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

By
J.A.M. Kenter¹, P.M. Harris¹, and J.F. Collins²

Search and Discovery Article #20048 (2008)
Posted May 20, 2008

*Adapted from oral presentation at AAPG and AAPG European region Energy Conference & Exhibition, Athens, Greece, November 18-21, 2007

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

Jeroen Kenter¹, P.M. (Mitch) Harris², and Joel F. Collins³

¹Chevron Energy Technology Company, Voorburg, Netherlands, ²Chevron Energy Technology Company, San Ramon, California, U.S.A., ³ExxonMobil 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 km²)
- “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

OUTER PLATFORM: FRACTURES + MATRIX POROSITY

ALLOCHTHONOUS SLOPE FACIES: FRACTURES + MATRIX POROSITY

CENTRAL PLATFORM: MATRIX POROSITY

AUTOCHTHONOUS SLOPE FACIES: FRACTURED MICROBIAL BOUNDSTONE

RANGE: <4000 to >16,000 BOPD
Platform Cycles and Correlation

Late Visean

N Flattened on Serp_SSB S

N S

© 2007 Chevron Corporation
Diagenetic Modification of Reservoir Quality – Stage 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

Volcanic ash
Low energy lagoonal
Burial diagenesis: differential deposition of bitumen “cement” across platform in matrix, (micro and macro) pores, vugs, fractures, etc.
DISTALLY-THICKENED WEDGE

STeeper Upper Slope

Distally-Thickened Wedge

Steep Lower Slope

Raised Rim Effect

Slump Scars

Allochthonous Slope

Autochthonous Slope

Platform

Slope Heterogeneity
**Upper slope**
- Ooid - coated grain grainstone
- Dipping skeletal packstone - rudstone
- Microbial boundstone (Type C)

**Middle slope**
- Boundstone (Type B)

**Lower slope**
- Boundstone breccia

**Lower apron**
- Bedded boundstone breccia

**Autochthonous slope**
- Outer platform
Facies

- breccia with platform clasts
- bedded boundstone breccia
- rudstone - floatbreccia
- boundstone breccia
- skeletal - microbial boundstone (with karst)

- laminated mudstone - grainstone
- low-resistivity zone
- ALLOCHTHONOUS SLOPE

© 2007 Chevron Corporation
Depositional History and Facies Distribution

1. DEBRIS APRONS

2. PROGRADING

middle slope
upper slope
platform

apron facies
lower slope

© 2007 Chevron Corporation
Reservoir Summary

OUTER PLATFORM: FRACTURES + MATRIX POROSITY

ALLOCHTHONOUS FACIES: FRACTURES + MATRIX POROSITY

CENTRAL PLATFORM: MATRIX POROSITY

FRACTURED MICROBIAL BOUNDSTONE

RANGE: <4000 to >16,000 BOPD
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

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 allochthonous 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