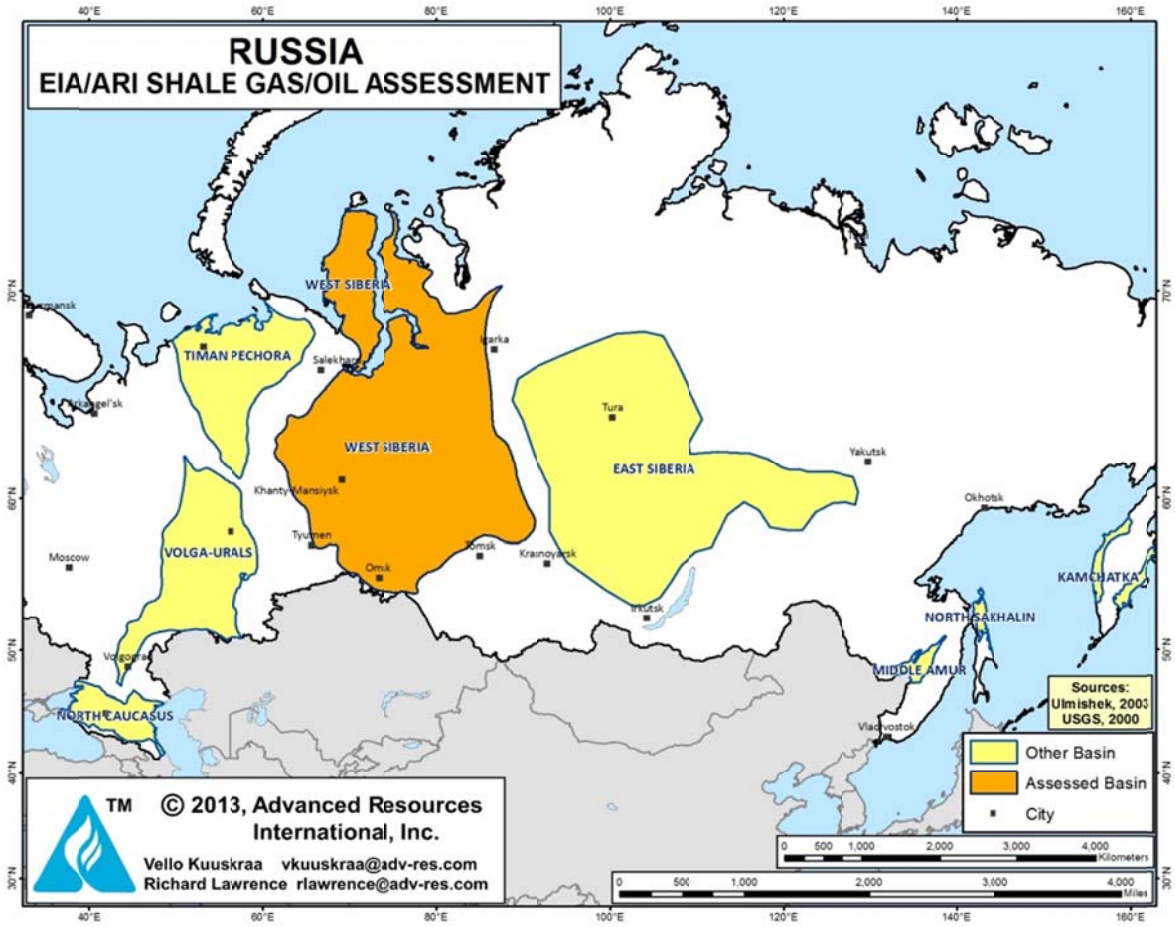
IX. RUSSIA

SUMMARY

Our shale gas and shale oil resources assessment for Russia addresses the Upper Jurassic Bazhenov Shale in the West Siberian Basin, Figure IX-1. This organically rich, siliceous shale is the principle source rock for the conventional gas and oil produced from the West Siberian Basin. We also examined other shale basins (e.g., Timan-Pechora) but were not able to assemble sufficient, publicly available data for a quantitative resource assessment.

Figure IX-1. Prospective Shale Gas and Shale Oil Basins of Russia



Source: ARI, 2013

Advanced Resources International, Inc.

For the Bazhenov Shale, we estimate 1,243 billion barrels of risked shale oil in-place, with 74.6 billion barrels as the risked, technically recoverable shale oil resource, Table IX-1. In addition, we estimate 1,920 Tcf of risked shale gas in-place, with 285 Tcf as the risked, technically recoverable shale gas resource, Table IX-2.

Table IX-1. Shale Oil Reservoir Properties and Resources of Russia

Basic Data	Basin/Gross Area		West Siberian (1,350,000 mi^2)			
	Shale Formation		Bazhenov Central	Bazhenov North		
	Geologic Age		U. Jurassic - L. Cretaceous	U. Jurassic - L. Cretaceous		
	Depositional Environment		Marine	Marine		
Physical Extent	Prospective Area (mi^2)		116,200	74,400	14,800	10,540
	Thickness (ft)	Organically Rich	100	100	100	100
		Net	85	85	85	85
	Depth (ft)	Interval	6,500 - 12,000	6,500 - 13,000	8,500 - 15,000	10,000 - 16,000
		Average	8,200	9,800	12,000	13,500
Reservoir Properties	Reservoir Pressure		Highly Overpress.	Highly Overpress.	Highly Overpress.	Highly Overpress.
	Average TOC (wt. %)		10.0%	5.0%	5.0%	5.0%
	Thermal Maturity (% Ro)		0.85%	0.85%	1.15%	1.45%
	Clay Content		Low	Low	Low	Low
Resource	Gas Phase		Assoc. Gas	Assoc. Gas	Wet Gas	Dry Gas
	GIP Concentration (Bcf/mi^2)		22.9	19.4	42.0	66.0
	Risked GIP (Tcf)		1,196.0	378.9	163.0	182.5
	Risked Recoverable (Tcf)		143.5	45.5	40.8	54.8

Source: ARI, 2013

Table IX-2. Shale Gas Reservoir Properties and Resources of Russia

Basic Data	Basin/Gross Area		West Siberian (1,350,000 mi^2)		
	Shale Formation		Bazhenov Central	Bazhenov North	
	Geologic Age		U. Jurassic - L. Cretaceous	U. Jurassic - L. Cretaceous	
	Depositional Environment		Marine	Marine	
Physical Extent	Prospective Area (mi^2)		116,200	74,400	14,800
	Thickness (ft)	Organically Rich	100	100	100
		Net	85	85	85
	Depth (ft)	Interval	6,500 - 12,000	6,500 - 13,000	6,500 - 13,000
		Average	8,200	9,800	12,000
Reservoir Properties	Reservoir Pressure		Highly Overpress.	Highly Overpress.	Highly Overpress.
	Average TOC (wt. %)		10.0%	5.0%	5.0%
	Thermal Maturity (% Ro)		0.85%	0.85%	1.15%
	Clay Content		Low	Low	Low
Resource	Oil Phase		Oil	Oil	Condensate
	OIP Concentration (MMbbl/mi^2)		18.5	13.4	4.3
	Risked OIP (B bbl)		964.8	261.5	16.8
	Risked Recoverable (B bbl)		57.89	15.69	1.01

Source: ARI, 2013

1. WEST SIBERIAN BASIN

1.1 Introduction and Geologic Setting

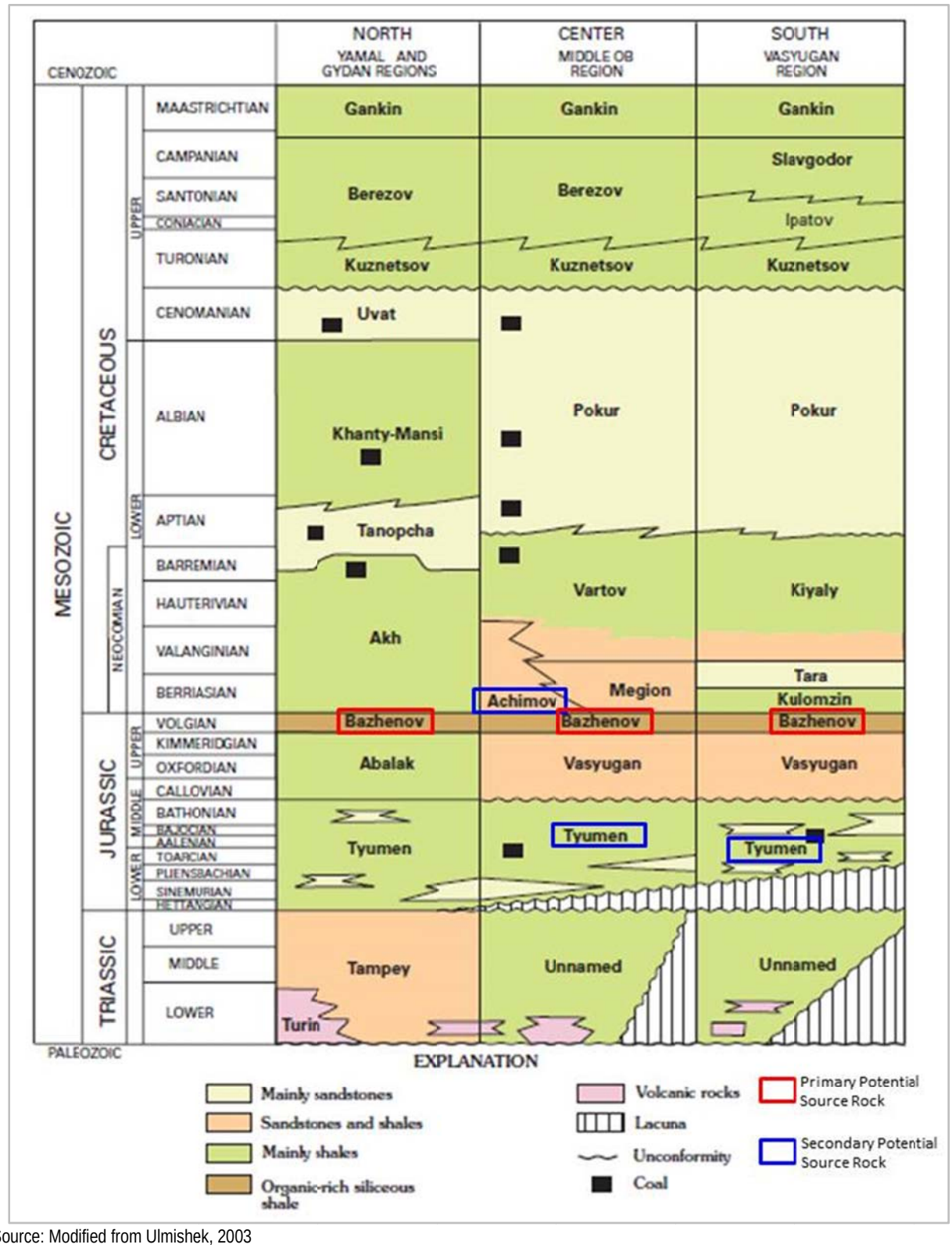
The 850,000-mi^2 West Siberian Basin is the largest petroleum basin in the world[1]. The basin lies between the Ural Mountains to the west and the Yenisey River to the east, while extending north offshore under the Kara Sea and reaching south to the border with Kazakhstan, Figure IX-1.

Conventional oil and gas production has taken place in the basin since the 1960's, with reservoirs found predominately in Cretaceous sandstone formations. Oil production occurs mainly in the southern and central regions of the basin, with gas fields more prevalent in the north. The West Siberian Basin contains tens of giant and super-giant fields such as the Samotlor oil field (28 billion barrels of original oil reserves) in the central Middle Ob petroleum region and the 350-Tcf Urengoy gas field north of the Arctic Circle. Although the West Siberian Basin still delivers over 60% of Russia's annual oil production, its output peaked in the late 1980's. Declining conventional production is stimulating interest in finding new oil and gas production from unconventional resources.

The Upper Jurassic Bazhenov Shale, a marine shale rich in TOC, is considered the main source rock for the Western Siberian Basin's conventional oil reservoirs. The Bazhenov Shale, the primary shale addressed in this resource assessment, has been selectively drilled, providing shows and variable quantities of oil production.

Other formations that may contain shales with gas and oil potential are the Lower Jurassic Tyumen and Lower Cretaceous Achimov formations, Figure IX-2. The Tyumen Formation is not considered prospective in the northern areas of the basin where it is projected to be at depths greater than 16,400 ft (5,000 m). The publicly available data for the Achimov Formation is not sufficient for a quantitative resource assessment. As such, these two formations were excluded from our shale gas and shale oil assessment.

Figure IX-2: Stratigraphic Column of the West Siberian Basin



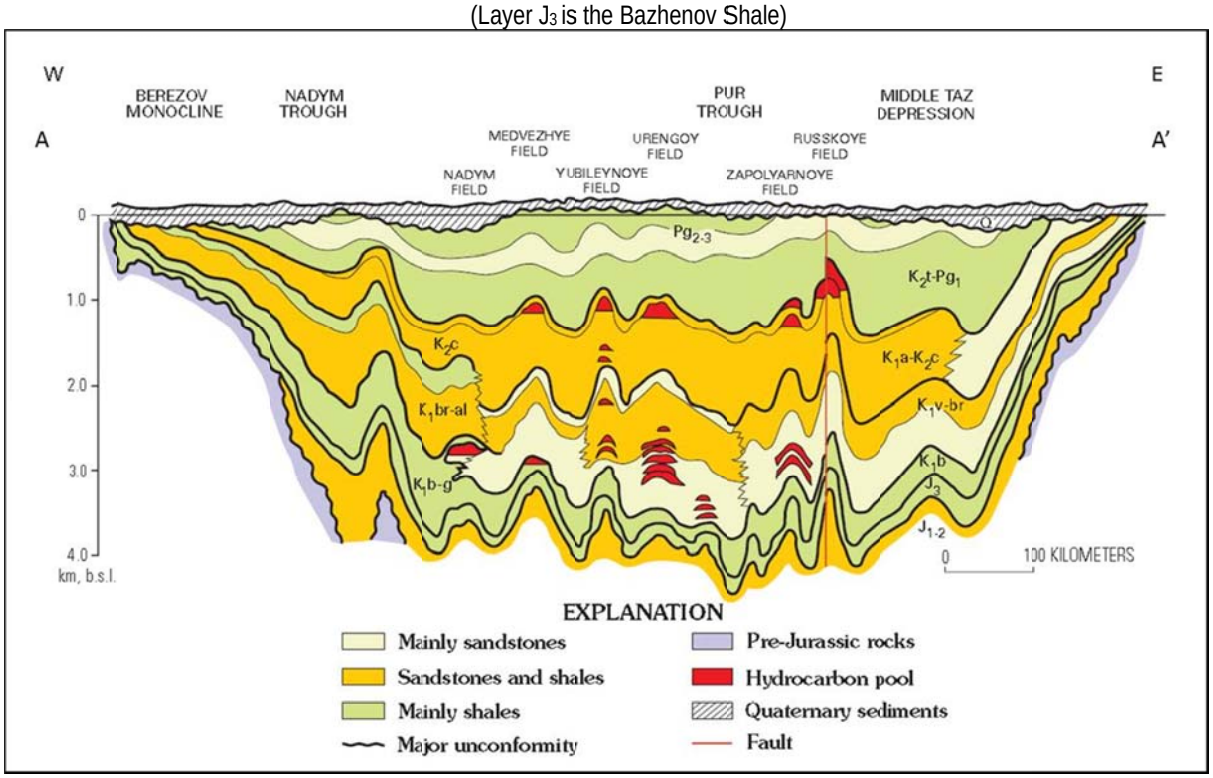
Source: Modified from Ulmishek, 2003

The West Siberian Basin is an intra-cratonic sag basin containing over 4,000 m (13,000 ft) of Mesozoic and Cenozoic sediments. Basement rocks of Paleozoic age were deeply eroded prior to the Triassic period, with subsequent early Triassic continental rifting primarily responsible for the formation of the basin. Major Triassic rifts and faults are oriented in a predominantly north-south alignment, influencing the structural alignment of large anticlines and synclines that formed in the late Mesozoic. The central tectonic element of the basin is the Triassic Koltogor-Urengoy graben, which extends 1800 km north-to-south and is 10 to 80 km wide.[2]

The majority of discovered conventional oil and gas reserves are found in gentle anticlinal uplifted structural traps, located on regional arches, Figure IX-3. Faults, where present, have a displacement of only a few tens of meters and seldom penetrate above the Lower-Middle Jurassic Tyumen Formation.

Figure IX-3. Cross-Section Across Central West Siberian Basin.
(See Figure 4 for location; vertical exaggeration 100x)

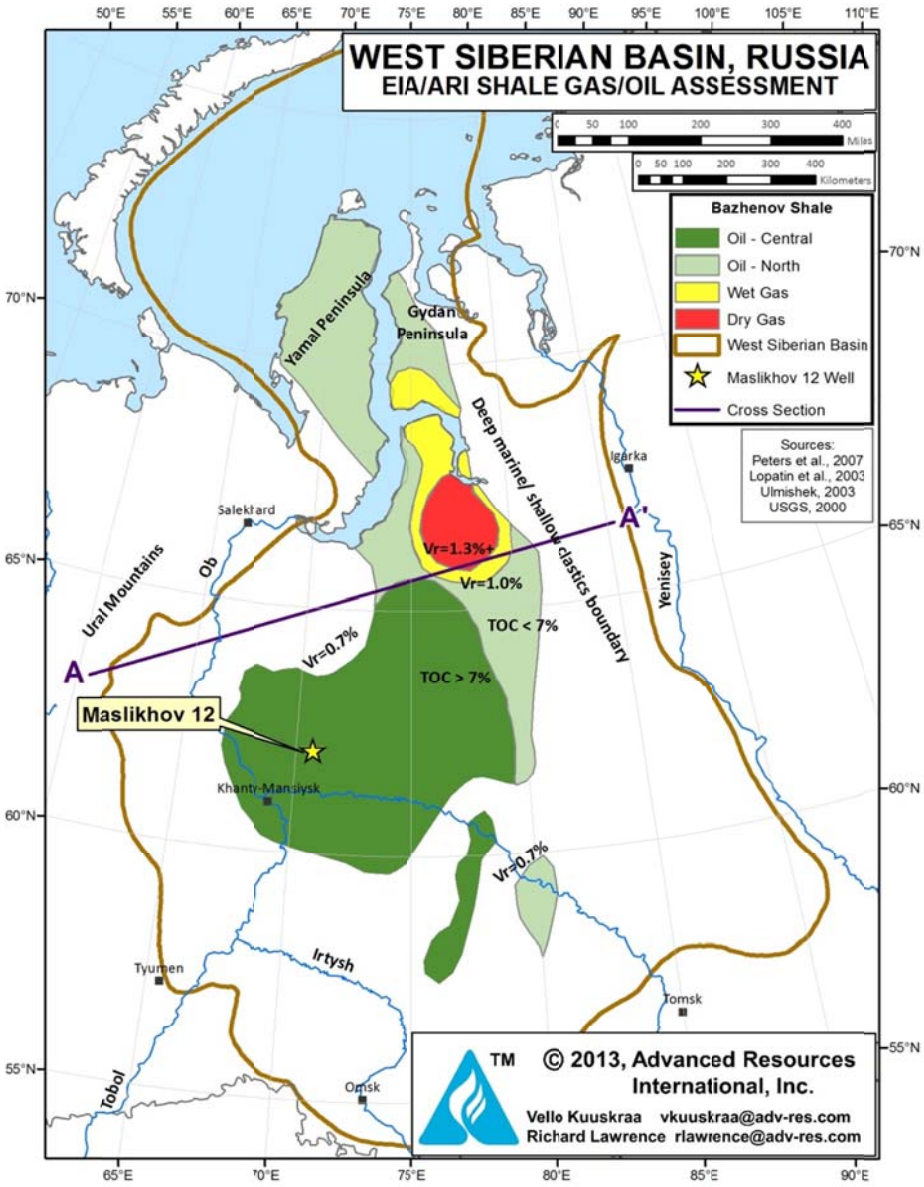
(Layer J_3 is the Bazhenov Shale)



Source: Ulmishek, USGS 2003.

We have partitioned the Bazhenov Shale in the Western Siberian Basin into two areas based on TOC and thermal maturity: Bazhenov North and Bazhenov Central.,. Bazhenov North, with a prospective area of 99,740 mi^2 and an average TOC of 5%, contains oil, wet gas/condensate and dry gas. Bazhenov Central, with a prospective area of 116,200 mi^2 and a high average TOC of 10%, is thermally mature for shale oil, Figure IX-4.[3,4]

Figure IX-4. West Siberian Basin, Prospective Areas for Shale Gas and Shale Oil



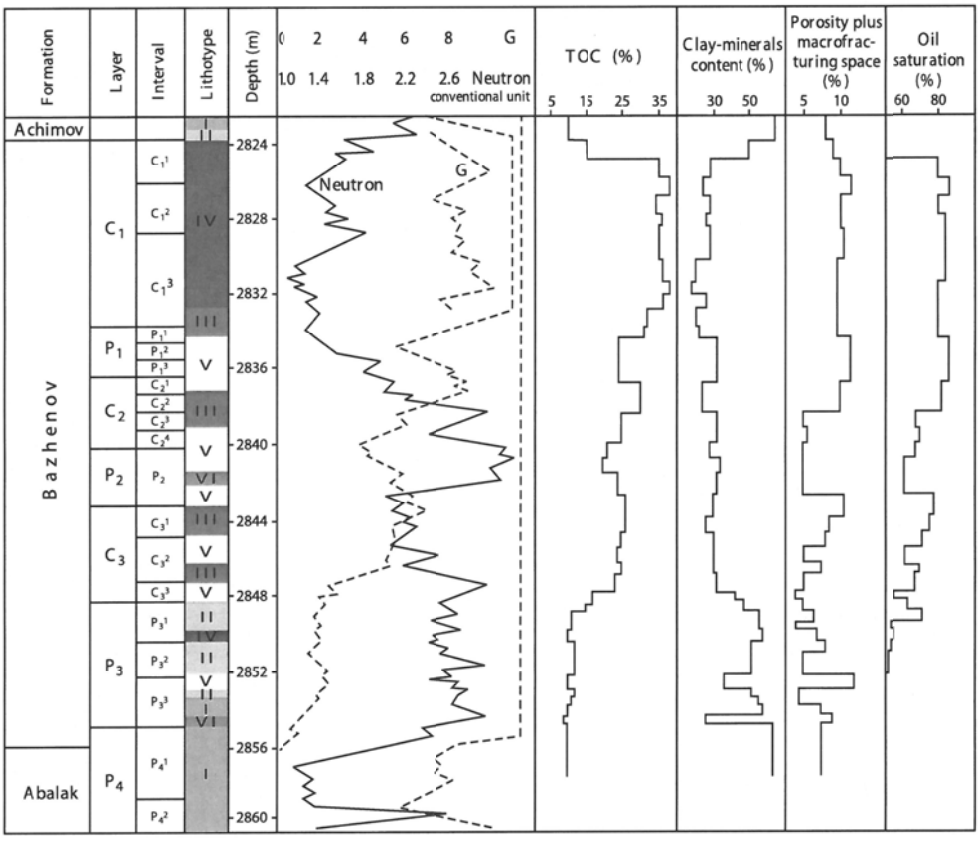
Source: ARI, 2013.

1.2 Reservoir Properties (Prospective Area)

The Upper Jurassic Bazhenov Shale is present across much of the West Siberian Basin, outcropping at the basin edges and reaching depths of over 16,400 ft (5,000 m) in the central northern region. The shale's gross thickness typically ranges from 65 to 160 ft (20 to 50 m), but can reach up to 200 ft (60 m) in localized areas.

The Bazhenov Shale was deposited in a deep marine, anoxic environment and is composed primarily of siliceous argillites, rich in planktonic Type II organic matter.[5] TOC contents are generally highest in the central region of the Basin, typically exceeding 15%, Figure IX-5.[6] TOC values decrease towards the periphery of the basin and to the north where the TOC typically ranges from 2 to 7%. TOC averages 5% in Bazhenov North and 10% in Bazhenov Central.[5]

Figure IX-5. Reservoir Properties of the Bazhenov Shale from Maslikhov Well.



Source: Lopatin et al., 2003.

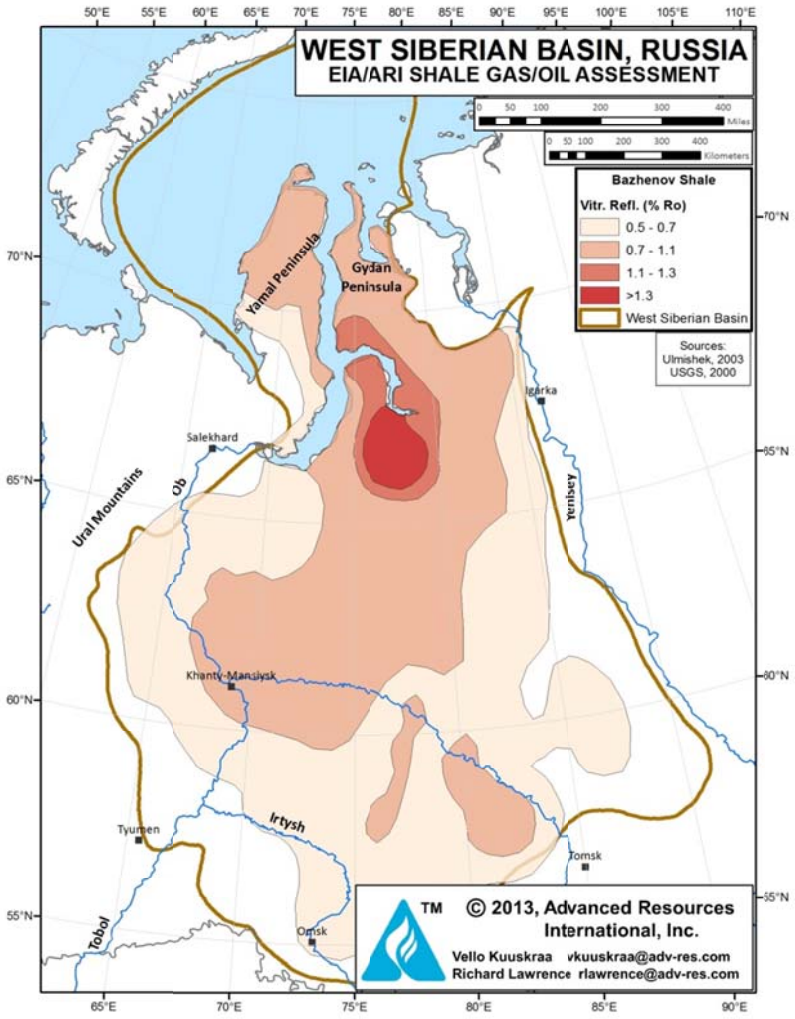
The literature describes the Bazhenov as being over-pressured, caused by oil generation and expulsion as the shales passed through the "oil window". Measured shut-in bottom-hole pressures in the Salym oil field region are reported in some wells to be abnormally high, up to 70% above normal hydrostatic pressure.[7] Temperature gradients are also high. Clay content is usually reported as less than 20%.

The Bazhenov reservoir structure consists of layers of high-TOC shale interbedded with carbonate/dolomite layers.[8] The shales are the source of the oil, with the fractured carbonate layers providing additional reservoir capacity. This is somewhat analogous to the Bakken Shale play of North Dakota, which comprises a carbonate reservoir "sandwiched" between two oil rich/saturated shales.

Bazhenov North is prospective for oil, wet gas/condensate and dry gas. The 74,400-mi^2 area prospective for shale oil in Bazhenov North is defined by vitrinite reflectance (R_o) values between 0.7% and 1.0%, TOC content greater than 2%, and reservoir depth greater than 3,300 ft. The 14,800-mi^2 area prospective for wet gas and condensate in Bazhenov North is defined by R_o values between 1.0% and 1.3%. The 10,540-mi^2 area prospective for dry gas is defined by R_o values greater than 1.3%, Figure IX-6A. The Bazhenov North prospective area is further constrained on the east side of the basin, where the Bazhenov Shale changes from a deep marine shale to shallow clastic deposit, Figure IX-6B.

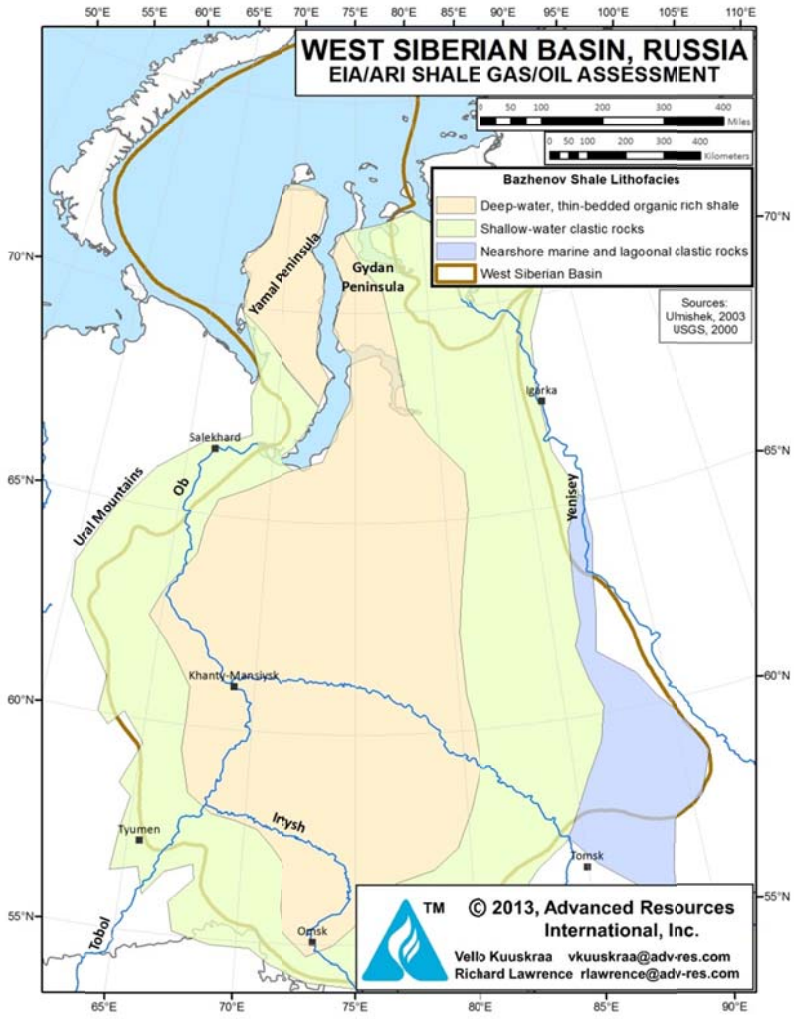
Bazhenov Central contains a 116,200-mi^2 prospective area for oil, with a thermal maturity (R_o) of 0.7 to 1.0%. The TOC content of the shale is high in Bazhenov Central, averaging 10%. Similarly, the Bazhenov Central prospective area is limited on the east by the marine shale to clastic sediments facies change.

Figure IX-6A. West Siberian Basin - Vitrinite Reflectance



Source: ARI, 2013.

Figure IX-6B. West Siberian Basin - Lithofacies Map



Source: ARI, 2013.

1.3 Resource Assessment

The shale oil in the Bazhenov North prospective area has an estimated resource concentration of 13 million barrels/mi^2 plus associated gas in the oil window; resource concentrations of 4 million barrels/mi^2 and 42 Bcf/mi^2 in the wet gas/condensate window; and a resource concentration of 66 Bcf/mi^2 in the dry gas window. The shale in the Bazhenov Central prospective area has an estimated resource concentration of 18 million barrels/mi^2 plus associated gas in the oil window.

For the total Bazhenov shale prospective area in the West Siberian Basin, we estimate a risked shale oil in-place of 1,243 billion barrels, with 74.6 billion barrels as the risked, technically recoverable shale oil resource, Table IX-1. In addition, for this prospective area, we estimate a risked shale gas in-place of 1,920 Tcf, with 285 Tcf as the risked, technically recoverable shale gas resource, Table IX-2.

In its 2011 Annual Report, Rosneft estimated the company had 4.4 billion barrels of recoverable oil resources from the Bazhenov "suite" on its license areas in Western Siberia.[9]

1.4 Recent Activity

The majority of Russia's current oil production (nearly two thirds) comes from large fields in the West Siberian Basin, located between the Ural Mountains and the Central Siberian Plateau, with the remaining oil production coming mainly from the Volga-Urals region, the Timan-Pechora Basin, the north Caucasus Region, and the Sakhelin Basin.

The oldest fields have produced since the 1940s and production rates are declining, even with the new technical focus on secondary recovery and hydro-fracturing. Exploration for conventional oil and gas is in the more remote East Siberian Basin and in the higher cost Arctic region. As such, Russian oil companies are becoming interested in the drilling and production techniques used in the U.S. to develop their unconventional oil and gas resources. Rosneft, Russia's national oil company, has signed agreements with ExxonMobil and Statoil with the aim of using horizontal drilling and large scale stimulation techniques to unlock the vast shale gas and shale oil resources of Russia.

To date, Rosneft and Exxon Mobil have announced plans to begin drilling the Bazhenov Shale in 2013, after completion of their geologic study. Gazprom Neft and Shell, as part of their West Siberia JV, proposed to start drilling the Bazhenov Shale in early 2014 near the Salym oil field, which has a history of Bazhenov Shale oil production. Lukoil has announced plans to test the Bazhenov reservoir in two area of West Siberia.[10]

Development of the Bazhenov Shale is complicated by Russia's current tax regime, which is geared towards conventional reservoirs. The Russian government is currently working on a proposal to change the mineral extraction tax (MET) for "tight oil" reservoirs with a permeability of less than 2 millidarcies (mD).[11] It is possible that shale gas and shale oil reservoirs would be incorporated into the proposed change in the MET.

2. TIMAN-PECHORA BASIN

The Timan-Pechora Basin covers an onshore area of about 122,000 mi^2 on the Arctic Circle of northern Russia, Figure IX-1. The principle source rock in this basin is the Upper Devonian (Frasnian) organic-rich shale in the Domanik Formation.[12]

These source rocks, composed of thin-bedded, dark siliceous shales, limestones and marls, were deposited in a deep water marine setting. The source rocks contain Type I and II kerogen with total organic content (TOC) ranging from 1% to 15%, typically averaging 5%[13]. These source rocks are present, with adequate thickness and maturity, over much of the Timan-Pechora Basin except for the southwestern margin. With thermal maturity of 0.6% to 1.0%, these source rocks are primarily in the oil window. The mineralogy of the shale appears to be favorable, with low (<10%) clay.[14]

While the gross thickness of the Domanik interval can range from 100 m to 300 m (330 to 1,000 ft), publicly available information is lacking on its net organic-rich interval, its porosity and pressure. The Domanik Formation has been correlated with the Duvernay Formation/Shale in Western Canada Sedimentary Basin.[13]

At current time, the publicly available geologic and reservoir data are insufficient to prepare a quantitative shale oil and gas resource assessment for the Domanik Shale in the Timan-Pechora Basin. Other source rocks and shales also exist in this basin, but have been excluded from the assessment. The Late Jurassic to Early Cretaceous (Kimmeridgian) shales in this basin have high TOC but are reported to be thermally immature. The Silurian-Ordovician shales in this basin appear to have low TOC of 0.5% to 1.5%.[12]

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