Seismic and Core-Based Reservoir Characterization, the Giant Priobskoye Field, West Siberia, Russia*

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Search and Discovery Article #20269 (2014)**
Posted August 29, 2014

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014

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Abstract

The Priobskoye Field is one of the largest stratigraphic traps in the world, covering over 5400 km^2 and with a recoverable resource of 5.86 BBO and 1.17 TCF of gas. The trap is a complex series of fine-grained, highly heterogeneous reservoirs varying from basin-floor fans to slope channels and shallow-water deltas. The traps are within an overall progradational 'clinoform' complex, with regional seals created where shoreface ravinement of the delta top sets has removed the reservoir facies landward and placed marine shales over prodelta shales and siltstones. Additional pure stratigraphic traps occur within a multitude of turbidite fans and slope channels in the 'Achimov' Formation. Hydraulic fracturing is generally needed to obtain commercial flow rates. Most reservoirs are dominantly meso- and microporous, with the best reservoirs in hummocky cross-stratified deltaic shore face and delta-front sandstones. Locally, 'massive' deep-water sandstones and bioturbated shoreface sandstones form effective reservoirs. Most of the other facies are microporous and have a high content of bound-water and high water saturations. 3D seismic facies analysis clearly delineates many of these productive trends and can be used to high-grade 'sweet' spots of better reservoir-quality rock in the complex. Recognition of these better reservoir fairways can be used to enhance production with additional infill drilling and perhaps even horizontal well placement. The Priobskoye Field is a superb analog for similar combination and stratigraphically trapped reservoirs in deltaic successions.

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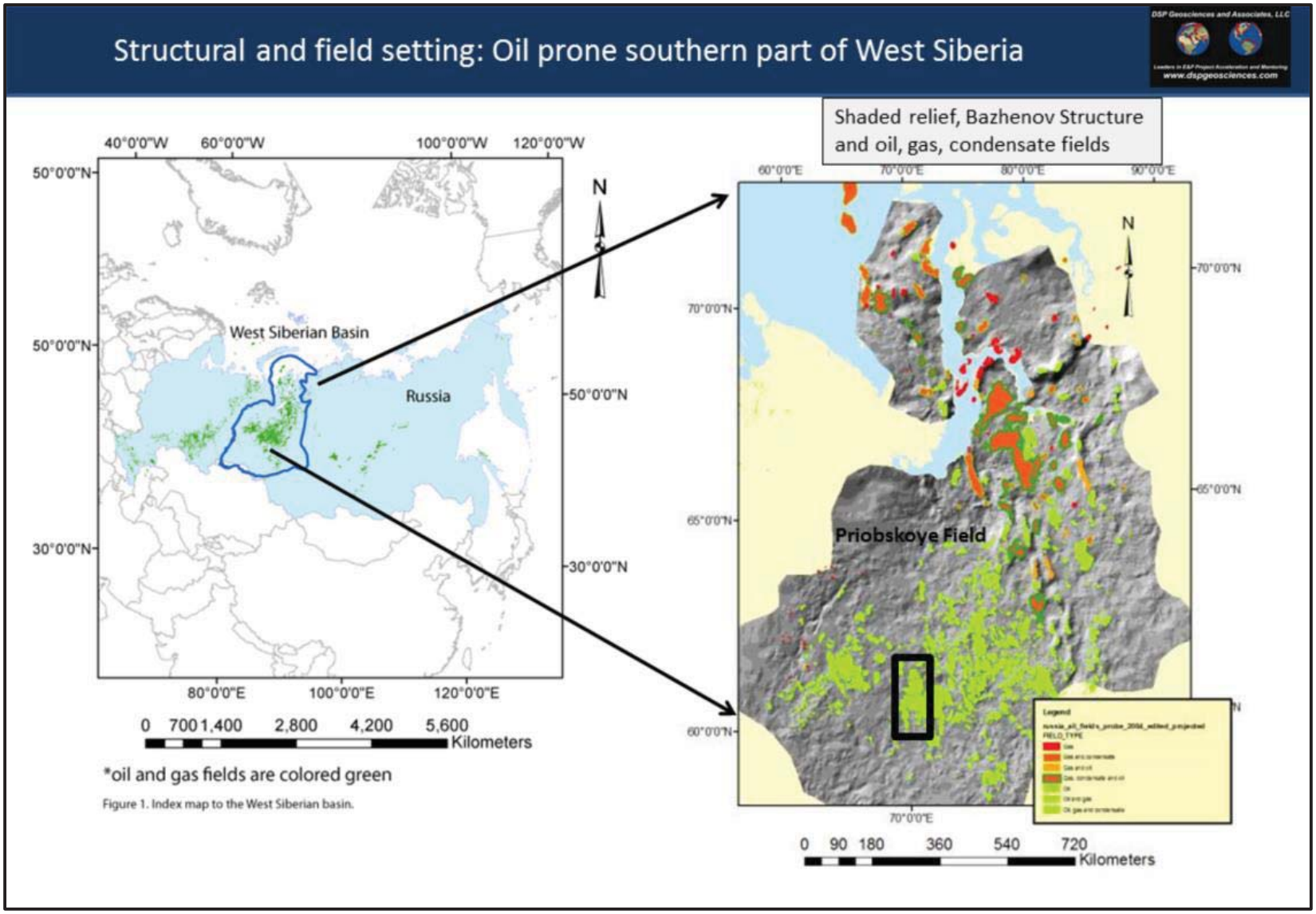
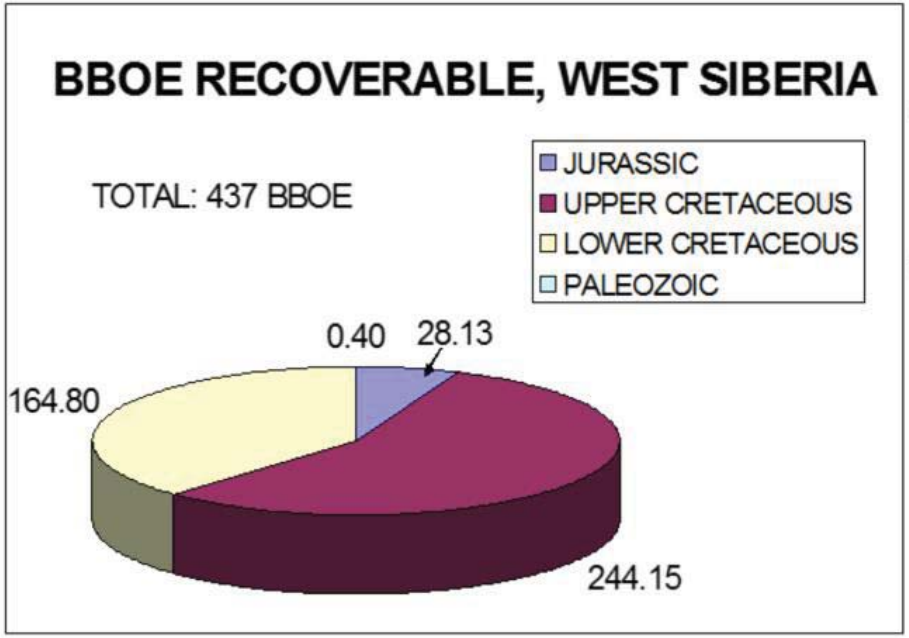
Acknowledgements

- The authors thank Gaspromneft for permission to publish this paper
- Many other Gaspromneft and consulting staff contributed to this study. These include but are not limited to
  - Gaspromneft
    - Natalia Nosova, Vasiliy Aranev, Victor Vasilyev
    - Elena Chuklantseva, Evgeniy Cherpanov, Yuri Pavlovskly, Yuri Chernyakov, Alia Shizyaeva, Mikhail Kolarov, Svetlana Malysheva, Andrei Betekhtin, Victoria Ovechkina, Olga Grobushkina
  - Geolograzvedka (St. Petersburg)
    - Maria Filatova
  - Geoseis Company (Tyumen)
    - Vladimir Igoshkin, Dimitri Sidorov



Slide originally from Igoshkin, V. J., J. C. Dolson, D. Sidorov, O. Bakuev, and R. Herbert, 2008, New Interpretations of the Evolution of the West Siberian Basin, Russia: Implications for Exploration, Search and Discovery Article #10161 (2008).

Basin Reserve Context



Over 6 BBOE in PRIOBSKOYE ALONE!

- Southern West Siberian Basin
- Largest Petroleum System in the World
- 450 + BBOE discovered
  - Neocomian
    - > 164 BBOE
  - Abundant stratigraphic trapping
    - Numerous giant stratigraphic traps
    - Thousands of smaller accumulations

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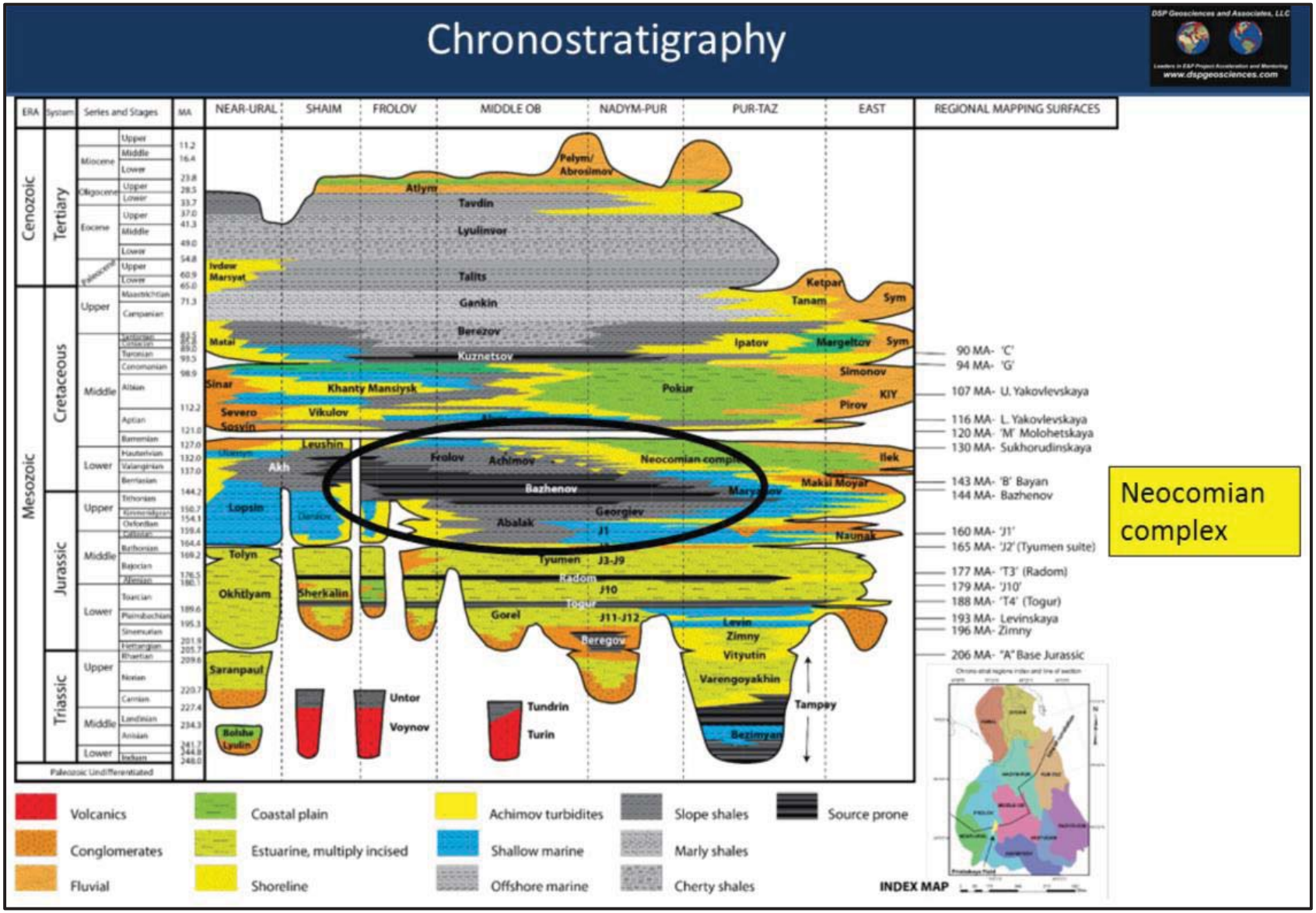
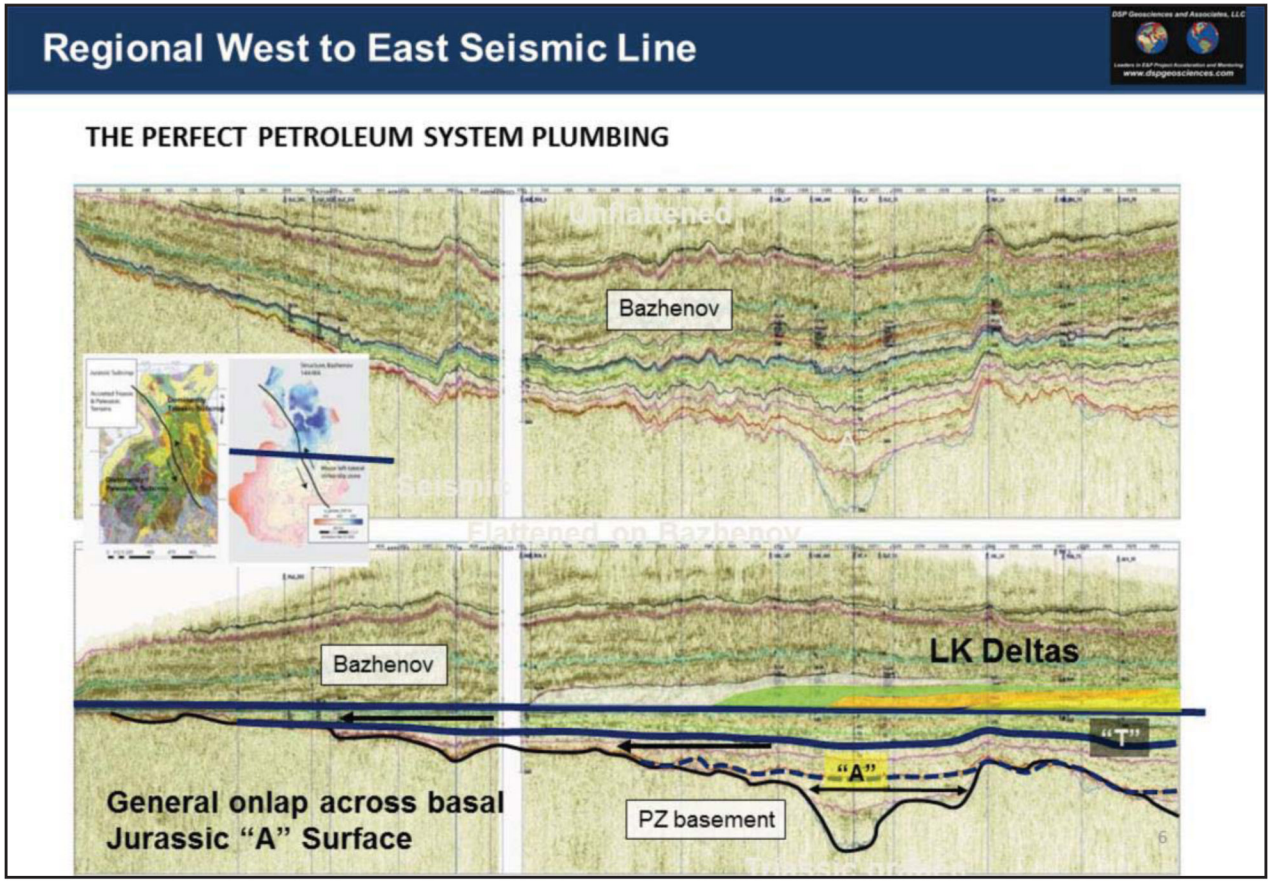


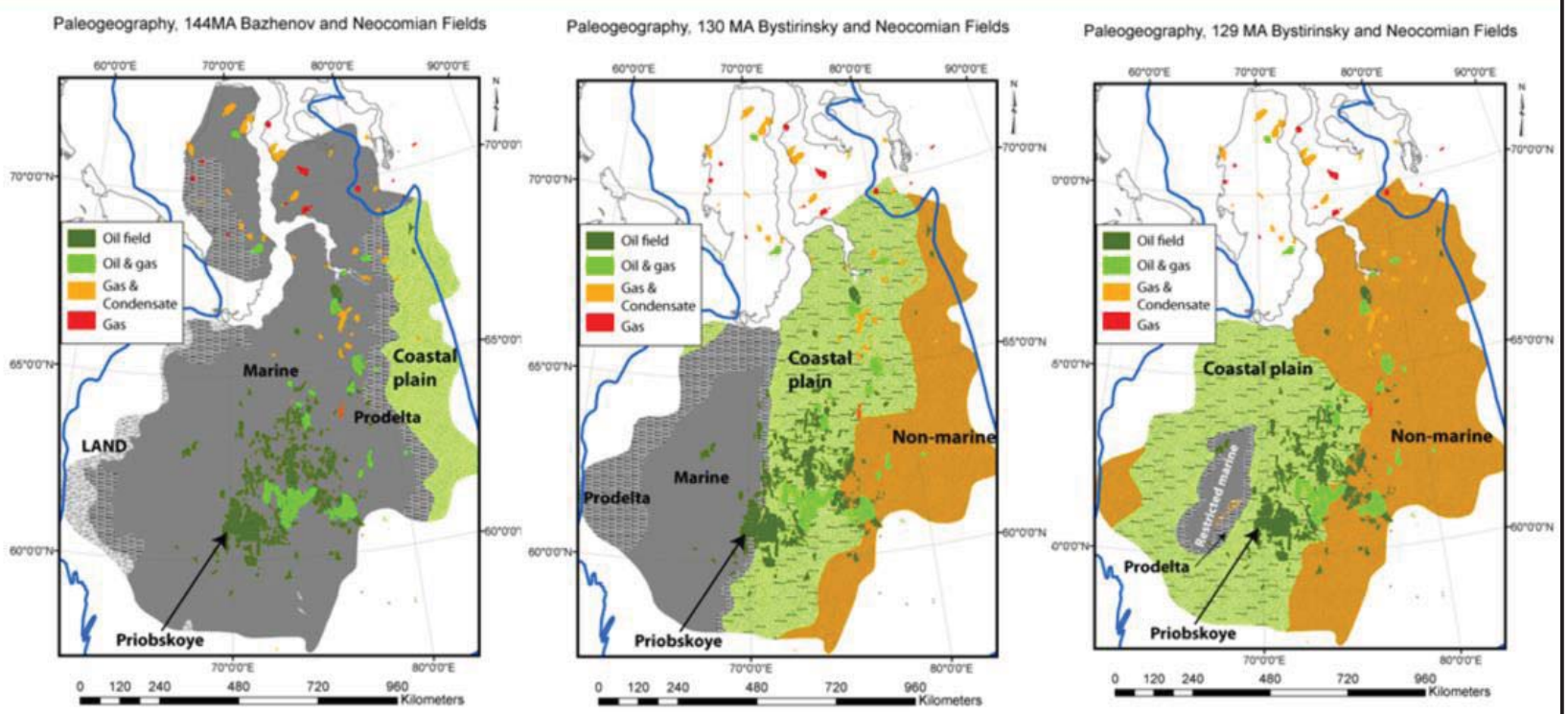
Modified from work done by Stephen Lowe, BP



Flattened and unflattened regional seismic illustrating a Triassic Rift and then the main surfaces (A-basement—actually the rift to drift unconformity), T surface (top of Tyumen or top of J2 *Glossifungites* surface regionally. Sections flattened on Bazhenov. Onlap and deep paleostructures are obvious below the A surface; topography is on rift shoulders and also on highly folded Paleozoic strata which formed pre-rift during Uralian collision.

Slide originally from Igoshkin, V. J., J. C. Dolson, D. Sidorov, O. Bakuev, and R. Herbert, 2008, New Interpretations of the Evolution of the West Siberian Basin, Russia: Implications for Exploration, Search and Discovery Article #10161 (2008).

Neocomian regression and Priobskoye Field location



- Regionally, at least 19 major clinoform packages
- Abundant stratigraphic trapping

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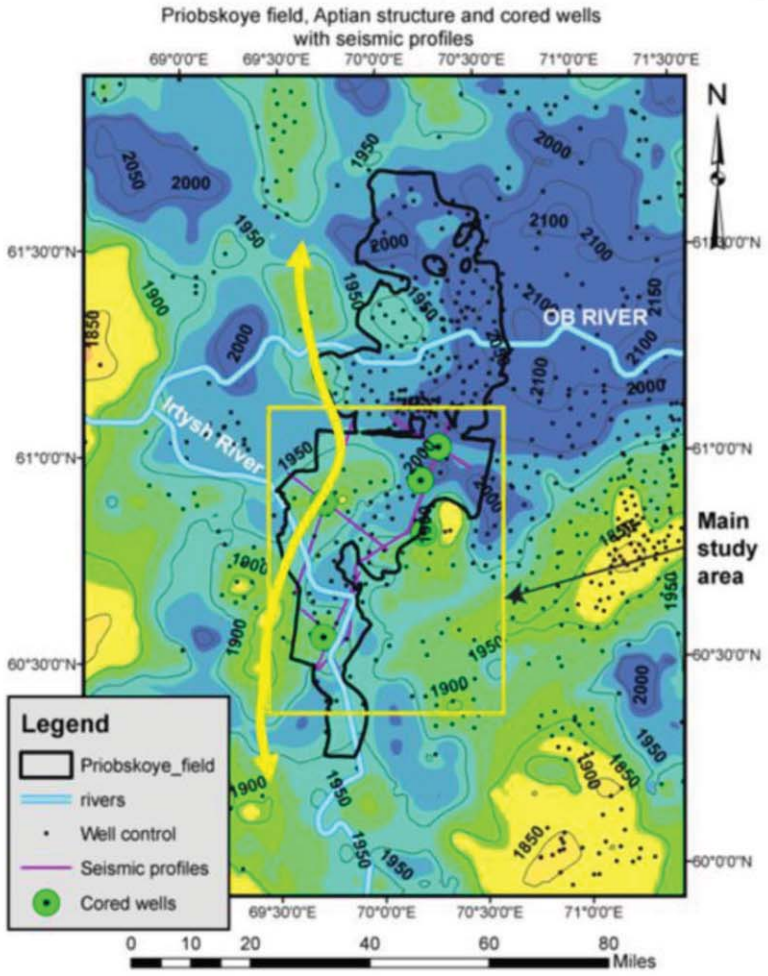
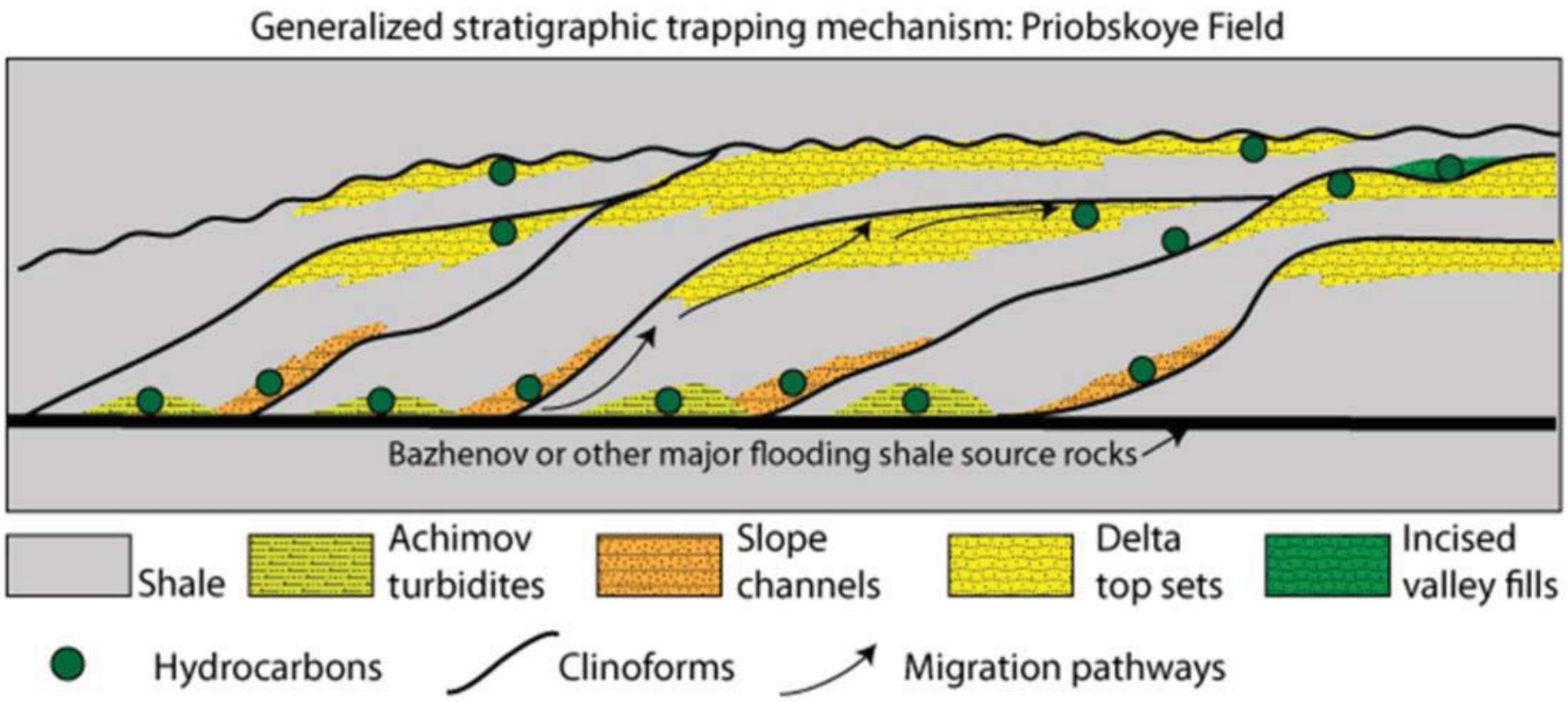
Detailed Study Area



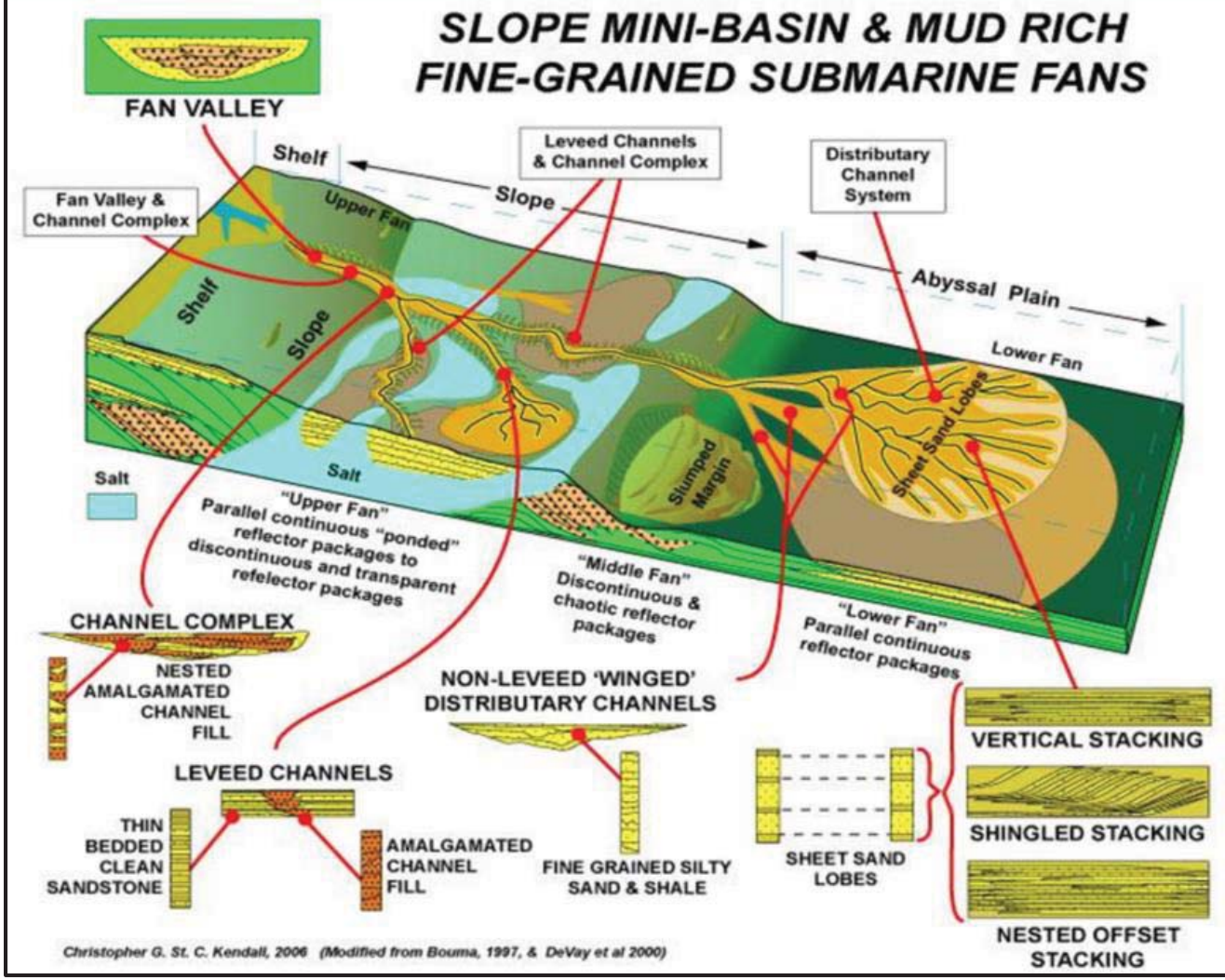
- Huge stratigraphic trap
  - **5.3 BBO + 1.17 TCF gas recoverable**
  - Field outline over 5000 km^2 trap
- Very gentle ramp dip on Aptian surface (a top seal)
  - Subtle arch, but no closure
- Study area southern ½ of field
  - 4 key wells with core and 3D seismic

Location of Priobskoye field, key cores, and seismic profiles. Colors show structural shapes on the Aptian 'M' seismic horizon (roughly the top seal), with contours displayed in positive TVDSS, meters.

A near perfect petroleum plumbing system



Depositional model (from Kendall, 2006)



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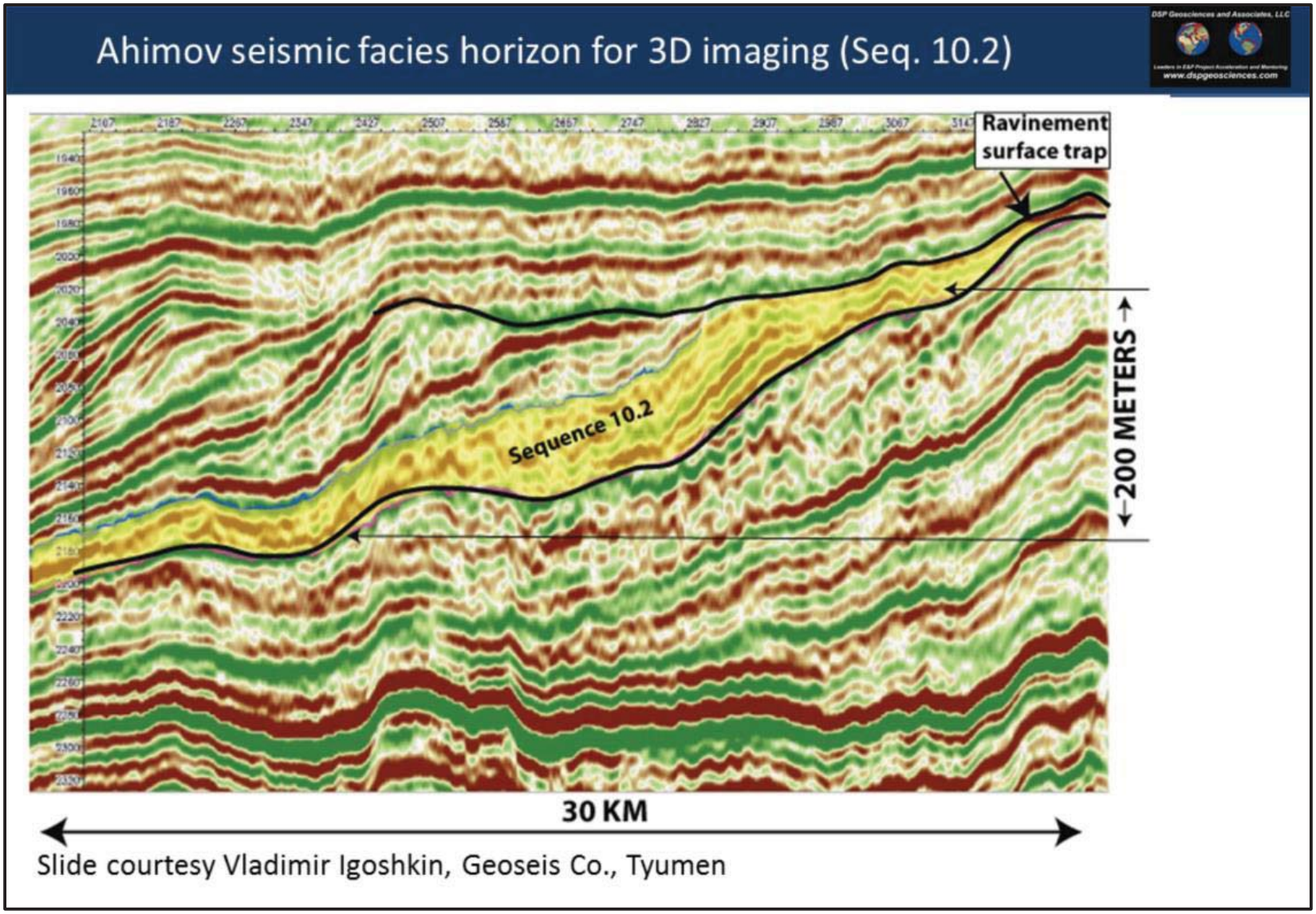

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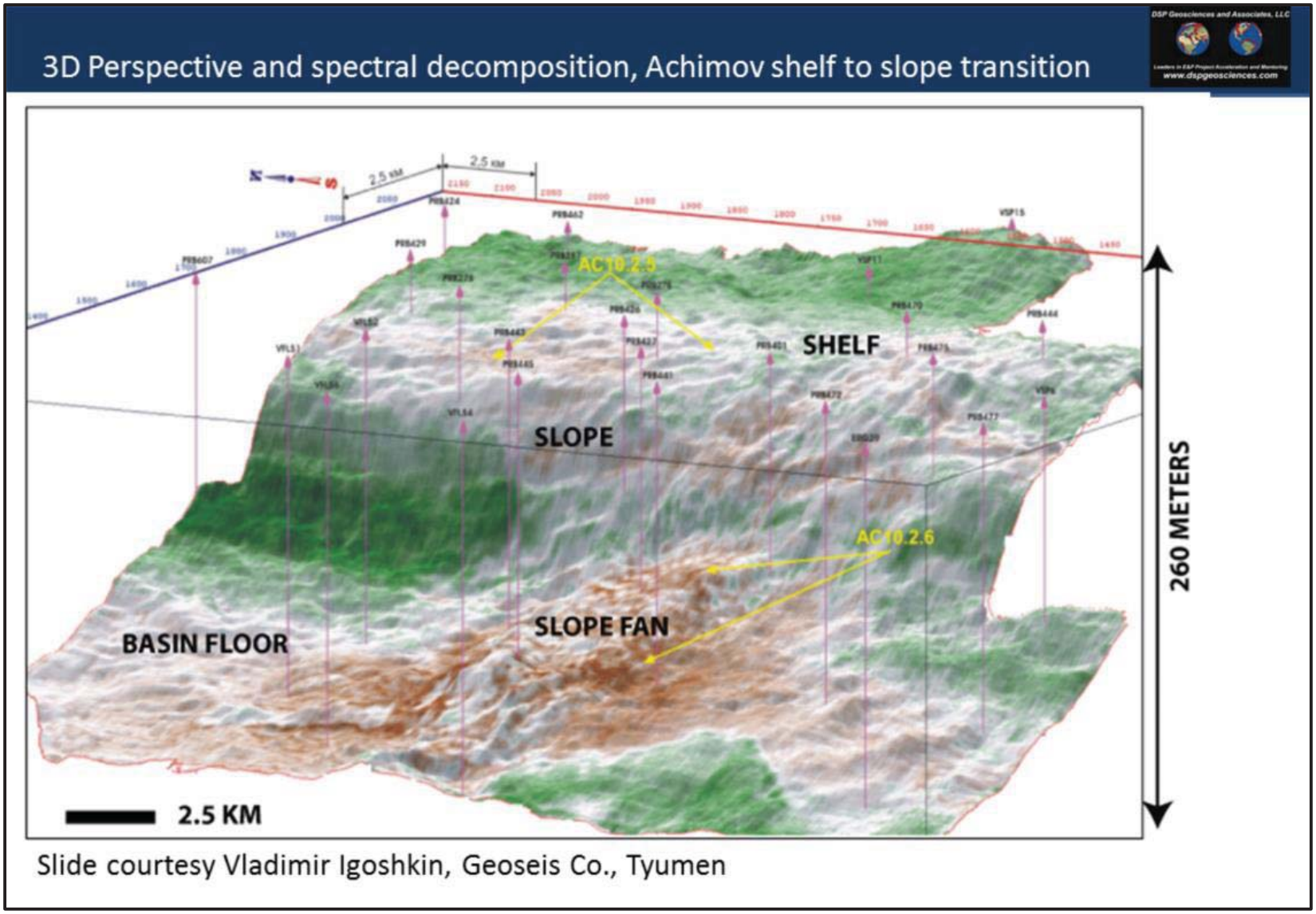

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Major cored facies classification

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Major Priobskoye Facies

Facies table
1 Shale or mud rock
2 Interbedded turbidities
- 2a sandstone dominated
- 2b sandstone turbidite and mudstone

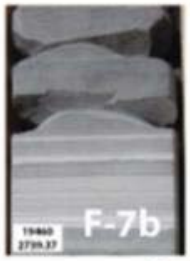
3 Sandstone
- 3a sandstone, cemented
- 3b sandstone, massive
- 3c sandstone, contorted

4 Debrite
5 Sandstone, vfg with mud rip ups
6 Siltstone
- 6a Siltstone, massive, contorted
- 6b Silstone, graded

7 Sandstone
- 7a sandstone, wavy bedded
- 7b sandstone, 50% mud, 50% sandstone

8 injectite
9 Sandstone, HCS bedding
- 9a Sandstone, HCS bedding, cemented

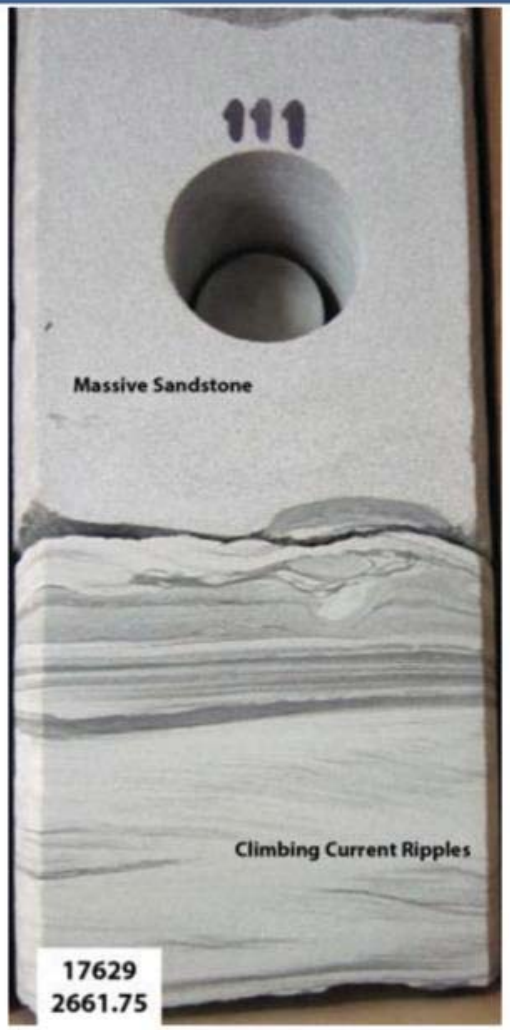
10 Sandstone, HCS with interbedded mudstone
11 Sandstone, bioturbated

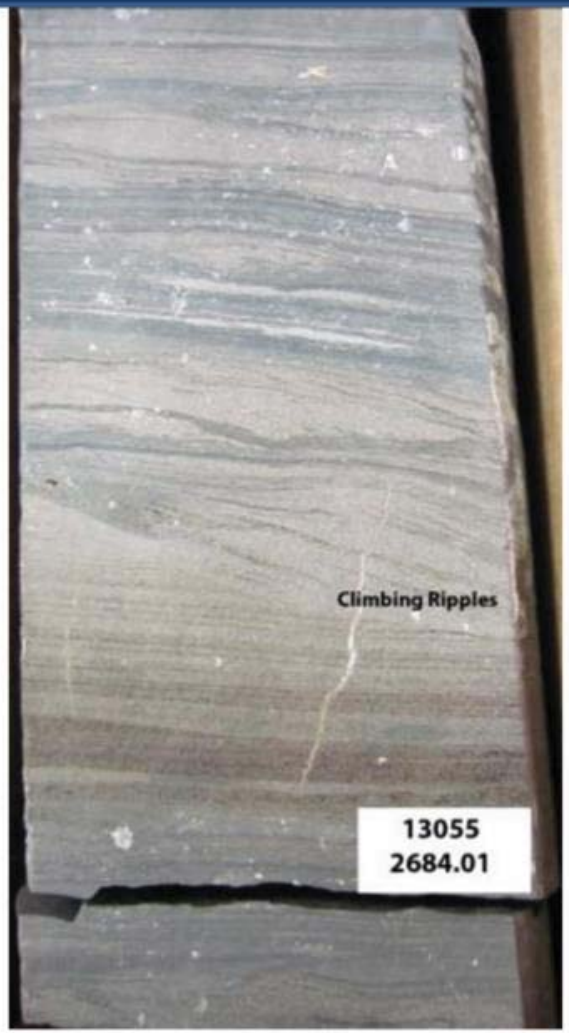


Sequence boundaries: Glossifungites Assemblage

Characteristic Bedding Styles and Physical Sedimentary Structures: Priobskoye Cores

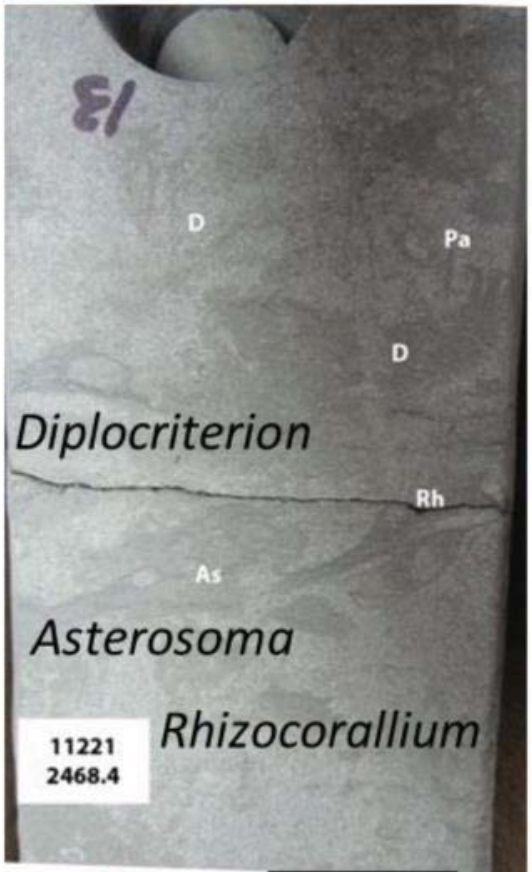
Indicators of Rapid Deposition: HCS, Current tipples

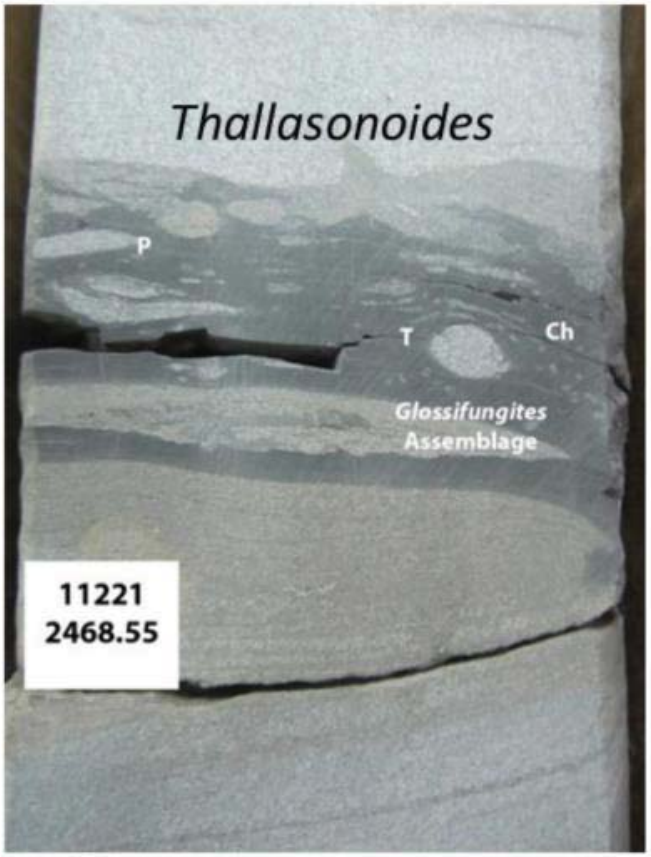


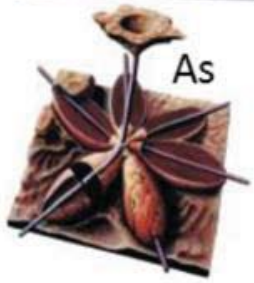


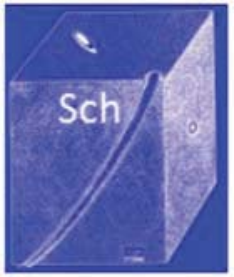
Indicators of Rapid Deposition: Micro faults and Ramp Creep

Major trace fossils

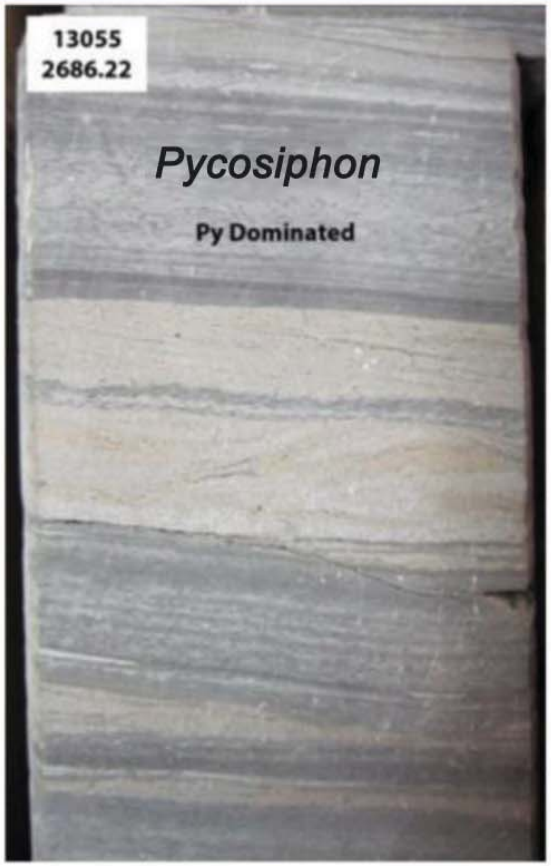


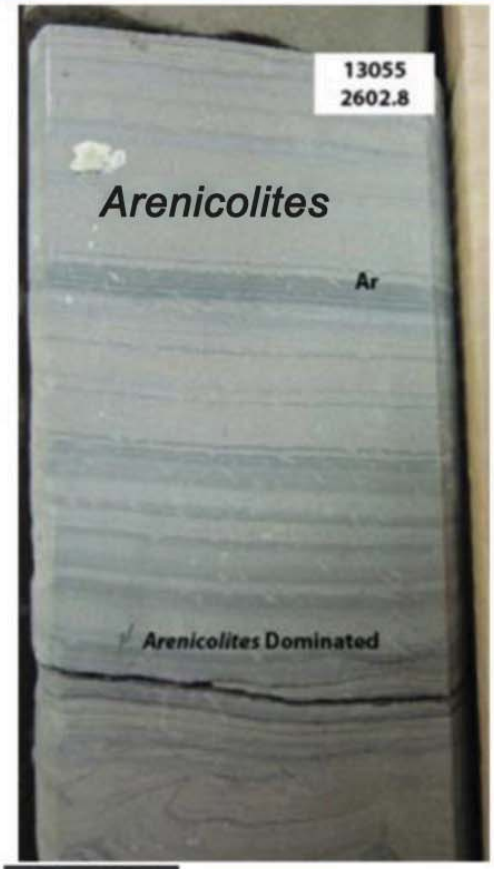






Trace Fossils

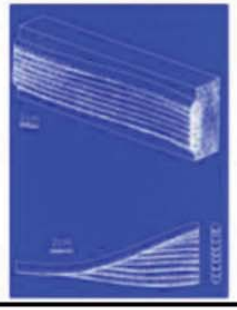




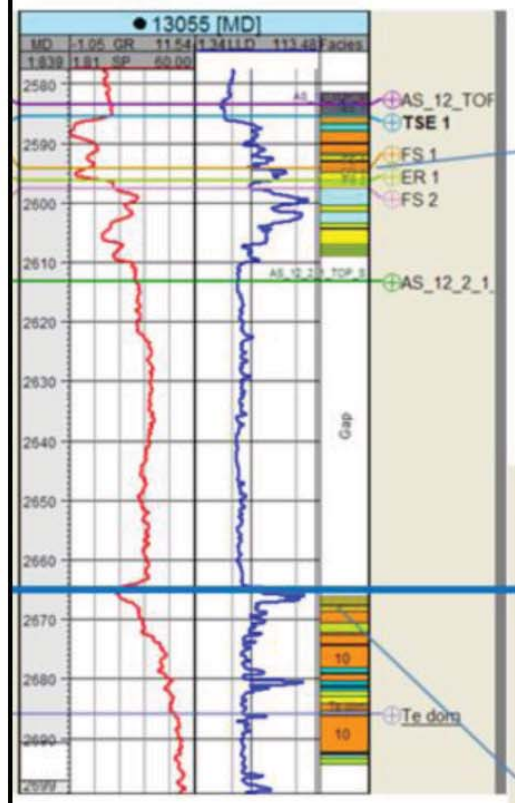
Py

Ar

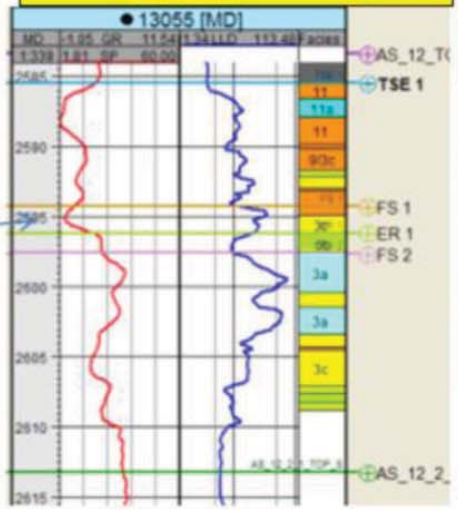
Te



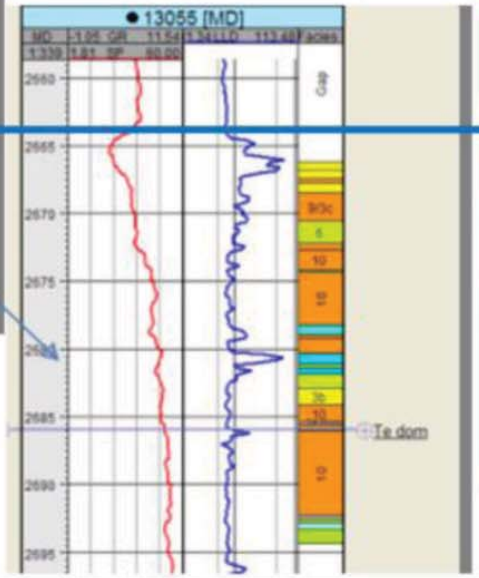
Shallow and slope marine facies: Well 13055



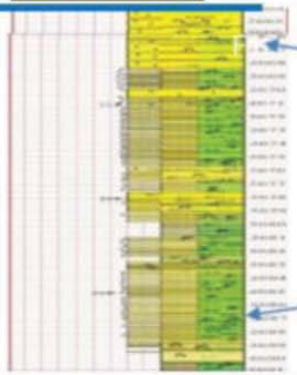
Shallow delta top sets



FS/SB

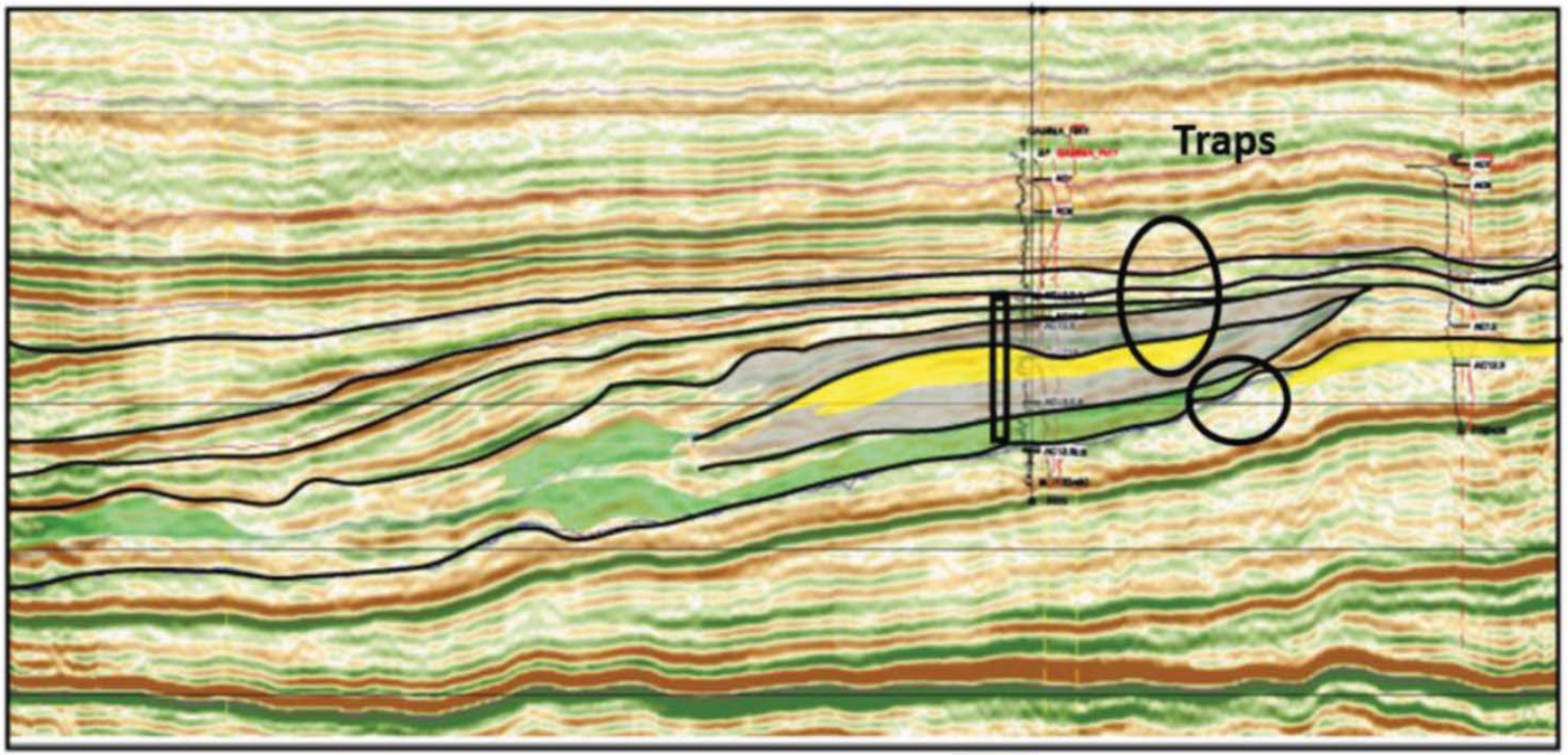


Slope Sequence



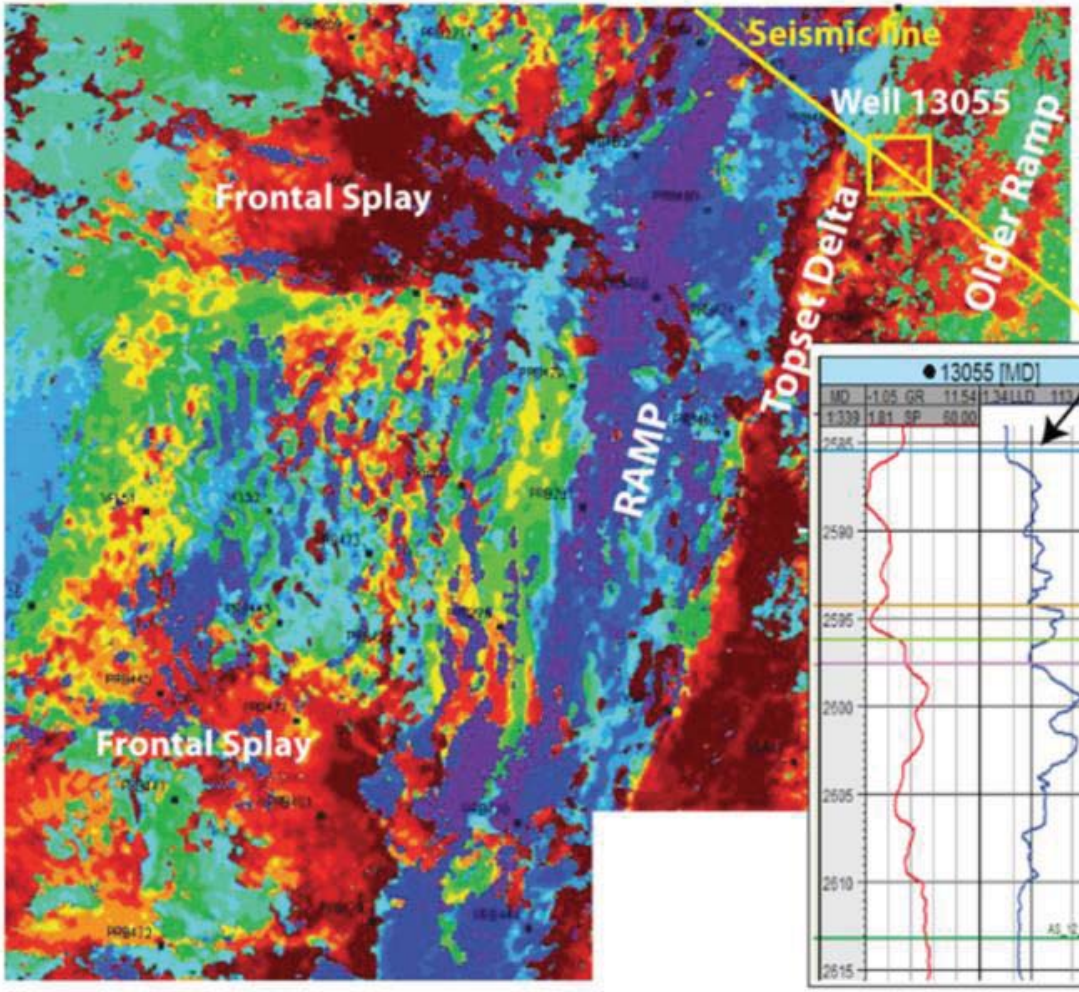
13055 Core and ravinement trap and slope turbidite pinchout

NW Seismic dip section A-A' 13055 Core PRB466 SE



Seismic wavelet classification (Stratimagic)

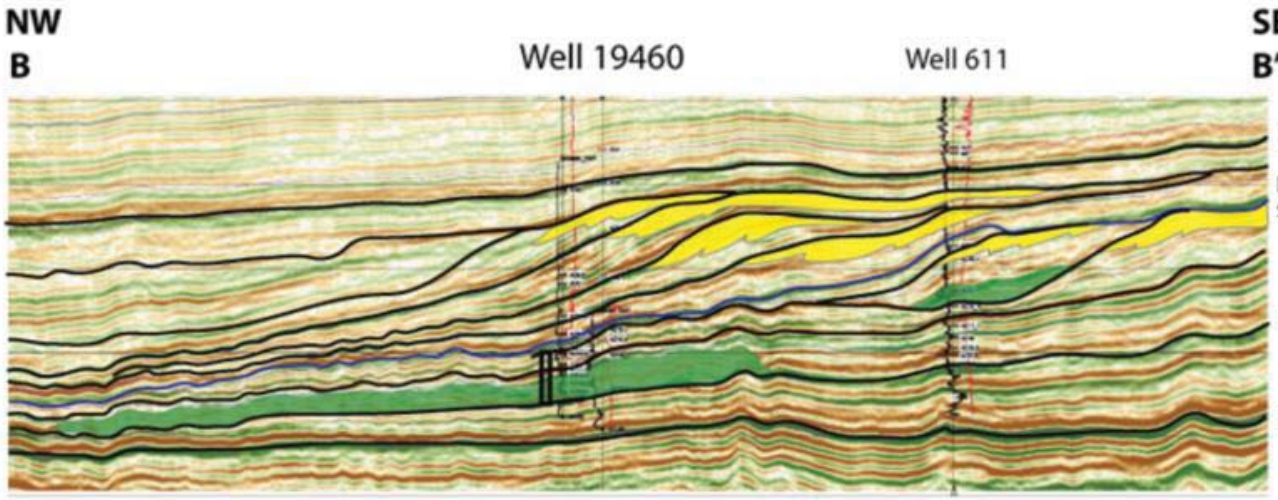
Seismic facies classification: Achimov AS12.1 to AS12.35 surfaces



Ravinement surface (TSE)

Well log and facies

Seismic facies through cored well 19460



Unflattened

Achimov turbidites

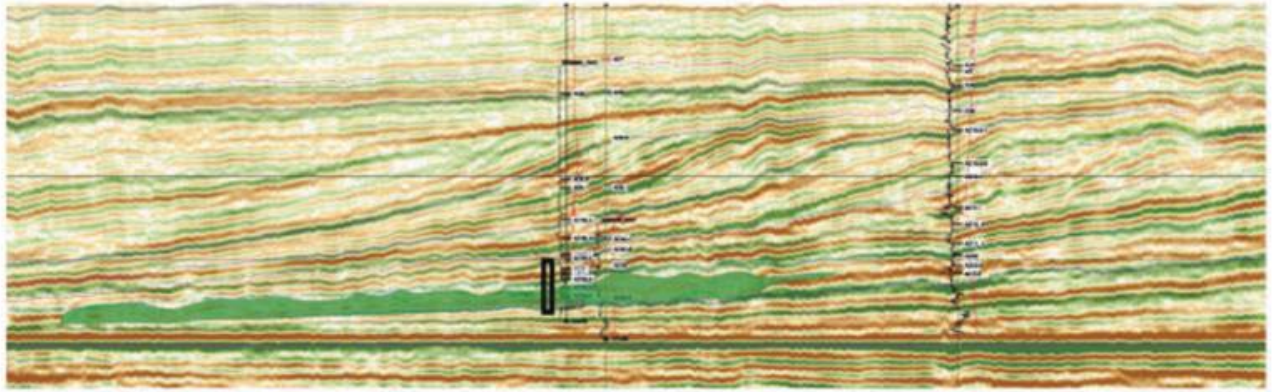
Delta top set sandstones

100 MS

22 KM

Cored interval

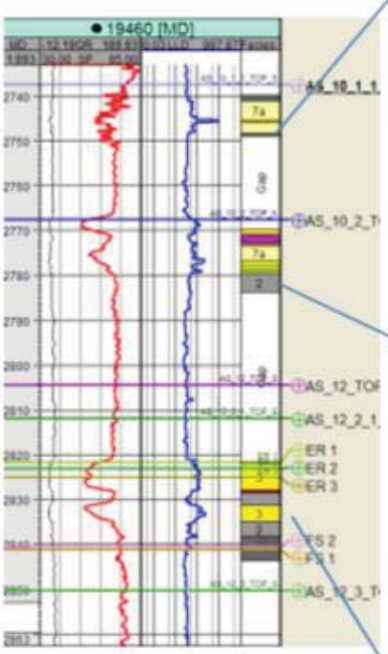
Flattened on Bazhenov

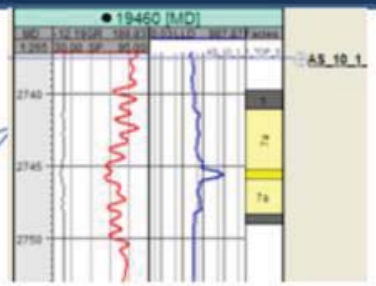


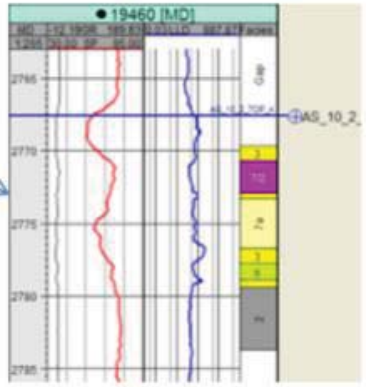
- Classic 'Achimov' turbidites
- Thick, widespread fans and sheet deposits

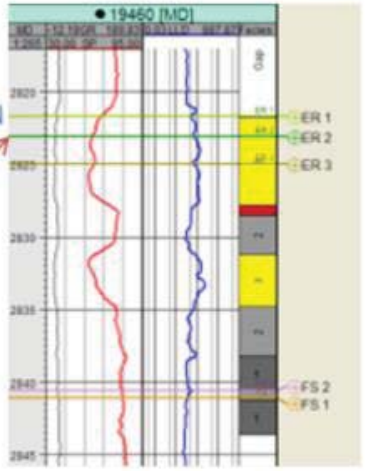
Deep Marine Facies: Well 19460

Well 19460



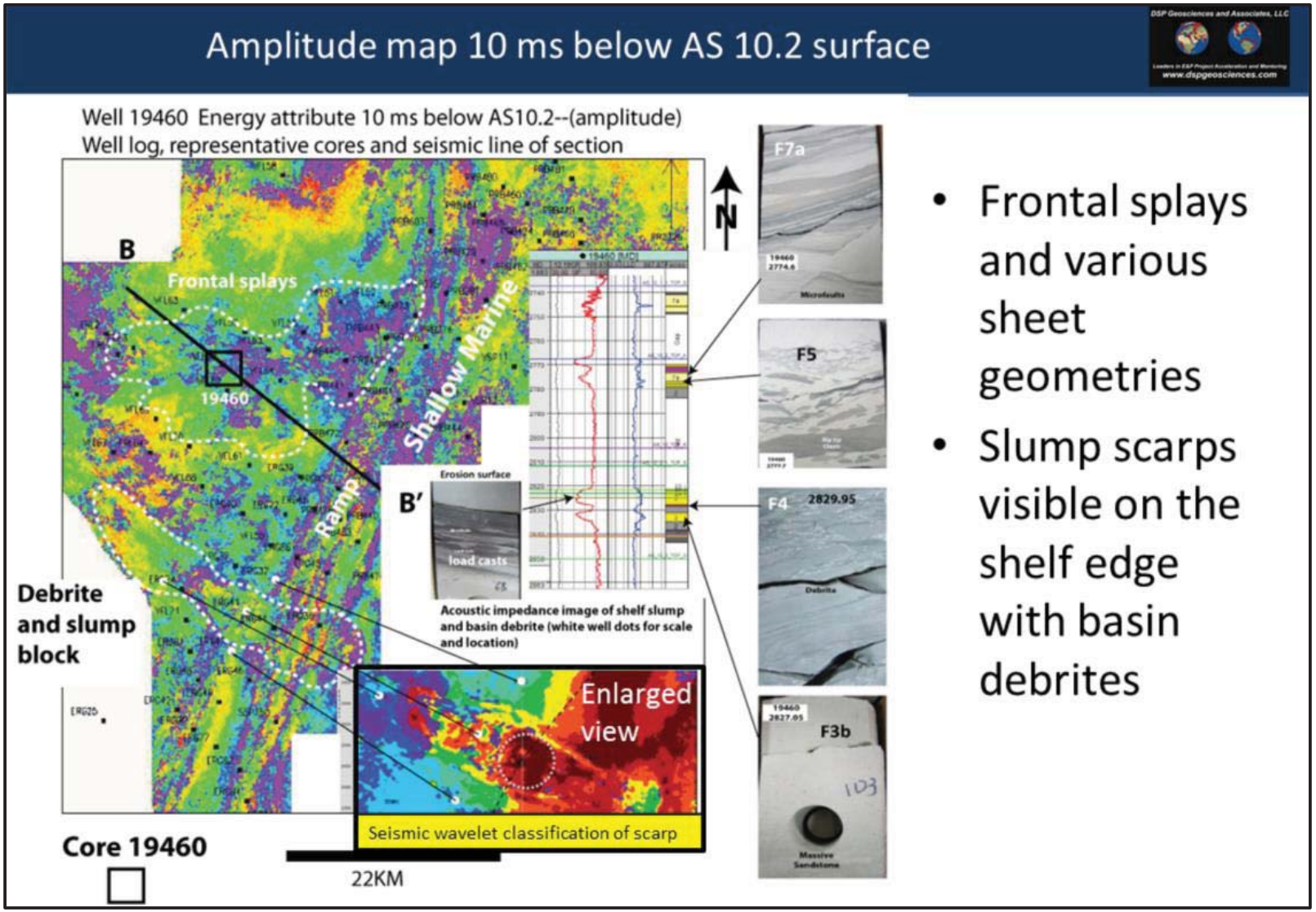






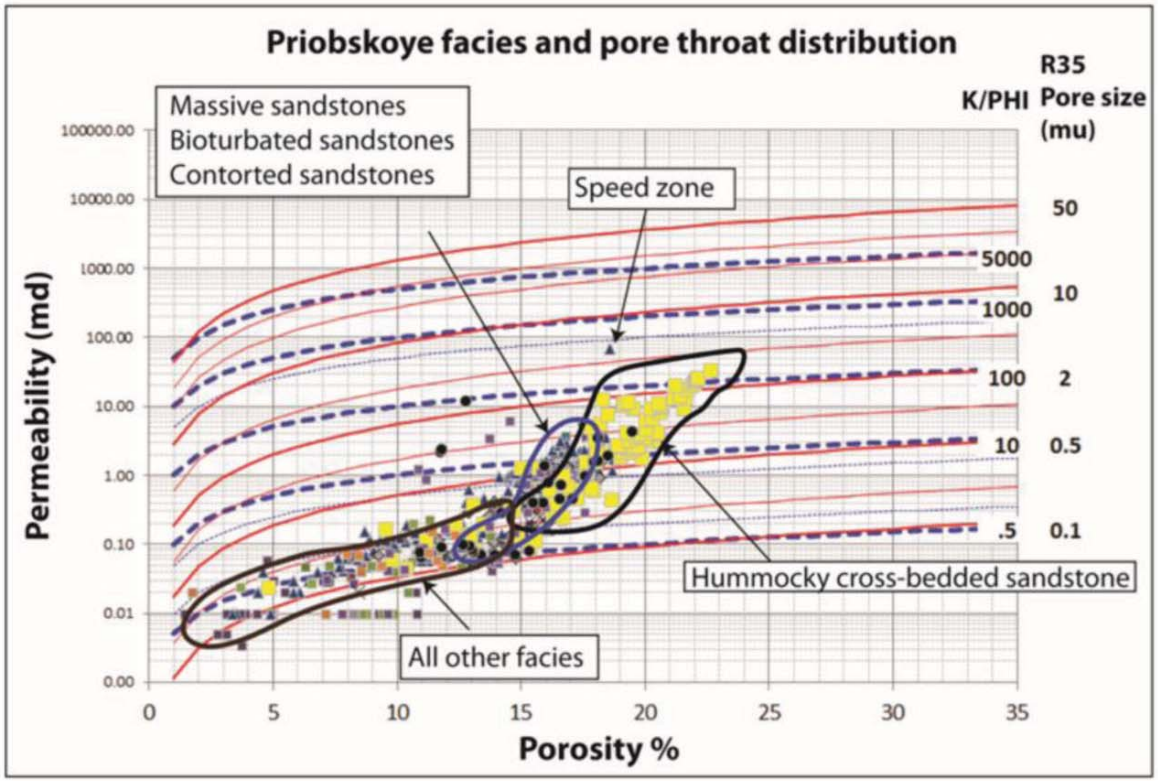
Erosion surface

Facies: Mud dominated (1, 2, 7b)
Silt dominated (6, 4)
Sand dominated (3, 5, 7a)



Seismic amplitude extraction at well 19460, with log and core facies. Shown in the bottom right of the seismic panel is an enlarged view of the debrite and slump block, using seismic wavelet classification. Slump-scarps like this are probably prevalent through the Priobskoye complex.

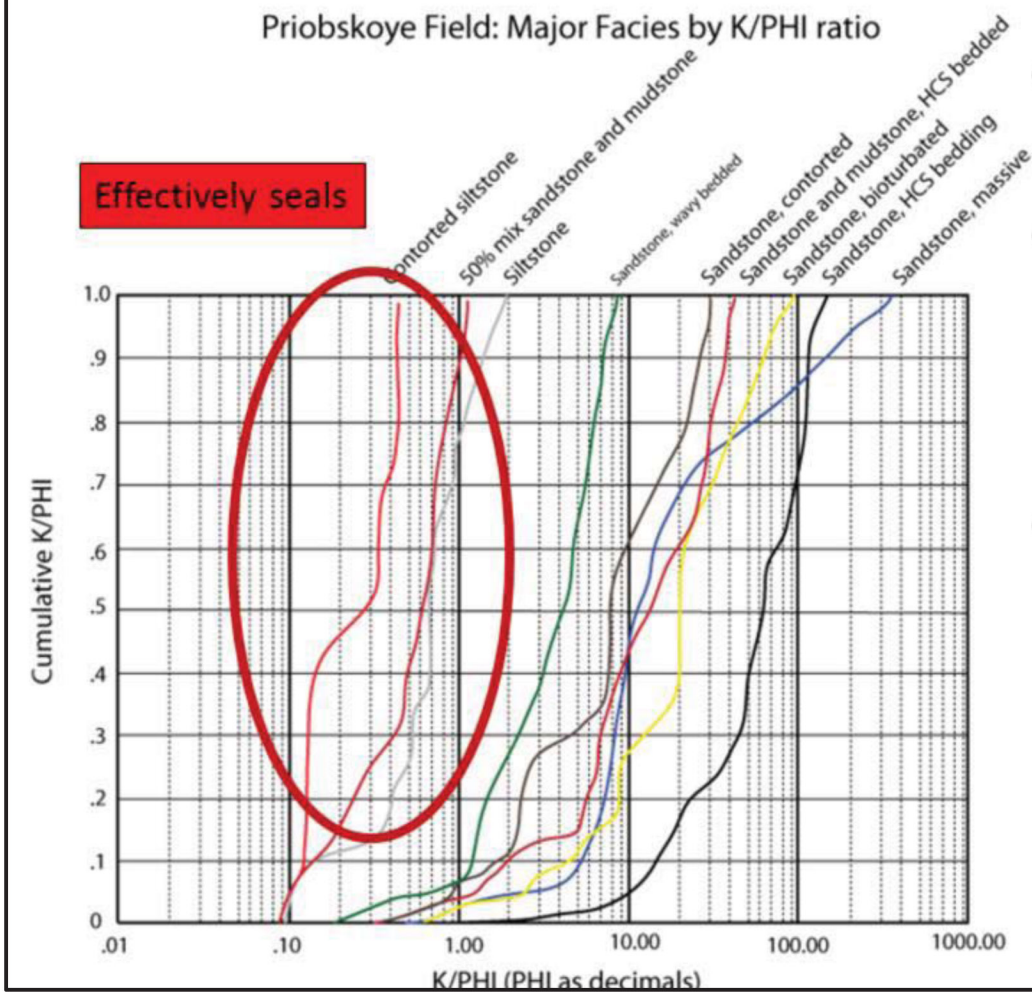
Windland Pore-throats by facies



- Reservoirs
  - Dominantly microporous
  - Hummocky sandstones best reservoirs
    - Dominantly deltaic top sets
  - Occasional 'speed zones' of high perm in turbidites with no calcite cement
  - Calcite cementation is a major cause of permeability reduction

Technique covered in Pittman, E., 1992, Relationship of porosity and permeability to various parameters derived from mercury injection-capillary pressure curves for sandstone: American Association of Petroleum Geologists Bulletin, v. 76, p. 191-198.

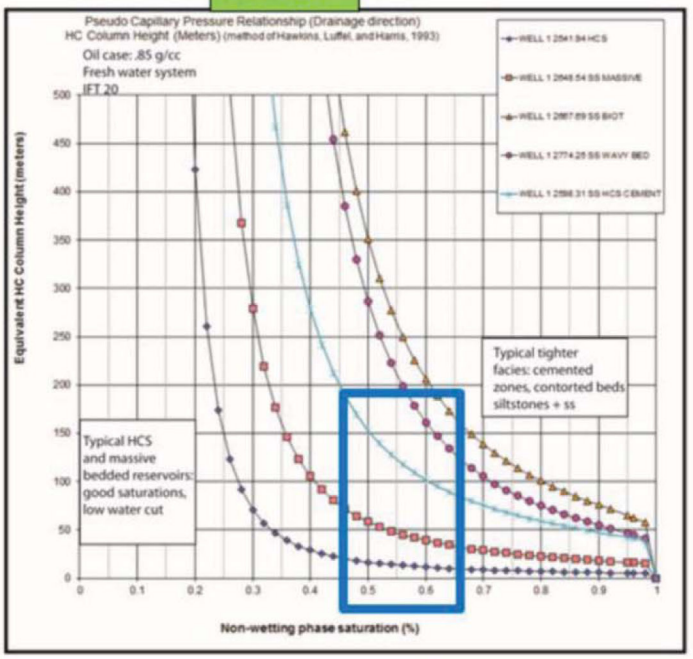
Facies breakout by K/PHI plots

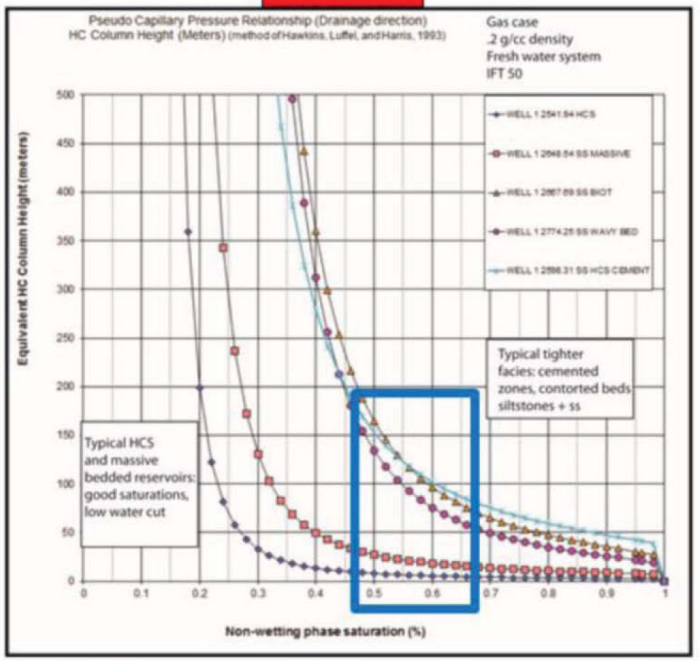


- Cumulative K/PHI plots
- SEALS:
  - Contorted silts, laminated muds/sands 50%
- RESERVOIRS
  - HCS-bedded sandstones
  - Low-calcite cement facies

Technique covered in Gunter, G. W., J. M. Finneran, D. J. Hartmann, and J. D. Miller, 1997, Early determination of reservoir flow units using an integrated petrophysical method: Society of Petroleum Engineers, v. SPE 38679, p. 1-8.

Representative pseudo-capillary pressure curves for major facies- Height above free water plot





'Transition zone high water cut saturations'

- Representative pseudo-capillary curves--mimic actual cap pressure in study
- HCS- and massive-bedded reservoirs
  - Low water-cut low on traps
- Cemented and other facies
  - High water-cut low on the traps

Equations for pseudo-capillary pressure analysis from:
Hawkins, J. M., D. L. Luffel, and T. G. Harris, 1993, Capillary pressure model predicts distance to gas/water, oil/water contact: Oil and Gas Journal, Jan. 18, p. 39-43.
Spreadsheet developed by Keith Shanley, DSP Geosciences

Conclusions

- **Ideal stratigraphic trapping geometries**
  - Turbidites and top-set deltaic sands plumbed directly onto underlying LK and JRSC source rocks
  - Primary shallow facies trapping is top-set truncation by marine ravinement
  - Primary deep-water (Achimov) facies is largely purely stratigraphic
  - Pervasively saturated with probably multiple free-water levels and trapping geometries
- **A global model for similar traps in 'clinoform' packages (including carbonates)**
- **Slope turbidite deposition**
  - Weakly developed slope channels and some slump-scarp development
- **Proper log correlation requires higher resolution 3D seismic with well ties**
  - Many older interpretations correlate deltaic top sets and Achimov facies as 'blanket' sheets of sandstone
- **Most reservoirs are micro- and mesoporous**
  - Require significant columns to produce water-free
  - Best reservoirs are top-set deltas and cleaner Achimov turbidites (less calcite cement)
- **Hydraulic fracturing**
  - Necessary for many commercial rates

A bit of humor--American Revenge on the Russian Language

- J. Dolson took weeks to learn the Russian word for 'oil field'—

—месторождение нефти

- He has enjoyed immensely forcing Russian colleagues to learn:

—*Glossifungites* ichnofacies

Thank You!

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