New Opportunities for Petroleum Exploration in the Urals Foreland Fold and Thrust Belt*

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Search and Discovery Article #10677 (2014)**

Posted December 8, 2014

*Adapted from oral presentation at AAPG International Conference and Exhibition, Istanbul, Turkey, September 14-17, 2014. Please refer to related article, Search and Discovery Article #10678 (2014), entitled “Petroleum Potential of the North Uralian Foredeep, Timan Pechora Basin, Russia.”

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Abstract

The Uralian fold and thrust belt was formed due to a series of collisional events that culminated in the Late Paleozoic in course of the Pangea assembly. It was followed by the late orogenic transpressional displacements. The subsurface data from different parts of the foreland thrust belt reveal significant along-strike structural segmentation. Northern and southern segments of the fold belt are characterized by multiple delamination of sedimentary cover, disharmonic folding, and tectonic wedging. The central part of the belt facing the East European craton exhibits simple emerging thrust successions. These changes are broadly correlatve with the heterogeneous basement domains flanking the Uralian suture on the west, the corresponding variations in stratigraphic composition of the foreland subbasins, and changes in paleostress orientation within the Uralian suture. World-class source rocks are recognized in the Uralian foreland. Past exploration campaigns were based on limited low-resolution data; nevertheless, they had resulted in several significant discoveries. Majority of the known fields were found in relatively simple structures with direct expression in the surface geology. New exciting opportunities for conventional petroleum exploration were revealed recently due to reinterpretations of vintage data coupled with study of new seismic surveys. More complex structural patterns involving large untested prospects were identified. Of prime interest are subthrust zones, passive-roof duplexes involving repetitions of reservoir units, and zones of carbonate build-ups. Modern exploration technologies are vital for successful unlocking of the exploration potential of the Uralian thrust belt.
References Cited


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Outlines

- Aim of this study; why the Urals?
- Regional setting
- Petroleum geology, past exploration
- Geology revisited
- New opportunities
Exploration in Russia

- Russian oil and gas production is heavily dependant on large fields, discovered mainly in 1960-1970s
- New discoveries are getting smaller; traditional exploration plays are mature
- Are there new conventional opportunities worth chasing onshore Russia?

Size of new fields, 2004-2012

Source: VNIGNI, 2013
Fold belts

✓ Birthplace of petroleum exploration

✓ The Rule ‘The biggest fields to be discovered first’ does not work well. Many “surprise” discoveries.

✓ The Urals is one of the biggest fold belts, next to the great basins, existing infrastructure.
New exploration technologies and ideas are game-changing factors in areas of complex geology. The Urals is the best candidate.

Evolution of structural Interpretations in the Uralian foreland

The same line, different vintages
Regional setting

Typical collisional orogen

Foredeep

Thrust belt

Study area

McClay & Whitehouse, 2004 with modifications

Urseis transect

Volga Uralian basin

Thrust belt

Magnitogorsk arc

The Main Uralian Fault

East Uralian zon

Transuralian zone

East European platform
Plate tectonic development

A. Vendian 630 Ma

B. Late Silurian 420 Ma

C. Late Devonian 360 Ma

D. Late Permian 255 Ma

E. Late Triassic 220 Ma

F. Paleocene 65 Ma

Legend:
- Cratons
- Neoproterozoic crust
- Paleozoic and partly Mesozoic accretionary wedges
- Vendian to Paleozoic immature arcs
- Sedimentary depocenters
- Direction of plate rotation
- Subduction zones
- Backarc spreading
- Rift
- Fault

Sobornov and Yakubchuk, 2004
Petroleum geology

- Main Source rock: Upper Frasnian Domanik Fm., secondary Silurian-Lower Devonian, Visean, Lower Permian
- Principal reservoirs: Upper Devonian-Lower Carboniferous, Upper Carboniferous-Lower Permian carbonates
- Seals: Ordovician salt (north), Visean shale, Kungurian anhydrites, intraformational
Exploration in the Uralian foreland

- Exploration started in the late 1920s; the first commercial oil flowed in 1929
- Prospect generation: surface mapping, structural drilling
Uralian Foreland, fields

- Numerous oil deposits in the platform
- Virtually unexplored the foredeep
- A few mainly gas fields in the thrust belt
- Successful exploration in 1950-1970, followed by a rapid decline
Work flow

- Data acquisition, digitizing, georeferencing
- Review of geological models, field observations, study of analogs
- Integrated G&G regional interpretation
- Identification of new play types, identification of new leads
Some observations

- Prominent changes in structural styles and composition across the fold belt
- Corresponding variations in petroleum habitat

[Map and diagrams showing geological structures and locations labeled A to D]
Northern segment

- Baikalian basement
- Thick sedimentary cover
- Multiphase structuring: Urals, Pay Khoy
- Large shortening, 100 km+
- Extensive detachment faulting
Central segment

- Ancient basement of the East European platform
- Thin, incomplete sedimentary cover, fewer reservoir-seal pairs
- Late Paleozoic transpression
- Limited shortening, 50 km-
South segment

- Rifted basement of the Precaspian basin
- Thick sedimentary cover, Kungurian salt
- Significant shortening, 50 km+
- Extensive detachment faulting, tectonic wedging, salt diapirism
Structural domains

- Structural domains flanking the Urals
  - Pechora plate
  - East European platform
  - Precaspian basin
New conventional play types

Reinterpretation of the vintage and new data on the Urals thrust belt allows identification of new conventional plays. They include:

- Thrust-related closures
- Buried carbonate build-ups
- Stratigraphic traps
- Synrift inversion structures
New exploration objectives

Conventional play types:
high-relief thrust-related closures, reefs, subtle traps, etc.

Modified after B. Bogdanov
Leads in thrust belt

Structural nose juxtaposed against a salt wall

Predicted trap types

Chernyshev swell

Kosyu Rogov foredeep

Polar Urals foredeep

O3 salt

Chernyshev backthrust

Sobornov & Danilov, 2014
Buried carbonate platform in the North Uralian foreland controlled by the Uralian rifting. Access to a large oil kitchen nearby.
Stratigraphic traps

Analog: Titov field, 600 MBO

Broad development of unconformities with shale overlying karst-prone carbonates

South Uralian foredeep

Hypothetic trap subcropping unconformity
Uralian synrift section

Untested potential of the synrift deposits in the Uralian Foreland.

Leads in synrift deposits

Inverted anticline

Pinch-out zone
Conclusion

Regional study of the Urals foreland fold and thrust belt provides new insight into geological structure and petroleum prospectivity of this area.

New conventional opportunities are recognized. These include:

- Thrust-related closures
- Buried carbonate build-ups
- Stratigraphic traps
- Synrift inversion structures
Acknowledgement

- The author would like to thank V.N. Danilov, A.B. Khabarov, S.L. Kostuchenko, A.V. Lipilin, S.M. Nikitina, N.I. Nikonov, F. Roure, J. Staffurth, V.S Shein, E.L. Teplov, and V.V. Yudin for helpful discussions and suggestions.
- N.S. Sokolov and S.Yu. Sokolov provided technical support.
- North Uralian Petroleum, RGF, TP NIC, VNIGNI.
Thank you!

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