[PS]Stratigraphy, Lithofacies, and Reservoir Distribution - Tengiz Field, Kazakhstan*

By

L. James Weber[1], Brent P. Francis[2], Paul M. (Mitch) Harris[3], and Michael Clark[4]

Search and Discovery Article #20059 (2008)
Posted July 1, 2008

*Adapted from poster presentation at AAPG Annual Convention, Salt Lake City, Utah, May 11-14, 2003

[1]ExxonMobil Development Company, Houston, TX; currently ExxonMobil Exploration Company, Houston, TX (jim.weber@exxonmobil.com)
[2]ExxonMobil Development Company, Houston, TX
[3]ChevronTexaco E & P Technology Company, San Ramon, CA (MitchHarris@chevron.com)
[4]Tengizchevroil, TCO Village, Kazakhstan; current address: Chevron, San Ramon, CA (micl@chevron.com)

Abstract

A supersequence-scale stratigraphic framework is developed for the super-giant Tengiz field of western Kazakhstan through the integrated interpretation of seismic, core, log, and biostratigraphic data. Tengiz produces oil from an isolated carbonate platform (areal extent of 580 km^2) of Devonian and Carboniferous age. An initial broad Late Devonian platform exhibits vertical growth and was followed by punctuated backsteps during the Early Carboniferous (Tournaisian and Viséan). The uppermost Lower Carboniferous (Serpukhovian) is characterized by several kilometers of platform progradation seaward of the Late Viséan platform break. The basal Upper Carboniferous (Bashkirian) platform succession was aggradational. Drowning in the Early Bashkirian halted carbonate platform growth. Paleotopographic relief on the top of the Bashkirian platform to the basin floor approaches 1500 meters within several kilometers lateral distance.

The stratigraphic architecture defined in this study is used to subdivide the reservoir. The reservoir is also partitioned, based on geographic position along a platform-to-basin profile. Time-slice mapping of synchronous depositional facies provides the basis for predicting reservoir distribution and continuity. On the platform, hydrocarbons are produced from Upper Viséan, Serpukhovian, and Bashkirian reservoirs in grainstone and mud-lean packstone lithofacies of the Shallow Platform and in packstone lithofacies of the Deeper Platform. Multiple pore types are recognized in Tengiz, but matrix permeability is controlled primarily by intergranular porosity. In-place, upper-slope microbial boundstone and transported lower-slope boundstone debris form thick and areally extensive mappable reservoirs (Late Viséan and Serpukhovian) that have distinctive seismic facies and production/performance characteristics. Fractures contribute to non-matrix permeability in these boundstones.

Stratigraphy, Lithofacies, and Reservoir Distribution - Tengiz Field, Kazakhstan

Authors: Weber, L. (James)[1], Francis, B. P.[1], Harris, Paul (Mitch)[2], and Clark, Michael[3]

Supersequence Framework

1

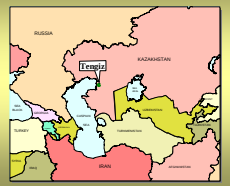
Abstract

A supersequence-scale stratigraphic framework is developed for the super-giant Tengiz field of western Kazakhstan through the integrated interpretation of seismic, core, log, and biostratigraphic data. Tengiz produces oil from an isolated carbonate platform (areal extent of 580 km^2) of Devonian and Carboniferous age. An initial broad Late Devonian platform exhibits vertical growth and was followed by punctuated backsteps during the lower Carboniferous (Tournaisian and Viséan). The uppermost lower Carboniferous (Serpukhovian) is characterized by several kilometers of platform progradation seaward of the late Viséan platform break. The basal upper Carboniferous (Bashkirian) platform succession was aggradational. Drowning in the early Bashkirian halted carbonate platform growth. Paleotopographic relief on the top of the Bashkirian platform to the basin floor approaches 1,500 meters within several kilometers lateral distance.

The stratigraphic architecture defined in this study is used to subdivide the reservoir. The reservoir is also partitioned based on geographic position along a platform-to-basin profile. Time-slice mapping of synchronous depositional facies provides the basis for predicting reservoir distribution and continuity. On the platform, hydrocarbons are produced from Upper Viséan, Serpukhovian, and Bashkirian reservoirs in grainstone and mud-lean packstone lithofacies of the Shallow Platform and in packstone lithofacies of the Deeper Platform. Multiple pore types are recognized in Tengiz, but matrix permeability is controlled primarily by intergranular porosity. In-place, upper-slope microbial boundstone and transported lower-slope boundstone debris form thick and areally extensive mappable reservoirs (Late Viséan and Serpukhovian) that have distinctive seismic facies and production/performance characteristics. Fractures contribute to non-matrix permeability in these boundstones.

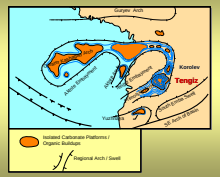
2

Caspian Region



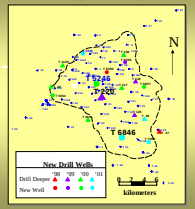
3

North Caspian Paleogeography



4

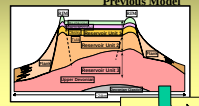
Tengiz Base Map Showing Well Location



5

Comparing Geologic Models

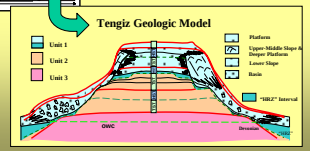
Previous Model



- 5 Layer Model
- 3 Geographic Subdivisions

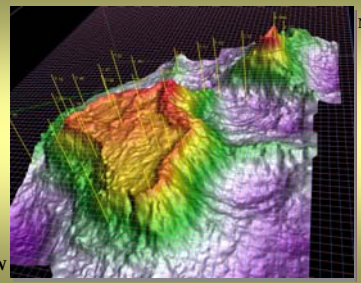
- 42 Layer Model with High Resolution Mapping
- Platform and Slope Subdivided into Depositional Facies
- Good Relationship between Porosity & Permeability
- Predictive Reservoir Quality Maps Generated
- New Model Successfully Predicts Reservoir Quality
- Geologic Concepts Validated by Reservoir Performance
- Lack of Data Limits Understanding of Deeper Units

Tengiz Geologic Model



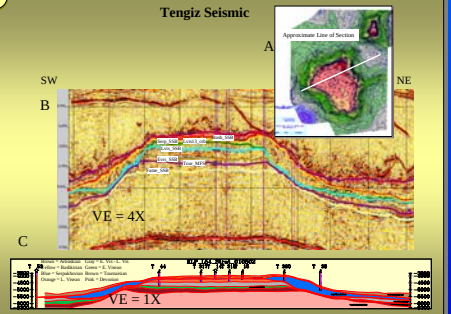
6

Tengiz Seismic



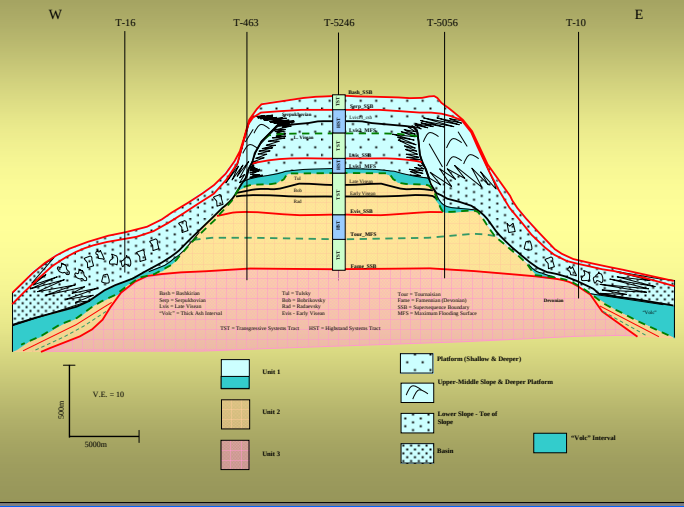
7

Tengiz Seismic



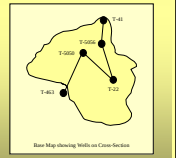
8

New Tengiz Geologic Model (2001)

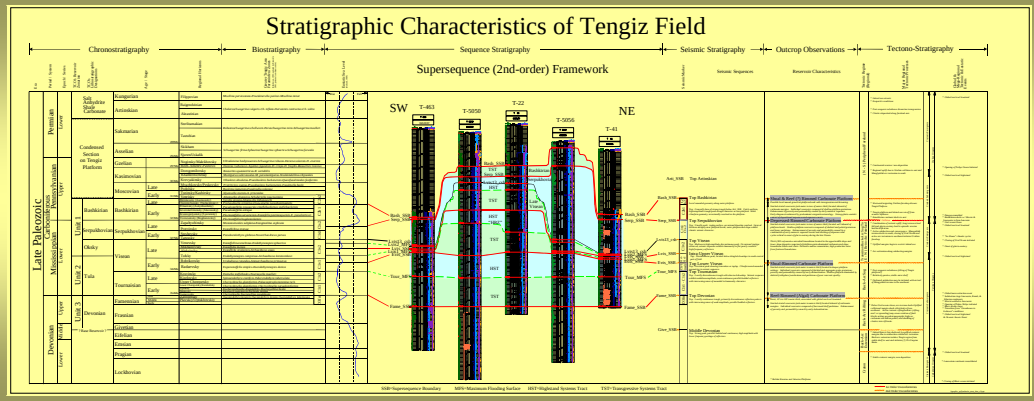


9

- 1000 sq km 3-D seismic
  - post-stack time
  - pre-stack depth
- 4000 m core, 47 wells (~2500 m, 11 wells TCO)
- 3000 thin section descriptions
- 300 biostratigraphy pinning points



Stratigraphic Characteristics of Tengiz Field



10

New Reservoir Subdivision

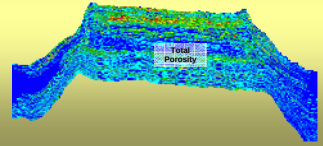
Mapping Horizon	New Reservoir Layers	Old Reservoir Layers	Geomorphic Bins
Bash_SSB	Bashkirian	Unit 1	Platform, Slope
Serp_SSB	Serpukhovian	Unit 1	Platform, Slope
Lvis13_csb	Visean A	Unit 1	Platform, Slope
Lvis_SSB	Visean B	Unit 1	Platform, Slope
Lvis1_MFS	"Volc"	Unit 1	
Evis_SSB	Visean C	Unit 2	Platform, Slope
Tour_MFS	Visean D	Unit 2	Platform, Slope
Fame_SSB	Tournaisian	Unit 2	Platform, Slope
	Devonian	Unit 3	Platform, Slope

11

Large-Scale Sequence Stratigraphy Summarized

Application to Geocellular Model

- Tied Seismic and Log Correlations Establish Large Scale Framework
- For 2nd Order Framework 7 Seismic Surfaces Used in Model, Additional 2 Surfaces Based only on Log Correlations
- Large-Scale Framework Constrains Fine-Scale Layering
- 42 Layer Model Hard-Wired into 3-D Geocellular Model



Stratigraphy, Lithofacies, and Reservoir Distribution - Tengiz Field, Kazakhstan

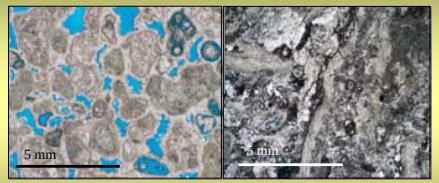
Authors: Weber, L. (James)[1], Francis, B. P.[1], Harris, Paul (Mitch)[2], and Clark, Michael[3]

Sequence Stratigraphy and Platform Reservoir Prediction

12 Objectives

- Predict Reservoir Quality
  - Impact: Optimum positioning of development wells to maximize rate; mitigate geologic risk for location and expansion of gas displacement projects
- Reservoir Architecture & EOD Polygons as Framework for a Deterministic 3-D Geologic Model
  - Population of Ø model
  - Transformation of Ø to matrix K
  - Impact: Develop best possible 3-D model w/ data-constrained geologic inputs to fluid flow simulation leading to defensible metrics of reserves and expected recovery

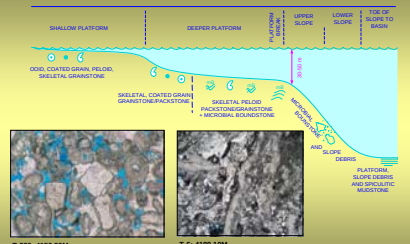
13 Grainstone versus Packstone



T-220, 4140.10m T-6, 4189.10m

- Depositional Environment 1st-Order Control on Res Qual for Lvis_SSB to Bash_SSB
- Controls Ø & K through influence on grain size, sorting, and interstitial mud content

14 Bathymetric Profile

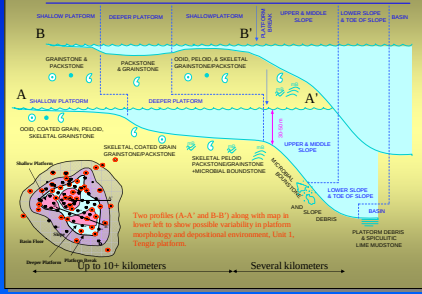


T-220; 4156.26M Coated grain and oid grainstone

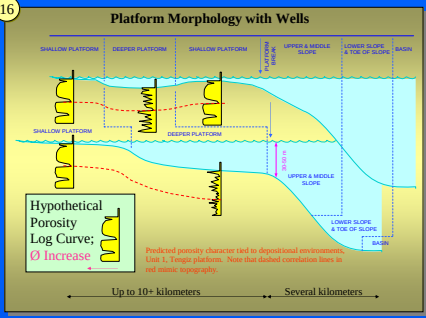
T-6; 4189.10M Skeletal Packstone

A bathymetric profile with associated lateral changes that are expected in rock composition, Unit 1, Tengiz platform.

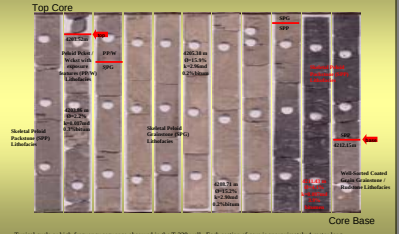
15 Platform Morphology



16 Platform Morphology with Wells

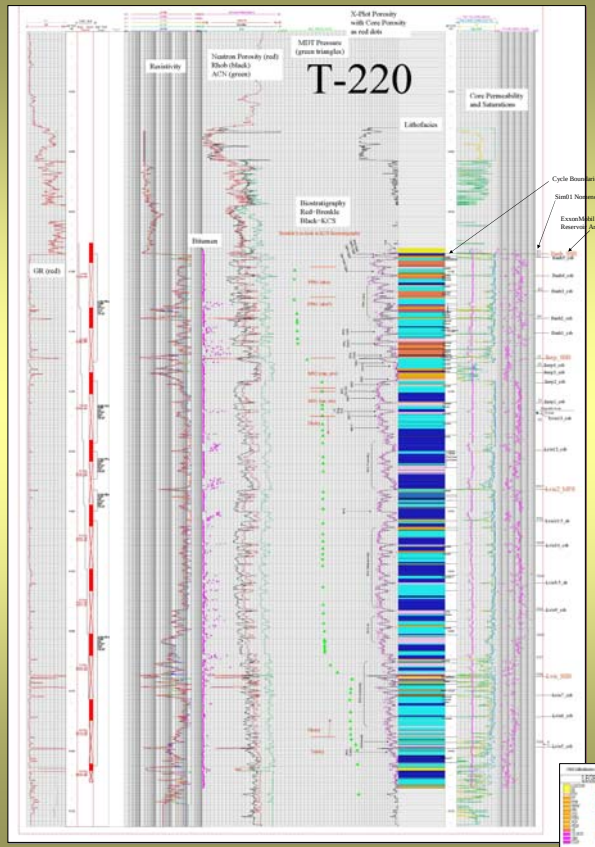


17 Platform Cycle/High Frequency Sequence

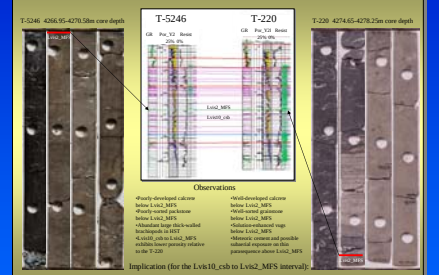


Typical cycle or high-frequency sequence observed in the T-220 well. Each section of core is approximately 1 meter long.

18 T-220 Well



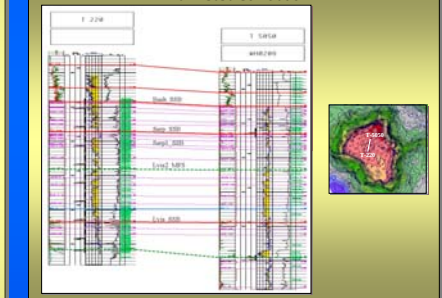
19 Comparison Between T-5246 & T-220



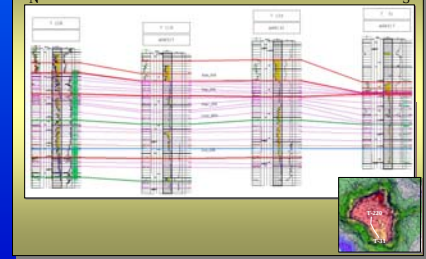
Implication (for the Lvis10_csb to Lvis2_MFS interval):

- T-220 is Updip of T-5246 on a Paleobathymetric Profile
- Porosity is Developed Best on Paleohighs

20 T220 - T5050 Correlation



21 T-220 - T-119 - T-123 - T-31 Correlation



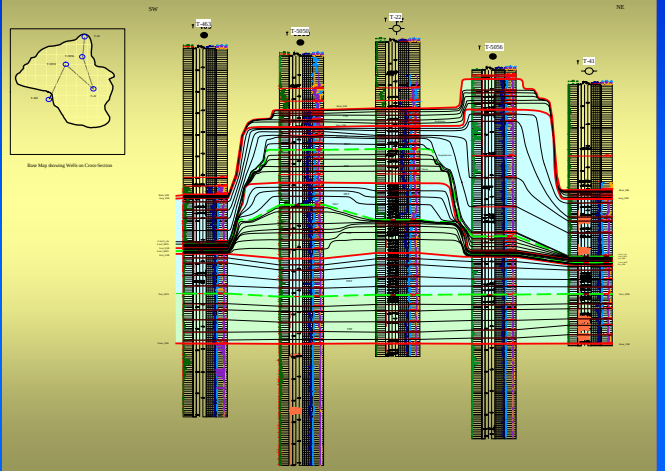
Stratigraphy, Lithofacies, and Reservoir Distribution - Tengiz Field, Kazakhstan

Authors: Weber, L. (James)[1], Francis, B. P.[1], Harris, Paul (Mitch)[2], and Clark, Michael[3]

Maps and Prediction of Reservoir Quality

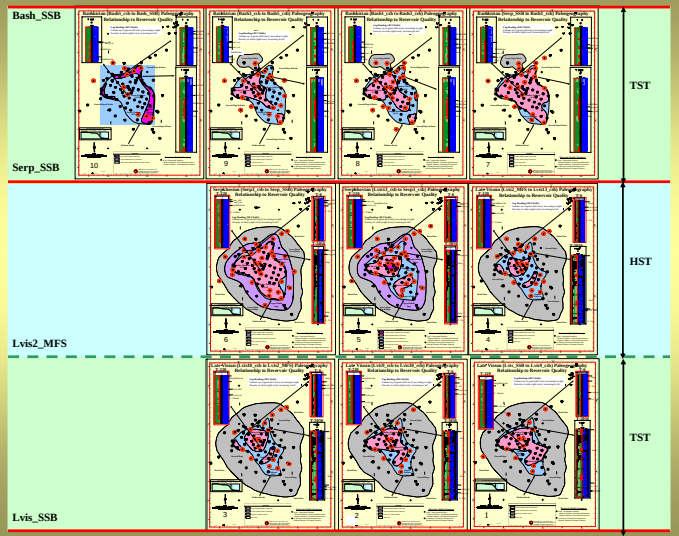
22

Tengiz Sequence-Scale Stratigraphic Framework



24

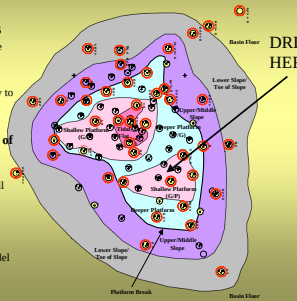
Map Series



25

Conclusions/Business Impact

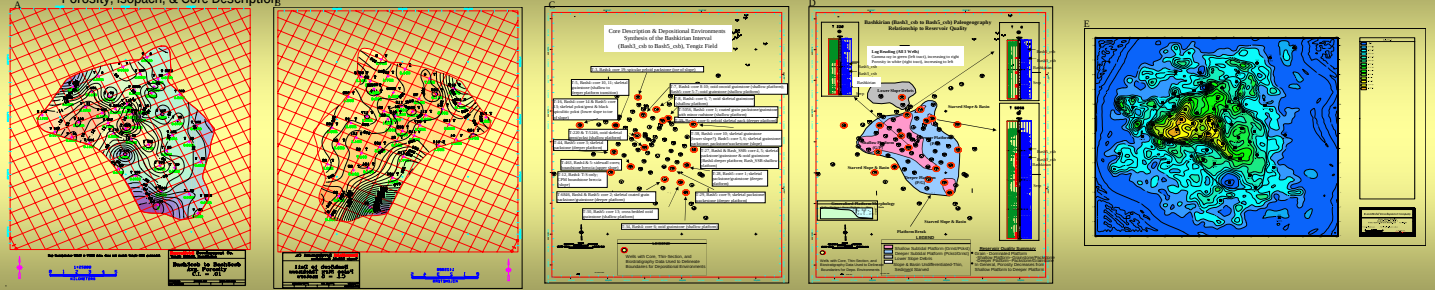
- **New Geologic Model Tested**
  - Successful Prediction of Lower Reservoir Quality, T-6846
- **18 Layers, Lvis_SSB to Bash_SSB**
  - Higher Resolution Mapping Possible
  - Better Constraint on Partial Penetrations
  - Hard Wired Architecture not as Easy to Scale Out of Simulation Model
    - Preservation of Heterogeneity
- **EOD Maps/Polygons Show Areas of Different Reservoir Quality**
  - Locate Development Wells to Maximize Rate on the Platform, Drill Areas of Stacked Pay
  - Position Gas Injection Wells in Optimal Location to Maximize Rate and Recovery
  - Used to Populate Ø & K in 3-D Model



23

EOD Map Derivation

Paleoenvironment Interpretation for the Bashkirian Interval (Bash3_csb to Bash5_csb) Contribution from Average Porosity, Isopach, & Core Description



An example of the maps that have been used in this study; (A) average porosity, (B) isopach, (C) rock description, (D) EOD, and (E) average porosity from geocellular model.

26

Acknowledgements

This study was a team effort. We sincerely thank the ExxonMobil "Tengiz team" for their hard work and many discussions of all aspects of Tengiz geology. Kevin Putney made porosity and isopach maps for the various reservoir layers; Steve Bachtel interpreted seismic cross-sections and maps; and Tom Kane analyzed well production data. Ray Garber and Phil Bassant (ChevronTexaco) provided core descriptions, which were instrumental in our work. We warmly thank Jeroen Kenter (Vrije Universiteit, Amsterdam), Paul Brenckle (Consultant), and Tom Heidrick (TengizChevroil) for the many stimulating technical discussions in the core warehouse facility at Tengiz. Jeroen's knowledge of modern and ancient carbonate slope settings, and Paul Brenckle's biostratigraphic data were invaluable to our studies.

We also recognize the significant contributions of many additional people from ExxonMobil (I. Mitchell, S. Perkins, L. Vaughn, B. Evans, P. Allred, and J. Grillot) and TengizChevroil (A. Azizi, P. Bateman, C. Brown, N. Dzhamikeshev, E. Furlin, J. Hohenberger, K. Nahm, O. Petrova, B. Robertson, L. Rowe, and A. Tyshkanbaeva).

We thank TengizChevroil and its shareholder companies (ChevronTexaco, ExxonMobil, Kazmunaigaz, and BPLukArco)for support of our studies and permission to publish this poster. Special thanks to Paul Prestridge and Robert Benevente of the graphics department at Exxonmobil for the design and layout of this poster.

[1]ExxonMobil Development Company, Houston, TX
[2]ChevronTexaco E & P Technology Company, San Ramon, CA
[3]TengizChevroil, TCO Village, Kazakhstan