Skoltech Center for Hydrocarbon Recovery

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Skoltech Center for Hydrocarbon Recovery

Skoltech Center for Hydrocarbon Recovery (SCHR) has been created following decision of Skoltech Board of Trustees made in December 2013. Main goal of SCHR is to provide world class research, education and innovations in the area of exploration and production of unconventional and hard-to-recover hydrocarbons. Our aim is to establish Skoltech as a leader in developing technology and people for Russia's future needs in the area of exploration and production hydrocarbons.

Main areas of SCHR activity in research, education and innovation are geomechanics, enhanced oil recovery, geophysics & petrophysics of unconventional reservoirs, thermal petrophysics, gas hydrates and advanced reservoir simulations. We focus our research efforts on development of new technological solutions for exploration and production of hydrocarbons at such geological objects as brown fields, tight oil, heavy oil, shale oil, oil fields in polar regions and Arctic shelf.

Following Skoltech strategy SCHR develops collaboration with world leading universities including Texas A&M University, USA, University of Calgary, Canada, Heriot-Watt University, Scotland and other. Among our university partner are famous Russian universities and including Moscow state university, Bashkir state university, Russian state university of oil and gas, and the institutes of Russian academy of sciences.

MS education programs was developed in collaboration with university partners and is focused on disciplines important for exploration and production of hard to recover and unconventional hydrocarbons including enhanced oil recovery, geomechanics, unconventional reservoirs, high performance computing and other.

Research facilities of SCHR includes computational laboratory and experimental laboratories focused on research in the areas of advanced petrophysics and geochemistry, geomechanics, enhanced oil recovery, and gas hydrates.

SCHR actively develops collaboration with Industry using different forms, including R&D and service contracts, research consortia, joint grants with government and other. Our main industry partners re Russian oil and gas majors, including GazpromNeft, Gazprom, Lukoil, Rosneft, Tatneft, Novatek and other oil and gas producers and service companies. Considerable part of SCHR budget comes from collaboration with industry.

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Skoltech mission and vision

- Skoltech - new international university located in Skolkovo innovation center
- Main business units of Skoltech - Centers for Research, Education and Innovations (CREI)
- Each CREI has been created following decision of the Board of Trustees in order to provide research, education and innovations in strategy directions of future RF economy
- Focusing on breakthrough technological solutions
- Partnership with world leading universities
- Partnership with Russian industry
- World level of innovations, immediate implementation of knowledge and technological solution into practice (creation of startups or direct contacts with leading companies)

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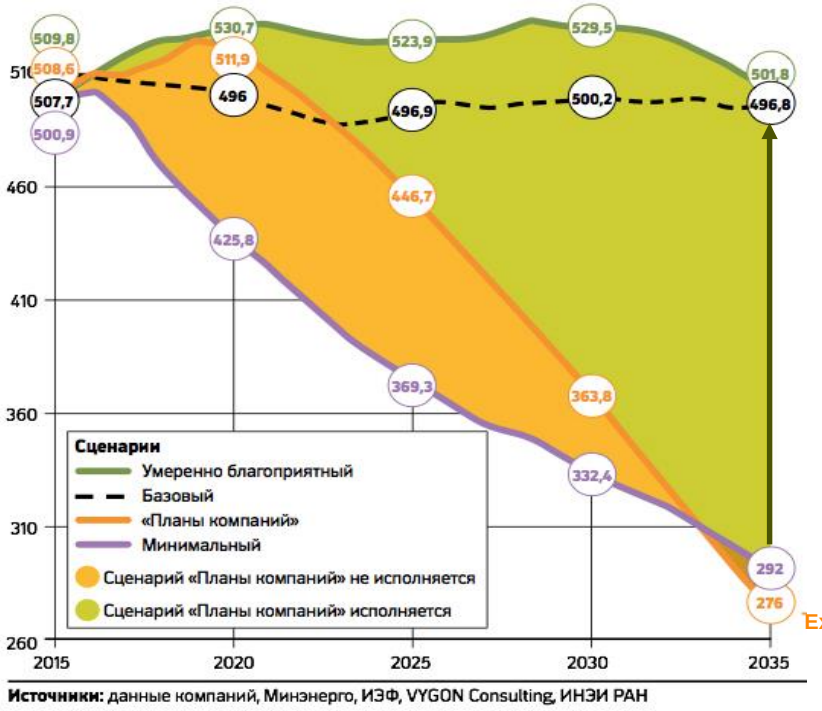
Forecast of oil production in Russia and required technologies

Oil production in Russia, mln ton per year
Data included in general plan of oil production in Russia up to 2035 г.)

РБК 3 сентября 2015, http://top.rbc.ru/business/03/09/2015/55e71b079a794701285a0c19



Источники: данные компаний, Минэнерго, ИЭФ, VYGON Consulting, ИНЭИ РАН

Industry needs in new technologies

200 mln ton per year

- Shale oil
- Heavy oil
- Enhanced oil recovery
- New oilfields (results of exploration)
- Arctic shelf and polar regions

Existing oilfields

To maintain hydrocarbon production at high level in future (20+ years) industry should be technologically prepared for production of all types unconventional resources (heavy oil, shale oil, tight oil, unconventional gas and other hard to recover resources) in traditional regions and production of hydrocarbons in new regions with extremely harsh climatic conditions – Arctic shelf and polar regions

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Main goals

To provide world class research, education and innovations in the area of exploration and production of unconventional and hard-to-recover hydrocarbons.

Establish Skoltech center as a leader in developing technology and people for Russia's future needs in unconventional and hard-to-recover hydrocarbon recovery.

Program term: 2014 – 2019

Research Areas:

- Geomechanics
- Enhanced oil recovery
- Gas hydrates and permafrost
- Geophysics & Petrophysics
- Advanced reservoir simulations

Hydrocarbon Resources:

- Brown fields,
- Tight oil
- Heavy oil
- Shale oil
- Gas hydrates
- Polar regions & shelf

Industry partners:

GazpromNeft, Lukoil, Rosneft, Tatneft, Surgutneftegaz, Zarubezhneft, Rospan, Salym Petroleum Development, other producers and service companies.

Funding

- Grant of Skolkovo foundation
- Other sources - up to 50% in 2018

Staff:

- 70 plan for the end of 2018, (25 now)

Research facilities:

- Geomechanic lab
- EOR lab
- PVT lab
- Advanced petrophysic lab
- Computational Lab

University Partners

- Partnership with 10 universities (USA, EU, UK, Canada,Russia)

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University partnership program

15 joint R&D projects

UNIVERSITY OF CALGARY

Thermal EOR
Prof. Raj Mehta

TEXAS A&M UNIVERSITY

Advanced reservoir modeling, HPC
Prof. John Killough

HERIOT WATT UNIVERSITY

Flow assurance, Gas hydrates
Prof. Bahman Tohidi

UNIL | Université de Lausanne

Geomechanics
Prof. Yuri Podladchikov

Universitetet i Stavanger

Chemical EOR
Roman Berenblyum (IRIS)

Unconventional hydrocarbons
Moscow State University

Geology and Lithology
Oil and Gas State University

Petroleum geophysics,
Inst of Petroleum Geology, RAS, Novosibirsk

Petrophysics
Institute of the Earth Physics, RAS, Moscow

Chemical EOR
Mining University St.Petersburg

Temperature Logging
Bashkir State University, Ufa

Research projects with industry

5 on-going R&D projects + 4 R&D projects under negotiations

Cazpromneft
Geomechanics, Bazhenov

Rosneft
Geomechanics, Arctic, Hydrates

Lukoil
Thermal EOR, Geomechanics, Petroleum basin modeling, Bazhenov

Cazprom
Geomechanics, Hydrates

Ritek
Thermal EOR, Bazhenov

Salym petroleum development
Chemical EOR (ASP flooding)

Thermal EOR

Thermal EOR

Chevron
Geomechanics modeling
Petroleum basin modeling
Full waveform inversion

Schlumberger
Adaptive meshing for in-situ combustion

Bashneft
Geomechanics, Bazhenov

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Research facility, education courses and joint R&D projects in collaboration with partner universities and Industry

Research direction	University partner	Research Facilities	Education courses	Joint R&D projects	Collaboration with Industry
Geomechanics	U Lausanne TAMU Heriot Watt	Geomechanics lab	✓ Geomechanics ✓ Hydraulic fracturing ✓ Unconventional hydrocarbons	2 R&D projects with IPGG	50% of budget in 2018 RF oil and gas majors, and other companies including ✓ Gazprom ✓ Gazpromneft ✓ Rosneft ✓ Lukoil, ✓ Ritek, ✓ Zarubezhneft ✓ SalymPetroleum ✓ Tatneft ✓ Surgutneftegas Forms of collaborations: ✓ Research consortia/JIPs ✓ R&D contracts ✓ Consulting ✓ Trainings ✓ Start-ups ✓ 4 on-going R&D contracts ✓ 5 R&D contracts under negotiations
Enhanced Hydrocarbon Recovery	U Calgary, Canada U Stavanger, Norw. Mining Univ., SPb	EOR lab. (ASP, SAGD, HPAI)	✓ Chemical EOR ✓ Thermal EOR	2 R&D projects with University of Calgary 1 R&D project – BSU	
Gas hydrates, Permafrost	Heriot-Watt MSU, Moscow IPE, Moscow	Gas Hydrate Lab	✓ Introduction to oil and gas engineering ✓ Gas hydrates and flow assurance	2 R&D projects with Heriot-Watt and 1 R&D projects with MSU	
Petrophyscis Geochemistry and Geophysics of unconventional reservoirs	U Utah IPGG, Novosibirsk MSU, IPE, Moscow BSU, Ufa	Petrophysics and Geochemistry lab	✓ Petroleum geophysics ✓ Computational algorithms ✓ Geophysical inversion ✓ Advanced petrophysics	3 R&D projects with IPE, BSU, MSU (bazhenov, domanik, hadum formations)	
Advanced reservoir simulation	TAMU BSU, Ufa MIPT, Moscow	Computational lab	✓ Fluid dynamics in Porous Media ✓ Petrophysics and reservoir engineering ✓ Geostatistics and reservoir simulation ✓ HPC in oil and gas	4 R&D projects with TAMU 1 R&D projects with BSU	

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Skoltech Center for Hydrocarbon Recovery: Educational Program

Fall Year 1				
Term 1 (Sept.-Oct.) 8 weeks	Energy Physics and Technology			Skoltech
	Introduction in Oil and Gas Engineering			Heriot-Watt
Term 2 (Nov.-Dec.) 8 weeks	Global Energy Decisions, Markets and Policy			Skoltech
	Petrophysics and Reservoir Engineering			Texas A&M
Winter (Jan.)	Research or Industrial Immersion			SCHR
Spring Year 1				
Term 1(Feb.-Mar.) 8 weeks	Fluid Dynamics in Energy Applications			SCHR
	Petroleum Geophysics			Skoltech
Term 2 (Apr.-May) 8 weeks	Unconventional Hydrocarbons: exploration and production			Skoltech
	Geostatistics and Reservoir Simulation			Texas A&M
Summer (Jun.-Aug.)	Field Camp (petroleum geology) or Industry Immersion			Skoltech
Fall Year 2	**Path 1**		**Path 2**	
Term 1 (Sept.-Oct.) 8 weeks	Geomechanics Hydraulic Fracturing	Lausanne university	Computational Algorithms	UT Austin
	Gas Hydrates and Flow Assurance	Heriot-Watt	HPC in Oil and Gas	Skoltech
Term 2 (Nov.-Dec.) 8 weeks	Chemical Methods for Enhanced Oil Recovery	Stavanger	Advanced Geophysical Inversion Methods	Utah
	Thermal Methods for Enhanced Oil Recovery	Calgary	Advanced Reservoir Simulation	Texas A&M
Winter (Jan.)	Research or Industrial Immersion			SCHR
Spring Year 2				
Term 1 (Feb.-Mar.) 8 weeks	Research or Industry Immersion			SCHR
	Research and MS Thesis			SCHR
Term 2 (Apr.-May) 8 weeks	Research and MS Thesis			SCHR
	Research and MS Thesis			SCHR
Summer (Jun.-Aug.)	Research and MS Thesis			SCHR

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Research equipment (planned for 2016)

Geomechanic lab

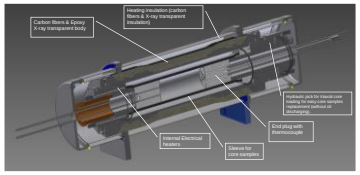
Universal Triaxial Loadframes MTS 816

- Full spectrum of mechanic tests ASTM, IRMS, ГОСТ
- Pressure (pore, confining) 140 MPa
- Temperature 0 - 200 ºC
- Porosity and permeability study at reservoir conditiobs
- Static and dynamic elastic modulus
- Microseismic monitoring

Enhanced oil recovery lab

Universal experimental unit for thermal EOR (University of Calgary)

- 6 000 Psi (400 атм), 400 C
- In situ combustion,
- High pressure air injection,
- Steam and hot water injection,
- SAGD,
- RTO



Universal flooding HPHT unit

- 80 Mpa
- 150 C
- 3 phases filtration
- X-ray control
- Full spectrum of flooding experiments, including fluids, gases, ASP, CO2, other

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Research equipment (installed)

Petrophysic and geochemistry lab

NMR for core analysis (Oxford instrument)

- Oil and water saturation, wettability, pore size distribution
- 2.5 Mhz
- 53 mm core ho;der
- Reservoir conditions (34 MPa, 100C)

Pyrolisis

HAWK workstation, Wildcat technology

- Maximum oven temperature: 850 ° C
- Oven temperature rates: adjustable from 0.1° to 75 ° C/minute
- Sample capacity: maximum sample weight is 400+ mg. Recommended weight is 70 mg.
- 126 sample capacity. 3 removable sample trays.
- F.I.D. pyrolysis detector (for hydrocarbons).
- Two infrared (IR) detectors (one for CO and the other for CO2).
- S1, S2, S3, S4, Tmax, Absolute Tmax, TOC (GOC and NGOC) and CC (carbonate carbon).
- HI, OI, PI, AI, OSI, POI, Roe and % CaCO3.

Thermal rock properties

Optical scanner for thermal rock property study (Russia)

- high-precision analysis of thermal conductivity, thermal diffusivity, thermal heat capacity
- Profiling of thermal properties at high space resolution (1 vv)
- Standard and reservoir conditions
- Different saturation (gas, water, oil)
- High efficiency (50 m of core samples per day)

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Research, education and innovation projects

Thermal EOR for Heavy Oil Fields: Collaboration with UofC

A.Cheremisin

Porf. R.Mehta

Prof. G.Moore

Prof. J.Belgrave

Research Projects

- High Pressure Air Injection (HPAI): Physical Modeling Matrix for HPAI Feasibility Assessment, Field Design and Kinetic Parameters
- Simulation of In Situ Combustion Process: Initial Calibration of Air Injection Kinetic-Displacement Model

Education

- MS course “Enhanced Oil Recovery” will be delivered by University of Calgary in 2016
- Training on thermal EOR for industry - planned for May 2016

Lab Facilities

- Unique High-Pressure System for Thermal Oil Recovery Methods Physical Simulation – ready for testing in Calgary (delivery in Jan 2016)

Planned Industry Collaboration

- Research proposal for joint industry on Thermal EOR has been accepted by Lukoil
- Proposal for creation of all Russia center on thermal EOR on the base of Skoltech developed and submitted to Ministry of Energy of the Russian Federation

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Innovative approach for hydrodynamic modeling of heavy oil reservoirs: joint project with Lukoil

Project Leader:
Stanislav Ursegov, Leading research scientist, PhD

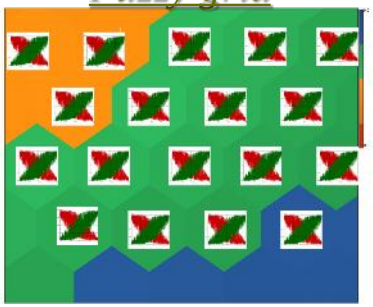
Client:	**Form of collaboration:**	**Project period**
Lukoil	R&D contract	Jun 2015 - Dec 2016

Project Title:
The development of a hybrid approach for geological and hydrodynamic modeling of the Permian – Carboniferous heavy oil reservoir of the Usinsk oil field.

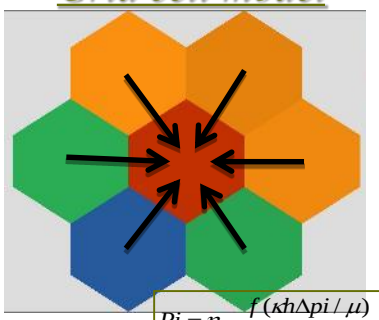
Main Task:
Due to the large size, the high complexity of the geological structure, and the long duration of the development period, the Client is able to perform multivariate hydrodynamic calculations of the heavy oil production in the Permian – Carboniferous reservoir using only sector models of its small pilot areas. In order to forecast the production level for the whole reservoir, an innovative hybrid approach should be developed;

Proposed Solution:
The innovative hybrid approach takes into account the strengths of both the sector deterministic modeling (the ability to respond to changes in the temperature conditions of the reservoir development) and the whole reservoir fuzzy logic modeling (the ability to pass the results of sector calculations through the actual history of the reservoir development thereby bringing them closer to the reality) and provides a high speed of hydrodynamic simulation.

Fuzzy grid

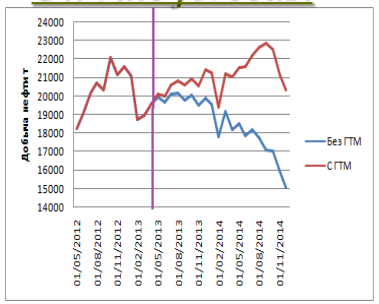


Grid cell model



$$Pi = \eta \frac{f(\kappa h \Delta pi / \mu)}{\sum (f(\kappa h \Delta pi / \mu)}$$

Oil rate forecast



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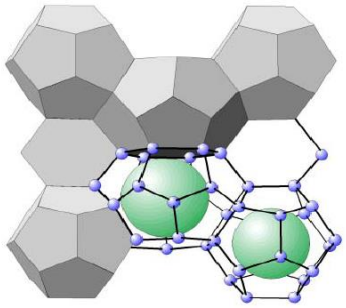
Gas Hydrate and Permafrost Research: collaboration with Heriot Watt and Total

Project leaders:

Prof. Evgeny Chuvilin, Prof. Vladimir Istomin



University partners

- Heriot Watt University (prof. Bahman Tokhidi),
- Moscow State University (Mikhail Tokarev)
- Guangzhou hydrate center (prof. Shuanshi Fan)

Research projects

- Properties of gas hydrate bearing rocks and permafrost
- Novel technologies for gas production from natural gas hydrates
- Geological risks related to gas hydrate an permafrost

MS courses

- Introduction in oil and gas engineering
- Gas Hydrates and Flow Assurance

External financing

- Grant of Russian Science Foundation
- R&D contract with Total on permafrost research (under negotiation)

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Oil Shale: Participation in Research Consortium on Bazhenov

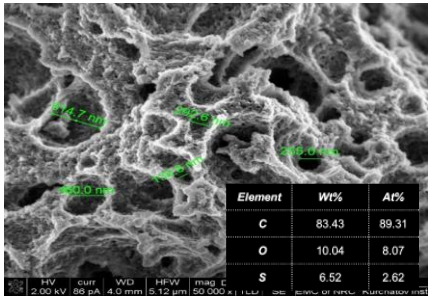
Project Title:
«Integrated study of Bazhenov formation: assessment of oil fields and new technologies for oil recovery»

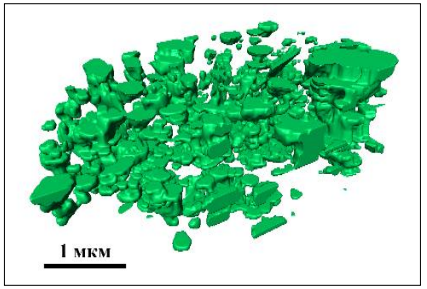
Project leader: Prof. Mikhail Spasennykh

Project term:
2014-2016

Project Funding – M 330 Rub
Ministry of education and Science -90%
Gazpromneft–10%

Project participants:
Gazpromneft (industry partner), MIPT, Skoltech, MSU, Gubkin University





Bazhenov kerogen pore structure, FIP/SEM

Scope of work:

- Integrated geological, lithological, geochemical and petrophysical study of Bazhenov formation at different regions of Western Siberia
- Development of integrated petrophysics model of Bazhenovfor different regions of western Siberia
- Comparison of Bazhenovwith oil shale reservoirs in US (Bakken, Eagle Ford, Barnett), evaluation of existing technologies for shale oil exploration and production
- Development of new technological solutions and tools for Bazhenovoil fields exploration and production (sweet spots, assessment of reserves, geomechanics and reservoir simulators, traditional and new technological solutions for oil production)

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Oil shales: characterization and pore space structure

Project leaders: Dr. A.Kazak, Dr.S.Chugunov **Clients: GAZPROMNEFT, NOVATEK**

Research goal

- Create 3D model of pore space image at a wide scale 1 nm – 1 m by integrating data from modern and novel methods of 3D tomography, microscopy and microstructural analysis

Current Status

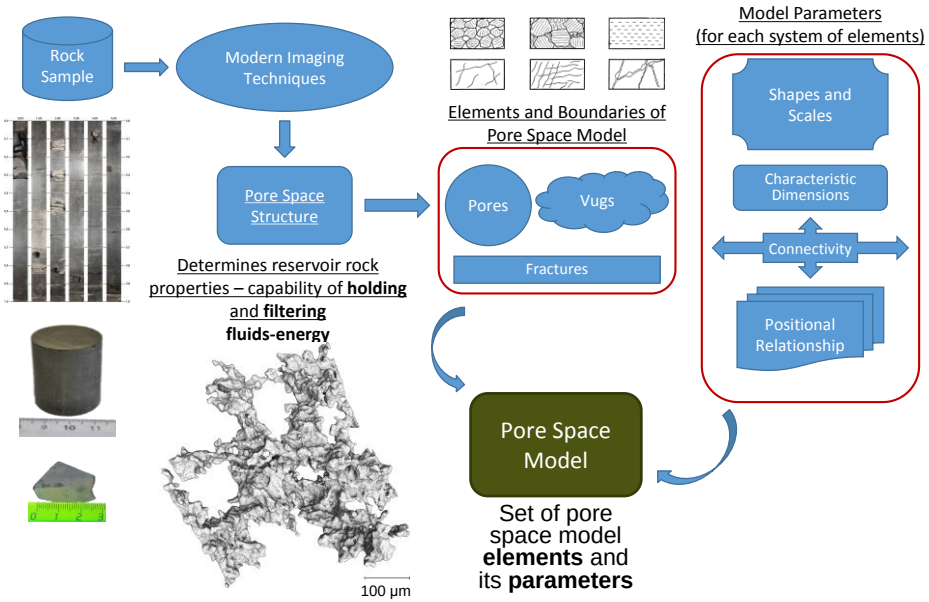
- Tight rocks were studied by X-ray micro-CT, FIB-SEM with elemental mapping, XRF scanning, mercury porosimetry and surface area.
- Discovered and studied porous structure of kerogen

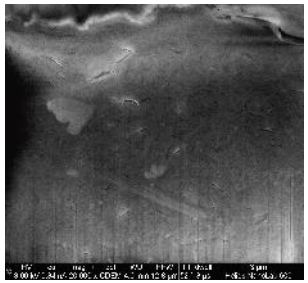
Results to Date

- Main results published in 5 papers in industrial journals and presented to professional community at 2 scientific-industrial conferences and workshops.

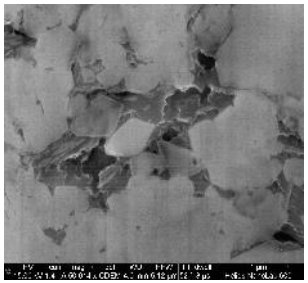
Next Steps

- To create 3D models for different types of tight rock from different regions of Eastern Siberia
- To implement obtained results for reservoir simulation

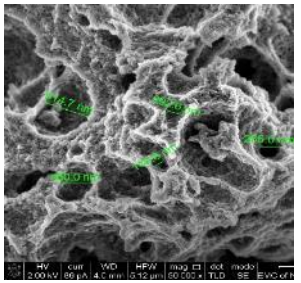




Kerogen without pores



Kerogen with small pores



Kerogen with large pores

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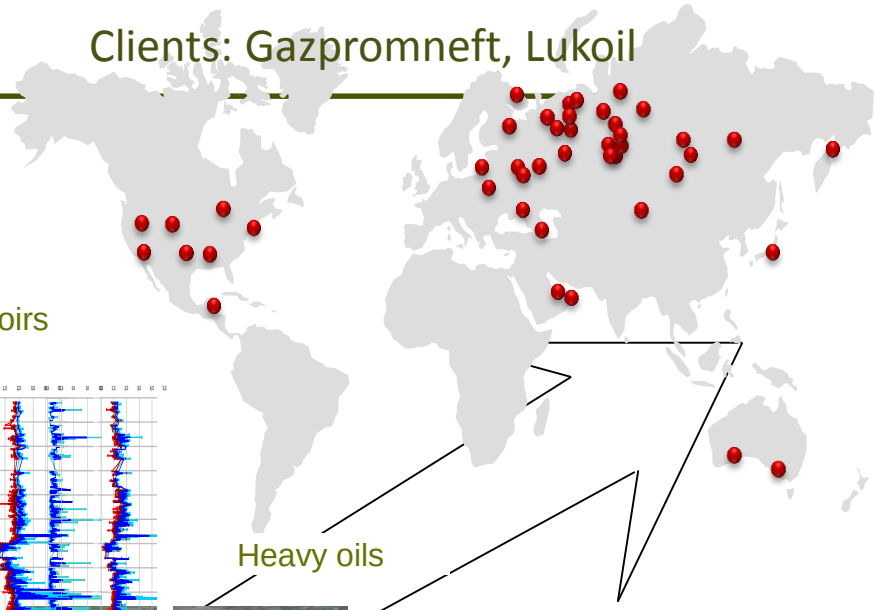
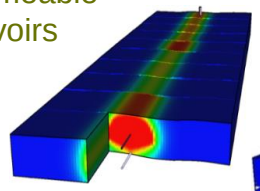
Thermal Petrophysics and Geothermics in application for oil shale formations

Project leader: prof. YuriPopov

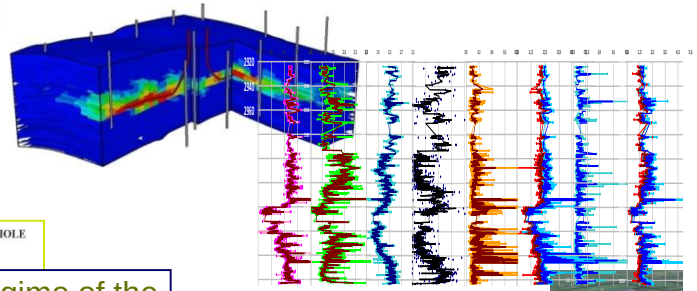
Clients: Gazpromneft, Lukoil



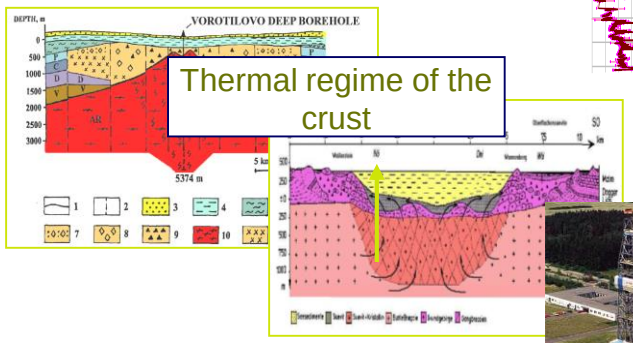
Low-permeable reservoirs



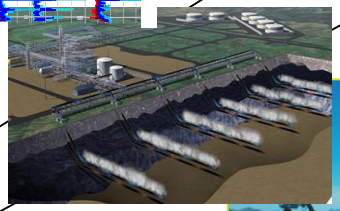
Traditional reservoirs



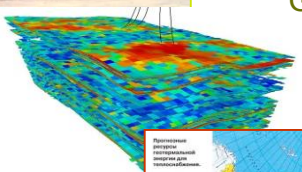
Thermal regime of the crust

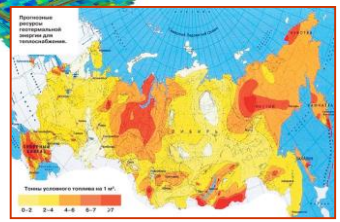


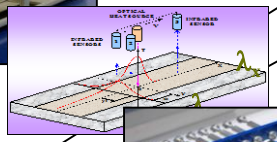
Heavy oils



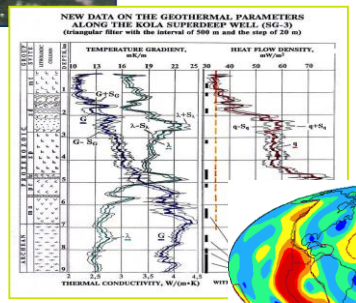
Geothermal energy

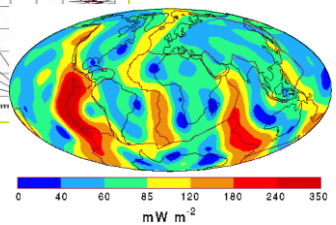






Advanced geothermal methods and equipment





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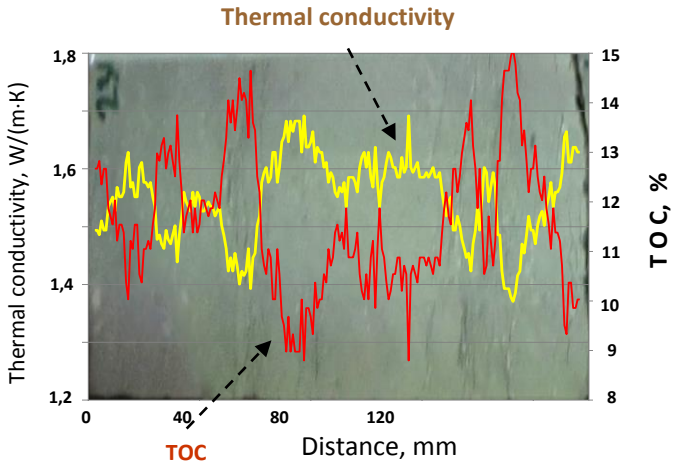
New method of high-resolution continuous total organic carbon (TOC) profiling (Skoltech, 2015)

Project leader:
Professor Yuri Popov

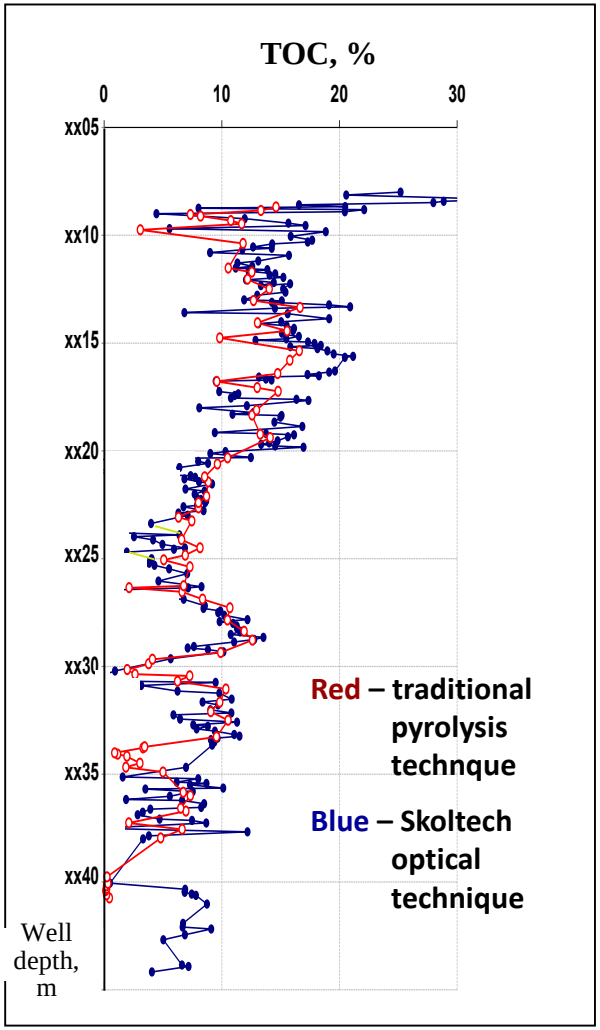
Research area:
Thermal petrophysics of oil reservoirs

Research goal:
Development and application of novel petrophysical methods for characterization of oil reservoirs

Current status:
- >30 wells studied
- Developed novel method for reservoir characterization
- 2 patent applications are under consideration
- 2 research reports delivered and accepted
- 4 seminars for industry



- Non-destructive TOC profiling
- First thermal core logging for studies of oil/gas field structure
- High-precision measurements of thermal properties for EOR and basin modeling
- Rock anisotropy and high-resolution heterogeneity profiling for geomechanics



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Hydro-geomechanics modeling of oil shale formation

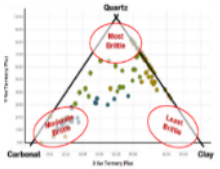
Project leader: Artyom Myasnikov, Dr. of Sci. **Clients:** GAZPROMNEFT, LUKOIL

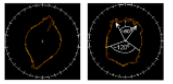
Goal: to develop novel technique of reservoir modeling for Bazhenov formation

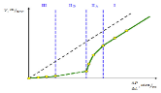
Expected results: Incorporation of specific shale physics in reservoir models

Challenges: specific shale physics generates fundamental problems:

- ❑ Elastic and strength properties significantly depend on mineral composition and organic content
- ❑ Alternation of brittle and ductile zones
- ❑ Fissuring is observed at all scale ranges from micrometer to kilometer
- ❑ Anisotropy strongly affects direction of the hydraulic fracture propagation and interpretation of breakouts observations
- ❑ Fluid rheology and phase equilibrium of liquid and solid phases strongly depend on stress-strain state of the formation
- ❑ Kerogen may form a filtrating system which disappears under specific PT conduction

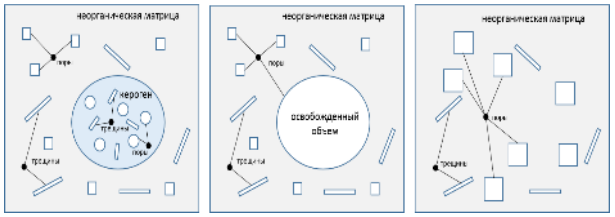




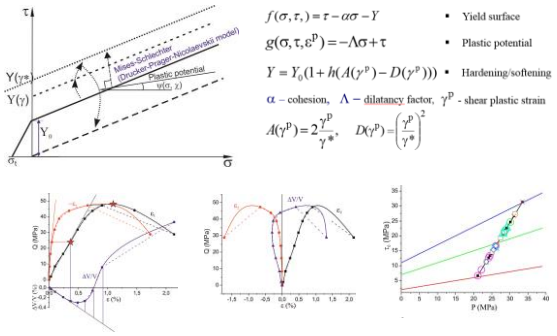


Obtained results 2015 : 2 *research reports (for Gazpromneft), 5 software products; 4 publications*

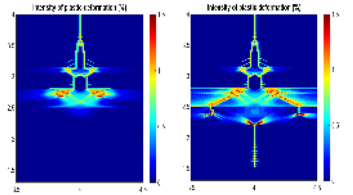
- A new concept of REV is developed which make it possible to model multiscale fissuring and kerogen transformation



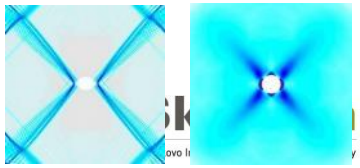
- New elastoplastic model shale formation is developed, initiated and validated



- HF propagation



- Wellbore stability

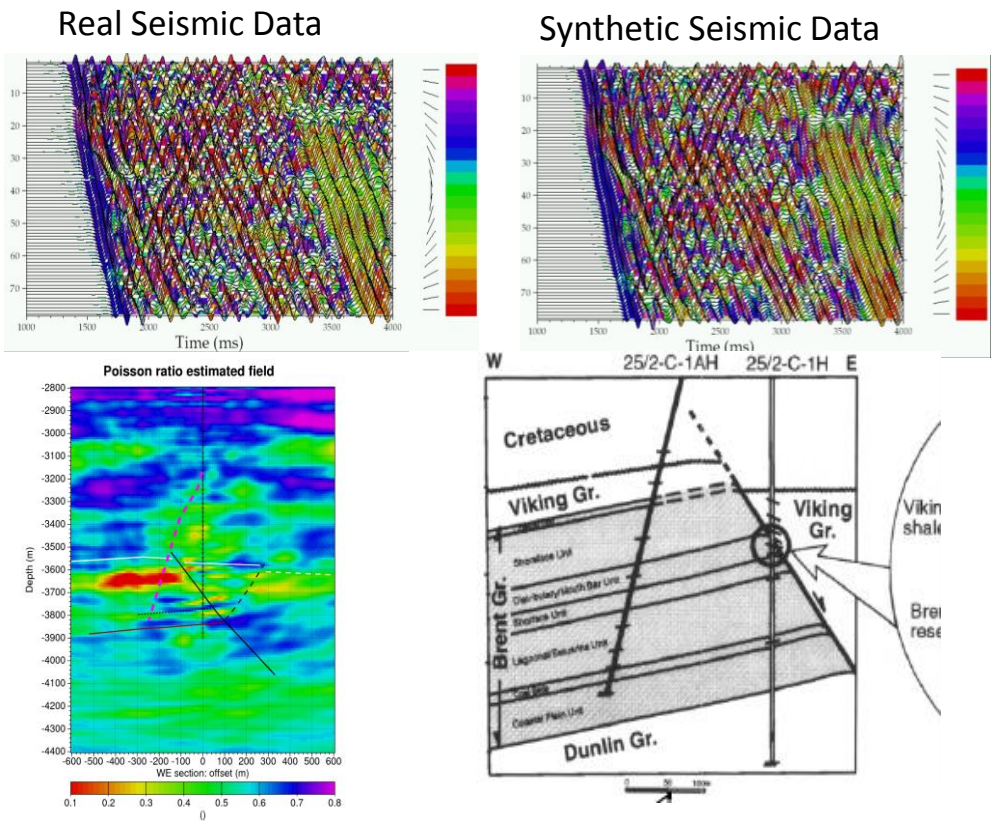


2D elastic full waveform inversion for the HPC

Project leader: Professor Marwan Charara

Project client: Governments of Russian Federation and Belorussia jointly

Seismic imaging is an important step in hydrocarbon reservoir exploration and characterization. To succeed in having reliable images of the subsurface, it is necessary to have good kinematical models, in order to properly positioning the seismic reflectors. New inversion techniques called "full waveform inversion" taking into account all the information in the seismograms not only for the pressure wave but also for the shear waves are successful in achieving this task but they are computationally intensive and require the use of high performance computing.



Source: Marwan Charara et all " Nonlinear inversion of seismic waveforms: A North Sea offset VSP example" SMR, Cergy University &Total, SEG 2010

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Thank you for attention!