribed to the release of vast quantities of CO₂ concomitant with the intrusion of carbonatite. This is accompanied by desilicification of adjacent country rock, silicification increasing distal to the zones of intrusion where the upwarp peripheries are generally granites and gneisses of the crystalline basement. DAWSON (1962) and ILLIES (1977) note such hinterland geology at the African and Rhine systems, respectively.

A 'fossilised' parallel may exist in Ireland. BROWN (1979) has commented on the problems of genesis of the Late Caledonian (Early Lower Devonian) British and Irish granites which were emplaced in a non-subducting tensional environment. In the present view the Irish granites are located at the margins of the post-Iapetus upwarp axis and distal to the zone of later, rift related alkaline igneous activity. The magmatic processes which the latter represents were certainly initiated by Late Devonian times (at least, see below), so that the Iapetus suture zone continued to act as an igneous 'hot' zone, long after the closure of the Iapetus ocean at the end of the Silurian.

There are warm springs in Ireland. Those familiar with Irish midlands 6" Ordnance Survey sheets know the commonly occurring annotation 'Spa Well'. Work on these springs is at a preliminary stage but it is known that some, at least, contain unidentified gas or gases (ALDWELL & BURDON, 1980). If these springs are true analogues of their Rhine/African 'counterparts', then they represent fossil relicts of ancient rifting in central Ireland and their constitution and composition will doubtless reflect the vagaries of time and geological processes.

In Late Devonian times volcanoes were active at the northern and southern margins of the central Irish sag. In the Fintona area (Fig. 1) lavas were chiefly andesitic (CHARLES-

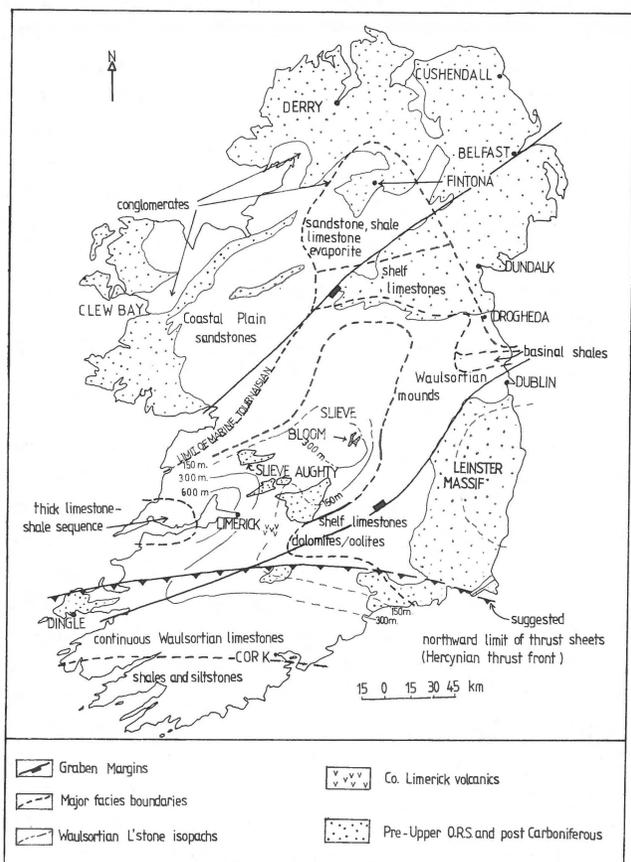


Fig. 2 The relationship of Late Tournaisian facies to the postulated Irish Carboniferous graben. The Irish 'shelf sea' negative element is clearly illustrated by the 150 m isopach for Waulsortian limestone north of the southern graben margin. This negative element is also clearly recognisable in Viséan facies distribution. South of the suggested Hercynian thrust front true facies relationships are obscured by allochthons. (Based on Macdermot & Sevastopulo, 1972).

WORTH, 1963) and shard-textured contemporaneous rhyolitic volcanics are recorded in the Devonian of the Clew Bay region (GRAHAM, 1981) at the northern margin of the sag. R.R. HORNE (pers. comm., 1982) notes the occurrence of a 2 m thick unspecified tuff in the upper part of the Dingle Group on the Dingle Peninsula at the sag's southern margin.

Thus the present author argues for the existence of a central Irish Devonian-Carboniferous rift which may have developed along the Iapetus suture (PHILLIPS ET AL., 1976) 'upwarp axis'. No carbonatites have to date been reported in the Irish graben. This could be a function of erosion – either they have been 'eroded out', or alternatively erosion has not yet reached their level. Alkaline igneous rocks characteristic of known carbonatite localities are certainly well represented in the Irish graben. If the Late Caledonian Irish plutons, mainly granites (KENNAN, 1979), are the igneous analogues of the African and European rift/upwarp marginal granites/gneisses then carbonatites may certainly have been intruded along the Irish graben's axis before and/or during its history. Subsequent events (see below) may, however, have destroyed most or all of the evidence of their intrusion.

The above speculation involves crustal evolution processes which are still little understood and suggests that the Iapetus suture zone (PHILLIPS ET AL., 1976) possesses a significance still only partially appreciated.

GRAVITY EVIDENCE

The Irish graben idea was first conceived while I studied the geology of the Red Sea area as presented by GASS (1980). The Red Sea evolved from its first manifestation as a rift or sag (COLEMAN, 1974) in Miocene times. Because of its extensively developed sulphide deposits (TINSLEY, 1973) and the considerations outlined previously (this paper), the Irish graben is here considered the geological analogue of this Miocene rift.

This consideration is important from the geophysical viewpoint. During its evolution the Red Sea area's geophysical expression presumably has changed from negative gravity values characteristic of density deficiency at ensialic graben structures – as the Miocene rift undoubtedly was (COLEMAN, 1974) – to the present day positive anomaly characteristic of increased density, due to basic intrusives, at oceanic spreading centres (GARSON & KRS, 1976). If the Irish graben was a transitory manifestation of 'attempted separation' of two crustal plates then its expected initial negative gravity response might have been subsequently contaminated by a positive influence, caused perhaps, by concealed basic intrusives which should be located along the graben's axis. If such basic intrusives existed they would represent the frozen 'foetus' of an embryonic spreading centre, an embryo which never developed to the birth phase. Irish regional gravity has been studied with these concepts in mind.

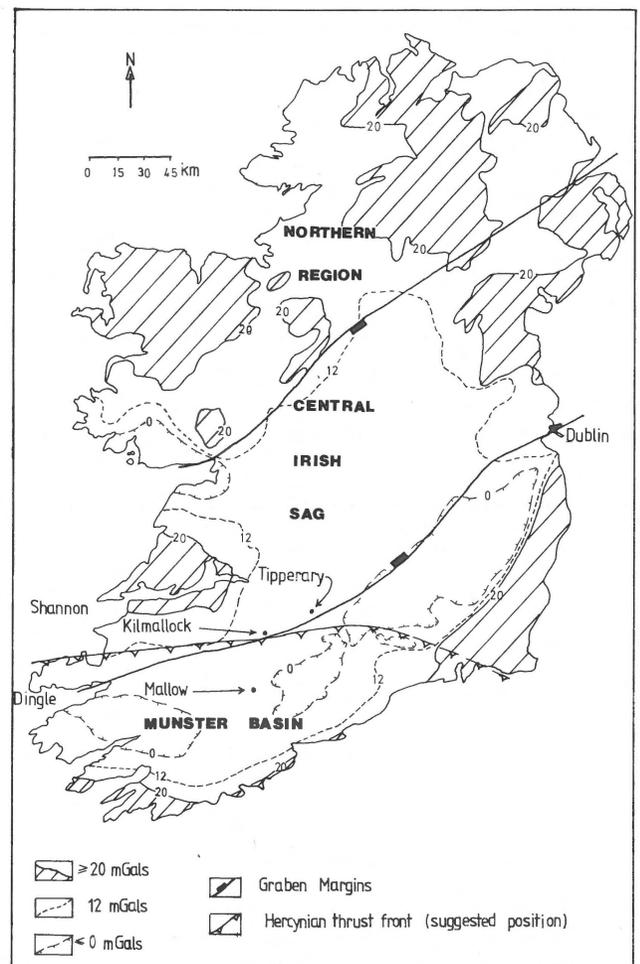


Fig. 3 Irish regional gravity (based on Atlas of the Royal Irish Academy Haughton et al 1979) and the postulated rift margins and suggested Hercynian thrust front.

The end-Tournaisian graben margins, the 0, 12, and 20 mgal gravity contours and the presently suggested Hercynian thrust front location are illustrated in Fig. 3. The northwest foreland (pre-Carboniferous) gravity 'signature' is amply illustrated by the 20 mgal contours in the northwest as is the pre-Carboniferous Leinster topographic 'high' by the 0 mgal contours in the southeast. The latter feature constituted the southern graben margin in Devonian-Carboniferous times and, being a granite batholith of low relative density, its presence 'obliterates' any positive gravity signature of the type which would be expected according to classic examples of rift geophysics (HOLMES, 1965).

The 0 mgal contours produce a well defined lineament (the South Ireland Lineament of GARDINER, 1978) from Dublin to Tipperary. This trend breaks up somewhat in the Kilmallock area but can be grossly traced southwestward to Dingle. The Kilmallock – Mallow – Dingle 'triangle' is a zone of gravity confusion; gravity trends interfere and this supports the hypothesis that in this area the southern graben margin

(represented by the Dublin – Tipperary lineament) has been buried beneath southerly derived (Hercynian) allochthons.

The Shannon gravity anomaly provides geophysical support for the ideas outlined at the beginning of this section; it could represent buried basic intrusives of the types characteristic of spreading centres – a ‘frozen oceanic spreading centre embryo’. In this view, the post-collisional crustal upwarp-related, and previously existing buried carbonatite plutons (previous section) would have been wholly or partially replaced by embryonic spreading centre basic intrusives that are currently beneath the Shannon gravity anomaly. The comments made at the end of the section ‘Igneous Evidence’ apply here also.

Northern English (LEEDER, 1974; JOHNSON, 1959) and east

central Irish (NAYLOR & SEVASTOPULO, 1980; MACDERMOT & SEVASTOPULO, 1972; GARDINER & MCGARTHY 1981; SEVASTOPULO, 1979) geology demand that the postulated central Irish Devonian-Carboniferous graben must have been shallowing and constricting towards the northeast. Syndepositional tectonism and horst/basinal features are indicated by all the cited works. Gravity evidence (Fig. 3) and isopachs (Fig. 2; BENNISON & WRIGHT, 1969, p. 199) support the hypothesis.

In view of the foregoing it is here suggested that Irish regional gravity patterns may be interpreted to be in evidence of the postulated Irish central Devonian-Carboniferous rift. This rift ultimately had reached the stage of an embryonic oceanic spreading centre (no such stage is operational anywhere today) before terminating activity for reasons presently unknown.

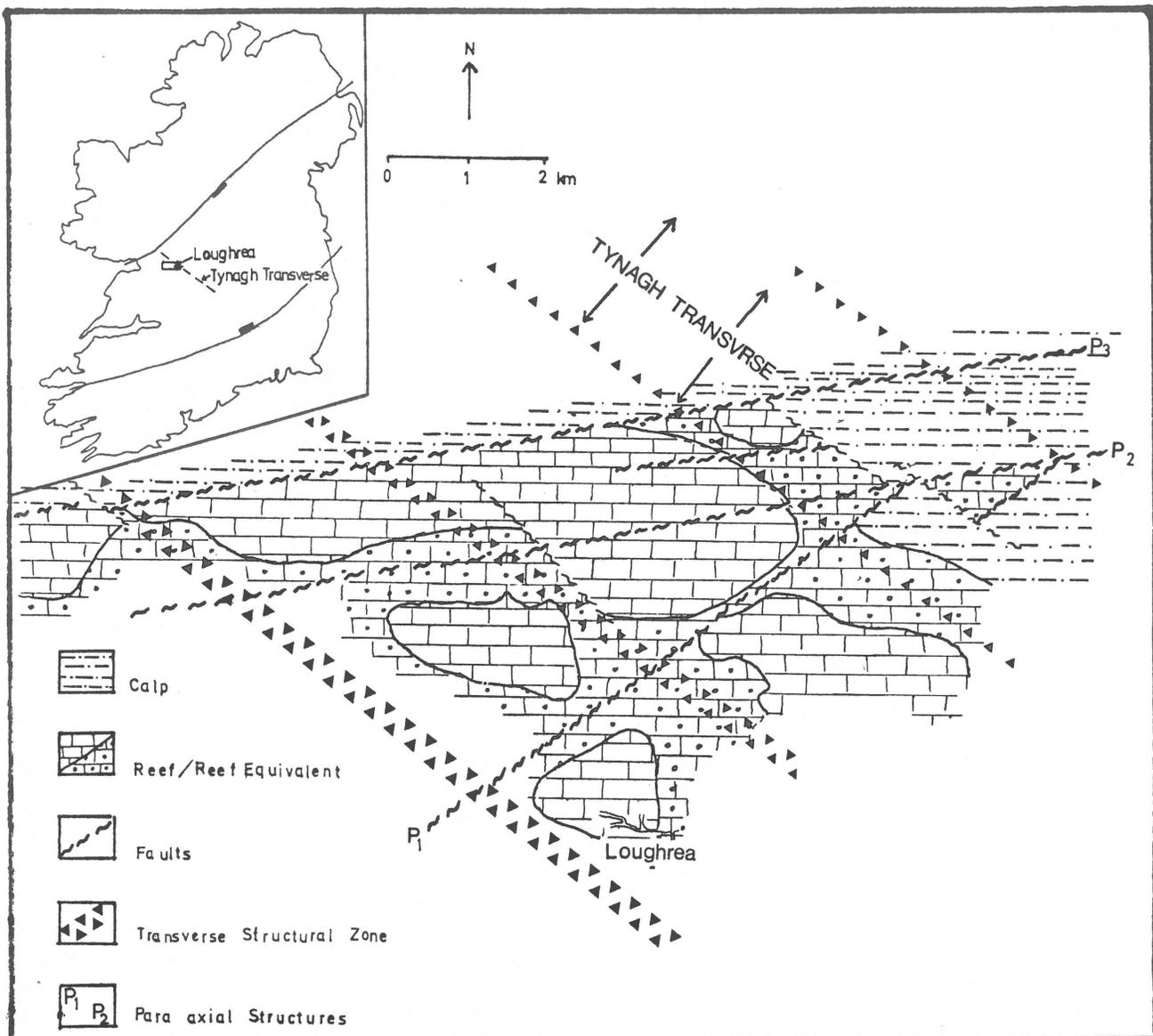


Fig. 4
 Geology of the northern margin of the Slieve Aughty ‘horst’ (see text). The para-axial structures are considered to be horst-marginal faults bounding the northern margin of the Slieve Aughty ‘horst’ (located 3 km south of Loughrea). Note the relationship of ‘Reef/Reef-equivalent’ (Waulsortian bank/off-bank) contacts to the para-axial/transverse structures.

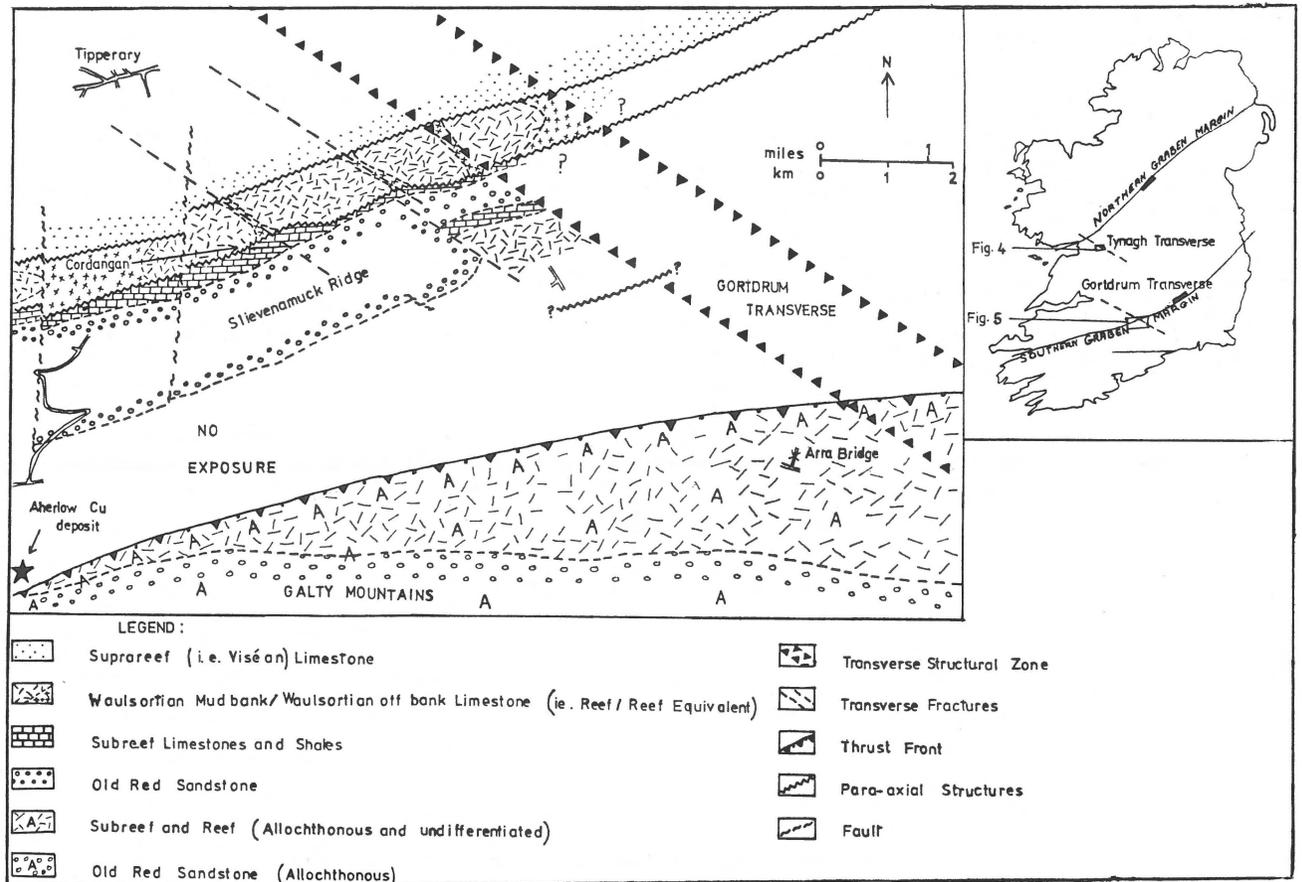


Fig. 5

The geology of the north Galty mountains-Slievenamuck area on the southern graben margin south of Tipperary town. Allochthonous (inferred) marine type Devonian-Carboniferous rests upon the in-place geology south of the suggested thrust front. North of this sediments represent deposition at the southern graben margin.

REGIONAL GEOLOGICAL EVIDENCE

If the graben hypothesis is correct there should exist in Ireland a system of northeast trending faults that were active during or shortly after deposition in the graben. Such is the case at the Tynagh (DERRY ET AL., 1965), Silvermines (TAYLOR & ANDREW, 1978) and Navan (ANDREW & ASHTON, 1981) ore deposits. Regionally, there is abundant lithological evidence that such a system exists (MACDERMOT & SEVASTOPULO, 1972; GARDINER, 1975; SEVASTOPULO, 1979; NAYLOR & SEVASTOPULO, 1980; GARDINER & MCCARTHY, 1981). This is particularly so for areas floored by Carboniferous deposits adjacent to inliers.

Geological interpretations of two such areas are depicted in Figs. 4 and 5.

Fig. 4 represents an area just north of the Slieve Aughty 'horst' (inliers within the graben limits are considered palaeographic horsts in this interpretation). Fig. 5 is an area at the graben's southern margin on the northern flank of the Galty mountains. In both areas control on para-axial structures (rift-type or graben-marginal faults, DEENY, 1981-a,b) is primarily topographic supported by wallrock, float, and

occasional exposures. The fault at Cordangan (Fig. 5, labelled 'para-axial') has been proven by exploration diamond drilling (Oliver Prospecting Ltd.) These para-axial structural zones are characterised by abundant occurrences of lithified breccias of obvious Carboniferous age. Widely varying sedimentological energy regimes are occasionally indicated by fossil debris component size. Facies boundaries (i.e. Waulsortian bank/off-bank) commonly trend parallel to the paraxials.

Fig. 5 is interesting in that it depicts a geological situation analogous to that proposed previously concerning the Dingle/Caherbla Groups (HORNE, 1974). In Fig. 5 the Galty mountains (O.R.S.) and the expanse of Carboniferous immediately to the north are inferred to be part of a southerly derived thrust sheet which now rests upon in situ (?) Devonian-Carboniferous as exposed in the Slievenamuck range (MAHBUB-I-KHUDA, 1953; SHELFORD, 1963) and proven by drilling in the Glen of Aherlow (at the Aherlow Cu deposit, Fig. 5; CAMERON & ROMER, 1975). 1 km south of the inferred thrust subcrop (there is no exposure on the intervening ground) near Arra bridge, Carboniferous exposure exhibits a well developed cleavage but is otherwise indistinguishable from Carboni-

Table I
The geological history of the Irish central rift.

TIME	EVENT	COMMENT	RIFT ASSOC. EVENTS
Late Ordovician to early Devonian	'Iapetus Plates' collision	Consequent upwarp and denudation. No Lower Devonian sedimentation along upwarp zone except towards southwest	Commencement of Late Caledonian granite intrusions. \pm Carbonatites along Iapetus suture?
early to middle Devonian	Upwarp – erosion	No sedimentary record. Gentle emergence in southwest	Carbonatite intrusions along upwarp axis?
Late Devonian and Courcayan	O.R.S./Tournaisian sedimentation	Gentle subsidence along Iapetus suture axis. Rugged relief, conglomerate-based fining upward sequences along northern and southern graben margins	Volcanism and assoc. 'syntectonic' movements
Late Courcayan and early Chadian	Mid-Dinantian regional tectonism	Development of Waulsortian bank/off-bank facies, regional 'minor' tectonism; coincidental northwestward/southeastward Visean overstep, volcanism and sulphide deposition	Main rifting episode Rift marginal ('shelf') and rift axial (basinal) facies develop. Basic intrusions (spreading centre type) on rift axis?
Chadian to Brigantian	Visean sedimentation	Continuous marine sedimentation along the Irish central graben	Marginal and axial facies; Minor local fault activity
(Holkerian)	First deltaic incursion	First evidence of freshwater sedimentary influence (Mullaghmore Sandstone)	Rift phase ending; Trough begins to fill
Namurian and Westphalian	Freshwater estuarine and deltaic sedimentation	Freshwater sedimentary influence progresses towards 'basinal' regions from north and southwest	The rift fills
End Westphalian to Permian	Hercynian Orogeny	Thrusting and considerable crustal shortening south of the graben producing present day juxtaposition of 'the graben province' and European-type marine Devonian-Carboniferous of the Munster Basin	

CARBONIFEROUS

ferous north of the thrust. The thrust itself is an eastward strike projection of the well known Aherlow Thrust (MAHBUBI-KHUDA, 1953; SHELFORD, 1963). Thus the (probable) in-place O.R.S. of the Slievenamuck range (like the Dingle/Caherbla Groups, representing the southern graben margin) is probably the only true indicator of underlying Devonian geology in the area. The northwest-trending structure/facies zones in Figs. 4 and 5 are inferred transverse structures (DEENY, 1981 a,b), here considered intrinsic to the Irish graben. They are not here utilised as evidence for the graben's former existence (DEENY, in prep.). Their deletion from the figures would be a sacrifice of strict geological interpretational integrity.

SUMMARY AND CONCLUSIONS

The present work argues that the Irish midlands basin represents the northeasterly end of a Devonian-Carboniferous rift which, in Carboniferous times, was both shallowing and constricting in the direction of the Southern Uplands/Northumberland Trough region of the British Isles. It has been argued that this rift may have been the culmination of a period of tectonism and intrusive activity which may have been initiated during the closing stages of the Iapetus Ocean's history. The climax of Devonian-Carboniferous rifting may

have been intrusion of basic magmas of oceanic spreading centre type, currently concealed possibly, beneath the positive gravity anomaly of the Shannon region. Why this 'embryonic spreading centre' subsequently failed is not known.

This synthesis has been compiled from studies of basement framework, Devonian-Carboniferous stratigraphy, facies, inferred palaeogeography, igneous evidence, geophysical (gravity) interpretation, and inferences concerning known regional fault systems. It argues (in partial parallel with GARDINER & MCGARTHY, 1981) that the Irish Devonian-Carboniferous developed in two separate sedimentary basins which, because of later (Hercynian) extensive thrusting and crustal shortening, now present an illusive picture of apparent uniformity; i.e. as the basin and shelf of a single Devonian-Carboniferous sea. Because of overthrusting it is difficult to unravel the separate evolutionary histories of the two, originally at least, separate basins. It is envisaged that the Irish graben continued as a separate entity possibly throughout Visean times and that that the deltaic incursions of the Namurian (CHARLESWORTH, 1963) heralded the termination of the Irish central rift as a marine province – the graben 'silted up'. A summary of the suggested geological history of the Irish central graben is presented in Table I.

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