Facies and Reservoir Quality of the Tengiz Isolated Platform, Pricaspian Basin, Kazakhstan*

By
J.A.M. Kenter[1], P.M. Harris[1], and J.F. Collins[2]

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[1] Chevron Energy Technology Company, Voorburg, Netherlands (jeroenkenter@chevron.com)
[2] Chevron Energy Technology Company, San Ramon, California, U.S.A. (MitchHarris@chevron.com)
[3] ExxonMobil Development Company, Houston, Texas, U.S.A.

Abstract

Tengiz field is an isolated carbonate buildup in the southeastern Pricaspian basin, containing a Late Famennian to Early Bashkirian platform succession. Platform backstepping resulted in approximately 800 m (2625 ft) of relief above the Famennian platform, followed by up to 2 km (1.2 miles) of Serpukhovian progradation.

The upper Visean, Serpukhovian, and Bashkirian form the main hydrocarbon-bearing interval at Tengiz. Visean and Serpukhovian platform cycles, several to 10's of meters thick, are laterally continuous and have predictable facies. In contrast, icehouse-driven, m-scale Bashkirian platform cycles show significant lateral facies heterogeneity. The distribution of reservoir rock types in platform facies is determined by burial diagenetic modification of an earlier reservoir system that included meteoric alteration and porosity enhancement below major sequence boundaries, and reduced dissolution along higher-order sequence boundaries associated with the presence of volcanic ash. The burial diagenetic overprint included corrosion and cementation phases followed by bitumen emplacement and associated corrosion.

The Serpukhovian progradational margin (rim) consists of in-situ upper slope microbial boundstone, and middle and lower slope breccias containing microbial boundstone clasts. Periodic rim failure during both Serpukhovian and Bashkirian time resulted in a high degree of lateral facies discontinuity. Solution-enlarged fractures, large vugs, and lost circulation zones enhanced mainly during late diagenesis form a high-permeability, well-connected reservoir in the rim and flank. This diagenetic overprint is associated with the presence of bitumen, and extends upward into overlying Serpukhovian and Bashkirian platform facies and inward into adjacent late Visean platforms, where it has substantially altered reservoir properties that remained after early diagenesis related to cyclic depositional processes.

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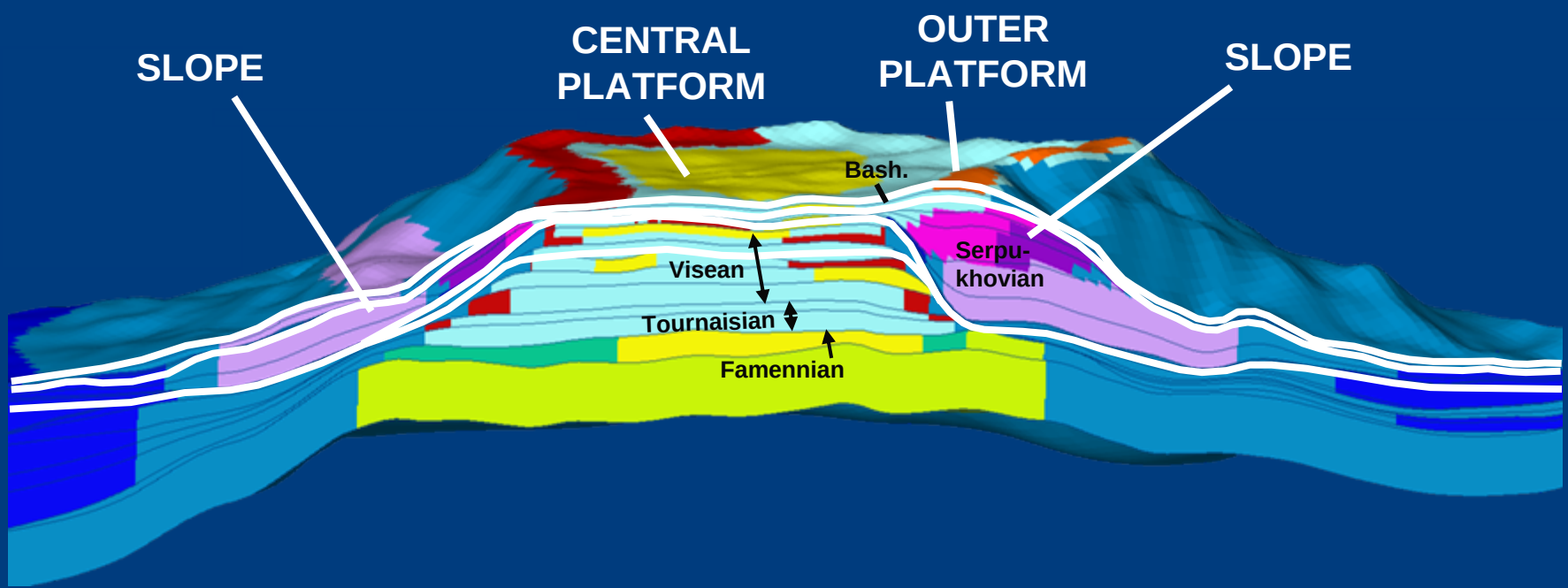
Jeroen Kenter[1], P.M. (Mitch) Harris[2], and Joel F. Collins[3]

[1] Chevron Energy Technology Company, Voorburg, Netherlands, [2]Chevron Energy Technology Company, San Ramon, California, U.S.A., [3]ExxonMobil Development Company, Houston, Texas, U.S.A.



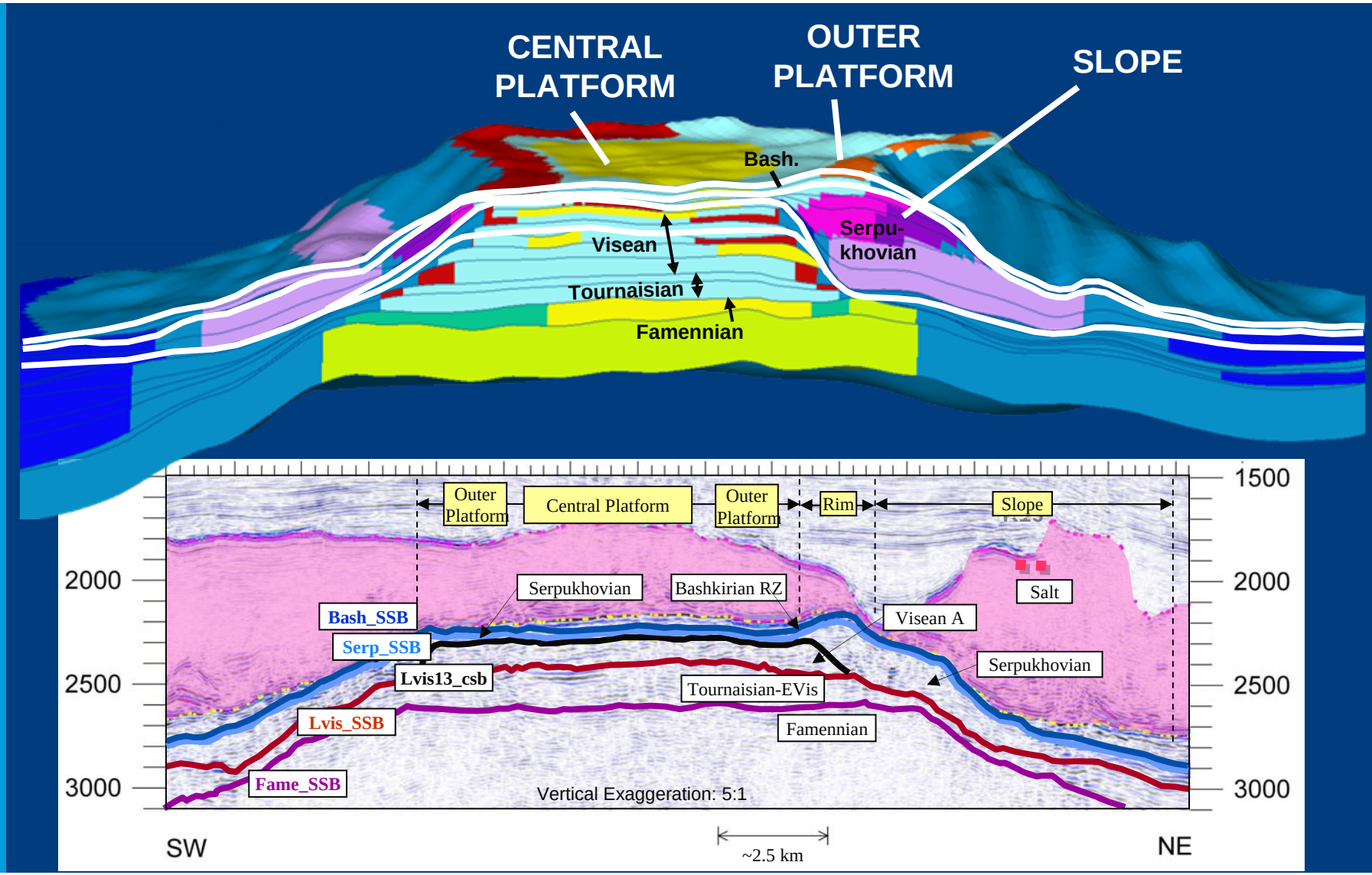
Outline

- Rationale
- Regional setting and history Tengiz Field
- Platform Depositional Rock Types and Cyclicity
  - Reservoir Quality and Diagenetic Modification
- Rim and Flank DRTs
  - Reservoir Quality and Diagenetic Modification
- Conclusions

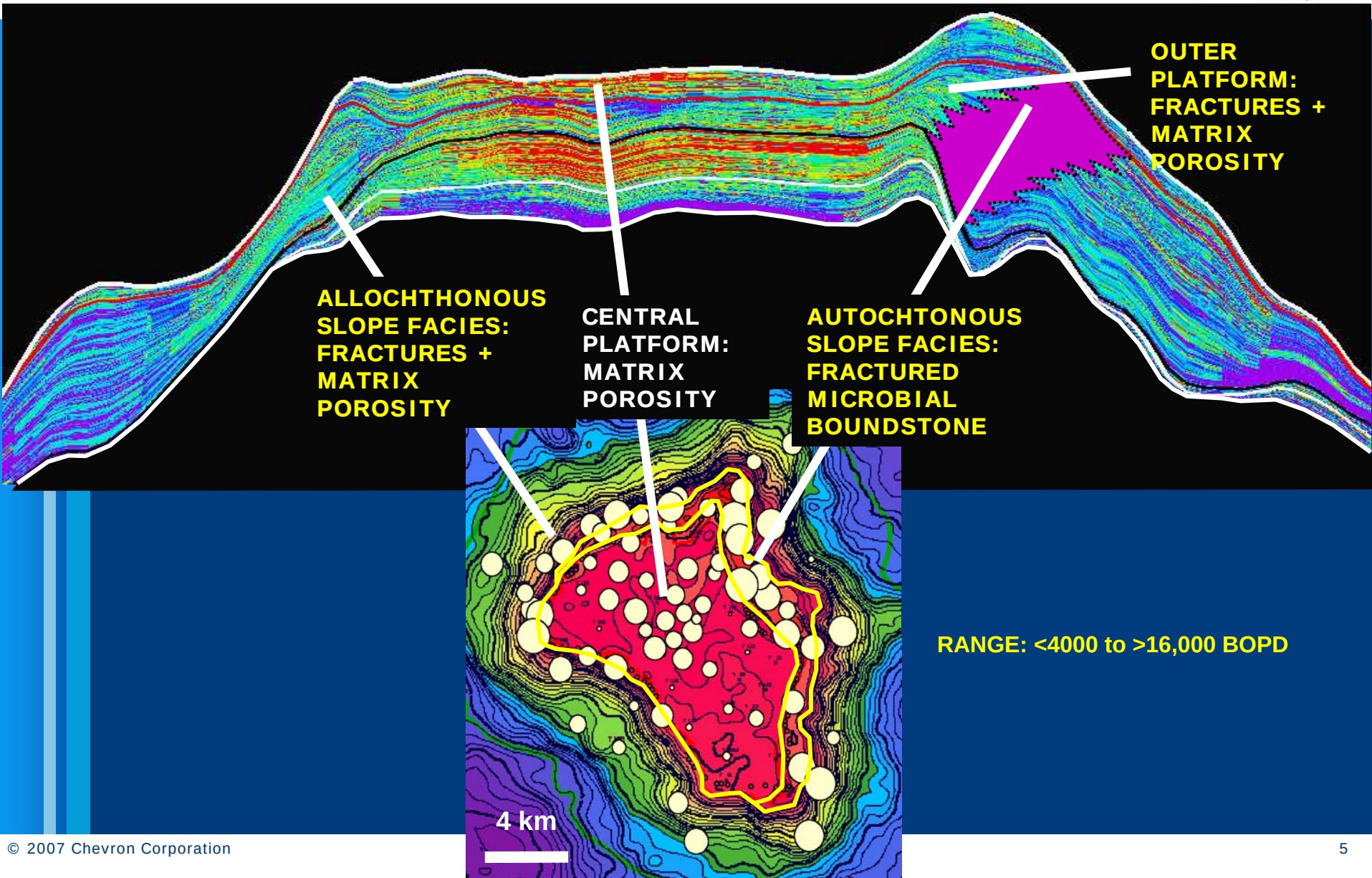
Tengiz Field – Background

- Produces oil from an isolated Devonian-Carboniferous carbonate platform (aerial extent of >110 km^2)
- “Giant” - one of the world's 10 largest oil fields with 6-13.5 billion barrels of reserves
- More than 115 wells
- Highest rate wells in the platform margin and slope in fractured carbonates with low (<6%) matrix porosity; platform wells higher porosity (up to 18%), but matrix permeability is typically low (<10 md)

General Environments of Deposition and Sequence Stratigraphy Framework

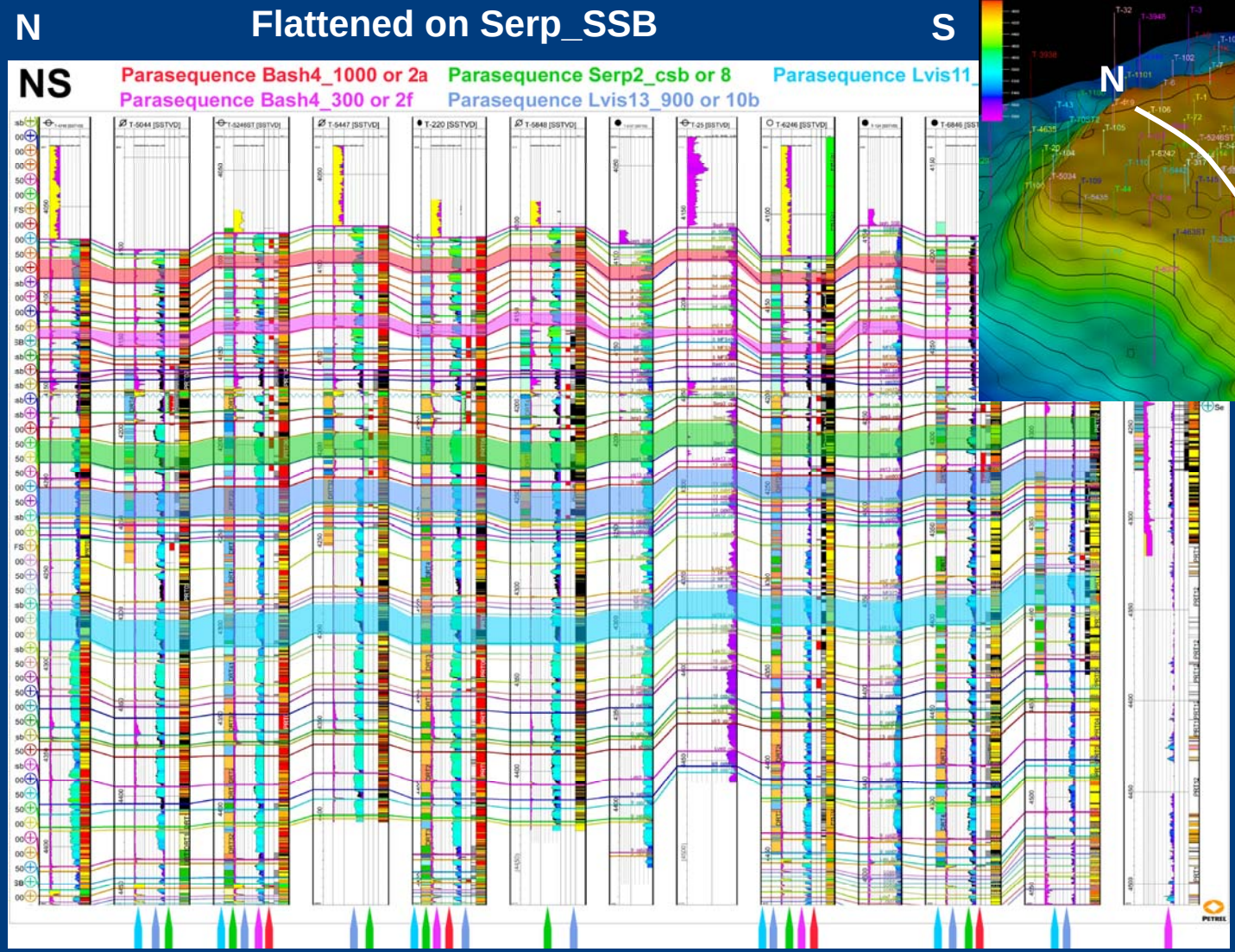


Reservoir Characterization

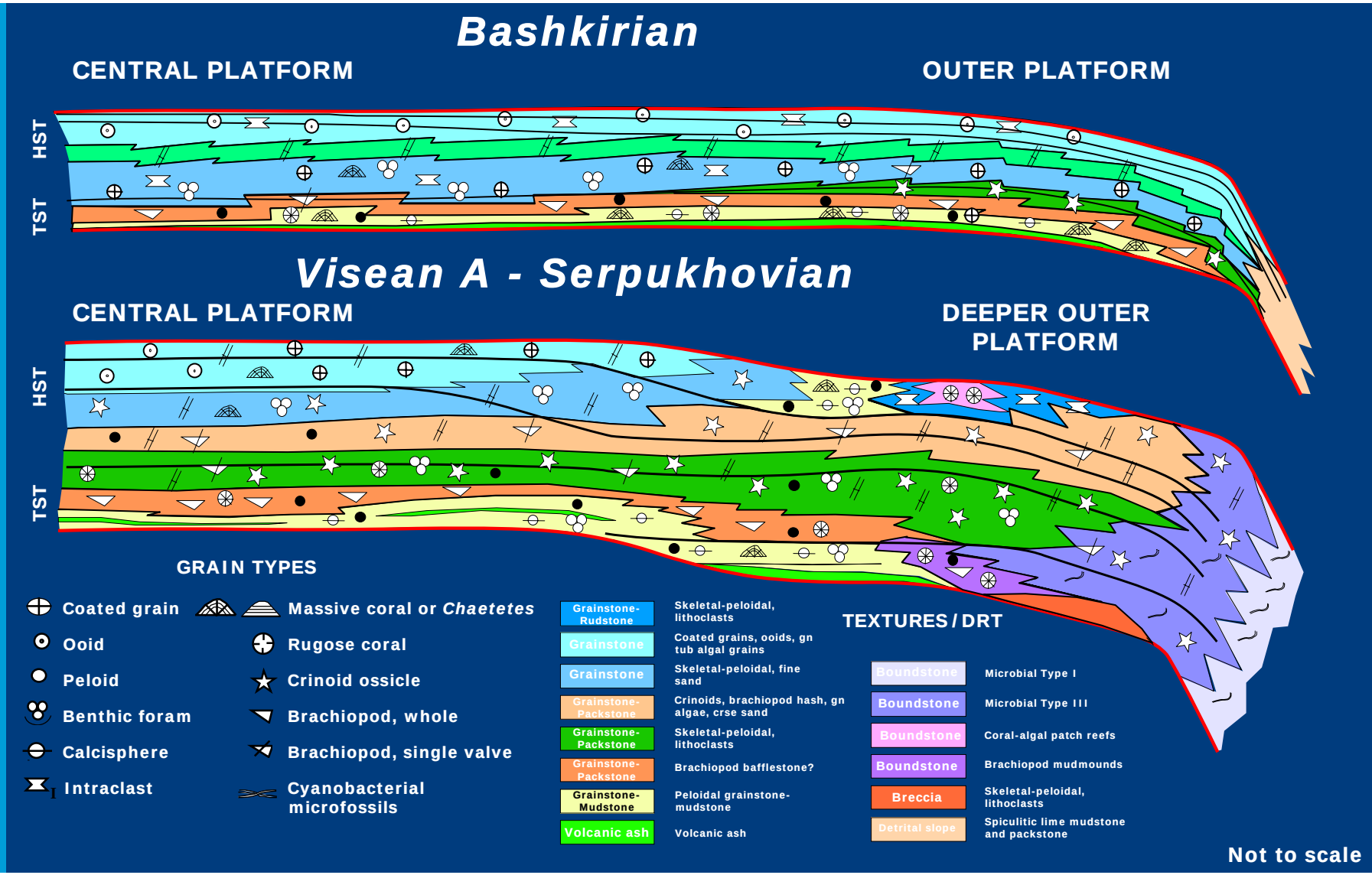


RANGE: <4000 to >16,000 BOPD

Platform Cycles and Correlation



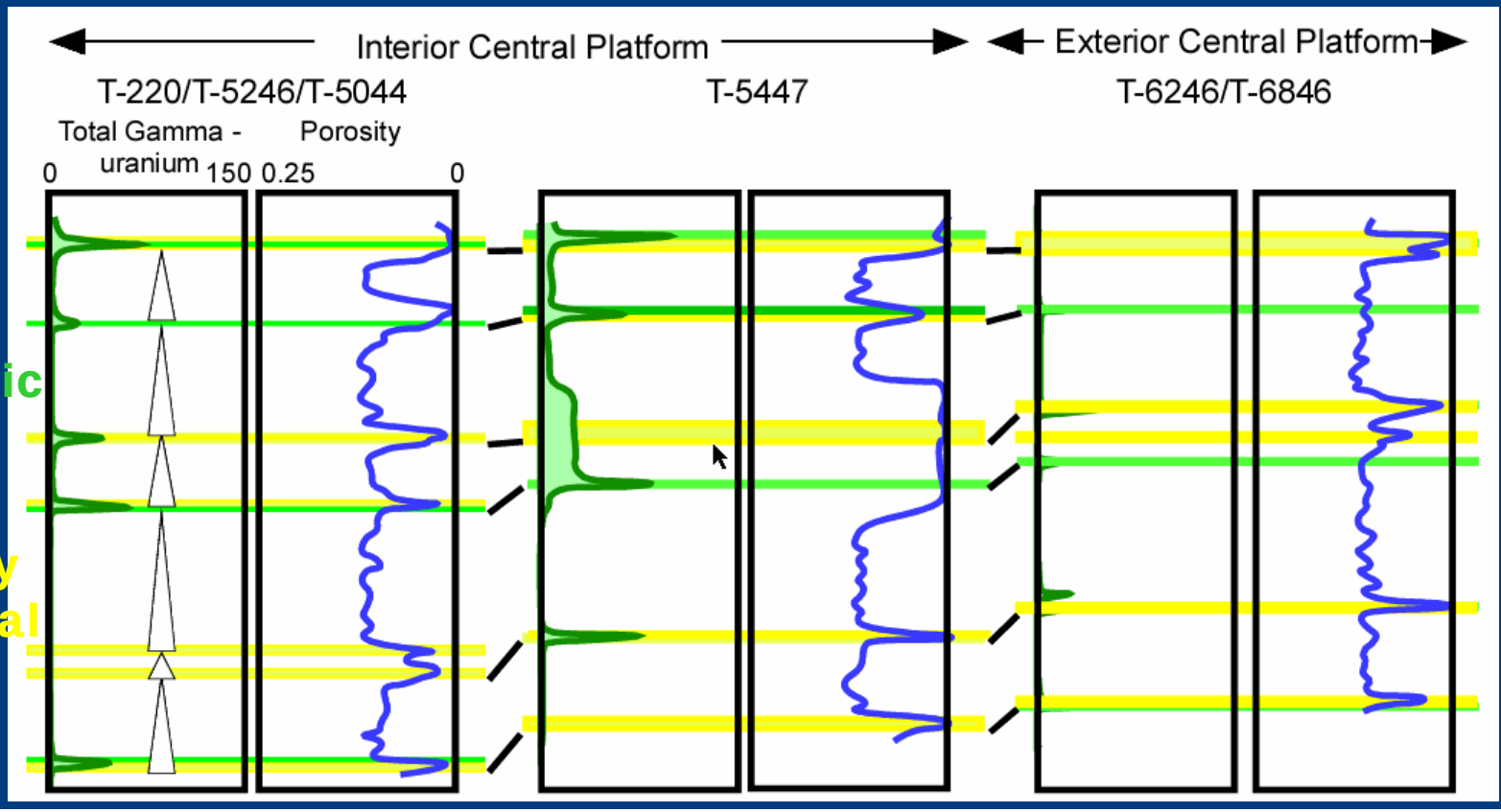
Simplified Depositional Models



Diagenetic Modification of Reservoir Quality – Stage 1

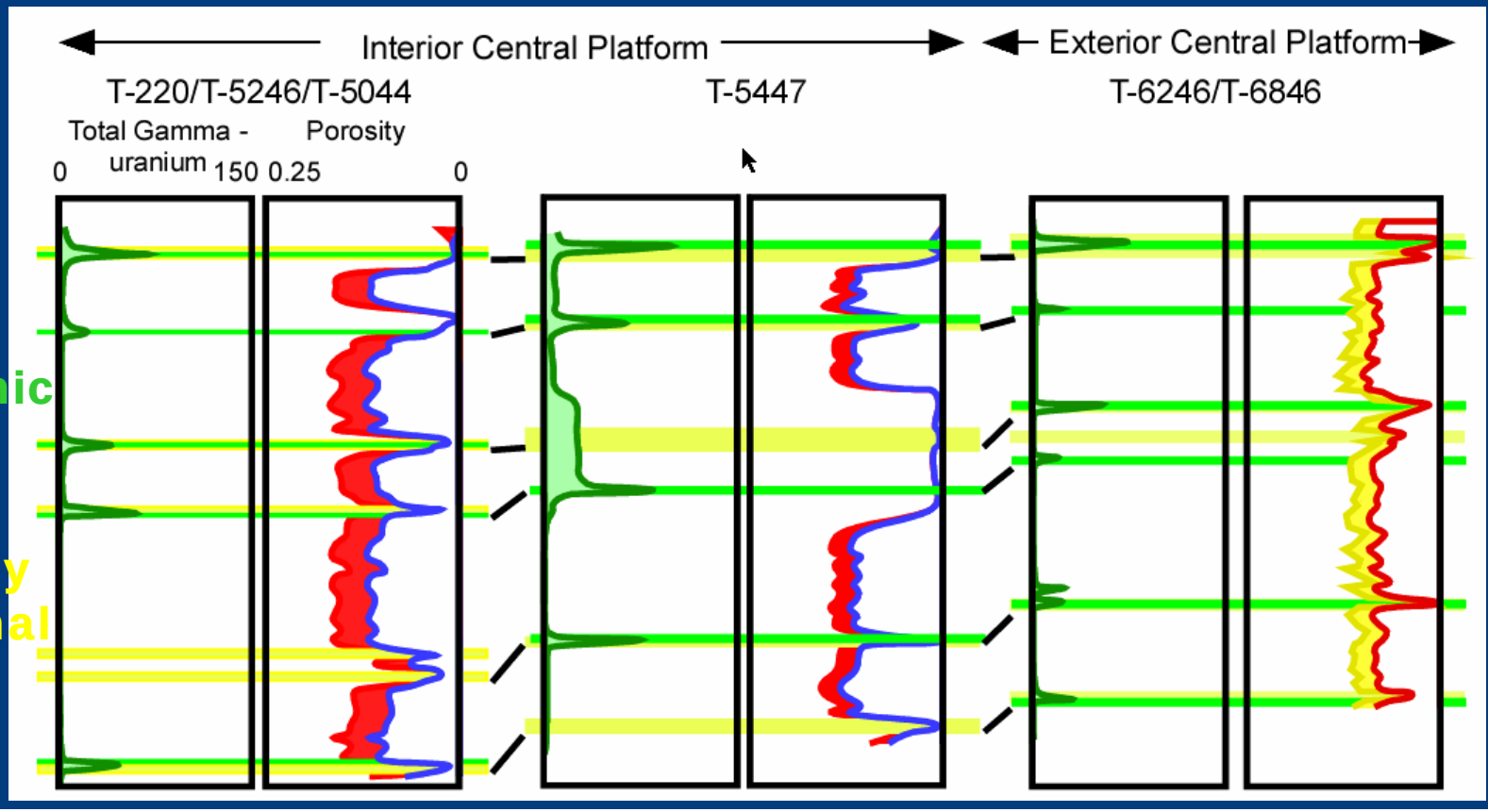
1

Early burial diagenesis: 1) differential porosity reduction in grainy (cemented) vs muddy (crushed) rock types, 2) tightening near cycle boundaries, 3) in dispersed ash intervals



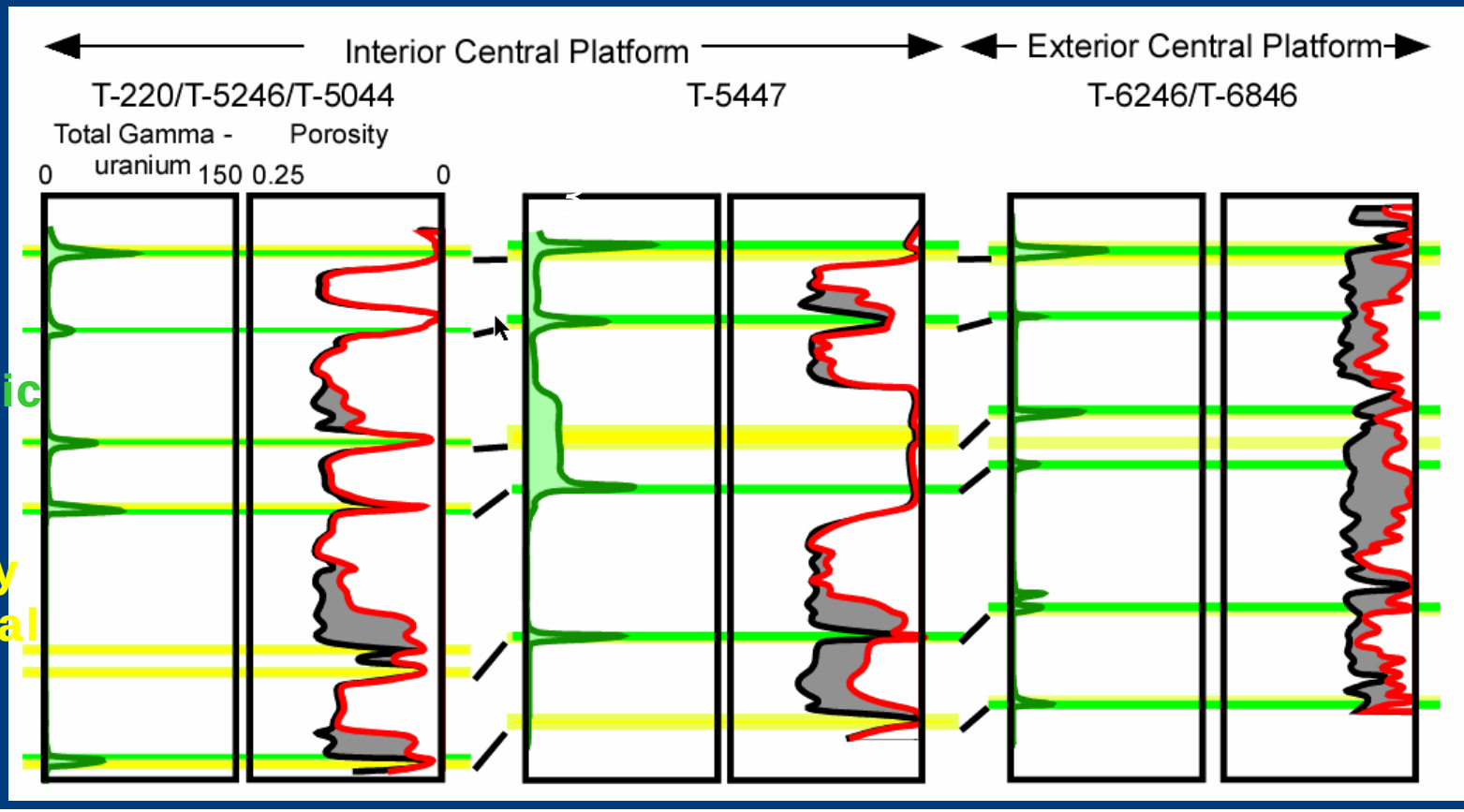
Diagenetic Modification of Reservoir Quality – Stage 2

2 **Burial diagenesis**: corrosion and differential cementation across platform

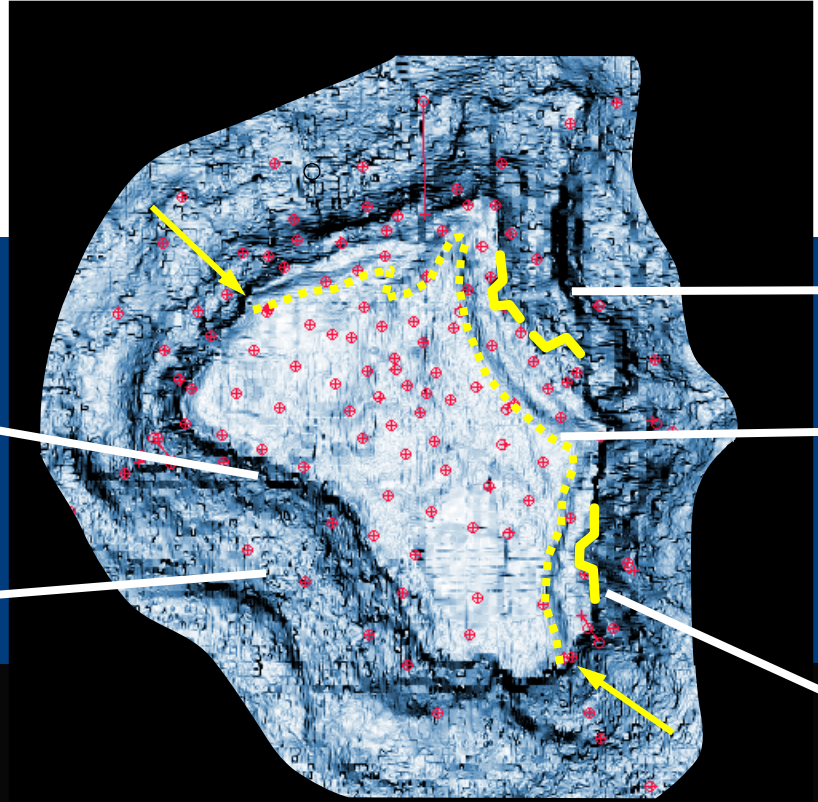


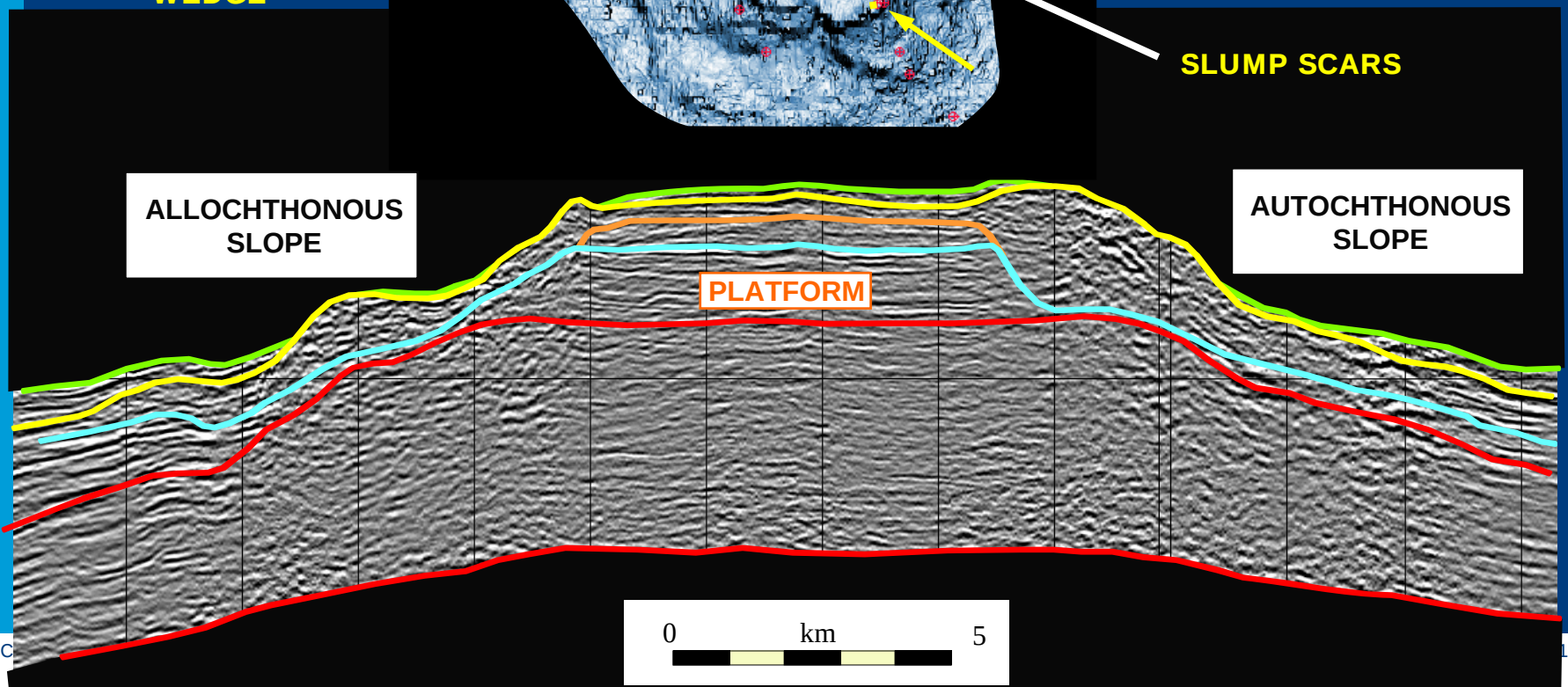
Diagenetic Modification of Reservoir Quality – Stage 3

3 **Burial diagenesis**: differential deposition of bitumen "cement" across platform in matrix, (micro and macro) pores, vugs, fractures, etc.



Slope Heterogeneity





Facies

ooid – coated grain grainstone

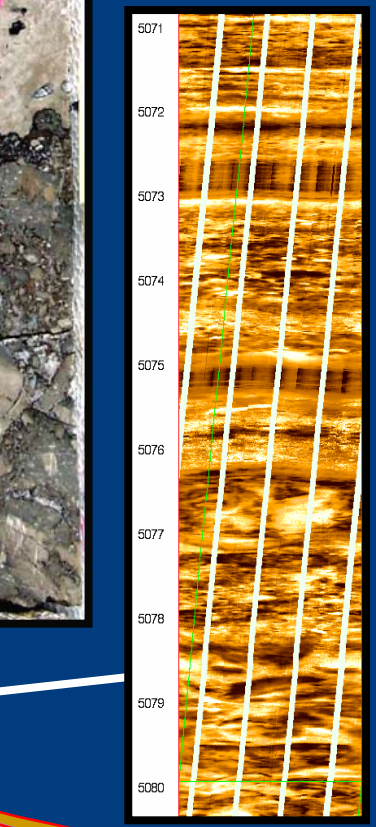
dipping skeletal packstone – rudstone

microbial boundstone (Type C)

boundstone (Type B)

boundstone breccia

bedded boundstone breccia



Bash

Serp

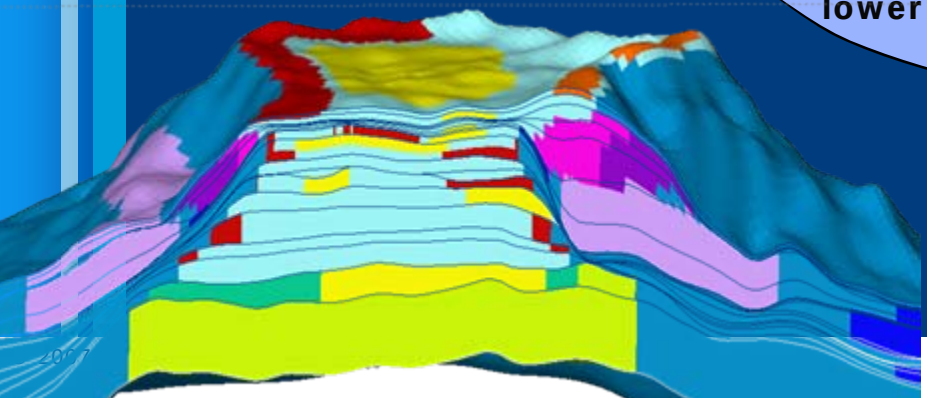
outer platform

upper slope

middle slope

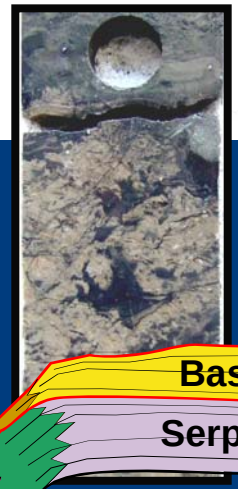
lower slope

lower apron

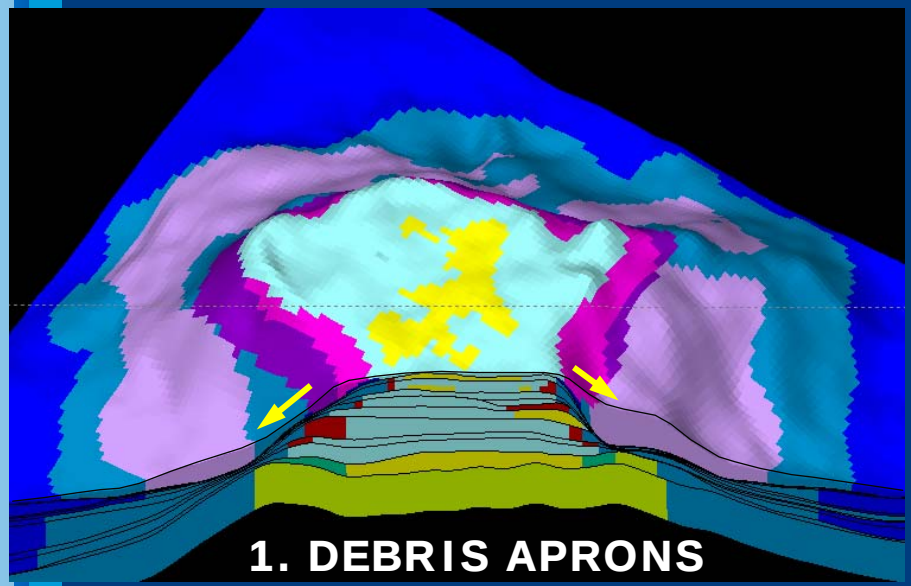


AUTOCHTHONOUS SLOPE

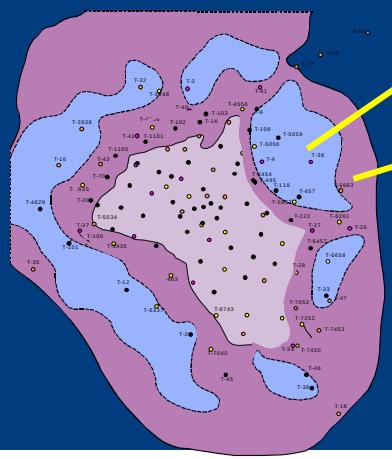
Facies

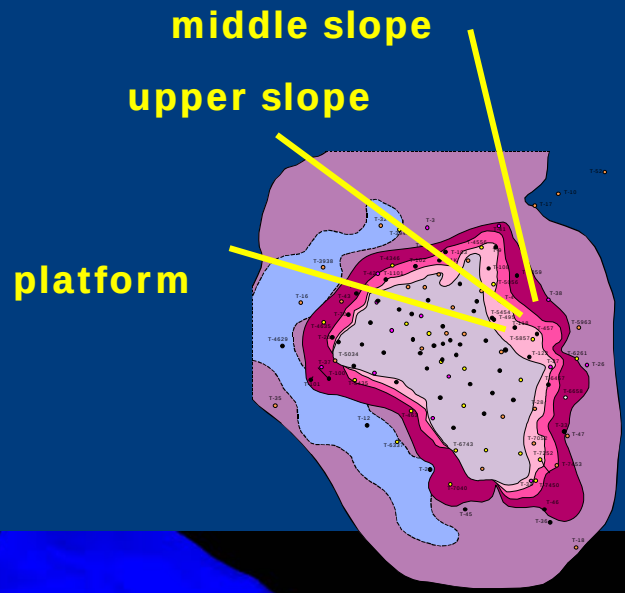


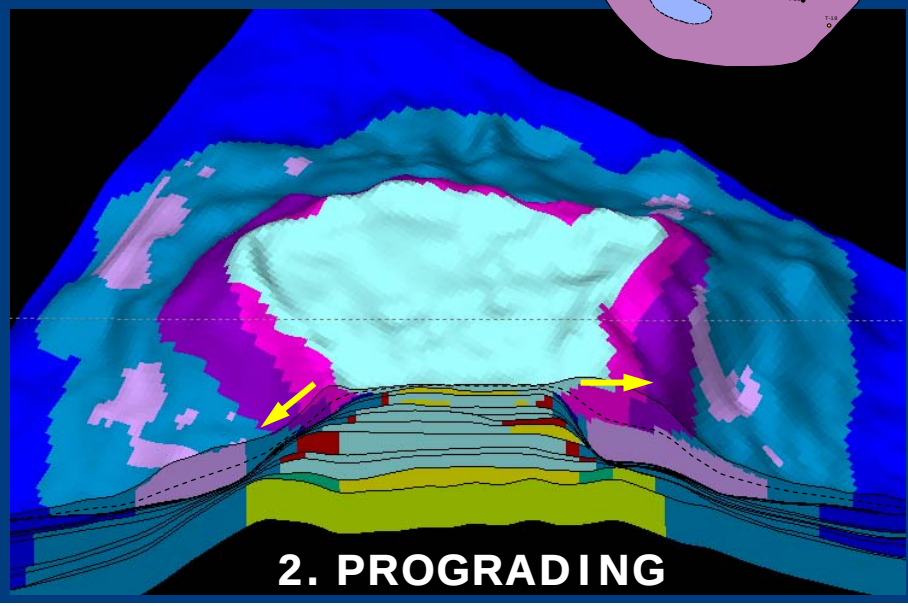
Depositional History and Facies Distribution



1. DEBRIS APRONS

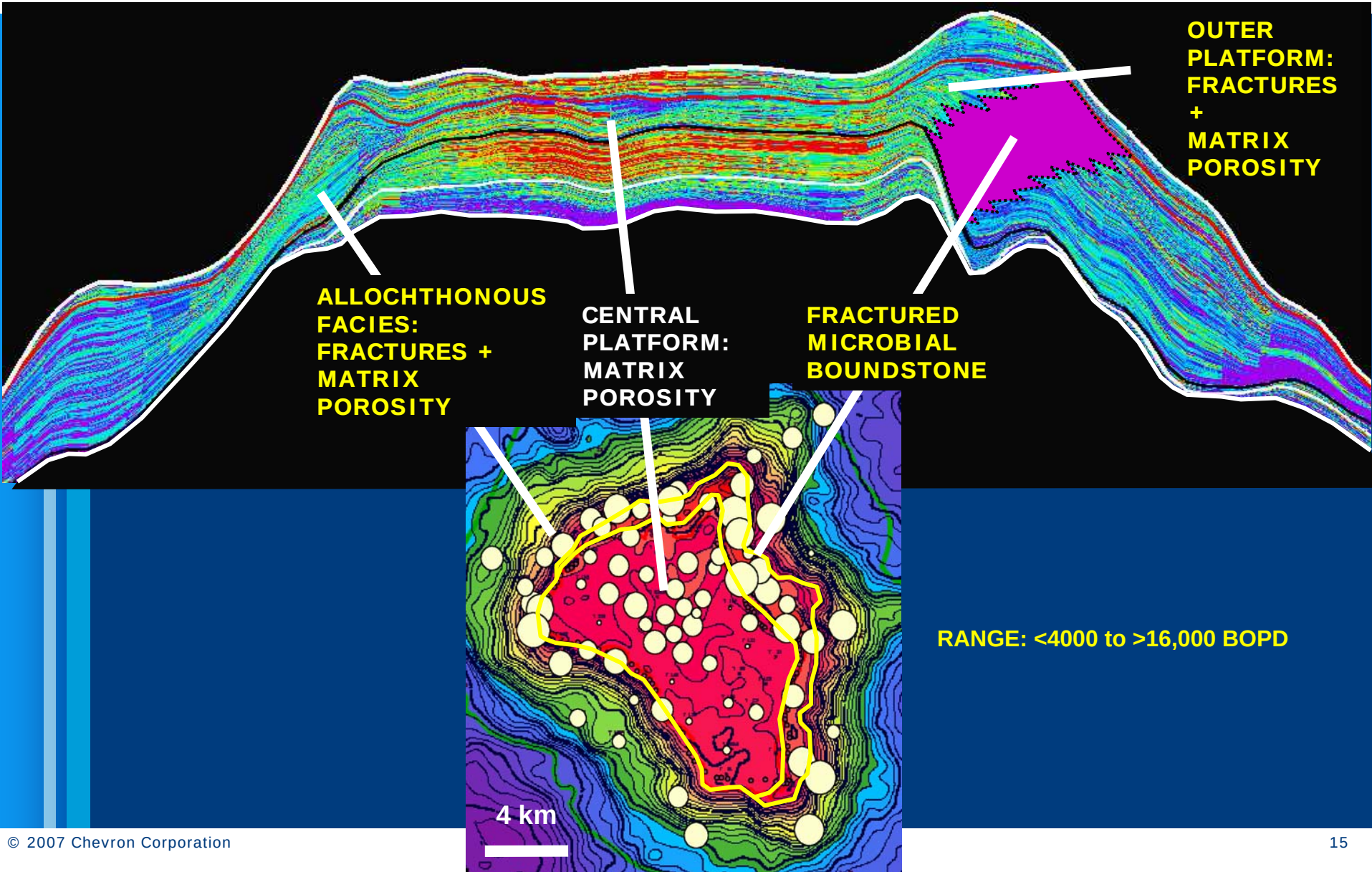






2. PROGRADING

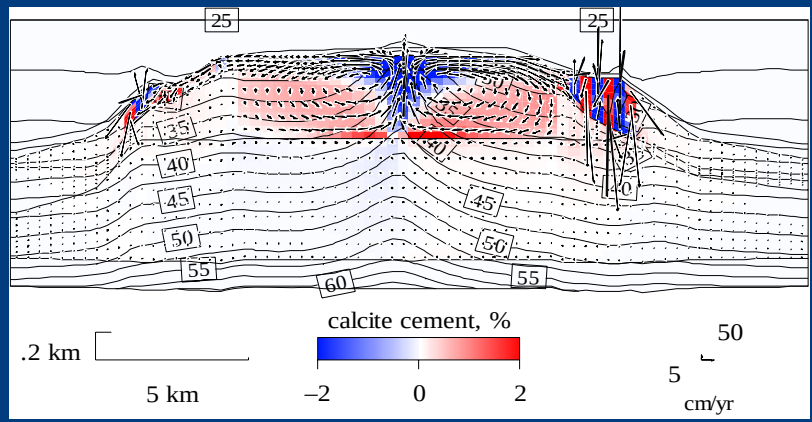
Reservoir Summary



RANGE: <4000 to >16,000 BOPD

Reactive Transport Modeling (RTM)

RTM models suggest burial free convection cells corroding the platform center and cementing the outer platform



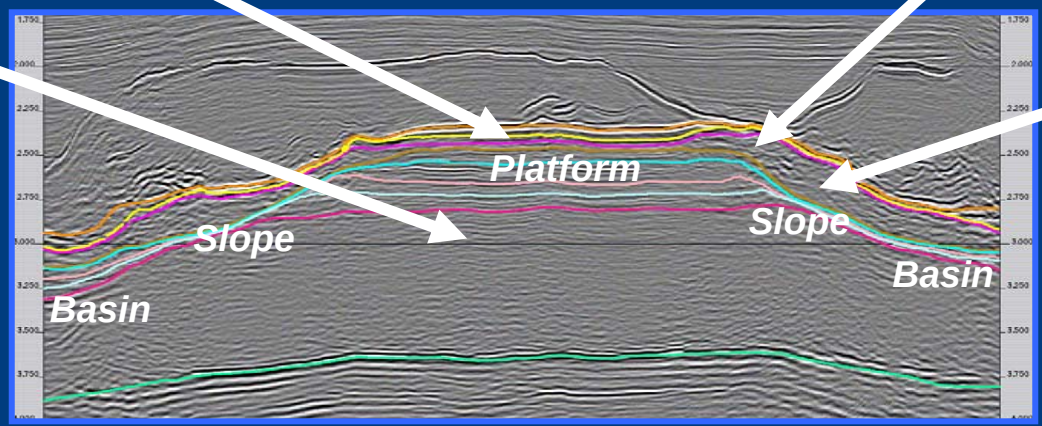
Burial dissolution in the central platform

Limited burial diagenetic modification of the Devonian

Limited potential for seawater dolomitization

Dissolution beneath salt withdrawal basins

Alternating vertical dissolution and cementation in boundstone slope

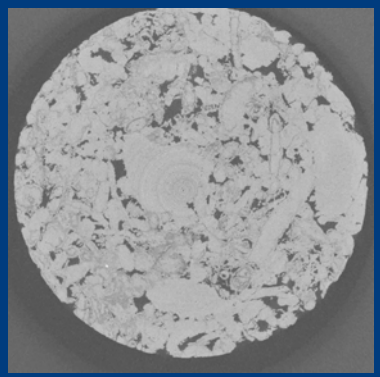


Jones & Xiao, AAPG Bulletin, 2006, V. 90, p. 1251-1272

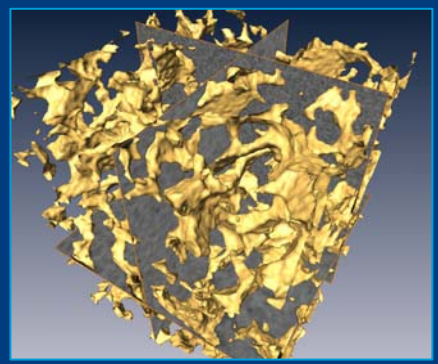
Summary

- Tengiz reservoir quality a product of primary facies and diagenetic modification with particular spatial trends
- Platform: cyclic depositional system overprinted by calcite cementation and bitumen, matrix controlled, minor fractures
- Rim-flank:
  - Deeper outer platform and allochtonous flank: matrix cementation (calcite & bitumen) and corrosion, minor fracturing
  - Autochthonous flank: minor matrix, mostly fractures and corrosion
- Spatial reservoir quality prediction linking diagenesis and petrophysics through pore network modeling

Pore Network Modelling Workflow

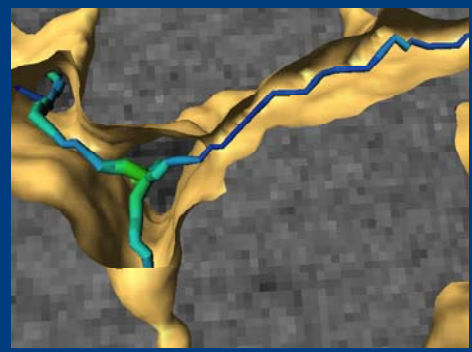


High resolution grey scale image of core plug

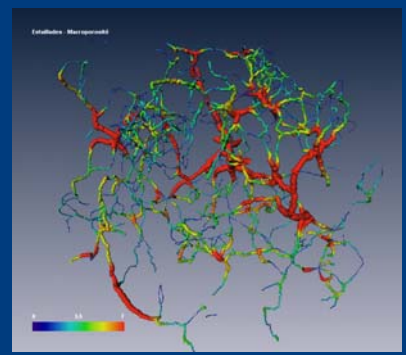


Pore volumes following thresholding

Pore throats mapped as function of diameter



Final 3D pore network mesh as input for calculation of transport properties



Mapping Differential Cementation