Permian Deposition in the Eastern Nappamerri Trough, Cooper Basin*

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Abstract

Prior to 2012, petroleum wells in the eastern portion of the Nappamerri Trough (Cooper Basin) were scarce, with only a handful of wells drilled in an area of approximately 5000 square kilometers. Recently, the Nappamerri Trough has become the focus for an extensive shale gas and basin-centered gas exploration campaign. Sparse regional 2D seismic lines through the trough were thought to be adequate for developing a regional structural model and for estimating distribution and thicknesses of the Permian strata. Between 2012 and 2014, six exploration wells were drilled in the ATP855 permit which covers the deepest portion of the trough. Wells drilled in this area penetrated formations that were generally thicker than predicted. The increased thickness coupled with apparent lithostratigraphic changes from east to west resulted in stratigraphic correlations having a high degree of uncertainty. Challenging drilling conditions due to the high geothermal gradient and overpressure in the trough limited data acquisition in some wells. The lack of log data in some wells exacerbated the problems of correlating the Permian formations. Although used routinely in other basins around the world, chemostratigraphic techniques were new to the Cooper Basin. Chemostratigraphy was used in ATP855 not only to assist in defining the standard lithostratigraphic correlations used basin-wide, but also to aid in the sub-division of the Permian formations. The chemostratigraphy was integrated with image-log-derived structural zones and cuttings analysis to better define the stratigraphic correlation scheme for the eastern Nappamerri Trough.

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Ob River – a commonly used analogue for Permian deposition in Cooper Basin

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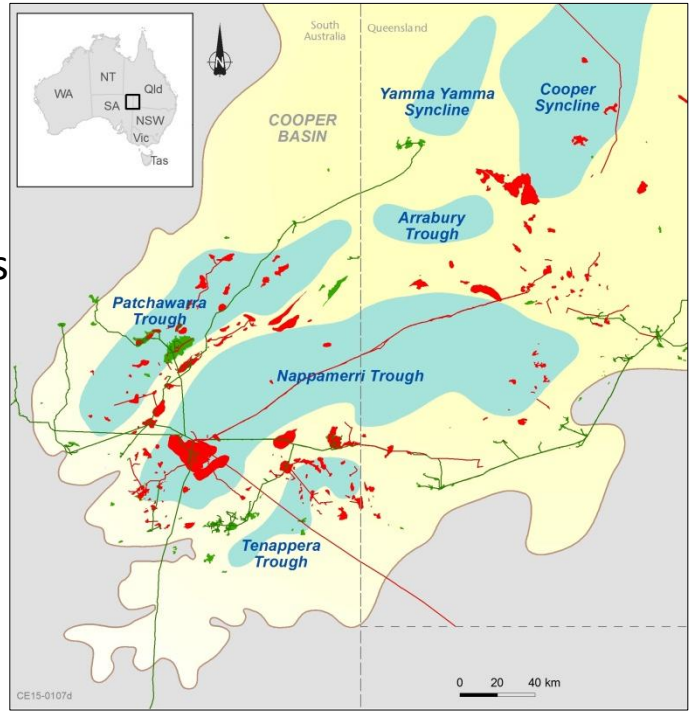
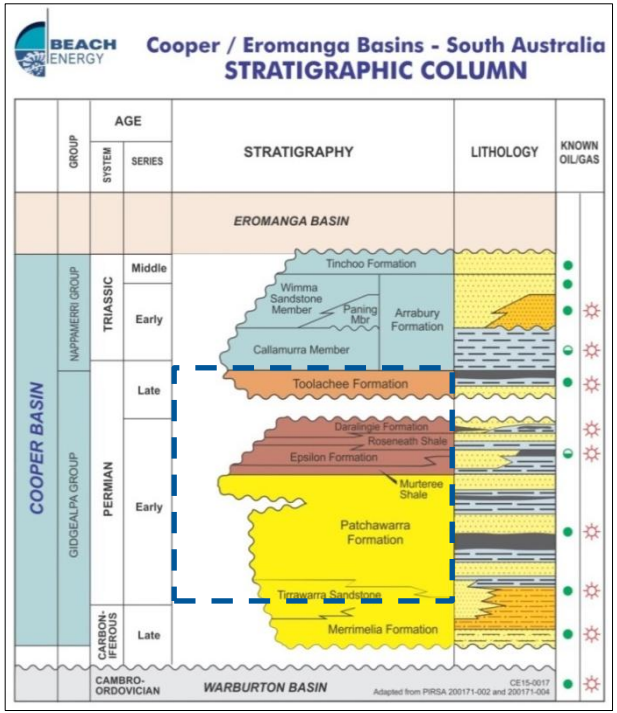
The Cooper Basin

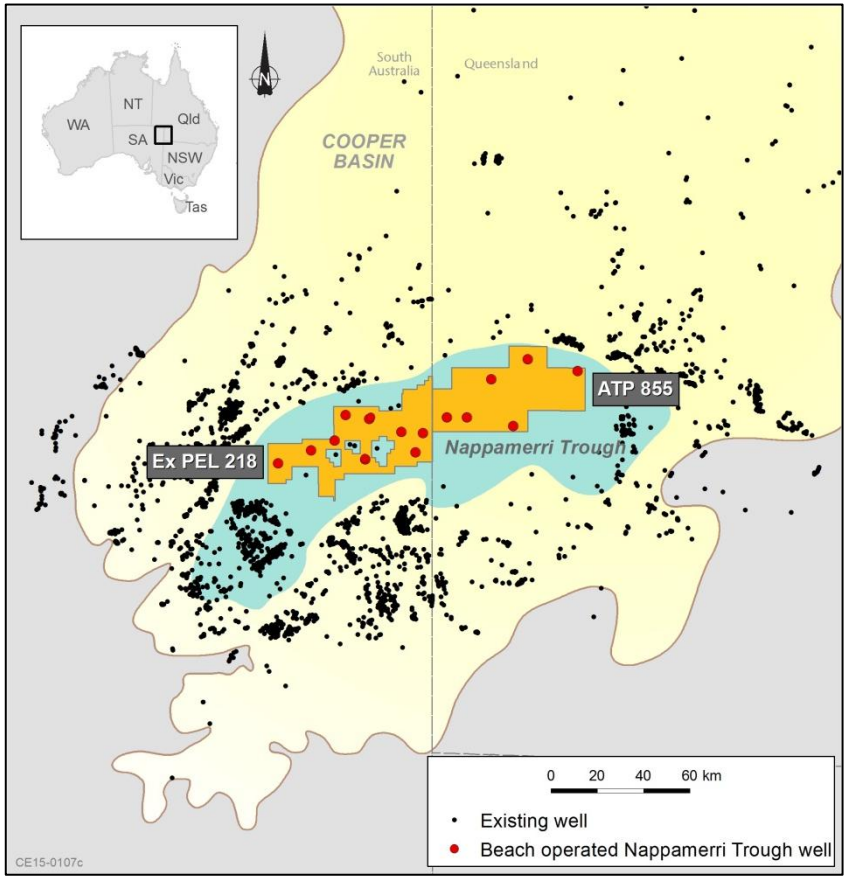
- Proven hydrocarbon province, producing gas from Permian strata since 1969
- Intracratonic basin made up of a series of NE-SW-trending troughs separated by intra-basin highs and ridges
- Strata are Late Carboniferous to Middle Triassic in age
- Patchawarra and Toolachee formations are coal measures sequences, with high sinuosity fluvial sands, braid plains, swamps and lakes
- Murteree to Daralingie section was deposited in a lacustrine-deltaic environment





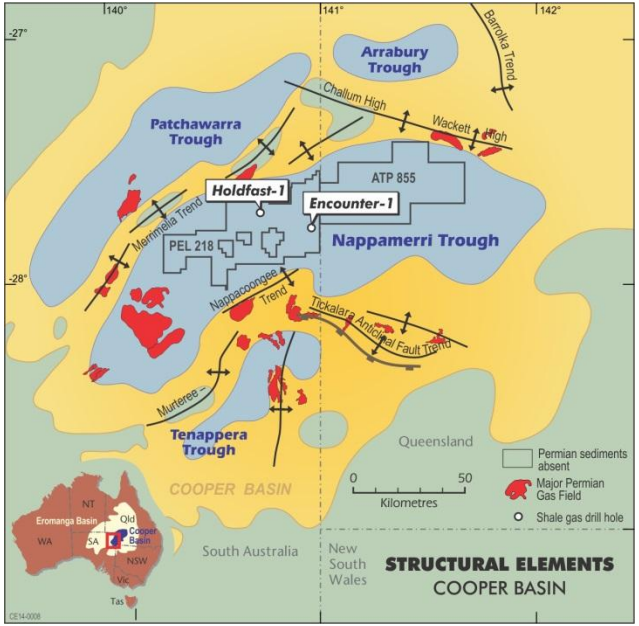
The project area

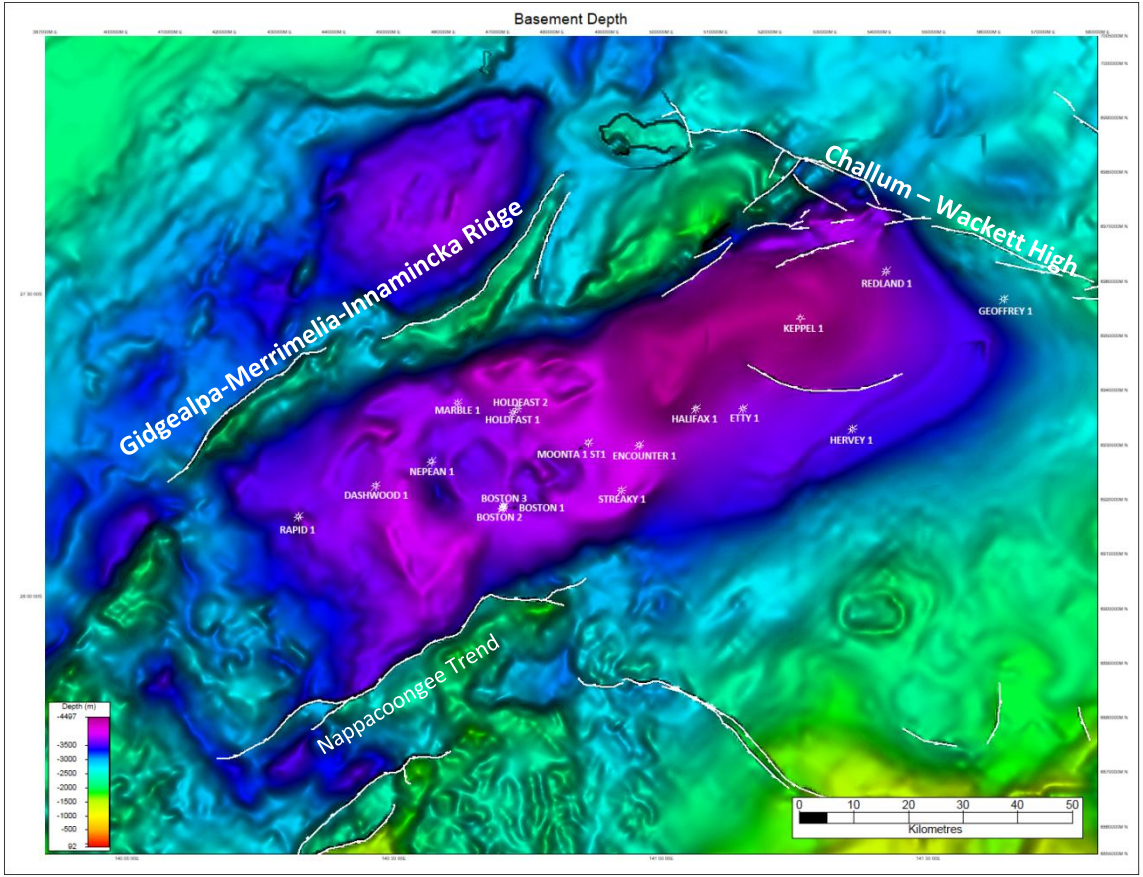
- The Nappamerri Trough is the deepest and largest of the troughs in the Cooper Basin
- Between late 2010 and 2014, 18 wells (16 vertical and 2 horizontal) were drilled within acreage operated by Beach Energy, targeting shale gas and basin-centered gas in Permian formations
- Project area is covered by sparse 2D seismic
- Well spacing between the new vertical exploration wells ranges from 9km to 22km
- The following data have been acquired in vertical wells: wireline/LWD logs (all wells), core and core analysis (5 wells), image log data (6 wells) and chemostratigraphy (7 wells)



Structural setting of the Nappamerri Trough

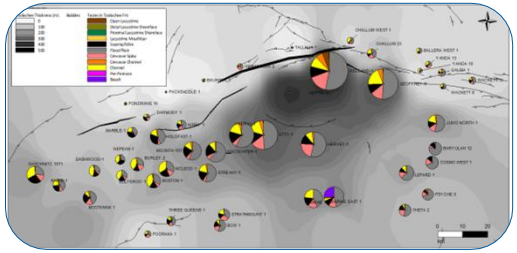
- Episodic growth along faults bounding the Nappamerri Trough
- Fault movement during Permian affected deposition

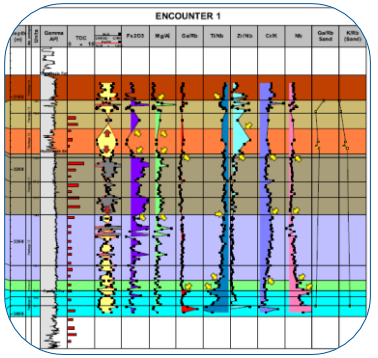




Basement grid and faults sourced from NGMA (1997/98)

Workflow





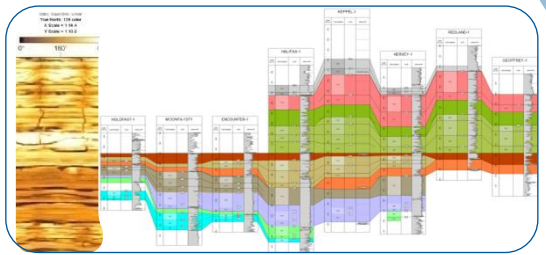
Lithostratigraphy & Chemostratigraphy

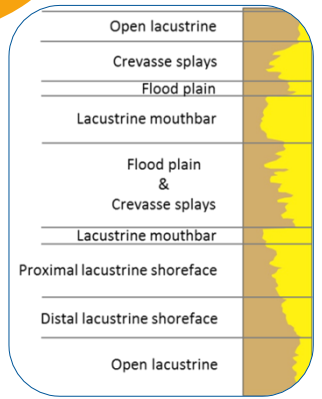
Facies classification & interpretation

Unit definition

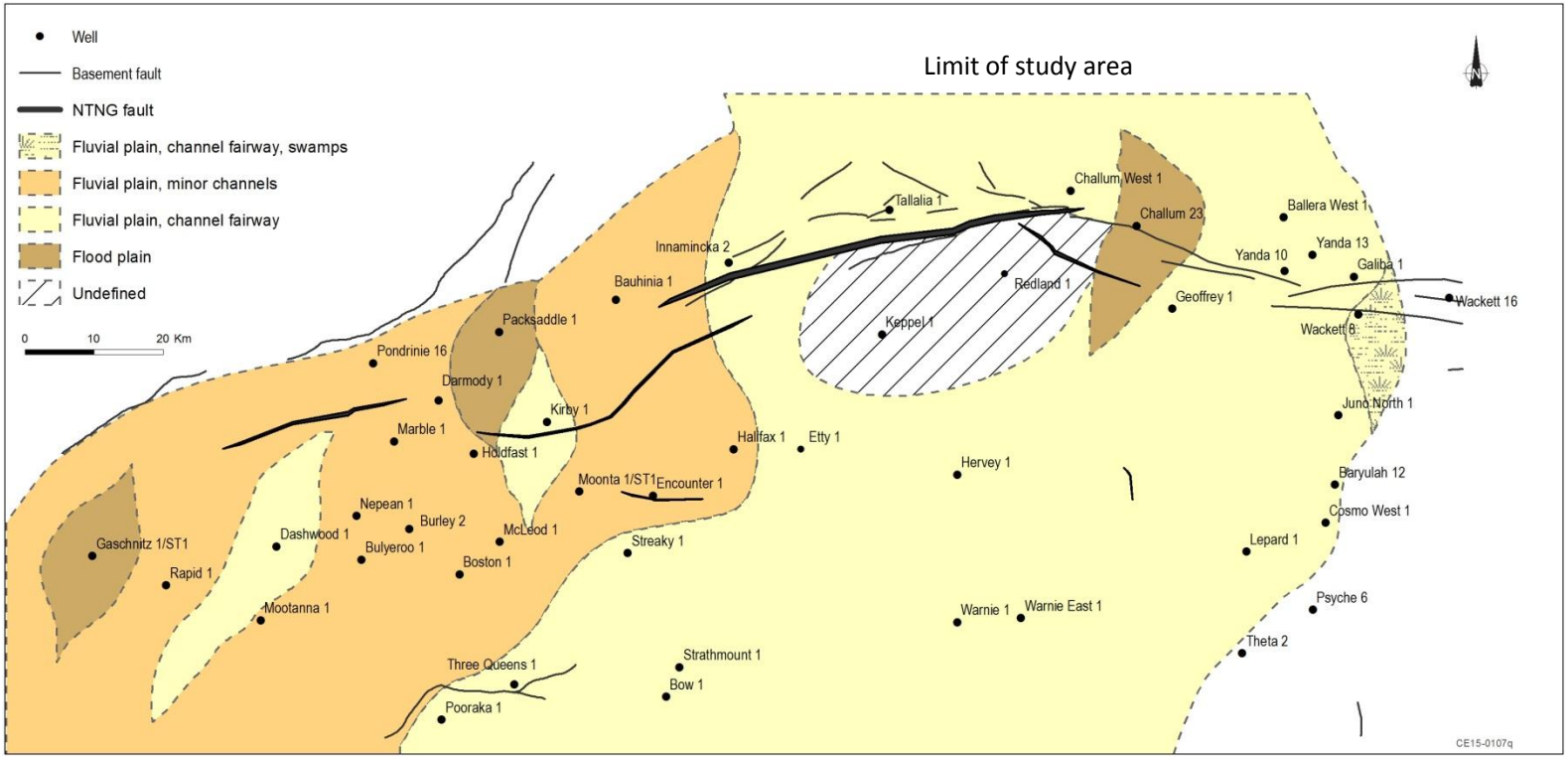
Graphical facies displays

Facies distribution maps



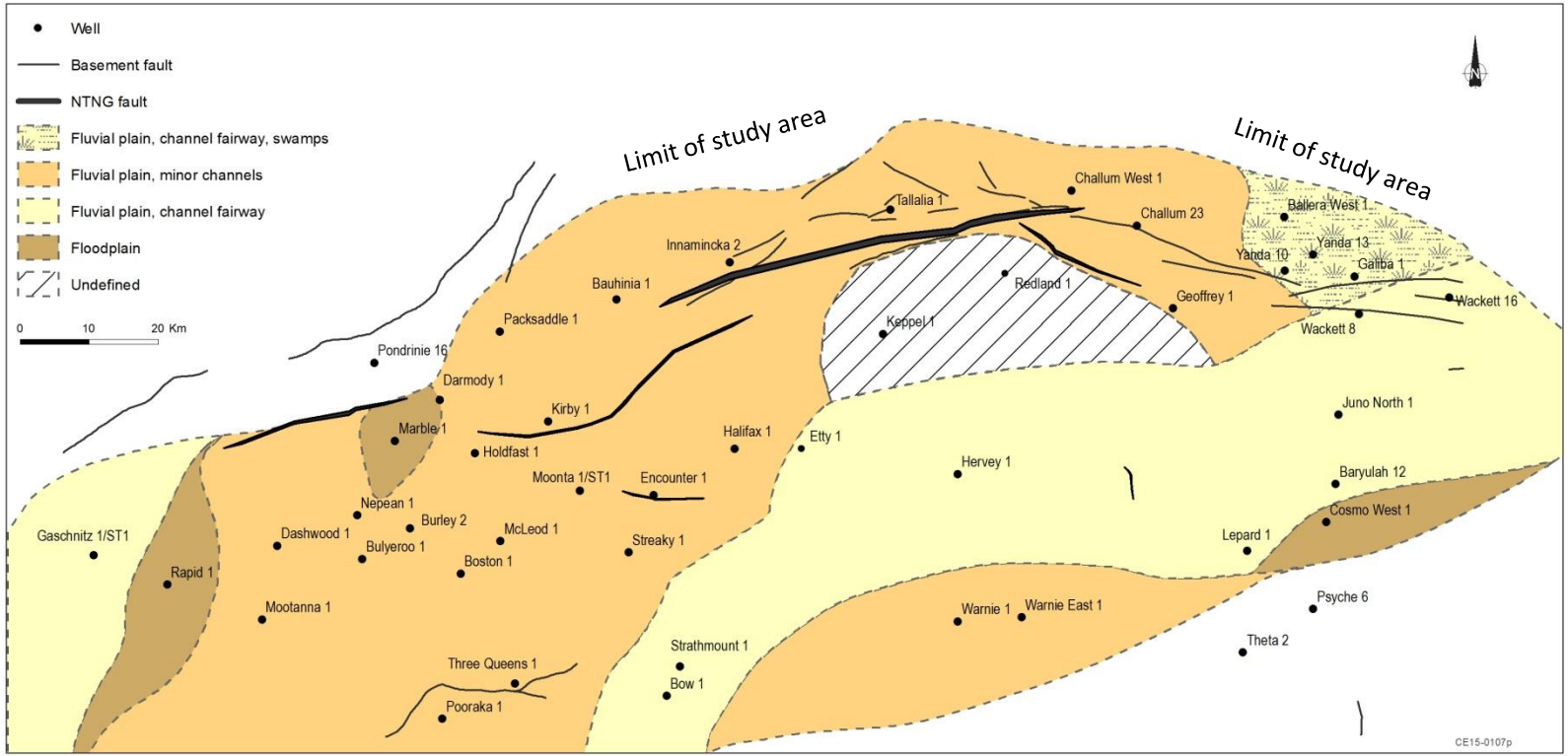


Early Patchawarra facies distribution



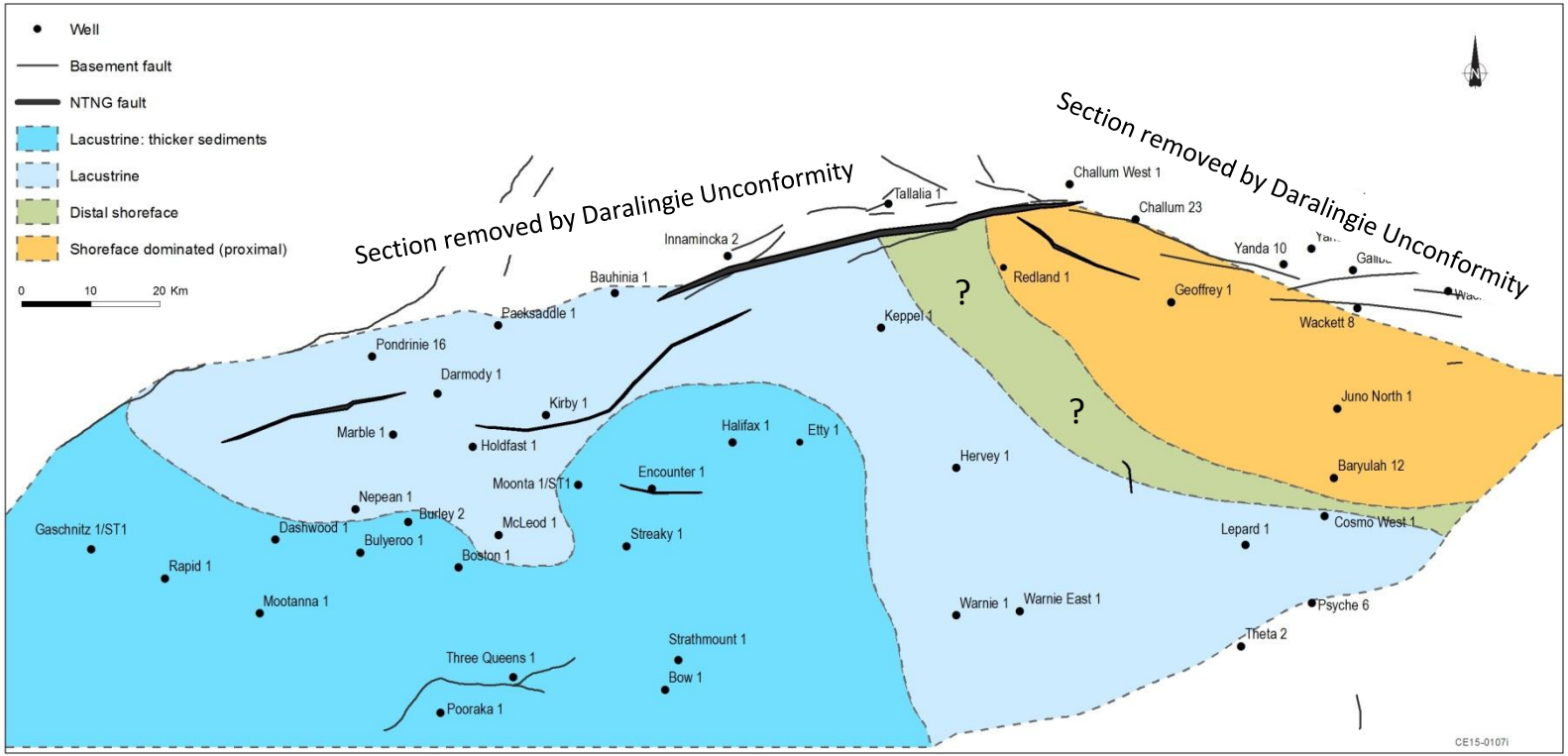
- Sediment sourced from metamorphic terrane, possibly Mt Painter Inlier to the south
- Multiple sediment dispersal directions from image logs, common for high sinuosity channel belts
- Multiple channel belts and amalgamated fluvial plains
- Overall thickening towards the northeast (towards current deepest trough)
- Sand fairway in the eastern trough area

Late Patchawarra facies distribution



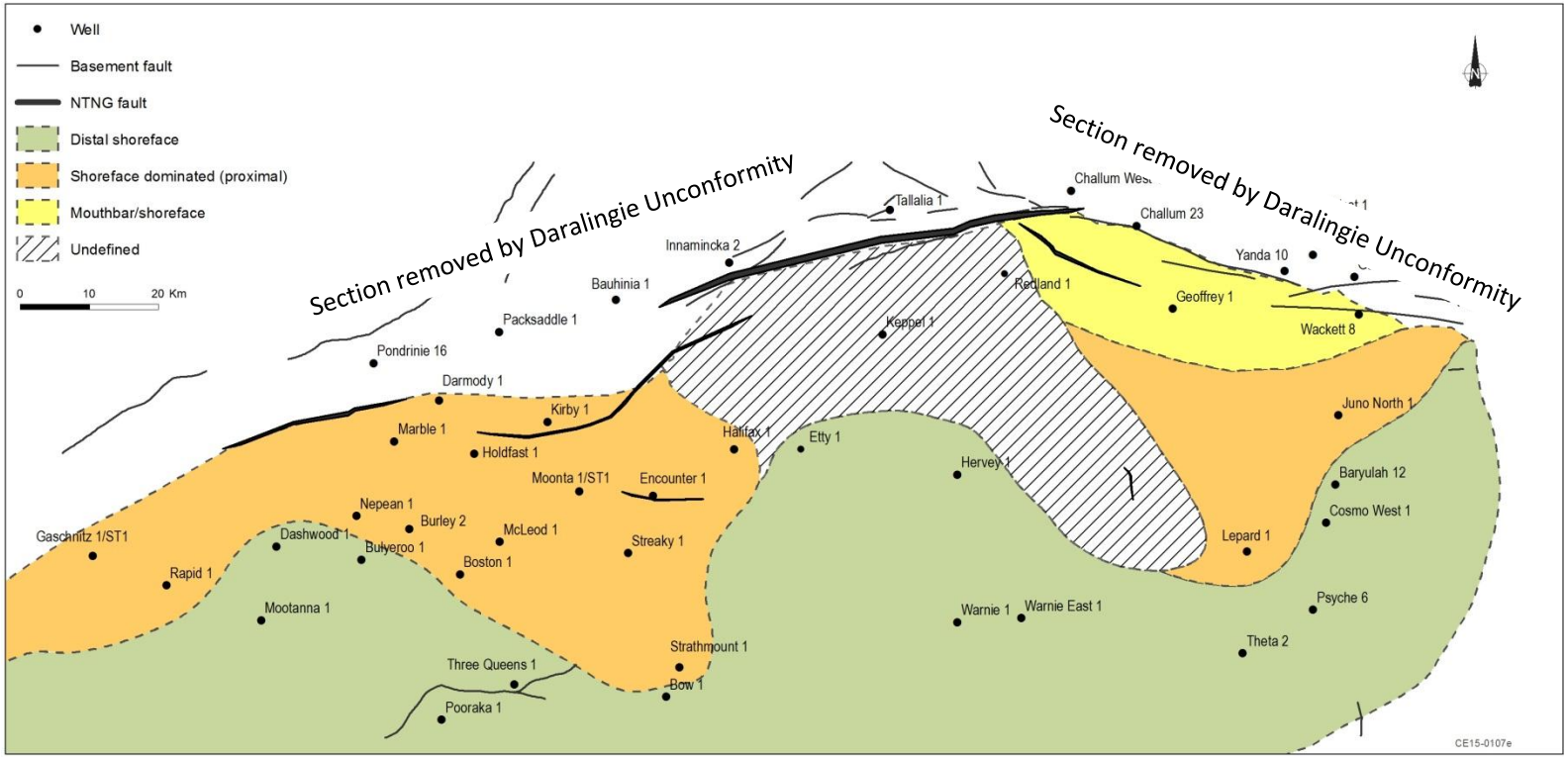
- No change in provenance compared to early Patchawarra
- Overall decrease in channel facies compared to early Patchawarra although persistent sand fairway in southeast
- Emergence of fluvial channels in the west of study area
- Increase in the amount of coal in the northeast
- Lack of coal compared to adjacent troughs
- Increasing accommodation space from west to east, increase in flood plain facies

Murteree facies distribution



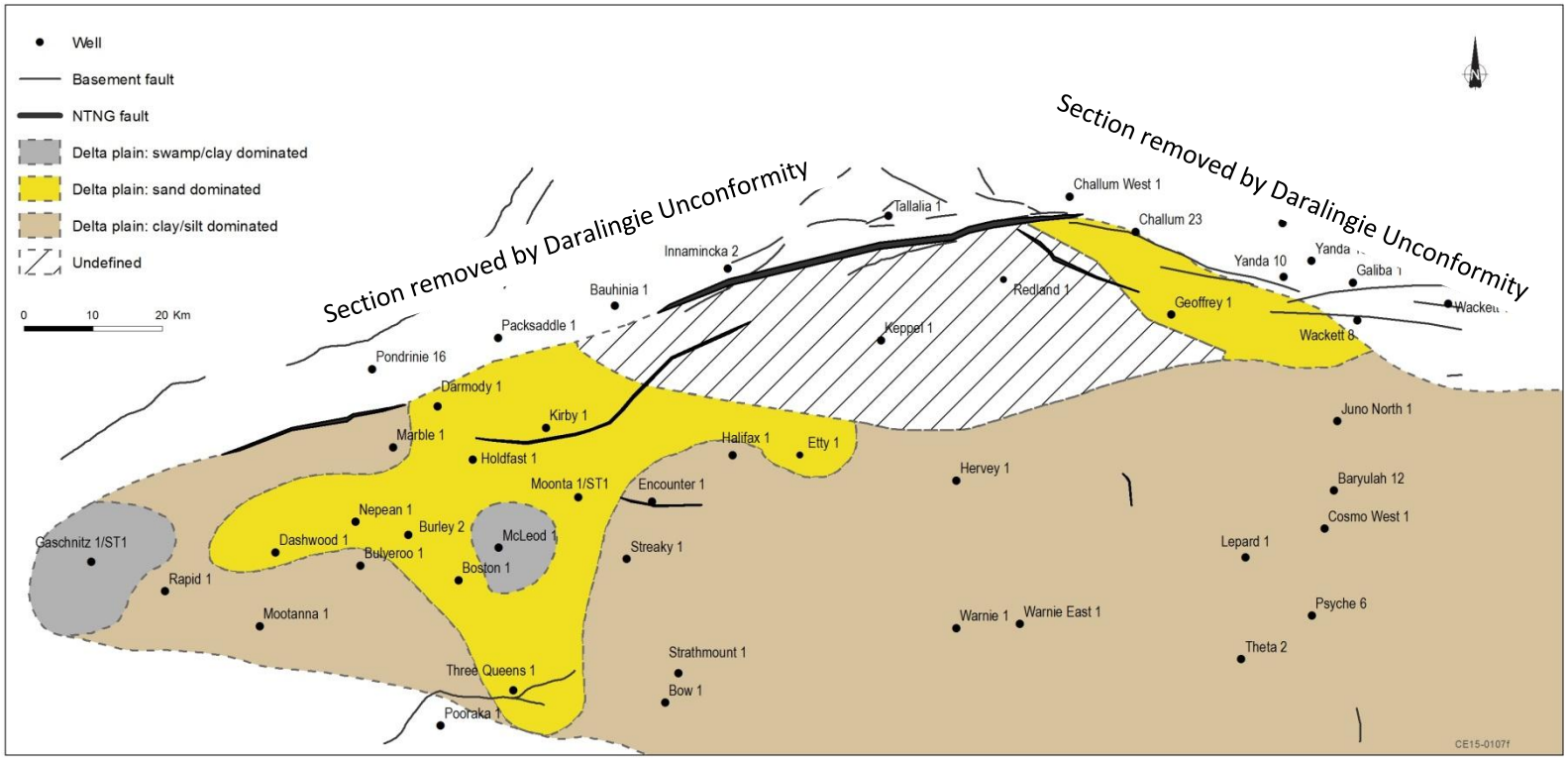
- Metamorphic provenance with long transport distances
- Common slumped facies at top Murteree/ transition into Epsilon
- Sediment input from northeast
- Consistent thickness of shale away from faults indicates flat topography
- Glacial lake as indicated by dropstones and varves
- Silty and clay rich laminae indicate seasonal deposition

Early Epsilon facies distribution



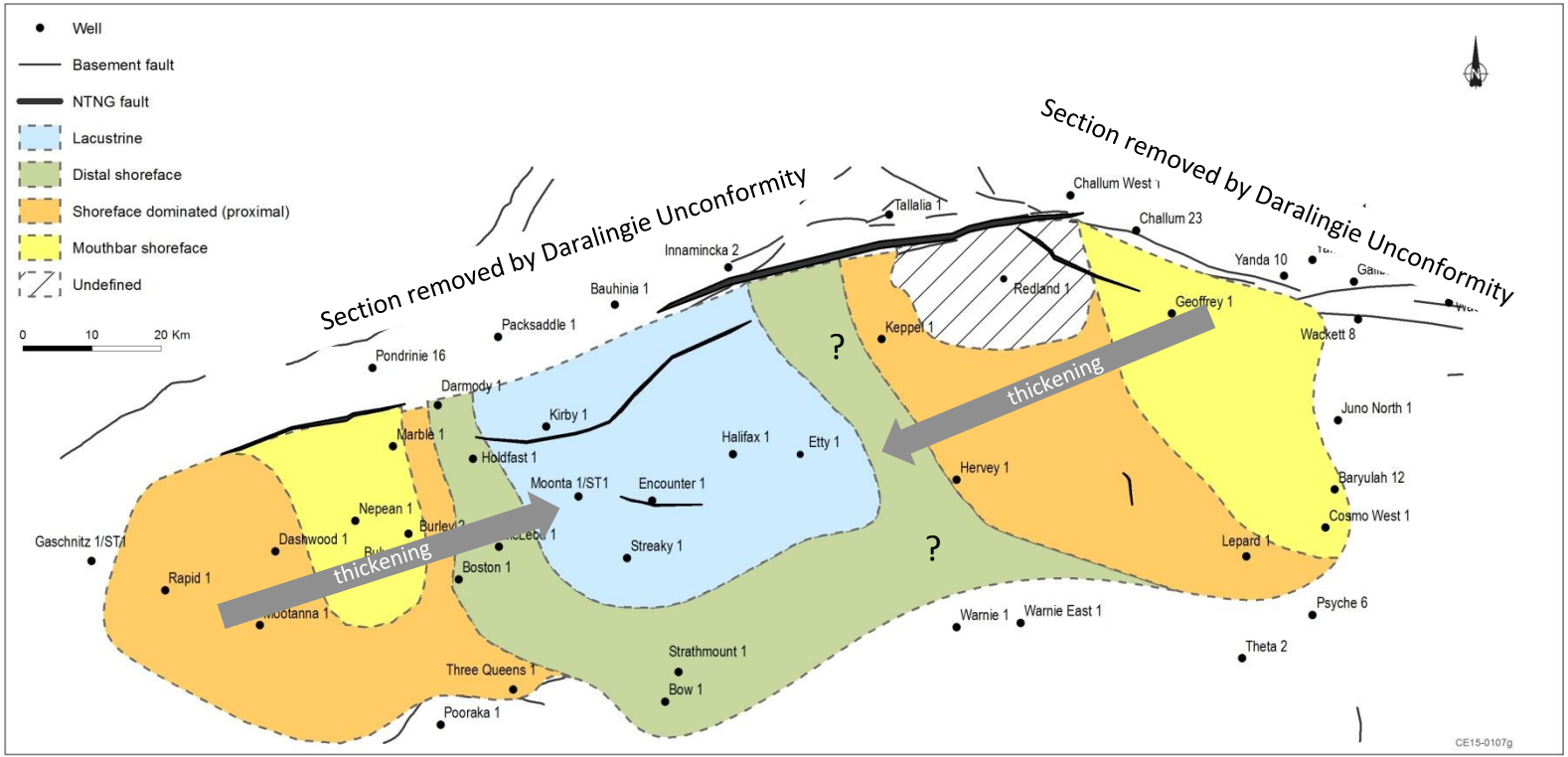
- Progradation of initial Epsilon deltas into the 'Murteree Lake'
- Metamorphic terrane consistent with that of the Patchawarra Formation
- At least two prograding delta systems
- Western delta distal from source compared to eastern delta around Geoffrey-1.
- Epsilon eroded on the northern ridges and highs
- Consistent thickness of unit across study area

Middle Epsilon facies distribution



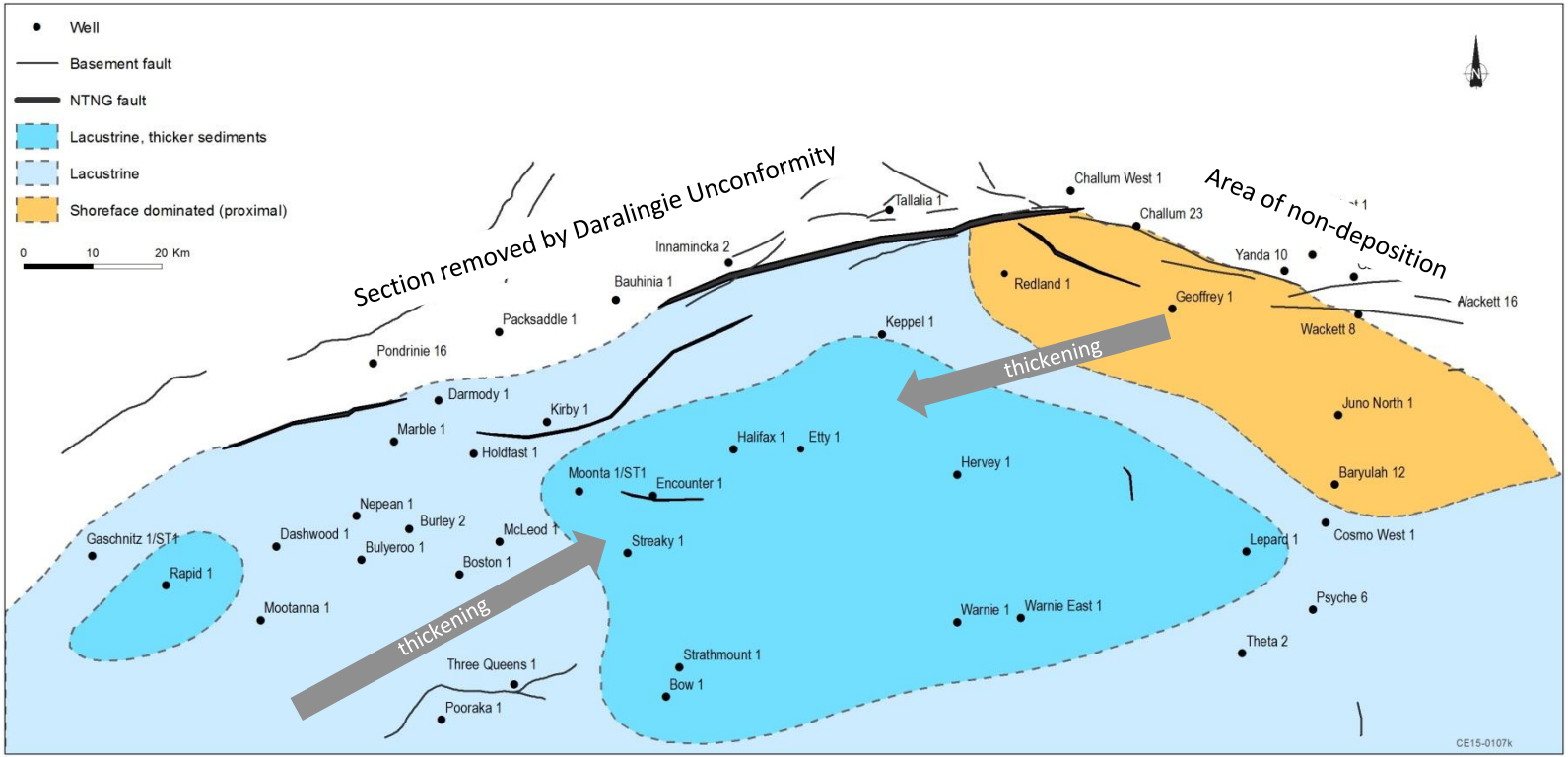
- Continued progradation of delta systems into the trough
- No change in provenance throughout the Epsilon
- Predominantly delta plain facies with higher sand deposition in the western area via mouthbar facies
- Continued sand input from the northeast
- Swamps/mires more common in the west

Late Epsilon facies distribution



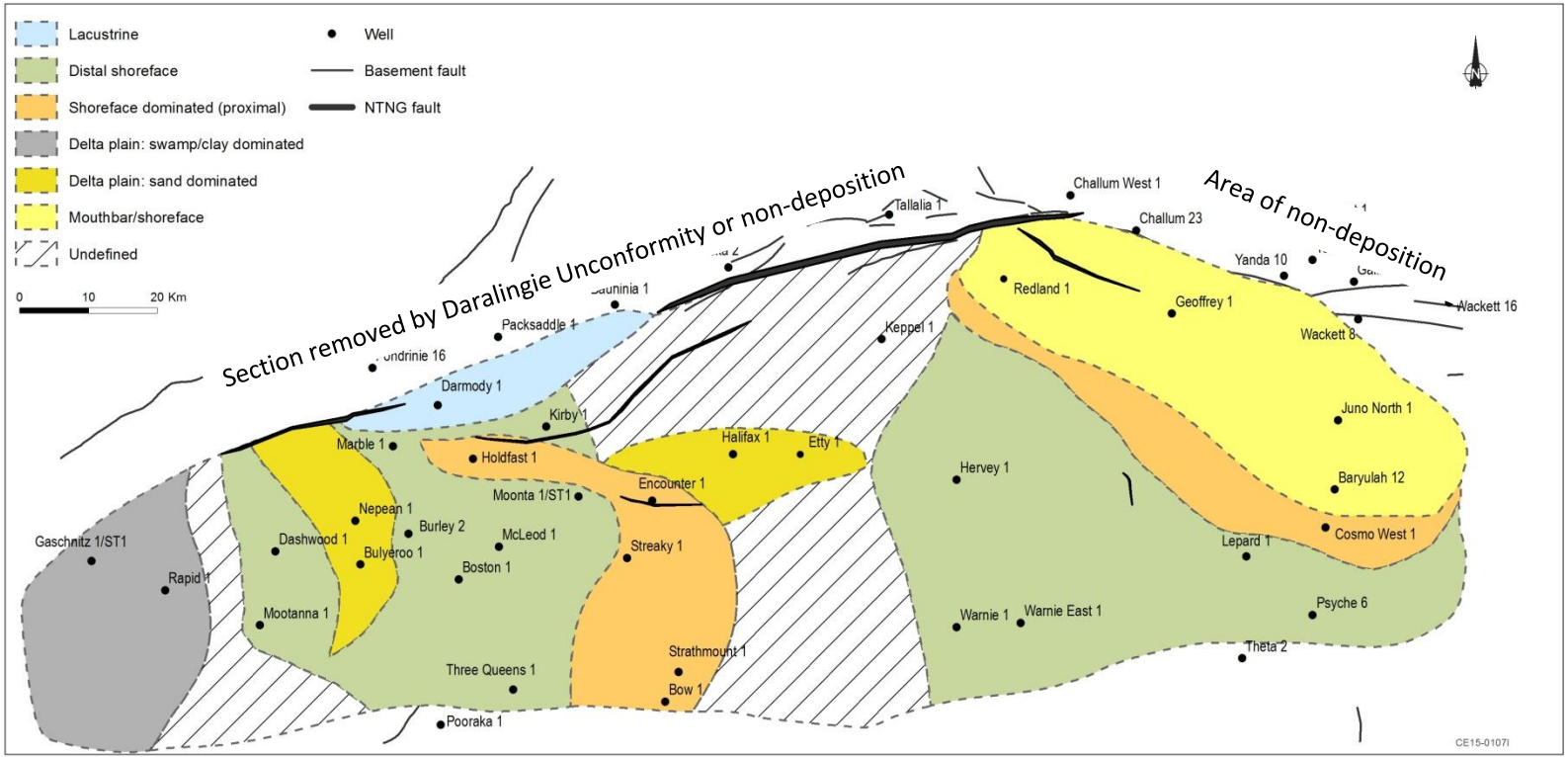
- Uppermost unit represents the start of the regression of the delta systems before the 'Roseneath Lake'
- This unit not present in all areas
- Lacustrine facies in topographically low areas in central trough with an overall thickening of the upper unit
- Still an increase in accommodation space in the central and eastern area
- Glacial lacustrine facies with dropstones and rhythmites

Roseneath facies distribution



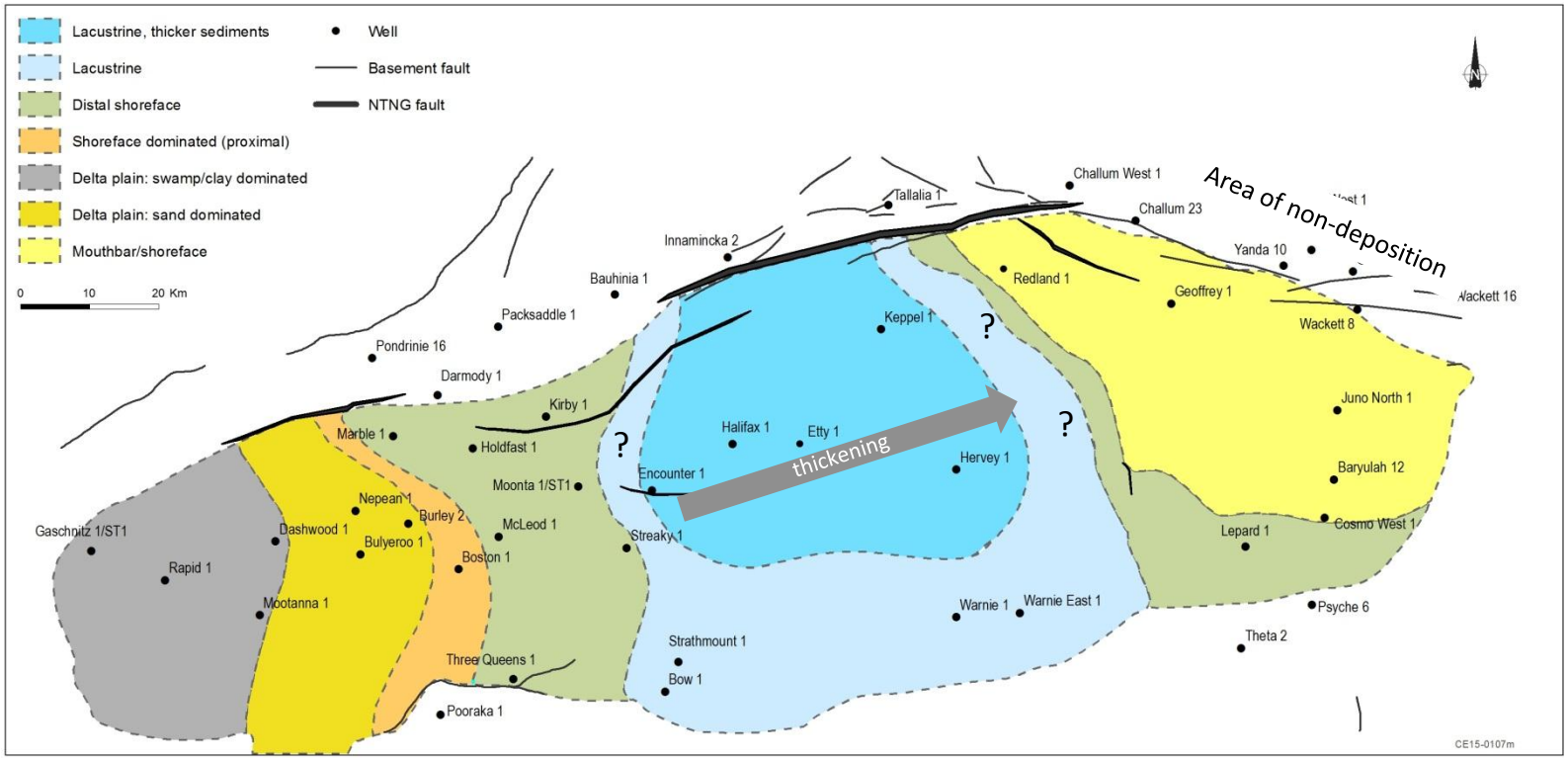
- Significant thickening of sediment in the central area consistent with previous units
- By late Roseneath-delta development in the east- continued structural growth
- Sediment maturity in Geoffrey-1 indicates reworking of Permian; facies indicates proximity to source
- Paleosols near mid-Roseneath indicates regression and exposure at that time
- Shorter transport distances compared to Murteree Shale
- Influences of lake level change

Early Daralingie facies distribution



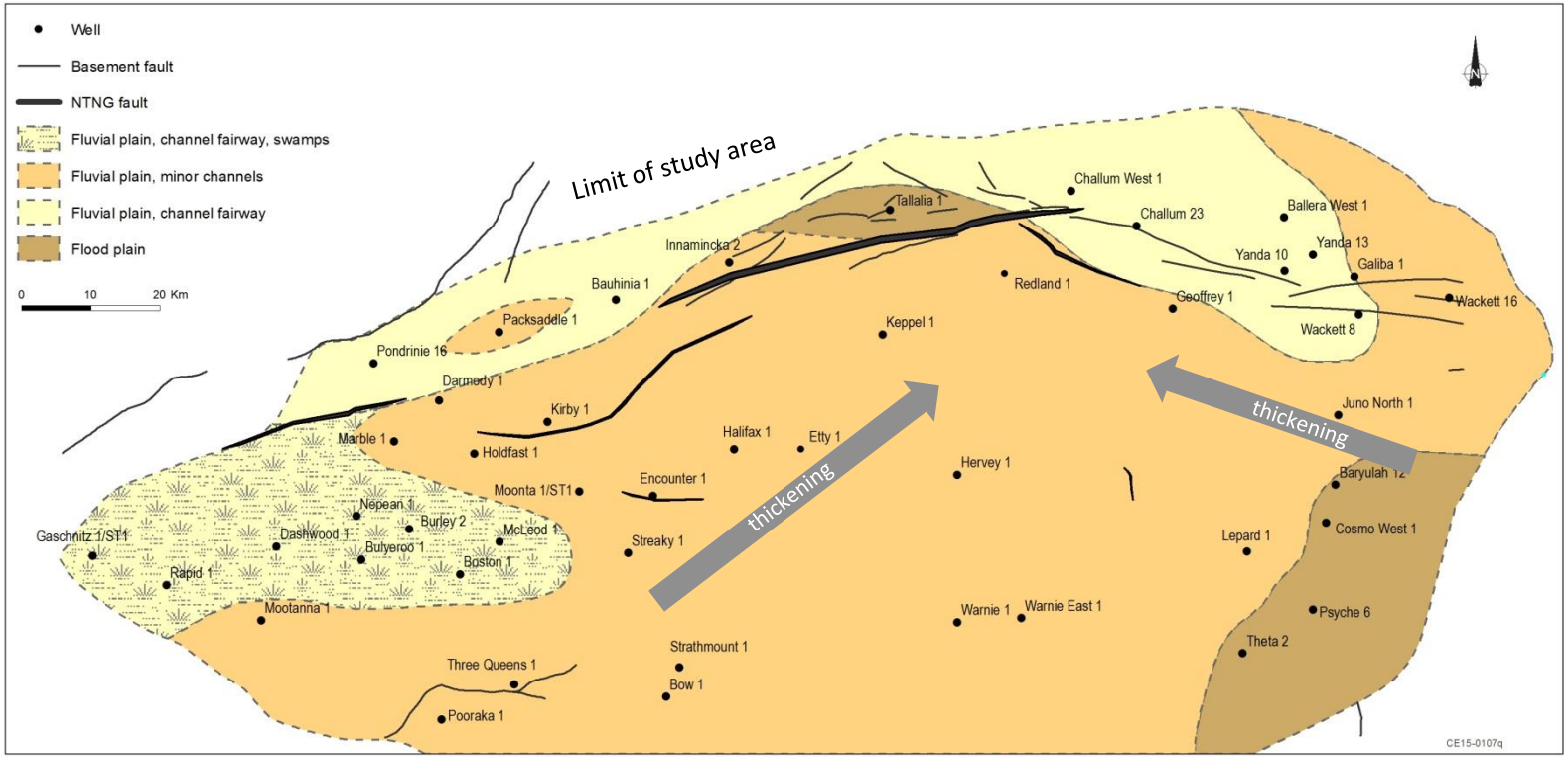
- Progradational sequence
- Large facies variation across the area – some uncertainty in facies distribution
- At least two different delta systems coming into the trough
- Longer transport distances from a metamorphic terrane
- Continued structural growth in east, with sediment erosion from the high and proximal deposition
- Chemostratigraphy was fundamental in correlation

Late Daralingie facies distribution



- Relatively long transport distances in the western area, shorter in the east, indicating at least two delatic systems
- Increased accommodation in the central area – predominance of lacustrine facies
- No apparent change in provenance compared to Roseneath and Patchawarra
- Unconformity at top of the unit confirmed by chemostratigraphy

Toolachee facies distribution



- Increased accommodation from west to east
- Western area contains higher proportion of both channels and coals
- Flood plain dominates central and eastern area – significant thickening
- Channel fairways or Toolachee sections with higher proportion of sand are found in structurally high areas and, commonly, unconformably overlie thin Patchawarra section or Basement

Summary

- Good consistency between data types, chemostratigraphy proved to be vital for correlation in eastern trough area where there were significant facies changes within a formation
- Facies distribution in the eastern trough area suggests that deposition continued into the deepest part of the trough during the onset of the structuring and regional uplift related to the Daralingie Unconformity – however not conclusive without palynology to confirm absence of time break
- Murteree and Roseneath shales have broadly similar depositional environments; however, the Murteree thickness and facies are more regionally consistent; the Roseneath was influenced more by local structure and variation in lake level
- This study has improved the understanding of Permian deposition in the Nappamerri Trough, but there is always scope for further work

Acknowledgements

- I would like to gratefully acknowledge
  - Beach Energy for permitting the material to be presented
  - My co-authors who provided a wealth of valuable feedback and assistance
  - The many consultants who worked on the NTNG project; all of them made a valuable contribution to the geological understanding of the Nappamerri Trough

Compliance statements

Disclaimer

This presentation contains forward looking statements that are subject to risk factors associated with oil, gas, geothermal and related businesses. It is believed that the expectations reflected in these statements are reasonable but they may be affected by a variety of variables and changes in underlying assumptions which could cause actual results or trends to differ materially, including, but not limited to: price fluctuations, actual demand, currency fluctuations, drilling and production results, reserve estimates, loss of market, industry competition, environmental risks, physical risks, legislative, fiscal and regulatory developments, economic and financial market conditions in various countries and regions, political risks, project delays or advancements, approvals and cost estimates.

All references to dollars, cents or $ in this presentation are to Australian currency, unless otherwise stated. References to “Beach” may be references to Beach Energy Limited or its applicable subsidiaries.

Unless otherwise noted, all references to reserves and resources figures are as at 30 June 2015 and represent Beach’s share.

Questions?

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