

ISPSG Project No. ISO4/04

## **Fourth Annual PhD report**

# **Tectonics and sedimentation in the Middle-Upper Jurassic and Late Cretaceous succession of the northeast Porcupine Basin (offshore Ireland)**

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### **EXECUTIVE SUMMARY**

The Late Cimmerian rifting phase is often regarded as the most important extensional phase in the northward propagation of the North Atlantic Rift system. In the Porcupine Basin, offshore Ireland, it resulted in the development of a thick syn-rift succession of Late Jurassic and locally Early Cretaceous age. The overall aim of this PhD project is to better constrain the Late Cimmerian tectonostratigraphic architecture of the northeastern part of the Porcupine Basin, from the analysis of an extensive 2D and 3D seismic dataset correlated to well data. The past year has involved detailed mapping of major fault systems, unconformity surfaces and igneous intrusions in the Mesozoic succession of quadrants 26 and 35, with specific focus on the Upper Jurassic-Lower Cretaceous succession. Overall, the deposition was controlled by a complex multiphase tectonism comprising a series of normal and strike-slip faulting episodes, separated by periods of uplift, magmatism and regional sea-level fluctuations.

Upper Jurassic sediments were deposited during a progressive base-level rise. At the Jurassic-Cretaceous transition, relative sea-level dropped significantly, and much of the Porcupine Basin lay above the storm-wave base. As a result, the crests of Jurassic fault-blocks were partially eroded, resulting in a widespread truncation surface and associated degradation complexes. This surface, commonly named the Late Cimmerian Unconformity, is also known as the Base Cretaceous Unconformity (BCU). On seismic data, the BCU is often described as a high-amplitude, seismic reflector marking the end of the Late Cimmerian rifting phase. Wells recovered Neocomian strata of various ages which unequally developed above the BCU within an open-marine environment. Those strata are often regarded as the sedimentary response to a post-rift, thermal subsidence subsequent to the Late Cimmerian rifting phase.

A re-evaluation of seismic and well data indicates that rifting most likely continued into earliest Cretaceous times, leading to the construction of a series of sedimentary depocentres. Their formation is controlled both by an irregular topography resulting from the BCU formation, and by fault-reactivation evidenced in the basal Neocomian strata. While no clear growth-faulting has been documented in the Neocomian, correlateable first- and second-order unconformities and disconformities have been observed merging toward the BCU on the margin of the depocentres. These are sometimes associated with intrusive magmatism. A series of erosional phases, resulting in successive sedimentary reworking and re-deposition, are suggested within the Neocomian. Two main events, characterised by the BCU and the Top Neocomian Unconformity (TNU), led to spectacular fault-scarp degradation. They bound a syn- to post-rift transitional sequence whose development was controlled by the interplay of rift pulses and relative sea-level fluctuations. In detail, the BCU is thought to be a strong indicator of a distinct rift pulse similar to those identified in the Upper Jurassic during earlier phases of the project. The TNU, of Barremian age, appears to mark the end of the Late Cimmerian rifting phase.

The third year of the PhD project was spent (a) mapping sedimentary packages based on previous wireline logs correlation, (b) detailed mapping of major fault systems, (c) constraining the formation and age of magmatic bodies, (d) constraining the age of the rifting/post-rifting transition and (e) refining the tectonostratigraphic models of the syn-rift evolution of the Jurassic to Early Cretaceous strata in the northeastern Porcupine Basin.

## 1. Summary of work in the past year:

The work carried out during the past year comprised the following:

- Attendance at conferences and industry meetings.
- Attendance at training courses on *Charisma* and *Petrel*.
- Processing and reloading a number of 2D seismic lines, mostly in Quadrant 35. Those lines had inconsistencies between navigation and SEGY files which required correction in order to enable seismic interpretation.
- Seismic mapping of unconformities, fault systems and seismic sequences in the southern part of Quadrant 26 and the northern part of quadrants 34 and 35. Seismic sequences identified during the previous years of the PhD were followed across the area. Magmatic bodies were identified, especially in the earliest Cretaceous succession of Quadrant 35, and their emplacement has been constrained in terms of nature (*i.e.* intrusive vs extrusive), age and relationships with older strata.
- Commencement of PhD thesis writing and continuing work on manuscripts for publication submission.

### 1.1 – Conferences and meetings:

Oral and poster presentations were given at the *Irish Geological Research Meeting* at Trinity College Dublin in February 2009 and the *Atlantic Ireland 2009* conference at the IMI in October 2009 (abstracts enclosed). Results were presented and discussed at informal meetings with researchers from industry (*e.g.* *Island Oil and Gas Ltd*, *Sosina Exploration Ltd*) and academia (Ireland, UK and Canada) during the year.

### 1.2 – 2D and 3D seismic interpretation and mapping:

Within the Jurassic interval, mapping of first order unconformities has continued across quadrants 26 and 35. These main unconformities are broadly equivalent to the surfaces defined in earlier work [*e.g.* [Bulois and Shannon, 2006; 2007 & 2008](#)]. Other geological features have also been analysed in detail and add to the geological model already presented in earlier reports. In particular, second order unconformities and sub-packages within the Jurassic succession have been documented but these are often difficult to map with confidence due to poor data quality of many of the 2D seismic lines.

Mapping of Early Cretaceous features has also taken place. Often described in the literature as a single unconformity running closed to the approximate Jurassic-Cretaceous transition, the Base Cretaceous Unconformity (BCU) in quadrants 26 and 35 study area typically comprises a composite surface. Thus, the BCU bounds the lower part of the Neocomian strata which are clearly truncated at their top by the distinct Top Neocomian Unconformity (TNU). Second-order unconformities and disconformities have been identified between the BCU and TNU. Unlike the BCU and TNU, these surfaces cannot be mapped over any significant distance with confidence due to seismic resolution difficulties and the lack of well data.

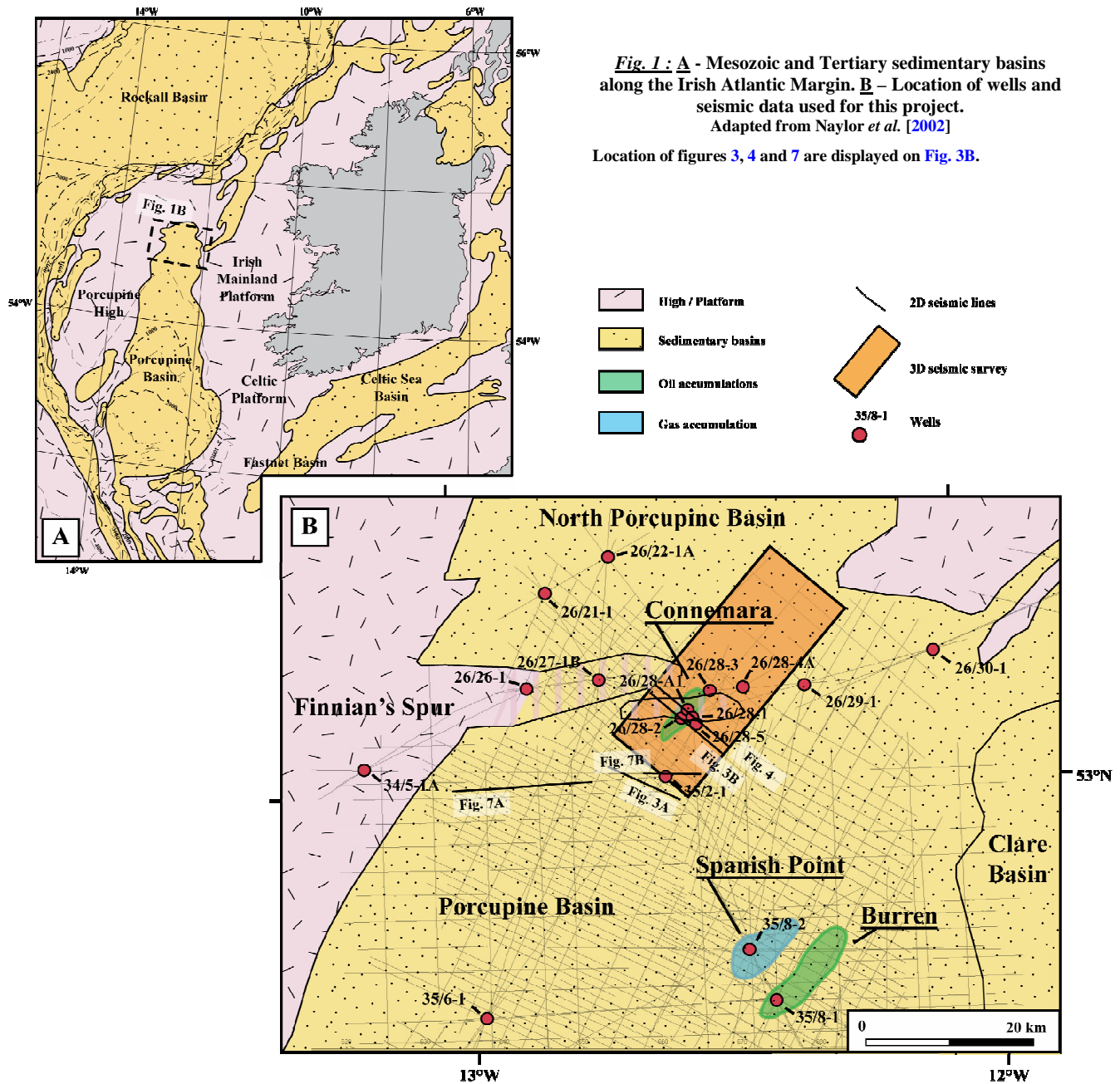
Magmatic bodies, mostly intrusive, have also been interpreted in several places. As in other parts of the Porcupine Basin, their age remains often unclear. A distinct population of sills and, sometimes, small intrusive centres cuts Late Jurassic-earliest Cretaceous strata, indicating a likely Neocomian magmatic event in the study area. At similar stratigraphic levels, some have also affected Cenozoic sediments with potential fluid escape indicating a younger age.

Fault systems have been mapped over scales of several kilometres throughout quadrants 26 and 35, both on 2D and 3D seismic. On the 3D data every 25<sup>th</sup> line (*i.e.* 312.5 meters) was generally interpreted, with more detail (every 5<sup>th</sup> to 10<sup>th</sup> line, *i.e.* 62.5 to 125 meters) in key areas, in order to provide a detailed map of fault characteristics. This technique also enabled the correction of navigation files for a number of 2D lines which have been reprocessed and add to the entire database.

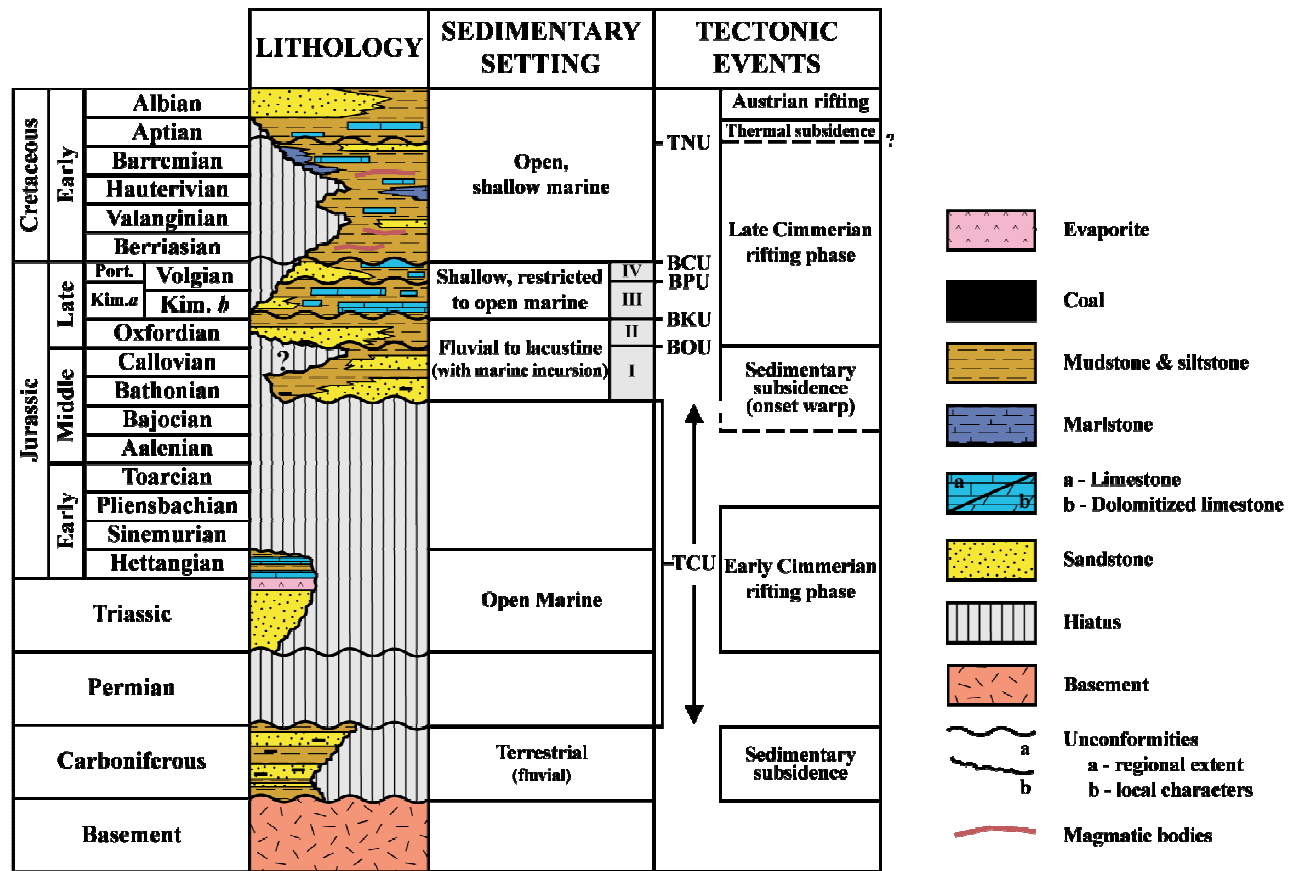
## 2. Regional geological framework:

The Porcupine Basin [[Fig. 1A](#)] is part of the northward propagating North Atlantic rift system [[Doré \*et al.\*, 1999; Spencer & MacTiernan, 1999 & 2001; Spencer \*et al.\*, 1999; Naylor & Shannon, 2005](#)]. It is underlain by thin and stretched continental crust [[Readman \*et al.\*, 2006](#)] and contains up to 10 km of Upper Paleozoic, Mesozoic and Cenozoic sediments [[Shannon, 1998; Naylor \*et al.\*, 2002; Naylor & Shannon, 2005](#)]. Its geological evolution is summarised in [Figure 2](#). Permo-Triassic and Lower Jurassic strata were rarely

# Tectonics and sedimentation in the Middle to Upper Jurassic succession of the northeast Porcupine Basin.



encountered in drilling in the Porcupine Basin. Middle and Upper Jurassic sediments typically rest unconformably on Permo-Carboniferous strata. They reflect a progressive base level rise resulting in deposition of fluvial-lacustrine to marine facies [Crocker & Shannon, 1987; Sinclair et al., 1994; Butterworth et al., 1999; Bulois & Shannon, 2007 & 2008]. Most of the Jurassic interval has been interpreted as syn-rift deposits, with an onset warp setting during the Bathonian followed by clear extension from the Oxfordian until the Portlandian-Volgian [Bulois & Shannon, 2006, 2007 & 2008; Bulois et al. 2007a & 2007b]. Lower Cretaceous strata are predominantly shale- and limestone-prone, which largely developed in a post-rift, thermal subsidence setting, with local Aptian-Albian minor syn-rift sandy strata developed in the northern part of the basin [Fig. 2]. The Cenozoic succession is essentially post-rift, with a complex mixture of deltaic to deep marine strata. Magmatic bodies, mostly of Cretaceous and Cenozoic ages, cut the sedimentary succession in many areas [e.g. Naylor et al., 2002; Jones et al., 2004; Praeg et al., 2005; Stoker et al., 2005; Naylor & Shannon, 2009].



**Fig. 2 :** Geological evolution of the northern Porcupine Basin.

Adapted from Bulois & Shannon [2007]

The tectonostratigraphic evolution is based on well and seismic analysis of regional scale. Symbols I, II, III and IV refer to the depositional zones defined by Bulois & Shannon [2007]. TCU: Top Carboniferous Unconformity; BOU: Base Oxfordian Unconformity; BKU: Base Kimmeridgian Unconformity; BPU: Base Portlandian Unconformity; BCU: Base Cretaceous Unconformity; TNU: Top Neocomian Unconformity.

While the predominant orientation of the basin is N-S, structures of NE-SW and E-W orientations are clearly identified in quadrants 26 and 35 [e.g. Bulois & Shannon, 2009]. NE-SW structures represent inherited basement structural fabrics of Caledonian and older ages [Doré *et al.*, 1997 & 1999; Spencer & MacTiernan, 2001; PESGB, 2009]. Many of the faults systems show evidence of syn-sedimentary activity in Mesozoic (especially Late Jurassic) times, with only minor reactivation identified in the Early Cretaceous.

The Mesozoic succession predominantly developed in response to a number of vertical movements of regional or local importance. The most important extensional period is known as the Late Cimmerian rifting [Fig. 2]. It consists in a series of extensional phases recorded in the Upper Jurassic succession [Bulois & Shannon, 2007; Bulois *et al.*, 2007a & b, 2008 & 2009a]. The syn-rift succession *stricto sensu* (i.e. where growth-faulting is recognised) is composed of three main packages related to at least three rift pulses in the Oxfordian, Kimmeridgian and Portlandian/Volgian. Upper Jurassic fault-blocks show rapid variations in facies and thicknesses, which are interpreted to reflect the formation of fault-controlled sub-basins. These are typically truncated by a widespread unconformity, usually recognised as a marker of the transition between the Jurassic extensional phase and the Cretaceous post-rift setting [e.g. Naylor & Anstey, 1987; Shannon, 1991]. However, the details of this transition are poorly constrained, both in terms of age and geometry.

### 3. The Jurassic-Cretaceous transition:

The Jurassic-Cretaceous transition has been widely described in most of the sedimentary basins of the Irish offshore as separating the rift deposits of Late Jurassic age (the product of the Late Cimmerian rifting event) from the thermal and sedimentary subsidence in the Early Cretaceous [e.g. Naylor *et al.*, 2002; Naylor and



Shannon, 2005; Naylor & Shannon, 2009]. Lower Cretaceous strata generally onlap Late Jurassic fault-blocks as rifting gave progressively way to the first occurrence of seafloor spreading in the North Atlantic province [e.g. Doré *et al.*, 1999; Spencer & MacTiernan, 2001; Shannon *et al.*, 2005]. It resulted in a major and widespread unconformity close to the approximate Jurassic-Cretaceous boundary [e.g. Shannon, 1991; Naylor & Anstey, 1987]. This surface is usually taken as a first-order marker indicating the syn-rift/post-rift transition.

However, the detailed nature and age of this transition are poorly constrained. In this report, the results of a comprehensive examination of a number of features identified around the Base Cretaceous Unconformity (BCU) within the quadrants 26 and 35 study area are presented. In particular, the transition from a syn-rift (*i.e.* broadly Upper Jurassic) to a post-rift (*i.e.* broadly mid-Early Cretaceous) settings is constrained in terms of age, morphologic features, tectonic markers (such as faulting) and sedimentary dispersal throughout the study area.

### **3.1 – Evolution of the Jurassic-Cretaceous transition in the northern Porcupine Basin:**

#### **3.1.a – Introduction:**

Seismic profiles on the Irish sedimentary basins are usually subdivided into a number of extensive seismo-stratigraphic units of Mesozoic age, showing various thicknesses and separated by well-defined reflectors representing regional unconformities or disconformities [e.g. Shannon, 1995; Naylor *et al.*, 1999 and 2002; Naylor & Shannon, 2005 & 2009]. At a regional scale, relative sea-level fell drastically from the high-stand of the Late Kimmeridgian to Portlandian/Volgian to reach a lowest point in the late Berriasian to early Valanginian [e.g. Vail *et al.*, 1977 & 1984; Hallam, 1988; Haq *et al.*, 1987 & 1988]. The upper surface of Late Jurassic sequences is likely to correspond to a major truncation across the Irish Atlantic Margin. It is named as the Late Cimmerian Unconformity, but also known as the Base Cretaceous Unconformity (BCU) [Fig. 2].

The onset of the BCU can be recognised using both seismic and well data in the northern Porcupine Basin. Seismic data provides evidence for growth-faulting and progressive rotation of tilted fault-blocks mostly in the Portlandian/Volgian and possibly in the Kimmeridgian and Oxfordian [Fig. 3B, 4, 5, 6; e.g. Bulois & Shannon, 2008]. During the Early Cretaceous, much of the Porcupine Basin was raised above storm-wave base. As a result, the crests of the hangingwalls are clearly truncated by an erosional surface. They are overlain by sub-concordant or unconformable strata, which developed during the Early Cretaceous in a fast-subsiding, marine environment. The contact between Jurassic or older strata and the Early Cretaceous is usually regarded as the BCU.

However, the strata immediately overlying the BCU infill residual topography, resulting in variable onlap, downlap and sub-conformable relationships [Fig. 3]. In addition, the age of the immediate post-BCU strata varies throughout the region [Tab. 1]. For example, strata overlie the BCU in Well 26/28-5 while the oldest post-BCU sediments in Well 26/28-4A are Late Aptian in age.

#### **3.1.b – Uncertainties around the BCU definition:**

The occurrence of the BCU is widely recognised in well data acquired in the northern Porcupine Basin [Tab. 1]. However, it does not always correspond to the earliest Cretaceous deposition in the study area. On the margins and in the central area of the Porcupine Basin, the base of the Cretaceous interval is usually characterised by a high-amplitude, continuous seismic reflector, which clearly correlates with the Jurassic-Cretaceous transition in well data. Toward the central and southern parts, the Cretaceous interval becomes more conformable [Moore & Shannon, 1995], suggesting the possible absence of a sedimentary hiatus at the Jurassic-Cretaceous boundary. Further north in Quadrant 26 and the northern part of Quadrant 35, the geometry of the BCU is much more complex and variable. There, the duration of the sedimentary hiatus appears variable between wells, as indicated by the different ages of sediments deposited above the BCU. Unfortunately, biostratigraphic records combined with periodic sedimentary reworking [see 3.1.d] are too poor to quantify accurately the age hiatus [Tab. 1].

The earliest Cretaceous deposits are usually absent in most wells, with the exception of wells 26/27-1B and 26/28-5 which recovered Late Valanginian-Hauterivian and Berriasian-Hauterivian sediments

## Tectonics and sedimentation in the Middle to Upper Jurassic succession of the northeast Porcupine Basin.

**Table 1:** BCU characters in selected wells drilled in the northern Porcupine Basin

	Depth of BCU (in m)	Depth of BCU (in ms TWT)	Lithofacies ages underneath BCU	Lithofacies ages above BCU
26/27-1B	1889.76	1765	Late Kimmeridgian	Valanginian - Early Hauterivian
26/28-A1	2650.00	-	Mid- to Late Kimmeridgian	Aptian
26/28-1	1955.30	1844	Portlandian/Volgian	Barremian
26/28-2	1947.00	1814	Portlandian	Aptian
26/28-3	1837.00	1746	Portlandian	Albian
26/28-4A	1065.00	110	Portlandian	Late Aptian/Early Albian
26/28-5	1990.00	1869	Middle Kimmeridgian/Early Portlandian	Berriasian/Hauterivian
26/29-1	946.00	1051	Kimmeridgian/Early Portlandian	Aptian/Albian
26/30-1	588.00	667	Kimmeridgian	Aptian/Albian
35/2-1	2642.00	2268	Portlandian	Berriasian to Valanginian
35/8-2	3858.80	-	Midle Volgian	Valanginian

Well location can be found on [Figure 1](#). Lithofacies ages are based on biostratigraphic studies published in well reports and well correlation proposed for the Jurassic period by Bulois & Shannon [2007].

respectively [e.g. [Bulois & Shannon, 2007, Tab. 1](#)]. Further south, Well 34/19-1 also drilled Neocomian clastic sediments, interpreted as a result of continuation of local fault activity until the Berriasian [[Croker & Klemperer, 1989](#); [Sinclair et al., 1994](#)]. Also, the Jurassic-Cretaceous transition most likely saw the development of low-standing areas and local highs throughout the northern Porcupine Basin. The low-standing areas acted as catchment areas, and their distribution, combined with possible faulting in their early stage, directly controlled the Neocomian deposition above the BCU. At the same time, regional highs such as the Porcupine High of the Finnian's Spur [[Fig. 1](#)], as well as the fault-block crests, were exposed and subject to erosion, resulting in deposition and preservation of variable amounts of Neocomian strata.

While the BCU may be restricted to a relatively simple unconformity (albeit the result of a long or repeated series of erosional events) separating the syn-rift from the post-rift stages in much of the Porcupine Basin [e.g. [Naylor & Anstey, 1987](#); [Shannon, 1991](#); [O'Driscoll et al., 1995](#); [Naylor et al., 2002](#)], the Jurassic-Cretaceous boundary is more complex in the study area in the northern part of the basin. In particular, the BCU does not necessarily mark the end of the Late Cimmerian rifting phase. Here, a progressive transition occurs between the Jurassic syn-rift setting and Cretaceous post-rift deposition.

### 3.1.c – Constraints and implication of the vertical position of the BCU:

As shown on [Table 1](#), most of the wells drilled in the northern Porcupine Basin penetrated the BCU. However, the vertical position of the BCU remains uncertain in many places and several reflectors may be mapped locally. Uncertainties in the mapping are accentuated in areas of lower seismic resolution or in areas where the truncation character is not obvious. [Figure 3](#) illustrates variations in seismic character and important difficulties encountered during the mapping.

In Block 35/2, the BCU shows some geometrical relationships with second-order unconformities and/or igneous bodies which developed at similar levels [[Fig. 3A](#)]. It is usually characterised by a decrease in the seismic amplitude of the BCU, so that mapping of the BCU becomes difficult. Furthermore, the Neocomian strata are almost conformable in some places and the truncation characteristic of the BCU is often unclear. In Quadrant 26 where most wells are located, a similar uncertainty is also possible [[Fig. 3B](#)]. Here, most of the uncertainty concerns the nature of strata straddling the BCU, their seismic character as well as the nature of the BCU itself. In addition, the lack of seismic resolution in places is probably due to gas escape and localised igneous bodies.

In the region of the *Connemara Oil Accumulation*, a high-amplitude reflector usually occurs in the vicinity of the BCU [[Fig. 3B, 4](#)]. It has been interpreted either as an intra-Portlandian marker [[Bulois et al., 2009b](#)] or as the BCU [e.g. [Hedley, 1984](#); [MacDonald et al., 1987](#); [Moore & Shannon, 1995](#)]. In areas of best seismic resolution, Neocomian strata often onlap this surface whereas, underneath it, strata appear to have been truncated. As a result, this marker has been mapped as the BCU. However, overlying strata indicate possible growth-faulting. In addition, Well 26/28-5 recorded Portlandian/Volgian sandy deposits, interpreted as the response of a late rift pulse and subsequent erosion and re-deposition [[Bulois et al., 2009b](#)]. Those deposits clearly merge toward this reflector, so

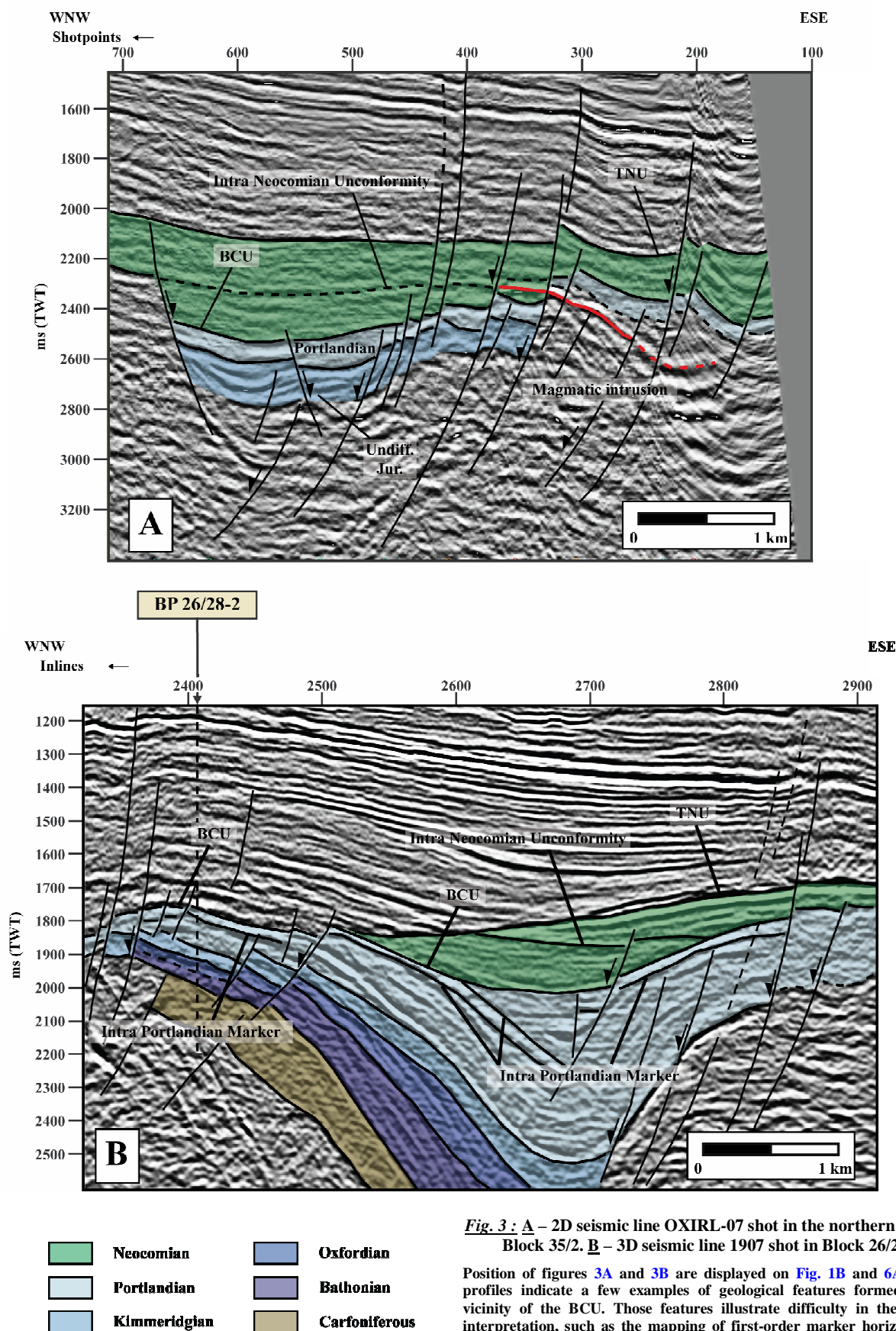


Fig. 3 : A – 2D seismic line OXIRL-07 shot in the northern part of Block 35/2. B – 3D seismic line 1907 shot in Block 26/28.

Position of figures 3A and 3B are displayed on Fig. 1B and 6A. These profiles indicate a few examples of geological features formed in the vicinity of the BCU. Those features illustrate difficulty in the seismic interpretation, such as the mapping of first-order marker horizons (*e.g.* Base Cretaceous Unconformity). Arrows represent the throw direction along the major normal faults. BCU: Base Cretaceous Unconformity; TNU: Top Neocomian Unconformity.



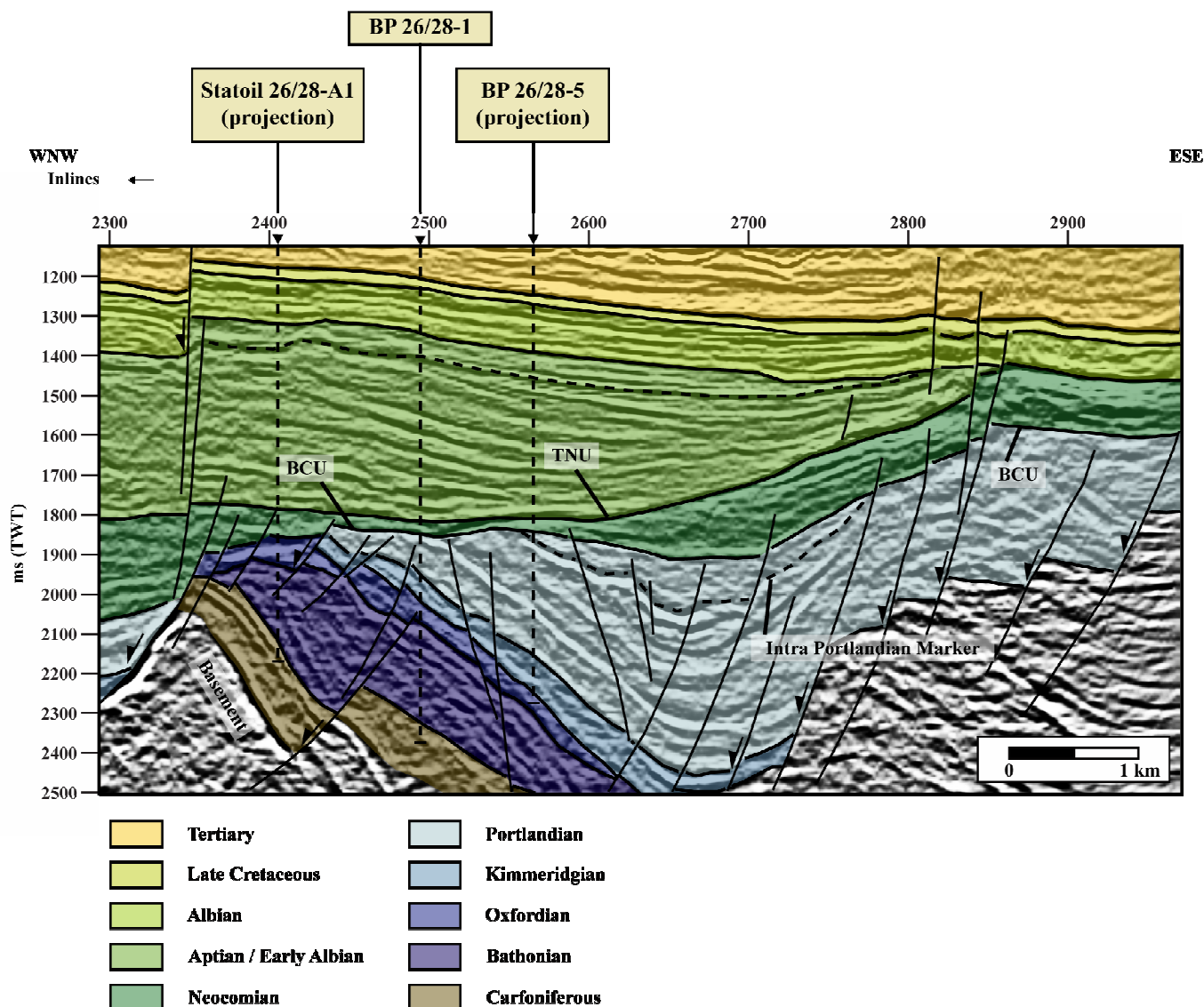


Fig. 4 : 3D seismic line 2000 shot in Block 26/28.

Position of the seismic section is displayed on Fig. 1B and 6A. Arrows represent the throw direction along the major normal faults. BCU: Base Cretaceous Unconformity; TNU: Top Neocomian Unconformity.

that the BCU appears higher in the succession. Other studies [e.g. MacDonald *et al.*, 1987; Valhalla Oil & Gas Ltd, 2004] followed the main Early Cretaceous unconformity much higher in the succession, producing a mis-match between seismic and well data in the *Connemara Oil Accumulation* area. Our seismic correlation suggests that their BCU matches the Top Neocomian Unconformity (TNU) of this report [Fig. 2].

Even if the position of the Early Cretaceous unconformity is still generally poorly constrained, these examples suggest that some rifting continued in the northern part of the Porcupine Basin in the interval bounded by the intra-Portlandian marker and the TNU.

### 3.1.d – Unconformities and depocentres associated with the BCU:

A number of second-order unconformities occur within the Neocomian succession [Fig. 3B, 4 & 5]. The basal unconformity is probably close to the BCU *stricto sensu* whereas the top unconformity

(TNU), clearly marks the top of the Neocomian strata [Fig. 2 & 4]. BCU and TNU bound a megasequence of Neocomian age, which developed at the transition of the syn-rift sediments and the post-rift strata deposited prior to the Austrian rifting phase [Fig. 2]. Internally, the Neocomian consists of various sub-conformable seismic packages which either downlap or onlap each bounding unconformity [Fig. 4 & 5]. Even if those minor unconformities can be recognised throughout the Neocomian strata, their age remain weakly constrained because of poor biostratigraphic control. With the exception of the TNU [Fig. 2 & 4] and locally the BCU [see 3.1b., Fig. 3 & 4] most of these surfaces are difficult to correlate throughout the seismic volume. In addition, biostratigraphic control is usually too poor to date them precisely.

Typically, the set of Neocomian unconformities merges into one composite erosion surface toward the crest of the hangingwalls. This is particularly well illustrated west of Well 35/2-1 or, as shown on Figure 4, in Block 26/28. In these areas, local depocentres have been identified. They show a synform-like shape and are usually fault-bounded by the main Upper Jurassic fault-zones. However, no evidence of growth-faulting has been clearly identified in any of those regions. This does not necessarily imply the absence of syn-tectonic deposition, which may have been simply attenuated by the development of those unconformities. Nevertheless, as most of the remaining strata do not show clear growth-faulting, the Neocomian deposition is most likely a result of passive sedimentation within rapid subsiding sub-basins.

Such observations confirm interpretations made by Croker & Klemperer [1989] and Moore [1992 & 1993]. Those authors described similar surfaces within Neocomian strata further south in the Porcupine Basin. Those features are compatible with the formation of contemporaneous sub-basins or depocentres developing through the Porcupine Basin, controlled by a combination of local and regional scale events. At the level of a sub-basin, the unconformities indicate local variations in the erosion and dispersal pattern, perhaps reflecting local topographic controls (see 3.1.e).

### ***3.1.e – Fault-scarp reworking, sedimentary provenance and associated features:***

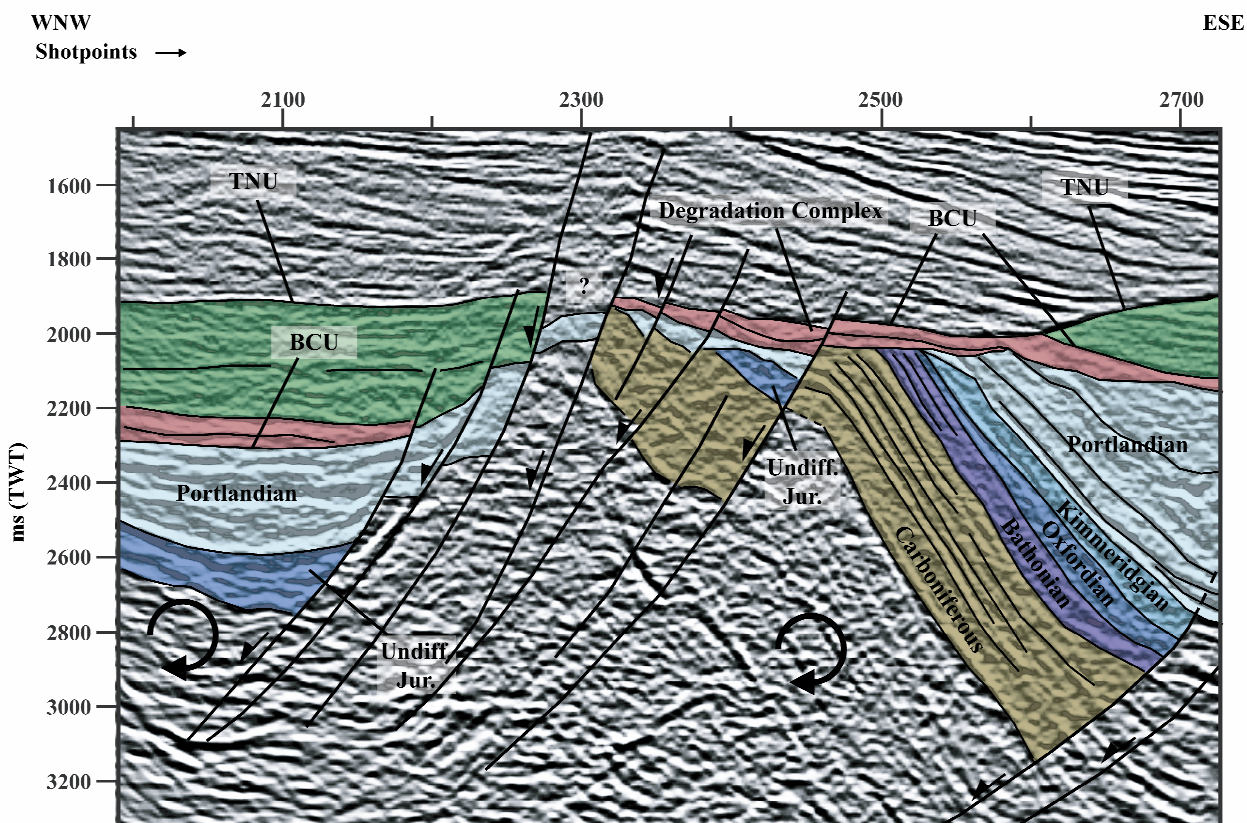
The presence of those unconformities suggests several erosional episodes through the Neocomian, implying local (*i.e.* at the scale of a fault-block) or regional (*i.e.* at the scale of the basin) reworking episodes. Sediment transport is obviously dependant on the magnitude of the unconformities. The BCU or the TNU, which have been correlated regionally, represent the two most important reworking episodes throughout the northern Porcupine Basin. The internal Neocomian unconformities are regarded as localised and generally less pronounced events.

The age of those events is poorly constrained. Bulois & Shannon [2006 & 2007] pointed out a number of age discrepancies from the reports of several wells drilled in Block 26/28. For example, the occurrence of Carboniferous and Jurassic species at various Lower Cretaceous levels [*e.g.* Athersuch *et al.*, 1982; Smith & Higgs, 2001] demonstrates the reworking of older material within the Neocomian. The geometry of unconformities along the fault-zones supports the likelihood of reworking at a local scale.

The crests of the hangingwall fault block structures in the study area are usually characterised by a high-amplitude reflector which usually correlates either with the BCU or the TNU [Fig. 4 & 5] or, in places, with smaller unconformities. It is often accompanied by a seismically-transparent drape, bounded by a basal truncation surface and onlaped by Neocomian strata. The drape probably represents a degradation complex developed along the fault-zones during the formation of the unconformities as a result of the newly formed topography. In places, a slightly chaotic seismic character at the base of the fault zones along the footwall [Fig. 5] is thought to correspond to the degradation complex. The degradation complex is sometimes offset by later normal faulting [Fig. 4 & 5; see 3.2].

Other morphological features illustrating the importance of hangingwall reworking have been identified in many places. Figure 6 shows a time-slice taken from the 3D seismic datasets at the top of an eroded fault-scarp in Block 26/28. Sub-circular to lobate and elongate features (kilometric scale) of medium to strong reflectivity occur on the eroded footwall crest. Their seismic character is





**Fig. 5 :** degradation complex on 3D seismic line 1800 shot in Block 26/28.

Modified after Bulois *et al.* [2009]

Position of the seismic section is displayed on Fig. 6A. Arrows represent the throw direction along the major normal faults. Circular arrows show the sense of rotation of fault-blocks. BCU: Base Cretaceous Unconformity; TNU: Top Neocomian Unconformity.

distinctly different to that of Neocomian strata in the hangingwall and to the underlying Jurassic and older strata. These small features are thought to represent infill of topographic lows, which act as local depocentres 'incising' the top of the hangingwall during the formation of the unconformities. The occurrence of these topographic lows is usually higher in the vicinity of the BCU, reflecting the regional importance of this unconformity on producing an irregular topography. Intra-Neocomian erosional events had minor effect on the fault-scarp reworking in terms of regional topography production, implying a preservation of those features at a wide scale.

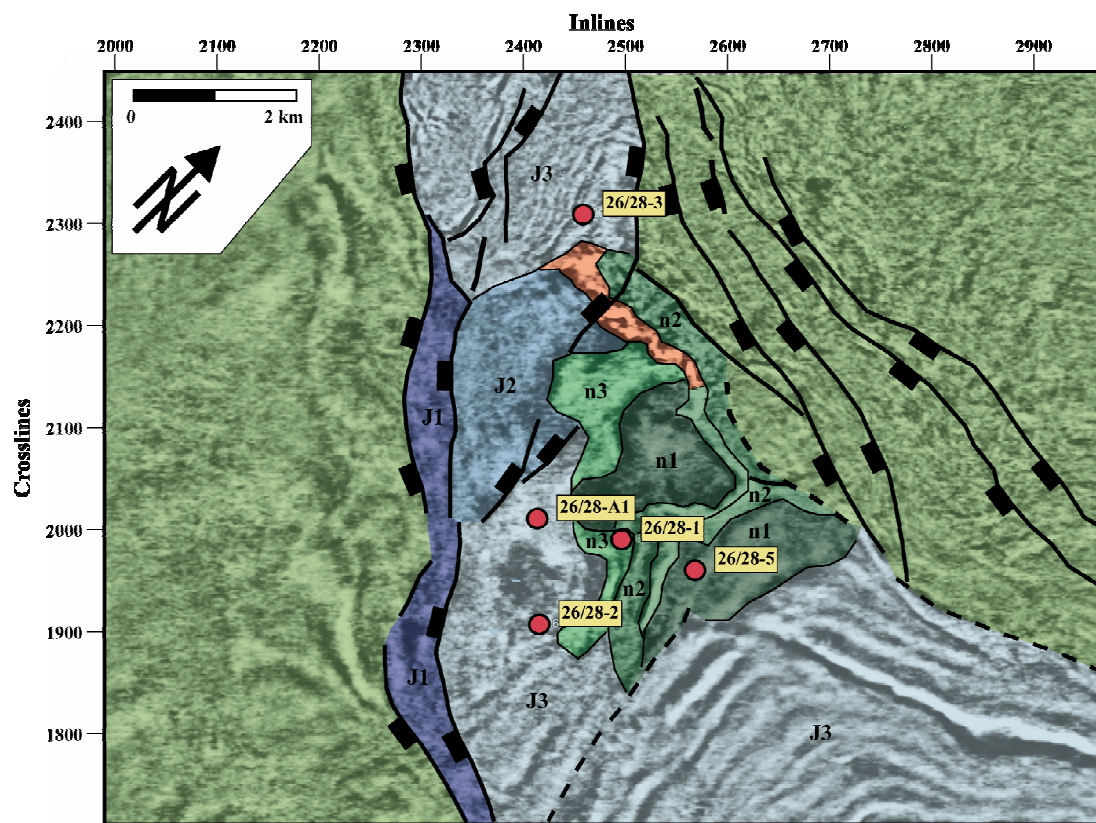
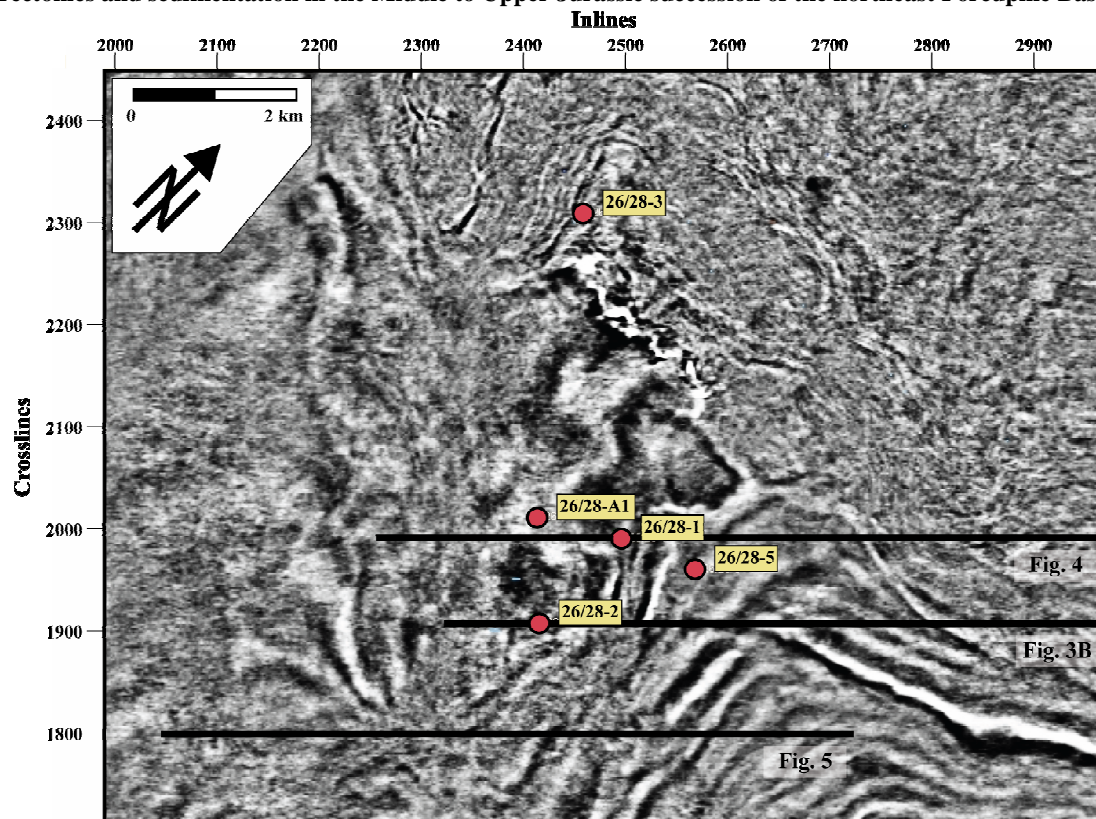
Higher in the succession (10 to 20 ms TWT), a WNW-ESE meandering channel is incising the hangingwall [Fig 6]. It leads into a lobate depocentre, described above. This clearly indicates that (1) the incision has been controlled by a sufficiently long-standing erosion phase and (2) the subsequent marine transgression has been rapid enough to preserve such a feature.

The fault-scarp degradation is also associated with smaller v-shape incisions of various sizes, which developed along the slope. It is still unclear if they constitute a network of incised valleys or are simply related to a local collapse of the sediments along the fault zones.

Although none of the wells directly penetrated the interpreted channels or the lobate depocentres, Well 26/28-5, located close by, encountered Berriasian-Valanginian sediments lying directly above the BCU [Tab. 1; Fig. 6]. The biostratigraphic assemblage suggests a marine, inner neritic depositional setting [Athersuch *et al.*, 1984]. The small lobate depocentres are therefore thought to be filled by sediments of possible continental nature since the Berriasian as well as sub-marine deposits. Located on the edge of these sub-basins, Well 26/28-1 indicates some Barremian sediments [Tab.1; Fig. 6] so that the latest infilling could be end-Neocomian.



# Tectonics and sedimentation in the Middle to Upper Jurassic succession of the northeast Porcupine Basin.



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| <span style="display: inline-block; width: 20px; height: 10px; background-color: #d9ead3; border: 1px solid black; margin-right: 5px;"></span> Undifferentiated Neocomian                     | <span style="display: inline-block; width: 20px; height: 10px; background-color: #f4cccc; border: 1px solid black; margin-right: 5px;"></span> Neocomian channel                           |
| <span style="display: inline-block; width: 20px; height: 10px; background-color: #cfe2f3; border: 1px solid black; margin-right: 5px;"></span> Neocomian n3 (Barremian)                       | <span style="display: inline-block; width: 20px; height: 10px; background-color: #a6c9ec; border: 1px solid black; margin-right: 5px;"></span> Jurassic J3 (Portlandian)                   |
| <span style="display: inline-block; width: 20px; height: 10px; background-color: #a6d854; border: 1px solid black; margin-right: 5px;"></span> Neocomian n2 (Hauterivian)                     | <span style="display: inline-block; width: 20px; height: 10px; background-color: #8db4e2; border: 1px solid black; margin-right: 5px;"></span> Jurassic J2 (most likely Kimmeridgian)      |
| <span style="display: inline-block; width: 20px; height: 10px; background-color: #b2df8a; border: 1px solid black; margin-right: 5px;"></span> Neocomian n1 (Berriasian to early Valanginian) | <span style="display: inline-block; width: 20px; height: 10px; background-color: #6aa84f; border: 1px solid black; margin-right: 5px;"></span> Jurassic J1 (Oxfordian and/or older strata) |

### **3.1.f – Summary:**

In summary, the Jurassic-Cretaceous transition is very complex in the northern Porcupine Basin area. Overall, it represents a transitional stage marking a gradual change from extensive, basin-wide faulting in the Upper Jurassic to a more localised extension progressively dying out during the Neocomian. Lower Cretaceous strata are present in several localised, while limited depocentres developed at the top of the remnant syn-rift topography after which the post-rift stage begins.

The transitional sequence developed strictly under marine conditions as the general sea-level rose through the Early Cretaceous except for a low-stand period in the Aptian [e.g. Sinclair *et al.*, 1994]. The development of several unconformities within the Neocomian suggests that most of the study area in the northern Porcupine area was above storm-wave base. However, it is still unclear if it results from basin-wide geological events, localised factors or a combination of regional and smaller scale episodes. Unfortunately, biostratigraphic control is often too poor to date intra-Neocomian surfaces or constrain the depositional environment within the Neocomian succession.

Several erosional features, including sub-circular structural to elongated lows and meandering channels of kilometre scale, have been extensively preserved at the top of the hangingwalls. They are thought to have been developed during the Berriasian-Valanginian. Those are surrounded by a degradation complex which is poorly dated. Together, they suggest episodic erosional events of various magnitudes, followed by a rapid marine transgression.

The BCU and the TNU represent the two main erosional events in the northern Porcupine Basin, but show local variations. The BCU is thought to have developed during the Berriasian and the TNU during the Barremian. As a result, the transitional sequence is Berriasian-Barremian in age. As the rifting most likely spanned the Neocomian, the BCU in this region constitutes a surface resulting from a basin-wide uplift event. The resulting topography has been modified by younger unconformities, with the development of the TNU signalling the end of the Late Cimmerian rifting event in the northern Porcupine Basin.

Those results partly confirm several observations published in the literature. Moore [1992 & 1993] described a transitional sequence southern of the study area and gave an age of uppermost Kimmeridgian/Volgian to end-Berriasian. Croker & Klemperer [1989] suggested that the Late Cimmerian rifting continued into Berriasian times in the area of Well 34/19-1, so that the BCU was part of the rifting. Sinclair *et al.* [1994] dated the syn-rift/post-rift transition as early or middle Valanginian in areas presenting a minimum of erosion.

## **3.2 – Fault reactivation through the Early Cretaceous:**

### **3.2.a – The Neocomian rifting phase:**

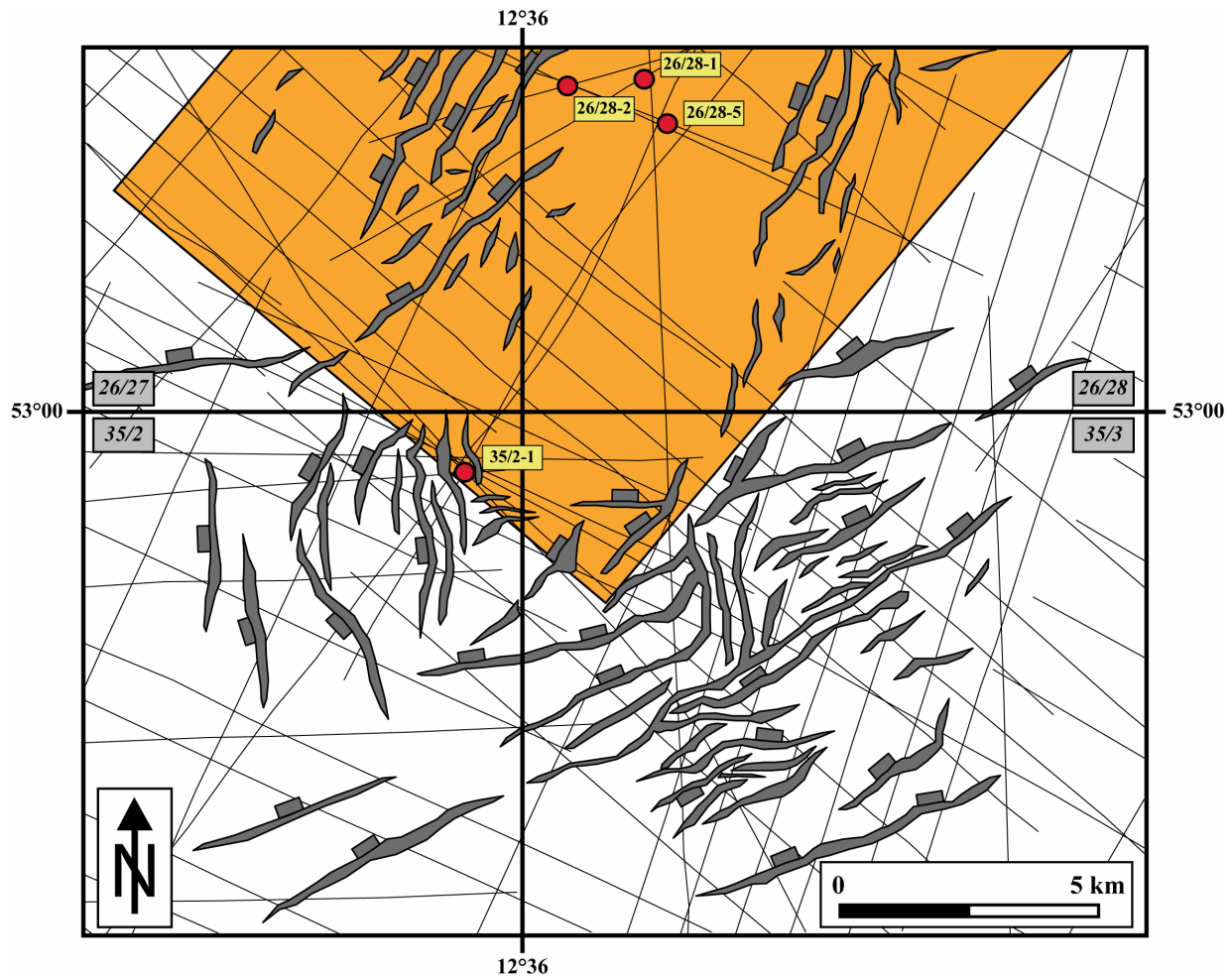
Jurassic fault-zones have been already described in the North Porcupine Basin and the northern part of the Porcupine Basin [e.g. Bulois & Shannon, 2007 & 2008]. ]. Even though the regional fault pattern is complicated, three main fault orientations have been distinguished throughout the northern Porcupine Basin. (1) kilometre-scale NE-SW normal fault-zones are usually predominant and accommodated most of the Late Cimmerian rifting. This NE-SW trend corresponds to a long-standing structural fabric inherited from the Caledonian time. (2) N-S fault-structures intersect the Caledonian trend. Those faults typically show normal fault offset but are shorter in length than the NE-SW faults, measuring typically a few hundred to about a thousand meters, sometimes up to 2 km. (3) E-W fault structures are usually found in the vicinity of Finnian's Spur and are thought to show a predominant strike-slip offset, associated with a minor normal displacement. Those results broadly confirm the main fault orientations on published maps in Block 26/28 [e.g. MacDonald *et al.*, 1987; Valhalla Oil & Gas Ltd, 2004] or at a more regional scale [e.g. Shannon *et al.*, 2005; PESGP, 2009].

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**Fig. 6 (previous page): hangingwall degradation at the BCU level.**

This timeslice has been made at 1840 ms TWT after flattening of the Base Cretaceous Unconformity reflector. Note the typical high reflectivity of the hangingwall, the shape of the Neocomian lobate depocentres and channel system situated above the BCU (need to indicate these features on the figure (see explanation in the text). Neocomian and Jurassic age (J1 to J3) are derived from well information and only shown here for information.





**Fig. 7 :** detailed fault map at the Base Cretaceous Unconformity in the northern Porcupine Basin.

Orange box indicates the extent of the 3D seismic dataset, lines represent the 2D seismic profiles. The fault movement is indicated on each major fault structure by a rectangle.

The distribution of Lower Cretaceous faults is broadly similar to the Upper Jurassic faults. Three main orientations have been determined. Figures 6 and 7 show the degree of complexity of the fault network at the Base Cretaceous level. Although Upper Jurassic fault-zones die out progressively through the Lower Cretaceous, detailed interpretation shows two main phases of deformation. (1) The Late Cimmerian rifting clearly continued during the Neocomian, resulting in the deposition of the transitional sequence [Fig. 2]. Two main unconformities, the BCU and TNU, bound this syn-rift sequence. (2) It was followed by a period of tectonic quiescence until the development of the Austrian rifting phase marked by the development of Aptian-Albian deltaic sediments. Other faults propagated through the Lower Cretaceous almost until the onset of Late Cretaceous deposition.

### 3.2.b – The Neocomian rifting phase:

The Jurassic-Cretaceous transition shows evidence of clear reactivation of the main Jurassic fault structures. As a result, the BCU is often offset by the main Jurassic fault structures [Fig. 4], indicating that the Late Cimmerian rifting period probably continued further than the formation of the BCU. Neocomian sub-basins [see 3.1.d] are typically fault-bounded in their lower to middle part by fault-zones which formed since the Upper Jurassic. Those structural features progressively die out through the Neocomian [Fig. 4] and are rarely accompanied by growth-faulting. In detail, deposition is not directly controlled by continuous rifting throughout the Neocomian but rather by a succession of

small, possibly localised extensional episodes. As a result, seismo-stratigraphic sequences are most likely undeformed and are developed 'sub-conformably' and successively within each depocentre. The set of unconformities and disconformities suggests several rift pulses.

As discussed previously [3.1.d & 3.1.e], the age determination of Neocomian strata is complicated by poor biostratigraphic control associated with the formation of unconformities in the area. It is therefore hard to date those unconformities or to fully distinguish when the brittle deformation stopped in the study area. However, correlations between seismic and well data in Block 26/28 indicate the end of the Late Cimmerian faulting within the Hauterivian. The Barremian shows only very minor fault displacement [Fig. 4]. Also, the end of the transitional sequence is thought to take place with the development of the TNU during the Barremian.

### 3.2.c – The Austrian rifting phase:

Sinclair [1992] and Shannon *et al.* [1993] showed that another rift pulse, the Austrian rifting phase [Fig. 2], took place during the Aptian. It can be identified by shallow marine strata which transgressively overlie a widespread mid-Aptian unconformity. This unconformity marks the basal boundary of the Austrian rifting phase and is overlain by thick progradational delta deposits. Those deltaic sediments are widely identified in the northern Porcupine Basin.

Evidence of fault-displacement within the Aptian-Albian is often unclear. Several fault systems within the Aptian-Albian lie above the top of the Jurassic rotated fault-blocks. In detail, two fault populations may be distinguished. The most obvious features consist of faults propagating through the entire Cretaceous and the Cenozoic succession, indicating that they are most likely related to local compactional effects rather than the Austrian rifting phase. In many places, seismic data show faults dipping with a larger-angle which usually hard-link into the Jurassic at depth [Fig. 5]. These faults usually stop under the Late Cretaceous unconformity, indicating that they partially controlled the Aptian-Albian topography.

Overall, the Austrian rifting phase overprints on the Late Cimmerian extensional event. It is also important to consider as it implies fault reactivation (mainly of the major fault-zones) and possible re-structuring or rupture of hydrocarbon traps.

### 3.3 – Discussion:

In the northern Porcupine Basin, the Jurassic-Cretaceous boundary is marked by a transitional sequence. A series of isolated small basins developed in response to rifting events, associated with relative sea-level fluctuations. Those continued, albeit at a diminishing rate and magnitude, through most of the Neocomian. The infill in the depocentres came, at least in part, from reworked sediments shed from the degradation of local topographic highs and footwall crests.

The development of the Jurassic-Cretaceous transition is contemporaneous to a major sea-level drop which took place all around the Atlantic province [*e.g.* Vail *et al.*, 1984; Hallam, 1988; Haq *et al.*, 1987 and 1988; Hiscott *et al.*, 1990]. Global sea-level curves show indeed a relative sea-level drop and low-stand during the Berriasian and Valanginian, which is consistent with the absence of contemporaneous sediments in most of the wells. In addition, the North Atlantic province experienced a discontinuous sea-level rise during the rest of the Neocomian period [Haq *et al.*, 1988]. The Berriasian-Valanginian and the Late Hauterivian-Barremian events (*i.e.* respectively co-eval to the BCU and TNU) are thought to be the two most important sea-level drops in the Neocomian.

Sea-level fluctuations have been surely controlled by various rift-pulses forming the set of unconformities all through the Neocomian. Such extensional and erosional phases combined to relative sea-level fluctuations emphasised the erosive character of the BCU in the northern Porcupine. Much of the region discontinuously rose above the storm-wave base, resulting in a wide variability of preserved sedimentary facies and ages recovered in wells and seen on seismic profiles. As a result, the BCU in the northern Porcupine Basin is regarded as a marker horizon marking a distinct pulsed fault block rotation event.



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The rifting events are possibly interspaced by small-scale uplift events. However, evidence of tectonic-related uplift, such as compressional events within the Neocomian period, remain highly uncertain in this region, so that sea-level fluctuations are most likely controlled by a discontinuous rifting phase which lasted through the Neocomian.

The detailed analysis of such events is important to constraint the hydrocarbon potential of the area. The small depocentres lying at the eroded crests of fault blocks may contain locally derived sand deposits. Unfortunately, they have not been drilled, so the nature of the infill is remains speculative. However, Valhalla Oil & Gas Ltd [2004] characterised a new prospect, the C1 Lead, in Lower Cretaceous strata north-west of the *Connemara Oil Accumulation*. Similarly, the *Burren Gas Condensate Accumulation* in Quadrant 35 developed at similar level. Together, those reservoirs indicate reservoir potential in Lower Cretaceous strata in the northern Porcupine Basin. Re-evaluation of the Neocomian succession throughout the northern Porcupine Basin is required as reservoirs may have developed locally within the Neocomian sub-basins.

### **4. Early Cretaceous magmatism in the Porcupine Basin:**

The existence of magmatism in the Porcupine region has been widely described in the literature. The main feature corresponds to a linear volcanic system, the Porcupine Median Volcanic Ridge (PMVR). The PMVR was first described from geophysical data by Young & Bailey [1974] and Roberts *et al.* [1981]. The age and the nature have been discussed by various authors [e.g. Ziegler, 1982 & 1988; Masson & Miles, 1986; Naylor & Anstey, 1987]. In the absence of well control, the ages are typically postulated on the basis of stratigraphic relationships. Naylor *et al.* [2002] mapped a number of associated features in the southern part of the basin and named the whole group as the Porcupine Volcanic Ridge System. The complex seems to be underlain by the BCU and is onlapped by probable Early Cretaceous sediments. Cook [1987] and Tate & Dobson [1988] suggested this to be a penetrative igneous body of possible Aptian-Albian age, whereas Masson & Miles [1986] suggested that the PMVR comprised discrete flows of early Aptian or older age, with possible intrusions as young as Cenozoic. Therefore, the age of the PMVR is still poorly constrained. In the northern Porcupine Basin, a number of magmatic bodies have also been mapped [Naylor *et al.*, 2002; Naylor & Shannon, 2009]. Most of them are thought to be associated to the Porcupine Volcanic Ridge System and probably formed during the Early Cretaceous. Again, their age is poorly constrained and the nature of the entire complex itself is still a matter of uncertainty [e.g. O'Sullivan *et al.*, 2009].

A review (below) of a number of magmatic bodies identified in quadrants 28 and 35 help to constrain accurately the architecture of the PMVR by elucidating the nature and timing of magmatic phase(s) in the northern Porcupine Basin.

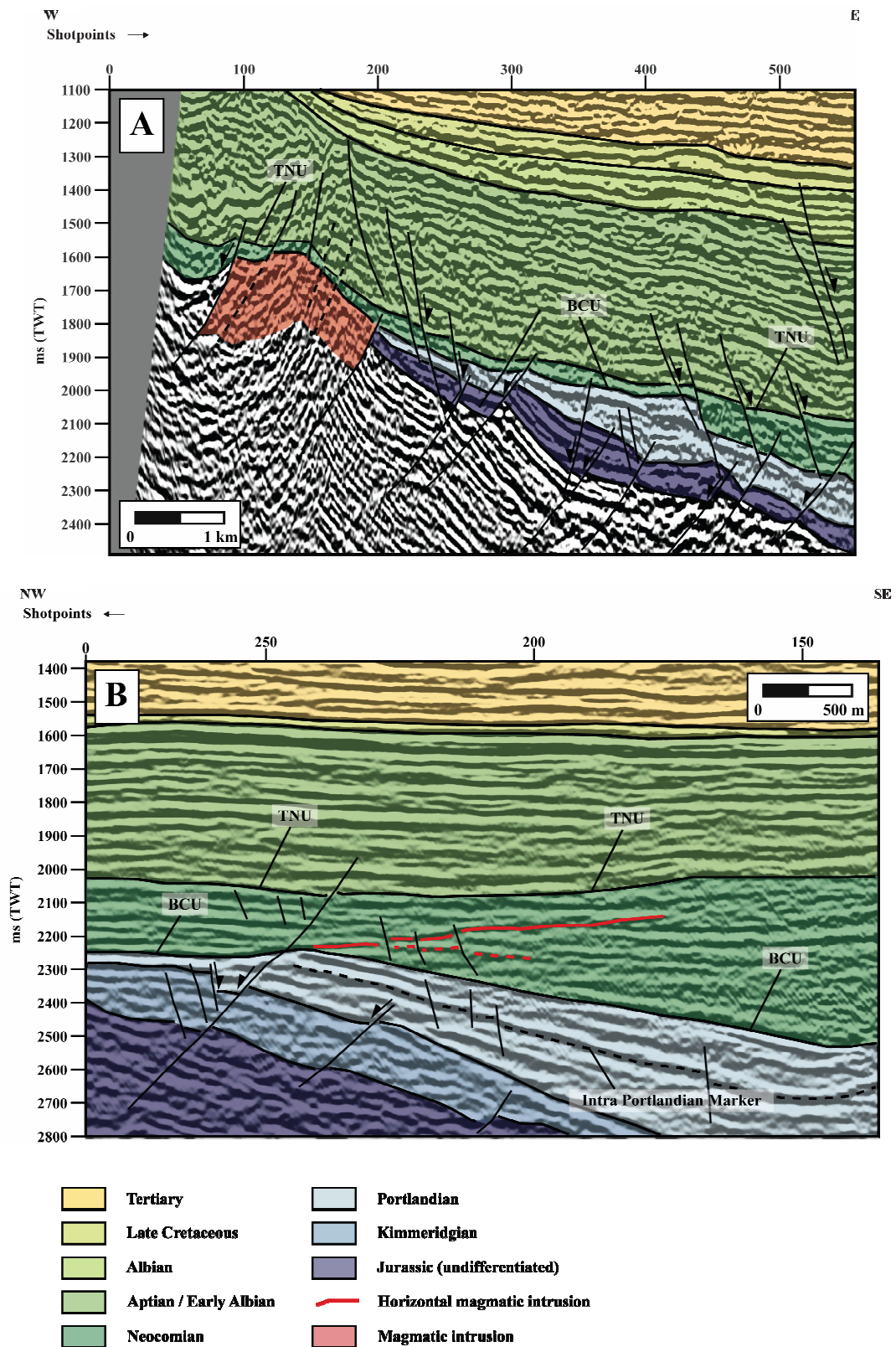
#### **4.1 – Magmatic intrusions in the northern Porcupine Basin:**

The northern part of Quadrant 35 contains magmatic bodies imaged at various levels in the basin and implying a poor resolution in the seismic signal of most of the 2D seismic surveys. Reprocessing of a number of key 2D seismic lines better constrain the geometry of several igneous.

Naylor *et al.* [2002] mapped a small, sub-circular igneous centre in the northeastern part of Block 35/1 [Fig. 8A]. A detailed re-analysis of Line MS81-78 indicates that the igneous centre is about 2 km wide and is fault-controlled. It has also clearly affected the BCU and is onlapped by strata of Early Cretaceous age deposited during the transitional sequence. Seismic correlation at a broader scale indicates that the TNU is probably not affected by the intrusion. Therefore, this suggests local magmatism prior to the formation of the BCU, possibly during the Berriasian or Valanginian.

A number of other magmatic bodies, mostly sills, have also been identified in the Upper Jurassic and Lower Cretaceous succession of Block 35/2 [Fig. 3A & 8B]. Figure 3A illustrates a sill intrusion within Portlandian and Neocomian (possibly Hauterivian) strata. This intrusion is parallel to the stratigraphy on each side of a fault as it probably developed along zones of weakness within the sedimentary column. It is also associated with a disconformity implying an association with local uplift. Figure 8B shows a low-angle intrusion north-east of Well 35/2-1 which cross-cuts most of the Neocomian transitional succession. Stratigraphically, this transgressive sill shows an intimate relationship with the

# Tectonics and sedimentation in the Middle to Upper Jurassic succession of the northeast Porcupine Basin.



**Fig. 8:** **A** – Magmatic intrusion on 2D seismic line MS81\_78 (Quadrant 35). **B** – Magmatic intrusion 2D seismic line PW93-314 (Block 26/28 and 35/2)

Position of the seismic sections are displayed on Fig. 1B. Arrows represent the throw direction along the major normal faults. BCU: Base Cretaceous Unconformity; TNU: Top Neocomian Unconformity.

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TNU at the top of the local fault-block. In addition, Well 35/2-1 recovered a Neocomian dolomitized limestone at more or less the same level than the intrusion. A Late Hauterivian to Barremian age is therefore indicated.

Further south in Quadrant 35, seismic survey OXIRL97 imaged spectacular saucer-shaped igneous structures within various levels of Upper Jurassic and Neocomian age, and possibly in the Aptian-Albian. They are possibly associated with one or several magmatic bodies similar to the one imaged on [Figure 8A](#). Unfortunately, the lack of wells prevents accurate dating and this area is still under investigation.

### **4.2 – Dating and nature of the magmatism in the northern Porcupine Basin:**

The dating of intrusive magmatic bodies remains often difficult. Despite the number of wells in the Porcupine Basin, there is a poor biostratigraphic control mainly due to reworking of Neocomian strata. The age of the Lower Cretaceous magmatic activity is therefore deduced from the stratigraphic and cross-cutting relationships. At least two main intrusive phases can be distinguished: (1) a period of Berriasian-Valanginian is illustrated by the development of a small intrusive body in the northwestern part of Quadrant 35 and (2) a second period of intrusion in the Hauterivian-Barremian. Those results corroborate broadly the interpretation proposed in other parts of the basin on in the adjacent Rockall Basin [e.g. [Naylor \*et al.\*, 1999 & 2002; Naylor & Shannon, 2009](#)]. These two distinct periods of intrusion may have had an influence on the formation of local unconformities, possibly by controlling local uplift.

The TNU possibly formed in shallow-marine to sub-aerial conditions. Also, a major magmatic event occurred contemporaneously with the Neocomian sea-level fall. Interestingly, evidence for shallow-water and sub-aerial, volcanic activity has been encountered in the Lower Cretaceous succession [e.g. [Croker & Shannon, 1987; Tate & Dobson, 1988; Tate, 1993](#)]. In particular Well 35/8-1 recovered multiple tuff levels interlaminated in Hauterivian-Barremian claystones and Well 26/21-1 encountered pyroclastics in Barremian-Aptian strata. Those are coeval with the formation of the TNU, suggesting a sea-level fall of regional extent within the Barremian.

Interactions between rifting and magmatism occur in the northern Porcupine Basin, as the earliest magmatic phase (Berriasian-Valanginian) is probably fault-controlled [[Fig. 8A](#)] and the two identified phases of magmatism are limited to the deposition of the syn-rift transitional sequence. Those support conclusions given by several authors who documented rift-related magmatic episodes in the Neocomian and earliest Aptian along the PMVR and sill complexes [[Masson & Miles, 1986; Naylor & Anstey, 1987](#)].

## **6. Future plans:**

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

- Complete the detailed seismic facies mapping of the Late and Early Cretaceous succession.
- Complete the fault mapping and calculate, where possible, erosion and tectonic subsidence rates.
- Complete manuscript on well correlation for submission to a peer-reviewed journal.
- Prepare a paper on the Jurassic-Cretaceous transition in the northern part of the Porcupine Basin.
- Present results at international conferences (e.g. *23rd Réunion des Sciences de la Terre*, the *Second Central and North Atlantic Conjugate Margins Conference* and the *Annual Meeting of the British Sedimentology Research Group*, respectively in Bordeaux, Lisbon and Southampton).

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# **Tectonics and sedimentation in the Middle to Upper Jurassic succession of the northeast Porcupine Basin.**

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**MULTIPHASE LATE JURASSIC – EARLY CRETACEOUS RIFTING IN THE  
PORCUPINE BASIN, OFFSHORE IRELAND**

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The Porcupine Basin contains a thick sedimentary succession developed during the northward propagation of the Atlantic rift system. In this study, 2D and 3D seismic data are integrated with petrophysical logs to examine the detailed Late Jurassic to Early Cretaceous evolution of the northeastern part of the basin, in the region of the Connemara oil accumulation. Syn-rift faulting during the Late Jurassic to Early Cretaceous controlled the development of depositional systems within a series of sub-basins in the region.

Well data show a progressive regional sea-level rise from Oxfordian to Neocomian times. However, seismic analysis suggests a complex sub-basin architecture during the Late Jurassic, followed by a regional flooding during the Early Cretaceous. Clear variations in thickness, facies and geometry occur within and between Jurassic fault-controlled sub-basins resulting from successive extensional pulses. The rift events are linked to a number of erosional unconformities of regional extent and, locally, to second-order erosional surfaces. Although evidence of growth-faulting along Early Cretaceous normal faults remains ambiguous, the Neocomian succession shows evidence of discrete rift phases resulting in Base Cretaceous and intra-Neocomian angular unconformities. Synrift footwall degradation offers the potential for sedimentary reworking and the generation of potential reservoir rocks within the sub-basins.

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## **JURASSIC AND CRETACEOUS TECTONO-STRATIGRAPHY OF THE PORCUPINE REGION**

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The Porcupine Basin, offshore Ireland, has been the subject of intermittent petroleum exploration leading to the Connemara (Quadrant 26), and the Spanish Point and Burren (Quadrant 35) discoveries. Hosted in Mid- to Upper Jurassic and Lower Cretaceous sandstones, the reservoirs in these accumulations developed during a major rifting phase. The present study reviews extensive 2D and 3D seismic data correlated to petrophysical logs to detail the rifting architecture in the basin and re-evaluate the basin development in a regional context.

Extensional fault structures of various ages and orientations are developed in the Upper Jurassic to Lower Cretaceous succession. The main rift activity took place predominantly along inherited NE-SW and E-W faults-zones in Quadrant 26, whereas N-S structures are of more major importance further south. Within the Jurassic, four main lithostratigraphic packages have been recognised through the wells and the seismic volume. The base of the Jurassic succession (Zone I), a thick sandy sequence deposited in a fluvial-lacustrine environment, is linked to Bathonian downwarping. During the Late Jurassic, a progressive sea-level rise, coincident with growth-faulting, produced Oxfordian transitory fluvial-lacustrine/marginal deposits (Zone II) passing from the Early Kimmeridgian to restricted marine deposition (Zone III). Fully marine conditions progressively took place in the Late Kimmeridgian and Portlandian/Volgian (Zone IV). Notable thickness variations in adjacent fault-blocks are linked to the development of regional unconformities and several rift pulses, mainly in the Oxfordian, Early Kimmeridgian and Portlandian/Volgian. These packages are overlain by variable thicknesses of marine Neocomian strata, with deposition driven by successive regional uplift phases preceding reactivation of major fault-zones.

The lateral facies distribution is interpreted as a series of changes in magnitude and timing during tectonism. Compartmentalised sub-basins probably opened through the Late Jurassic, before a regional basinwide subsidence through the Neocomian. A similar pattern of rifting and uplifting phases is interpreted in the Jurassic and Early Cretaceous of other Irish and UK sedimentary basins, suggesting regional-scale tectonic movements which may be linked to major crustal extension in the Rockall region and seafloor spreading on the Iberian margin.

This project is funded by the Irish Petroleum Infrastructure Programme (PIP).

**MIDDLE TO UPPER JURASSIC TECTONOSTRATIGRAPHIC DEVELOPMENT OF THE  
NORTHEASTERN PORCUPINE BASIN, OFFSHORE IRELAND**

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The northeastern part of the Porcupine Basin, off the west coast of Ireland, contains the *Connemara* (Quadrant 26), *Spanish Point* and *Burren* (Quadrant 35) hydrocarbon accumulations. The reservoirs developed in various depositional environments in response to a major regional rifting of Late Jurassic to Early Cretaceous age, and are overlain by post-rift Cretaceous and Cenozoic sediments. In this study, petrophysical logs from wells in the southern part of Quadrant 26 are integrated with seismic profiles and published biostratigraphic data in order to detail the local tectonostratigraphic evolution.

Four main lithostratigraphic packages have been recognized throughout the region. A Middle Jurassic (?Bajocian-Bathonian) succession (Zone I), comprising a thick sandy sequence, was deposited directly above Carboniferous strata in a fluvial-lacustrine environment within an early onset warp rift setting. This passes upward into an Oxfordian fluvial-lacustrine/marginal succession (Zone II) and restricted marine Kimmeridgian strata (Zone III). Fully marine conditions (Zone IV) developed in the Late Kimmeridgian/Volgian. This general base-level rise is associated with repeated growth-faulting and several unconformities of variable extent and magnitude. The tectono-sedimentary architecture and the lateral distribution of Jurassic (and older) strata suggest several rift pulses within compartmentalised sub-basins.

This project is funded by the Petroleum Infrastructure Programme.