Combined Meeting of the IEAGHG Modelling and Monitoring Networks

Progress of the Tomakomai CCS Demonstration Project

7 July 2016
Japan CCS Co., Ltd. (JCCS)
Outline

Progress of the Tomakomai CCS Demonstration Project

1. Brief Look at the Tomakomai Project
2. Progress of the Project
3. Current Injection Schedule & Test Injection Records (preliminary)
4. Public Outreach Activities
5. Seismic Monitoring and Modeling Schedule
6. Passive Seismic Imaging with Seismic Interferometry (trial)
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Site Location

- Tomakomai Area
- Hokkaido Is.
- Sapporo
- Tokyo

Distance: ca. 800 km
Bird’s eye view of the City and Port of Tomakomai

175,000 people live in the city

Tomakomai City Hall

3.6km

Oil Refinery

Gas containing CO2

JCCS Facilities

Two Injection Wells
Down to beneath the seabed

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Reservoirs and Cap Rocks

※Cross-sectional view along the trace of the injection well for the Takinoue Formation

Depth in meters (bMSL)

-3600m
-3200
-2800
-2400
-2000
-1600
-1200
-800
-400

Landward

0 400 800 1200 1600 2000 2400 2800 3200 3600 4000 4400 4800m

Seaward

Quaternary sediment

Mukawa Fm. (sandstone, mudstone, etc.)

Moebetsu Fm. (Mudstone)

Cap rock

Reservoir

Moebetsu Fm. (Sandstone)

Nina Fm. (Mudstone)

Biratori-Karumai Fm. (Mudstone)

Fureoi Fm. (Mudstone)

T1 Member of Takinoue Fm. (Volcanic Rocks)

Miocene saline aquifer composed of volcanic and volcaniclastic rocks of about 600m thick.

Takinoue Fm. (Mudstone)

Observation Well for Moebetsu Fm.

Moebetsu Fm. (Mudstone)

Cap rock

Reservoir

V:H=1:1
Injection Wells and Monitoring Systems

- **Onshore seismometer**
- **Observation well OB-1 for Takinoue Formation (deviated)**
- **Observation well OB-2 for Moebetsu Formation (vertical)**
- **Observation well OB-3 for Takinoue Formation (vertical)**
- **2 Injection wells (deviated)**

**Working area of 4D seismic survey**

- **OBC (Ocean Bottom Cable)**: used for 2D seismic survey and monitoring of micro-seismicity and natural earthquakes.
- **OBS (Ocean Bottom Seismometer)**: used for monitoring of micro-seismicity and natural earthquakes.
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Progress of the Project

- Survey
- Preparation
- CO₂ Injection
- Baseline Monitoring
- Monitoring

Fiscal Year in Japan (April – March)


Today!
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# Current Injection Schedule ( JFY2016 )

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Upper Reservoir</th>
<th>Lower Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>4</td>
<td>Test Injection</td>
<td>T1 Member of Takinoue Fm. (Volcanic Rocks)</td>
</tr>
<tr>
<td>2016</td>
<td>5</td>
<td>Fall off Test</td>
<td>Moebetsu Fm. (Sandstone)</td>
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<tr>
<td>2016</td>
<td>6</td>
<td>Full-scale Injection</td>
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<tr>
<td>2016</td>
<td>7</td>
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<tr>
<td>2016</td>
<td>8</td>
<td>Full-scale Injection</td>
<td></td>
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<tr>
<td>2016</td>
<td>9</td>
<td>Suspension</td>
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<td>11</td>
<td>Full-scale Injection</td>
<td></td>
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<tr>
<td>2017</td>
<td>12</td>
<td>Suspension</td>
<td></td>
</tr>
</tbody>
</table>

Today!

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**Legend:**
- **Moebetsu Fm. (Sandstone)**
- **T1 Member of Takinoue Fm. (Volcanic Rocks)**
Test injection at a rate of 200,000 CO$_2$-tons/year $\times$ 50%
Test injection at a rate of 200,000 CO$_2$-tons/year $\times$ 100%

Test injection at a rate of 200,000 CO$_2$-tons/year $\times$ 75%
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Our Public Outreach Activities

1. Released CCS DVD via website
2. Installed camera showing live construction site via website
3. Organizing panel exhibitions
4. Organizing annual CCS forums for citizens
5. Arranging site visits
6. Conducting lectures at universities
7. Arranging science classes for schoolchildren
8. Continuing information transmission through media
9. Disclosure of monitoring results of injection operations to residents
Current state of the project is open to public at the entrance hall of City Hall. The same contents are available on JCCS website. (http://www.japanccs.com/) * in Japanese!
Recent noticeable tremor recorded at Tomakomai site
Well bottom pressure at Injection well and observation well (updated monthly)

Concentration of CO2 based on marine and land environmental survey (updated 4 times a year)
Public Disclosure at City Hall

日本CCS調査（株）からのお知らせ

・What’s New
  ・二酸化炭素の圧入を開始しました。

平成28年4月6日（水）より、分離回収した二酸化炭素の圧入を開始致しました。

二酸化炭素（CO₂）圧入量実績

<table>
<thead>
<tr>
<th>CO₂圧入量、累積圧入量（速報）</th>
<th>2016年4月30日のCO₂圧入量</th>
<th>0.0 トン</th>
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</thead>
<tbody>
<tr>
<td>累積CO₂圧入量</td>
<td>(2016年4月6日～2016年4月30日)</td>
<td>2,563.9 トン</td>
</tr>
</tbody>
</table>

現在圧入を停止しています。GW明けに再開する予定です。
Other Recent Activities

① **Panel Exhibitions**: total 20 times in Sapporo, Tomakomai and neighbor towns

② **Site Visits**: for universities, research associations, local government, etc.

③ **Environmental Exhibitions**: booths in “Eco-Products 2015” and “2015 Global Warming Prevention Exhibition” in Tokyo

④ **Kids Science Classes**: learn about global warming, CO₂ and CCS through games and experiments, totally 12 times in Tomakomai

⑤ **CCS Forum**: held on March 14, 2015 in Tomakomai
Numbers of Visitors to Demo Site (As of 2016.5.31)

Numbers of Visitors:
- 2014 FY: 608
- 2015 FY: 1570
- 2016 FY: 3000 or more?
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## Monitoring (Modelling) Schedule

<table>
<thead>
<tr>
<th>Year</th>
<th>survey</th>
<th>Preparation</th>
<th>CO₂ Injection</th>
<th>Monitoring</th>
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<td>2019</td>
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<tr>
<td>2020</td>
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</tbody>
</table>

- **3D seismic**: ★ (baseline survey)
- **2D seismic**: ★ (baseline survey)
- **CO₂ Injection**:
  - 2016: ★
  - 2017: ★
  - 2018: ★
- **Monitoring**:
  - 2016: ★
  - 2017: ★
  - 2018: ★

**Today!**

**Fiscal Year in Japan**

(April – March)

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History matching, geomechanical modelling, etc.
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Seismic Interferometry

Continuous data recording by permanent-type OBC

Pseudo-shot-gathers

Seismic Interferometry

Seismic reflection processing

Seismic Reflection Profile

Time Lapse Application

4D Response

(Shiraishi et al., 2008)
Permanent-type OBC at Tomakomai Site

Schematic Diagram of Permanent-type OBC

- OBC Length 3.6 km
- 4-Component Sensors at every 50m (total 72 Locations)
- OBC is buried 2m below the Seabed

3C sensor module

- Length: 1.37 m
- Diameter: 9 cm
- Weight: 12.6 kg

Cable burying machine (water-jet tool)
Input Data for Seismic Interferometry

- **recording period:**
  - 2015/01 ~ 2015/11

- **target event:**
  - local natural earthquakes
  - occurring in $(225\text{km} \times 250\text{km})$ area
  - epicentral distance $> 48\text{km}$
  - magnitude $> 2.0$
  - with clear P-wave onset

- total 158 events were extracted
Examples of extracted natural seismic events

- **2015/02/08 21:55 (M3.1)**
  - Distance: 47 km
  - Depth: 165 km

- **2015/05/04 13:42 (M4.1)**
  - Distance: 138 km
  - Depth: 42 km

- **2015/09/16 19:17 (M3.3)**
  - Distance: 92 km
  - Depth: 70 km
Pseudo-shot-gathers obtained by seismic interferometry

Interferometry (with 1 event)

Interferometry (with 158 events)

Active Source (air-gun)
Seismic reflection profiles by seismic interferometry

Interferometry (with 1 event)
Interferometry (with 158 events)
Active Source (air-gun)
Current Status ( instead of Conclusion … )

1. Injection has just begun this April (2016)

2. To date, 7162.9 tons of CO2 have been injected

3. To date, no significant induced micro-earthquakes have been detected in the area of interest

4. Monitoring results are open to public

5. 4D seismic survey (3D monitor survey) is planned to be conducted in 2017

6. Modelling-monitoring loop trial will start at the end of 2017!
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Marine environment shall be surveyed based on “Act on Prevention of Marine Pollution and Maritime Disaster” by which geological storage of CO$_2$ under the seabed is regulated.

1. Survey Area (Fig)
   - At 12 survey points in the Tomakomai port area

2. Methods of Survey
   - Seabed survey by Side-Scan Sonar and Sub-bottom Profiler
   - Current direction and speed survey by Current Meter
   - Sampling of seawater by Water Sampler for concentration of salt etc. and plankton observation
   - Seabed mud survey by Bottom Sampler
   - Collection of benthos by Net or Dredge Unit
   - Observation of benthos by divers or ROV

3. Surveys in three stages
   - During EPC (Engineer procure construction) period
   - During demonstration operation
     - During CO$_2$ injection
     - After CO$_2$ injection
   - After demonstration operation