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Third Annual PhD report

Tectonics and sedimentation in the Middle and Upper Jurassic succession of the northeast Porcupine Basin (offshore Ireland)

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EXECUTIVE SUMMARY

The overall aim of this PhD is to constrain the tectonic and sedimentary evolution for the Late Jurassic to Early Cretaceous period in the NE Porcupine Basin. The main scientific focus of the past year has been on documenting the interplay of faulting and sedimentation within the study area. This has been carried out with an extensive database of 2D and 3D seismic data, correlated with petrophysical logs in order to characterise the detail of the Late Jurassic/Early Cretaceous rift transition in the region.

Three main sedimentary packages of Upper Jurassic age have been correlated regionally. Well data, supported by biostratigraphic data, suggest deposition developed during a progressive sea-level rise. The base of the succession is composed of Oxfordian transitional fluvial-lacustrine/marginal deposits, overlain by restricted marine strata of Lower Kimmeridgian age. Fully marine conditions took place in the Late Kimmeridgian and Portlandian/Volgian times and persisted during the Early Cretaceous, interrupted by periodic rift-related shallowing phases. Overall, sedimentation patterns were controlled by a regional N-S oriented fault system, with local influence from E-W and NE-SW fault systems. In detail, the three lithostratigraphic packages show thickness, and facies variations within and between fault-controlled depocentres. These are interpreted as the response to pulsed rift events and result in localised growth-faulting, regional erosional unconformities and local second-order erosion surfaces. Overall, these features suggest regional variations in rift magnitude and timing, leading to compartmentalized, fault-controlled depositional sub-basins developing in response to regional east-west extension.

The rift transition from Late Jurassic to Early Cretaceous time is complex. Jurassic strata are overlain by variable thickness and facies of Neocomian and Aptian sediments. Although Early Cretaceous growth-faulting is tenuous, extension is characterised by regional uplift phases associated with a main Base Cretaceous and second-order intra-Neocomian angular unconformities. In many places, these are associated with footwall scarps. Degradation of contemporaneous footwalls, especially in Block 26/28, is often spectacular and suggests reworking of Jurassic and Carboniferous strata. This rift transition is followed by major, rapid regional thermal subsidence resulting in marine strata developed within a single large basin.

The third year of the PhD project was spent on **(a)** gathering and loading selected 2D and 3D seismic data in Block 26/28 and its immediate environs, **(b)** mapping and integrating seismic and wireline interpretations of the Late Jurassic-Early Cretaceous sedimentary packages, **(c)** detailed mapping of major fault systems and **(d)** developing and refining models of the Jurassic to Early Cretaceous tectonostratigraphic evolution of the NE Porcupine Basin.

1. Regional geological framework

The Irish Atlantic Margin (IAM) represents a major frontier exploration area. The Porcupine Basin [Fig. 1], one of largest basins in the region, has been the subject of intermittent petroleum exploration phases since the latest 1970's. A significant number of exploration and appraisal wells have been drilled, supplemented by a large volume of 2D and 3D seismic data. Two currently sub-commercial discoveries have been made: the Connemara (Quadrant 26) and Spanish Point (Quadrant 35), mainly hosted in Middle and Upper Jurassic sandstones and consisting in a working petroleum system. However, the detailed evolution of the basin is still

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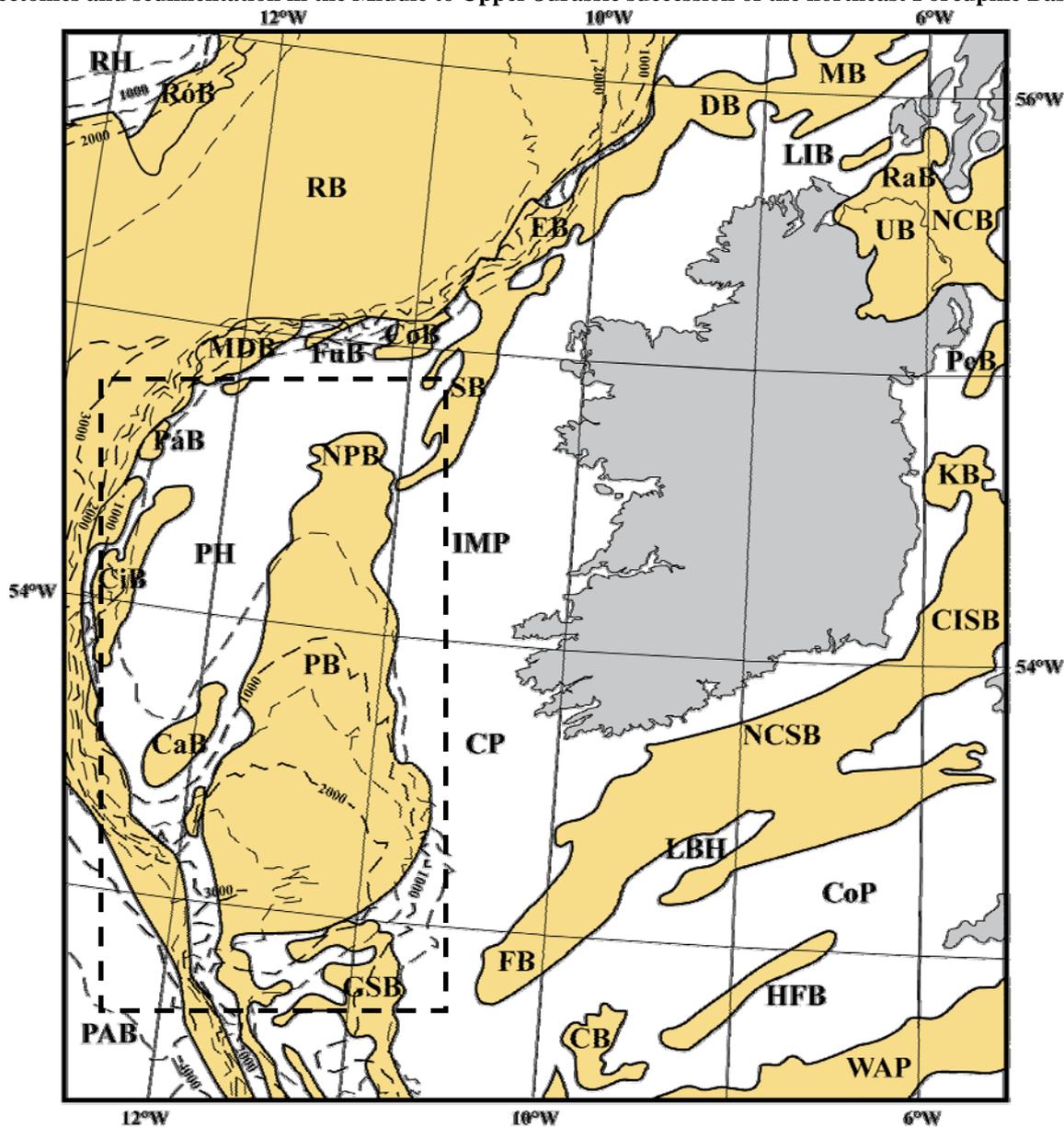


Fig. 1 : Location of Mesozoic and Tertiary sedimentary basins along the Irish Atlantic Margin
 [After Naylor *et al.*, 2002 and Naylor & Shannon, in prep.]

Dashed box indicates location of Figure 2. Bathymetric contours are at every 500 m. CaB : Canice Basin, CB : Cockburn Basin, CiB : Cillian Basin, CISB : Central Irish Sea Basin, CP : Celtic Platform, CoB : Colm Basin, CoP : Cornubian Platform; DB : Donegal basin , EB : Erris Basin, FB : Fastnet Basin, FuB : Fursa Basin, GSP : Goban Spur Basin, HFB : Haig Fras Basin, IMP : Irish Mainland Platform, KB : Kish Bank Basin, LIB : Loch Inaal Basin, MB : Malin Basin, MDB: MacDara Basin, NCB : North Channel Basin, NPB : North Porcupine Basin, PáB : Pádraig Basin, PAB : Porcupine Abyssal Plain, PB, Porcupine Basin, PeB : Peel Basin, PH : Porcupine High, RaB : Rathlin Basin, RB. : Rockall Basin, RH: Rockall High, RóB : Rónan Basin, SB : Slyne Basin, UB : Ulster Basin, WAP : Western Approaches Basin

poorly constrained. The aim of this PhD is to better define the Jurassic tectonosedimentary development of the NE part of the Porcupine Basin, with a major focus on documenting the interactions between tectonics, sedimentation and erosion phases in the region.

The Porcupine Basin contains up to 10 km of strata of Late Palaeozoic to Cenozoic age [e.g. Shannon, 1998; Naylor *et al.*, 2002; Naylor & Shannon, 2005] whose the deposition is intimately related to the northward propagation of the Atlantic Rift system [e.g. Doré *et al.*, 1999; Spencer *et al.*, 1999 and 2001; Naylor *et al.*, 1999 and 2005]. Wells have shown Jurassic sediments resting unconformably upon Permo-Carboniferous strata and are overlain by a variable Early Cretaceous succession [e.g. MacDonald *et al.*, 1987; Croker & Shannon, 1987; Tate & Dobson, 1988 and 1989; Trueblood & Morton, 1991; Moore, 1992; Tate, 1993; Sinclair *et al.*, 1994; Naylor *et al.*, 2002]. The succession developed in response to a number of vertical

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movements of regional and/or local extent. Lower Cretaceous strata are covered by a thin Upper Cretaceous chalk succession and thick Eocene deltaic to submarine fan deposits, resulting from ridge-push effects of sea-floor spreading in the west of the Rockall Basin. The following is a summary of the tectonostratigraphic evolution of the Jurassic to Early Cretaceous in the Porcupine Basin, based upon published studies and the work carried out since the start of this PhD.

1.1 – Early and Middle Jurassic :

Lower Jurassic sediments, encountered only in the North Porcupine Basin [Fig. 1], overlap an irregular pre-Jurassic topography. The succession is a marine transgressive sequence comprising limestone, shales and intercalated siltstones mainly of Rhaetian and Hettangian ages. It lies conformably on Triassic strata. However, it still remains unclear if the regional absence of Lower Jurassic strata terrains in Quadrant 26 and further south is due to non-depositional or erosional effects.

Middle Jurassic (?Bajocian to Bathonian) strata have a wide distribution throughout the Porcupine Basin, resting unconformably on Lower Jurassic strata (North Porcupine Basin) or Upper Carboniferous sediments (northern part of the Porcupine Basin). The succession is mainly composed of alternations of thick, coarse sandstones passing upwards to muddier strata [Croker & Shannon, 1987; MacDonald *et al.*, 1987; Butterworth *et al.*, 1999]. This has been interpreted as a result of braided to meandering, fluvial systems which shows progressive lacustrine affinities toward the top of the succession [Athersuch *et al.*, 1983; Harvey *et al.*, 1990; Bulois & Shannon, 2007]. Sinclair *et al.* [1994] interpreted this sequence as the product of an onset warp setting prior to the main Cimmerian rifting, which evolved during the Late Jurassic [Cf. Fig. 3 in Bulois & Shannon, 2007].

1.2 – Late Jurassic :

Upper Jurassic (Oxfordian to Portlandian) strata have been penetrated in most wells drilled in the Porcupine Basin. They developed in response to a punctuated northward marine transgression. In earlier reports, three main sedimentary packages have been identified and correlated [Bulois & Shannon 2007, Bulois *et al.*, 2007a & b and 2008]. However, differences occur between fault-blocks, especially in the earlier part or the Upper Jurassic series where facies and thickness can vary rapidly. This is interpreted as a result of the sub-basin architecture during the Oxfordian and early Kimmeridgian, and possibly the earlier part or the Portlandian/Volgian before regional marine transgression.

In blocks 26 and 35, the base of the succession (Zone II of Bulois & Shannon [2007]) is composed of Oxfordian strata resting unconformably on Middle Jurassic sediments and consisting in sandstones of variable thickness intercalated with siltstones and mudstones. Calcrete development is also recorded in various places. Bulois & Shannon [2007] proposed a coastal/estuarine deposition environment, with evidence of non-marine to brackish conditions becoming shallow marine. The thickness of the succession is very variable, suggesting that the deposition has been mainly controlled by pre-existing (*i.e.* Middle Jurassic) topography, together with an early rift phase. This is supported by evidence of growth-faulting in the eastern part of Quadrant 26.

Oxfordian strata are separated from Kimmeridgian strata (Zone III of Bulois & Shannon [2007]) by an angular unconformity. Recognised almost entirely through Quadrant 26, the succession is composed of thin siltstones intercalated with limestones and dolomites, much thicker and better developed than in Zone II. Occasional sandstones developed significantly toward the north at the expense of limestone layers. Seismic data shows evidence of fault-block rotation, growth-faulting and thickness variations at this level in the succession. Micropaleontological data suggests that the sequence represents a marginal setting evolving under transgressive marine conditions. However, these data also show evidence of restricted marine environment, which are supported by the presence of submarine fan at the edge of a tectonically active slope in Quadrant 35 (*e.g.* well 35/8-2).

The Portlandian/Volgian succession (Zone IV of Bulois & Shannon [2007]) occurred during open marine conditions. The strata are characterised by very thin limestone layers intercalated with thick mudstones. A number of very thick sandstone bodies (*e.g.* wells 26/27-1B, 26/28-4A and 26/28-5) reflect rift-related deepening and erosion of rotated fault blocks. Several authors [Croker & Shannon, 1987; MacDonald *et al.*, 1987; Moore, 1992; Sinclair *et al.*, 1994] showed that the onset of block rotation was synchronous with a Late Kimmeridgian influx of coarse siliclastic debris.

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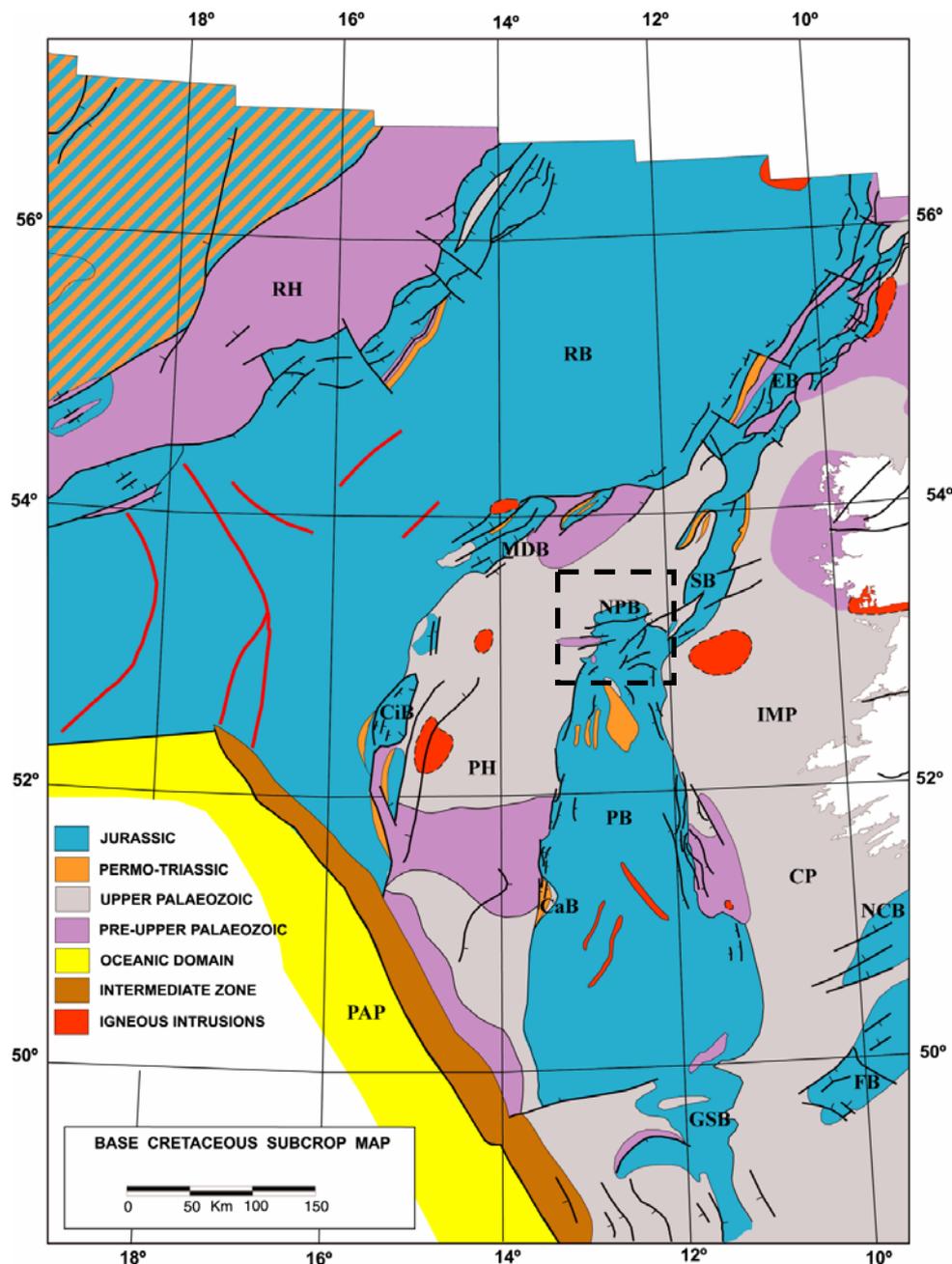


Fig. 2 : Structural framework of the Irish Atlantic Margin at the Base Cretaceous Unconformity (BCU)
 [After Naylor & Shannon, 2005]

Dashed box indicates location of **Figure 3**. See **Figure 1** for the meanings of the abbreviations.

Lower Cretaceous strata were deposited in an open marine environment across the entire Porcupine Basin above the Base Cretaceous Unconformity (BCU). Their distribution is controlled by a Late Jurassic rift phase which possibly continued through the earlier part of the Cretaceous and later, by Aptian-Albian rifting. As a result, Neocomian strata are observed unconformably overlying sequences of Jurassic to Carboniferous ages and are even absent in a few wells [Bulois & Shannon, 2007].

Earlier studies described fault structures of various orientations. However, in the northern part of the basin, the N-S trend similar intersects with reactivated NE-SW caledonoid structural features [Fig. 2, e.g. Croker & Shannon, 1987; MacDonald *et al.*, 1987; Sinclair *et al.*, 1994; Doré *et al.*, 1997 and 1999; Spencer & MacTiernan, 2001; Naylor *et al.*, 1999 and 2002; PESGB, 2009]. Detailed seismic analysis (see below) shows a more complex pattern, with the predominant fault pattern running NE-SW in the southwest of Block 26/28 and E-W orientation in the vicinity of Finnian’s Spur.

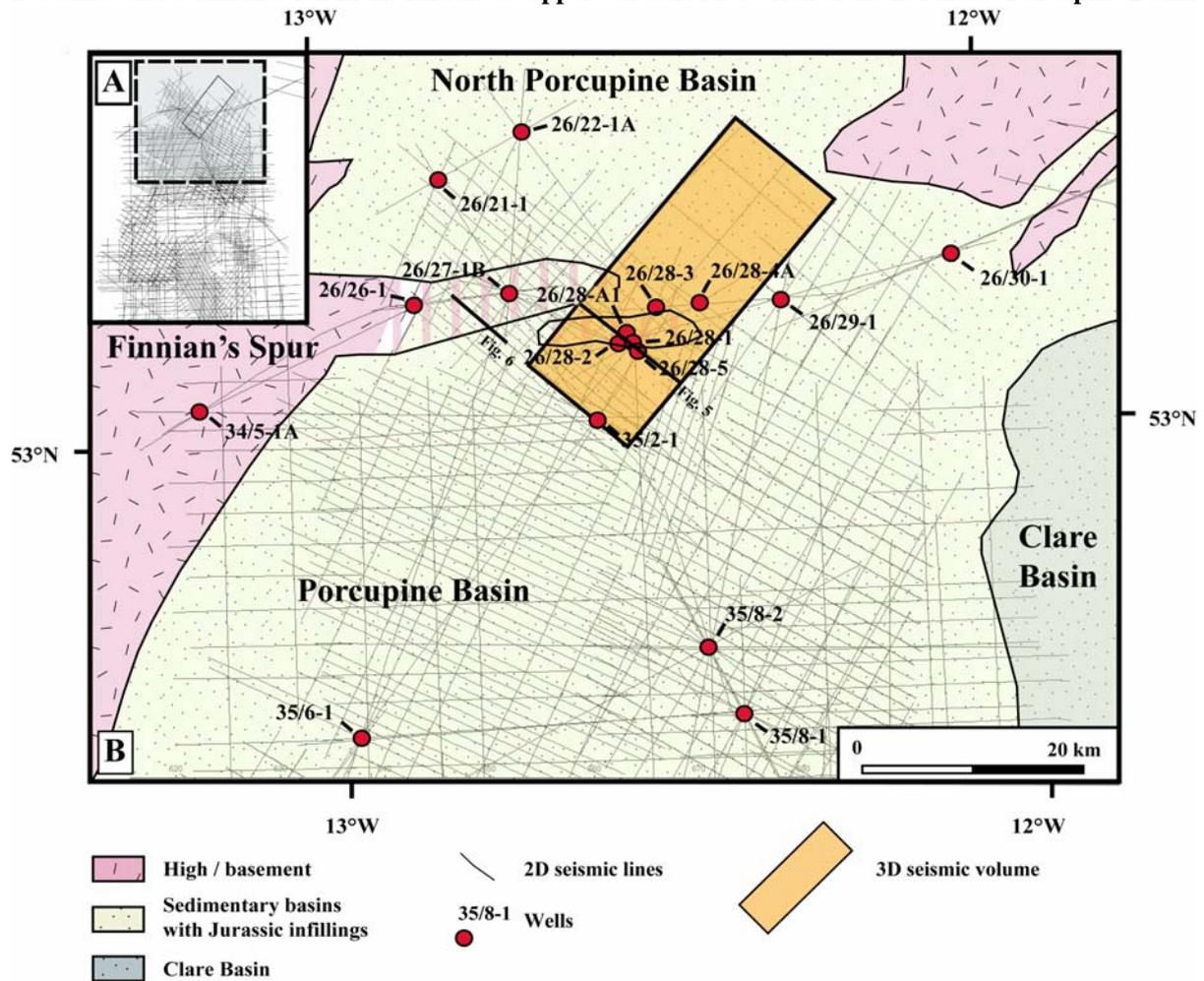


Fig. 3 : Position map of well and seismic data used in this study

A : Position map of the entire SEGY seismic dataset available in-school. B : Position map of the data set used in this study. Position of figures 5 and 6 are displayed on Fig. 3B.

2. Summary of work:

The work carried out in the third year of the PhD included the following:

- Conferences in Ireland and UK.
- Seismic data selection and loading.
- Interpretation and detailed mapping of seismo-stratigraphic units, depositional sub-basins and fault systems.

2.1 – Conferences :

Attended the *Annual General Meeting of the British Sedimentological Research Group* at University of Birmingham (late December 2007) and the annual *Irish Geological Research Meeting* at University College Dublin (end February 2008). Oral presentations were given at both conferences (see enclosed abstracts). Visits were made to *Island Oil and Gas Ltd* to discuss progress, results and ideas.

2.2 – Seismic data selection and loading :

2D and 3D seismic data in SEGY format from quadrants 26 and 35 were selected and facilitated by Michael Hanrahan (*Petroleum Affairs Division*). Paper copies of some other key lines, not available in SEGY format, were also reviewed. Contacts were made with Université de Bretagne Occidentale and IFREMER (Brest, France) to convert some of these key profiles to SEGY. To date approximately 5000 km of 2D seismic lines from 7 surveys, together with a 3D dataset from Block 26/28 have been loaded on the *Charisma* seismic interpretation package. These provide a very good coverage of the study area [Fig. 3].

2.3. –*Seismic mapping* :

Approximately 10 seismic reflectors have been mapped over Block 26/28 and in the vicinity of the well 26/27-1B. The main unconformities defined during the first and second years of the PhD [Bulois and Shannon, 2006 and 2007] have been studied in more details in order to constrain precisely their geometry. Several second-order erosional unconformity surfaces and local seismic packages have also been documented in the Jurassic and Early Cretaceous successions.

The identified surfaces developed in response to extensional faulting and demonstrate composite and discontinuous rifting taking place from the Oxfordian to the Early Cretaceous. Seismic packages and fault structures were mapped on each 2D seismic line where the data resolution is good enough. 3D seismic data were interpreted every 25 lines (*i.e.* 312.5 meters) or every 5 to 10 crosslines (*i.e.* 62.5 or 125 meters) in complicated and/or key areas. Maps showing the geometry of the fault zones and sedimentary units have been produced.

3. Seismic correlation:

3.1. – *Fault mapping* :

The extensive 2D and 3D seismic dataset enables analysis of the details of fault orientations in the study area. Figure 4 shows the structural trends in blocks 26/27, 26/28 and in the northern part of the well 35/8-2, at the BCU and the base of Zone IV [Bulois & Shannon, 2007], corresponding to the Base Portlandian Unconformity (BPU). These two maps are preliminary and part of work in progress.

The fault pattern varies from place to place, and is influenced by basement structures as indicated from gravity and magnetic studies [*e.g.* Readman *et al.*, 2005] or previous seismic-based analysis [*e.g.* Naylor *et al.*, 1999 and 2002; Naylor & Shannon, 2005]. Three main populations have been recognised in the study area, on the basis of their orientation. Fault structures are predominantly E-W at the south of Finnian's Spur and in the vicinity of well 26/27-1B [Fig. 4]. In the middle part of Block 26/28, the general direction progressively turns toward the northeast to adopt a NE-SW orientation, similar to Caledonian trend recognised regionally, both onshore and offshore [Figs 1 and 2]. N-S structures are predominant in Quadrant 35 [Fig. 4A]. They tend to be minor in the study area, at the exception of the eastern part of Block 26/28 where NE-SW structures adopt gradually a N-S trend. These features have been particularly active during the Portlandian/Volgian but progressively died out through the Early Cretaceous (Figures 4B and 4C). These N-S trending features are probably a remanence of a long-standing structural fabric giving place to the Porcupine embayment.

McDonald *et al.* [1987] and regional well reports described similar structural patterns in Block 26/28 but accorded a lot of importance to N-S fault structures. Figure 4C shows that the N-S trend is more minor than illustrated by these authors for a similar period of time. Running at the base of Zone IV, the BPU represents one of the nearest event to the top of the Bajocian to Kimmeridgian reservoir [Bulois & Shannon, 2007]. Figure 4C indicates then that the reservoir is highly faulted, even if fault movements are often very small (less than 10 to 20 m) in the Portlandian/Volgian time, and consequently are difficult to map from 2D and 3D seismic data in some areas.

On more regional scale [Fig. 2 and 4A], there is a continuity of structural fabrics between the Finnian's Spur and the Slyne-Erris domain with major tectonic structures reactivated throughout the Jurassic and/or Early Cretaceous. For instance, the Finnian's Spur, a fault-bounded basement feature, has been clearly active during the Late Jurassic and Early Cretaceous [Fig. 4]. It acted as a structural barrier between the Main Porcupine and North Porcupine basins until early Cenozoic times. This main feature shows a complex fault network, which extends toward the south of well 26/27-1B into several buried, narrow horsts [Fig. 4C and 6]. Variations in sedimentary thickness are recorded in well data during deposition of Zone IV [*cf.* Fig. 4 in Bulois & Shannon, 2007].

Similarly, a number of half-graben has been mapped in the study area. They are usually bounded by a main fault zone, whose the degree of complexity varies from place to place [Figs 5 and 6]. These faults can be followed on several kilometres [Fig. 4]. They are often very steep all across the entire sedimentary succession but, in the

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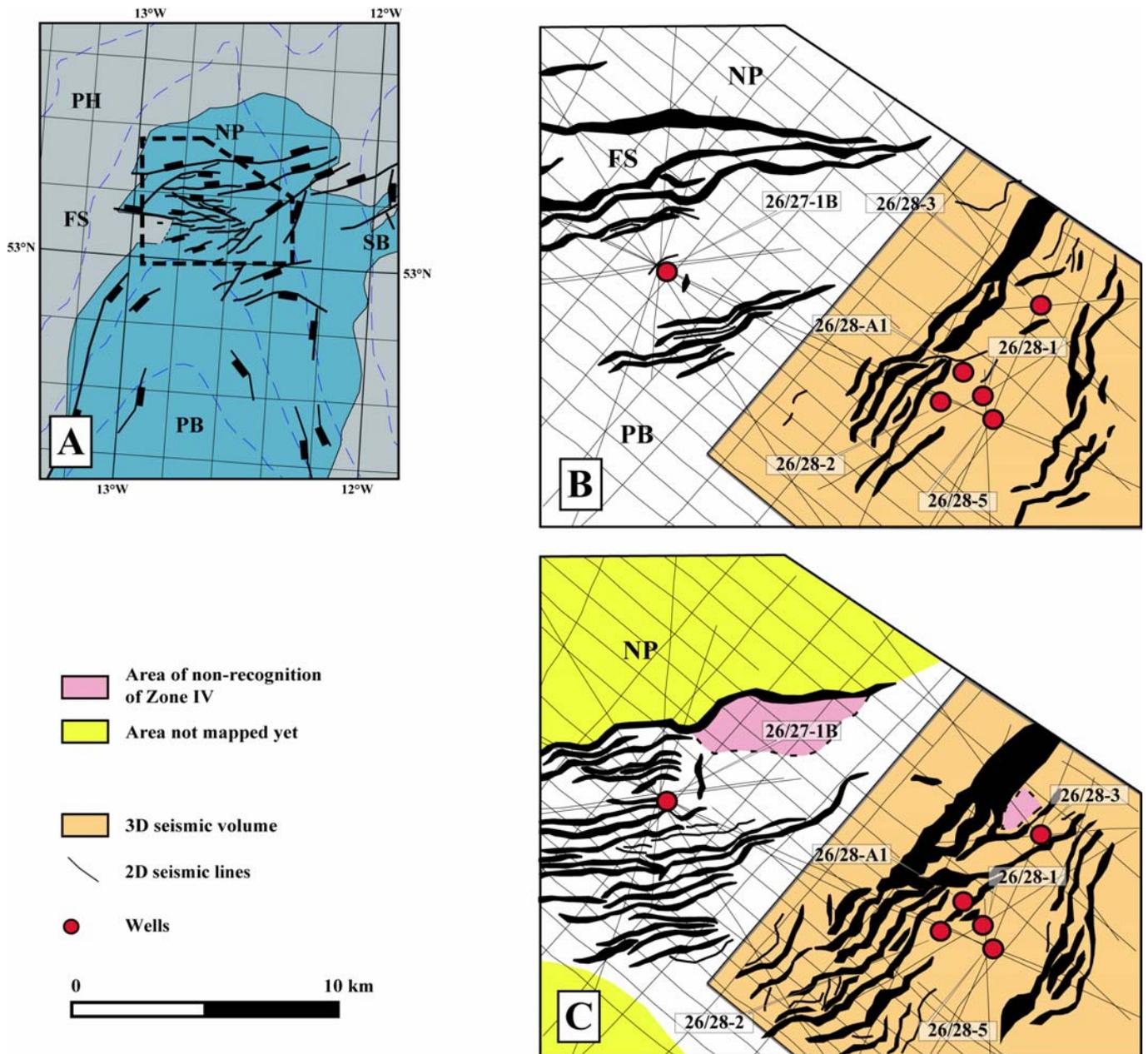


Fig. 4 : Fault maps in the area of blocks 26/27 and 26/28

A : Regional map modified from Naylor & Shannon [2005] and later 2D seismic data analysis. Box in dashed line indicates the position of figures 4B and 4C. **B :** Detail map of fault structures at the Base Cretaceous Unconformity (BCU). **C :** Detail map of fault structures at the Base Portlandian Unconformity (BPU) (i.e. base of former Zone IV [Bulois & Shannon, 2007]. These maps are shown here as a work in progress.

vicinity of E-W transfer zones, their dip tends to flatten significantly [Fig. 5]. This is particularly obvious in the vicinity of well 26/28-2, where Carboniferous strata show higher dip angles as a result of an increased rotation along bounding fault planes. Some complications in the structural pattern are also seen in places where structures are associated with secondary, synthetic and antithetic faults which offset various marker horizons. Thus, the broad picture of a 'simple' Cretaceous fault pattern [Fig. 4B] ends up to a higher complication of the fault-block geometry [Fig. 4C]. Consequently, the tectonic control on the sedimentation differs and area of non-deposition and/or erosion can be documented in various places [Fig. 4C].

In Block 26/28, major bounding faults are associated with growth-faulting, possibly originating as early as Late Kimmeridgian times, but predominantly in Portlandian/Volgian strata [Fig. 5]. On the eastern margin of the Porcupine Basin, growth-faulting is obvious within the Oxfordian, Kimmeridgian and Portlandian [Bulois & Shannon, 2007, Bulois *et al.*, 2007a & b and 2008] but remains unclear in the western part of Quadrant 26

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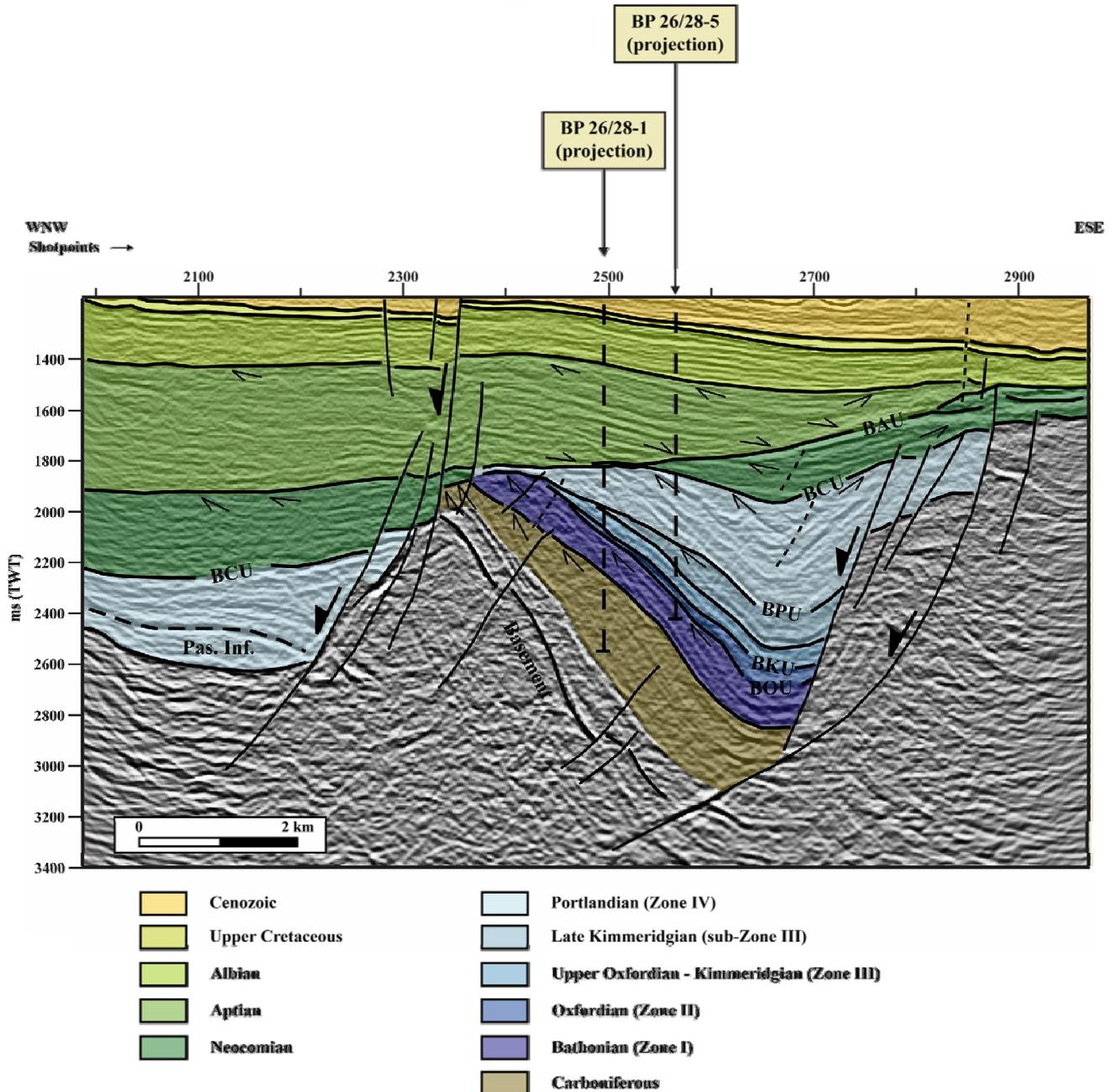


Fig. 5 : 3D crossline 1975, Block 26/28

BAU : Base Aptian Unconformity, BCU : Base Cretaceous Unconformity, BKU : Base Kimmeridgian Unconformity, BOU : Base Oxfordian Unconformity, BPU : Base Portlandian Unconformity, Pas. Inf. : potential passive infilling. Thinner arrows indicate major truncations. Thicker arrows represent the throw direction along the major normal faults identified during the seismic interpretation. Dashed line indicates position of intra-zones unconformities. The location of the section is indicated on Figure 3.

where rifting occurrence is only suggested by the development of regional erosional unconformities [Fig. 6]. Overall, growth-faulting appears to be localised but evidence of the extent of such growth-faulting may have been removed by the erosional effects of later major unconformities [e.g. BCU and BPU; Fig. 6; Cf. Fig.3 in Bulois & Shannon, 2007].

Normal faulting is evident along major NE-SW and N-S fault systems, while E-W structures show little vertical displacement. It has been widely recognised that the dominant extensional stresses took place along an E-W and WNW-ESE direction throughout the Jurassic to Cretaceous development of the Porcupine Basin [e.g. Sinclair *et al.*, 1994; Doré *et al.*, 1999]. The E-W structures therefore probably contain a predominant strike-slip component, with the associated fault-blocks opened in a transtensional setting. Reactivation of these structures occurred through the Cretaceous and locally in the Cenozoic. On the eastern part of the *Connemara Oil Accumulation*, gas escape is interpreted on seismic data, both in the Cretaceous and Cenozoic successions. It

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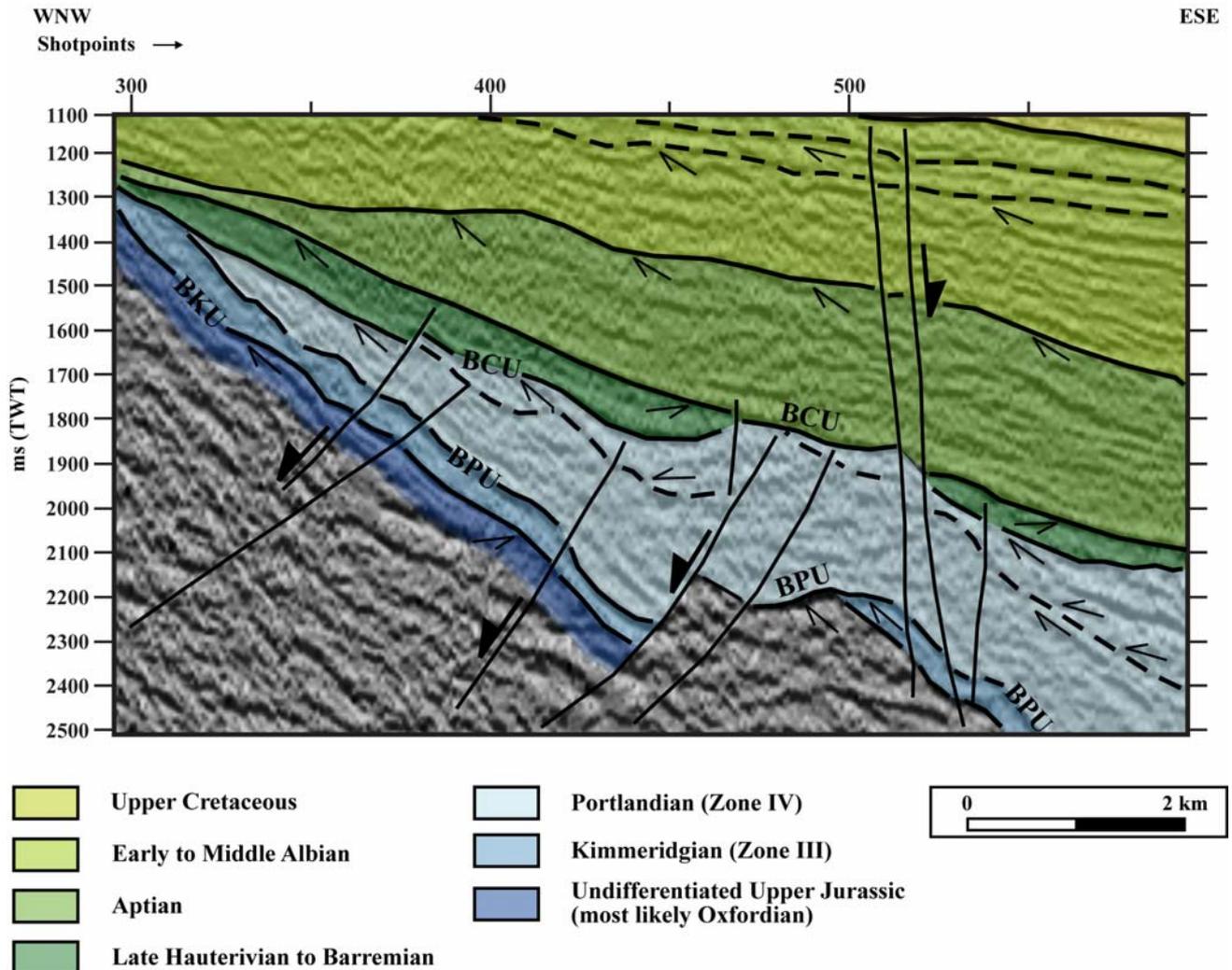


Fig. 6 : detail of 2D seismic line IR80-27, Block 26/28

BAU : Base Aptian Unconformity, BCU : Base Cretaceous Unconformity, BKU : Base Kimmeridgian Unconformity, BPU : Base Portlandian Unconformity. Thinner arrows indicate major truncations. Thicker arrows represent the throw direction along the major normal faults identified during the seismic interpretation. Dashed line indicates position of intra-zones unconformities. The location of the section is indicated on [Figure 3](#).

appears to be controlled by major faults structuring a relatively shallow basement and extending preferentially along an E-W direction. In various places, displacement along minor reactivated faults has been sufficient enough to partially invert the normal component of such structural systems.

3.2 – Jurassic seismo-stratigraphic packages, major unconformities and rifting phases:

The four Jurassic seismo-stratigraphic packages identified in earlier work on this project [[Bulois & Shannon, 2006](#)] have now been mapped more regionally through the study area. They correlate well to the packages identified on well data [[Bulois & Shannon; 2007](#)]. These packages bounded by angular unconformities which extend through blocks 26/27 and 26/28. Even though evidence of growth-faulting for the entire Upper Jurassic succession remain unclear in areas, these unconformities are thought to result from regional faulting corresponding to rift episodes. The response to the three main rift episodes of Oxfordian, Kimmeridgian, and Portlandian/Volgian ages are seen within various fault blocks. The Portlandian/Volgian unconformity (BPU) is recognised everywhere in the study area as the most important rifting event and is clearly associated with growth-faulting in most of the fault blocks [[Fig. 5 and 6](#)]. In Block 26/28, displacement took place predominantly along NE-SW and N-S structures [[Fig. 4C](#)]. Oxfordian (BOU) and Kimmeridgian (BKU) unconformities are harder to distinguish regionally but are identified on 3D seismic data. The mapping supports the model of the development of a series of separate fault-controlled depositional basins from the onset of Upper Jurassic rifting.

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Second-order unconformities, of local and/or fault-block scale, are identified within some of the lithostratigraphic packages. These unconformities are not necessarily a direct consequence of erosional processes linked to rifting but might simply be an effect of 'passive' infilling above an irregular basin-floor topography. This is supported by the recognition of sub-packages which developed very locally, often without clear erosion [Fig. 5].

3.3 – Jurassic-Cretaceous rift transition:

The transition from the Jurassic to the Early Cretaceous is marked by a clear unconformity (former BCU), characterised by a pretty continuous reflector of high to very high amplitude [Figs 5 and 6]. In detail, the Jurassic-Cretaceous boundary shows a complex geometry and the BCU is locally associated with second order unconformities or erosive features [Fig. 6]. In contrast to the Jurassic pattern, the Early Cretaceous fault pattern is restricted to reactivation of structures [Fig. 4] and fault offset in the Lower Cretaceous is often, but not necessarily, connected with the main Jurassic bounding faults. Jurassic faults probably commonly reached the surface but erosion at the BCU unconformity tended to remove the topography [e.g. Fig. 6].

The residual topography of the BCU probably influenced the pattern of early Cretaceous sedimentation. Neocomian strata have been identified in a small number of wells [e.g. Bulois & Shannon, 2007] and downlap Jurassic strata and occasionally Carboniferous or older strata [Figs 5 and 6]. They are mainly composed of marine shales deposited in a poorly oxygenated basin [Sinclair *et al.*, 1994]. In Block 26/28, the upper part of the succession is truncated by an angular intra-unconformity, possibly developed during the Barremian. Second-order unconformities are also seen within the succession. The thickness of the Neocomian has also been affected by fault structures (and associated topographic scarps), periodically reactivated through the Early Cretaceous. Figure 6 shows that the south of the study area experienced minor tectonic movements along reactivated faults. In other places, the entire Neocomian interval suggests deposition in a tectonically active setting, with several phases of minor vertical movements of local and/or regional extent. Thus, the Berriasian sedimentation most likely occurred in rotated fault-blocks with footwalls partially eroded. It has been followed by a major phase of subsidence during the Valanginian, particularly pronounced in the central part of the study area. This is marked by mudstone-prone sediments deposited in a marine shelf environment.

The top of the Neocomian succession is truncated by another major angular unconformity at the base of the Aptian sequence [Figs 5 and 6]. Aptian and Albian strata onlap on Neocomian, Jurassic and Carboniferous sediments. Reactivation along major Jurassic faults occurred within the Aptian and Albian but little evidence of growth-faulting has been documented in the study area. It forms a structurally simple succession which can be subdivided into several seismo-stratigraphic units. In detail, correlations between well and seismic data show that these seismic packages were deposited in a marine environment suggesting a clear deepening of the basin in response of a major thermal and sedimentary subsidence. This period of relative quiescence was interrupted by thick deltaic deposits, reflecting a late rifting phase of mainly Albian age. The source of the clastic detritus probably lay to the northern and eastern margins of the basin, as the southern part of the Porcupine Basin was much deeper and under fully marine conditions [e.g. Croker & Shannon, 1987; Naylor & Shannon, 2005]. Moreover, Mid-Aptian sediments are absent in the area, due to a regional unconformity coincident with the onset of sea-floor spreading in the Iberian and French sectors [Sibuet *et al.*, 2003; Naylor & Shannon, 2005]. In summary, the earliest Cretaceous in the region shows a continuation of rifting, albeit less dramatic than in the Late Jurassic, with occasional mid-Cretaceous localised rifts.

3.4 – Sedimentary provenance and footwall degradation:

Earlier work on the project [Bulois & Shannon, 2006 and 2007] pointed out a number of discrepancies in the ages given by well reports. The biostratigraphic data suggests reworking of older material into the Mesozoic succession [Athersuch *et al.*, 1982; Smith & Higgs, 2001]. The development of the major unconformities, both in the Jurassic and the Early Cretaceous, also implies such recycling of sedimentary materials. Seismic analysis indicates vertical movements of local and regional importance [Fig. 5]. In this context, the formation of major unconformities controlled sedimentary remobilisation. Erosional processes are increased in several places by the association of several unconformities (*i.e.* BCU followed by intra-Neocomian unconformities).

Episodes of rifting leading to fault footwall uplift are interpreted in Block 26/28. Such vertical movements in other basins involve degradation of the top of the fault-blocks and the development of submarine fans [McLeod & Underhill, 1999, Allen & Densmore, 2000]. Major submarine fans have been recorded in Portlandian/Volgian

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strata (wells 26/28-4A and 26/28-5). The built-up of these systems is increased by rotational movements along the main fault scarps generated at the surface of the basin-floor. Local wedges of sediments are preserved adjacent to the eroded footwalls of fault scarps. These suggest local sedimentary transport at the scale of individual fault-blocks. Their preservation indicates a rapid sea-level rise. Similar clastic inputs are considered for older sediments, such as the development of sandy-dominated Zone II [Bulois & Shannon, 2007].

4. Future plans:

The major tasks and objectives of the coming months are as follow:

- Continue detailed seismic facies mapping of the Late Jurassic and early Cretaceous succession to constrain the extent of the lithostratigraphic packages, the main unconformities and detailed sub-basin depositional architecture.
- Quantify movement, age and subsidence rate along the major fault systems, in order to constrain the geological evolution.
- Present results at the annual Irish Geological Research Meeting (late February 2009); at a UCD School of Geological Sciences seminar (April 2009); and at the 12th meeting of the Association des Sédimentologues de France (October 2009).
- Prepare and submit a paper focused on well correlations for publication consideration to a peer-reviewed international journal.
- Write and submit the PhD thesis.

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Rift architecture in the Jurassic of the NE Porcupine Basin, offshore Ireland

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The Porcupine Basin, off the west coast of Ireland, contains a thick Mesozoic-Cenozoic sedimentary sequence deposited in response to the northward propagation of the North-Atlantic Rift system. The northeastern part of the basin has been the focus of hydrocarbon exploration since the late 1970's, leading to the discovery of the *Connemara* and *Spanish Point* oil accumulations hosted in Middle and Upper Jurassic sandstones. Previous studies demonstrate that the main extensional phase took place during the Late Jurassic to Early Cretaceous.

In this study, petrophysical logs and 2D/3D seismic profiles, supplemented with biostratigraphic information and limited core data, are used to constrain the Jurassic sedimentary response to rift evolution in the northeast part of the basin. The identification of a number of significant erosional unconformities suggests a rift event in the Oxfordian, with later phases of rifting in early Kimmeridgian and Volgian times. Base level rose on a regional scale during the period of rifting and early thermal subsidence, resulting in fluvial-lacustrine deposition giving way through time to marine strata. Four correlateable lithostratigraphic sequences have been traced between the wells and through the seismic volume. Lateral variations within the sequences are recognized from fault-block to fault-block, involving changes in facies, thickness and geometry. These sequences are interpreted as the response to changes in the magnitude and timing of rift-related localised faulting, coupled with regional subsidence across a number of broadly co-eval linked sub-basins.

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Evidence of sub-basin architecture in the northeastern Porcupine Basin, offshore west of Ireland

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Jurassic faulting has been recognized in several Irish sedimentary basins as part of the northward propagation of the Atlantic rift system. In the northeastern Porcupine Basin, previous studies broadly documented Middle to Upper Jurassic strata deposited in various environments, with a main extension phase along N-S and NE-SW faults during the Late Jurassic to Early Cretaceous. In this study, petrophysical logs and 2D/3D seismic data, supplemented with biostratigraphic and core information, are used to constrain the Jurassic sedimentary response to crustal extension.

Four lithostratigraphic packages have been regionally correlated. The Bathonian succession was deposited in a fluvial-lacustrine environment within an early onset-warp setting. It passes upward to Upper Jurassic sediments, showing a progressive sea-level rise and characteristic syn-rift deposition. In detail, a number of significant erosional unconformities suggest several rift events within Oxfordian, early Kimmeridgian, Portlandian/Volgian and Lower Cretaceous strata. They are expressed differently from fault-block to fault-block and through time, involving lateral variations in facies, thickness and geometry. These sequences are interpreted as a result of compartmentalized sub-basins, opening contemporaneously along localized, mainly E-W and NE-SW fault structures.

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