# The evolution of hyperextended basins: Lower Cretaceous tectono-stratigraphy of the Porcupine Basin


**Lewis Whiting, Peter Haughton & Patrick Shannon**

*Irish Centre for Research in Applied Geoscience, University College Dublin*

*UCD School of Earth Sciences, University College Dublin*

**Contact details**
lewis.whiting@icrag-centre.org


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## 1.0 Summary and implications

- The Late Jurassic-Cretaceous succession in the Porcupine Basin includes several structurally-rotated depocentres perched on the flanks of the main basin.
- These drape syn-rift half-graben, many of which were already filled and are onlapped by the younger Lower Cretaceous infill of the main basin.
- They are preserved as erosionally-trimmed and locally slumped remnants as they were rotated during a phase of basin-centred subsidence. They may hold the key to understanding the transition from normal rifting to hyperextension and the wider bathymetric evolution of the Porcupine area.


## 2.0 Introduction

The Porcupine Basin is unusual in that it displays a strong north-to-south lateral strain gradient with evidence for Late Jurassic - Early Cretaceous hyperextension. Fault controlled half-graben were followed by a protracted phase of thermal subsidence to produce a thick Cretaceous succession (Figure 1) of up to 4 km (Moore & Shannon, 1995). Important clues to the evolution from normal rifting to hyperextension, prior to thermal subsidence, are preserved in structurally-rotated lowermost Cretaceous successions. Interestingly, these earlier remnants, which are capped by highly erosive unconformities, are preserved perched on the flanks of the main basin and are passively overstepped by younger Cretaceous main basin infill. A detailed study of the Moling sub-basin (Naylor et al., 2002) was conducted where exploration wells 35/19-1 and 35/30-1 penetrate a Berriasian to Aptian remnant succession.

### 2.1 Aims and objectives

- Map the Near-Base Cretaceous and Aptian unconformities to construct a Lower Cretaceous tectono-stratigraphic framework.
- Identify the timing and systematics of the sedimentary response of normal to hyper-extended regimes.
- Interpret the South Porcupine Basin from insights gained from the Moling sub-basin, located on the northeast flank.

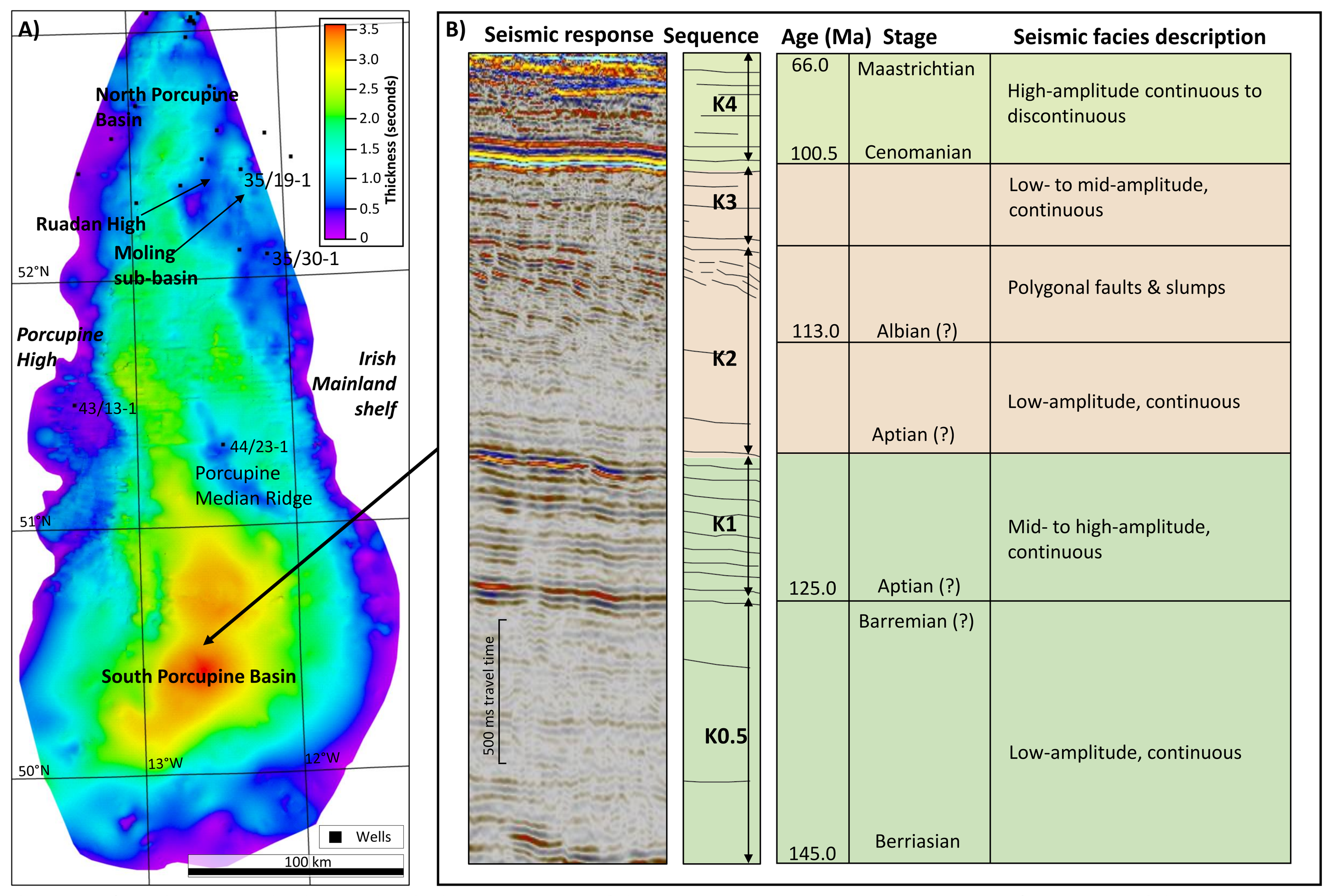


*Figure 1. **A)** Isochron map displaying the thickness variation of the Cretaceous sedimentary succession. **B)** Summary of the main basin seismic facies and seismic stratigraphy for South Porcupine Basin.*

## 3.0 Main Porcupine Basin

### Moling sub-basin evolution

**Late Jurassic rifting** reflecting Pangean break-up (Dore & Stewart, 2002) accommodated a transition from Bathonian fluvial-deltaic systems to fully marine by Late Oxfordian - Kimmeridgian.

The **Near-Base Cretaceous unconformity** formed as active faulting discontinued.

**Berriasian to Aptian** transgressive mud-dominated successions with localised turbidite sandstones infilled a tectonically-inactive hanging wall depocentre.

**Aptian erosion** produced a major unconformity which truncates underlying Cretaceous successions, isolating them on the Rudian High from the main basin (figures 2 & 3).

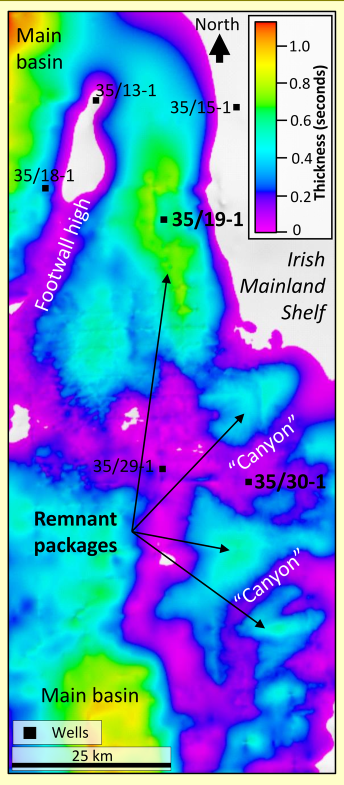


*Figure 2. Isochron map of Base Cretaceous – Aptian succession.*

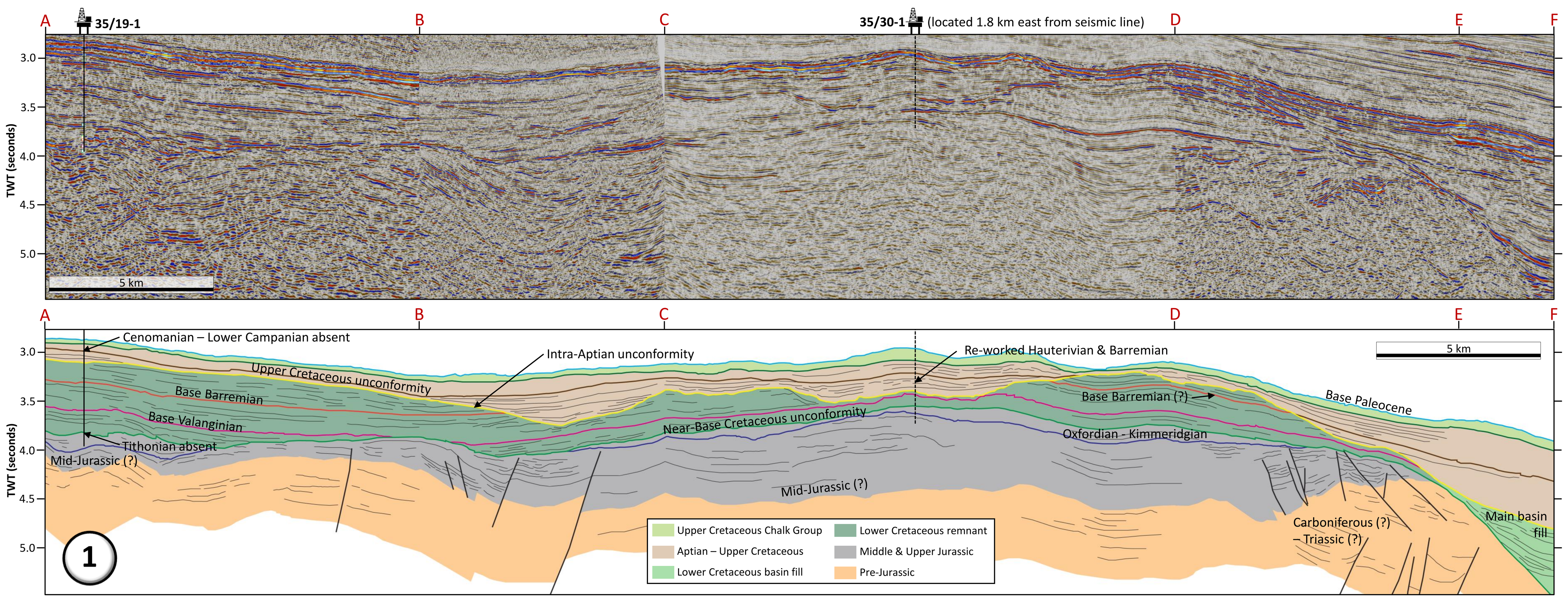


*Figure 3. Composite 2D seismic line across the Moling sub-basin (above) with interpreted section (below).*

## 4.0 South Porcupine Basin

### 4.1 Margin collapse and erosion

On the southwestern flank of Porcupine Basin (Figure 4), structural rotation of the margin and partial slope failure has formed a large gravity-driven mass transport deposit (Figure 5), onlapped by younger shallower-dipping basinal facies (K1, K2, K3 and K4). The upper section of the remnant has been erosionally-truncated.

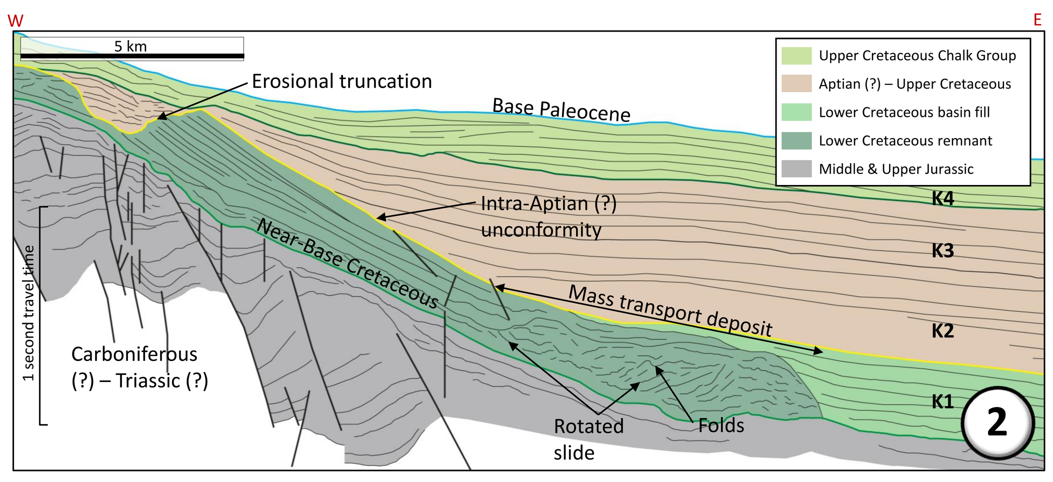


*Figure 5. Line diagram of remnant sequence mass transport deposit.*

### 4.2 Cretaceous uplift

***Seismic evidence** (Figure 6):*

- Basinward wedging and internal downlapping (rotated onlaps) of Lower Cretaceous remnants.
- Large collapse features within the Jurassic and Lower Cretaceous.
- Intra-Cretaceous faulting.
- Draping of Lower Cretaceous over topographic high.
- Two Lower Cretaceous unconformities.

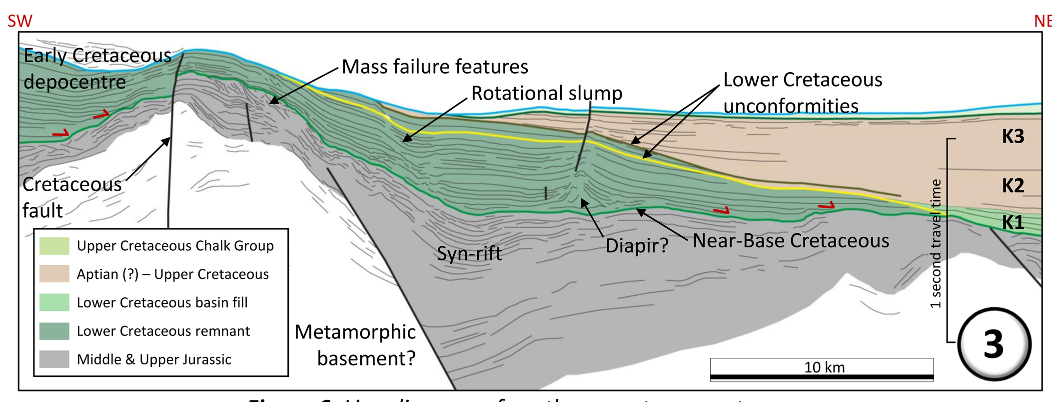


*Figure 6. Line diagram of southernmost remnant sequences.*

### 4.3 Cretaceous unconformities

The "Mid-Cretaceous unconformity" (yellow) truncates Lower Cretaceous remnant packages, isolating them on paleotopographic highs (Figure 7). Lower Cretaceous unconformities are locally observed.

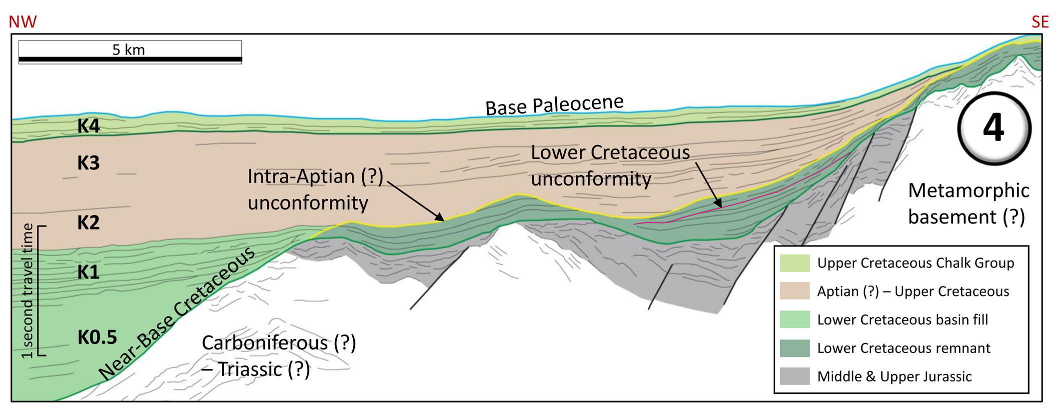


*Figure 7. Lower Cretaceous unconformities.*

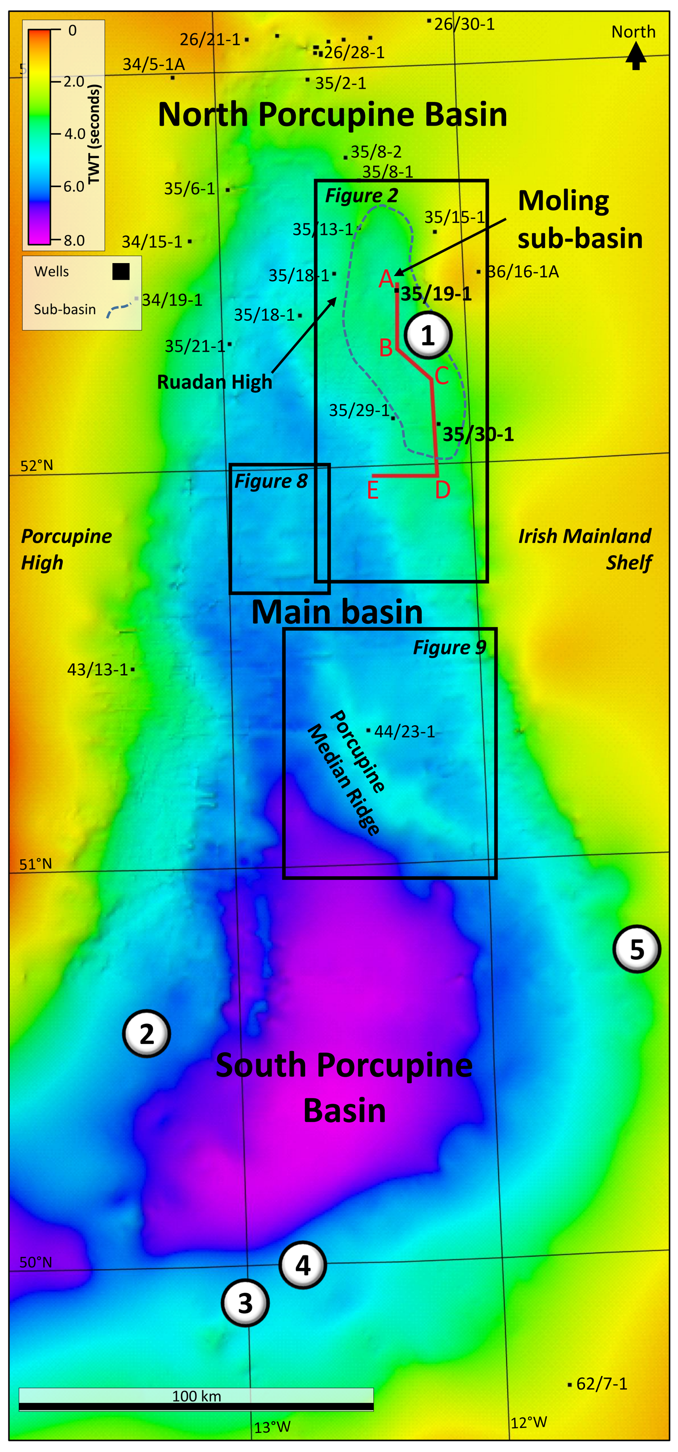


*Figure 4. Location map of Near-Base Cretaceous unconformity time structure.*

### 4.4 Tilted flanks

Both the structurally rotated eastern and western flanks contain steeply-inclined Lower Cretaceous remnant sequences (Figure 10) indicating basinward tilting of margins.

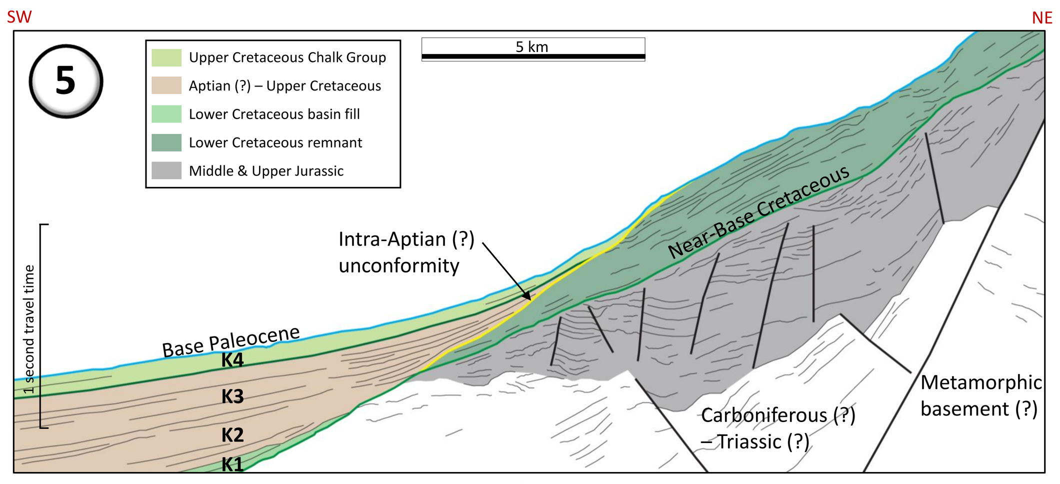


*Figure 10. Line diagram of dipping remnant sequence.*

### 5.0 Intra-basinal structures

There are a number of major structures including the deep-crustal "Arch" reflector (Figure 8) and the Porcupine Median Ridge (Figure 9), the origin of which are a matter of debate.

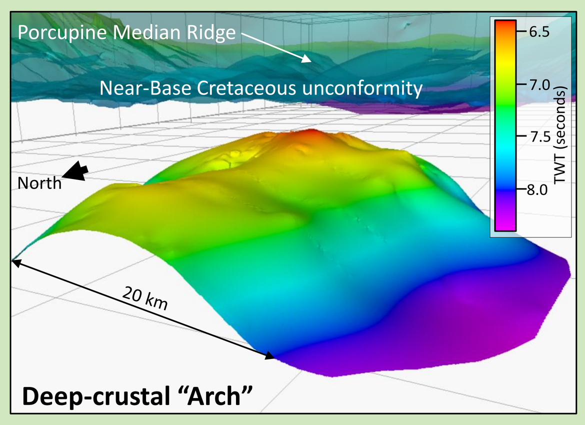


*Figure 8. 3D representation of the deep-crustal "Arch" structure, the origin of which remains unresolved (Mohorovicic discontinuity (?), mafic igneous intrusion (?) etc.).*

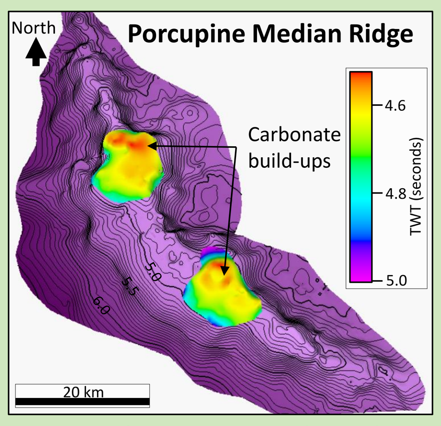


*Figure 9. The Porcupine Median Ridge is capped by northern and southern carbonate build-ups. The origin of the ridge is disputed (serpentinised mantle ridge (?), igneous centre (?), detached sedimentary fault block (?) etc.).*

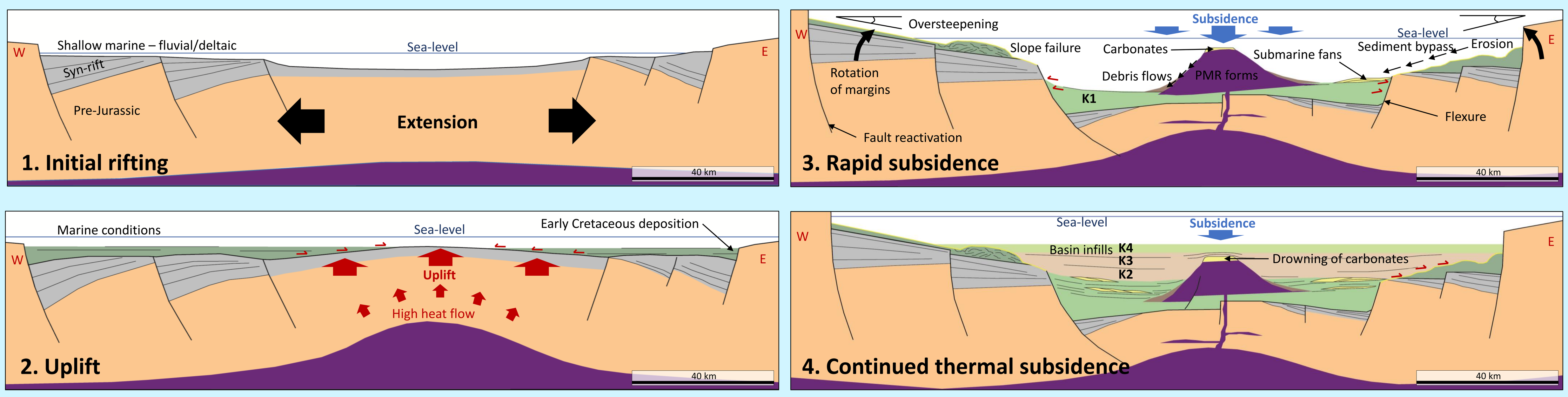


*Figure 11. Conceptual diagram of Porcupine Basin evolution.*

## 6.0 Geological evolution of the Porcupine Basin (conceptual model)

1. Moderate Mid- to Late Jurassic extension creating fault-controlled basins culminating in marine flooding and filling of half-graben.
2. Transition to hyperextension with initial flank depocentres draping half-graben with differential uplift of basin centre.
3. Rapid basin-centred subsidence and whole-scale rotation of basin flanks leading to erosion and local gravity failure of oversteepened earlier depocentres and potential basin-centred volcanism (Porcupine Median Ridge feature).
4. Thermal subsidence and passive infill of new depocentre, onlapping median ridge capped by carbonates.


### 6.0 References

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