Petroleum Geology of Ireland*

Patrick M. Shannon[1] and David Naylor[1]

Search and Discovery Article #10395 (2012)
Posted February 27, 2012

*Adapted from article published in AAPG European Region Newsletter, September, 2011 (http://europe.aapg.org/newsletter/aapg_newslettersept2011). Appreciation is expressed to AAPG European Region Council, Vlastimila Dvořáková, President, their Editorial Board, Karen Wagner, Chief Editor and Coordinator of Exploration Country Focus, and Jeremy Richardson, Office Director, AAPG European Region.

[1]UCD School of Geological Sciences, University College Dublin, Belfield, Dublin 4, Ireland (p.shannon@ucd.ie)

Introduction

Since petroleum exploration in Ireland commenced just over 50 years ago, there have been periodic phases of onshore and offshore activity interspersed with periods of reflection and relative inactivity. Overall, the results have been generally disappointing, with the discovery of four offshore gas fields. Three of these are in production, with the fourth due to be brought on-stream in the next couple of years. A number of other oil, gas, and condensate discoveries remain to be fully appraised. Approximately 20 exploration/appraisal wells have been drilled onshore in Ireland, where petroleum prospectivity is limited. As of August 2011, 156 exploration/appraisal wells have been drilled in the offshore basins. This article focuses mostly on the exploration activities in the Republic of Ireland, and especially on the prospective under-explored offshore basins. A recent summary of the geology and petroleum exploration history of Ireland can be found in Naylor and Shannon (2011).

Licensing

Regulation of exploration activities in Northern Ireland is administered by the Department of Enterprise, Trade and Investment, Belfast (http://www.detini.gov.uk/deti-energy-index.htm), and in the Republic of Ireland by the Petroleum Affairs Division of the Department of Communications, Energy and Natural Resources (http://www.pad.ie). Onshore licenses have generally been awarded through an 'open-door' policy. However, a formal onshore licensing round in the Republic resulted in the award in 2011 of licensing options in the NW Carboniferous Basin and in the Clare Basin, both of which focused on tight gas/shale gas prospectivity. In the offshore, licensing has normally followed formal licensing rounds, with emphasis in recent years on Frontier Licensing Rounds in the Atlantic margin basins. As in UK waters, each 1° Latitude x 1° Longitude sector of the Irish offshore is numbered and divided into 30 license blocks. Each block measures 10' in latitude and 12' in longitude and has an area of approximately 250 sq. km.

Onshore

With the exception of the NE part of the country, Ireland consists of Palaeozoic and older rocks. A comprehensive account of the onshore geology of Ireland (Figure 1) can be found in Holland and Sanders (2009). Lower Palaeozoic metasediments and associated granites, especially in the eastern half of the country, have a pronounced NE-SW structural fabric, reflecting Caledonian orogenic deformation, while Upper Palaeozoic strata in the southern part of the country have a strong E-W Variscan deformation fabric. There was relatively limited deposition over the land area of Ireland during the Mesozoic, and any such deposits have been largely removed by erosion, except in the northeast. During Cenozoic time Ireland was uplifted and underwent erosion. Onshore oil and gas exploration in the Republic of Ireland has met with little success to date, with the exception of some modest gas flows recorded during the early exploration of the NW Carboniferous Basin. Lower Palaeozoic and older rocks are regarded as having negligible petroleum potential, due to the structural complexity, the absence of reservoirs, and the over-maturity of any potential source rocks. Some minor prospectivity in tight sands and shales is likely in the Upper Palaeozoic successions of the northern third of the country, with the maturation levels in the lower two-thirds of the country generally regarded as being over-mature for hydrocarbon generation, having undergone higher levels of thermal maturation than their counterparts in the offshore basins and in Britain. The thick Permo-Triassic sequences of the Ulster Basin in the northeast of the island retain some exploration potential, particularly for gas.

Offshore

The extensive Irish offshore region contains a large number of basins of different orientations and with different geological histories (Figure 2). These reflect the breakup of the Pangaean supercontinent, resulting in rifting and ultimately breakup to form the North Atlantic passive margin. Continental crust beneath Ireland, typically 30 km thick, represents unstretched crust. Beneath the basins of the south and east coast, the crust is slightly thinner (20-24 km), while beneath the largest Atlantic margin basins the crust is considerably thinner, sometimes less than 5 km thick.

Celtic Sea

The Celtic Sea basins, south of Ireland, lie in relatively shallow waters (100-200 m) and contain several kilometres of Triassic to Cenozoic strata resting upon deformed Variscan basement. The basins have a general ENE-WSW orientation (Figure 3), reflecting reactivation of inherited basement structures. Ninety-six exploration or appraisal wells have been drilled in these basins. The region contains the Kinsale Head (1.5 Tcf recoverable), Ballycotton, and Seven Heads gas fields (Figure 3). Other oil and gas discoveries have been made since drilling started in 1970, and several of these are currently being reappraised, leading to hopes for commercial development of some of these prospects. The main reservoirs lie in Cretaceous sandstones, with accumulations also recorded in Middle and Upper Jurassic sandstones. The producing gas fields are in Palaeogene inversion structures, with oil and gas accumulations also encountered in Jurassic tilted fault blocks and in Cretaceous stratigraphic traps.

Irish Sea Basins

A set of relatively small basins lie in the shallow (<100-m) waters between Ireland and the UK. Nine exploration wells have been drilled in the Irish sector of these basins (the Kish Bank and Central Irish Sea basins). While source rock (mostly Carboniferous Coal Measures), reservoirs (mostly Permo-Triassic sandstones) and structures (fault blocks, four-way dip-closed structures and stratigraphic traps) have been identified, no oil or gas flows have been recorded to date. Although there are some remaining (mostly gas) prospects in these basins, the lack of success to date means that they are regarded as relatively high risk and, in contrast to the other groups of basins, there has been relatively little recent interest in exploration acreage in these basins.

Atlantic Margin Basins

A set of basins of various shapes, sizes, and ages wrap around the western Irish Atlantic shelf. They lie in deep water, ranging from less than 300 m to more than 2 km. The larger basins (Porcupine and Rockall) are overlain by deep-water embayments, indicative of sediment under-supply in Neogene times. The smaller, narrower basins (e.g., Slyne, Erris and Donegal) lie closer to the Irish mainland, have a less pronounced bathymetric expression that reflects a combination of less dramatic basin subsidence and a greater amount of Late Mesozoic and Cenozoic uplift, inversion, and erosion. Fifty-one exploration and appraisal wells have been drilled to date in these basins. However, most of the basins remain significantly underexplored, with only 30 wells drilled in the northern part of the Porcupine Basin, 4 wells in the Irish sector of the Rockall Basin, and 1 well in the Goban Spur region. Overall, the results demonstrate the presence of working petroleum systems in all the basins drilled to date. Shows of oil, gas, and condensate have been recorded, with the Corrib gas field in the Slyne Basin due to come on stream within a couple of years. Source rocks are proven at Jurassic, Carboniferous, and Lower Cretaceous levels, while reservoir successions have been encountered at Triassic, Middle and Upper Jurassic, Lower Cretaceous, and Lower Cenozoic levels. Most of the exploration to date has targeted large structural traps, with only a few wells drilled on stratigraphic traps. A range of traps occurs within the basins. These include Carboniferous, Triassic, and Jurassic tilted fault blocks, Jurassic, Cretaceous, and Cenozoic submarine fans, Cretaceous and Cenozoic deltas and clinoforms, and Upper Cretaceous stratigraphic traps (Naylor and Shannon, 2011). The Porcupine Basin remains an area of exploration promise in a challenging physical environment with a number of oil and condensate discoveries and some large undrilled prospects (Figure 4). A major uncertainty within the basin is in the extent and quality of Jurassic reservoirs in the deep-water parts of the basin. The structural complexity of the Slyne, Erris, and Donegal basins is probably the major risk in these narrow basins (Figure 5). However, the discovery of the Corrib gas field (~ 1 Tcf recoverable) in Triassic reservoirs, and indications of oil at Jurassic level in the south of the Slyne Basin have given encouragement to exploration in these basins. The major risks in the Rockall Basin are the poorly known nature of source and reservoir rocks. Nevertheless, the recent Dooish gas condensate discovery (Figure 5) on the eastern margin of the basin demonstrates the ingredients for a working petroleum system. At the time of writing, the announcement of the award of licenses from the 2011 Frontier Licensing Round is awaited; indications are of a high level of interest from the industry.

References

Holland, C.H., and I.S. Sanders, 2009, The Geology of Ireland, 2nd Edition: Dunedin Academic Press, Edinburgh, 568 p.

Naylor, D., and P.M. Shannon, 2011, Petroleum Geology of Ireland: Dunedin Academic Press, Edinburgh, Scotland, 262 p.

Naylor, D., P. Shannon, and N. Murphy, 1999, Irish Rockall Basin region – A standard structural nomenclature system: Petroleum Affairs Division, Special Publication 1/99, Dublin, Ireland, 42 p.

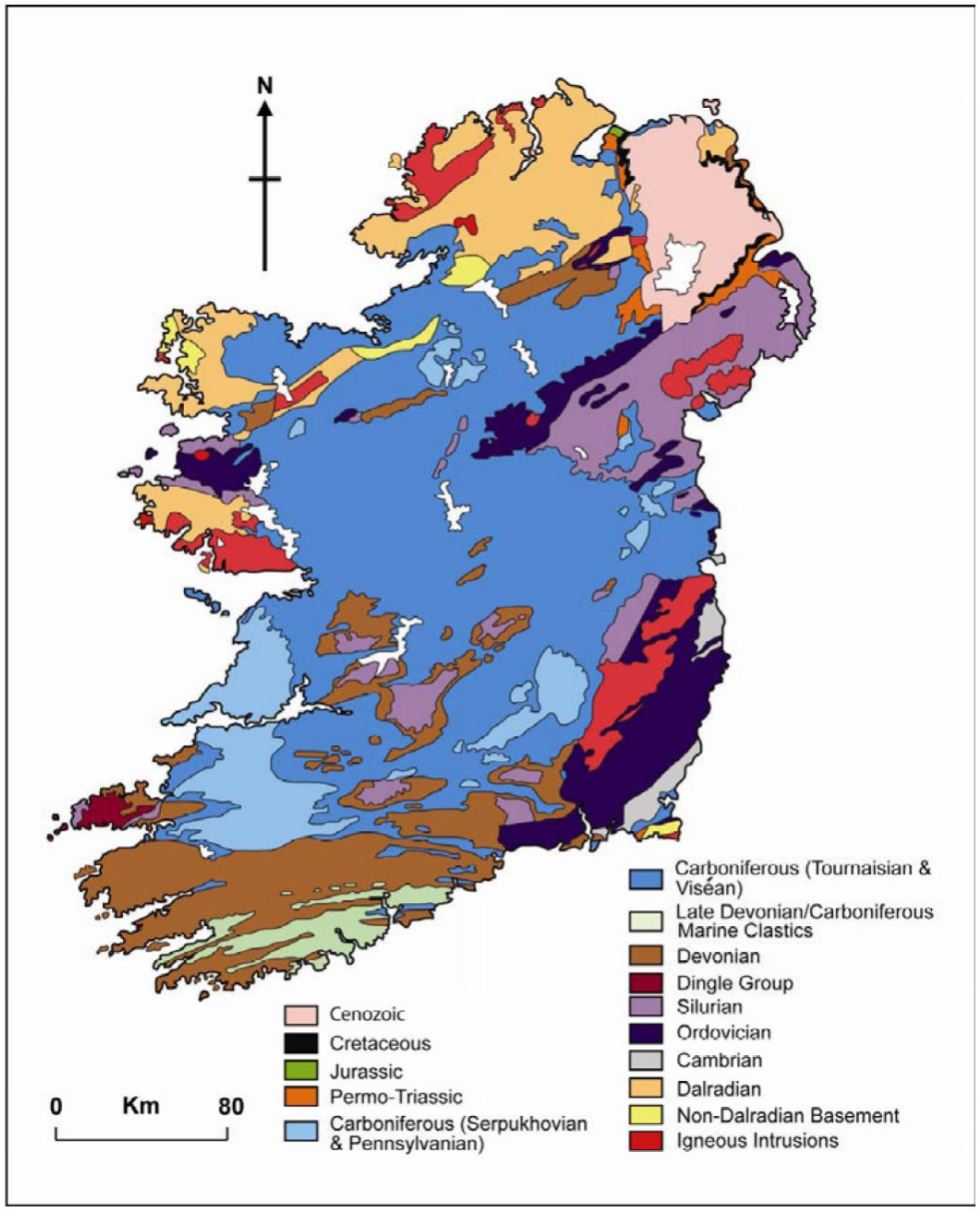

Figure 1. Geological map of Ireland (modified from Holland and Sanders, 2009; Naylor and Shannon, 2011).

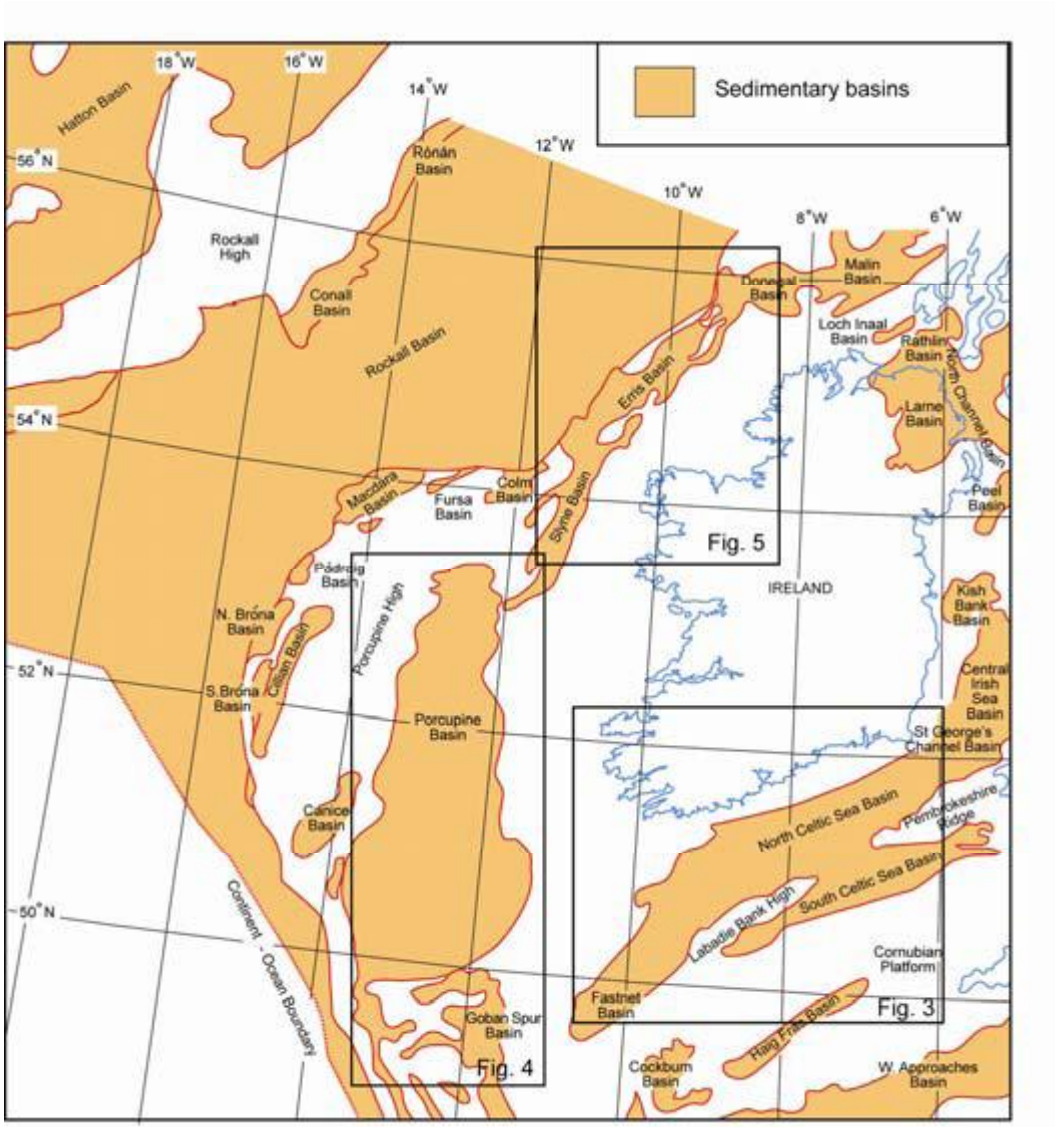

Figure 2. Sedimentary basins around Ireland (from Naylor and Shannon, 2011).

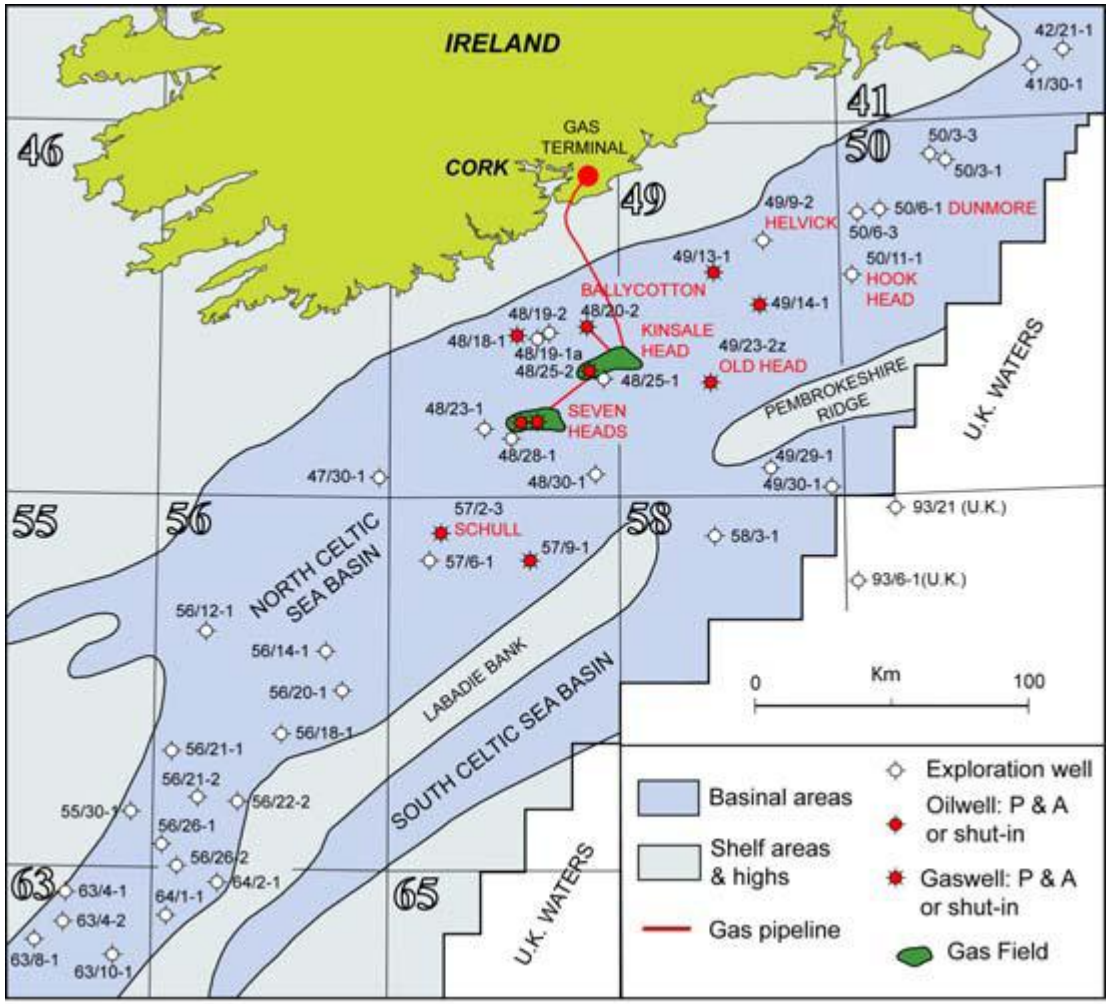

Figure 3. Fields, discoveries and location of some of the key wells drilled in the Celtic Sea basins (modified from Naylor and Shannon, 2011).

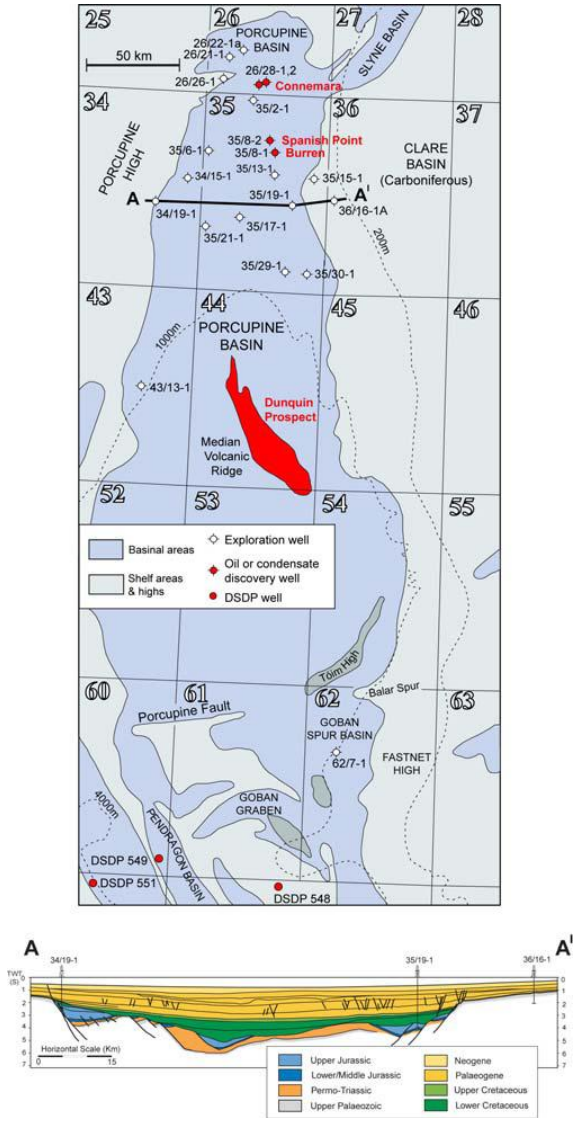

Figure 4. Fields, discoveries, and key wells/boreholes in the Porcupine Basin region (from Naylor and Shannon, 2011). Geoseismic section A-A' through the Porcupine Basin is after Naylor et al. (1999).

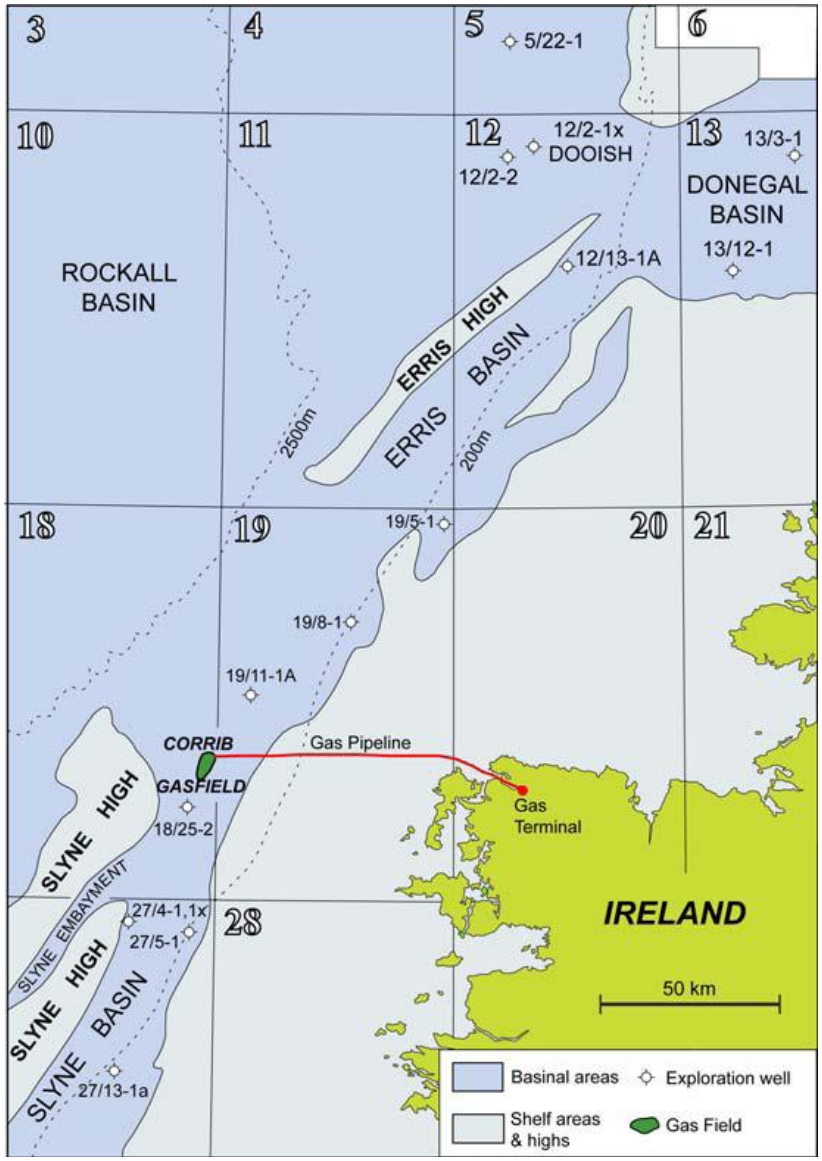

Figure 5. Fields, discoveries, and key well in the basins of the Slyne, Erris, Donegal and Rockall basins (modified from Naylor and Shannon, 2011).