#### The Precambrian Petroleum Systems of Eastern Siberia: Evidence from Oil Geochemistry and Basin Modeling\*

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#### **Abstract**

Uncertainties regarding the number, location, and areal extent of Precambrian petroleum systems in Eastern Siberia are primarily attributed to a lack of direct source rock data. This study provides an indirect characterization of source rocks contributing to petroliferous areas (PAs) in the southern Lena-Tunguska region through an assessment of available geochemical data from oils and gases contained in reservoirs from the Vendian through Lower Cambrian. Geochemical data and basin modeling were used to: (1) establish the number of source rocks contributing to hydrocarbon accumulations; (2) define source-rock depositional systems and lithology; (3) estimate source-rock thermal maturity; and (4) predict source location and migration patterns.

In this study, geochemical interpretations are made on oil and gas data available from the published literature and GeoMark Reservoir Fluid Database and include comparisons of samples from the Nepa-Botuoba, Angara-Yenisey, Katanga Saddle, and Baykit PAs. Analysis of these data within the paleogeographic context of Eastern Siberia indicate significant geochemical differences among oils from the Nepa-Botuoba, Angara-Yenisey, and Baykit PAs, strongly supporting hydrocarbon generation from three distinct source rocks. Biomarker evidence and bulk fluid properties indicate long distance, lateral migration of Nepa-Botuoba oils across the anteclise, resulting in hydrocarbon accumulations nearer the inferred source, with the hydrocarbons being heavier and containing relatively more gas and sulfur, although these trends are somewhat complicated by local structures and multiple, stacked reservoirs.

One-dimensional maturity models of pseudo-wells in the Nepa-Botuoba and Angara-Yenisey PAs are constructed incorporating inferred source-rock characteristics to constrain the timing and thermal histories of the petroleum system components. The drowning of the Siberian platform and formation of thick salt layers during the Early Cambrian controlled both accumulation and preservation of hydrocarbons in the Eastern Siberian PAs. In addition, the highly saline pore waters created during this period prevented biodegradation of hydrocarbons in the reservoirs, independent of reservoir temperature history. These results suggest that large accumulations of hydrocarbons in the Nepa-Botuoba PA are more likely to be limited by the lateral continuity of reservoir units than by the timing of hydrocarbon accumulation and preservation.

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#### **Selected Reference**

Clarke, J.W., 1985, Petroleum Geology of East Siberia: United States Department of the Interior Geological Survey, Open-File Report 85-367, 132 p.

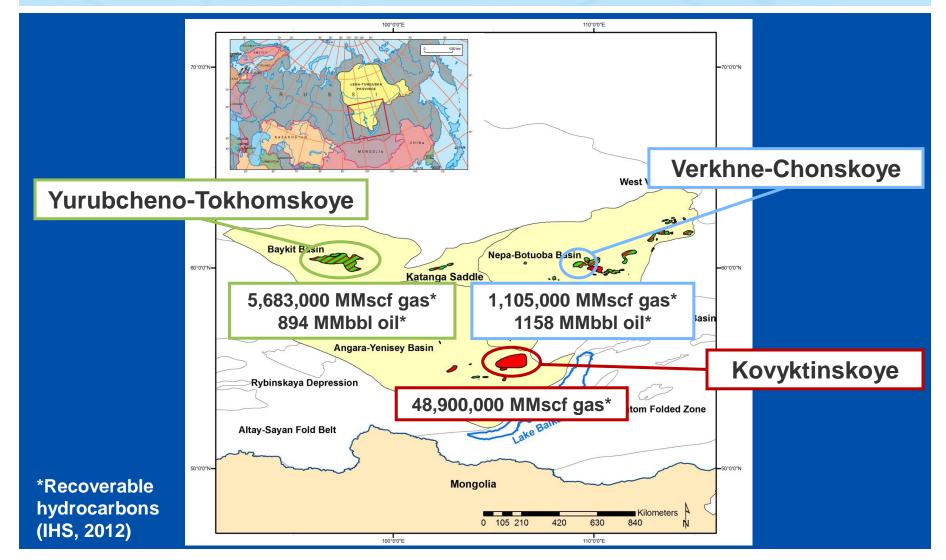
## The Precambrian Petroleum Systems of Eastern Siberia: Evidence from Oil Geochemistry and Basin Modeling





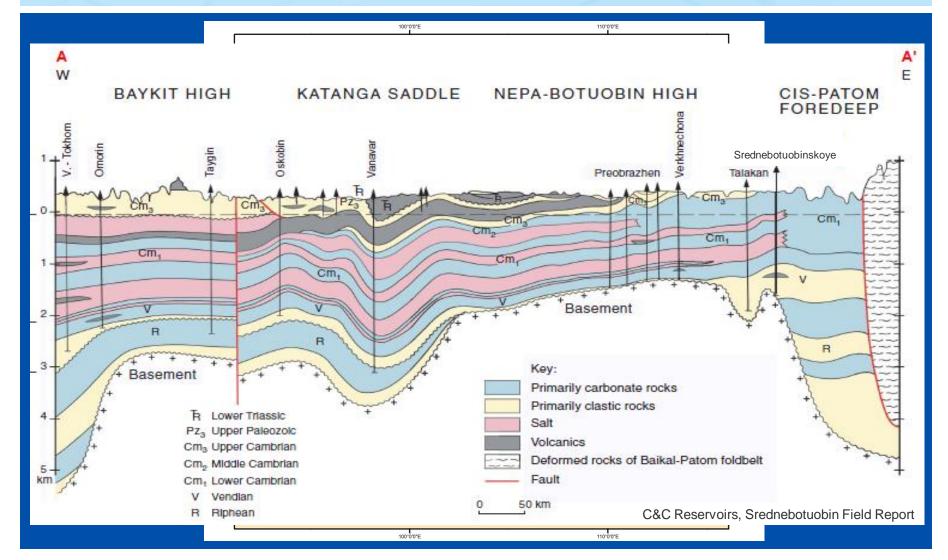
## Evidence for Effective Petroleum System(s) in Eastern Siberia





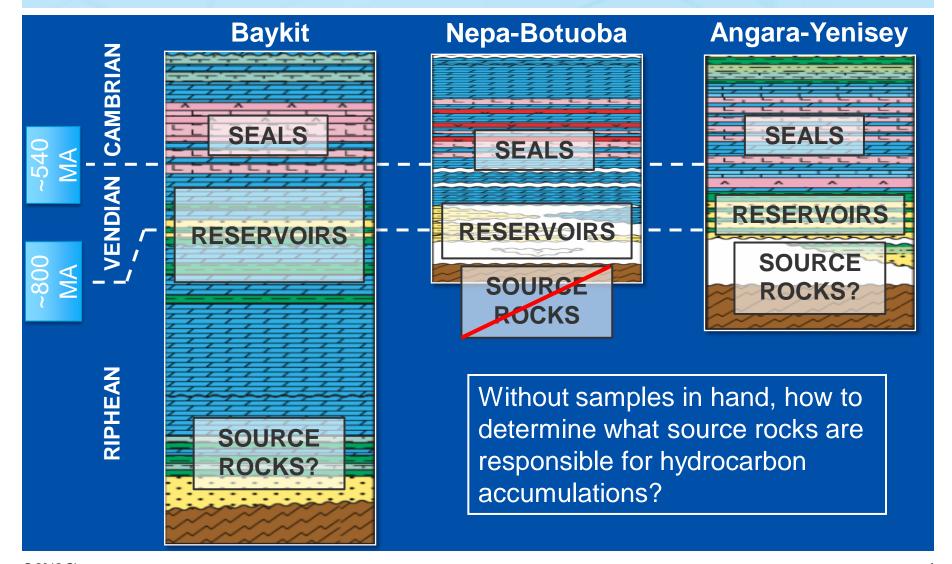
### Tectono-Stratigraphic Development





## Known Petroleum System Components and Key Uncertainties





## Geochemical and Petroleum Systems Analysis Workflow



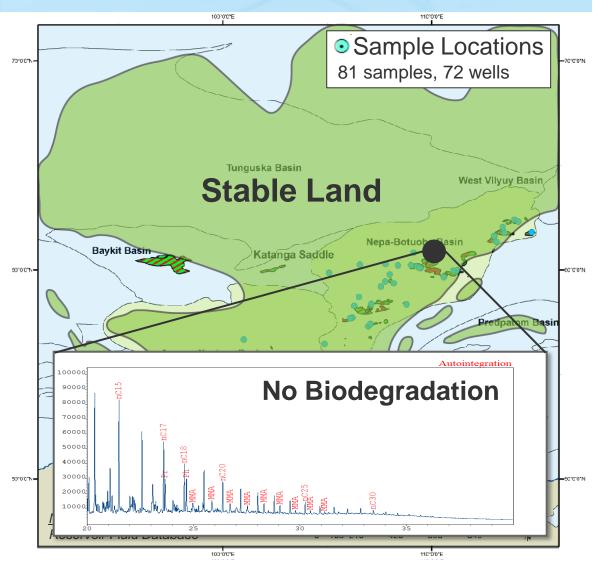
Compare oil data to determine oil families; differences reflect source rock origins



Use oil interpretations and paleogeography to determine possible SR environments and depocenters

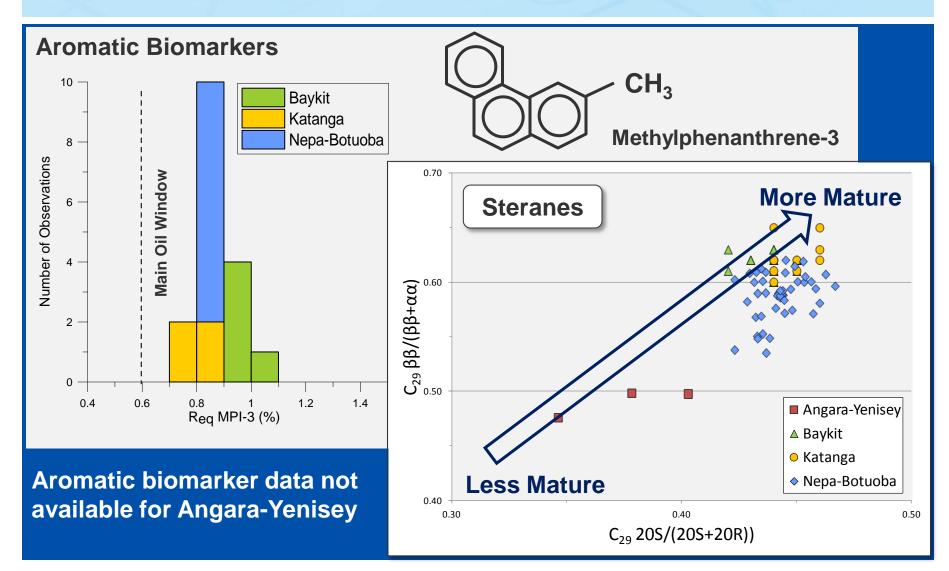


Construct 1D models of pseudo-wells to constrain burial and thermal histories



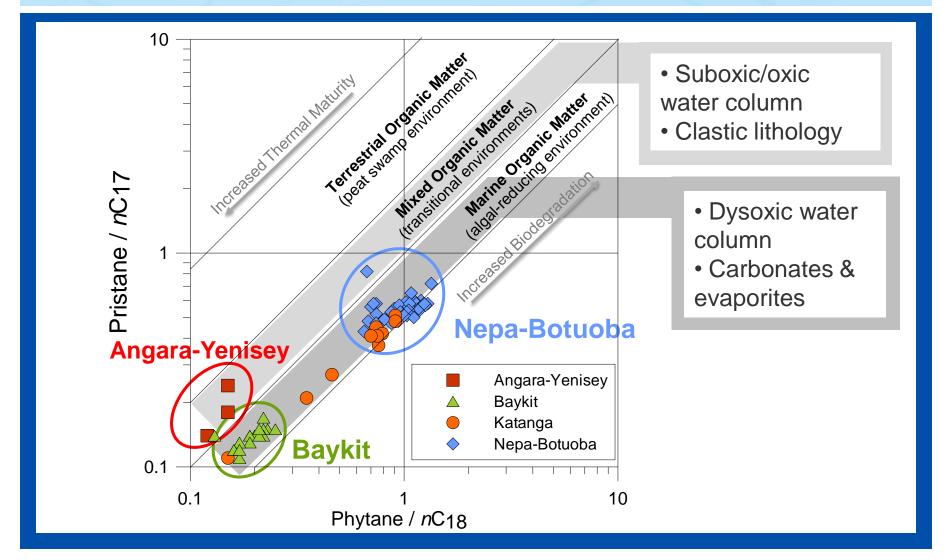
## Thermal Maturity of Eastern Siberian Oils





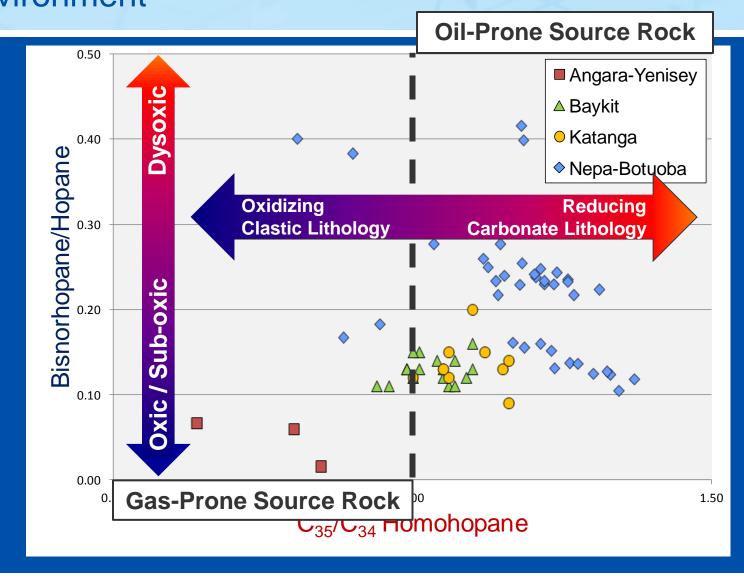
## Whole-Oil Indicators of Source Rock Depositional Environment & Organic Matter





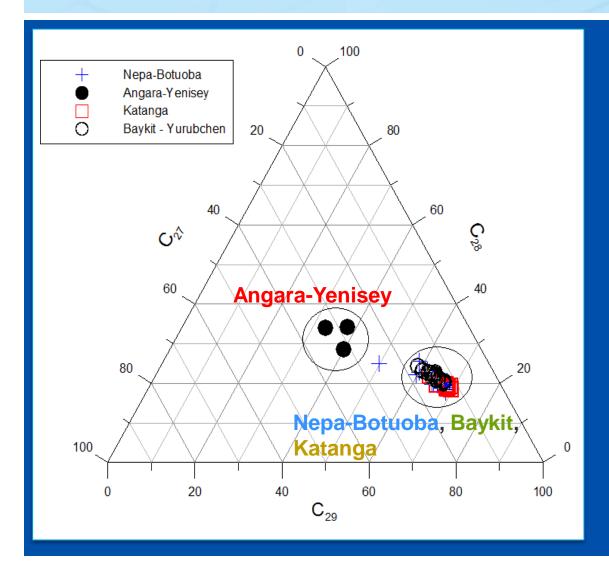
### Biomarker Indicators of Source Rock Depositional Environment





## Biomarker Indicators of Source Rock Depositional Environment & Organic Matter



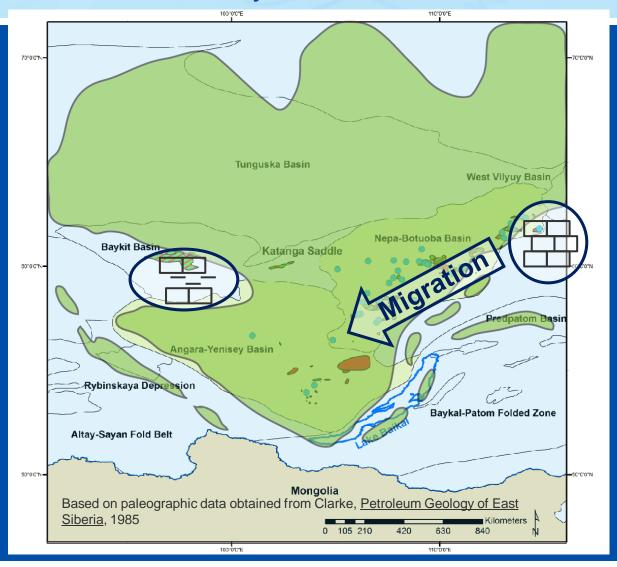


- Oils from Nepa-Botuoba, Katanga and Baykit show  $St_{29}$  dominance, similar to that seen in oils from the carbonaceous Ara Fm. (Oman Basin)
- Oils from Angara-Yenisey show nearly equal proportions of St<sub>27</sub>, St<sub>28</sub>, and St<sub>29</sub>, similar to the sterane distribution in the clastic Nafun Fm. (Oman Basin)

# Probable Source Rock Depocenters for the Baykit and Nepa-Botuoba Petroleum Systems

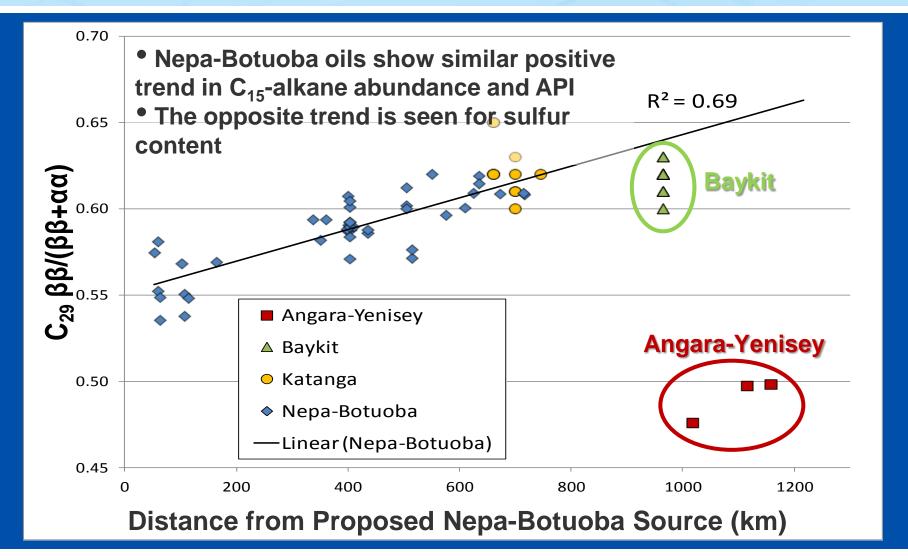


Early – Middle Late Riphean



### Evidence for Three Separate Petroleum Systems

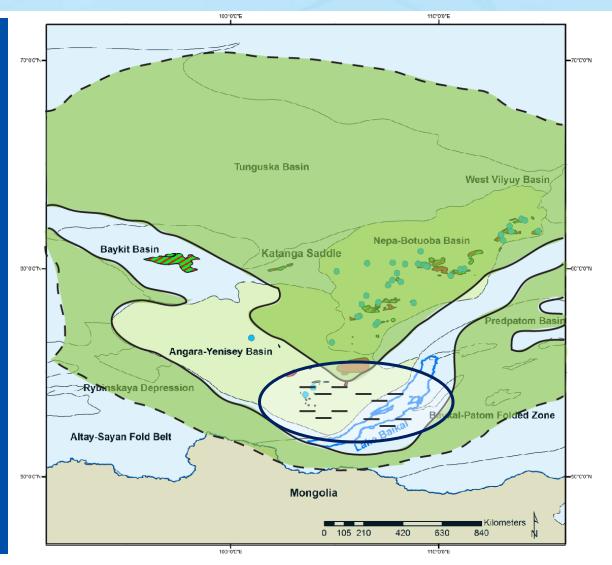




## Probable Source Rock Depocenter for the Angara-Yenisey Petroleum System

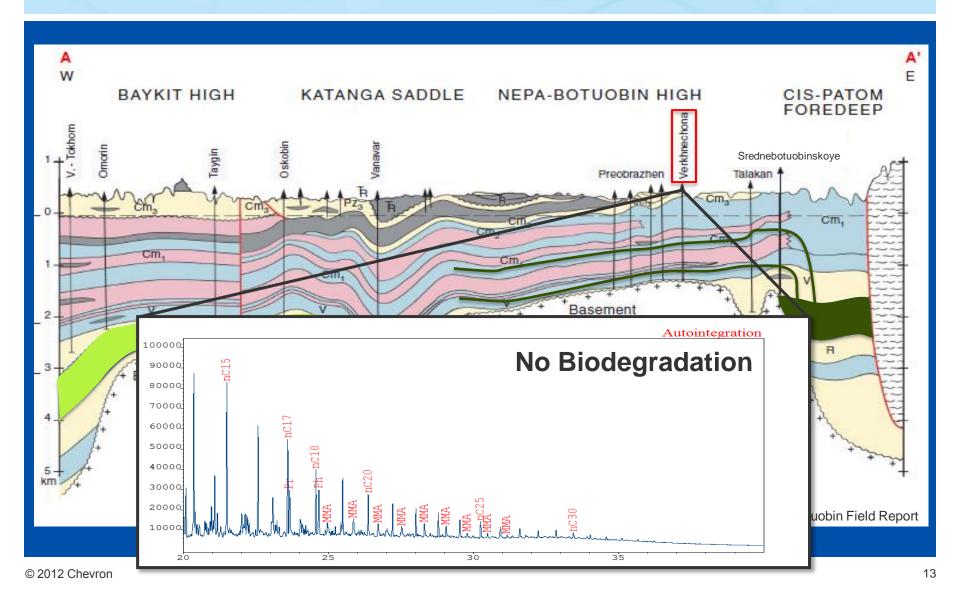


Late Riphean – Early Vendian



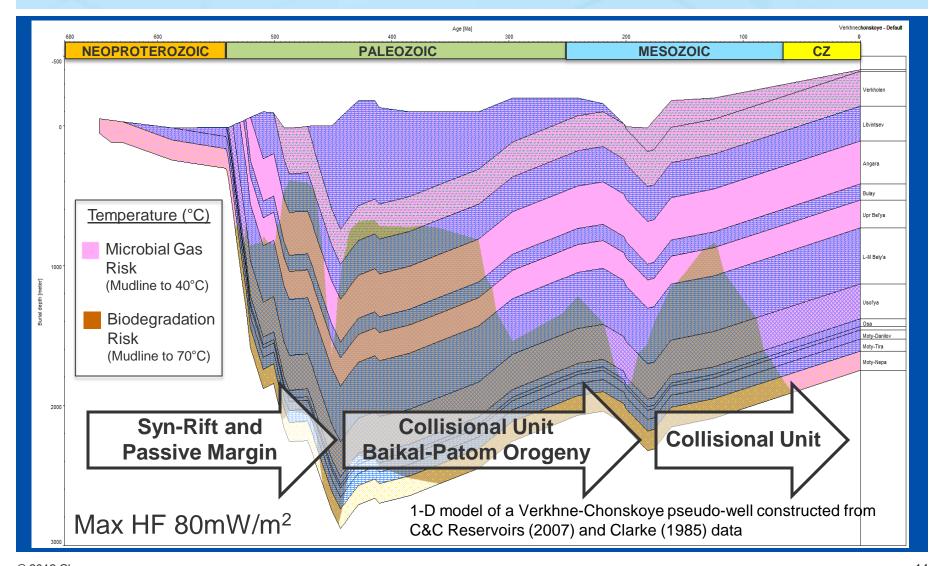
# Salt and the Preservation of Proterozoic Hydrocarbons





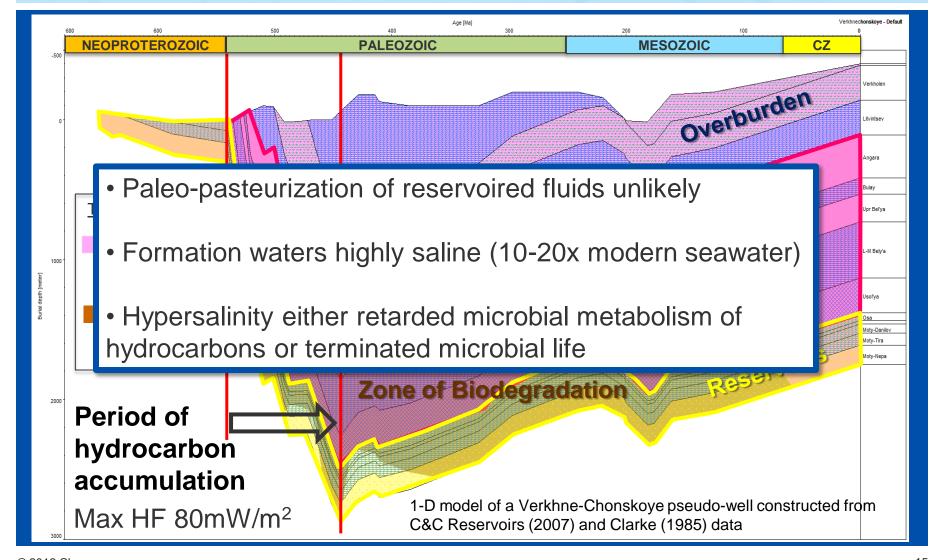
# Burial and Reservoir Temperature Histories for a Verkhne-Chonskoye Pseudo-Well





# Burial and Reservoir Temperature Histories for a Verkhne-Chonskoye Pseudo-Well





### Conclusions



#### **Angara-Yenisey Petroleum System**

- Source rock deposited in a siliciclastic, suboxic-oxic, open marine setting
- Depositional conditions led to a gas-prone system

#### **Baykit Petroleum System**

 Source rock lithology likely carbonate – carbonaceous shale, deposited in a dysoxic, restricted marine setting

#### **Nepa-Botuoba Petroleum System**

- Source rock depositional environment similar to that of Baykit
- Depositional conditions increased preservation of oil-prone organic matter
- Hydrocarbon migration, accumulation and preservation
  - Timing controlled by deposition of a regional salt seal in the Cambrian
  - Long-distance migration affected oil character, hydrocarbon phase and volume
  - Saline pore waters probably inhibited biodegradation

### Acknowledgements



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