JOGMEC’s Domestic and International Activities on Unconventional Oil and Gas Resources

Japan Oil, Gas and Metals National Corporation

10th July, 2018
JOGMEC Unconventional Team
Shigehiro Kitamura
Overview of JOGMEC

Mission
Securing Stable Supply of Oil, Natural Gas, Mineral Resources, Coal and Geothermal energy to Japan

Functions
Financial Support (equity capital finance, guarantees for loans)
Technology Development and Technical Support
Unconventional resources in Japan

Onnagawa Tight Oil

- Miocene
- Siliceous mudstone
- Main source rock of north Japan oil field
- Similar to Monterey formation in CA, US

Akita Basin

North East Japan

Diatom

White and Black band Mud stone
Unconventional resources in Japan
Onnagawa Tight Oil

- JAPEX with support of JOGMEC conducted acid stimulation in 2012. They observed remarkable increase in a well productivity.
- JOGMEC/JAPEX try to investigate quantitatively the mechanism of productivity improvement
- The final objective is to construct the evaluation methodology of acidizing and acid frac from labo analysis to simulation work

Compared with other field experience (Main Pass Sandstone, offshore Louisiana), the result of acid operation in Ayukawa filed showed a outstanding improvement.

Source : Modified from SPE-14827
Unconventional resources in Japan

Water–soluble natural gas

- Gas in place: >18Tcf ※Japan Natural Gas Association
- Biggest gas field exist under Tokyo
- Biogenic methane gas
- Produce formation water containing gas, separate gas on the ground, return water to underground
- Land subsidence is a big problem
- JOGMEC research land subsidence prevention

※Japan Natural Gas Association
Unconventional resources in Japan

Methane Hydrate

- Crystalline solid that consists of a methane molecule surrounded by a cage of interlocking water molecules
- Deep Sea
- 2nd production test in 2017 by JOGMEC
History of JOGMEC’s Shale Research Area

- Core Analysis (Onnagawa)
- Core Analysis (Marcellus)
- Core Analysis (Horn River)
- Core Analysis (Montney)
- Core Analysis (Cooper Basin)
- Well Stimulation Frac & Acidizing (Onnagawa)
- Frac & Reservoir Simulation (Cordova)
- G&G / Core / Frac/Microseismic (Montney)
- Frac & Reservoir Simulation (Eagle Ford)

Companies Involved:
- Nexen (CNOOC)
- INPEX
- Encana Mitsubishi
- JAPEX
- Anadarko
- MOECO
- Mitubishi
- JAPEX
- Progress (Petronas)
- ENCANA
Shale R&D Workflow
All for Project Optimization

Integrated Laboratory study
(FIB-SEM, NMR)
Deep understanding of shale properties.

Nano-micro scale simulation
Physical explanation of measured core data

Geomechanical study
wellbore geomechanical property change

Integrated G&G study
Sweet Spot Map

Microseismic Fracing Area

Lab Scale Fracturing Study
Frac Visualization and AE Analysis

Reservoir Simulation
Frac Model to Flow Model
Integrated Laboratory Study

- Basic and advanced lab analysis
  - Porosity / Permeability
  - TOC
  - Pore size distribution (NMR, Hg injection, N2 adsorption)
  - MD simulation
  - Etc.
- Iterative process with engineers
- Understand uncertainties

- Medical X ray CT scanner
- Micro focus X ray CT scanner
- FIB/SEM

- Multiphase flow visualization during core flooding
- 3D visualization at Micro scale
- 3D visualization at Nano scale

James Weir Fluid Laboratory HP
Joel D. Walls, E&P Magazine
Shale pore size?

- **Scanning Electron Microscope (SEM)**: nm ~ μm
- **Medical X-ray CT**: 100μm ~ m
- **Computer simulation**
- **Micro focus X-ray CT**: μm ~ mm

**Images**:
- **SEM (Shale)**: 10μm
- **Micro X-ray CT (Sand Stone)**: 5.5mm
- **Core Plug**: Plug core 25mm
- **Virus**: 10nm
- **Blood cell**: μm
- **Human Hair**: 100μm
- **Shale pore**: nm~100nm
- **Sandstone pore**: μm~10μm
- **Oils**: 1A

**Comparison**:
- **Human Hair**: 100μm
- **Sandstone pore**: um~10μm
- **Plug Core**: 25mm
FIB-SEM

- Resolution: 10nm/pixel
- 3D Volume: 10 um x 10 um x 20 um
- 3D pore structure is reconstructed by preprocessing and segmentation

Focused Ion Beam - Scanning Electron Microscope
Complicated but well connected inter granular pore

Isolated pore in pyrobitumen

Blue: Pore
Red: Organic
Nano Scale Simulation Study

**Adsorption Behavior**
- To model gas adsorption isotherm of shale rock from pore size distribution (PSD) using molecular simulation techniques.

**Simulating System**

**Molecular Model**
- Kerogen
- Methane

**Isotherm Curve**

**Slip Flow**
- Slip phenomenon is one of major characteristics of gas flow through narrow pore throat (nanopores) in shale formations. Consequently, permeability correction needs to be considered for evaluating the flow ability of gas in these reservoirs.

\[ K_n = \frac{\lambda}{L} \]  
(\( \lambda \): mean free path, \( L \): pore size)

- Pyrophyllite
- Beskok et al.

- **Methane**
- **Quartz**

**Simulation System**
Hydraulic Fracturing Experiment Study

- Under 3 axial loading condition
- Frac by acrylic resin w/ fluorescent substance
- Observed fracture path under UV
- AE monitoring while HF
- Locate AE events and do the moment tensor analysis

Granite Rock

Inai Shale

Japan Oil, Gas and Metals National Corporation
Hydraulic Fracturing Simulation Study

A simulation result by using UT’s peridynamics-based hydraulic fracturing simulator

*Granite specimen having K-feldspar (K), plagioclase (P) and quartz (Q)

(Personal Communication with Mr. Agrawal [2017])
Hydraulic Fracturing Experiment Study at Outcrop

JOGMEC HF Research Area

Fracture Extension Simulation (UT)

Field scale

Intermediate

Core scale

Mangrove Simulation Study

Montney HF Monitoring (DAS+MS)

Conceptual design of experiment study at outcrop

Depth 5-20m

Granite Rock

Inai Shale

Montney HF Monitoring (DAS+MS)

AE sensor

Injection well

AE monitoring well
Hydraulic Fracturing Experiment Study at Outcrop

Pre-Survey Jun-Jul, 2018

Onnagawa Core (White and black band)
Hydraulic Fracturing Experiment Study at Outcrop

Pre-Survey Jun-Jul, 2018
Big Data Analysis for Tight gas development

Problem: Sand production during flowback

- Required extra time to flowback, sand separation before tie-in to production line
- Extra cost for well completion

Data set
- Geological parameter A
- Geological parameter B
- Geological parameter C
- Drilling parameter A
- Drilling parameter B
- Drilling parameter C
- Completion parameter A
- Completion parameter B
- Completion parameter C

~150 wells

Results
- Found high risk area and formation in the field
- Establish a equation for sand production volume prediction

Sand flowback volume = $a_1 \times$ completion parameter A

Geological parameter B $G_2 < 64$

Low risk

Area A

Geological parameter A $G_1 < 0.2$

Yes

No

Geological parameter B $G_2 < 64$

Low risk

Area A

Geological parameter C $G_3 < 0.9$

Yes

No

Geological parameter B $G_2 < 64$

Low risk

Area B

Sand flowback volume = $b_1 \times$ completion parameter B

High risk

Area C

Sand flowback volume = $c_1 \times$ completion parameter C + $c_2 \times$ drilling parameter C

High risk

Sand flowback volume = $d_1 \times$ drilling parameter D

Area C

Findings:
- Sand production during flowback
- Required extra time to flowback, sand separation before tie-in to production line
- Extra cost for well completion

Area A

Area B

Area C

24-26 September 2018
Dallas, Texas, USA
Case Study - Canada Montney Field
JOGMEC’s Shale Projects in Canada

**JAPEX Montney Ltd.**
- **Area**: Montney
- **Operator**: Progress Energy Canada Ltd. (90%)
- **Company**: Japex – JOGMEC (10%)

**INPEX Gas British Columbia Ltd.**
- **Areas**: Horn River/Cordua/Liard
- **Operator**: Nexen Inc. (60%)
- **Company**: INPEX – JGC – JOGMEC (40%)

**Cutbank Dawson Gas Resources Ltd.**
- **Shale Gas Investment Canada Ltd.**
- **Area**: Montney
- **Operator**: Encana 60%
- **Company**: Mitsubishi Corporation – JOGMEC (40%)
Montney Formation

• Lower Triassic siltstone, very fine sandstone reservoir

• Up to 300m thick in British Columbia, Canada

• Tight siltstone matrix permeability play

Past Technical Challenges: To Improve Productivity
- Labo Analysis, Cuttings, Mud Gas Analysis
- Sweet Spot Detection
- Geomechanics Study

Current Technical Challenges: Drilling & Completion Cost Reduction
1. Optimization of Well Design
   - Do longer wells gain more production?
   - Current standard completion design (cluster spacing, tonnage volume, etc.) is based on past experiential rule
     ⇒ Monitor fracturing efficiency and productivity along horizontal section and investigate the relation with well design

2. Optimization of Well Spacing
   - Current standard well spacing is based on past experiential rule
     ⇒ Evaluate the size of stimulated volume and investigate the relation with well design

- Stage/Cluster Injection Profile
- Frac Fluid Placement
- Stimulation Effectiveness
- Production Profile/Temperature Profile
- Wetness Variation along lateral well path
- Rock Property Variation along the lateral length
- ...
Summary of research on Montney Tight Gas Play

- 2013-2016
  - Lab analysis to improve the understandings of Montney formation
  - Sweet spot analysis for identifying the best drilling location (Seismic base)
  - Fracturing modeling for designing the economical completion (Geomechnics)
  - Microseismic analysis for identifying the fracture geometry

- 2017.3-
  - Integrated Science Drilling Study for the optimum well design and spacing
    - Fiber optics (DAS, DTS)
    - Microseismic
    - Wire line log
    - Mud gas & Cuttings analysis
    - Chemical tracers (Water soluble, Oil soluble)
Our Goal:

• To establish a method of creating sweet spot map (high gas rate and liquid-rich areas) in Montney tight gas reservoir by integrating all available data including 3D seismic data.
Sweet spot mapping: Result

Predicted CGR Map

\[ \log_{10}(\text{CGR}) = -0.34 \times Pp - 85.8 \times V_{\text{gas}} + 45.2 \times V_{pb} - 41.6 \times \text{SeismicPR} + 22.1 \]

- Predicted Cum. Production Map

Operator refers these maps to select better well location and drilling schedule and to expand our methodology to the other areas.
Detect hydraulic fractures' geometry
Optimize well spacing, lateral length, cluster design and frac pump rate
Evaluate impact of lateral heterogeneity to frac/production

Our team has 2 Microseismic specialists (one is PhD and the other is ex-service company’s experts with over 100 wells MS interpretation)
Integrated Science Drilling Study

Objectives
- Optimize well spacing, lateral length, cluster design and frac pump rate
- Detect hydraulic fractures’ geometry
- Evaluate impact of lateral heterogeneity to frac/production
- Determine the feasibility of using the fiber optics (DAS) as MS listening device

Data acquisition
- Fiber optics (DAS, DTS)
- Chemical tracers (Water soluble, Oil soluble)
- Wire line log (Triple combo, Dipole sonic, OBMI, CBL)
- Microseismic (Geophone, DAS*)
- Mud log*
- Cuttings (Mineralogy, Pore size distribution) *

*JOGMEC analyze
Distributed Acoustic Sensing (DAS)

Interrogator: Laser, optical and electronic components

Waterfall plot [Magnitude of acoustic signal]

Depth

Time

Japan Oil, Gas and Metals National Corporation

Courtesy from optasence
DAS: Example

OptaSence
Integrated Science Drilling Study: Key learnings

- Cuttings and DAS/DTS studies revealed relationship between Geology, Fracking and Production

- Relationship between DAS MS and Borehole MS

- Tracer study indicates Interference between production wells due to tight space drilling

Based on the above results, operator is going to optimize well spacing, lateral length, cluster design and frac pump rate.
Conclusion

• Main activity areas are Canada and Onnagawa.
• Lab analysis to development design.
• Our mission is support for Japanese companies.
• However if there are technically interesting things, we may be possible to collaborate with NOC and organizations.
Thank you so much for your kind attention
ご清聴ありがとうございました
謝謝您