

STRUCTURAL NOMENCLATURE

PORCUPINE GOBAN REGION

PSG Project P00/1

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STRUCTURAL NOMENCLATURE: PORCUPINE GOBAN REGION

1. INTRODUCTION

This project has been carried out as Project P00/1 for the Porcupine Studies Group (PSG) within the Petroleum Infrastructure Programme. Technical direction was given by the PSG Management Committee.

The principal aim of the project was to examine the available seismic data and to propose a formal and agreed structural nomenclature for the Porcupine Basin-Goban Spur region. A number of major structures in the region have been identified in previous work by research institutions and oil industry exploration. These, together with additional structures recognized during the project, need to be formally defined and named to avoid misunderstanding and to prevent a proliferation of names. The area covered by the study was within 11°00'W (west coast of Ireland) to 15°00'W (excluding the Celtic Sea Basins) and 48°30'N to 54°00'N. Part of the project comprised a desk study review of published information and of previously named features. An earlier study of the Rockall Basin, carried out as Project 97/3 for the Rockall Studies Group and published as PAD Special Publication 1/99 (Naylor *et al.* 1999), included the Porcupine Basin within the mapped area. Although the Porcupine Basin was peripheral to the main aims of the Rockall project, a number of structural features in the basin were shown on Enclosure 1 of Special Publication 1/99, taken largely from published sources. The current project has produced considerable amendment in the Porcupine area to the version shown on the earlier map. The limits of the present map (Enclosure 1) have been extended to overlap with that of the Rockall project (Naylor *et al.* 1999 Enclosure 1), and the details of the Slyne Basin and of the east Rockall margin have been carried over from the earlier work.

The main part of the Porcupine-Goban project has involved a review of seismic data, mainly from a number of speculative seismic programmes. From these datasets, key seismic lines which display the main structural elements were selected for interpretation. The PAD facilitated the project by providing access to the seismic data, including older proprietary programmes, together with data for a number of exploration wells which tied to the selected lines. The authors have reviewed in excess of 40,000 km of reflection seismic lines and have carried out independent interpretation of the selected lines. This process resulted in the preparation of working geoseismic sections and map, submitted for discussion to PSG Workshops in December 2000, March 2001 and July 2001. Interpretation of additional seismic lines, together with suggested amendments and editing arising from the Workshop discussions, was then undertaken. The results of a gravity and magnetic study, carried out by Paterson, Grant & Watson Ltd. as PSG project P00/4, were briefly reviewed in conjunction with the interpretation and mapping work with a view to constraining major structural features and trends.

The compilation and interpretation work on the project has been carried out by Dr D. Naylor of ERA-Maptec Ltd and Professor P.M. Shannon of University College Dublin. Members of ERA-Maptec GIS/cartographic staff (E. Vaughan, M. Bassett & S. O'Reilly) produced the base maps, and the final map, diagrams and geoseismic sections. The report is accompanied by a map showing the major structural zones and elements (Enclosure 1) and a series of geoseismic sections which serve to illustrate and act as type sections for the features (Enclosure 2). The locations of the geoseismic sections are shown on Enclosure 1 & the inset to Enclosure 2. A description of each of the named structural features is given later in the report. As discussed below, many of the boundaries are structurally complex and have been simplified on the map. Detailed fault mapping has not been attempted in this regional project.

Thanks are due to Fugro-Geoteam, NOPEC – Western Geophysical, and Spectrum Energy (Seitel International) for permission to use non-exclusive seismic data in the compilation of the report, the map and the geoseismic sections, and to the PAD for facilitating access to well and seismic data.

2. REGIONAL SETTING

The continental shelf west of Ireland extends out more than 300 km in many places, particularly in the region of the Rockall Plateau. South of the Goban Spur (Enclosure 1 inset), the continental edge curves eastwards, and the continental slope is cut by deep canyons. The Goban Spur is a remote plateau area on the continental margin some 250 km southwest of Ireland and south of the Porcupine Basin.

Bathymetrically the Goban Spur comprises a smooth platform sloping gently westwards away from the Celtic Shelf to depths of 2000 m at the margin (GEBCO 1978, inset to Enclosure 1). North of the Goban Spur the foot of the continental slope swings out westwards from Ireland around the Rockall Plateau. The Porcupine Seabight and Rockall Trough are deep water embayments within the shelf which separate a number of higher plateau areas. Porcupine Seabight is a large (320 x 240 km) north-south trending deep water area which opens southwestwards onto the Porcupine Abyssal Plain. Water depths increase from about 350 m in the north of the Seabight to more than 4 km in the south. The Seabight is bounded on three sides by bathymetrically shallow platforms (Fig. 1). The Irish Mainland Shelf lies to the east, the Slyne Ridge to the north, whilst the western boundary is formed by the Porcupine Ridge, extending southwards from Porcupine Bank. The existence of Mesozoic and older rock units on the Irish Atlantic margin was first indicated by the dredge samples reported by Cole & Crook (1910).

A number of Late Palaeozoic to Tertiary sedimentary basins extend along the western seaboard of Ireland (Figure 1). These follow a general NNE-SSW trend and form part of a chain of structurally-linked basins that extend from mid Norway to west of Iberia (Doré *et al.* 1997a,b). Within the Irish sector a band of narrow (inboard) basins, including the Slyne and Erris basins, lie landward of a set of larger (outboard) basins that include the Rockall, Hatton and Porcupine basins. A number of small, elongate, probably early Mesozoic basins are located in the footwalls of the Rockall Basin (Naylor *et al.* 1999).

The crust beneath the basins is continental in nature and is typically 15-25 km thick beneath the inboard basins but thins to as little as 7 km beneath the outboard basins (Makris *et al.* 1988, 1991, Hauser *et al.* 1995, Shannon *et al.* 1994). Crustal thinning beneath the Rockall Basin, and probably the Porcupine Basin, was effected by differential stretching, with greater upper and middle crustal extension facilitated by rheologically-controlled detachments at the top of the lower crust.

The basins in the Atlantic region contain a variable thickness of Upper Palaeozoic to Recent strata. The thickest succession is in the Porcupine Basin where in excess of 10 km are preserved. The basins in the Rockall region contain up to 6 km of strata (Shannon *et al.* 1995, 1999) while the thickness of strata in the Slyne and Erris basins is typically of the order of 3-4 km (Trueblood 1992, Scotchman & Thomas 1995, Chapman *et al.* 1999, Dancer *et al.* 1999).

A number of rift episodes are recognized in, or suggested for, many parts of the Atlantic Margin region. The major ones are of Permo-Triassic, Middle and Late Jurassic, and Early to Late Cretaceous age. The through-going rifting from Rockall to Vøring during the Cretaceous first created the unity of the region which, following Palaeogene igneous activity and Atlantic opening, finally became the Atlantic Margin. The basins west of Ireland experienced rapid thermal subsidence during the Tertiary.

The Atlantic basins have seen little exploratory drilling, so that the subsurface geology of only the Porcupine Basin, with 30 exploration wells and a greater density of seismic data coverage, is understood to any significant extent. Only one exploration well has been drilled in the Goban Spur province. Early investigations which determined the major structural features in the region relied on gravity, magnetic and shallow seismic surveys (Bott & Watts 1970, Gray & Stacey 1970, Eden *et al.* 1970, Roberts 1970, Bailey *et al.* 1970, 1971, Clarke *et al.* 1971, Young & Bailey 1973, 1974, Riddihough 1975, Dingle & Scrutton 1979, and others). General accounts of the region can be found in Naylor & Shannon (1982) and Shannon (1991a), whilst the first comprehensive assessment of the hydrocarbon potential is to be found in Whitbread (1975).

3. STRUCTURAL ELEMENTS MAP (ENCLOSURE 1)

The project region comprises a number of distinct geological/geomorphological provinces - see Figure 2:-

- Porcupine Basin
- North Porcupine Basin
- Irish Mainland Platform
- Porcupine High
- Celtic Platform
- Goban Spur Province
- Porcupine Abyssal Plain

3.1 Porcupine Basin

Background

North of the Goban Spur is the large (320 x 240 km) north-south trending deep water area of the Porcupine Seabight, which at its southern end merges southwestwards into the Porcupine Abyssal Plain.

Research by academic and research institutions, combined with many thousands of kilometres of oil industry seismic reflection data, have delineated the Porcupine Basin, together with the principal structural trends and sediment thicknesses and variations within the basin (Bailey *et al.* 1971, Gray *et al.* 1971, Lefort & Max 1984, Riddihough & Max 1976, and others). The papers of Bailey (1975a&b, 1979), Roberts *et al.* (1981), Scrutton (1981), and Masson *et al.* (1985) are helpful in viewing the basin in its regional context. Scrutton *et al.* (1971), Ziegler (1982, 1990), Naylor & Shannon (1982), Masson & Miles (1986 a&b), Tate & Dobson (1989 a&b), Croker & Klemperer (1989) and Tate (1993) have reported on the form, development and stratigraphy of the basin.

Thirty petroleum exploration wells have been drilled to date (August 2001) in the Porcupine Basin, many of which are released and available to the oil industry. A synthesis of much of the released information was presented by Croker & Shannon (1987). Seismic reflection studies (Naylor & Anstey 1987, Tate 1993) reveal extensive thicknesses of Mesozoic to Recent sediments overlying an often block-faulted and tilted Late Cimmerian surface. Several major Mesozoic-Tertiary seismo-stratigraphical units are recognised, extending throughout most of the basin. These are separated by well-defined reflectors representing regional unconformities or disconformities.

Gravity data indicate that the axial zone of the basin is underlain by a zone of thinned continental crust, which narrows northwards (Bailey 1979, Masson *et al.* 1985). Geophysical data also show that the bounding shallow ridges are characterised by continental crust approximately 30 km thick (Buckley & Bailey 1975), overlain by a veneer (less than 2 km) of Mesozoic to Recent sediments.

Seismic refraction and wide-angle reflection profiles (Makris *et al.* 1988) have demonstrated that the crust beneath the southern part of the Seabight, out to water depths of more than 4000 m, is of continental type. Crustal thicknesses decrease from 23 km in the east (inclusive of sediment) to 10 km at the sharp continent-ocean transition at the mouth of the Seabight onto the Porcupine Abyssal Plain. Gravity and magnetic modeling in the same area (Conroy & Brock 1989) broadly confirm this picture, but indicates that the crustal thinning occurs beneath the central part of the basin. The overall picture is of thinned and stretched continental crust (White *et al.* 1992) with intrusive igneous bodies, and a large granite batholith within crystalline basement at the eastern margin of the basin (approximately 51°05'N, 11°00' W).

The name *Main Porcupine Basin* was introduced by Naylor & Shannon (1982). However, in recent years the oil industry has tended to use *Porcupine Basin* for the equivalent feature. Naylor *et al.* (1999) therefore proposed that the name *Porcupine Basin* be adopted as the formal name for the basin lying between the North Porcupine Basin in the north and the northern limit of the contiguous *Porcupine Seabight Basin* at approximately 51°00'N Latitude in the south. This latter name (amended from Tate's (1992, 1993) *Seabight Basin*) was intended to cover the little-known portion of Porcupine south of 51°00'N Latitude, which

appeared to be characterized by a southwesterly trend towards the Porcupine Abyssal Plain. However, the present study has shown that the region within the bathymetric embayment between 53°05'N and approximately 50°00'N comprises a single sedimentary basin. For this reason we propose that the name *Porcupine Seabight Basin* be discarded, and *Porcupine Basin* be used for the whole feature.

Upper Palaeozoic sediments, largely undeformed, have been encountered by drilling in the Porcupine Basin (Croker & Shannon 1987, Robeson *et al.* 1988). Permo-Triassic to Lower Jurassic basins in the region developed on the eroded landscape of the Variscides along reactivated NE-SW Caledonian features (Shannon 1991c). These are well-preserved in the Slyne-Erris region and on the flanks of the Rockall Basin, where they probably formed a linked rift system which became fragmented as a result of the large-scale rifting activity during the Cretaceous (Corfield *et al.* 1999). Permo-Triassic basins are less well-defined in the Porcupine Basin (Croker & Shannon 1987) and their configuration is difficult to map on seismic sections. Permo-Triassic to Lower Jurassic sequences are likely to comprise continental to shallow marine sandstones, evaporites and limestones deposited during the initial rift phase marking the breakup of the Pangean supercontinent. Rhaetian strata in marginal facies follow conformably upon the continental deposits.

Lower Jurassic rocks are known in the North Porcupine Basin where they appear to onlap irregular pre-Jurassic topography. Middle Jurassic strata are widely developed throughout the Porcupine Basin. The succession comprises a braided fluvial deposits which are interpreted (Sinclair *et al.* 1994) as the product of an onset warp phase of tectonism prior to the Late Cimmerian rifting.

Upper Jurassic strata within the Atlantic region reflect deposition in a syn-rift setting, with the development of a range of lithologies and facies. Within the Porcupine Basin these range from basin-edge alluvial fans and braided to meandering fluvial strata and deep marine submarine fans (Croker & Shannon 1987, MacDonald *et al.* 1987).

Lower Cretaceous strata in the Porcupine Basin represent the product of two rift episodes - the residual phase of Late Jurassic rifting and locally an Aptian-Albian rift phase. The Late Jurassic rifting waned during the early part of the Cretaceous and a major unconformity marks the approximate Jurassic-Cretaceous boundary (Naylor & Anstey 1987). The Cretaceous throughout most of the Atlantic margin region consists of shale-prone marine strata, but in the Porcupine Basin shale deposition was interrupted by deltaic sandstones which reflect Aptian-Albian rifting. Upper Cretaceous chalk was deposited through most of the basins, including Porcupine Basin.

There is a thick Tertiary succession in the Porcupine Basin. A sandy Eocene succession in deltaic to submarine fan facies (Moore & Shannon 1992, Shannon 1992) is interpreted (Shannon *et al.* 1993) as resulting from ridge-push effects caused by sea-floor spreading and oceanic crustal development in the region to the west of the Rockall region. The compressional stresses associated with these processes led to flank uplift on the margins of the Porcupine Basin. This produced sediment source areas, while co-eval subsidence in the basin provided the accommodation space for the deposition of the thick clastic deposits.

The post-Eocene succession in the region is represented by a general deepening marine succession, interrupted locally in early Oligocene times by a number of unconformities (Naylor & Anstey 1987). Fluctuations in relative sea-level resulted in the development of slump structures and occasional submarine fans (Moore & Shannon 1991).

Enclosures 1 & 2

The north-south aligned Porcupine Basin contains a Jurassic-Recent (and locally Permo-Triassic) sequence, in excess of 8 km thick, overlying Carboniferous and Devonian clastic strata. A number of structural zones within the basin are depicted on Enclosure 1, and illustrated on geoseismic profiles on Enclosure 2. There are problems in depicting a long-lived multi-phase basin on a single map. We have chosen to show only the outline of the major Tertiary sag basin, which is otherwise clearly illustrated on the geoseismic sections, and have concentrated on the map in the depiction of pre-Tertiary basin structure. Although we have reviewed in excess of 30,000 km of data within the basin, we have not fully interpreted and mapped these

data. The limits of the structural zones on the map are therefore generalised lines – in many cases the boundaries are fault-controlled and may in detail, for example, comprise *en echelon* faults and relay ramps. More detailed fault interpretations on specific horizons are to be found in Naylor & Anstey (1987) and Tate (1993).

At the basin margins it is often possible to distinguish on the seismic records between layered Upper Palaeozoic strata and metamorphic basement (Lower Palaeozoic or older). The Carboniferous Clare Basin is believed to extend from the County Clare coast to the northeast margin of the Porcupine Basin (Croker 1995). Sequences with similar seismic signature are seen further south on both margins of the basin and are depicted as Upper Palaeozoic on Enclosure 1. In some cases also, as shown on geoseismic sections (Enclosure 2: SPB97-121 and MS81RE-78) Upper Palaeozoic rocks can be seen extending out into the basin beneath the Mesozoic succession.

The limits of the Mesozoic basin beneath the Tertiary cover are often fault-controlled – see for example Geoseismic Section PW93-304 (Enclosure 2). In these cases the limit shown on the map is approximately coincident with the shelfward limit of the zone of rotated fault blocks, although a veneer of Cretaceous strata may extend beyond the basin-bounding faults onto the basement platform beneath the Tertiary. Along other parts of the margin, however, the Cretaceous section thins gradually and onlaps the basement, without marked fault control – e.g. Geoseismic Section SPB97-138 (Enclosure 2). The basement element of the Porcupine High is generally covered by a relatively thin Tertiary sequence, although some bathymetrically shallower areas may be bald of younger cover. The limit of the Tertiary basin on Enclosure 1 is arbitrarily taken at approximately 0.5 sec.TWT of Tertiary cover, in order to show the form of the basin.

Around much of the Porcupine Basin there is, on the seismic data, a clearly discerned zone of rotated Jurassic fault blocks beneath the Late Cimmerian surface. This is particularly well developed along the western margin of the basin – e.g. Geoseismic Section SPB97-113 (Enclosure 2). In places this zone may be wholly or partly occupied by a structural terrace or inclined ramp area, lacking obvious rotational movement. The inner (basinwards) margin of the zone is sometimes difficult to define, but usually – as on Geoseismic Section SPB97-113 (Enclosure 2) – equates with the lip of the deeper central portion of the Cretaceous depositional basin. This central zone is structurally simple, with the base of the Cretaceous at a depth of 6 sec.TWT in the basin centre, and narrows northwards until the zones of rotated fault blocks on each flank merge together in the north of the basin.

The eastern flank of the Mesozoic basin is structurally varied. South from 11°55'W /52°00'N, a narrow basement horst separates Upper Palaeozoic rocks to the east from the main Mesozoic basin to the west. Further south again, at 51°10'N, the Túr Igneous Centre forms a conspicuous bulge on the eastern margin, which is mimicked by Upper Palaeozoic rocks on the western margin. The nature of the basin margins and of the zone of rotated fault blocks appear to change at intervals along the basin. Approximately E-W orientated transfer zones cross the basin, but are difficult to identify on the seismic sections. These appear to occur at 51°05'N, 51°30'N, 51°55'N, 52°20', 52°45', and are accompanied by changes in the basement type and form of the margin, or a change from rotated fault blocks to a structural terrace within the basin.

The existence of a linear volcanic ridge in the Porcupine Basin has been recognized for two decades. The feature was noted on seismic data by Roberts *et al.* (1981) and discussion of age and descriptions of the feature followed in Ziegler (1982, 1988), Masson & Miles (1986b), Naylor & Anstey (1987); it was described and named by Tate & Dobson (1988). The *Porcupine Median Volcanic Ridge* (PMVR) is an elongate NW-SE median feature which is onlapped by probable Cretaceous strata and appears to be underlain by the Jurassic-Cretaceous unconformity surface. The ridge exhibits extrusive characteristics in places but appears intrusive in others. It is thought to be predominantly of Early Cretaceous age, possibly with a later phase of Tertiary intrusion.

The PMVR has been depicted on maps (Naylor & Anstey 1987, Tate & Dobson 1988, Tate 1993, Naylor *et al.* 1999) as a SSE-trending feature, somewhat sigmoidal towards the south and terminating with a southeasterly twist at about 51°N. Tate (1992) suggested that the median ridge terminated against the eastwards extension of the Clare Lineament, a precursor of the Charlie-Gibbs Fracture Zone, and that this same zone formed the boundary between the Porcupine Basin and the Porcupine Seabight Basin. Whilst it

appears that a zone of structural discontinuity exists at or immediately north of 51°N, the present project has provided more data regarding the median ridge.

On intersecting Geoseismic Sections SPB97-121&138 (Enclosure 2) which cross the basin at about 51° 10' two additional volcanic ridges are seen to the west of the PMVR. Unfortunately there are few seismic lines crossing this part of the basin and it has been possible to trace these features only a short distance to the south. They are similar in character to the PMVR, but smaller, and clearly they do not extend far to the north, or they would be seen in the area of denser data coverage. Either they fade out northwards or merge into the PMVR. Mapping of the PMVR itself suggests that southwards, as it approaches 51°N, the trend is more N-S than shown on previous maps. Nevertheless, the feature appears to fade out southwards at this point. Taken as a group the volcanic ridges can be seen to roughly parallel the two basin margins, as indeed do other zonal boundaries in the basin. It seems possible that during rifting several linear volcanic zones developed, but that one of them, now termed the PMVR, became the dominant zone.

South of 51°N Latitude, and directly on trend with the crest of the PMVR, a different structural feature extends N-S, approximately along the 12°W Longitude. This comprises, in cross-section (Figure 4) a lensoid, possibly rotated or sheared, structural high with internal reflectors, at a depth of about 6 sec. TWT on the seismic sections. The linear structure appears to be related to a structural discontinuity along the basin axis in this region.

At its northern end the PMVR narrows and terminates at approximately 51°42' N, to the north of Geoseismic profile SPB93-113 (Enclosure 2). However, extending northwards on trend with the PMVR to at least 52°20'N Latitude is a deep arched reflector (6 sec.TWT: Geoseismic profile SPB97-103). Linear structural or volcanic features have thus been identified extending along the axis of the Porcupine Basin between 50°30'N and 52°20'N.

On the eastern margin of the basin at 51°10'N and 11°20'W there is a NW-SE trending extrusive igneous body near the base of the Tertiary section, together with a nearby small extrusive centre with sills (see Geoseismic section SPB 97-138:Enclosure 2). This is approximately coincident with, or to the west of, the Inferred Igneous Centre B of Tate & Dobson (1988), which was identified on magnetic and gravity data. The igneous intrusive body identified on one seismic line at 50°50'N and 11°40'W (Enclosure 1) may be related to this centre of Tertiary activity, but could also be related to the PMVR.

3.2 North Porcupine Basin

Background

The North Porcupine Basin, defined and named by Naylor & Shannon (1982), is a structurally-complex small basin extending north from the Porcupine Basin at about 53°05'N Latitude.

Enclosures 1 & 2

The basin fill comprises a Jurassic to Recent succession overlying Permo-Triassic strata, which in turn rest unconformably upon Carboniferous and older rocks. Tate & Dobson (1989a) identified a fault-bounded basement feature projecting from the western basement margin and forming a partial barrier between the two basins, and named this *St Finnian's Spur* (modified to *Finnian's Spur* by Naylor *et al.* (1999)). Seismic data suggest that the structure plunges eastwards across the basin and may break into a number of small narrow horsts.

The Mesozoic section in the northern basin is more complete than the section in the northern part of the Porcupine Basin, and the Upper and Lower Cretaceous intervals differ radically in thickness between the two basins. Along the northern margin of the basin, the Tertiary section thins gradually onto the basement rocks of the Porcupine High and an arbitrary form line is shown on Enclosure 1. Thin Tertiary (and in places, Cretaceous) sediments are present over large parts of the Porcupine High.

3.3 Irish Mainland Platform

Background

The strata and geological structures of onshore Ireland extend westwards onto the shallow portion of the continental shelf beneath a thin Tertiary-Quaternary sequence. There are no detailed maps of the nearshore area, due to the lack of sampling or drilling, and an absence of seismic coverage. A number of different interpretations have been proposed for the extension of major faults and lineaments westwards from Ireland across the Continental Platform, based in the main on gravity and magnetic data (Young & Bailey 1973, Riddihough 1975, Max *et al.* 1982, Masson *et al.* 1985). Nevertheless there is general agreement that the Great Glen and Fairhead-Clew Bay fault systems trend southwestwards towards the north of the Porcupine Basin. Klemperer & Ryan (1989) considered that the Great Glen and Clew Bay faults, and possibly the Variscan Front, can be identified on deep seismic profiles acquired by BIRPS. Klemperer (1989) suggested that north-dipping reflectors west of the Shannon estuary on the BIRPS WIRE 1 profile are structures related to the Iapetus Suture (see also Klemperer *et al.* 1991). Some of the suggested extensions of major faults and lineaments eastwards from the Irish mainland are depicted by Naylor & Anstey (1987 Figure 3). Any westward extension of the Variscan Front or the Iapetus Suture could be anticipated to cross the Porcupine Basin, but these have not been identified.

Enclosures 1 & 2

The outlines of the Clare Basin and the Brendan Igneous Centre on Enclosure 1 are taken directly from Naylor *et al.* (1999). Further south, along the eastern margin of the Porcupine Basin some of the available seismic lines extend onto the basin margin. Here it was generally possible to distinguish between Upper Palaeozoic strata and the older metamorphic sequences on the western rim of the Irish Mainland Shelf. Otherwise no further work was carried out under the project with respect to the platform area.

3.4 Porcupine High

Background

Named by Naylor *et al.* (1999) from the bathymetric feature of Porcupine Bank. The name covers the basement feature which underlies the bathymetric elements of Porcupine Ridge, Porcupine Bank and part of the Slyne Ridge. The high generally has a thin Tertiary (-Mesozoic) cover, which may be absent over the higher parts of the feature. The pre-Permian geology probably comprises Precambrian, Lower Palaeozoic and Upper Palaeozoic sequences, strongly influenced by major faults in the Porcupine Bank-Slyne Ridge area (Riddihough & Max 1976, Bailey *et al.* 1977, Max 1978). Submersible dives and dredging on the western margin of the High around 51° 20'N (Masson *et al.* 1989) revealed foliated metamorphic strata overlain by gently-dipping much-faulted Upper Palaeozoic strata of uncertain thickness, part of which was dated as Westphalian. 'Mesozoic rocks are preserved as isolated remnants in down-faulted blocks, although seismic reflection data suggest that Mesozoic sequences were never widely developed' (Masson *et al.* 1989). Upper Jurassic to Upper Cretaceous samples have been retrieved. The occurrence of Mesozoic strata in this area was indicated on Enclosure 1 of Naylor *et al.* (1999) and is repeated on Enclosure 1 of the present work.

Enclosures 1 & 2

The details of the Porcupine High and of the perched basins on its Rockall Basin margin are taken directly from Naylor *et al.* (1999). However, the eastern margin of the High has been modified in the light of the newer seismic studies. In particular it has proved possible to distinguish between probable Upper Palaeozoic rocks and older metamorphic sequences along the basin margin, although the boundaries between these units have not been traced over the remainder of the High due to the lack of seismic coverage and sampling.

3.5 Celtic Platform

Background

The sea area between Ireland and Brittany is generally referred to as the Celtic Sea (Le Danois 1938) and the geological entity, mainly comprising Palaeozoic rocks, will be referred to as the *Celtic Platform*. The portion of the Celtic Sea between Ireland and southwest England is a relatively shallow (less than 200 m) extensive shelf area underlain by the two east-northeast trending, parallel, fault-bounded, sedimentary troughs of the North and South Celtic Sea Basins (Figure 1) which contain 3-9 km of Mesozoic sedimentary rocks. The southern boundary of the two grabens is formed by the offshore southwestward extension of Cornubian peninsula, to the south of which lies the Western Approaches Basin. The Fastnet and North Celtic Sea basins are separated from the narrower Cockburn, Southern Celtic Sea Basin (SCSB) and Bristol Channel basins by the discontinuous Pembrokeshire Ridge and its southwestwards continuation, the Labadie Bank Basement High (Fig. 1) which are cored by Palaeozoic rocks and covered by thin Mesozoic sequences. The orientation and shape of the various basins in the area are governed by an interplay of the predominant basement trends. The Caledonian-Variscan structural grain, essentially coincident in the immediate area onshore, exerts the dominant control on the basins, but northwest-trending faults break the basins into segments and play an important role in basin development (Pinet *et al.* 1987, Shannon 1991a).

A blanket of Upper Cretaceous to Tertiary strata subcrops the sea-floor over most of the Celtic Platform (Blundell 1979), and is underlain by a thick Lower Cretaceous sequence. A variable, but thick, Jurassic section overlies a Triassic sequence throughout most of the Celtic Sea basins. Regional summaries of the stratigraphy and structure are to be found in Delanty *et al.* (1981) and Naylor & Shannon (1982). Major inversion (post-Maastrichtian and pre-Middle Eocene) affected the central portion of the NCSB, with perhaps 1 km of uplift (Tucker & Arter 1987), with a further phase of regional uplift also taking place in Oligo-Miocene time (Murdoch *et al.* 1995). Within the SCSB, there were phases of inversion in both Middle Cretaceous and late Cretaceous-early Tertiary times.

Enclosures 1 & 2

The small and narrow *Fastnet Basin* is the westward extension and termination of the NCSB (Robinson *et al.* 1981). The Fastnet Basin is partially fault-bounded, with the boundary faults most noticeable at the northwestern and southwestern margins of the basin. Shallow basement platforms lie to the north (Fastnet Ridge), south (Labadie Bank High extension) and west, and are comprised of probable Palaeozoic rocks covered by a thin layer of Tertiary and/or Upper Cretaceous strata. The basement high to the west, which separates the Fastnet Basin from the Goban Spur basins, has been termed the *Fastnet High* (Cook 1987). The basin has an extended history of Mesozoic and Tertiary sedimentation and sediment thicknesses in places exceeding 4.5 km. Details of the basin which are shown on Enclosure 1 are simplified after Robinson *et al.* (1981) and Caston *et al.* (1981).

The main aim of the present project was to establish the nature of the contact or transition between the Celtic Platform and the Goban Spur Province, and also to identify major faults which might extend from the Platform westwards to exercise structural control in the Goban Spur region.

3.6 Goban Spur Province

Background

Bathymetrically the Goban Spur (Day 1959) is a westward projecting plateau area on the continental margin south of the Porcupine Basin. Structurally the area comprises a number of fault-bounded ridges, of dominantly NE-SW and NW-SE trend, with intervening sedimentary sub-basins. Prior to seafloor spreading, this generally sediment-starved passive continental margin lay adjacent to the Flemish Cap-

Orphan Knoll areas of the eastern Canadian shelf. Knowledge of the Goban Spur region is based mainly on gravity, magnetic and reflection seismic surveys (Dingle & Scrutton 1977, 1979, Scrutton 1979, 1984, Roberts *et al.* 1981), and on results from the Deep Sea Drilling Programme (Montadert *et al.* 1979, Graciansky *et al.* 1985). Important information has also come from dredging and gravity coring (Auffret *et al.* 1979) and from submersible dives and dredging (Masson *et al.* 1989). One deep oil exploration well (Esso 62/7-1: Enclosure 1) has been drilled (see below) and the results published, together with the synthesis of additional geophysical and palaeontological data (Cook 1987, Colin *et al.* 1992).

The distinctive Goban Spur province is separated from the Porcupine Basin by the ENE-trending Porcupine Fault (Dingle & Scrutton 1979), together with the positive structural elements of the Tóim, Balar Spur and Tír na nÓg Highs. In contrast to the broadly north-south orientation of bounding faults and structural zones within the Porcupine Basin, the geology of the Goban region is controlled by an interplay between NNW-trending faults parallel to the oceanic-continental transition boundary and a well-defined ENE- and E-trending fault set. In general terms the Goban Spur has been portrayed in the geological literature as an extension of the Cornubian Platform. However, it is evident from Figure 1 and Enclosure 1 that the faults and highs which effectively comprise the northern margin of the Goban province, are on trend with the northern margin of the North Celtic Sea Basin, possibly with the faults at the northern edge of the Fastnet Ridge. The southern boundary of the Goban province may be related to the faults controlling the northern margin of the Western Approaches Basin.

From the late 1950s onwards the Goban continental margin was the target of geophysical research projects by a number of British and French institutions and universities, which produced a succession of publications. Two drilling campaigns under the DSDP-IPOD programmes along the Goban-Biscay margin provided stratigraphic control for the ongoing seismic studies, and the results were recorded in a series of publications:- Montadert *et al.* 1977, 1979, Masson *et al.* 1984, Graciansky *et al.* 1985, and many others. Dredging and submersible programmes also added to this database (Masson *et al.* 1989).

In 1980 the Irish government granted Esso a 30 block seismic option on the Goban Spur and a neighbouring seismic option to Amoco. Both companies carried out seismic programmes which produced in excess of 5,000 km of multifold seismic reflection data. Amoco did not exercise their option, but in 1981 Esso converted their seismic option to a 14 block Exploration Licence, and after acquisition and interpretation of a further 3,400 km of seismic data, in 1982 drilled the Esso 62/7-1 well (Cook 1987). The location was in 1,075 m of water and the well was P&A at a TD of 4671 m. This remains the only petroleum test drilled in the region. In the past two decades there has been a reduced level of research and oil industry activity in the area.

Hercynian granodiorites (250-291 Ma), metamorphic and sedimentary (black shales, sandstones and shallow water limestones: probably of Carboniferous age) were retrieved by dredging prior to the DSDP programme (Auffret *et al.* 1979). Subsequent submersible dives and dredging on the Pendragon Escarpment at 49° 30'N (Masson *et al.* 1989) provided one sample of sandstone, possibly of Devonian age, near the base of the escarpment, overlain by Barremian limestones. Cook (1987), on the basis of seismic interpretation, suggests that Triassic sediments are present in the basinal areas, with evaporites in the upper part of the section.

The 62/7-1 well bottomed in probable lower Sinemurian strata and the overlying Jurassic (c. 1500 m) ranged up to Oxfordian-Callovian in age, with the Upper Jurassic absent. The Jurassic section predominantly comprised siltstones and claystones with thin limestone interbeds deposited in inner shelf to outer neritic environments. At the top of the sequence Callovian-Bathonian claystones and sandstones were overlain by 214 m of Mid-Jurassic porphyritic andesite and basalt flows. The Late Cimmerian unconformity is characterized on the seismic data by erosion and onlap of the overlying Lower Cretaceous strata.

During the Late Jurassic the continental slope of the Western Approaches Basin (DSDP Sites 401 *et seq.*) was a carbonate platform which extended as far north as 48°N Latitude (Emery & Uchupi 1984). Opening of the Bay of Biscay occurred during latest Jurassic to earliest Neocomian, with seafloor spreading

beginning during the Aptian in the Meriadzek region (inset, Enclosure 1) and early Albian west of the Goban Spur.

The syn-rift rocks are littoral-sublittoral Barremian-?Hauterivian mudstones, limestones and silty clays. At the 62/7-1 location possible Neocomian marine sandstones and cherty limestones containing terrestrial palynomorphs are overlain by shallow marine Barremian to lower Aptian limestones and claystones. On Goban Spur and in the Western Approaches Basin a widespread unconformity separates the syn-rift from the drift sequence. On Goban Spur this surface extends out to water depths of 2000 m and has been dated as Aptian to pre-Aptian in age. Cook (1987) cites gravity, magnetic and seismic data evidence for extensive Aptian-Albian volcanic rocks at the eastern margin of the Goban basin, coincident with the initiation of sea-floor spreading. Late Albian basaltic pillow lavas were penetrated in the DSDP drilling at Site 550 southwest of the Goban Spur. In the 62/7-1 well there is a marked facies change at the top of the lower Aptian sequence. The overlying Cenomanian to Maastrichtian limestone dominant sequence was deposited in outer shelf and upper bathyal environments. The Turonian is absent in the well. On the seaward edge of Goban Spur, at DSDP Site 549, the Upper Cretaceous sequence of Cenomanian to Maastrichtian nanno-chalk, a section disrupted by hiatuses, rests unconformably on middle Albian siltstones. Sea-floor spreading in the Atlantic domain continued through the Cretaceous with increasing water depths and relative sediment starvation in the Goban area. The uppermost Maastrichtian is missing in the 62/7-1 well as a result of latest Cretaceous-early Tertiary uplift, as in the North Celtic Sea region.

The end Cretaceous tectonism, uplift and basin inversion had a widespread influence throughout the basins of the Northwest European shelf. On Goban Spur Eocene to Oligocene nanno-chalks rest unconformably on Upper Cretaceous sediments. Graciansky *et al.* (1985) identified four major hiatuses in the Cenozoic section at DSDP Site 548 (early Paleocene, early Eocene/late Eocene, early Oligocene/late Oligocene, and middle Miocene/late Miocene). At the 62/7-1 location the base of the Tertiary sequence consists of upper Paleocene-lower Eocene claystones; the younger Tertiary succession was not sampled. Seismic data reveal a major mid-Oligocene erosive unconformity with onlap above, resulting from regional uplift (Cook 1987). Subsidence throughout the Tertiary, combined with limited sediment supply has resulted in the present-day water depths.

Subduction of Biscay oceanic crust beneath the northern margin of the Iberian peninsula, which terminated in the late Eocene, affected the area from Galicia Bank to Goban Spur (Boillot *et al.* 1979, Montadert *et al.* 1979). Late Eocene compression formed the narrow east-west folds which run along the Meriadzek segment (Enclosure 1 inset) of the southern margin of the Spur (Masson & Parson 1983). Early Tertiary inversion features are also seen in the southern part of the Porcupine Basin (Masson *et al.* 1984) and at the southeastern margin of the Porcupine High (Enclosure 1).

Enclosures 1 & 2

The interpretation of the Goban Spur province shown on Enclosure 1 results from a review of some 8000 km of seismic reflection data acquired by Esso and Amoco in the 1980s, allied with interpretative maps published by Cook (1987), Graciansky *et al.* (1985) and others. The structural elements shown on Enclosure 1 for the eastern and central parts of the Goban area are similar to those shown by Cook (1987). In particular, the main basinal areas are in the same position. There are, however, some important differences. Cook depicted the faulted eastern margin of the Goban Spur Basin as being broken into stepped segments by ENE-SSW trending faults. We interpret the same margin as having a number of fault-controlled, ENE-SSW trending basement spurs which project and plunge westwards into the basin. The positive element in the north of the *Goban Spur Basin*, which Cook termed the *Portmarnock Horst* (here renamed the *Tir na nÓg High*), is seen by us as a discrete element which plunges and terminates westwards, rather than curving northwards to link with the basin margin, as envisaged by Cook. There are differences in detail elsewhere on the map, but a striking similarity is the recognition in the centre of the area of the large curved listric fault zone at the northern margin of the *Goban Graben*.

Masson *et al.* (1984) summarised the regional structure of the Goban region from a synthesis of reflection seismic and drilling carried out within the DSDP programme. An earlier version of this map (Dingle & Scrutton 1979) had introduced a number of names, mainly derived from Arthurian legend, for the main

structural features. Their use is discussed later in this document. The structural detail of the southern margin of the Enclosure 1 map, and along the Atlantic margin of the Goban Spur is adapted from Masson *et al.* (1984) and Dingle & Scrutton (1979). The Esso seismic survey interpreted by Cook (1987), and reviewed in this project, covered a part of the Masson *et al.* map in which few structural features had been identified, with the exception of a convex-northwards fault coincident with the curved listric fault at the northern margin of the Goban Graben on Cook's (1987) map.

3.7 Porcupine Abyssal Plain

In the area west of Porcupine Ridge, at the south margin of Rockall Trough, the oceanic crust of the Porcupine Abyssal Plain is delimited northwards by the important Atlantic east-west transfer zone, the Charlie-Gibbs Fracture Zone (see Naylor *et al.* 1999 Enclosure 1). The *Clare Lineament* (Tate 1992), a precursor of the Charlie Gibbs Fracture Zone in south Rockall (Dingle *et al.* 1982), extends eastwards as a gravity/magnetic feature and (originally termed the *Clare Trend* by Megson 1987) to intersect the Porcupine Basin at c. 51°N.

In the oceanic domain at DSDP Site 550 seaward of the Goban Spur, uppermost Albian to middle Cenomanian calcareous mudstones rest on oceanic basement. These are in turn unconformably overlain by Coniacian-Santonian mudstones, then succeeded by Campanian massive dark mudstones. Unconformably overlying the Campanian are Maastrichtian to upper Paleocene nanno-chalks and calcareous turbidites. Upper Paleocene siliceous chalks and mudstones are capped by lower Eocene brownish nanno-chalks. Following a latest Eocene-earliest Oligocene hiatus (the widespread seismic marker termed Horizon R4 in the literature) the sequence at Site 550 comprised upper Oligocene and Pliocene nanno-chalks, chalks and oozes.

3.8 Gravity & Magnetic Maps (PSG Project P00/4: Paterson, Grant & Watson Ltd)

The gravity and magnetic maps resulting from PSG Project P00/4 were examined, and discussed with the authors, in order to constrain the location of major structural and igneous features, particularly in areas of limited seismic coverage. The following brief comments on the suite of maps produced under Project P00/4 relate to their bearing on the major geological features of the area. It should be noted that the comments are not intended as a detailed appraisal of the gravity-magnetic data.

In comparing the Project P00/4 maps with the Enclosure 1 map of this report (derived almost entirely from an interpretation of seismic data) it is noted that the main features correspond closely to structures and features mapped in this work. In particular, the following points can be made:-

- The major geological elements of the region including the Porcupine High, the Porcupine Basin, the Mainland and Celtic Platform margins, major igneous centres, Fastnet Basin, are well displayed on the datasets. The regional NE-SW to ENE-WSW Caledonian-Variscan tectonic grain is also clearly seen.
- The Finnian's Spur, a positive element which separates the Porcupine Basin from the North Porcupine Basin, has a very strong magnetic signature (P00/4: Map 12). The gravity data in the same area (Map 22) are also strongly influenced by major ENE-WSW lineaments.
- A number of igneous centres are proposed on P00/4 Map 1. These have different levels of expression on the mapped data. Six of the proposed centres lie along the western margin of the Mainland-Celtic Platforms. Of these, the Seabight, Túr and Brendan Igneous Centres have been recognized previously and are shown on Enclosure 1. The remaining three – Centres 1, 3 & 5 on P00/4 Map 1 – are smaller and are not depicted or named on Enclosure 1. Further west, on the Porcupine High, the Drol and Donn Igneous Centres shown by Naylor *et al.* (1999) are identified on P00/4 Map 1. A further large centre (No 2 on P00/4 Map 1) is shown SW of the Donn Centre and is marked by a strong magnetic anomaly on P00/4 Map 12. The outline of this feature has been transferred onto Enclosure 1 where it is named the Lir Igneous Centre.

- An obvious NW-SE grain is evident on some of the P00/4 project maps, and particularly on the gravity data (see Maps 8 & 22). In particular, a well-defined lineament traverses the Porcupine region and appears to delimit two distinct gravity domains. This lineament is shown on Enclosure 1 (as a yellow zone) and coincides with a number of geological features – notably the SW boundary of Fastnet Basin, the NE termination of the Tóim High, the southern termination of the PMVR (and the N limit of the Fionn High), the northern termination of the western ridge pair of the Volcanic Ridge System, and the northern limit of the Canice Basin.
- As mentioned above, interpretation of the seismic data suggests that a number of approximately E-W structural zones cross the Porcupine Basin, although these are not clearly imaged. Rather their positions are indicated by abrupt changes in the basement type at the basin margin, by indentations in the form of the margin, by terminations of rotated fault blocks within the basin or north to south transitions from fault blocks to structural terraces. These zones are thought to occur at 51°05'N, 51°30'N, 51°55'N, 52°20'N and 52°45'N and strong support for their existence is provided by contour alignments and anomalies on the gravity-magnetic maps (P00/4 Maps 8, 12 & 22).

4. PRINCIPLES OF NOMENCLATURE

4.1 General

The formal name of a subsurface structural feature comprises two parts, both capitalised:-

- the first name (the feature name) usually has a local association
- the second name places the element within a structural category.

The Supporting Volume to the General Bathymetric Chart of the Oceans (GEBCO) Digital Atlas (1997) contains an Annex related to the Standardisation of Undersea Feature Names. Again, a two-part format is used; the first name having local or historic association and the second describing the shape or form of the bathymetric feature.

4.2. Feature Name

The approach to the naming of geological structures taken here is in line with that adopted in Norway (see Blystad *et al.* 1995) and the Irish Rockall Basin (Naylor *et al.* 1999).

Geographic names in the vicinity of the feature - names of shelf bathymetric features, fishing grounds or ocean areas - are given priority. In the case of offshore west Ireland there is a shortage of such names, and existing names have already been used. Except for structural elements situated close to the coast, names taken from coastal features or towns are considered confusing and are not recommended.

Naylor *et al.* (1999) used the names of Irish saints for new basins, a practice begun in the Porcupine area (Mohr 1982, Tate 1993). The names relate to established figures in Irish history, albeit embellished by folklore. In the case of structural highs and prominent igneous features, names of mystical islands and associated waves/breakers or mythological characters that are long established and well founded in Irish folklore, were used. This practice is continued in the present document, although in the case of Goban region, there are many pre-existing names. Day (1959) named several of the newly discovered bathymetric features of the Goban region, using names from Celtic tradition. This was continued by most later workers, although these later names were mostly based on the Arthurian legend. Names which have been applied to geological features in publications, and which have priority, have been accepted, except where confusing or obviously inappropriate. The detailed history of the new names comes largely from Ó hÓgáin (1990), and we are again grateful to Professor Dáithí Ó hÓgáin of the Department of Irish Folklore, UCD, for his kind assistance in carrying out the research for the project.

An attempt has also been made to separate geological (normally subsurface geological) from bathymetric names. In most cases, the oceanographic usage was earlier, e.g. Porcupine Bank, and the second element (category) of the name has been changed to define the geological feature. Established bathymetric names in the region are shown on the inset to Enclosure 1, and should be used only in this sense. Only geological features and names are shown on the main Enclosure 1 map.

There is considerable overlap between the area shown in Enclosure I and that covered by Petroleum Affairs Division Special Publication 1/99 (Naylor *et al.* 1999). In the case of the Porcupine Basin, more detailed work has been undertaken for this report and new elements have been defined. No further detail has been added for Porcupine High, except along its eastern margin, and the structural elements shown on Enclosure 1 for the Slyne Basin and along the eastern margin of the Rockall Basin are a reprise of those in the earlier report. For completeness, the definitions of these elements are also repeated in the list below.

4.3 Category Name

Bathymetric and structural geological terms generally form the second part (category) of the names put forward here. To avoid confusion, the following bathymetric and structural definitions illustrate the

meaning intended by their use as either a category name or as a descriptive term in the text of this report. The definitions rely heavily on the A.G.I. Glossaries (1960, 1997) and GEBCO (1997).

Abyssal Plain

An extensive, flat, gently sloping or nearly level region at abyssal depths (GEBCO 1997, Heezen & Laughton 1963).

Arch

A term in structural geology for a broad, open anticlinal fold of regional scale: usually a doming of the basement.

Bank

In the oceanographic sense, for an elevation over which the depth of water is relatively shallow, but normally sufficient for safe surface navigation (GEBCO 1997).

Basin

In the sense of a sedimentary basin, i.e. an area in which sedimentary strata have accumulated in substantial thickness. A segment of the crust which has been downwarped, usually for an extended period, but with intermittent risings and sinkings. (Landes 1951). *Sub-basin* is used to delineate a discrete and distinctive older sedimentary depocentre lying within a basin.

Embayment

In a structural geology sense (AGI 1960, 1997) to designate a downwarped re-entrant of sedimentary rocks which extends into a terrain of older rocks.

Escarpment

An elongated and comparatively steep bathymetric slope separating flat or gently sloping areas (GEBCO 1997).

Fracture Zone

An extensive linear zone of irregular topography characterised by steep-sided or asymmetrical ridges, troughs or escarpments (GEBCO 1997).

Graben

A depression produced by subsidence of an elongate area between two high angle normal faults. A block, generally long compared with its width, which has been downthrown along faults relative to the rocks on either side (Billings 1954).

High

High is used widely in geological literature for features such as a crest, culmination, anticline or dome. In this document it is used for a positive element which has persisted as a structurally high area over a period of time.

Also: A contoured high feature on gravity and/or magnetic data which is believed to outline a structural feature.

Horst

A term first used for the older mountain massifs which limit the Alps to the north and west. It is used here for a block of the Earth's crust, generally long compared to its width, that has been uplifted along faults relative to the rocks on either side (Billings 1954).

Plateau

Used here in the oceanographic sense to mean a flat or nearly flat area of considerable extent, dropping off abruptly on one or more sides (GEBCO 1997).

Rise

A broad elongate smooth elevation of the ocean floor.

Ridge

A long narrow submarine elevation with steep sides (submarine ridge). Having steeper sides and less regular topography than a *Rise*.

The exception to this usage here is the retention of the established name *Porcupine Median Volcanic Ridge* for the linear volcanic feature in the Porcupine Basin.

Although the term *ridge* is used in a geomorphological sense, it has no well-defined usage in structural geology. It has been used previously in the Goban area for a number of linear tilted basement horst blocks in the footwalls of major faults e.g. *Pendragon Ridge* (Dingle & Scrutton 1979), but this usage is not followed here.

Shelf

A zone adjacent to a continent, or around an island, and extending from the coastline to a depth at which there is a marked increase of slope towards oceanic depths (GEBCO 1997).

Spur

In a structural geology sense for a subordinate narrowing feature, usually with fault-controlled margins, projecting from a larger structural feature. An exception has been made in the retention of the established name *Goban Spur* for the westward-projecting bathymetric feature.

Terrace

A relatively flat horizontal or gently inclined bathymetric surface, sometimes long and narrow, which is bounded by a steeper ascending slope on the one side and by a steeper descending slope on the opposite side e.g. Meriadzek Terrace and Pendragon Terrace (Day 1959, GEBCO 1997).

Trough

In the oceanographic sense of 'a long depression of the seafloor characteristically flat-bottomed and steep-sided and normally shallower than a trench e.g. Rockall Trough' (GEBCO 1997).

5. BATHYMETRIC FEATURES

The named bathymetric or oceanographic features in the region are shown on the Enclosure 1 inset. The earlier bathymetric feature name has also often been loosely used in the literature for a coincident geological feature. To avoid confusion some renaming has been undertaken so as to have a clear distinction between geological and bathymetric features. The following is a brief description of the features shown on Enclosure 1 inset, including information on the derivation of the name.

Austell Spur

References: Hadley (1964) and on maps of many later authors.

Name: The name was first applied by Hadley (1964) 'following the example of Day (1959)' i.e. in the use of Celtic names. From the early Cornish saint St Austell, after whom the town in Cornwall is also named.

Description: A SSE-trending bathymetric ridge on the southwest margin of Goban Spur, which is about 95km long with crestal water depths increasing from 2100 m to 2900 m. The side walls have gradients up to 1 in 7, and to the west lies the major King Arthur's Canyon system.

Goban Spur

References: Day (1959) and on many maps and publications since that time.

Name: The feature was named by Day (1959) using 'a name from Celtic mythology'. Goibhniu was a Celtic god of smithcraft corresponding to Vulcan (Eluère 1993). He lived on in oral tradition in Ireland as a famous mason call the Gobán Saor. He made weapons for the warriors under the leadership of Lugh in the decisive battle against the Fomhóire oppressors of Ireland (Rolleston 1986). The lore suggests that he made the first auger ever. His carpentry skills were legendary and magical – he could cut timber by drawing a sharp rope through it (Ó hÓgáin 1985). Legend also tells of how the Gobán Saor assisted St Moling in the building of his monastery at Ros Broic (now St Mullins in Co. Carlow).

Description: A major bathymetric projection at the southern margin of the Porcupine Seabight and extending westwards from the continental shelf, with water depths increasing from 200 m to 2000 m.

King Arthur Canyon

References: Laughton *et al.* (1975) and on subsequent maps by many authors.

Name: The feature was named by Laughton *et al.* (1975) 'after the Celtic legend, following the usage of Celtic names by Day (1959)'. The legendary c.5th century British king fought against the Saxon invaders – from legends first formalized by Geoffrey of Monmouth (c.1130; Thorpe 1966), based on, and embellished after, earlier Welsh and English written records and oral traditions. The legend was further embellished in the 15th century by Malory (Vinaver 1975) and in the 18th century by Tennyson (Gray 1996).

Description: an incised submarine canyon on the southern margin of the Goban Spur and lying west of the Austell Spur. At its northern end it lies between the geological basement features of the King Arthur High to the east and the Merlin High to the west (see below).

Menez Braz

Reference: Pautot *et al.* (1976).

Name: Derived from the translation of ‘a mountain in Brittany’ (Menes = mountain, Breizh = Brittany).

Description: A submarine hill lying immediately west of the southern end of the Pendragon Escarpment at 3000-4000 m water depth (Enclosure 1 inset). The feature is on trend with the Outer Boundary Fault as mapped to the north, and is thought by Pautot *et al.* (1976) to be cored by granite.

Meriadzek Terrace

References: Day (1959), Smith & Van Riessen (1973) and appearing on many maps since that time.

Name: Day (1959) named the feature after ‘an early Cornish saint’. *Meriadzek* or *Meriasek* are Cornish derivations from *St Meriadoc*. The literature is uncertain on his date of birth (Doble 1960), generally reporting 758 AD but also suggesting it could be 578 or 587 AD. Meriadoc, who is patron of Camborne, was a Breton monk who settled in Cornwall and who is also well known in North Wales and Brittany (where his bell is venerated). A supposed dialogue between Meriadoc and his servant on arriving on the Cornish shore is preserved in a fifteenth century Cornish manuscript by an unknown author (Jackson 1971). His feastday is 7th June

Description: A gently sloping bathymetric feature extending southwestwards from the southern margin of the Goban Spur. It is about 100 km long and 50 km wide in water depths around 2000 m.

Pendragon Escarpment

References: Day (1959), and appearing on many maps since that time.

Name: Day (1959) named the feature after ‘the father of King Arthur in Celtic legend’. The title *Pendragon* was historically given to a British or Welsh prince holding or claiming supreme power (Welsh = Chief Leader in War). In Arthurian legend Uther Pendragon was the father of Arthur by Igraine of Cornwall.

Description: A linear bathymetric feature sloping seawards from the western margin of Goban Spur with slope angles locally of 45°, and extending from the southern margin of the Porcupine Seabight at 49° 40'N Latitude southwards to approximately 48° 30'N.

Pendragon Terrace

Reference: Day (1959).

Name: The title historically given to a British or Welsh prince holding or claiming supreme power (Welsh=Chief Leader in War).

Description: An elongate NNW-SSE trending bathymetric feature on the southwestern margin of Goban Spur. It comprises a relatively flat-topped area bounded on its eastern margin by the precipitous Pendragon Escarpment (see above) and at its outer, western edge by the topographic scarp formed by the westward-throwing Outer Boundary Fault.

Porcupine Abyssal Plain

References: The region was surveyed in 1869 by the survey vessel HMS *Porcupine* (Thompson 1873). The term *Abyssal Plain* follows Heezen & Laughton (1963).

Name: After the survey vessel and the neighbouring bank.

Description: A relatively flat seafloor plain lying to the southwest of Porcupine Ridge, Porcupine Seabight and Goban Spur and extending from the Charlie-Gibbs Fracture Zone at Latitude 52°N southwards to 48°N.

Porcupine Bank

Reference: Surveyed in 1869 by the survey vessel HMS *Porcupine* (Thompson 1873) and appearing on charts thereafter. Also previously used in the geological literature for the geographically coincident basement high with thin or absent Mesozoic cover - see *Porcupine High* below.

Name: From the survey vessel HMS *Porcupine*.

Description: A prominent oval-shaped shallow water bathymetric feature at the northeast margin of the Porcupine Seabight embayment. The flanks of the bank are smooth and gently sloping.

Porcupine Ridge

Reference: Clarke *et al.* (1971).

Name: After the survey vessel HMS *Porcupine*.

Description: An elongate shallow water bathymetric element extending southwards from Porcupine Bank.

Porcupine Seabight

Reference: Surveyed in 1869 by the survey vessel HMS *Porcupine* and named by the British National Committee for the Nomenclature of Bottom Features (Day 1959).

Name: After HMS *Porcupine*. *Bight* derives from the Old English *byht* - to bend, and probably from Original Teutonic *buhti* - to bow. Later to mean bending or a loop of rope. Geographic use from the late 15th century to indicate an indentation of the coast, recess of a bay or bend in a river.

Description: Porcupine Seabight is a conspicuous bathymetric embayment in the continental margin southwest of Ireland, which opens to the SW onto the Porcupine Abyssal Plain.

Rockall Trough

References: Roberts (1975) and many others.

Name: From the emergent islet on Rockall Bank.

Description: A long bathymetric depression, elongate NE-SW, which extends from the area of the Anton Dohrn Seamount in the north to the Porcupine Abyssal Plain in the south.

Slyne Ridge

Reference: Bailey *et al.* (1977).

Name: After Slyne Head on the adjacent Irish coastline.

Description: A bathymetric feature connecting Porcupine Bank to the Irish mainland shelf.

6. GEOLOGICAL FEATURES: FORMAL DEFINITIONS

Balar Spur

Reference: Identified and described in this paper.

Name: Balar was a one-eyed tryant who lived on Tory Island off the Donegal coast (Ó hÓgáin 1990). He was the leader of the demonic Fomhóire race, who were embattled in a power struggle with the indigenous Tuatha Dé Danann race (Jackson 1971). Balar's daughter (Eithne) was given to Cian, of the Tuatha Dé Danann, in an attempt to establish peace between the two races. Their son, Lugh, eventually killed and beheaded his evil grandfather in the battle of Moytirra (in Co. Sligo).

Type section: Seismic profile GS81-101 (Figure 2).

Description: A narrow ENE-WSW trending positive element projecting westwards from the margin of the Celtic Platform immediately south of 50°N Latitude. The fault-bounded feature plunges westwards, so that the basement rocks which subcrop the Tertiary in the east are progressively overlapped by Mesozoic strata to the west. One of three basement elements which, together with the Porcupine Fault, separate the Porcupine Basin from the Goban Spur Basin – the Tír na nÓg High and Tóim High being the others. The feature is coincident with part of an igneous centre termed the Seabight Igneous Centre (Tate & Dobson 1988) – see below. However the seismic lines which cross the Spur do not show typical igneous signature and the pre-Mesozoic sequence is interpreted as being Upper Palaeozoic.

Breasal High

References: Introduced and defined in Naylor *et al.* (1999).

Name: Breasal, also known as Uí Bhreasail, occurs on maps as the name of an island off the western Irish coast from the 14th century onwards, and remained on some nautical charts as something of an anachronism even as late as the year 1865. It is clearly shown as *Brazil* on Mercator's *Nova Europae Descriptio* of 1606 (McQuillan 1996). So influential was the name of this wished-for land, that upon the discovery by the Portuguese of a vast new colony in the western world in the year 1599 they decided to use this name, Brazil, for it.

Type section: Geoeismic profile GSR96-204 (Enclosure 2 of Naylor *et al.* 1999).

Description: A southward-narrowing basement ridge extension between the Cillian and North Bróna basins which is 3-10 km wide and 60 km long. The high is fault-bounded on each side and is seen as a narrow well-defined feature on the type section. There is a thin cover of Tertiary strata and, based on seismic character, the high is thought to be cored by a bedded Upper Palaeozoic sequence. Further south, on Seismic Line GSR96-0202 (Enclosure 2 of Naylor *et al.* 1999) there is no equivalent basement feature separating the South Bróna and Cillian Basins. The Breasal High is thought to link across a saddle with the Clíona High which lies west of the South Bróna Basin.

Brendan Igneous Centre

References: Gray & Stacey (1970) identified a possible large intrusive or uplifted block of magnetic basement in this area, on the basis of limited magnetic and gravity data. The centre was recognized and mapped on magnetic data by Riddhough (1975) and described by Riddhough & Max (1976). Named by Mohr (1982) as the 'Brendan Centre'.

Also: 'Brendan Igneous Centre' (Tate 1993, Naylor *et al.* 1999). Also figured by Croker (1995).

Name: Derivation after St Brendan, the Navigator, a sixth century saint also known as Bréanainn. His name in Latin was Brendanus, from which the English name Brendan is derived. He was a great founder of monasteries - the best known of these being at Clonfert and at Annaghdown in Co. Galway, Inishadroum in Co. Clare, and Ardfert in Co. Kerry. Reputedly also a great traveller he was said to have visited Scotland, Wales and Brittany. His fame owes much to a text *Navigatio Brendani* which has been interpreted both as a description of a spiritual journey and a physical journey from Ireland across the Atlantic Ocean via Iceland to North America. The journey reputedly commenced from the coast of Co. Kerry in the shadow of Mount Brandon (named after Brendan). He was buried at his monastery in Clonfert. His feastday is 16th May.

Type section: Identified from magnetic and gravity data - see for example Croker (1995). No seismic section across the body has been published.

Description: A presumed (unsampled) early Tertiary igneous centre. A 40 km diameter complex zone of high frequency magnetic anomalies and strong positive anomalies. It possibly comprises a number of separate centres.

Bríd Basin

Reference: Identified and named here for the first time.

Name: The name Brighid (or the earlier Brigit) is spelled Bríd in modern Irish orthography, and in anglicised form appears as Bridget and Bride. It has a very long history of association with Ireland. The cult of 'the high lady' (Brigenta) was widespread among the Celts, e.g. the placenames Brigantion (La Coruña, Brienne and Bregenz), and also the strong British Celtic tribe of the Pennines called Brigantes ('highland-dwellers' and/or 'Brigenta-worshippers'). Defeated by the Romans in 74 AD the Brigantes may have been the ancestors (in or about 300 BC) of the Irish tribe called Laighin, i.e. Leinstermen (c.f. the Leinster cult of Brighid). The Celtic goddess Brighid was honoured in Ireland for her 'protecting care'. Her better known namesake was a fourth and fifth century female Irish saint who died in 524 AD. The earliest surviving reference to her dates from around the year 600 AD. Bríd has a strong connection with Kildare where she established her convent. Among the customs still associated with her is that of the St. Brighid's Cross, a small cross woven from rushes or straws and placed, on her feast day, under the rafters of the dwelling house to ensure health and good fortune for the ensuing year. Her feastday is 1st February.

Type Section: Seismic profile PSB97-58 (Figure 3).

Description: A small basin at the northern end of the Lugh High, similar in seismic character to the nearby Canice Basin but a separate discrete basin. The feature is aligned N-S and is approximately 35 km long and 10 km wide. The basin fill is assumed to be mainly Neogene in age, but a thin Cretaceous layer may also be present.

Bróna Basin

References: Originally named the *Bean Basin* by Tate (1993) to define a NNW-SSE trending basin on the west side of Porcupine High. Renamed by Naylor *et al.* (1999).

Name: After a seventh-century female saint, also known as St Bronach and the Virgin of Glen-Seichis. Her church was among the mountains of Mourne within the modern parish of Kilbrony (anglicised from Cill Bróna - Bróna's church). There are numerous references to her in fourteenth and fifteenth century literature. Her feastday is 2nd April.

Type section: Geoeismic profile GSR96-202 (Enclosure 2 of Naylor *et al.* 1999).

Description: A N-S aligned Mesozoic basin on the west flank of Porcupine High. The basin contains some 3 sec (TWT) of section interpreted as being Permo-Triassic, Jurassic and Cretaceous in age, overlain by

Neogene strata, in places more than 0.5 sec in thickness. Much of the basin is probably underlain by Upper Palaeozoic strata. The Mesozoic succession is preserved as a rotated fault block bordered by a major fault system to the east. The thickness variation within the Permo-Triassic section as interpreted may be due to salt movement, but overall there is no evidence of significant syn-depositional growth at the basin margin during Permian to Jurassic time. The basin is divided into the *North and South Bróna Basins* by a basement saddle linking the Clóna and Breasal Highs. The *North Bróna Basin* is 60 km x 20 km in extent, whilst the smaller *South Bróna Basin* is 50 km x 15 km.

Canice Basin

References: Named by Tate (1992), further discussion in Tate (1993).

Name: After Saint Canice, also known as Cainneach and anglicised to Canice, Kenneth and Kenny, was born c. 521 AD in Glangiven, County Derry. He was for a while a member of the community of Colm Cille on the island of Iona. He studied in Wales where he was ordained a priest. The literature describe Canice as a small bald-headed man. He was celebrated for his beautiful handwriting in copying sacred texts, and also for his eloquence in speech. He founded a church at Kilkenny, thus giving that place its name (Cill Chainnigh). He died c. 599 AD. His feastday is 11th October.

Type section: The unidentified seismic section in Tate (1992: Fig. 3) is the only published section across the basin. No type section has been designated.

Description: A structurally-complex basin trending NNE-SSW on Porcupine Ridge and. containing up to approximately 1.8 sec. (TWT) of strata (see Fig 3. of Tate 1992). Basin development was facilitated by early Tertiary faulting, which produced a complex basin, 90 km long and up to 30 km wide, with a number of intra-basinal horsts. These are covered by a thin (200 msec.) layer of flat-lying, presumed Oligocene-Recent strata.

Cillian Basin

References: Previously known as the *Galway Graben* - figured and named by Tate & Dobson (1989a), with further detail in Tate (1993). Renamed by Naylor *et al.* (1999).

Name: Several monks/saints had this name. The best known was Cillian of Würzburg. He was born about 640 AD in Mullagh in Co. Cavan. He was commissioned a travelling bishop without a see by Pope Conon. His mission took him to Würzburg in Austria where Christianity was taking root. He was murdered there in 689 AD. Emperors from Charlemagne to Barbarossa visited his tomb and Würzburg became an emporium of Irish manuscripts, the greatest treasure being an ivory-bound manuscript of the Gospels in Gaelic and Latin called Cillian's Bible. His feastday is 8th July.

Type section: Geoseismic profile GSR96-0204 (Enclosure 2 of Naylor *et al.* 1999).

Description: An elongate Tertiary graben (150 km x 15-20 km) along the Porcupine Ridge east of the North Bróna Basin. The basin trends NE-SW at its northern end, but is aligned NNE-SSW for much of its length, narrowing to a half-graben in the south. The infilling sequence is assumed to be Neogene in age, possibly underlain by Upper Palaeozoic strata. The narrow southern section of the basin is seen on Seismic Line WI-32 (F, Enclosure 2 of Naylor *et al.* 1999), but the basin probably closes a short distance south of this intersection.

Clare Basin

References: Defined and named by Croker (1995) based on gravity, magnetic and limited seismic reflection data.

Name: Derivation from County Clare on the adjacent coast.

Type section: Seismic profile WIRE 1 (Croker 1995 Figures 7&8).

Description: E-W trending Carboniferous Basin which is an extension of the onshore West Clare Namurian Basin (Gill 1979).

Clíona High

References: Named and described in Naylor *et al.* (1999).

Name: Clíona, also known as Clíodhna, is otherworld lady in Irish literary and oral tradition. She was drowned in the bay at Glandore, County Cork by a great flood at the breaker (a wave presumed to mark the site of a buried land) which bears her name (the Wave of Clíona). This was one of the three great waves of Ireland, according to the ancient topographical system and her association with it was an expression of the idea that the deities resided in water. In post-mediaeval tradition Clíona was regarded as one of the principal otherworld women of the province of Munster and was said to reside in a palace under Carraig Clíona, a conspicuous large rock south of Mallow in County Cork.

Type section: Geoseismic profile GSR96-1202 (Enclosure 2 of Naylor *et al.* 1999).

Description: A narrow (90 km x 5-8 km) N-S basement feature separating the South Bróna Basin from the main Rockall Basin. The high is covered by a veneer of Tertiary and probably consists of older Palaeozoic rocks and is fault-bounded along its western margin. In the north the high links with the Breasal High across the basement saddle separating the North and South Bróna Basins.

Colm Basin

References: Described and named in Naylor *et al.* (1999).

Name: After a saint and missionary, born at Gartan in County Donegal around 521 AD. In the year 546 he founded a monastery at a place known as his 'oakwood', Doire Cholm Cille (i.e. Derry), and later several other monasteries, including ones at Dairmhaigh (Durrow, Co. Laois) and Ceannannas (Kells, Co. Meath). In 563 he left Ireland and settled on Iona off the southwest coast of Scotland where he died in 597. He is also known by his nickname of Colm Cille, meaning 'dove of the church'. The word 'colm' is derived from Latin - which form, Columba, is anglicised as the saint's name. A copy of the Psalms, said to have been written by the hand of the saint himself, still survives, as does the casket in which it was carried. His feastday is 9th June.

Type section: Geoseismic profile DGER96-46 (Enclosure 2 of Naylor *et al.* 1999).

Description: A fault-bounded basin, which is currently poorly-constrained at its southern margin. The basin lies on the northern flank of the Porcupine High at the inflection caused by the change of strike of the Rockall margin from E-W to NE-SW. The basin infill comprises up to 0.5 sec (TWT) of presumed Neogene strata which are seen to downlap against the footwall uplift of the Rockall Basin bounding fault to the northwest. The basin is bounded to the south by the Porcupine High and to the east by the Slyne High, and is possibly underlain by Upper Palaeozoic rocks.

Donn Igneous Centre

References: Identified by Bailey (1979) and Young & Bailey (1974). Gray & Stacey (1970) had previously suggested an igneous centre immediately to the west at 53° 15'N -13°50'W, an area in which Cole & Crook

(1910) had obtained granitic and gabbroic bottom samples. Figured as Centre “A” by Tate & Dobson (1988). Named by Naylor *et al.* (1999).

Name: This otherworld island was described by Plutarch in the 1st century AD. He documented how the Britons believed that an otherworld lord reigned over the dead on an island lying a good distance from the southwest coast of Ireland. This personage corresponds to Donn in early Irish tradition, and his island 'the house of Donn' is where the ancient Celts throughout Europe believed all spirits went after death. This tradition is documented in early (ninth century) Irish literature.

Type section: Inferred from magnetic data. No type seismic section.

Description: An inferred, unsampled and unnamed igneous centre within the Porcupine High, identified by a number of authors.

Fastnet Basin

Reference: The name was in general use in the oil industry in the 1970s and the basin was figured and named in Reeves *et al.* (1978). A synthesis of seismic and drilling data for the basin was presented by Robinson *et al.* (1981).

Name: The name is taken from the Fastnet Rock which lies 10 km south of the coast of southwest County Cork. Although the rock does not strictly fall within the basin, the name is embedded in the literature and is accepted here.

Type section: Line A: seismic profile and geoseismic section (Robinson *et al.* 1981 Figure 4).

Description: A small (110 km x 40 km) elongate NE-SW basinal extension from the North Celtic Sea Graben containing in excess of 4.5 km of Mesozoic-Tertiary sediments. Separated from the Goban Spur and Porcupine Basins by the *Fastnet High*. Caston *et al.* (1981) describe an area of olivine-dolerite intrusions (igneous centres and major sills) in the southeastern portion of the basin. The magmatism appears to have been active from the mid-Jurassic to the early Tertiary.

Fastnet High

Reference: Figured and named by Cook (1987, Figure 4).

Name: After the adjoining Fastnet Basin, and ultimately after Fastnet Rock off southwest County Cork.

Type section: None designated.

Description: The High comprises the faulted rim of the Celtic Platform, lying between the Fastnet Basin and the Goban Spur Basin. The Mesozoic-Tertiary sequence thins eastwards out of the Goban Spur Basin onto the High. Cook (1987), on the basis of seismic, gravity and magnetic data, considered the basement here to be intruded and covered by Lower Cretaceous volcanics (part of the Seabight Igneous Centre: see below).

Fastnet Spur

References: Petrie *et al.* (1989), PESGB (2000).

Name: After the adjoining Fastnet Basin, and ultimately after Fastnet Rock off southwest County Cork. Named the *Fastnet Ridge* by Petrie *et al.* (1989) and renamed here as *Fastnet Spur*, in line with the separation of bathymetric (Ridge) and geological (Spur) terminology.

Type section: None designated.

Description: The feature comprises a part of the northwestern Celtic Platform at the northern margin of the Fastnet Basin. Petrie *et al.* (1989) showed the Spur as narrowing northeastwards, being bounded to the south by the main NE-SW bounding fault at the north margin of Fastnet Basin, and to the north by two ENE-SSW faults with downthrow to the north. Faults in this position are shown on the PESGB (2000) map and their western portions are copied on Enclosure 1. In discussing the feature the same authors state 'The reactivated Variscan detachment surface controlling the North Celtic Sea basin appears to be the main basin-controlling fault. Pembroke Ridge, Labadie Bank and Fastnet Ridge are interpreted as hanging-wall horsts on the major detachment surface.' If this is accepted, then the northern bounding faults of the Ridge are important in the regional context, and they are on trend with the northern margin of the Goban Spur.

Fastnet Volcanic Province

Reference: Caston *et al.* (1981).

Name: After the name of the Basin, and ultimately after Fastnet Rock off southwest County Cork.

Type section: None designated.

Description: Two plugs, and a multiple sill complex of olivine dolerites and microgabbros of Bathonian age intrude the Lower Liassic sequences of the Fastnet Basin. A further plug and sill are of possible Paleocene age (Caston *et al.* 1981). Due to the geographic proximity, Tate & Dobson (1988) considered the Fastnet igneous rocks within a review of the Porcupine igneous province, but because of the dominantly Jurassic age of the intrusions, we have regarded the Fastnet magmatism as a separate entity.

Finnian's Spur

Reference: Defined and named by Tate & Dobson (1989a). Further detail in Tate (1993).

Name: After a 6th century Irish saint. The name was shortened from *St Finnian's Spur* to *Finnian's Spur*, in line with the use of saints' names for other features defined in Naylor *et al.* (1999). There are a number of instances of monks/saints with the name Finnian (also known as Finnen). The best known was Finnian of Clonard. He was born into Leinster nobility and studied there and later in Wales with St David. He was a bishop as well as an abbot and founded an abbey at Clonard in about 520 AD. This was one of Ireland's great monastic schools, and Finnian trained so many of Ireland's greatest saints (including Ciarán, Brendan, Colm and Canice) that he was called the Tutor of Saints. He wrote a handbook for penitents, called a penitential, which is one of the oldest on record. He died in the year 549 AD. His feastday is 12th December.

Type section: The feature is shown on a number of published maps e.g. Tate (1993), but no suitable type section has previously been published or designated. The N-S Geoseismic profile PW93-309 which ties the 26/27-1 well in the Porcupine Basin and the 26/22-1A well in the North Porcupine Basin (Enclosures 1 & 2), passes over a portion of the structure and is taken as the type section for the feature.

Description: A fault-bounded basement feature on the western margin between the Porcupine and North Porcupine Basins - tonalitic gneisses were drilled on the feature in the Shell 26/26-1 well. The basement feature subcrops the Tertiary in the west, as described by Tate (1993), but plunges eastwards beneath Mesozoic cover, possibly breaking up into several discrete narrow horsts. Taken overall the feature effectively separates the Porcupine Basin from the North Porcupine Basin. Map 12 of the P00/4 project map suite (Total Magnetic Field) shows a strong symmetrical magnetic anomaly along the trend of Finnian's Spur, suggesting shallow magnetic basement along this zone.

Fionn High

Reference: Identified and described in this paper.

Name: After Fionn mac Cumhaill, a celebrated hero in Irish literature and folklore. Stories regarding him are continuous in the literature for more than a thousand years (Ó hÓgáin 1987, 1990) and he is probably the best known figure in Irish folklore. In the earliest texts his name appears as 'Find', in Middle Irish it was 'Finn' and in Modern Irish is 'Fionn'. He is always portrayed as a great warrior-seer, with strong associations with Leinster. Many of the stories relating to Fionn centre about his wisdom, which he gained by placing his thumb in his mouth. On a geological note is the claim, in lore, that Ireland's Eye (a small island off the Dublin coast) was taken by him from Co. Wicklow, thereby causing a large lake to spring up in Glendalough in its place. A more grandiose story tells of how the Isle of Man was a rock flung by him from the site of Lough Neagh in a contest with an English giant.

Type section: Seismic profile SPB97-146 (Figure 4).

Description: A N-S to NNW-SSW trending high south of 51° 00' Latitude and directly on trend with the Porcupine Median Volcanic Ridge. The structure is at 6 sec. TWT on the seismic sections and appears to be a complex faulted or thrust high paralleling the bathymetric trend of the eastern margin of the Porcupine Seabight, becoming difficult to discern south of 50° 30'N.

Fursa Basin

References: Recognised by Corfield *et al.* (1999). Named and defined by Naylor *et al.* (1999)

Name: The mediaeval biographies of the 7th century St Fursa state that he was the son of a Munster prince. When he came of age he decided to become a monk and went to a monastery on an island in Lough Corrib in County Galway. He later crossed to England, where he was well received by King Sigbert of East Anglia. From there Fursa proceeded to the Continent, where he was supported by the Frankish king Clovis II. He died in or about the year 648 and was buried at Peronne. He had a celebrated vision involving flames and angels and the earliest account of this is given by the English historian Bede in the year 731. The vision became widely known in mediaeval Latin literature, and it was very likely the source which suggested to Dante the plot of his *Divina Comedia*. His feastday is 16th January.

Type section: Geoseismic profile GSR96-0118 (Enclosure 2 of Naylor *et al.* 1999).

Description: A small (45 km x 8 km) Mesozoic (Permo-Triassic to Cretaceous) basin on the northern outer margin of Porcupine Bank. The basin trends NE-SW oblique to the general run of the Rockall Basin margin, which is here E-W. The Mesozoic sequence is preserved as a rotated fault block, with some thickening of units into the southeast bounding fault.

Goban Fault

References: Dingle & Scrutton (1979), Cook (1987).

Name: From the bathymetric feature of the Goban Spur.

Type section: Seismic profile GS81-72 (Figure 5).

Description: The name was applied by Dingle & Scrutton (1979) for a linear ENE-WSW fault crossing the Goban Spur between 12°00'W-14°00'W and 49°10'N-49°30'N. At its western end the fault was shown as giving a dextral offset to the Outer Boundary Fault at the oceanic margin. However, in a later synthesis of the DSDP project data, in which the Scrutton was a co-author (Masson *et al.* 1984; also Graciansky *et al.*

1985), the linear fault and offset have been deleted and an arcuate concave-southwards fault was shown, coincident with Cook's later (1987) 'listric fault zone'. Cook used the name Goban Fault for this structure, which forms the northern margin of the Goban Graben, and we follow that usage here.

Goban Graben

References: Dingle & Scrutton (1979), Cook (1987).

Name: After the Goban Spur bathymetric feature. The name was introduced by Dingle & Scrutton (1979) for a westward-narrowing sedimentary basin lying south of a straight ENE-WSW trending fault, which they named the *Goban Fault* (see above). Cook (1987, Figure 3) used the name for a roughly coincident basin south of a prominent arcuate listric fault zone. We retain the name here, despite the fact that the basin is a classic half-graben, rather than a true graben.

Type section: Seismic profile GS81-72 (Figure 5).

Description: The relatively small Goban Graben is a westward projection from the contiguous Goban Spur Basin. Seismic data suggest that up to 6 km of Mesozoic-Tertiary strata are present in the basin centre. The Mesozoic section is thickest in the north, against the listric fault, and thins southwards by onlap and erosion onto a positive element at the southern basin margin. A reef has been interpreted within the Lower Cretaceous section of the basin (Masson & Roberts 1981, Cook 1987), which is thought to have been initiated 'at the southern hinge-point of the graben' and to have developed upwards and shelfwards in response to subsidence and a relative rise in sea-level (Cook 1987). An extensive, mounded, layered seismic unit is clearly seen on seismic lines crossing the half-graben. However its large areal extent and central position within the small basin is not typical of reef development.

Goban Spur Basin

References: Cook (1987).

Name: From the physiographic feature of the Goban Spur.

Type section: Geoseismic profile PORC97-60 (Enclosure 2).

Description: Cook (1987, Figure 6) applied this name to the Mesozoic-Tertiary basin lying on the eastern part of the Goban Spur, and within which the Esso 62/7-1 well was drilled. The name is used here in the same sense, but is extended to cover the basinal area lying approximately between Latitudes 49° 15'N and 50° 00'N on the eastern part of the Goban Spur, adjoining the Celtic Shelf. A number of intra-basinal basement elements and basin margin spurs segment the basin into several smaller depocentres. The 62/7-1 well penetrated almost 4000 m of Mesozoic-Tertiary sediments and the seismic data suggest that in excess of 6000 m of Mesozoic-Tertiary may be present in the deeper parts of the basin. The Basin is contiguous in the south with the narrow King Arthur Basin.

Intermediate Zone

References: Dingle & Scrutton (1977, 1979), Scrutton (1979), Roberts *et al.* (1981), Masson *et al.* (1984), Graciansky *et al.* (1985).

Name: From the transitional nature of the crust in the zone between clear continental crust to the east and the oceanic crust boundary

Type section: Seismic profile CM 10 (Graciansky *et al.* 1985 Figure 12, Masson *et al.* 1984 Figures 5 & 11).

Description: The zone underlies the physiographic feature of the Pendragon Terrace and was first identified by Dingle & Scrutton (1979) who suggested that the oceanic-continent boundary lay along its western edge. The continental crust of the zone was interpreted as being heavily intruded by basic bodies and interleaved with basaltic flows related to the initiation of sea-floor spreading. Subsequent analysis (Dingle & Scrutton 1979) confirmed this picture, but also indicated considerable complexity within the zone. The zone is approximately 10 – 25 km wide, lying between the Outer Boundary Fault and the Pendragon Fault Zone. A linear high extends along the western margin of the zone, in the footwall of the Outer Boundary Fault, and this was drilled in the DSDP-IPOD programme at Site 551 (see below). The sedimentary cover on basement thickens eastwards from Site 551 towards the Pendragon Fault (Graciansky *et al.* 1985 Figure 12). In the deeper parts of the half-graben Aptian-Albian, and possibly syn-rift Barremian, sediments may be present.

King Arthur Basin

References: Defined and named here for the first time.

Name: After the N-S trending submarine feature King Arthur's Canyon (Laughton *et al.* 1975) and the King Arthur High situated at its head (see below). Ultimately after the legendary c.5th century British king who fought against the Saxon invaders – from legends first formalized by Geoffrey of Monmouth (c.1130; Thorpe 1966), based on, and embellished after, earlier Welsh and English written records and oral traditions. The legend was further embellished in the 15th Century by Malory (Vinaver 1975) and in the 18th Century by Tennyson (Gray 1996).

Type section: There are no published seismic profiles across the feature. Geoseismic sections of line OC603, which crosses the feature, have been published by Dingle & Scrutton (1979 Figure 13) and Masson *et al.* (1984 Figure 11).

Description: Dingle & Scrutton (1979) introduced the name *King Arthur Ridge*, here renamed the *King Arthur High*, for a wide complex positive zone. The current mapping suggests that a narrow grabenal basin extends southwards from the Goban Spur Basin, between the King Arthur High and the Celtic Platform, which we name the *King Arthur Basin*. The basin appears to contain Mesozoic and Tertiary sequences. Its southerly extent is not known. Dingle & Scrutton (1979 e.g. Figure 13) clearly show a narrow grabenal basin between the 'King Arthur Ridge' and the Celtic Platform, but their feature is further east than the King Arthur Basin as mapped (see *King Arthur High*, below)

King Arthur High

References: Dingle & Scrutton (1979), Cook (1987), using the name *King Arthur Ridge*.

Name: After the N-S trending submarine feature King Arthur's Canyon (Laughton *et al.* 1975) at the head of which the feature is situated. Ultimately after the legendary c.5th century British king who fought against the Saxon invaders. *High* is preferred here for *Ridge* used in the original name.

Type section: There are no published seismic profiles across the feature. Geoseismic sections of line OC603, which crosses the feature, have been published by Dingle & Scrutton (1979 Figure 13) and Masson *et al.* (1984 Figure 11).

Description: Dingle & Scrutton (1979) introduced the name *King Arthur Ridge* for a broad complex NW-SE trending high, immediately west of the Celtic Platform. Cook (1987) applied the same name for a structurally high area defined from magnetic data, which extended further west than the originally defined feature, incorporating parts of the Merlin and Shackleton Ridges of Dingle & Scrutton's work. Our seismic review (limited to the area north of 49° 00'N) shows two merging NW-SE and NNW-SSE highs at the

southern limit of the Goban Spur Basin (11° 45'W – 49° 00'N) which are on trend with two faults shown by Masson *et al.* (1984) and also coincident with the feature originally defined by Dingle & Scrutton. The name *King Arthur High* is applied here to this feature, in preference to the Cook's (1987) broader usage. The feature shown on the map (Enclosure 1) is in fact narrower than the original feature, the eastern part of which is now replaced by the narrow King Arthur Basin. Dingle & Scrutton (1979) identify a basin along the eastern margin of the King Arthur High, but place this further east than our mapping indicates, with the bounding fault of the Celtic Platform also further east (see their Figures 2 & 13).

Lir Igneous Centre

Reference: Identified and interpreted as an igneous body (Centre 2) on Map 1 of PSG Project P00/4 (Paterson, Grant & Watson Ltd. Centre 2 is interpreted as being at a depth of 7 km or less.

Name: Lir was a mythical or fictional chieftain, one of the Tuatha Dé Danann. He occurs in sources from the 12th century onwards. He was the father of the sea-god Manannán, lord of the sea, who appears in many Irish myths (Rolleston 1986). The only real narrative concerning Lir is in a text written in the 15th century *Oidheadh Chlainne Lir* (the Tragic Fate of the Children of Lir). This tells of how his four children were magically turned into swans by their jealous step-mother. They spent 300 years on Lake Derravarragh in Co. Westmeath, followed by 300 years off Erris, Co Mayo and finally 300 years on Inishglory, an island in the bay of Erris. Finally they met a Christian missionary, St Mochaomhog. When their period of enchantment ended they turned into three withered old men and an old woman. The saint baptised them and they died happily and were buried together.

Type section: None designated

Description: A strongly defined ovoid (approximately 25 x 20km) magnetic anomaly, elongated E-W, at 14° 50'E and 52° 17'N. The interpreted igneous body is unsampled and its nature and lithology are unknown.

Lugh High

References: Identified and named here for the first time.

Name: Lugh (originally Lugus) was a mythical hero, originally a Celtic deity. Julius Caesar wrote that the Gauls worshipped a god whom he equated with the Roman Mercurius. It is thought likely that this was Lugh. He was also the focus of a harvest cult, and the celebration of the festival of Lughnasadh was celebrated in all Celtic areas (Eluère 1993) and has been current in Ireland since very early times, being celebrated on 1st of August (Lughnasadh is the Irish word for the month of August). An 11th century text tells of relations between the divine race (the Tuatha Dé Danann) and the demonic race known as the Fomhóire. In the battle of Moytirra (in Co. Sligo) Lugh came face to face with his tyrant grandfather, Balar, the Fomhóire leader whom he killed.

Type section: Seismic profile CM 06RE (Figure 6).

Description: The Lugh High is oriented NNW-SSE and extends southwards, on trend, from the Porcupine High. The feature is relatively narrow and well-defined, and unlike the broad Porcupine High, which is largely devoid of Mesozoic strata, has some degree of at least Cretaceous cover along most of its length. The Lugh High effectively separates the Porcupine Basin from the sediments of the oceanic domain of the Porcupine Abyssal Plain. At the southern end of the High its western margin is in line with the Pendragon Fault Zone.

Macdara Basin

References: Faulting along this section of the Rockall margin was shown by Dingle *et al.* (1982) and Bentley & Scrutton (1987). The Mesozoic basin was recognised by Corfield *et al.* (1999) and named and defined in Naylor *et al.* (1999).

Type section: Geoseismic profile GSR96-114 (Enclosure 2 of Naylor *et al.* 1999).

Name: Macdara was a seventh century saint. His father's name was Dara and his own name was Sineach, but he is popularly known as Mac Dara or Macdara. He settled on a little island (Cruach Mac Dara) off the Galway coast in the present Ballynahinch Barony and in the parish of Moyrus. Near the landing place of this island Macdara is supposed to have built a small stone church, the ruins of which still remain in a good state of preservation, and show evidence of erection almost coeval with the first establishment of Christianity in Ireland. He lived here in quiet and friendly harmony with his herd of cattle and flock of sheep. Local folklore has it that when his animals were stolen by raiders they were miraculously restored. His feastday is 16th July.

Description: A relatively large Mesozoic basin northwest of Porcupine Bank, protruding into Rockall Basin. The basin, oriented NE-SW, is 90 km long and is 40 km at its widest part. The basin fill is interpreted as ranging from Permo-Triassic to Cretaceous in age, underlain by Upper Palaeozoic basement. The southeast margin is bounded by a major fault and a series of basin margin-parallel NE-SW normal faults subdivide the basin into a number of elongate fault blocks. Variations in stratigraphic thickness, particularly in the Permo-Triassic sequence, but also in the Jurassic, probably reflect syn-depositional fault growth. In the southeast of the basin, on the geoseismic section for Seismic profile GSR96-0114, a number of smaller faults appear to sole within the Permo-Triassic and may be indicative of evaporites in the sequence. In the west, the fault contact between the basin sequence and the pre-Tertiary succession at the margin of Rockall Basin is rather obscure, due in part to poor seismic data quality.

Merlin Basin

References: Dingle & Scrutton (1979), Graciansky *et al.* 1985 Figure 5, Masson *et al.* (1984 Figures 6 & 11). Named here for the first time.

Name: From the associated Merlin High and ultimately from Arthurian legend (see below).

Type section: Seismic profile OC 202 (Graciansky *et al.* 1985 Figure 5, Masson *et al.* 1984 Figures 6 & 11)

Description: A small NW-SE trending basin on the northeast flank of the Merlin High. A thin Upper Cretaceous chalk sequence extends out from the basin onto the Merlin High, and this was penetrated at IPOD-DSDP Site 548. The basin is interpreted (Graciansky *et al.* 1985, Figure 5) as containing Barremian and possibly younger Cretaceous sediments beneath Palaeogene and younger Tertiary sediments.

Merlin High

References: Dingle & Scrutton (1979), Cook (1987). Named the *Merlin Ridge* by Dingle & Scrutton (1979), and here re-named the *Merlin High*.

Name: From Arthurian legend (e.g. Thorpe 1966). Merlin was a magician who became King Arthur's counsellor. Amongst other things, he was said to have brought the 'Giants' Dance' – Stonehenge – from Ireland to England. Merlin took Arthur from King Uther at birth and gave him into the care of Sir Ector. He revealed the secrets of his magic to Nimue, maiden of the lake, who then imprisoned him in a cave.

Type section: Seismic profile OC 202 (Graciansky *et al.* 1985 Figure 5, Masson *et al.* 1984 Figures 6 & 11)

Description: A NW-SE trending, fault-controlled positive feature figured and named by Dingle & Scrutton (1979). A high with a bounding fault along the western margin is shown in the same location by Masson *et*

al. (1984) and Graciansky *et al.* (1985). Cook (1987, Figure 6) interpreted magnetic data as showing a positive basement element at 12°30'W and 49°05'N, which is coincident with the northern part of the Dingle & Scrutton (1979) feature. Enclosure 1 incorporates the feature directly from Masson *et al.* (1984). Dingle & Scrutton (1979 Figures 2 & 13) show the feature as extending north of the Goban Graben, whereas we have chosen to take the graben as its northern boundary.

DSDP Site 548 was drilled on the high (Graciansky *et al.* 1985) in 1,246 m of water, and penetrated 20m of Hercynian basement above a TD at 551.5 m below sea-floor. Basement comprised quartzite and black shales, the latter containing Middle to Upper Devonian palynomorphs. Resting unconformably on the Hercynian surface were 60m of white chalk of late Campanian to Danian age. A distinct discontinuity separates this sequence from upper Paleocene clays and marls and Lower Eocene nannofossil chinks with a significant volcanic and terrigenous clastic content. There is an unconformity between the lower and middle Eocene chalk sections which provides a widely traceable seismic reflector. The same lithologies continue through the Oligocene, but the lower and upper Oligocene sections are separated by an unconformity which 'is the most dramatic regional event recorded on our seismic profiles in the vicinity of Site 548' (Graciansky *et al.* 1985). This unconformity is present throughout the area of this study and is often accompanied by deep erosional channeling. At Site 548 deposition of nannofossil chinks and oozes continued through the Miocene and Pliocene. A prominent disconformity between the Middle and upper Miocene is correlative with a marked seismic unconformity in the vicinity of the site. Muddy turbidites are intercalated in the sequence from the late Miocene to Pleistocene, associated with increasing water depths.

Moling Sub-basin

References: Defined and named in this paper.

Name: Named after a seventh century saint. Anecdotes concerning him were in circulation soon after his death in 697 AD. His original name was Dairchill. He became known as 'Moling' (the holy levitator) and stories claim that an old woman first gave him this name when she saw him jump over a river in Co. Kerry. He founded a monastery at Ros Broic (now called St Mullins) in Co. Carlow. A small bible, said to be written by his hand but probably penned by his followers, is held in Trinity College Dublin. He was said to be one of the four chief prophets of Ireland. His feastday is 17th June.

Type section: Geoseismic profile PW93-304 (Enclosure 2).

Description: A well-defined sub-basin of the Porcupine Basin which lies along the eastern margin of the Ruadan High (see also Tate 1993 Foldout 1). From the evidence of the 35/19-1 well at its eastern margin, the basin is probably underlain by Triassic strata with evaporites, and the seismic data suggest a full overlying Mesozoic sequence. As the Ruadan Ridge terminates to north and south, the sub-basin becomes indistinguishable from the zone of rotated fault blocks along the eastern margin of the basin.

North Porcupine Basin

References: Defined and named by Naylor & Shannon (1982).

Name: Derived from existing names, and ultimately from the 19th century survey vessel HMS *Porcupine*.

Type section: Geoseismic profile PW93-309 (Enclosure 2).

Description: A structurally-complex small basin extending northwards from the Porcupine Basin. The basin fill comprises a Jurassic to Recent succession overlying Permo-Triassic strata, which in turn rest unconformably upon Carboniferous and older rocks. The degree of linkage between the North Porcupine Basin and the Slyne Basin is uncertain - compare, for example, Enclosure 1 with Figure 1 of Chapman *et al.* (1999). The N-S trending Geoseismic section PW93-309 (Enclosure 2) crosses *Finnian's Spur* and demonstrates the different development of the Porcupine and North Porcupine basins.

Outer Boundary Fault

References: Dingle & Scrutton (1979), Masson *et al.* (1984).

Name: The westernmost ('outermost') major fault along the Goban margin.

Type section: Seismic profile CM10 (Graciansky *et al.* 1985 Figure 12, Masson *et al.* 1984 Figures 5 & 11).

Description: The NNW trending fault lies immediately west of DSDP Site 551 and along this sector comprises the boundary between fully oceanic crust and the continental crust of the Intermediate Zone (see above). Dingle & Scrutton (1979) show the fault zone as continuing northwards at least to 49° 40'N Latitude, whereas Masson *et al.* (1984) extend the faulted margin only as far north as 49° 10'N, beyond which it continues as an unfaulted continent-ocean transition. This latter interpretation has been copied onto the southern portion of the Enclosure 1 map.

Outer Boundary High

References: Dingle & Scrutton (1979), Masson *et al.* (1984).

Name: Named here for the first time, after the westernmost major fault along the Goban margin.

Type section: Seismic profile CM10 (Graciansky *et al.* 1985 Figure 12, Masson *et al.* 1984 Figures 5 & 11).

Description: Masson *et al.* (1984) show the structural high drilled at DSDP Site 551 as extending northwards in the footwall of the Outer Boundary Fault. This interpretation has been incorporated in Enclosure 1. However, the sinuous high east of the oceanic boundary and north of 49° 50'N on the Masson *et al.* (1984) map has been omitted since it appears to be related to the southwest margin of the Porcupine High in an area where we have no control data.

DSDP Site 551 was located immediately east of the Outer Boundary Fault on the high in 3,909 m of water. The hole penetrated only ~140 m of sediment below the seabed before entering deeply altered basaltic lavas and pillow lavas (59 m to T.D.). The age of these extrusives is unknown and Graciansky *et al.* (1985) point to the possibility that they represent complexly intruded continental crust, perhaps covered by oceanic crust during the initial phase of sea-floor spreading (as suggested by Scrutton 1979), or alternatively that the deep alteration of the basalts encountered in the hole may reflect a long time interval (possibly from Jurassic or Cretaceous times, correlative with one of the older igneous episodes known in the region).

The basalts at Site 551 are overlain by an abbreviated (<100 m) Upper Cretaceous to Eocene section of chalks and oozes overlain by calcareous oozes and mudstones. There was only limited sampling of the remaining Cenozoic and Pleistocene section.

DSDP Site 550, which was drilled on the Porcupine Abyssal Plain to the west of the Outer Boundary Fault immediately south (48° 36'N) of the southern limit of the Enclosure 1 map, encountered basalt flows and pillows interbedded with limestones not older than late Albian (above T.D. at 720.5 m sub sea-floor). The oceanic basalts at this site were overlain by Cenomanian mudstones and then by Upper Cretaceous nanno-fossil chalks and Cenozoic chalks with mudstone and calcareous turbidite intercalations.

Pádraig Basin

References: Described and named in Naylor *et al.* (1999).

Name: The basin is known informally in the oil industry as the Patrick Basin, after Saint Patrick, and was given the Irish version of that name. Saint Pádraig (anglicised to Patrick and derived from the Latin Patricius), the patron saint of Ireland was born in the fifth century somewhere in the west of Britain into a family of Romanised Celts. At the age of 16 he was seized by an Irish raiding party and brought to Ireland as a slave. After 6 years herding pigs and sheep he escaped to the Continent where he studied for the priesthood, before returning to Ireland as a missionary. The date of his mission was traditionally given as from the year 432 to 461 AD, but a more likely dating is from 456 to 493 AD. Two documents from his hand survive, the most famous being his *Confessio*. The earliest surviving biographies of his life date from the second half of the 7th century. Pádraig (Patrick) looms large in Irish folklore. The notion that he banished snakes from Ireland first became attached to him in the 12th century, although various writers more than a century before he was born had referred to their absence from Ireland. The custom of wearing a sprig of shamrock on St Patrick's day does not seem to be very ancient, the first known mention of it dating from 1681. His feastday is 17th March.

Type section: Geoseismic profile GSR96-0108 (Enclosure 2 of Naylor *et al.* 1999).

Description: A small (35 km x 17 km) Mesozoic basin on the western margin of Porcupine Ridge. The basin is defined by a major fault at its eastern margin and cut by a sequence of smaller west-facing faults and their antithetic counterparts. In the west the Mesozoic sequence is in fault abutment with the pre-Tertiary sequence of the Rockall Basin. Within the Pádraig Basin there is considerable thickness variation in the section interpreted as Permo-Triassic in age, which may be salt-related or may be syn-depositional.

Pendragon Basin

References: Dingle & Scrutton (1979), Masson *et al.* (1984), Graciansky *et al.* 1985. Named here for the first time.

Name: After the Pendragon Fault Zone which forms the western margin of the Pendragon High. Ultimately from Arthurian legend in which Uther Pendragon was the father of Arthur by Igraine of Cornwall.

Type section: Seismic profile CM 10 (Graciansky *et al.* 1985 Figure 10, Masson *et al.* 1984 Figure 4).

Description: The Pendragon Basin is a half graben developed on the eastern flank of the Pendragon High. The faulted margin of the Shackleton High forms the eastern boundary of the basin. The reduced section on the Pendragon High was penetrated by DSDP Site 549 (see below). Seismic profile CM 10 shows clear thickening of the sedimentary sequence eastwards from the drill site into the half graben. A thick Barremian (-late Hauterivian?) sequence overlies the Hercynian basement, and this unit and the overlying Aptian? thicken markedly towards the eastern bounding fault. They are overlain in turn by well-developed Albian, Upper Cretaceous, Palaeogene and Neogene successions. The Cretaceous sequences thin and wedge out against the eastern bounding fault and only Neogene and thin Palaeogene beds overlap the Shackleton High.

Pendragon Fault Zone

References: Dingle & Scrutton (1979), Graciansky *et al.* 1985.

Name: After the approximately coincident bathymetric feature of the Pendragon Escarpment (named by Day 1959). Pendragon was a title historically given to a British or Welsh prince holding or claiming supreme power (Welsh=Chief Leader in War). Also, in Arthurian legend Uther Pendragon was the father of Arthur by Igraine of Cornwall.

Type section: Seismic profile CM 10 (Graciansky *et al.* 1985 Figure 10).

Description: A complex NNW trending major fault zone extending from the southern margin of the Porcupine Basin at 49° 40'N along the line of the Pendragon Escarpment and then southwards at least to Latitude 48° 25'N.

Pendragon High

References: Dingle & Scrutton (1979).

Name: After the Pendragon Fault Zone which forms its western margin. Ultimately from Arthurian legend in which Uther Pendragon was the father of Arthur by Igraine of Cornwall.

Type section: Seismic profile CM 10 (Graciansky *et al.* 1985 Figure 10, Masson *et al.* 1984 Figure 4).

Description: The Pendragon High is an elongate Hercynian basement feature which forms the footwall of the Pendragon Fault Zone. The feature was penetrated by DSDP drilling at Site 549, located in 2,335.5 m of water east of the rim of the basement high (Montadert *et al.* 1985). The hole was drilled to 1000 m below sea-floor and terminated in 37m of foliated sandstones believed to be Devonian (Old Red Sandstone) in age. Basement was overlain by 290 m of syn-rift Barremian (- ? Hauterivian) transgressive terrigenous mudstones with plant debris overlain by carbonates and calcareous sandy mudstones. A post-rift unconformity at Site 549 separates lower Barremian from Albian rocks. Seismic data suggest that possible Aptian and Albian units in the half-graben basin to the east thin westwards onto the high, such that only the upper two-thirds of the Albian sequence is present at the drill site. The Albian comprises calcareous siltstones overlain by interbedded carbonates and calcareous claystones. A probable hiatus between the Albian and the Cenomanian is overlain by nanno-fossil chinks comprising the relatively thin (<100 m) Upper Cretaceous section. A disconformity separates upper Maastrichtian from upper Danian strata at the drillsite, with a thinned Paleocene section above. Submarine topography across the high then became sufficiently subdued for the deposition of an unbroken bathyal sequence of Eocene to early Oligocene nanno-chalks. There is a probable unconformity beneath the upper Oligocene, correlative with the break at Site 548. Deposition of nannofossil chinks and oozes continued through to the Pleistocene, with increasing marl content in the upper section resulting from increased terrigenous input.

Porcupine Arch

References: Described and named for the first time in this paper.

Name: From the Porcupine Basin, in turn named after the survey vessel HMS *Porcupine*.

Type section: Geoseismic profile SPB97-103 (Enclosure 2).

Description: A deep (6-7 sec. TWT on the seismic sections) arch feature marked by a well-defined high-amplitude reflector which may represent the basement surface. The structure trends N-S and can be traced northwards 51° 38' to 52° 22'N and is directly on trend with the northern termination of the Porcupine Median Volcanic Ridge.

Porcupine Basin

References: Defined and named as the *Main Porcupine Basin* by Naylor & Shannon (1982) to avoid confusion with the generalised use of *Porcupine Basin* at that time to cover all the basins in the Porcupine bathymetric embayment.

Name: Derived from the existing named bathymetric features, and ultimately from the 19th century survey vessel HMS *Porcupine*. There was early recognition that the Porcupine Seabight bathymetric embayment

was underlain by a deep sedimentary basin (Stride *et al.* 1969, Scrutton *et al.* 1971). The terms *Porcupine Seabight Basin*, *Porcupine Basin*, *Seabight Trough* or *Seabight Basin* were used by a number of authors to cover the entire basin area from Slyne Ridge to the Porcupine Abyssal Plain. The names *Main Porcupine Basin* and *North Porcupine Basin* were introduced by Naylor & Shannon (1982) for two parts of the basin north of 51°N. An apparent difference in basin orientation south of this approximate latitude had been noted earlier, e.g. Buckley & Bailey (1975), Riddihough & Max (1976). The more restricted use of 'Seabight Basin' for the area south of 51°N was suggested by Tate (1992, 1993), and subsequently modified to *Porcupine Seabight Basin* by Naylor *et al.* (1999).

Although the name *Main Porcupine Basin* has achieved some usage (e.g. Tate 1993), in recent years the oil industry has tended to use *Porcupine Basin* in a more restricted sense for the equivalent feature. Naylor *et al.* (1999) therefore proposed that the name *Porcupine Basin* be adopted as the formal name for the basin lying between the North Porcupine Basin in the north and the northern limit of the Porcupine Seabight Basin at approximately 51°N Latitude in the south. However, as discussed above, the present study has shown that the region within the Porcupine Seabight bathymetric embayment between 53°05'N and approximately 50°00'N comprises a single sedimentary basin. For this reason we propose that the name *Porcupine Seabight Basin* be discarded, and *Porcupine Basin* be used for the whole feature.

Type section: Geoseismic profile MS 81-27 (Enclosure 2 of Naylor *et al.* 1999).

Description: North-south aligned Mesozoic-Tertiary basin extending from approximately 51°N northwards to Finnian's Spur at the southern margin of the North Porcupine Basin. The basin contains a Jurassic-Recent (and locally Permo-Triassic) sequence, in excess of 8km thick, overlying Carboniferous and Devonian clastic strata.

Porcupine Fault

References: Figured and named by Dingle & Scrutton (1979) and shown with the same trend and almost identical position by Masson *et al.* (1984).

Name: From the adjoining Porcupine Basin, in turn named after the survey vessel HMS *Porcupine*.

Type section: None designated

Description: Shown by Dingle & Scrutton (1979), Masson *et al.* (1984) and Graciansky *et al.* (1985) as a ENE-WSW trending major fault forming the boundary between the Porcupine Basin and the Goban province. There is sparse seismic coverage in the region of the fault. At its western end there is a distinct change from the relatively narrow Lugh High to the north and a wider positive zone, bordered by the Pendragon Fault, to the south. At 12° 30' W – 49° 50'N there is a narrow distinct high on the south side of the proposed line of the fault (coinciding with a fault shown by Masson *et al.* 1984), but the lateral extent of this feature is not known. At its eastern mapped extent the fault is on trend with the southern end of the Tóim High. Map 1 of the P00/4 project suite, interprets a line of faults trending WSW from the Fastnet Ridge across the south of the Porcupine Basin, parallel to, but north of, the Porcupine Fault shown on Enclosure 1. The gravity data (P00/4 Map 8) show this clearly, although less marked parallel trends lie to the south. It seems likely that the gravity is imaging the linear inversion zone immediately north of the Porcupine Fault.

Porcupine High

References: Clarke *et al.* (1971), Riddihough & Max (1976), Bailey *et al.* 1977) and others. Named by Naylor *et al.* (1999).

Name: from the bathymetric feature of Porcupine Bank (in turn named after the survey vessel HMS *Porcupine*). The name is here used in a wider sense to cover the basement feature which underlies the bathymetric elements of Porcupine Ridge, Porcupine Bank and part of the Slyne Ridge.

Type section: None designated.

Description: The high generally has a thin Tertiary (and probably Cretaceous) cover - e.g. as on Geoseismic profile GSR96-0118 (Enclosure 2 of Naylor *et al.* 1999), but the bathymetrically higher parts may be bald of sedimentary cover. The pre-Permian geology probably comprises Precambrian, Lower Palaeozoic and Upper Palaeozoic sequences, strongly influenced by major faults in the Porcupine Bank-Slyne Ridge area (Riddihough & Max 1976, Bailey *et al.* 1977, Max 1978).

Porcupine Median Volcanic Ridge

References: Noted on seismic data by Roberts *et al.* (1981). Discussion of age and descriptions in Ziegler (1982, 1988), Masson & Miles (1986b), Naylor & Anstey (1987). Described and named by Tate & Dobson (1988). It has been interpreted by Reston *et al.* (2001) as a serpentinite-mud volcano or diapir.

Name: From the name of the basin.

Type section: Geoseismic profile MS-81-27 (Enclosure 2 of Naylor *et al.* 1999).

Description: An elongate NW-SE median non-penetrative volcanic ridge along the axis of the Porcupine Basin. It is part of the Porcupine Median Volcanic Ridge System (see below). It is overlapped by probable Cretaceous strata and appears to be underlain by the Jurassic-Cretaceous unconformity surface. It exhibits extrusive characteristics in places but appears intrusive in others. The ridge is thought to be predominantly of early Cretaceous age, probably with a later phase of Tertiary sill and dyke intrusion. This study has modified the shape of the Porcupine Median Volcanic Ridge in plan view, and has shown that the axis of the body is on strike with the axis of the contiguous Porcupine Arch to the north, and with the Fionn High to the south.

Porcupine Volcanic Ridge System

References: Identified and named in this paper.

Name: From the name of the basin, and from the Porcupine Median Volcanic Ridge.

Type section: Geoseismic profiles SPB 97-121 & 138 (Enclosure 2).

Description: Although the Porcupine Median Volcanic Ridge is the longest and most prominent volcanic ridge in the basin, further similar sub-parallel ridges have been identified in the southern part of the basin. Due to the sparse seismic coverage in this region it is not possible to be certain of the number of additional ridges, or even their correlation from one seismic line to the next. With this in mind, we have not named the other individual ridges but prefer to group them all under the term *Porcupine Volcanic Ridge System*. Two ridges are profiled west of the PMVR on the intersecting Geoseismic sections SPB97-121&138 (Enclosure 2). The igneous body east of the median ridge at 11°40'W –50°50'N is probably part of the same intrusive system.

Rockall Basin

References: Scrutton & Roberts (1971), Roberts (1970, 1975) and many others.

Name: From the emergent granite islet of Rockall on Rockall Bank.

Type section: Geoseismic profile GSR 96-0116 (Enclosure 2 of Naylor *et al.* 1999).

Description: The term is here used to describe the Tertiary sag basin which is broadly coincident with Rockall Trough bathymetric feature. Tilted pre-Tertiary fault blocks are imaged on seismic lines along both the western and the eastern margins of the basin. The deeper section is poorly imaged over much of the central part of the basin, due in part to sill development.

Ruadan High

Reference: Described by Tate (1993) who named the feature *Ruadan Ridge*. Re-named here the *Ruadan High*, in line with the retention of the term *ridge* for bathymetric features only. Although the correct spelling of the name should be Ruadhán, we suggest retaining the anglicised version of the name as established in the geological literature in order to prevent unnecessary confusion.

Name: After a sixth century Irish saint who died in 584 AD. His name, Ruadhán, means ‘red-haired man’. He founded the monastery of Lothra (Lorrha) in north Co. Tipperary. The several accounts of him in Latin and Irish derive from a lost biography which was compiled in the 10th or 11th century. He was educated by St Finnian of Clonard, Co. Meath. He is said to have worked many miracles, including restoring the sight to the blinded Eochaidh mac Maolughra, king of Munster. A fiction grew up that he placed a curse on Tara, the site of the inauguration of the high-kings down to the 9th century, which led to its ultimate abandonment. His feastday is 15th April.

Type section: Tate (1993, Figure 17) figured an unlocated interpreted seismic section across the Ruadan Ridge at approximately 52°20' N. Geoseismic profile PW93-304 is designated as the type section for the feature (Enclosure 2).

Description: Tate (1993) described an elongate N-S structural high, almost 100 km long, in the northern part of the Porcupine Basin. This feature is approximately coincident with the arched structure mapped in the present project (e.g. Geoseismic section PW93-304), and therefore the same name is used. The feature, which is markedly sinuous in plan, is a complex N-S structural high extending for 140 km between latitudes 51°40'N and 52°45'N. Tate (1993) pointed to a period of inversion across the Jurassic-Cretaceous boundary and cited the Phillips 35/8-2 well which intersected Kimmeridgian to mid-Volgian turbidites on the high overlapped by Valanginian shales (Crocker & Shannon 1987). Geoseismic section PW93-304 is interpreted as showing Cretaceous strata resting on the Triassic, although elsewhere on the structure Jurassic strata are preserved. The Ruadan High may be the product of a shearing or inversion episode which gave rise to linkage between *en echelon* sets of individual bounding faults having different strike vectors between different segments of the structure.

Seabight Igneous Centre

Reference: A pronounced magnetic and gravity anomaly at 11°30'W and 49°50'N inferred to have an igneous origin by Roberts *et al* (1981) and Naylor & Shannon (1982). Named by Tate & Dobson (1988).

Name: From the Porcupine Seabight bathymetric embayment.

Type section : None designated

Description: On the basis of gravity-magnetic data Cook (1987) identified a zone of high basement with two closely related areas of ‘penetrative igneous bodies’ (shown on Enclosure 1). Taking into account the regional setting and the seismic and gravity/magnetic evidence the same author considered that the basement in this area was ‘intruded and covered by Lower Cretaceous volcanics’ (Albian-Aptian), and these extrusives are also shown on Enclosure 1. The northern area of intrusions is positioned partly over the Balar Spur, and the smaller southern area is close to a further basement promontory. As noted above, the

seismic sections crossing the Balar Spur do not show obvious igneous features, but there is only limited seismic coverage of this part of the Celtic Platform margin.

Shackleton Basin

References: Dingle & Scrutton (1979), Masson *et al.* (1984), Graciansky *et al.* (1985). Named here for the first time.

Name: After the survey vessel *RSS Shackleton*, and ultimately after the Irish Antarctic explorer. Sir Ernest Shackleton was born in Timolin, Co. Kildare, in 1874. He was involved in many memorable Antarctic expeditions and died in South Georgia in 1922.

Type section: Seismic profile CM 10 (Masson *et al.* 1984 Figure 6, Graciansky *et al.* 1985 Figures 3 & 6).

Description: A NNW-trending half-graben on the eastern flank of the Shackleton High and bordered to the east by the Merlin High. The basin has not been drilled and the stratigraphic interpretation of Seismic profile CM10 depends on the DSDP drill sites 549 (to the west on Pendragon High) and 548 (to the east on Merlin High). The basin is believed to contain Barremian (-late Hauterivian?), Aptian-Albian and Upper Cretaceous sequences overlain by Tertiary sediments. The Cretaceous section is clearly seen to abut against the western bounding fault of the Merlin High. As shown on Enclosure 1, the basin is believed to terminate northwards at 49° 05'N. Latitude.

Shackleton High

References: Dingle & Scrutton (1979), Masson *et al.* (1984), Graciansky *et al.* (1985) and this paper. Named the *Shackleton Ridge* by Dingle & Scrutton (1979), and here re-named the *Shackleton High*.

Name: After the survey vessel *RSS Shackleton*, and ultimately after the Irish Antarctic explorer.

Type section: Seismic profile CM 10 (Masson *et al.* 1984 Figure 4, Graciansky *et al.* 1985 Figure 10).

Description: A NNW trending basement high which was figured and named by Dingle & Scrutton (1979). Masson *et al.* (1984) show a similar feature in this location between the Pendragon High to the west and the Merlin High to the east (see also their Figure 3 cross-section). The details of their interpretation have been incorporated into the southernmost portion of the Enclosure 1 map. On the basis of seismic interpretation the High is thought to have only Tertiary cover at its crest and to plunge towards the north.

Slyne Basin

Reference: Recognised and named as the Slyne Trough by Clarke *et al.* (1971). The name was extended to cover the basin system extending northwards from Slyne Ridge by Bailey (1979). Defined in the current sense by Naylor & Shannon (1982), using the name *Slyne Trough*, renamed Slyne Basin by Naylor *et al.* (1999).

Name: From the previously named bathymetric feature of the Slyne Ridge, and ultimately from Slyne Head on the Connemara coastline.

Type section: Geoseismic profile E93-EI07-21 (Enclosure 2 of Naylor *et al.* 1999).

Description: An elongate (140 x 25 km) NNE-SSW trending half-graben system which changes polarity along strike. The basin contains a thick development of Lower and Middle to Upper Jurassic strata, overlain by a relatively thin Tertiary section (Trueblood 1992). The underlying Permo-Triassic sequence

includes a development of Zechstein evaporates (Chapman *et al.* 1999). Upper Palaeozoic strata are thought to underlie a substantial part of the basin.

Slyne Embayment

Reference: Dancer *et al.* (1999).

Name: From the adjacent basin, and ultimately from Slyne Head on the coastline of Connemara. A basinal feature in this position is shown and named by Dancer *et al.* (1999).

Type section : Geoseismic profile DGER96-46 (Enclosure 2 of Naylor *et al.* 1999).

Description: A narrow (50 km x 5 km) fault-bounded re-entrant extending from the western margin of the Slyne Basin in a SW direction, interpreted as containing up to 2 sec. (TWT) of Triassic and Jurassic sediments. The shape of the embayment is poorly constrained, and there is considerable difference between the shape suggested by Dancer *et al.* (1999) and that shown on Enclosure 1.

Slyne High

References: Bailey *et al.* (1977), Dancer *et al.* (1999).

Name: derivation: from Slyne Head on the adjacent coast of Connemara in western Ireland. The feature is shown and named by Dancer *et al.* (1999)

Type section: Geoseismic profile DGER96-46 (Naylor *et al.* 1999 Enclosure 2).

Description: Slyne Ridge is a bathymetric feature connecting Porcupine Bank to the Irish Mainland shelf, and the name has also been employed geologically for the coincident basement high (the larger part of which is considered in this document to be part of the *Porcupine High*), with thin or absent Mesozoic cover. As described by Bailey *et al.* (1977) the feature included the element now designated as the Slyne High. The high is a narrow northwards prolongation from the Porcupine High and separates the Colm Basin from the Slyne Basin. It is bifurcated by the elongate Slyne Embayment.

Stifin High

Reference: Described and named by Naylor *et al.* (1999).

Name : The mystical island of Stifin, also known as Cill Stuífín and Cill Stuihín was said to have been a tract of land which had sunk long ago under the waves outside Liscannor Bay, County Clare. Accounts of Stifin are similar to those of other mystical islands - it had gold-roofed towers and large buildings, a monastery, and luscious fields on which cattle and horses graze. It surfaces once in every 7 years and there is a strong tradition that whoever sees it dies within the year.

Type section: Geoseismic profile GSI Line 1 (Enclosure 2 of Naylor *et al.* 1999).

Description: A small narrow (2 km) horst of uncertain length which separates part of the Macdara Basin from the main Rockall Basin, and interpreted as being formed by Upper Palaeozoic strata.

Tír na nÓg High

References: Cook (1987) identified and described the feature.

Name: The name *Portmarnock Horst* introduced by Cook (1987) was derived from the golf-course in eastern Ireland, and as such, despite some use in the literature, is thought to be inappropriate. The feature is here re-named the *Tír na nÓg High*. It is named after a timeless realm (The Land of the Young People). Medieval lore describes how Oisín, son of Fionn mac Cumhaill, was out hunting when he met a beautiful lady who enticed him to Tír na nÓg, a land of eternal youth. After 300 years had passed Oisín wished to visit his homeland. He was warned not to set foot on the soil and so returned home on horseback. Meeting a group of men who had difficulty in lifting a heavy load, he leaped from the saddle and immediately turned into an old man. It is said that he then met St Patrick, and the two argued the merits of the old warrior life of Oisín and the new monastic life of Patrick. Several 13th to 18th century verses were composed to echo the conversation.

Type section: Geoseismic profile PORC 97-60 (Enclosure 2). See also Masson *et al.* 1984 Figure 7.

Description. An east-west trending elongate positive element in the northern part of the Goban Spur Basin. Because of its relative lack of gravity and magnetic signature, Cook (1987) considered that it was most likely to be cored by Palaeozoic metasedimentary strata. Cook (his Figure 3) shows basement as sub-cropping the Late Cimmerian unconformity on the western part of the structure. The basement is then shown as extending in a crescent to link with a basement feature approximately in the position of the Tóim High (see above, and Enclosure 1). In our interpretation, the High is seen as a discrete element, plunging to east and west, with no connection to the Tóim High. West of about 12°W, however, the structure appears devoid of Mesozoic cover. The Tír na nÓg High is the southernmost of three positive elements which, with the on-trend Porcupine Fault, separate the Porcupine Basin from the Goban Spur Basin.

Tóim High

Reference: Identified and described in this paper.

Name: A strong tradition on the Iveragh peninsula and as far north as the Dingle peninsula existed regarding a sunken island-city under the wave of Tóim. This breaker is outside Rossbeigh and the city is known as Cathair Tonn Tóime. Its name is derived from the word ‘túaim’ meaning ‘bank’ or ‘tumulus’. The legend concerns a man who tried to retrieve a cloak from an island. The island began to sink as the wave of Tóim raced after the man. The tradition of the wave of Tóim is an old one. The actual legend of the man retrieving the cloak, however, was probably derived from a version of the story of Jason’s Fleece, with the subject of the folk tradition being a man named, in Irish, Mac Uí Shé (Shea’s son = Jason) (Ó hÓgáin 1999).

Type section: Geoseismic profile PSB97-35 (Enclosure 2).

Description: A narrow, elongate positive element extending between 50° 00’N and 50° 30’N at the southeastern margin of the Porcupine Basin. It appears to comprise unlayered basement rocks, with Mesozoic cover absent along the crest. A narrow extension of the Mesozoic basin separates the Tóim High from the sub-Mesozoic rocks of the Celtic Platform.

Túr Igneous Centre

Reference: First recognized on the basis of gravity/magnetic data by Tate & Dobson (1988) who referred to the feature, of unknown age and lithology, as *Inferred Igneous Centre ‘B’*. Here re-named as the *Túr Igneous Centre*.

Name: Túr Chonaing is a mystical otherworld tower located in the sea to the west of Ireland. It was the site of a primeval battle between two otherworld armies. The tower (‘túr’ or ‘tuire’) is sometimes identified with the pinnacled Tory Island off the Donegal coast.

Type section: Geoseismic profile SPB97-138 (Enclosure 2).

Description: A complex of extrusive flows and related small stocks of probable early Tertiary age and located at the western margin of the Celtic Platform. Lava and debris flows occur immediately downslope from the main extrusive field. The centre occurs at a prominent change in the alignment of the eastern margin of the Porcupine Basin, and it is worth noting that the western margin bulges outwards at approximately the same Latitude. This suggests that an important E-W structural zone crosses the basin at, or immediately north of, 51° 00'N Latitude. The case for this is further strengthened by the southward termination of the Porcupine Median Volcanic Ridge at this point and its southwards replacement by the Fionn High. It is not known whether the small intrusion at 11° 35'W - 51° 00'N, or the larger igneous body at 11° 40'W - 50° 50'N are part of the igneous activity associated with the igneous centre, although the latter is more likely part of the Porcupine Volcanic Ridge System. Because of this uncertainty these igneous bodies have not been separately named.

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8. TEXT FIGURES

Figure 1. Regional distribution and location of basins in the Irish offshore.
After PESGB 2000, Naylor *et al.* 1999, and this project).
Bathymetry (dashed lines) is in metres.

Figure 2. Seismic profile showing the Balar Spur.

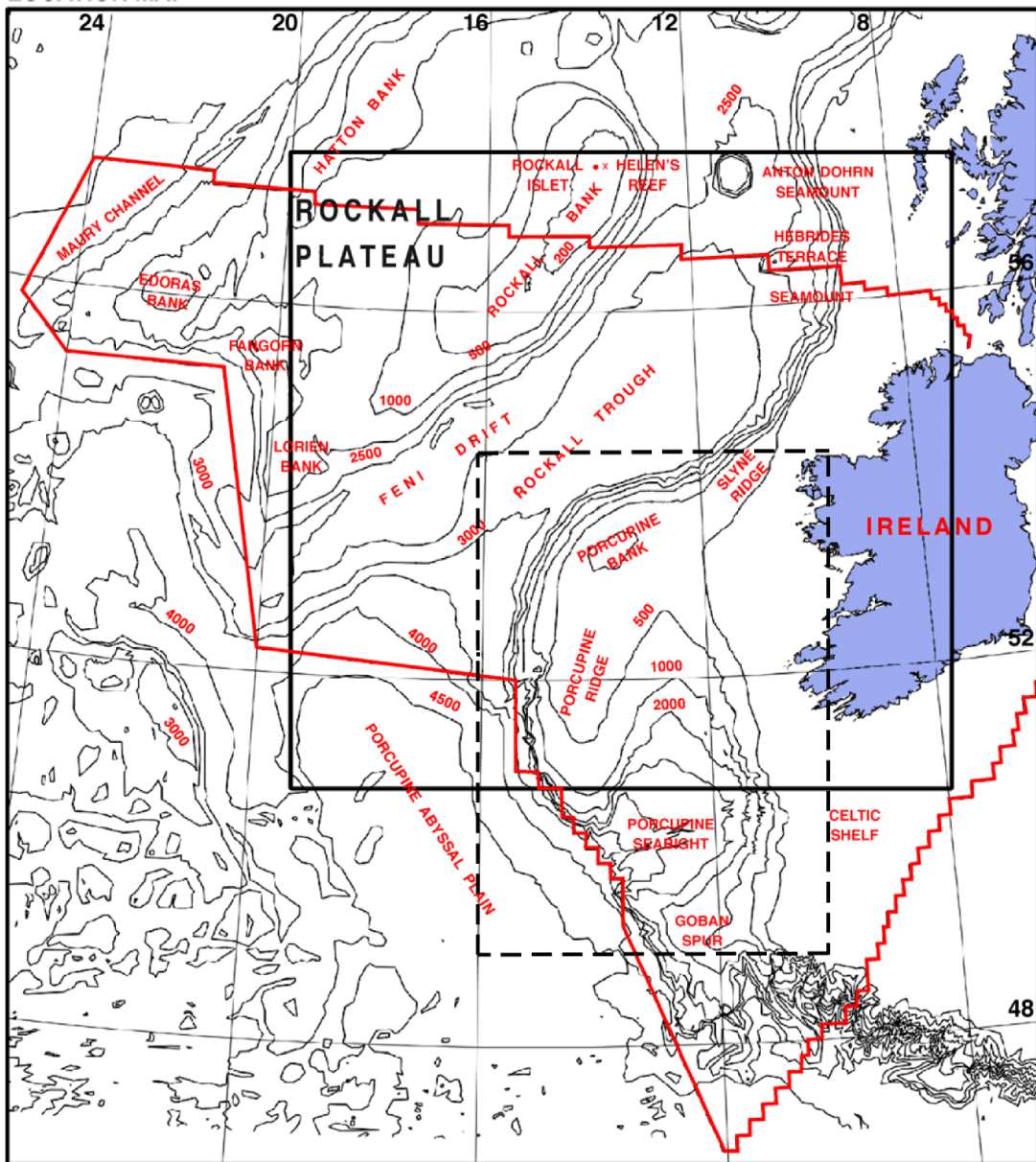
Figure 3. Seismic profile showing the Bríd Basin.

Figure 4. Seismic profile showing the Fionn High.

Figure 5. Seismic profile showing the Goban Graben.

Figure 6. Seismic profile showing the Lugh High.

LOCATION MAP



Limit of Irish
Designated Area



Area of
Rockall Project



Area of
Porcupine Project

Bathymetry in metres