

Atlantic Ireland 2017 Conference

Clayton Hotel, Upper Leeson St, Dublin

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A Biostratigraphic, Lithostratigraphic & Sequence Stratigraphic Framework of Offshore Ireland

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⁵ Riley Geoscience Ltd, ⁶ University of Birmingham



Roinn Cumarsáide, Gníomhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment

PIP

Petroleum
Infrastructure
Programme

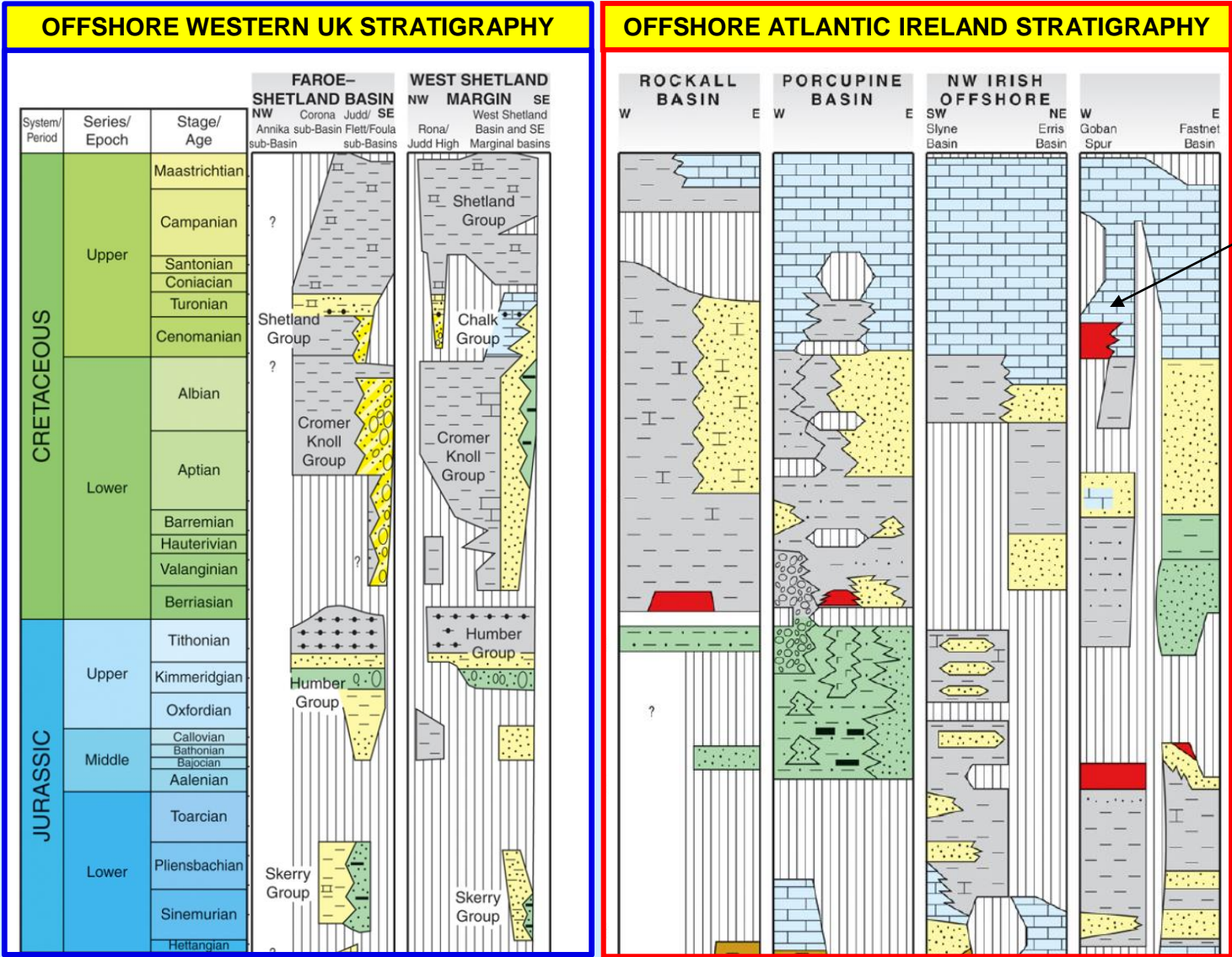


Aims of presentation

- Background to the project IS16/04 “*Integrated Biostratigraphic & Lithostratigraphic framework of offshore Ireland*”
- Provide summaries of some of the results to date
 - Focus on west of Ireland
 - Jurassic
 - Lower Cretaceous
 - Palaeocene
 - Radiometric dating
- Other aspects of the project results are shown on our posters
 - Palaeozoic
 - Upper Cretaceous
 - Geochemistry

All interpretations shown in this presentation are **PROVISIONAL and therefore subject to change**

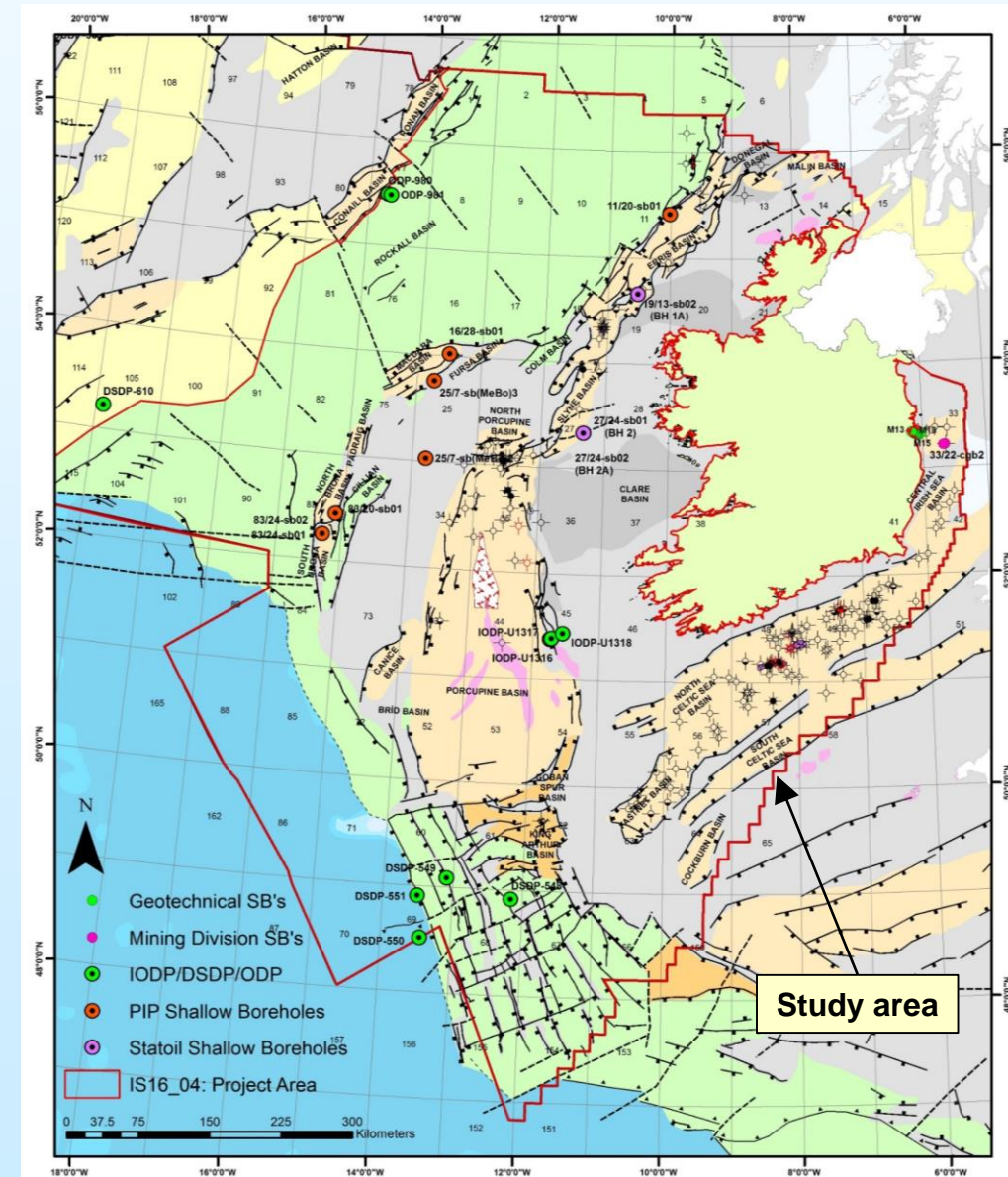
Mesozoic stratigraphy of north west Atlantic margin



No names available for Ireland

Background

- Despite long history of exploration in Ireland (first offshore well in 1970) there is no “official” stratigraphic nomenclature in place.
- Workers and researchers use a mixture of informal, in house or UK names
- PIP therefore commissioned a project in 2016 to define a new stratigraphic framework for offshore Ireland for all workers in the area to use
- A Merlin-led consortium was awarded the project to develop this framework, incorporating...
 - New lithostratigraphic subdivisions and nomenclature
 - Biostratigraphic database (legacy and new data)
 - Biozonation schemes
 - Sequence stratigraphy schemes (well based)
 - Definition of major seismic horizons/sequences
 - Maps showing the distribution of newly defined lithostratigraphic units
 - Palaeogeography maps
 - Comparisons with Eastern Canada and North Sea
 - Integration with geochemistry database



Composition of the Merlin consortium

- Team of 16 people
- Stratigraphers
- Geochemists
- Seismic interpreters
- Petroleum geologists
- Igneous geologist
- GIS geoscientists
- Data managers
- Project management

PALAEODATE LTD

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DUNFORD EXPLORATION LTD

- **Project steer and management**

- PIP; Nick O'Neill, Martin Davies
- PAD; Kara English (mentor), Clare Morgan, Michael Hanrahan
- Steering Group (as above + Cairn, Providence, Statoil, Woodside)

- **Stratigraphic Nomenclature Committee**

- Pat Shannon (Chairman), plus PAD, PIP, D. Naylor, G. Sevastopulo, P. Haughton, S. Tyrrell, A. Doré, P. Copestake, N. Ainsworth
- Aim to guide the process of defining new offshore lithostratigraphy and seismic sequences

- **Deliverables**

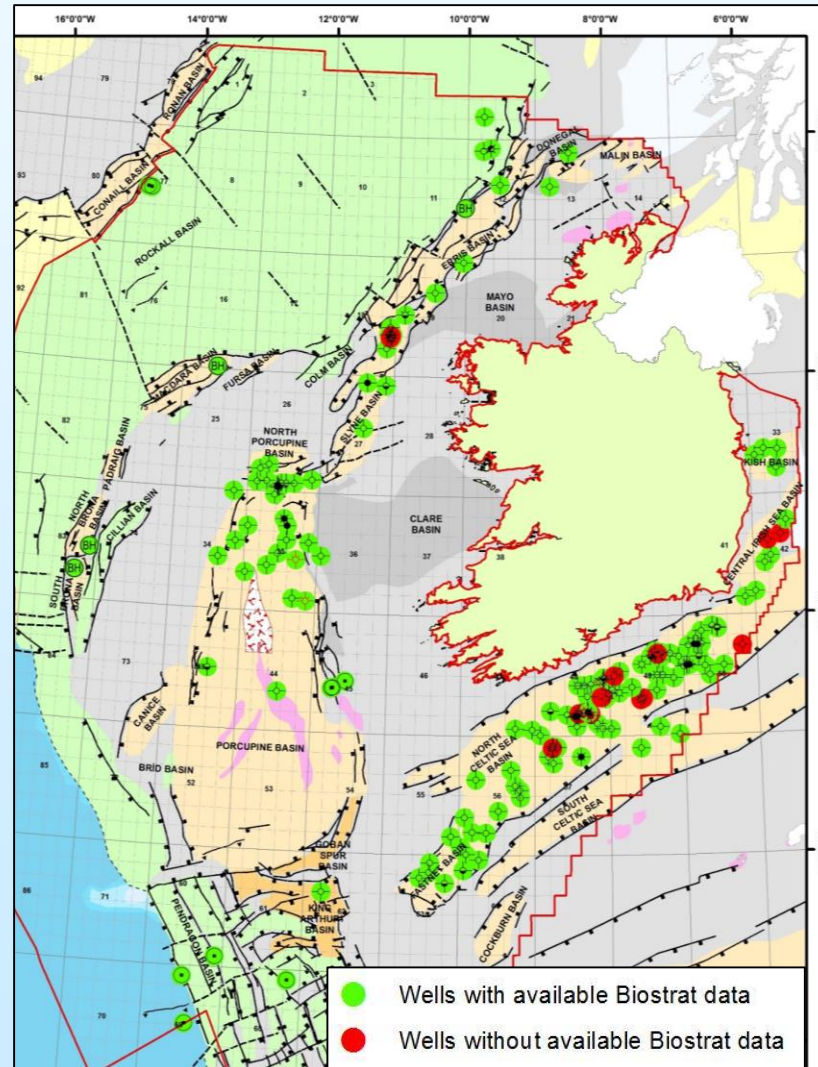
- Report
- Atlas
- Project databases

- **Project due for completion in 2018.**

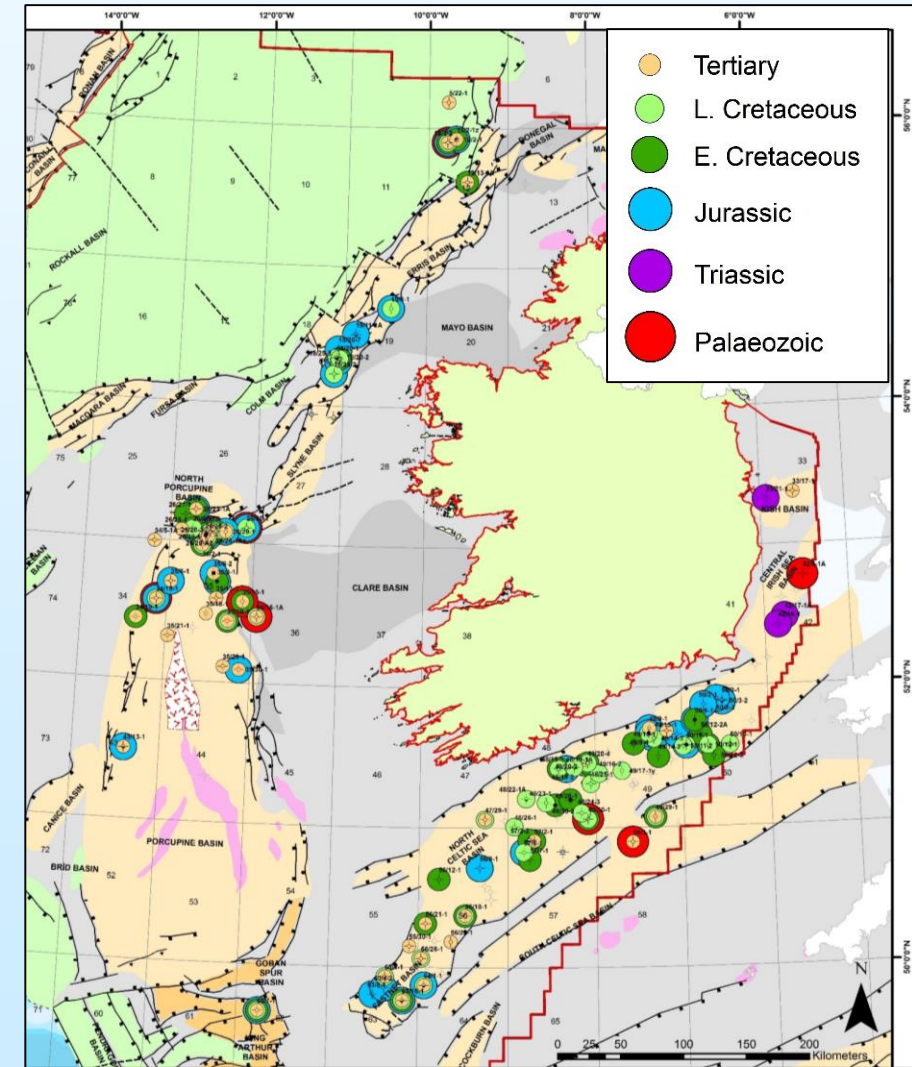
Database; biostratigraphy coverage & sampling

- Legacy biostratigraphic database:
 - 163 Wells
 - 9 IODP/DSDP/ODP sites (30 holes)
 - 10 Shallow Boreholes
 - 203 total wells & boreholes
 - 313 data sets
- All interpreted (chronostratigraphy, initial lithostratigraphic subdivisions, key biostratigraphic markers synthesized)
- Entered into Stratabugs & IC databases, summary logs & correlation panels created
- Litho and chrono tops into IHS Kingdom seismic database to constrain seismic interpretations (see poster for seismic database)
- Lithologies interpreted and entered into IC database
- Re-Sampling:
 - 106 wells sampled
 - focus on filling data gaps and addressing particular stratigraphic problems

Legacy biostratigraphy coverage:



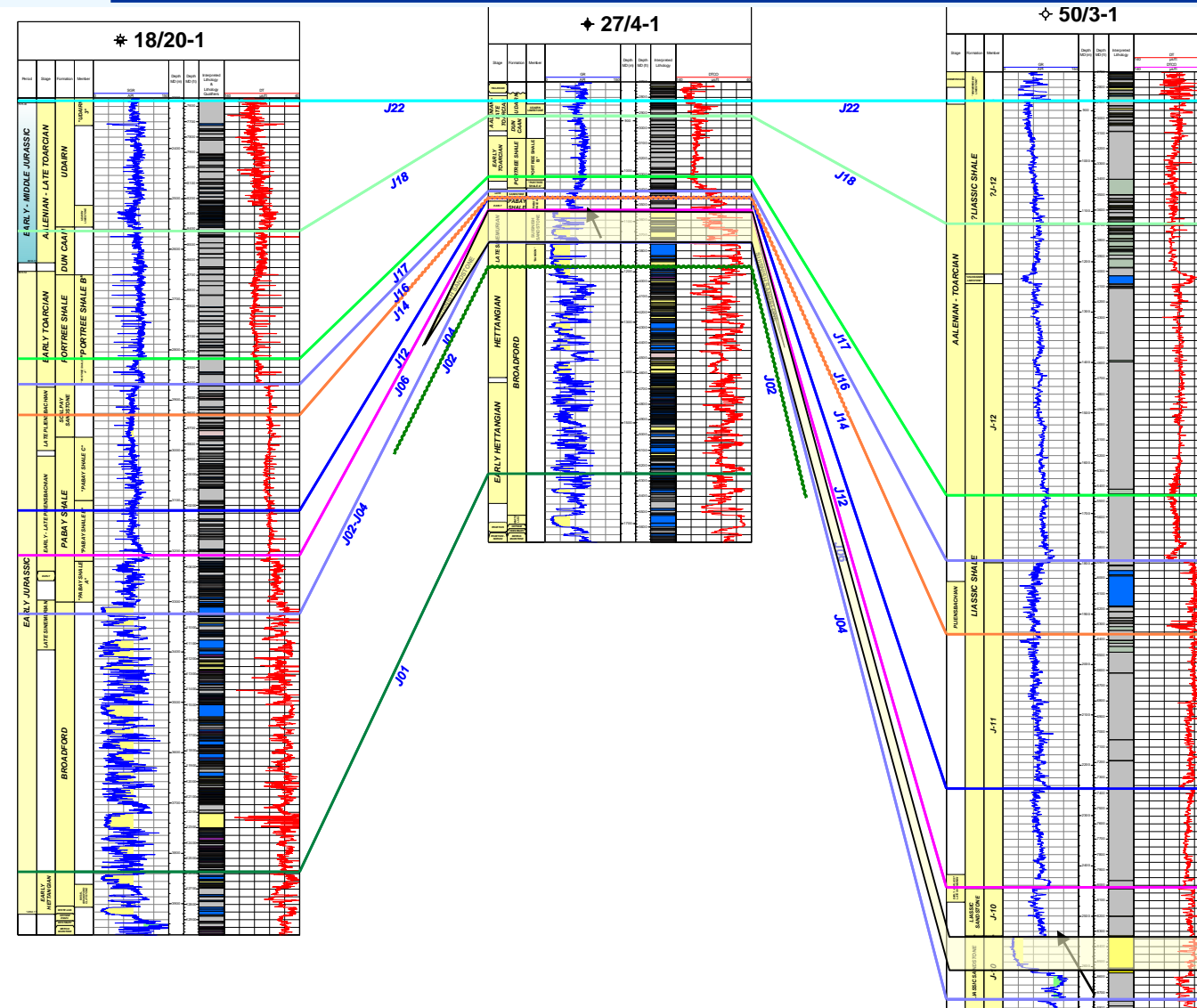
Wells & age intervals re-sampled:



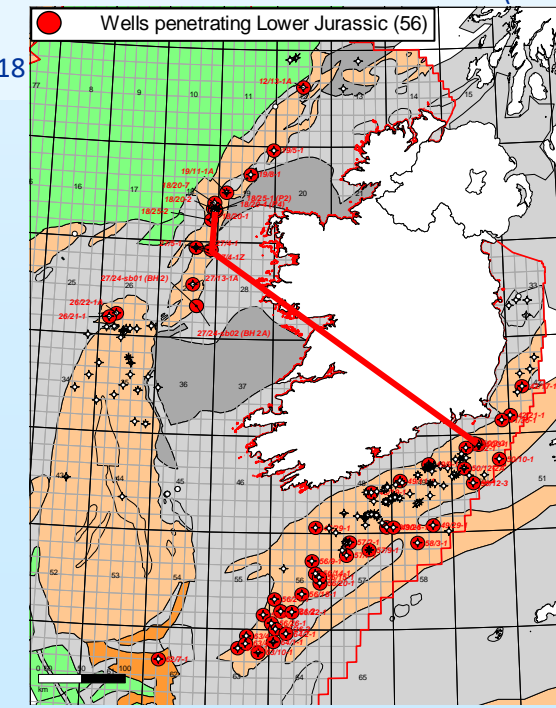
Summaries of initial results to date

(note all lithostratigraphic subdivisions shown in the following slides are informal and will need agreement with Stratigraphic Nomenclature Committee, followed by establishment of new names)

Lower Jurassic development eastern and western offshore Ireland

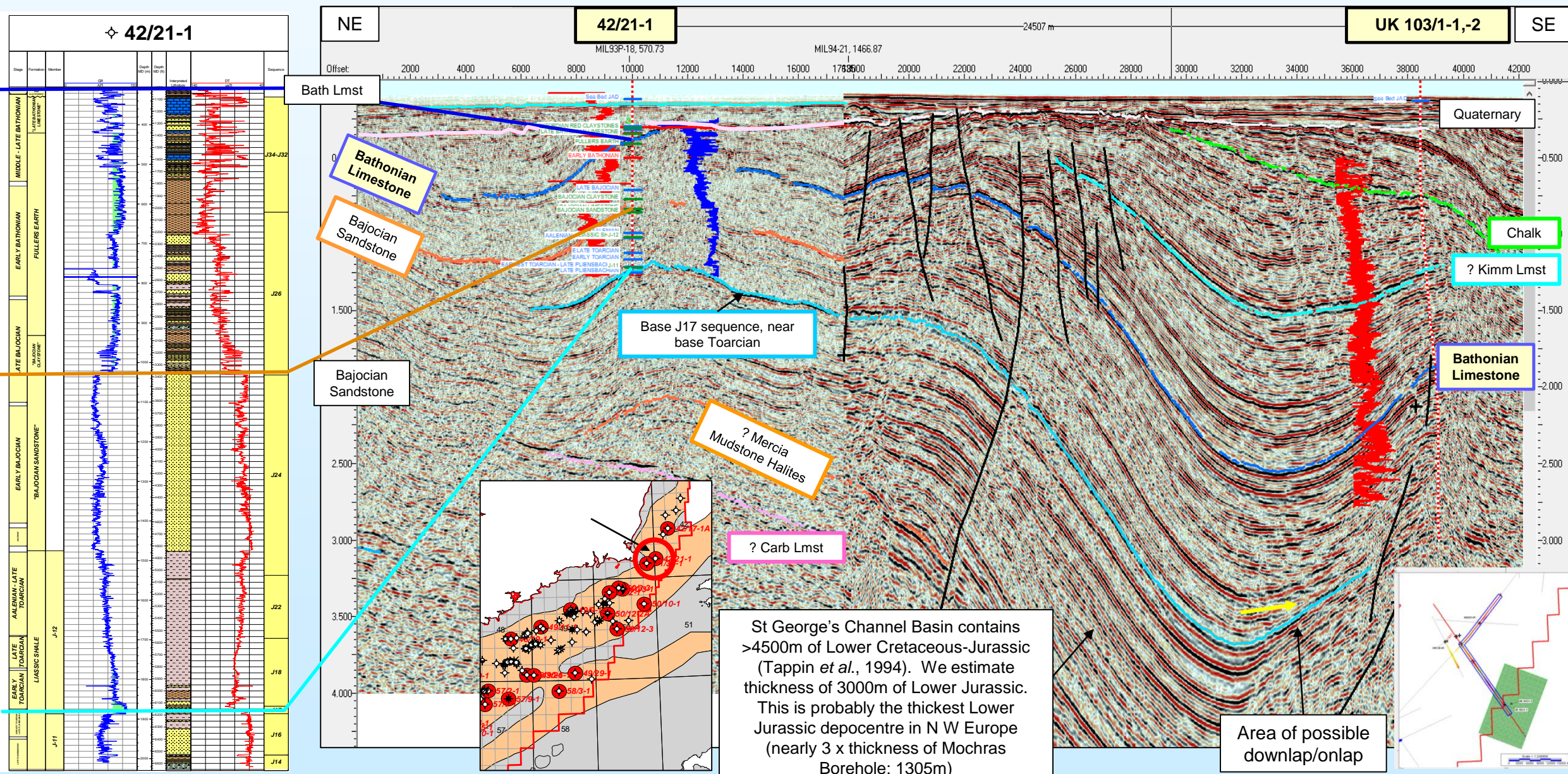


- North Sea – UK published J sequences (Partington *et al.*, 1993) can be applied at least for the marine parts of the Jurassic offshore Ireland
- 10 J sequences through Lower Jurassic
- Presence of major unconformity, intra Upper Pliensbachian (base J16 sequence), plus at Sinemurian/Hettangian boundary (base J04 sequence)
- Overall background claystone succession
- Punctuated by major limestone and sandstone units
 - Limestones in Hettangian – earliest Sinemurian in Celtic Sea-Fastnet Basins
 - Overlain by Sinemurian sandstones
 - Limestones range younger in west of Ireland; often called Broadford Beds
 - Overlain by Late Sinemurian “Suisnish Sst”, oil reservoir in 27/4-1 (Bandon) discovery
 - This sandstone correlates with Sinemurian Sandstone east of Ireland (in J06 sequence)
- Early Toarcian high gamma claystone J17-J18

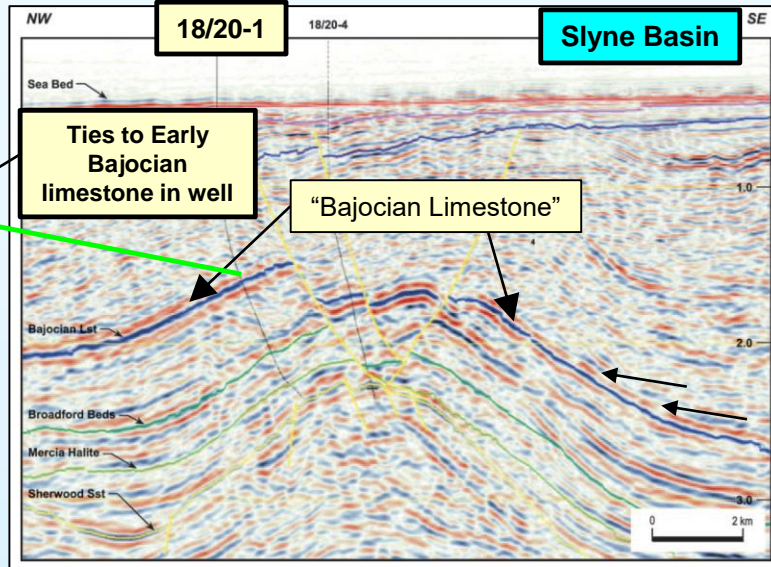
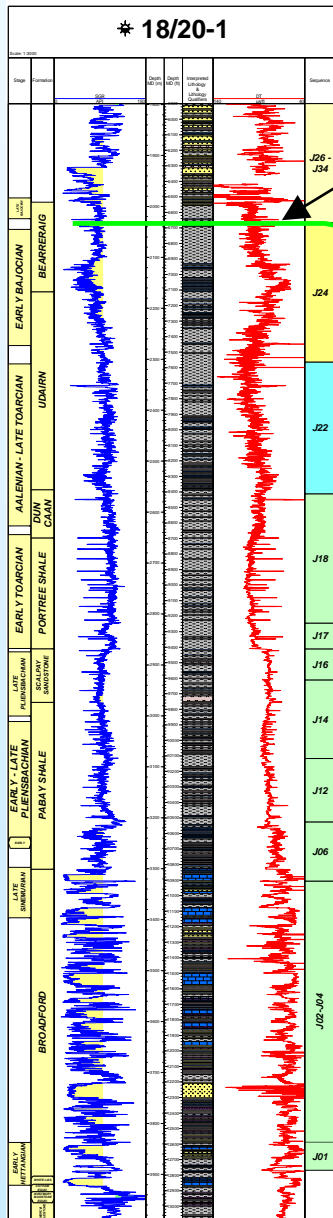


50/3-1, 50/3-3 together represent thickest Lower Jurassic in Ireland, 2350m

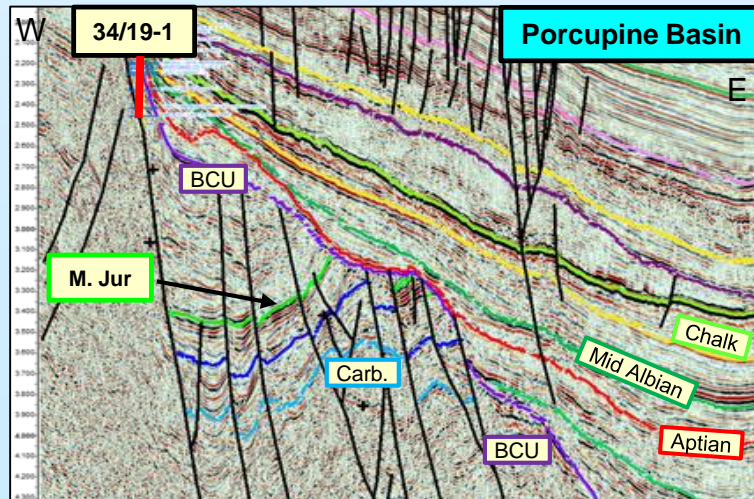
Jurassic development in St George's Channel Basin



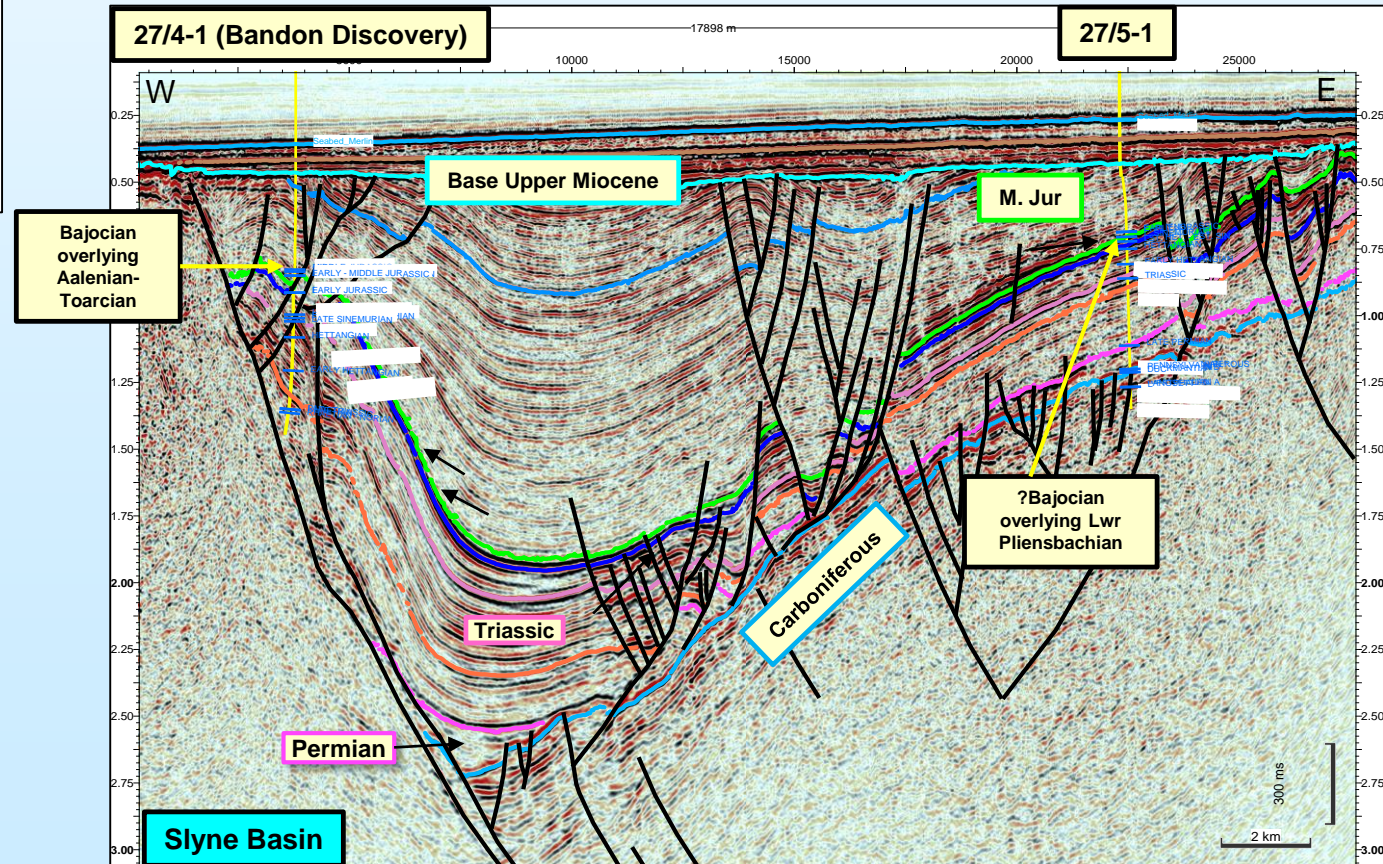
Middle Jurassic & age of Bajocian Unconformity



Seismic line across Corrib Field (Dancer et al., 2005)



- It is likely that the unconformity is the same age in all areas, though difficult to pin down; need relatively complete succession
- Ties to period of rapid subsidence and extension in Slyne Basin
- Best estimate of age is Intra Bajocian
- Similar age to Intra Aalenian, J20 unconformity in North Sea, but younger
- Intra Bajocian age unconformity also in Greenland (Surlyk & Ineson, 2003)
- We have not seen an equivalent significant break in the Fastnet-Celtic Sea basins

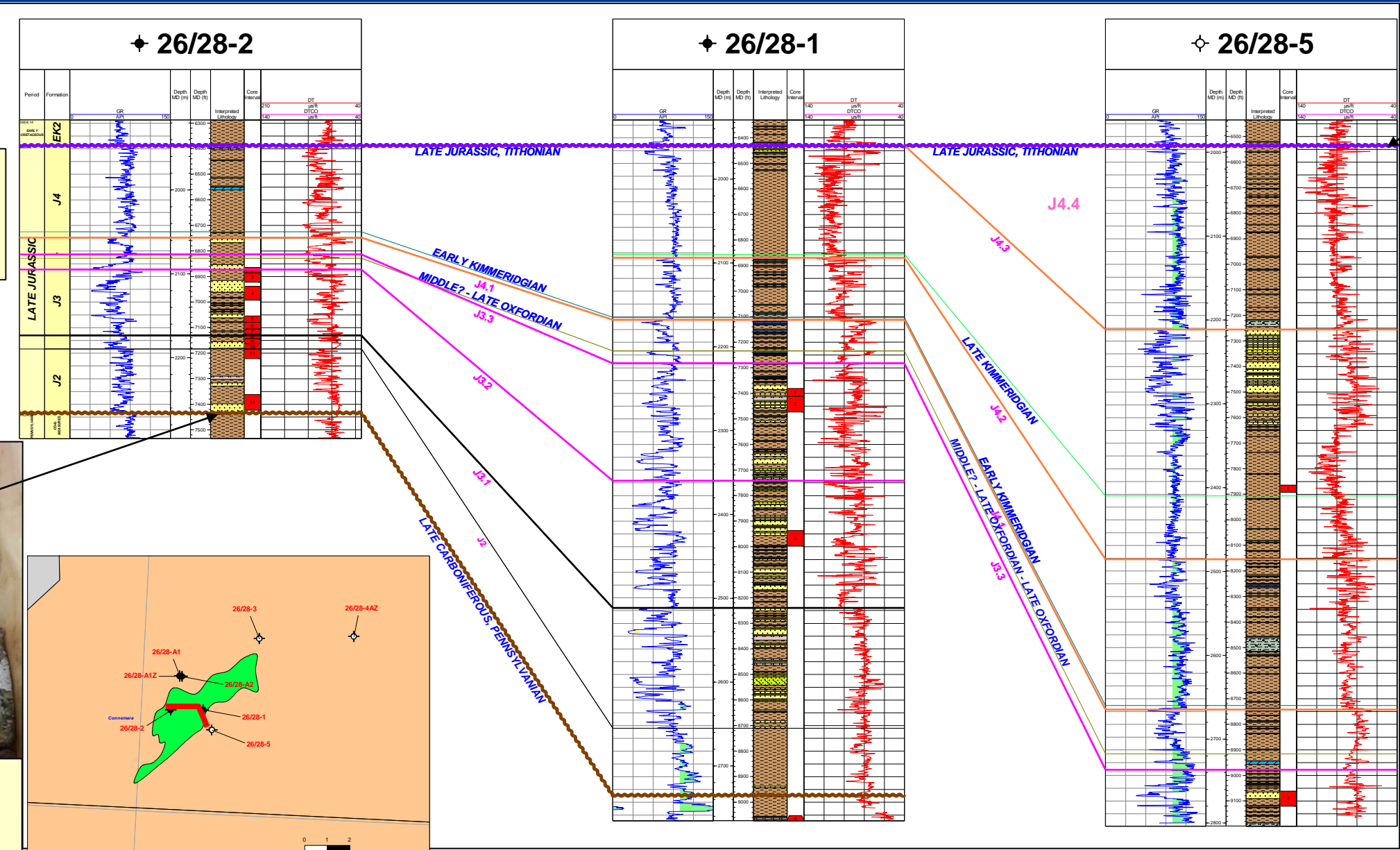


Upper Jurassic stratigraphy, Porcupine Basin, Connemara Discovery

Upper Jurassic non to shallow marine in Porcupine Basin



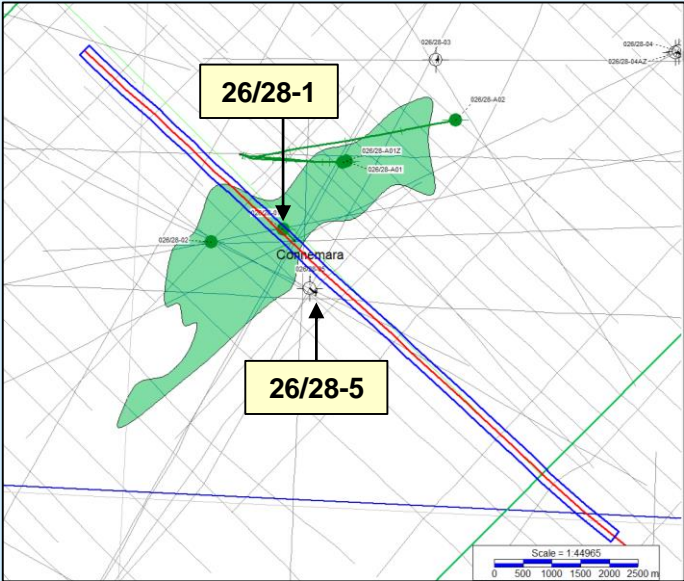
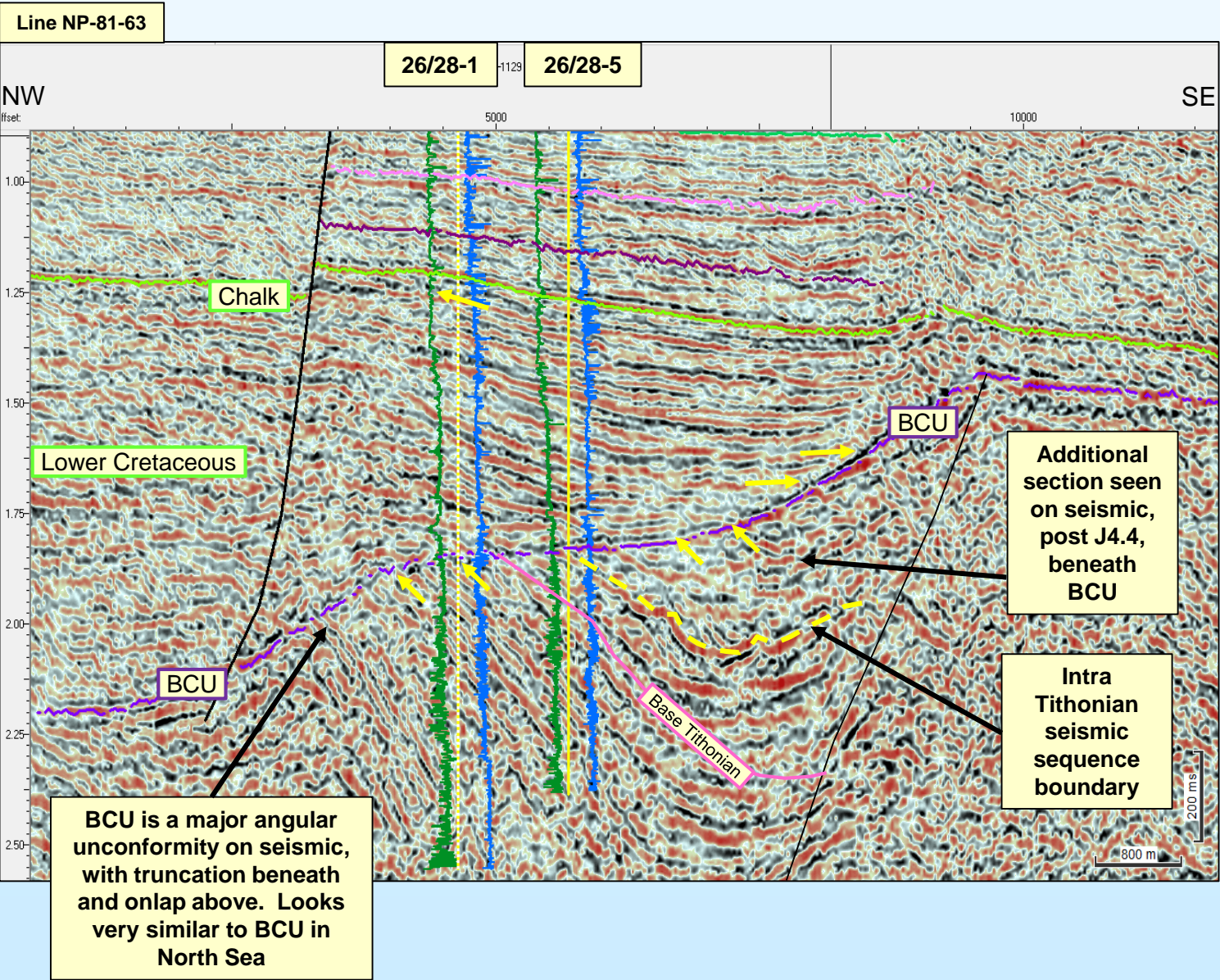
26/28-2 Conglomerates in red claystone matrix; core 12



Additional section seen on seismic, post J4.4, beneath BCU. ?Undrilled in basin

- BCU is, where minimal unconformity, at the Berriasian/Tithonian boundary.
- Note this is older than the North Sea BCU. The Ireland BCU equates with a different sequence boundary in the North Sea, that at the base of J73

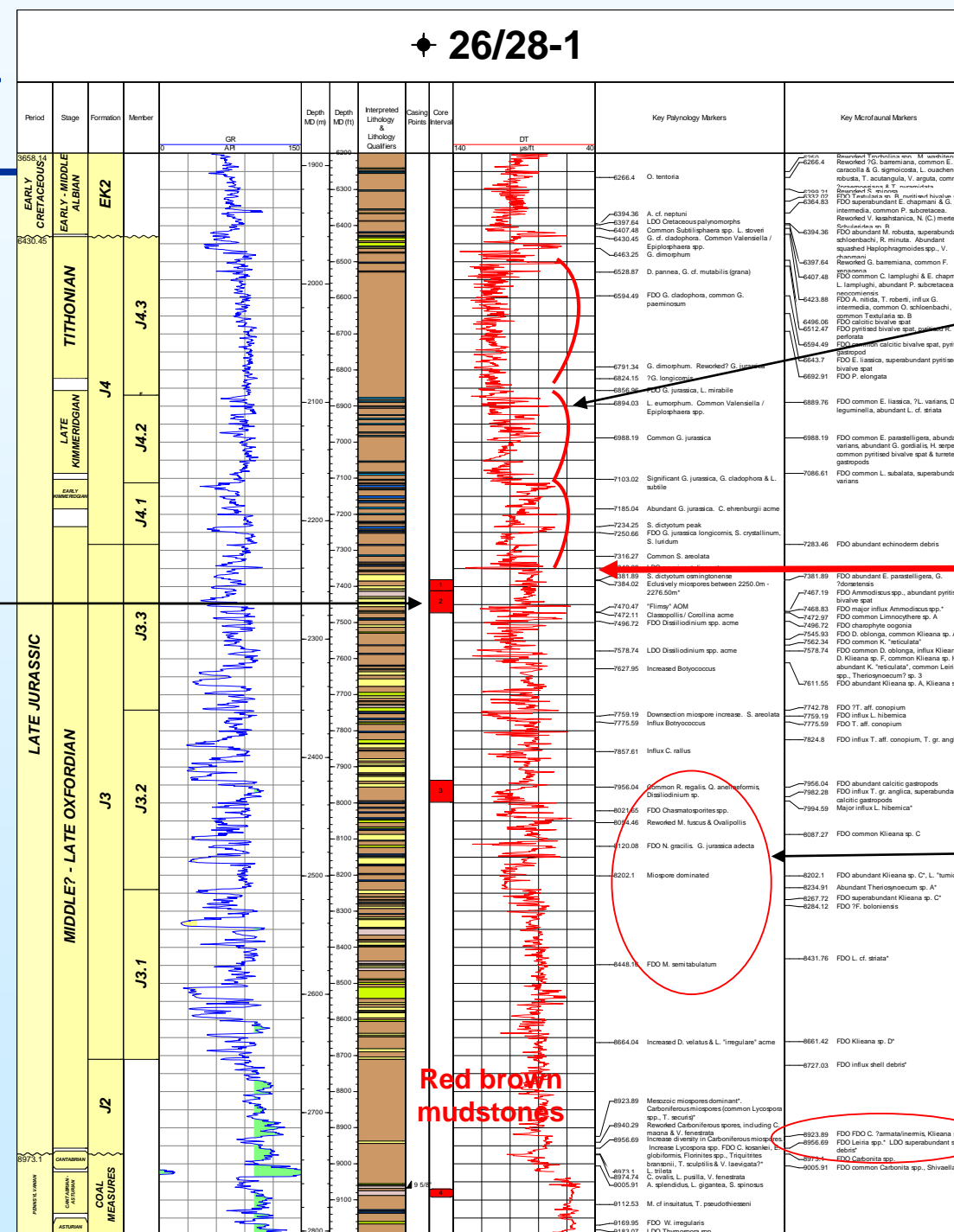
Seismic line across Connemara Field



Upper Jurassic biostratigraphy & potential sequence stratigraphy



J3.3 sandstone/shale boundary in core 2; Middle?-Late Oxfordian in age



Potential stratigraphic sequences recognisable within marine J4 unit

- Upwards shift from marginal/non-marine to marine palynofloras and microfaunas; indicative of major flooding
- Late Oxfordian in age
- Correlates with base J56 MFS in North Sea

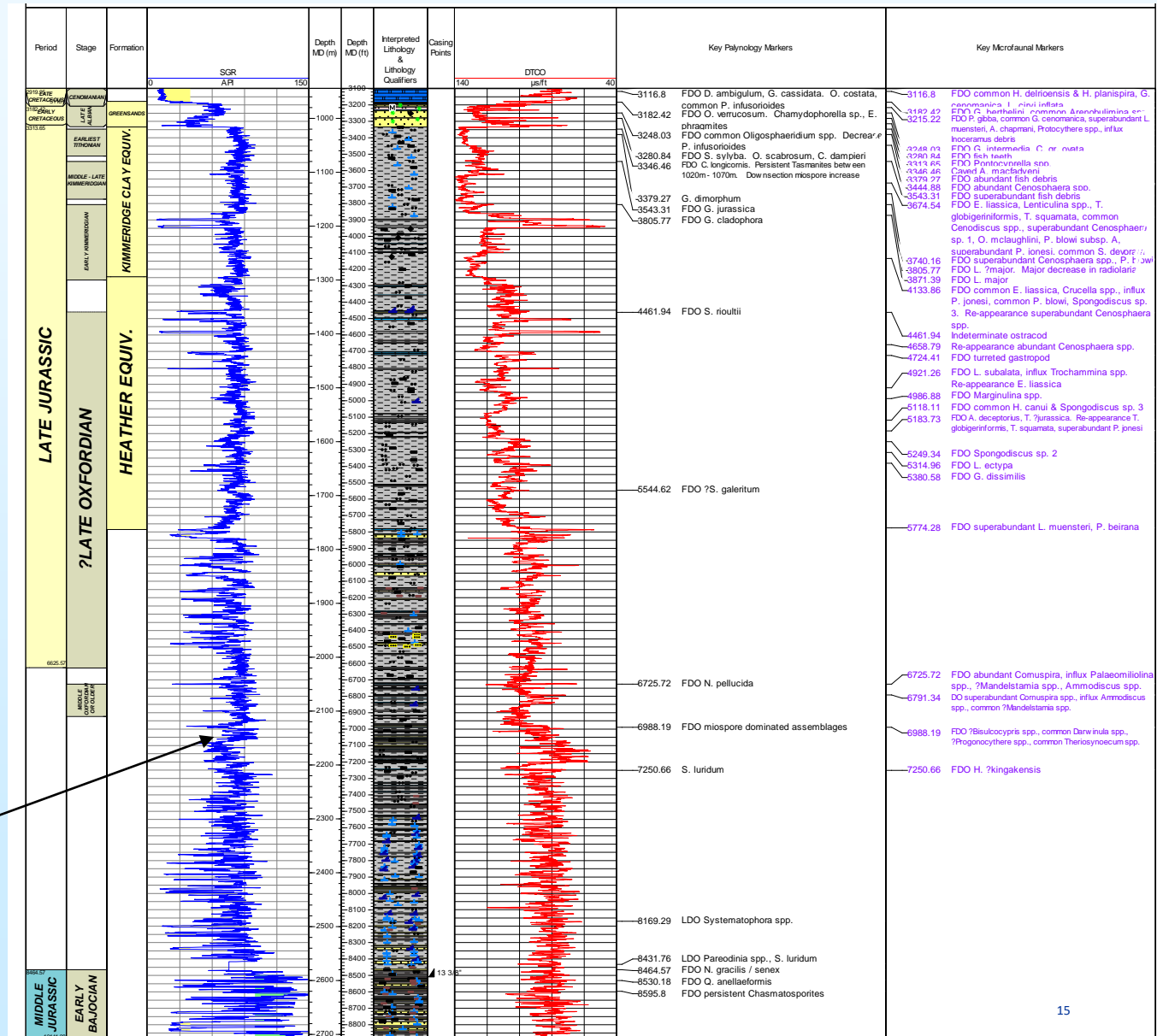
Middle Jurassic dinocysts present; interpreted as reworked. Previously interpreted as in situ Middle Jurassic

Non marine ostracods (*Cetacella*, *Leiria*), Late Jurassic, similar forms seen in Kimm-Oxfordian of North Celtic Sea & Portugal

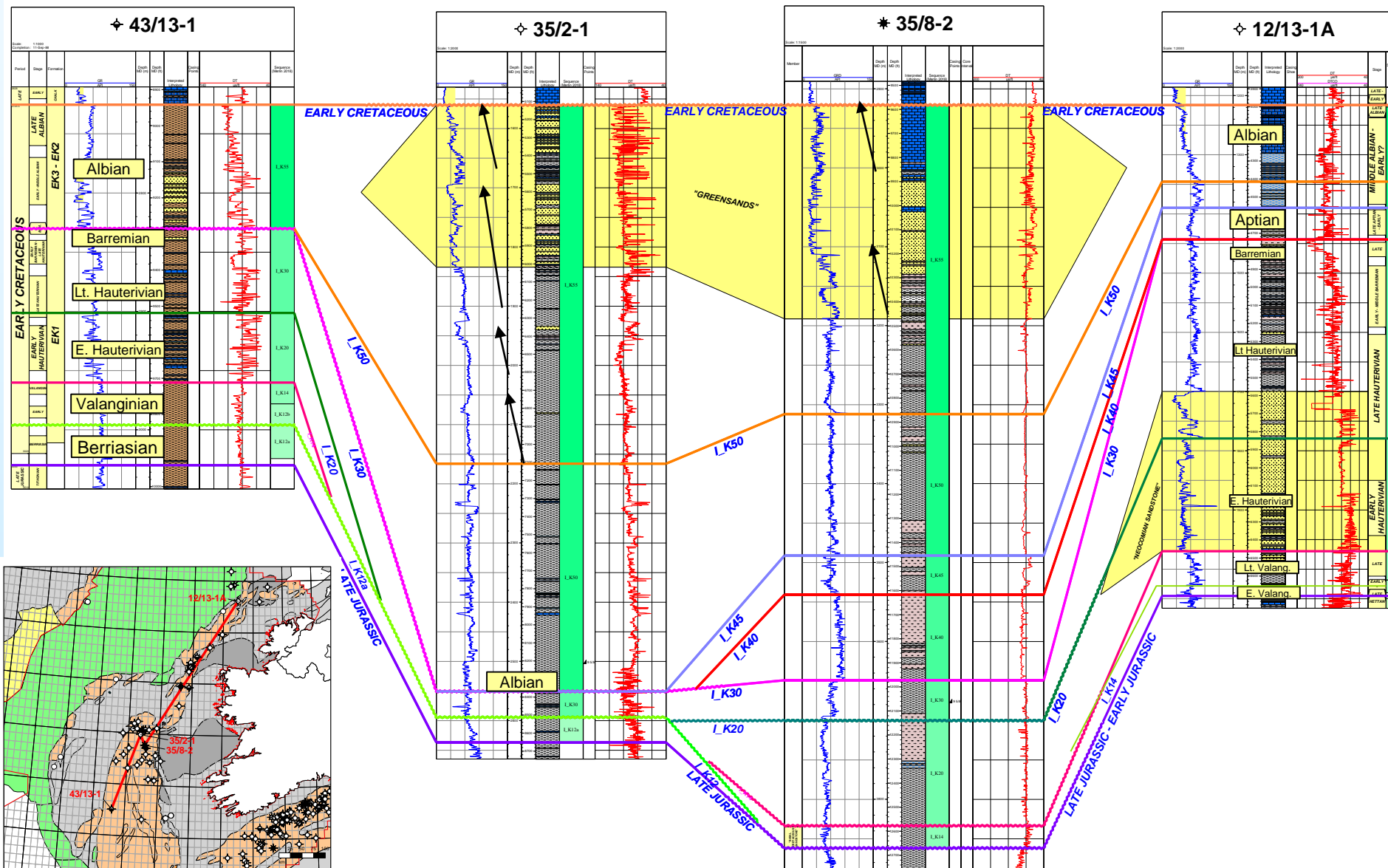
19/11-1A Upper Jurassic

- Typical North Sea type Kimmeridge Clay & Heather with matching biostratigraphic content (e.g. dinocysts, radiolaria)
 - Further example in Dooish area (see later slide)
- Part way down the Upper Jurassic section a distinctive ostracod association appears that has been interpreted by some as Bathonian, but which we consider to be Oxfordian
- In some wells this is associated with red beds
- These red beds are believed to correlate with Celtic Sea and Porcupine basins

Operator top Bathonian



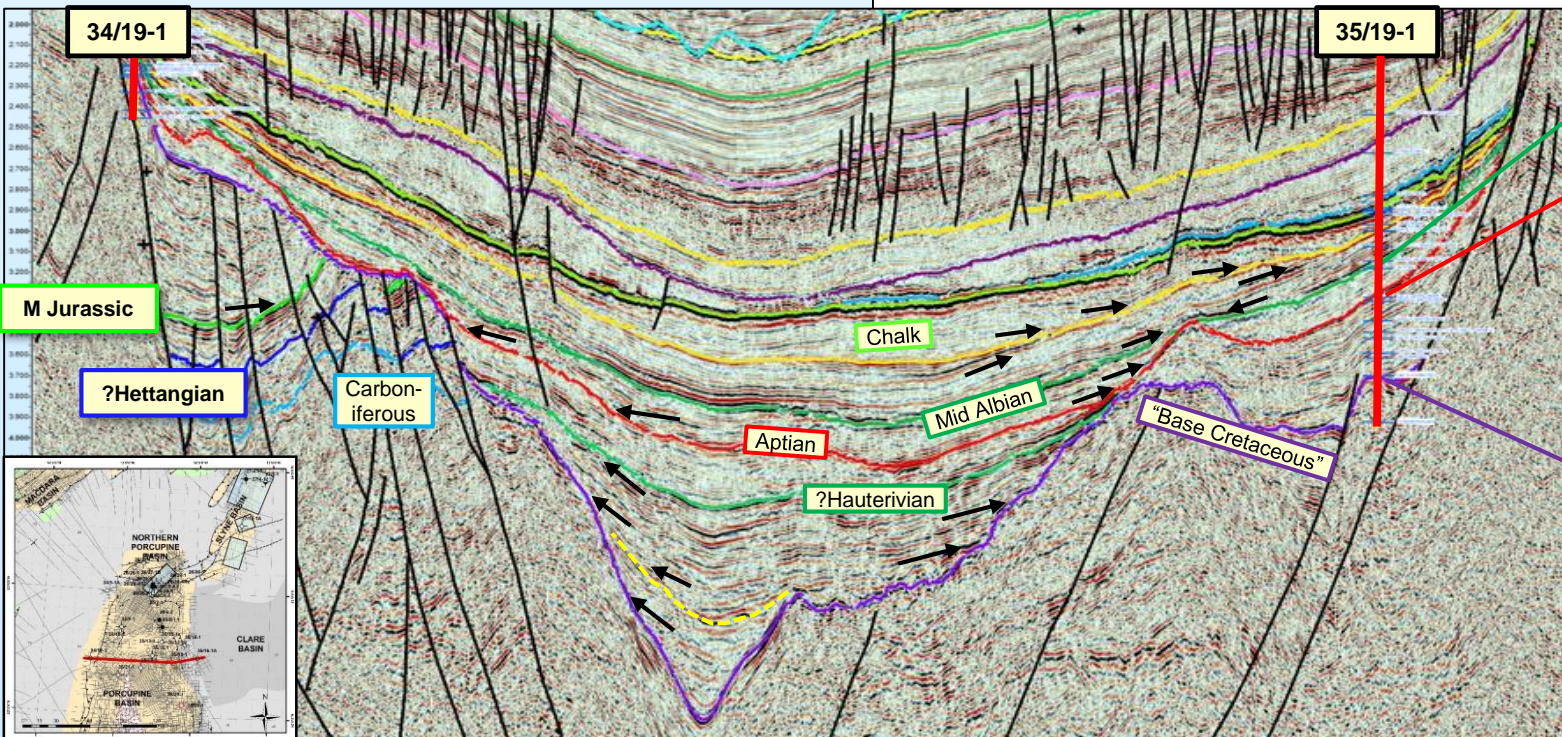
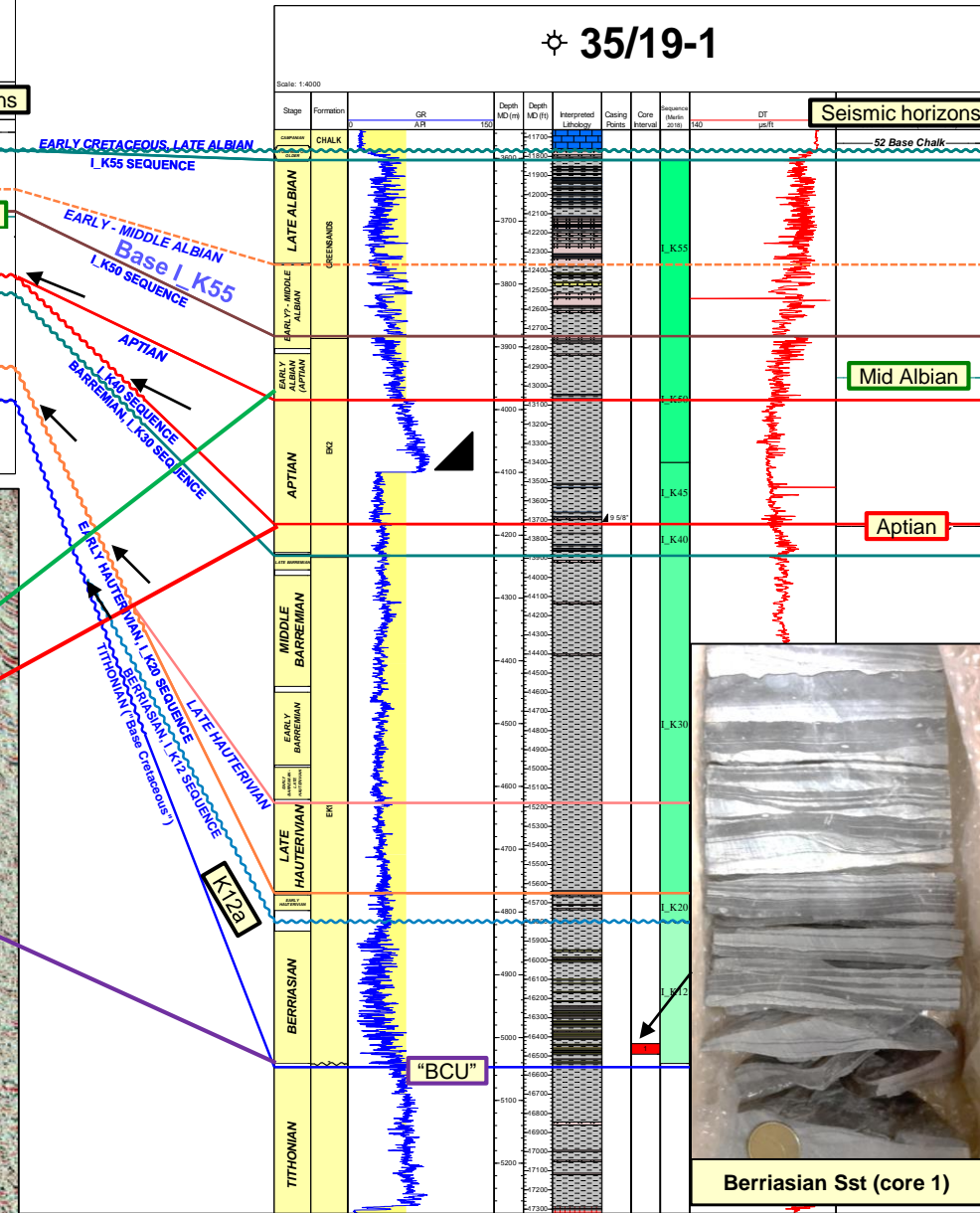
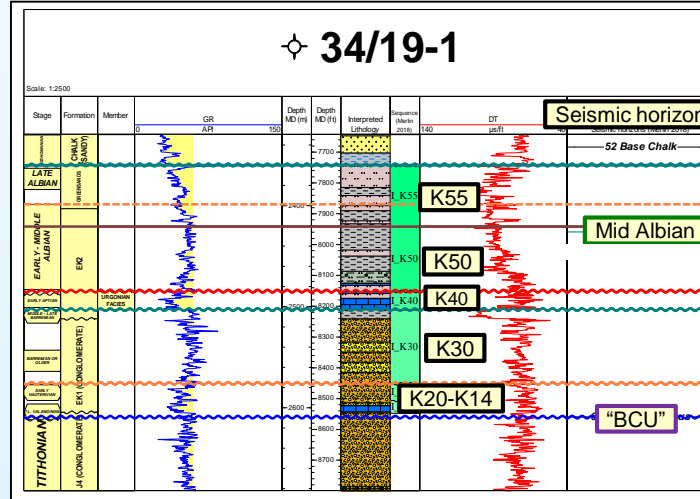
Lower Cretaceous succession west of Ireland



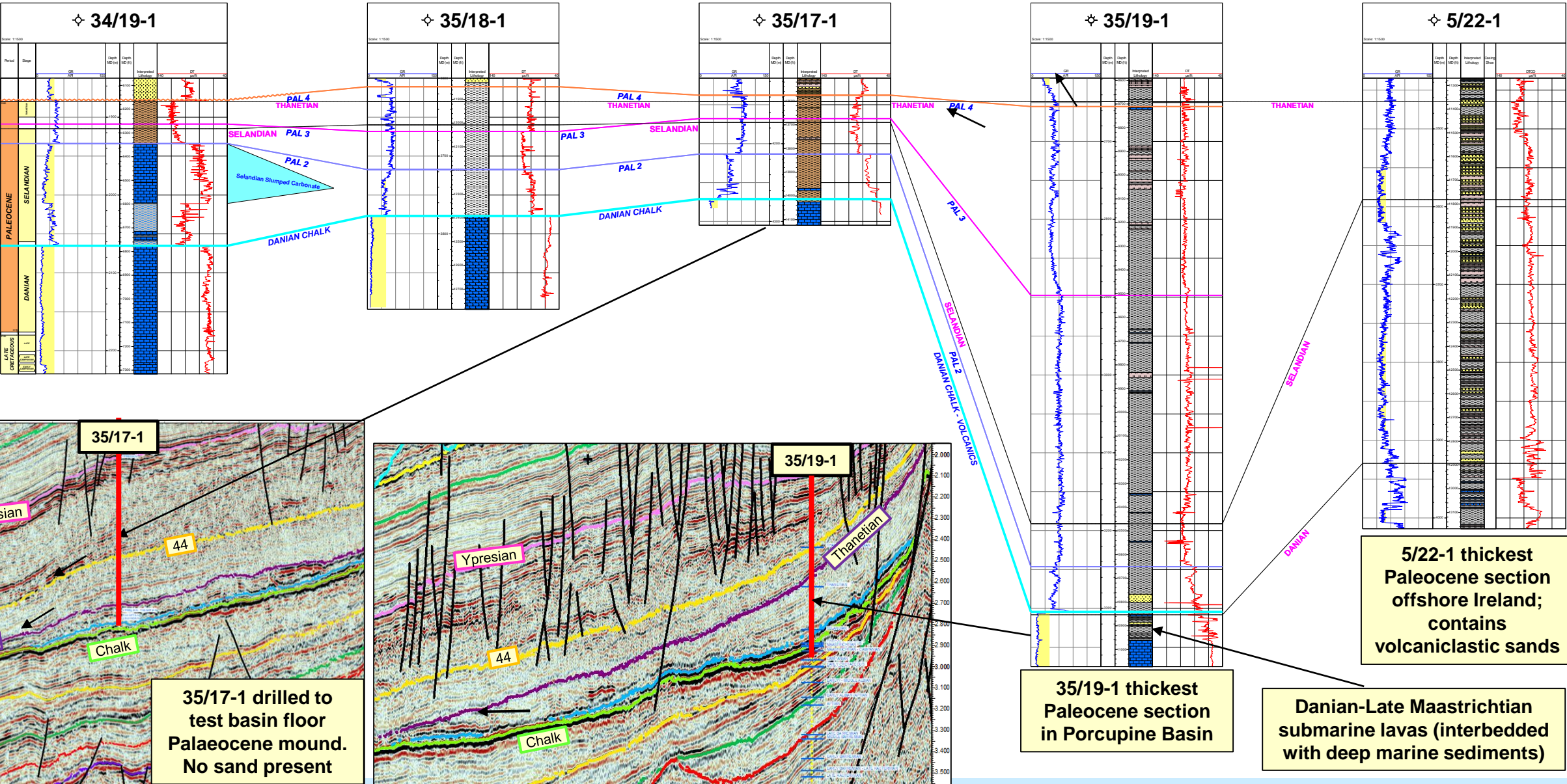
- Marine deposition throughout
- Most well developed sandstones are “Greensands” in Middle-Late Albian
- Widespread around margin of Porcupine Basin
- “Neocomian Sandstone” (Hauterivian age) in 12/13-1A in Erris Basin
- 12/13-1A succession very similar to North Sea
 - Formations & log units identifiable
 - Biostratigraphy is also North Sea type
- Set of depositional sequences provisionally recognisable
 - I_K12 to I_K55
 - Appear to correlate with published North Sea K sequences (Copestake *et al.*, 2003; Millennium Atlas)

Lower Cretaceous seismic stratigraphy west of Ireland

- 4/5 seismic horizons identified
 - Base Upper Cretaceous (Base Chalk)
 - Mid Albian
 - Aptian
 - ?Hauterivian
 - 1 deeper horizon, not yet tied to well
- Aptian horizon tied to base I_K45
- Mid Albian horizon ties to base I_K55
- From wells there are three unconformities fairly close to each other; intra Aptian, base Aptian, Mid Albian; each of which can be confused with "Intra Aptian seismic sequence boundary"
- Plus other older unconformities; base I_K30, base I_K14

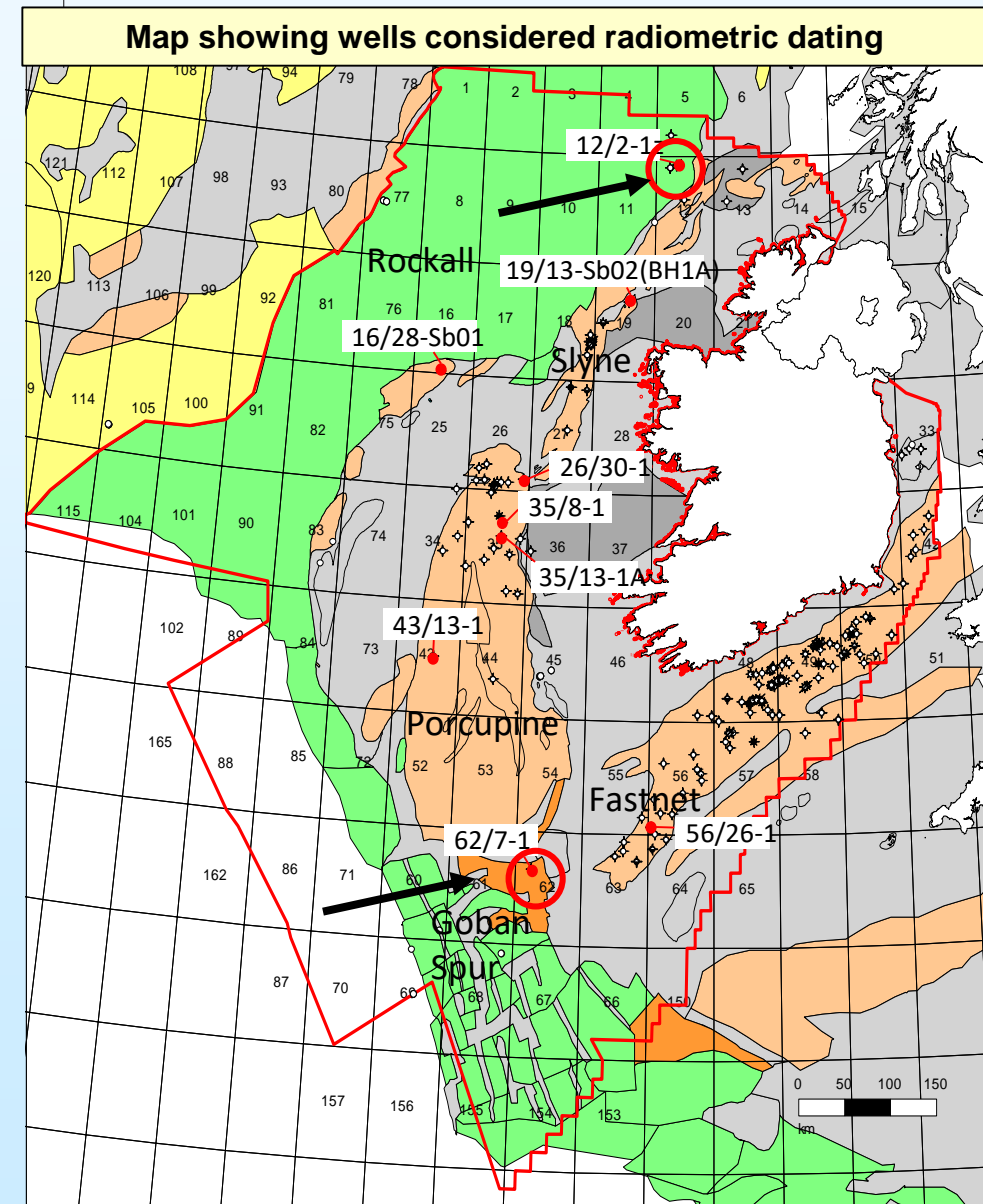


Lower Tertiary (Paleocene) of western offshore Ireland

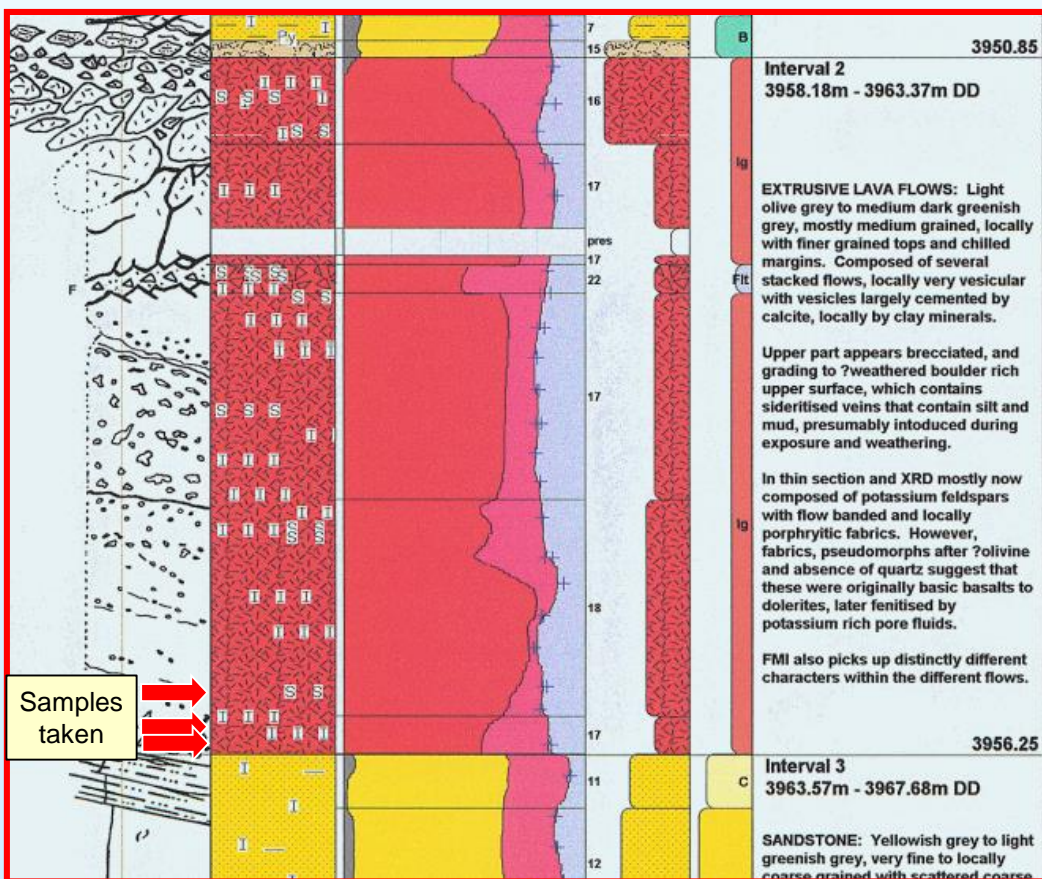


Igneous rocks and radiometric dating

- Selected igneous rock units proposed for radiometric dating
 - Lavas
 - Tuffs
 - Intrusions
 - Basement
- Units selected for dating are either previously undated or where a check on previous dating needed
- Focus on core samples
- These have been described and studied petrographically (Dr Carl Stevenson, University of Birmingham)
- Samples with appropriate mineralogy and freshness high graded for dating
- Two examples illustrated here
 - 12/2-1Z
 - 62/7-1.



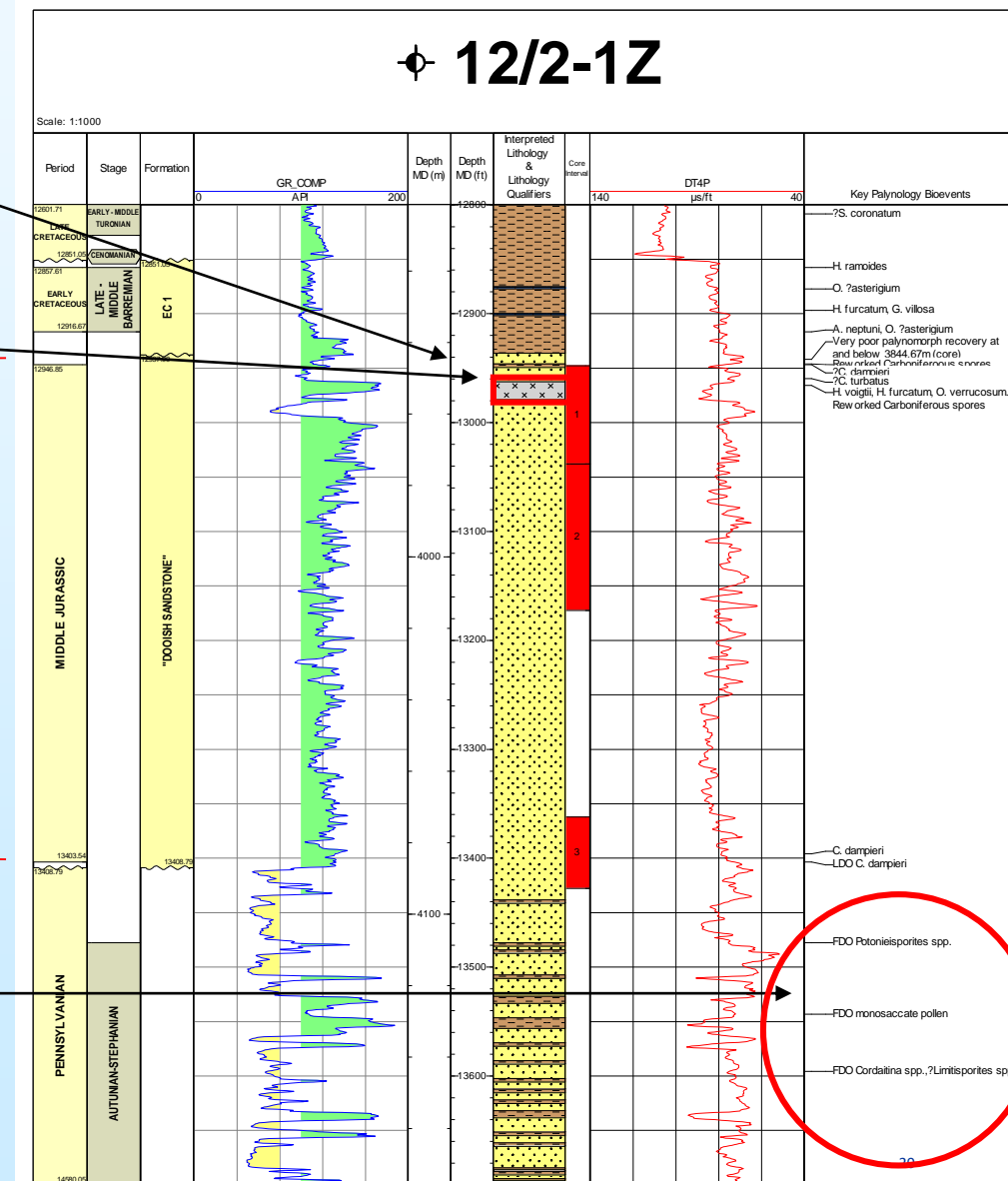
12/2-1Z lava within the “Dooish Sandstone”



Lava flow within “Dooish Sandstone”, if can be dated, will provide valuable evidence of age

“Dooish Sandstone” yields very poor biostratigraphic data, both in legacy data and new analysis

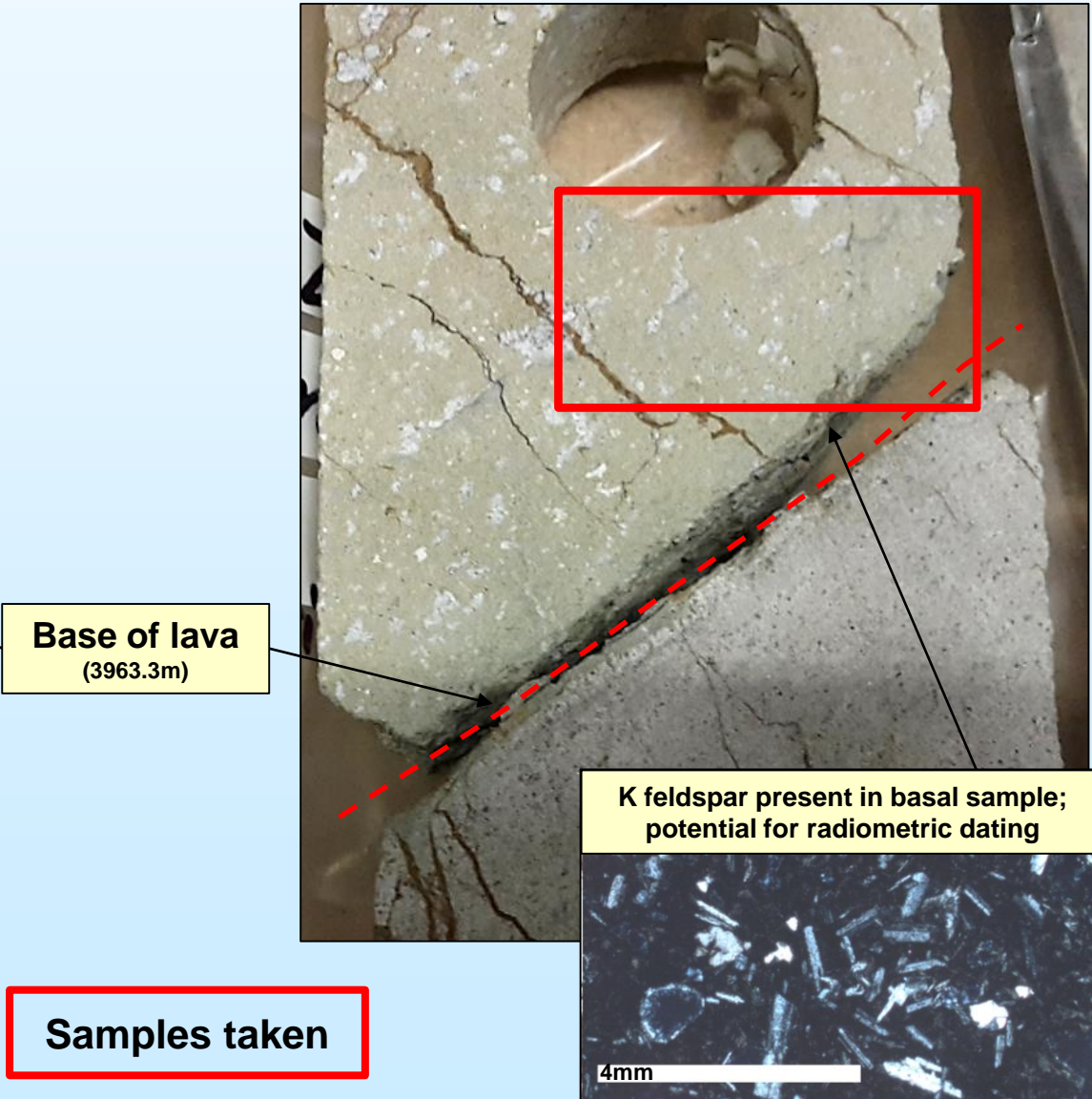
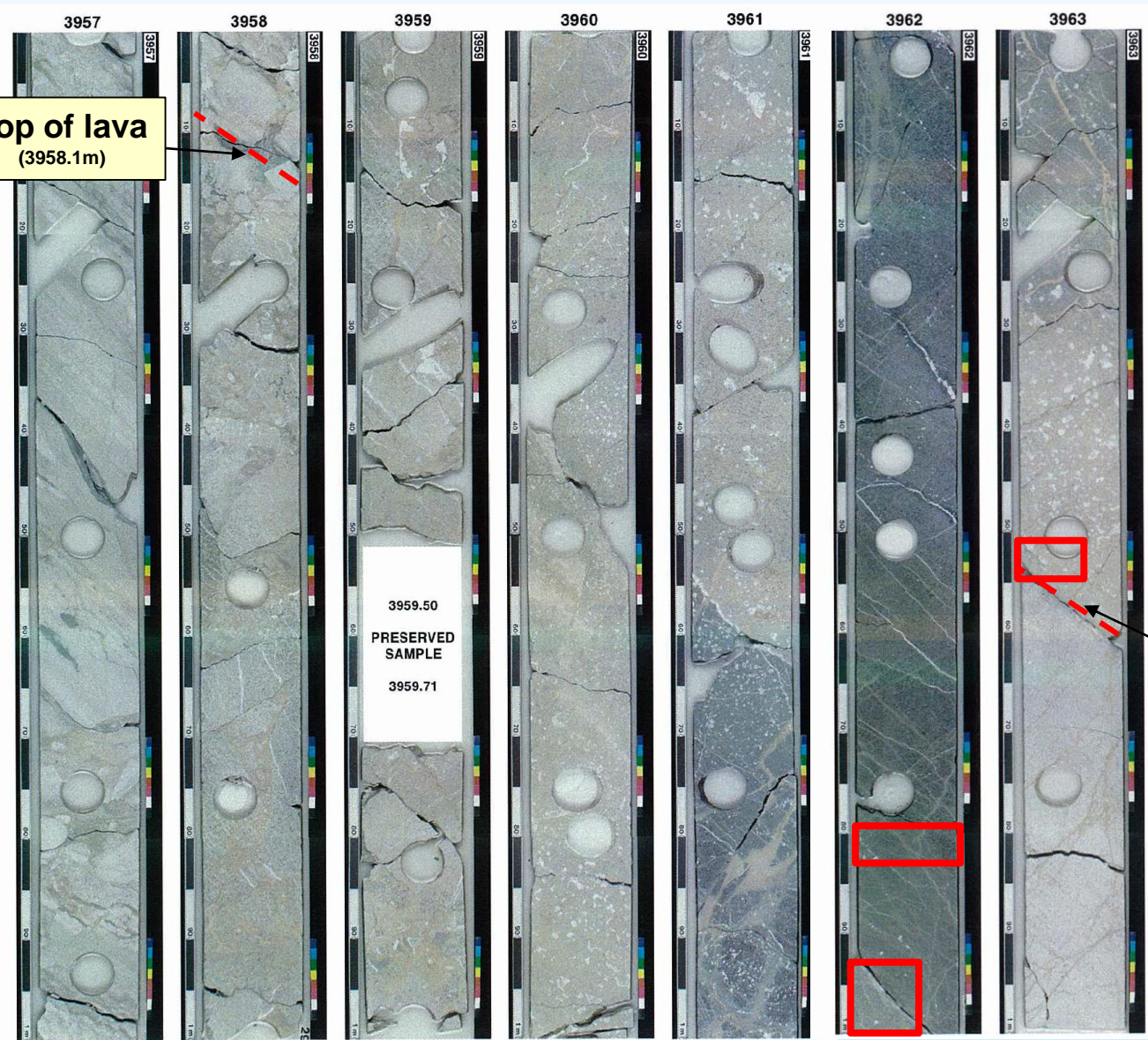
Late Carboniferous (Pennsylvanian) biostratigraphy in lower sandstone unit

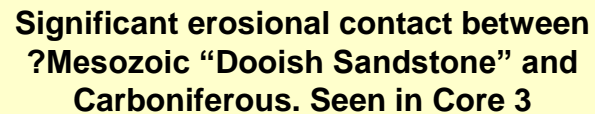


Core log (Reservoir Geological Study; Robertson, 2004)

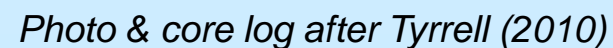
Radiometric date of 250 Ma from core 1 (3950.85-3956.25mMD) (final well report); = Early Triassic on current time scale.

12/2-1Z lava within the “Dooish Sandstone”



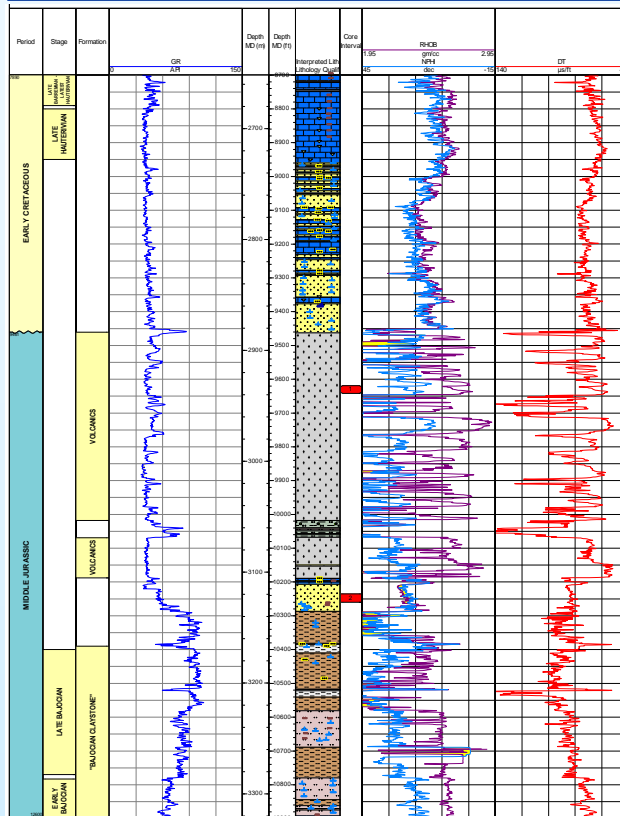


We await the results of the radiometric dating

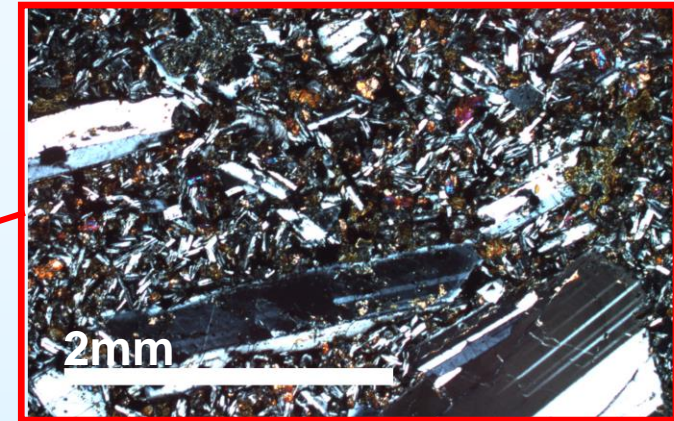




Goban Spur well 62/7-1



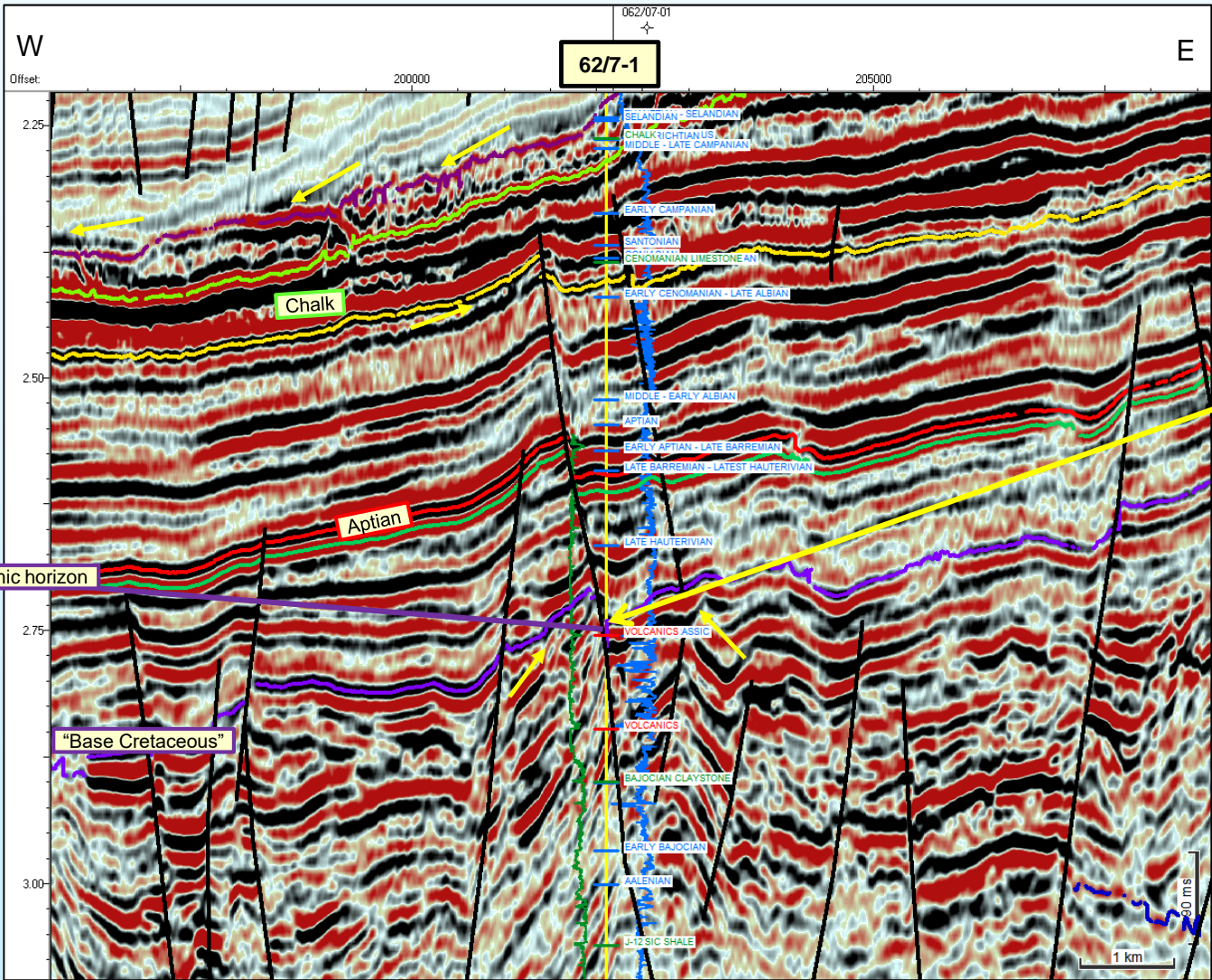
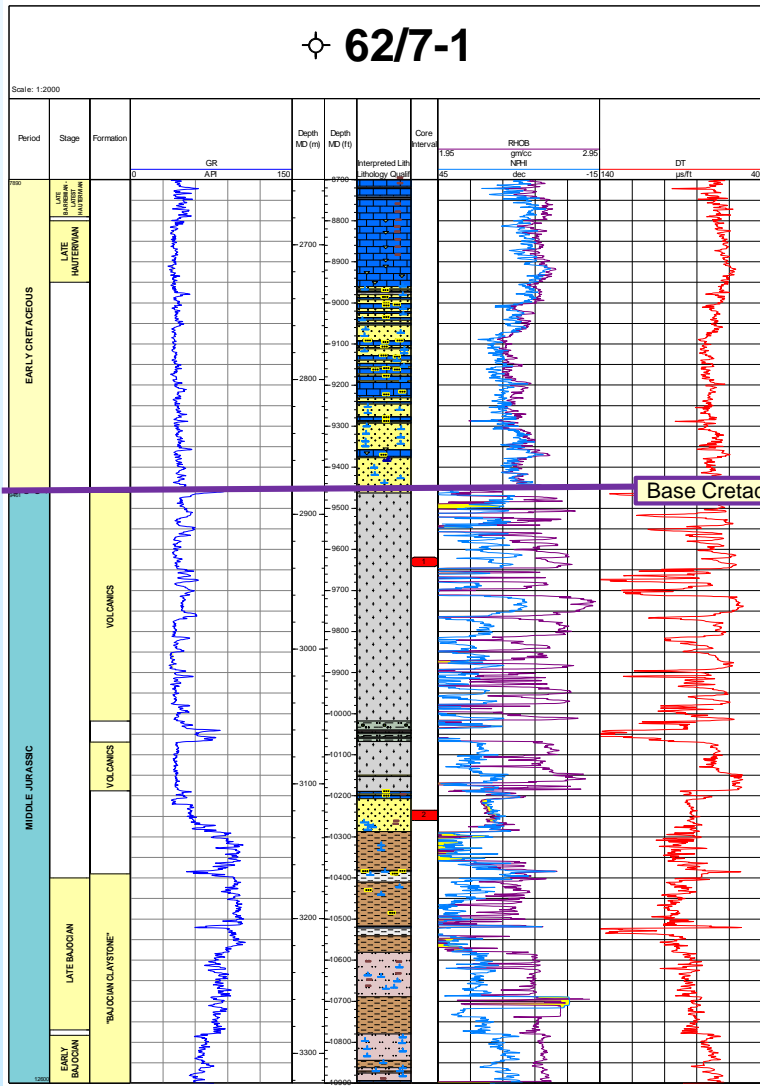
Sample
from core 1



- 200m of porphyritic basalt with interbedded coals
- 2-10mm phenocrysts of alkali feldspar
- Overlain by Hauterivian sediments
- Immediately underlain by undated sediments
- Various radiometric dates for the lava published by Esso (Colin *et al.*, 1982; Bathonian), 130-137 Ma (Valanginian) (Tate & Dobson, 1988), 93.8 Ma (Turonian) (BGS, 2009)

- Porphyritic texture with large partly fragmental plagioclase phenocrysts
- Potential for radiometric dating of phenocrysts or groundmass
- Once dated, comparison should be made with 56/26-1 microgabbro sample from Fastnet, previously dated as Middle Jurassic

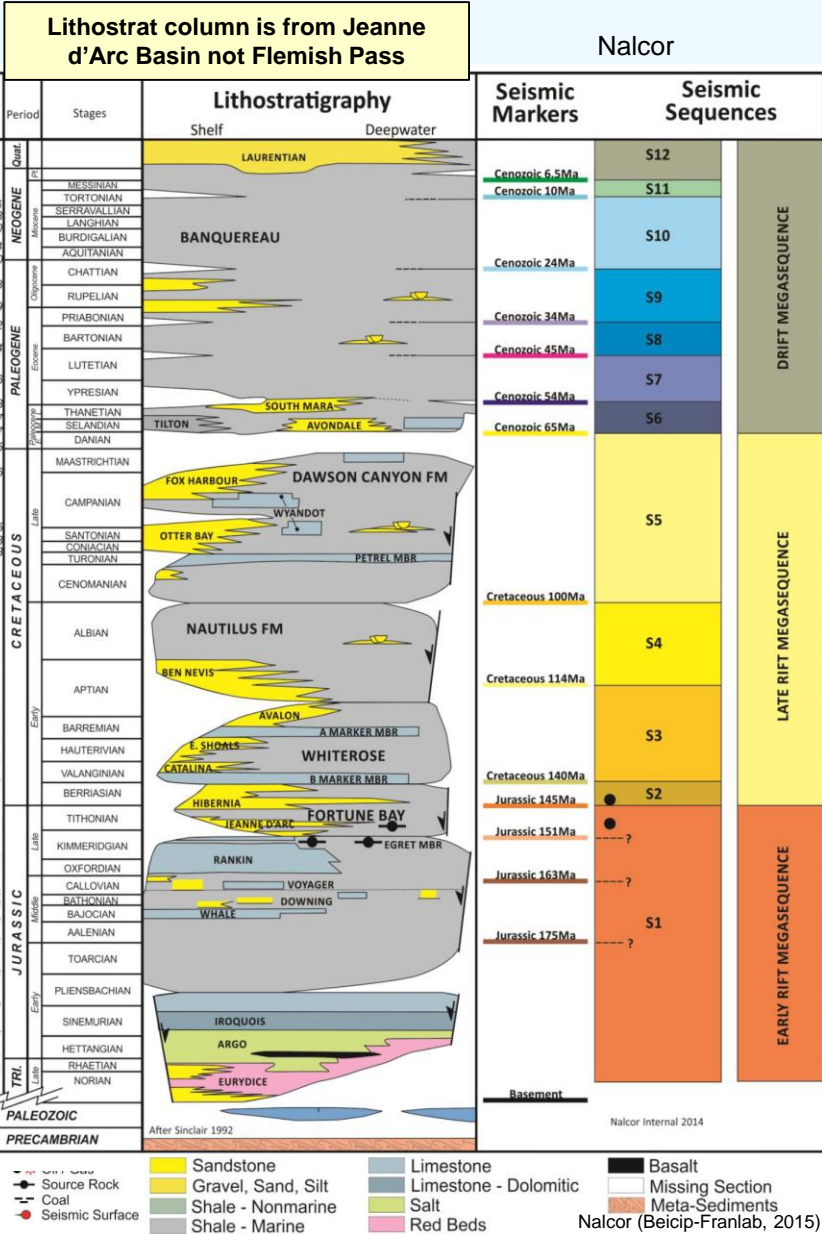
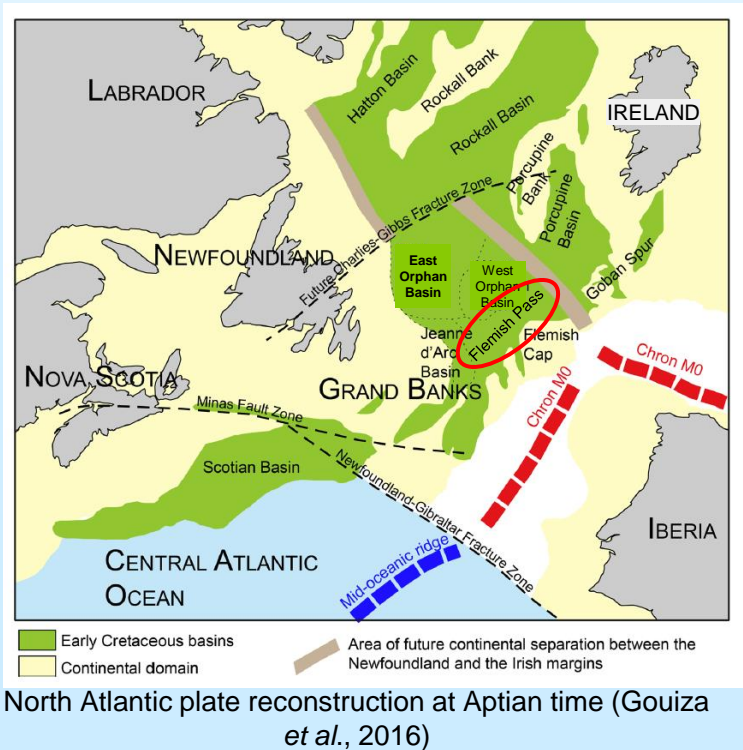
Goban Spur well 62/7-1



Base Cretaceous horizon currently interpreted above the lavas, so favours Jurassic age. Probable faulted contact at well

We await the results of the radiometric dating

Comparisons with Eastern Canada (Flemish Pass Basin)



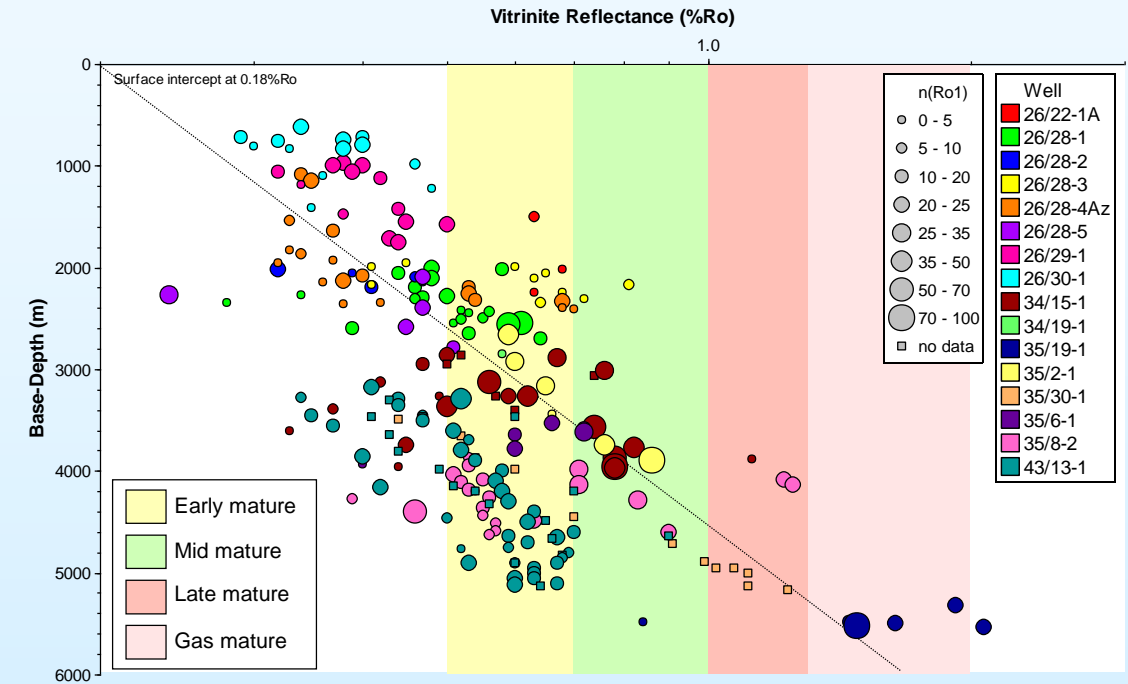
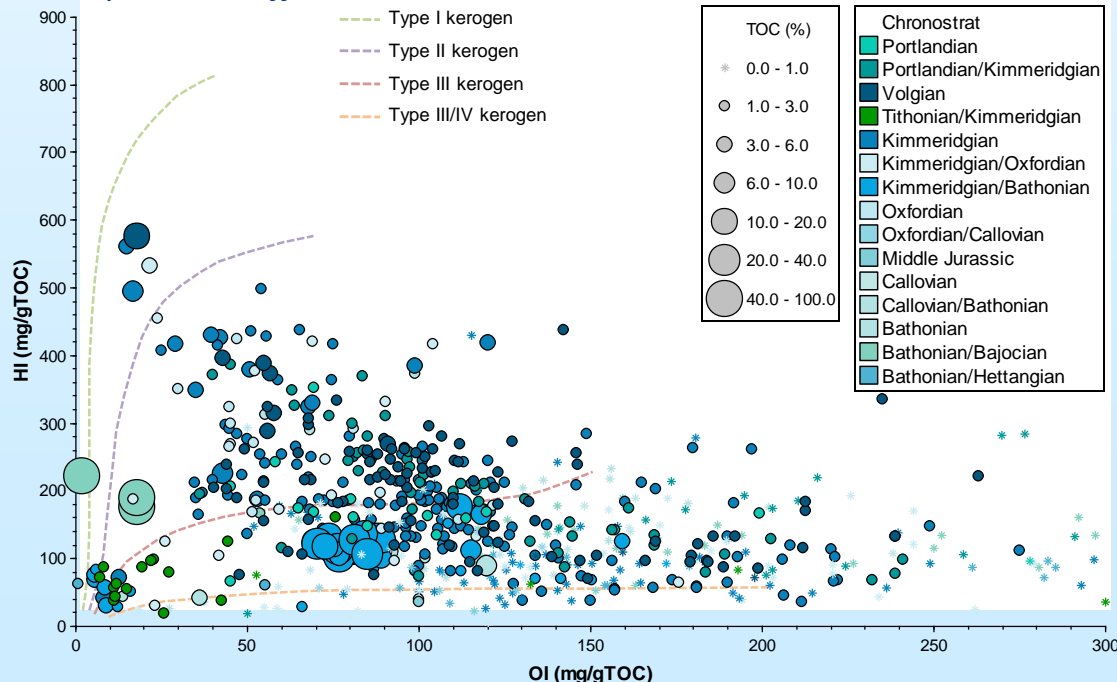
Comparisons with Ireland:-

- Cenozoic seismic markers/sequences compare well to Ireland
- Major unconformities developed at similar times, e.g. Santonian, base Cenomanian, Middle Albian/Barremian, base Cretaceous, suggesting similar structural histories
- Fewer clastics in Paleocene-Eocene compared to Ireland
- Base Tertiary unconformity more major in Flemish, Danian absent
- Upper Cretaceous, "Chalk" facies in both areas
- More Albian sands in Ireland
- No observed Aptian sandstones in either area to date
- Some sandstones in basal Cretaceous in both areas
- Tithonian reservoirs (Bodhran Fm/Jeanne d'Arc in Flemish) not yet seen in Ireland, but suggestion from biostrat that incomplete Tithonian in Ireland wells drilled to date
 - Major unconformity at base of Bodhran, which correlates with Jeanne d'Arc Basin, not yet proven in Ireland but may be present on seismic data
- Faunas and floras in Tithonian very similar to Porcupine Basin, but not to Slyne-Erris basins

Geochemical database and interpretation

Geochemical database:

- A fully integrated geochemical database has been compiled based on the data available from the Source Rock Atlas project (IS16/01) carried out by Beicip-Franlab
- When finalised the new stratigraphy will be applied to the database within the IS16/04 project
- Detailed information on the contents of the database are available on the poster *"An integrated geochemical database for petroleum exploration offshore Ireland"*



Geochemical interpretation (future work):

- The compiled database will be used to characterise source intervals in the context of the updated stratigraphy
- Organic richness, kerogen type, hydrocarbon generation potential, and maturity will be documented for individual source intervals
- Source intervals will be characterised for each basin and lateral variations highlighted within and between basins

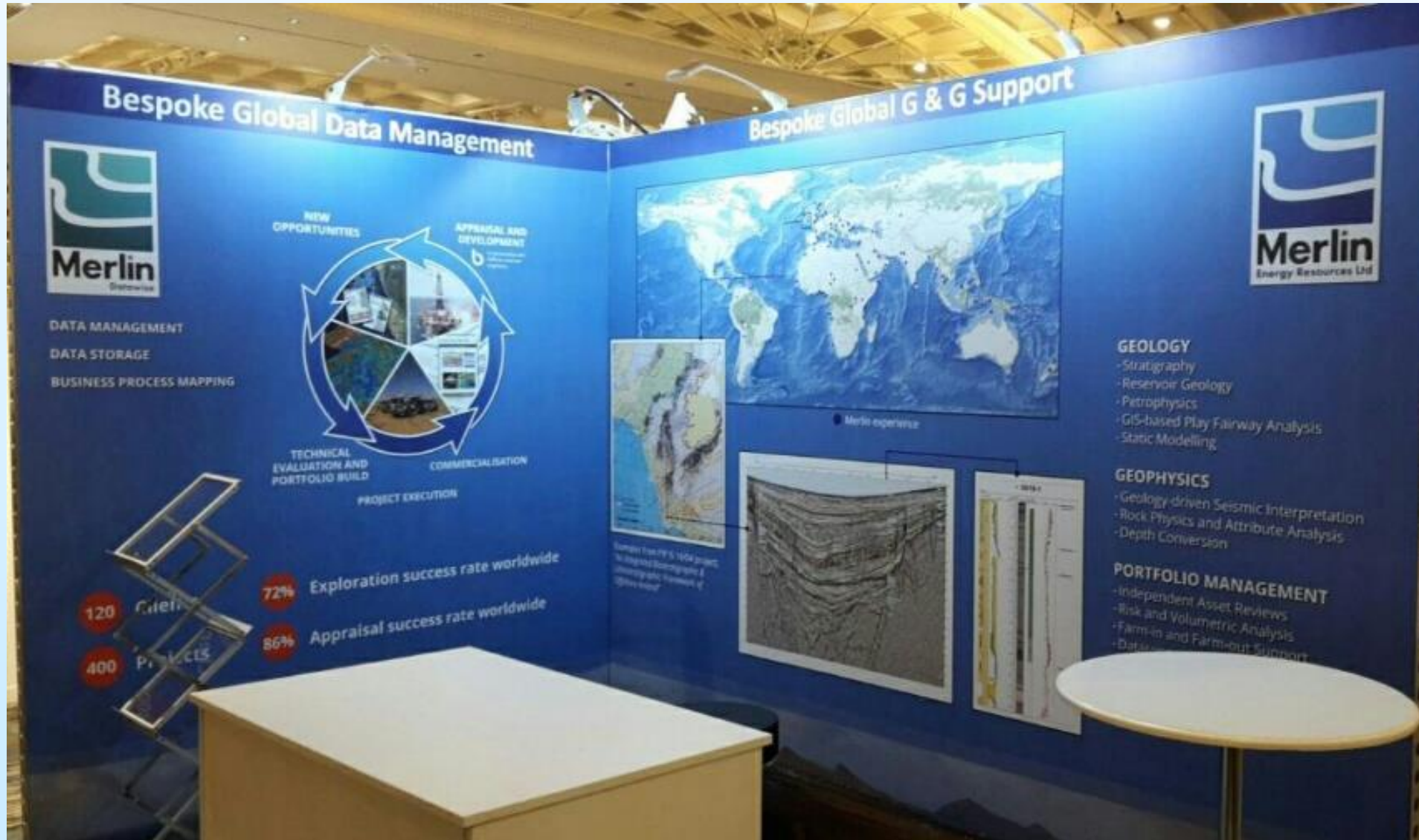
- Major new stratigraphic framework project initiated, funded by 18 oil companies and PAD
- This will standardise the stratigraphy for the whole of offshore Ireland
- Legacy stratigraphic database from 200 penetrations has been reinterpreted, supplemented by new biostratigraphic data generated on key wells and intervals
- Initial comparisons with East Canada and the North Sea becoming apparent
- Significant progress made regarding subdivisions and correlation of Palaeozoic, Jurassic, Lower Cretaceous, Upper Cretaceous, Paleogene
- Initial sequence stratigraphy subdivisions proposed from wells and seismic ties
- Once new stratigraphy is finalized, this will be integrated with the geochemistry database to generate enhanced understanding of source rock intervals
- Project due for completion next year, to include report, atlas and databases.

- We thank the PAD/DCCAE and PIP for permission to give this presentation



- This project is funded by the Irish Shelf Petroleum Studies Group (ISPSG) of the Petroleum Infrastructure Programme (PIP). The ISPSG comprises the following 19 organisations:-
 - AzEire Petroleum, BP, Cairn Energy, Chevron, ENI, Europa Oil & Gas, ExxonMobil, Nexen Petroleum, DCCAE/PAD, Providence Resources, Repsol, San Leon Energy, Serica Energy, Shell, Sosina Exploration, Statoil, Total, Tullow Oil and Woodside Energy

Come and talk to us over coffee and at the Merlin stand



The image shows a large blue exhibition stand for Merlin Energy Resources Ltd. The stand is divided into two main sections: "Bespoke Global Data Management" on the left and "Bespoke Global G & G Support" on the right. The left section features a circular diagram with four quadrants: "NEW OPPORTUNITIES", "APPRAISAL AND DEVELOPMENT", "COMMERCIALISATION", and "TECHNICAL EVALUATION AND PORTFOLIO BUILD". Below this diagram, it lists "DATA MANAGEMENT", "DATA STORAGE", and "BUSINESS PROCESS MAPPING". It also displays two statistics: "120 Countries" and "400 Projects". The right section features a world map, a smaller map of the UK, and a large geological cross-section. It lists services under "GEOLOGY", "GEOPHYSICS", and "PORTFOLIO MANAGEMENT".

Bespoke Global Data Management

Merlin
Energy Resources Ltd

DATA MANAGEMENT
DATA STORAGE
BUSINESS PROCESS MAPPING

NEW OPPORTUNITIES
APPRAISAL AND DEVELOPMENT
COMMERCIALISATION
TECHNICAL EVALUATION AND PORTFOLIO BUILD
PROJECT EXECUTION

120 Countries
400 Projects

72% Exploration success rate worldwide
86% Appraisal success rate worldwide

Bespoke Global G & G Support

Merlin
Energy Resources Ltd

GEOLOGY

- Stratigraphy
- Reservoir Geology
- Petrophysics
- GIS-based Play Fairway Analysis
- Static Modeling

GEOPHYSICS

- Geology-driven Seismic Interpretation
- Rock Physics and Attribute Analysis
- Depth Conversion

PORTFOLIO MANAGEMENT

- Independent Asset Reviews
- Risk and Volumetric Analysis
- Farm-in and Farm-out Support
- Data Management

Thank you for listening



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