Overview of Unconventional Oil & Gas Potentials in Japan

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Same parts was provides from JAPEX
<table>
<thead>
<tr>
<th>No.</th>
<th>Basin name</th>
<th>Age of the bottom sediment</th>
<th>Oil&amp;Gas Field</th>
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<tbody>
<tr>
<td>1</td>
<td>Akita-Yamagata Basin</td>
<td>Neogene</td>
<td>O</td>
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<tr>
<td>2</td>
<td>Okushiri Basin</td>
<td>Neogene</td>
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<td>3</td>
<td>Oshima Basin</td>
<td>Neogene</td>
<td></td>
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<tr>
<td>4</td>
<td>Ishikari Basin</td>
<td>Upper Mesozoic-Neogene</td>
<td>O</td>
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<tr>
<td>5</td>
<td>Teshio(Tenpoku) Basin</td>
<td>Upper Mesozoic-Neogene</td>
<td>O</td>
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<td>6</td>
<td>Niigata Basin</td>
<td>Neogene</td>
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<td>Toyama Basin</td>
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<td>Fukue Basin</td>
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<td>Okinawa Trough Basin</td>
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<td>13</td>
<td>Shimajiri Basin</td>
<td>Neogene</td>
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</table>

*offshore basin*
• Several small oil-fields located in sedimentary basins in Hokkaido.
• These oil-fields are classified two types based on biomarker analysis.
Depositional Environment of Source Rocks by Biomarker Analysis

**Major Parameters of biomarkers**

- Pristane/Phytane ratio
- Sterane C27, C28, C29 ratio
- Oleanane, C30Hopane ratio
- Diterpane
Diterpane

- Cyclic saturated hydrocarbon
- Important component of higher plants
- Good indicator for coal source rock

**Diterpane**

**Tricyclic Terpane**
- Peak C: 19-Norsopimarane
- Peak D: Fithtelite (Nor-abietane)
- Peak E: Pimarane
- Peak F: Abietane

**Tetracyclic Terpane**
- Peak G: 16β(H)-Phyllocladane
- Peak H: 16α(H)-Phyllocladane

Akabira COAL In Ishikari
Diterpane in Coals in Hokkaido

m/z 191  diterpane  triterpane

Poronai

Akabira

Minami-Oyubari

time
Diterpane in Crude Oils

- Rich in Tenpoku oils
- No show in Northwest Ishikari (Atsuta oil)
- Rich in Southeast Ishikari (Yufutsu Oil)
- No show in Oshamanbe oil in Oshima Basin
Hokkaido

- Several small oil-field located in sedimentary basins in Hokkaido.
- These oil-fields are classified two types based on biomarker analysis.
  - Terrestrial sources rock
    # Tenpoku Basin
    # Southeast Ishikari Basin
  - Marine shale source rock
    # Northwestern Ishikari
    # Oshima Basin
- High shale oil potential in Oshima & Northwest Ishikari Basin
Siliceous Hard Shale

- Akita-Yamagata Basin has highly potential for shale oil (tight oil).
- Siliceous shale of Onnagawa Formation is important shale Formation.

Onnagawa Formation (siliceous hard shale)
We have a commercial oil & gas production from Onnagawa shale since 1985, in the Ayukawa-Yurihara field.
Porcelainite reservoirs with conventional trap core.

- **Black band**: clay rich, better source rock
- **White band**: reservoir property (~30% 1md)

Polished core and SEM image of "white".
Ayukawa field: commercial production from Onnagawa shale with conventional trap

Commercial production
- From Dolerite, Tuff and Qtz-Porcelanite partly fractured
- Common gas-oil contact → one pressure system
We have proposed a diagenetic trap model in Yurihara-Ayukawa field; where opal-CT porcelanite as a seal and Qz porcelanite as a reservoir.
We also have much and continuous oil shows in the Onnagawa shale far below the trap, which is indicative of a shale oil system.
Shale oil

Lower 48 states shale plays

Source: U.S. Energy Information Administration based on data from various published studies.
Update: May 9, 2011
Bakken Shale in USA

hot shale + dolomite ⇒ hybrid shale

100- ft / 8000 ft : TOC 10~20%

Sonnenberg, 2011

Lefever

Headington Oil Company
Waseda et al. (1995) studied the Onnagawa formation in Yurihara area.

Over 30 samples (actual over 200) from outcrops were analyzed.
Vertical Variation at narrow area

- TOC and S2/S3 are varied in a narrow area
- Sweet spot zone is important for resources evaluation

Fig. 9 The millimeter to centimeter-scale variation of TOC, S2/S3 of Rock-Eval, kerogen carbon isotope compositions and detritus contents in 4 samples in the Onnagawa Formation.
Estimation of Tight Oil Reserves (after Dr. S. Yokoi, JAPEX)

Ayukawa Area in Akita Basin:
simply 2 million bbl

Mature Area near Ayukawa-Yurihara:
- No Commercial tight oil product
  -> difficult to estimate proven play
- Adapting Rock-Eval Using Downey et al. (2011) Method (S1 based method)
- Based Sirayukigawa SK1D well data
  area: 10km², thickness: 30m, average S1: 6mg/g, etc
- Simply estimated: 100 million bbl
- Whole Akita basin: 1 billion bbl?
Quick Look: Determination of Oil-In-Place in Oil Shale Resource Plays

Maelan W. Dressy1, Julio Garcia2, R. C. Lagomarsino3, and David F. Nicklin2

Search and Discovery Article #90764 (2011)
Published: June 30, 2011

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Abstract

Quantitative measurements of gas-in-place volumes for coal gas and shale gas resource plays have been important and powerful starting points for planning optimized economic gas extractions. Quantitative reserves measurements of gas-in-place have strongly aligned investor confidence in the exploitation of coal gas and shale gas plays. Gas-in-place measurements provide the resource target that can justify ongoing technical and business investments in gas shale resource plays.

With recent successes in apparent commercial extraction of oil from shale, such as in the Eagle Ford Shale of South Texas and the Woodford Shale of southern Oklahoma, the question arises as to the efficiency of oil recovery using current completion and drilling technologies. Given the high likelihood that these plays will prove to be long-term milestones, it is a strategic and economic imperative that recovery efficiency be optimized, the starting point being the reliable estimation of the size of the oil-in-place resource. While this approach does not determine how much oil will be recovered, it provides a measurement of the maximum amount of oil-in-place, the target volume of the play area.

We propose a quantitative measure of oil-in-place from measurements of the distillable oil in an oil shale, specifically from the S1 measurements of a standard RockEval analysis. The measurements obtained may then be upscaled to calculate oil-in-place for a given formation, trend, or basin. By comparing these estimates to reserves of ultimate recovery per well and per producing formation, operators may glean greater insight into their recovery efficiency, and as a result determine the need for, and lay plans to carry out the minimum amount of drilling and formation fracturing to ensure the maximum amount of oil extraction. The ultimate recovery efficiency will be determined over time by invasive applications of technology.

In testing the technique, measurements were made in the Eagle Ford Shale of South Texas and in the Woodford Shale of southern Oklahoma. Comparisons were made between immature, mature, and over-mature source rocks and between core-derived measurements and those obtained from drill cuttings. Guidelines are proposed for a simplified quick-look approach with pointers to avoid potential pitfalls and ensure accuracy.

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METHODOLOGY (CONT.)

Step 2: volume of oil per section (cc)

\[ V_{S1HC} = M_{S1HC} \cdot \rho_{oil} \]

Where:

\[ V_{S1HC} = \text{Volume of S1 hydrocarbons per section (cc)} \]

\[ M_{S1HC} = \text{Mass of S1 hydrocarbons per section (g)} \]

\[ \rho_{oil} = \text{Density of oil (g/cc)} \]

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**METHODOLOGY (CONT.)**

Step 3: barrels of oil per section

Oil in Place per section (Bbl) = \( V_{S2HC} \times 6.29E-6 \text{ bbl/cc} \)

**OIL IN PLACE FROM S1**

Simplified Equation

Oil in Place per 640 acre/ft = \( 9677.48 \times (S1_{Av}) \)

Where:

- \( S1_{Av} = \text{Average } S1 \text{ (mg/g)} \)

Assumes:

- 2.5 g/cc Bulk Density
- 50° API Oil Gravity

**OIL IN PLACE FROM S1**

Simplified Equation

Oil in Place per 640 acre/ft = \( 4965.36 \times (\rho_{Av})(S1_{Av})(\rho_{oil}) \)

Where:

- \( \rho_{Av} = \text{Average bulk density (g/cc)} \)
- \( S1_{Av} = \text{Average } S1 \text{ (mg/g)} \)
- \( \rho_{oil} = \text{Density of oil (g/cc)} \)

**QUICKLOOK CONVERSION OF S1 TO OIL**

Using S1 in mg/g to BBL of Oil in 640 acres/foot

(R.C. Lagomarsino)

Assumes:

- 2.5 g/cc Bulk Density
- 50° API Oil Gravity
1.0 MMBBL/640 Ac. = 4.25 MMBBL/km²
• effective thickness: >100m
  Shale oil and shale gas development, fracturing, is limited only less than 100m.
• Hot Spot or Hot zone is important
• Geochemical data is necessary.
• S1 value of Rock-Eval analysis is effective for evaluation
Shale Gas is mainly in OM pores as absorbed and free.

Barnett shale: nano pore of kerogen

Loucks et al. & Chalmers, 2012
Marcellus shale

Organic pore (kerogen) / TOC 10%+

Marcellus 3D FIB-SEM Images (Wet Gas)

View video of pore geometry

White: Pyrite
Light gray: Minerals of density 2-3 g/cc
Dark gray: Kerogen
Black: Pore space
Blue: Connected porosity
Red: Non-connected porosity
Green: Kerogen (+ nano-pores)

Majority of porosity and permeability is associated with kerogen. Three visible pore types: large mega pores, smaller pores, and a third textural indication any level of smaller pores below resolution and included in Kerogen in the right image.
Marcellus shale
What is controlling its productivity?

⇒ Organic-rich shale thickness

Thickness of OSS (organic siliceous shale)

50ft~ / 4000ft~
TOC 10%+

Wang & Carr, 2013

Yang et al., 2013
Hydro-fracturing using Coiling Tube (CT)

**Hydra-Jet Anchor Service:** IMPROVED EFFICIENCY WITH WELLBORE DIVERSION

To further improve the efficiency of the CobraMax service, the Hydra-Jet™ Anchor enhances performance in pinpoint stimulation operations by centralizing the tool, preventing unwanted movement, and creating diversion while helping improve proppant packs of the near wellbore formation.

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