Progress of CO_2 Injection at the Tomakomai CCS Demonstration Project

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Japan CCS Co., Ltd. (JCCS)

GomCarb & SECARB Joint Partnership Meeting
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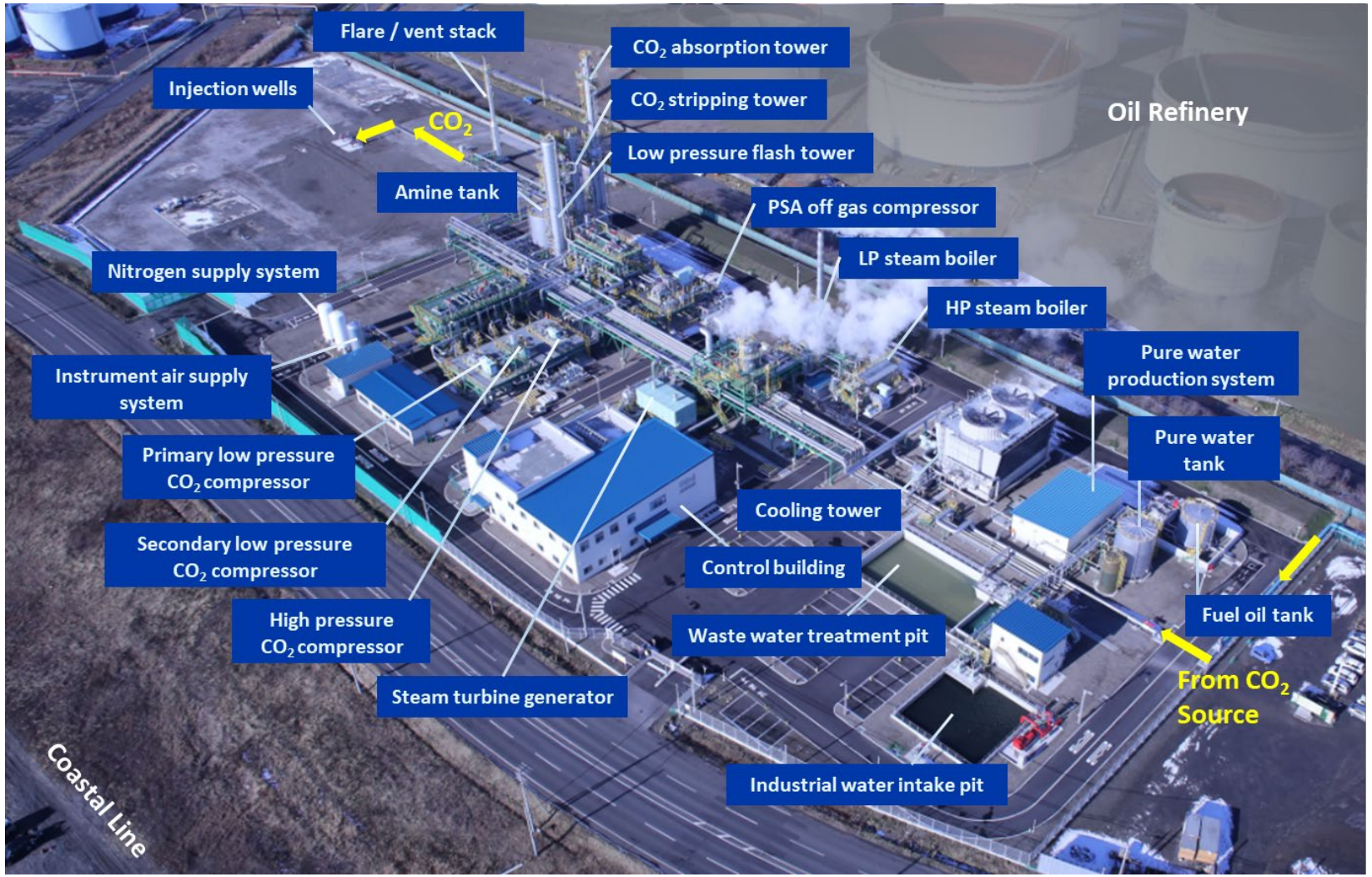
Main characteristics of Tomakomai CCS Project

- World first offshore CCS project in a busy port area of large city
- CO_2 storage governed by Japanese law reflecting London 1996 Protocol
- Energy efficient CO_2 capture process
- Two highly deviated injection wells drilled from onshore targeting two separate sub-seabed reservoirs with injection intervals exceeding 1,100m
- Extensive onshore and offshore monitoring system for observation of CO_2 behavior in the reservoirs, micro seismicity and natural earthquakes
- Marine environmental surveys conducted each season

Bird's Eye View of Capture and Injection Facilities



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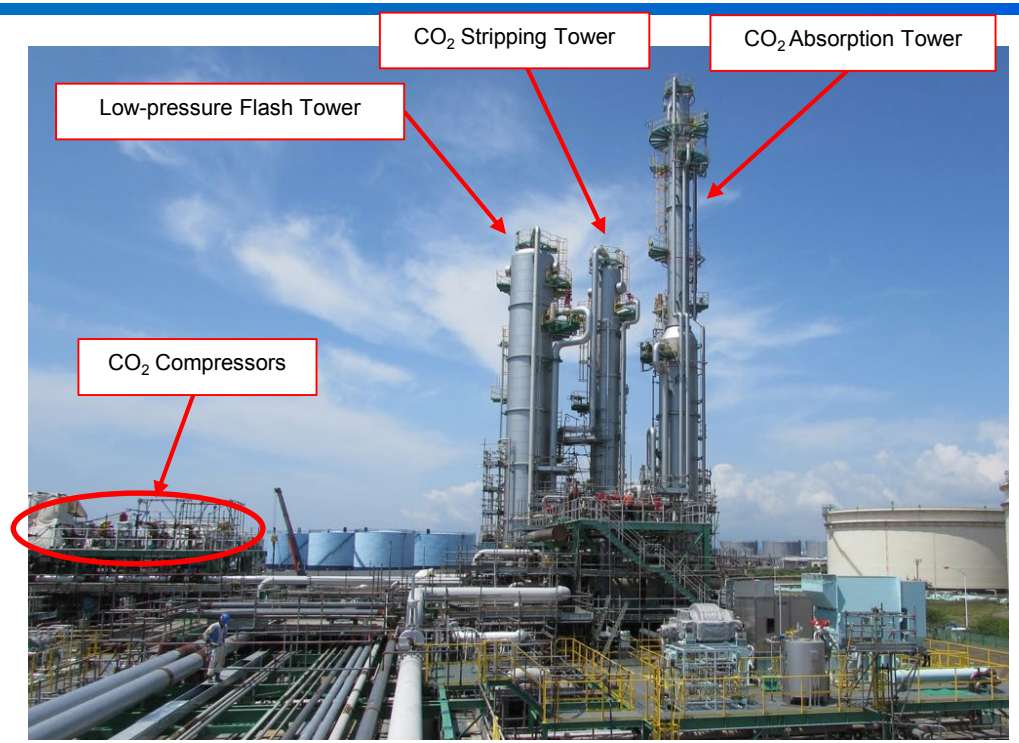
Tomakomai CCS Demonstration Project : Fact Sheet



◆ **Project Objectives**

- To demonstrate that large-scale CCS systems with offshore reservoirs are safe and reliable, confirm that the technologies adopted in the project work properly, efficiently through the operation of a full chain CCS system from capture to storage
- To define areas which need to be further improved or identify issues that need to be resolved towards commercial scale implementation of CCS

Project	: Tomakomai CCS Demonstration Project
Funder	: Ministry of Economy, Trade and Industry (METI)
Implementer	: New Energy and Industrial Technology Development (NEDO)
Consignee	: Japan CCS Co., Ltd. (JCCS)
Project type	: CO_2 Capture + Storage (below seabed)
Scale	: Middle
Status	: Operation
Year of operation	: 2016
CO_2 source	: Hydrogen production unit in oil refinery
CO_2 capture type	: Industrial separation
CO_2 capture capacity	: 600 tonnes/day (200,000 tonnes/year)
CO_2 recovery ratio	: over 99.9%
CO_2 concentration	: over 99%
CO_2 capture process	: Two stage absorption system + Low-pressure Flash Tower
Capture technology	: Chemical Absorption (Activated Amine)
Transport of CO_2	: None
Storage type	: Deep Saline Aquifer (2 layers)
New or retrofit	: New
Capex	: Apr.30 billion yen (without Tax)
Location	: Tomakomai, Hokkaido Prefecture, Japan
Facility Construction	: JGC, JAPEX, JFE Engineering

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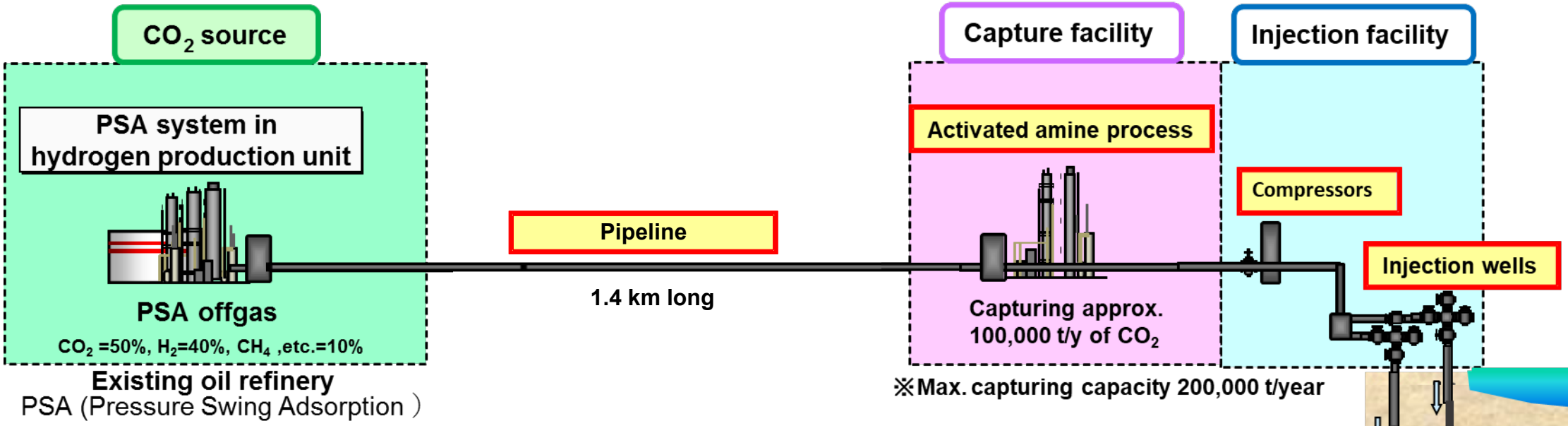
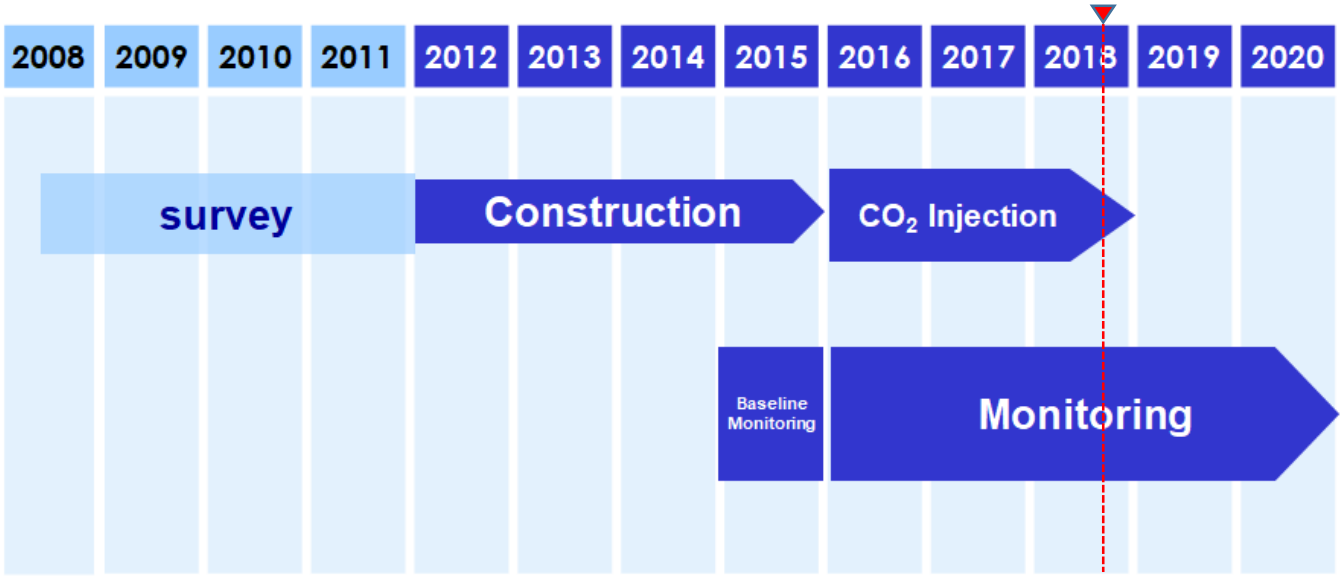
Project overview & schedule

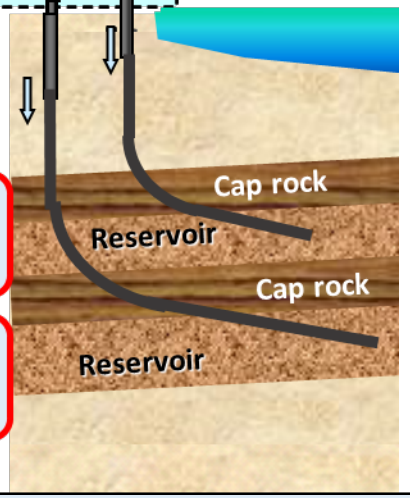




Storage

Sandstone layers of the Lower Quaternary Moebetsu Fm.
1,000～1,200m under the seabed

Volcanic Rocks layers of the Miocene Takinoue Fm.
2,400～3,000m under the seabed



◆ **First full-chain CCS system in Japan from capture to storage**

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Objectives and tasks of Tomakomai CCS Demonstration Project

Develop practical CCS technology by around 2020

- Demonstrate full-chain CCS system from capture to storage
- Confirm existing technologies adopted in the system work properly and efficiently

Tasks

- Demonstrate CCS system is safe and reliable
- Confirm effectiveness of site selection guideline prepared by METI by demonstrating no leakage
- Remove concerns about earthquakes by the data collected;
  - No influence by natural earthquakes on CO_2 stored
  - No perceptible earth tremors induced by CO_2 injection
- Confirm guidelines for geological models (building and improvement)
- Prepare technical standards regarding operation and safety of CCS projects
- Disclose project information & data and enhance understanding of CCS by local residents
- Clearly define areas to be improved or solved toward commercialization

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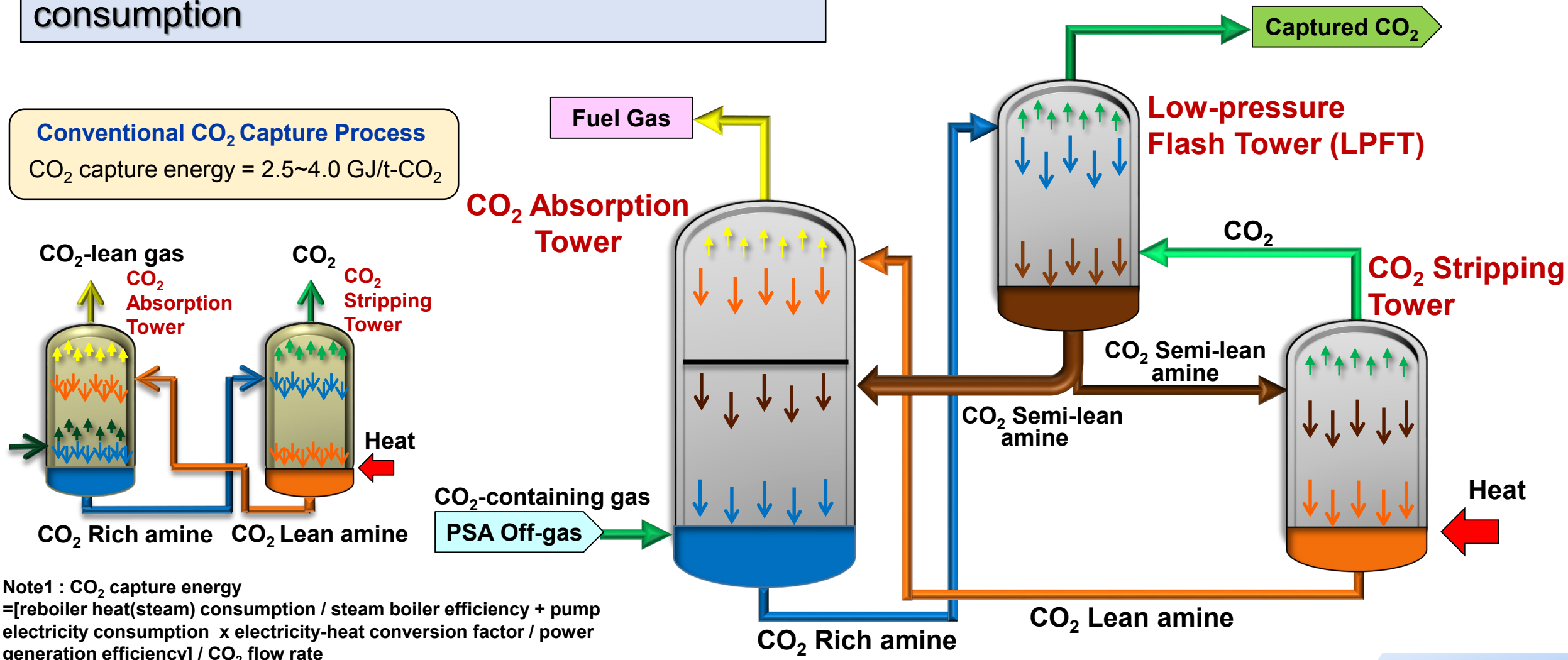
CO_2 capture process

◆Two-stage CO_2 absorption system with low-pressure flash tower providing for low energy consumption

Tomakomai CO_2 Capture Process
CO_2 capture energy = 1.16 GJ/t-CO_2

Conventional CO_2 Capture Process
CO_2 capture energy = 2.5~4.0 GJ/t-CO_2



Note1 : CO_2 capture energy
=[reboiler heat(steam) consumption / steam boiler efficiency + pump electricity consumption x electricity-heat conversion factor / power generation efficiency] / CO_2 flow rate

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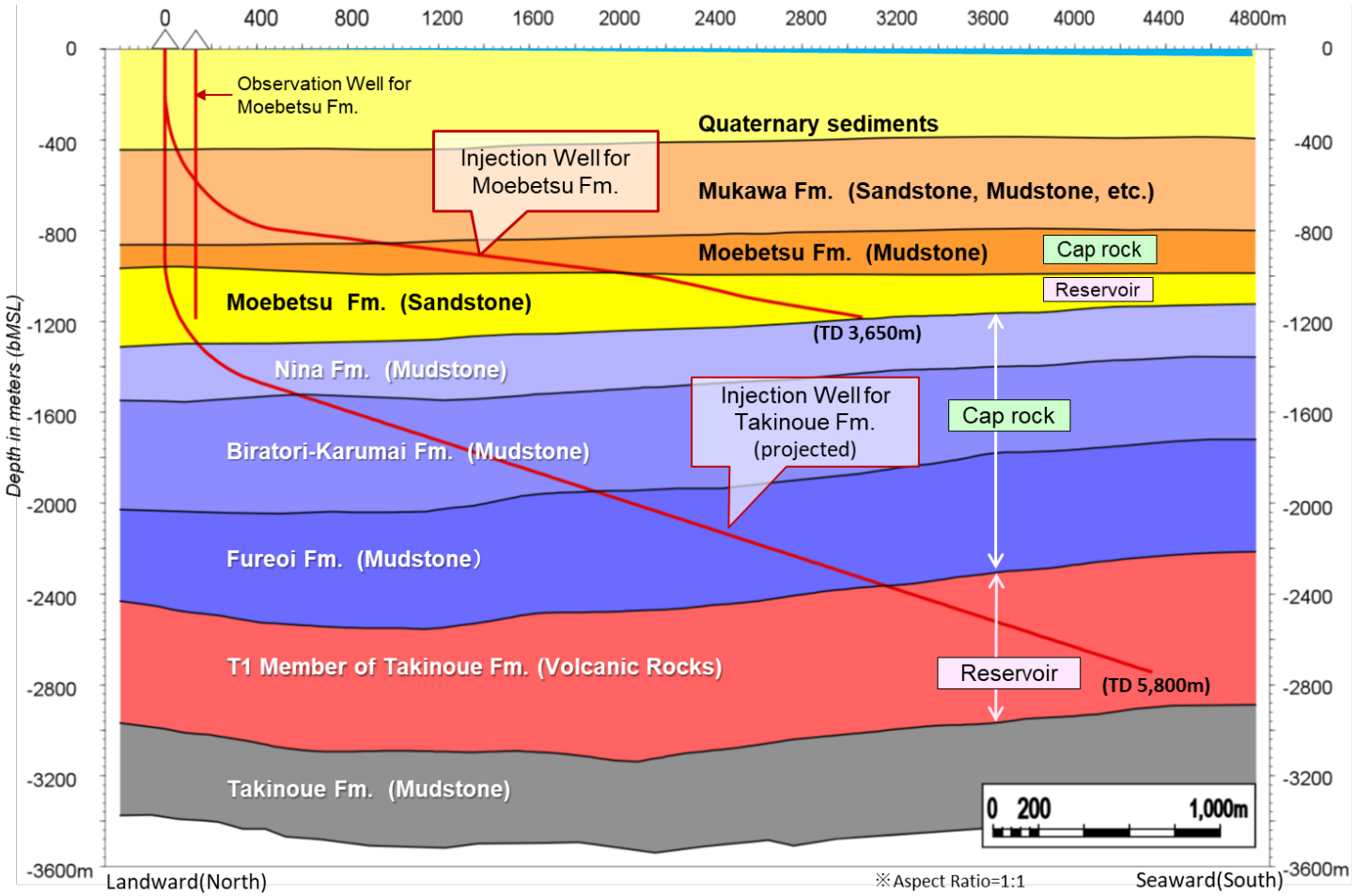
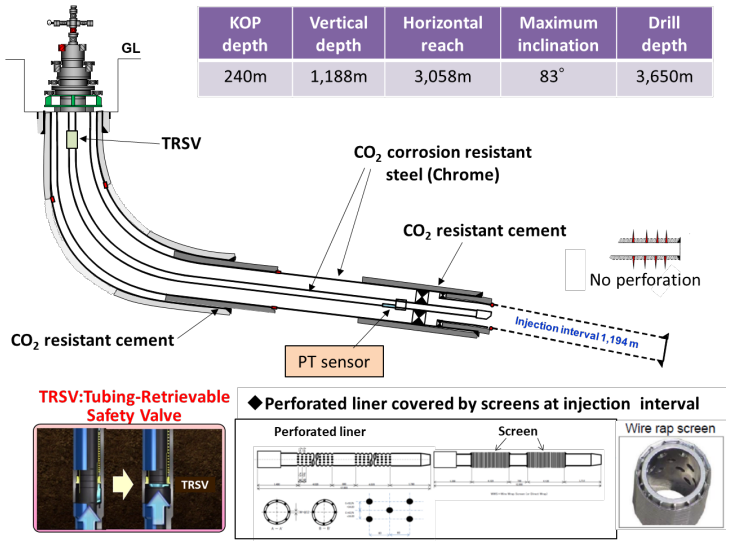
Onshore-to-offshore injection scheme

- ◆ Deviated CO_2 injection wells drilled from onshore into offshore reservoirs
  - ➢ Cost reduction of drilling, operation and maintenance
  - ➢ No disturbance on marine environment and harbor operation
- ◆ Injection interval length exceeding 1,100m to enhance injection efficiency



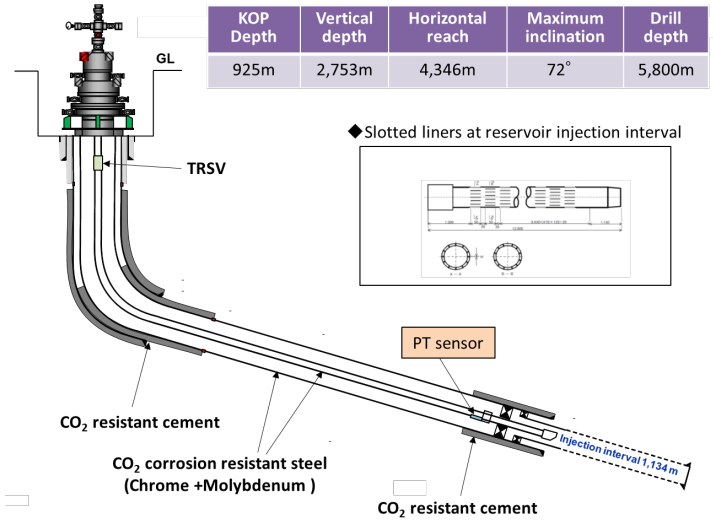
Injection well for Moebetsu Formation

KOP depth	Vertical depth	Horizontal reach	Maximum inclination	Drill depth
240m	1,188m	3,058m	83°	3,650m



Injection well for Takinoue Formation

KOP Depth	Vertical depth	Horizontal reach	Maximum inclination	Drill depth
925m	2,753m	4,346m	72°	5,800m



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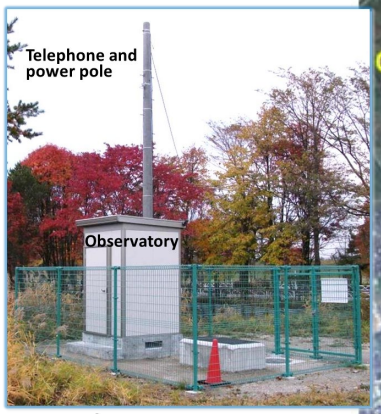
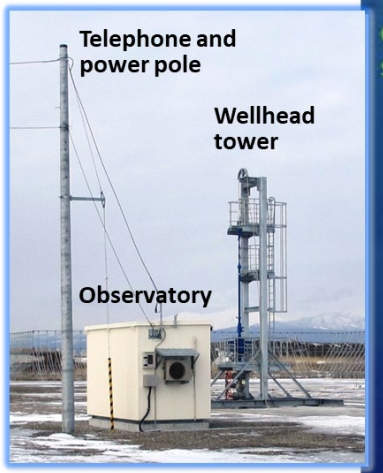
Layout of monitoring system

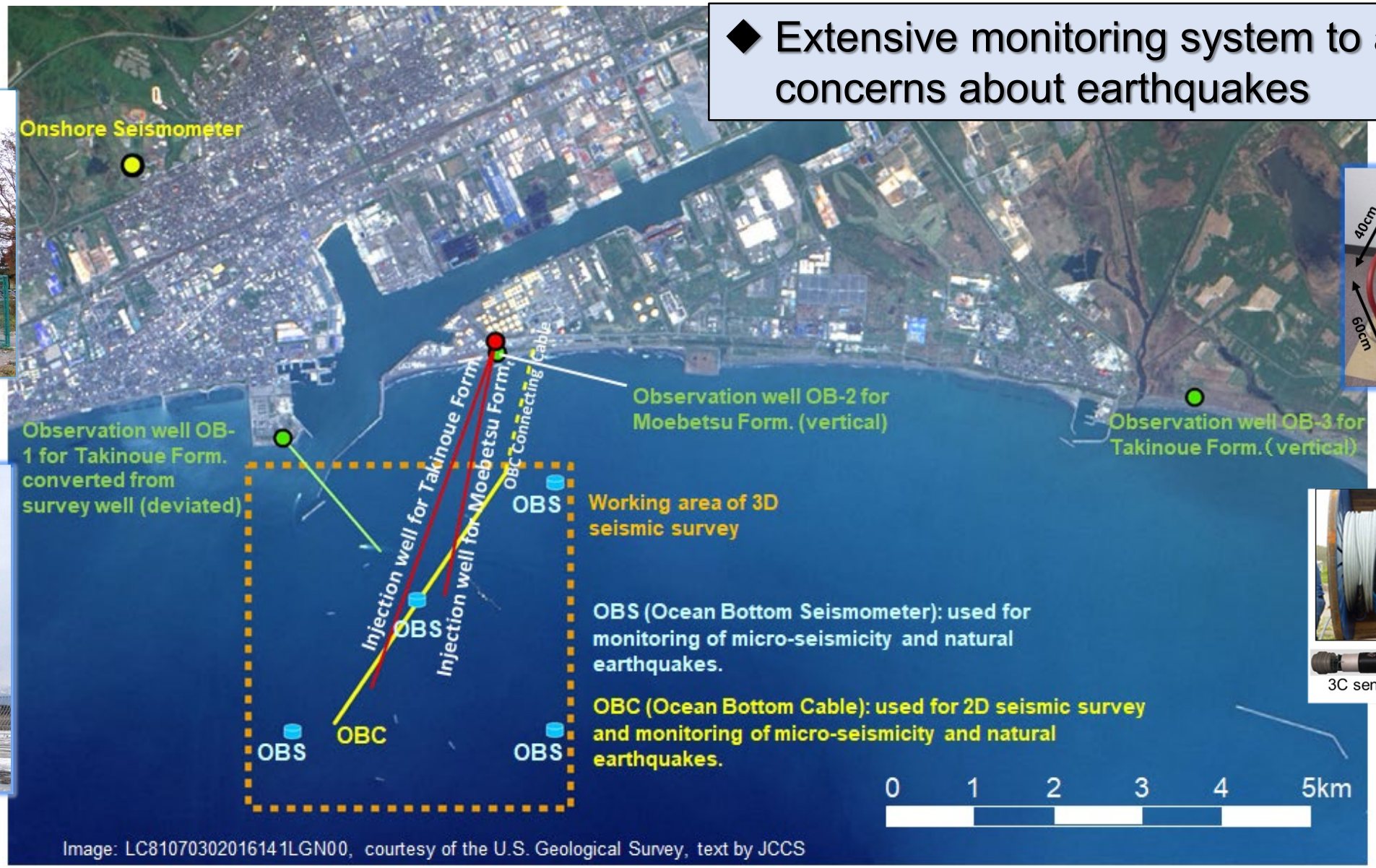
◆ Extensive monitoring system to address concerns about earthquakes



Onshore Seismic Station



Observation well OB-1



OBS

OBC

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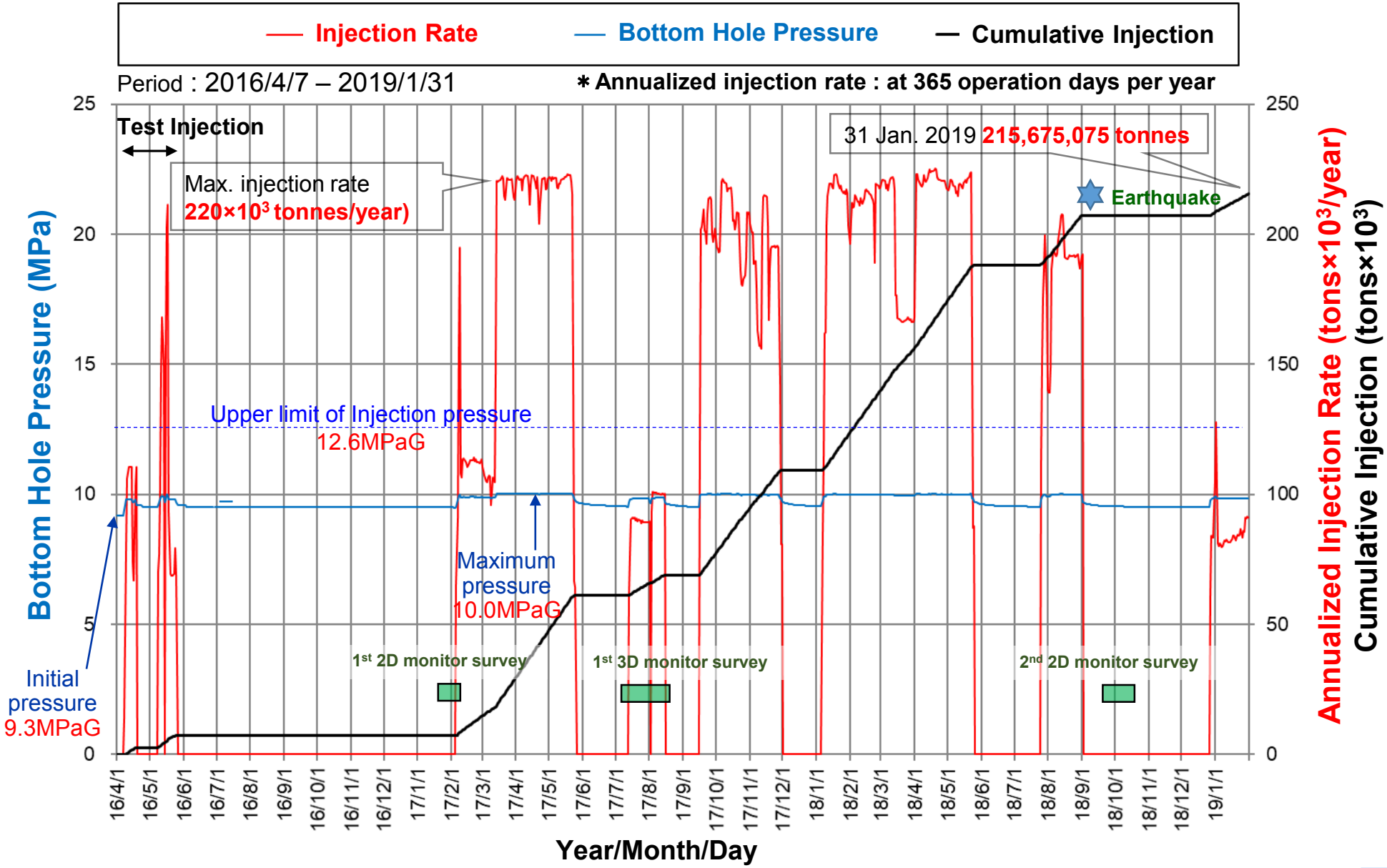
CO_2 injection record of Moebetsu Formation



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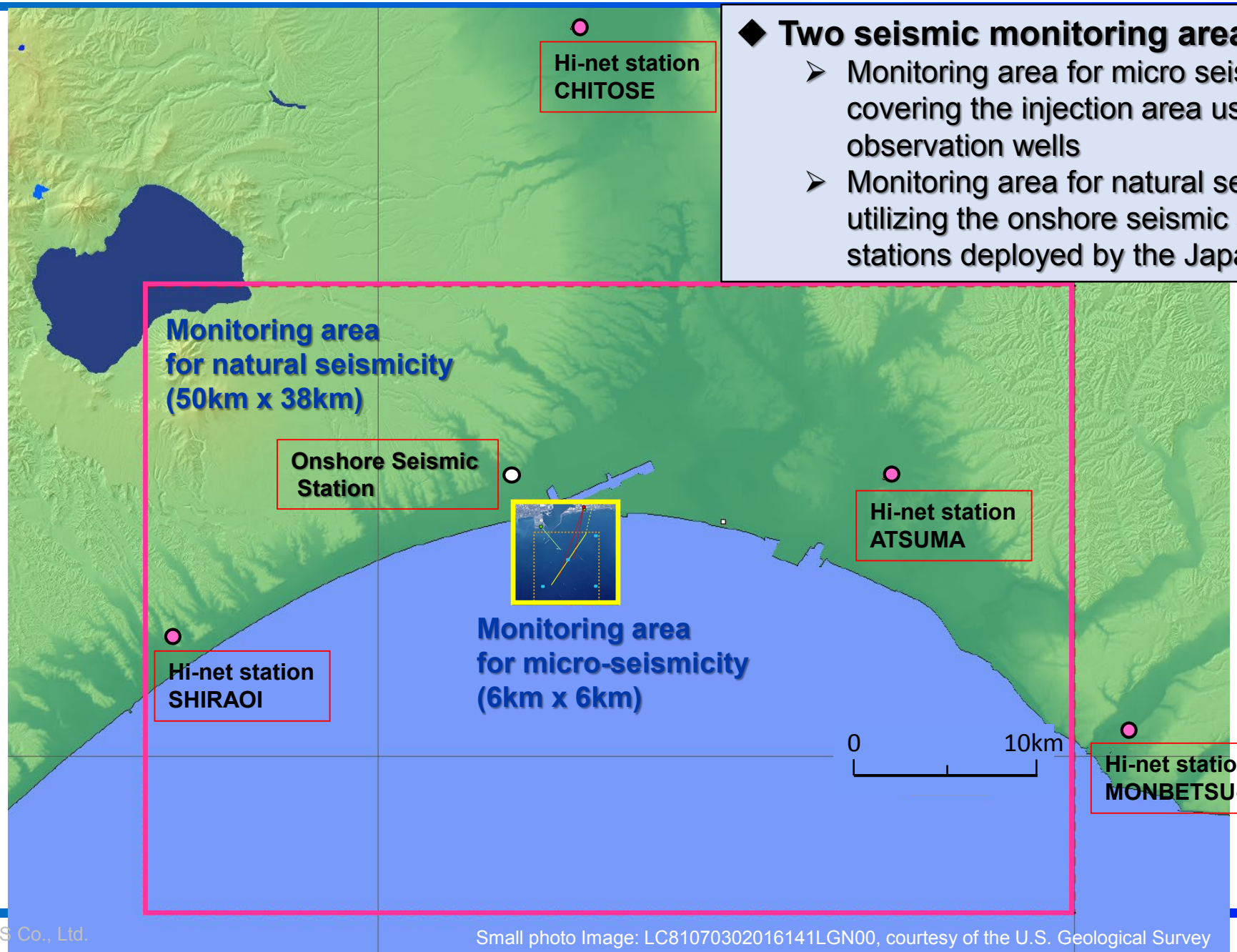
Monitoring areas for seismicity



◆ **Two seismic monitoring areas**

- Monitoring area for micro seismicity 6km by 6km covering the injection area using the OBC, OBSs and observation wells
- Monitoring area for natural seismicity 50km by 38km utilizing the onshore seismic station and nearby Hi-net stations deployed by the Japanese government

※The onshore seismic station of the project has the same specifications conform to Hi-net stations: High-Sensitivity Seismograph Network" of National Research Institute for Earth Science and Disaster Prevention.

Small photo Image: LC81070302016141LGN00, courtesy of the U.S. Geological Survey

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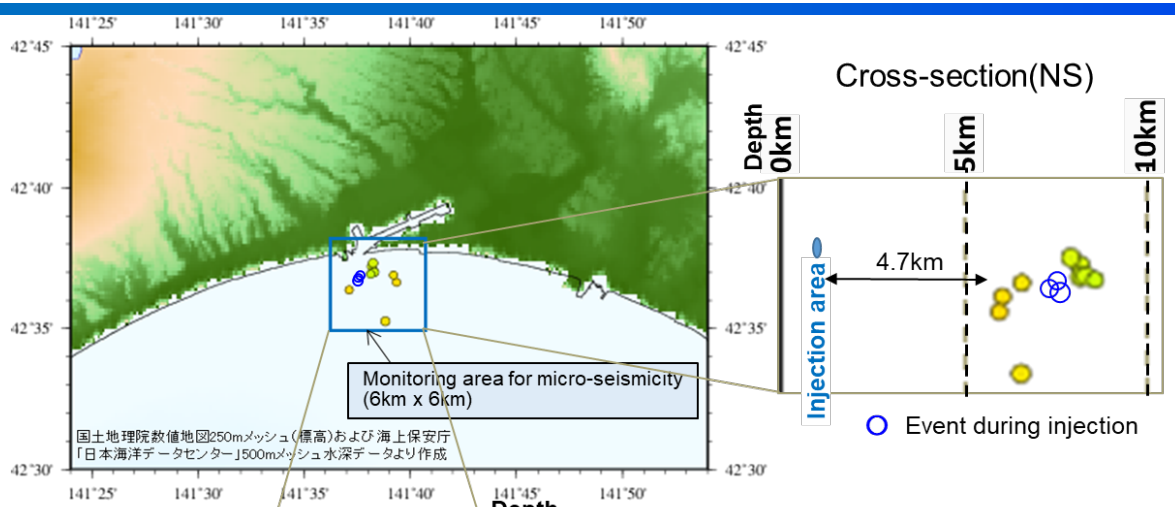
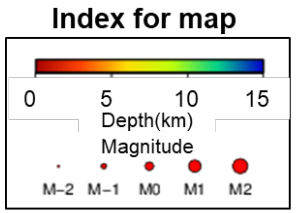
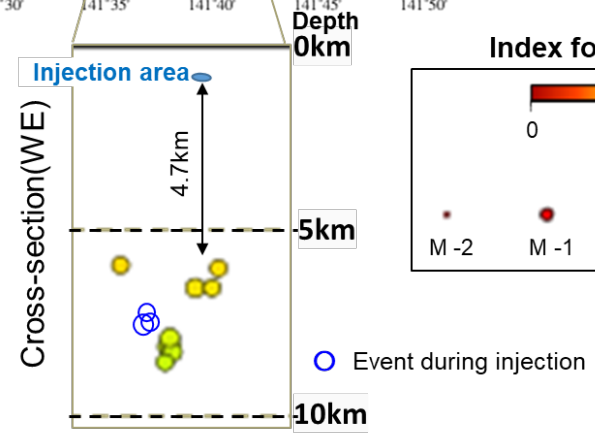
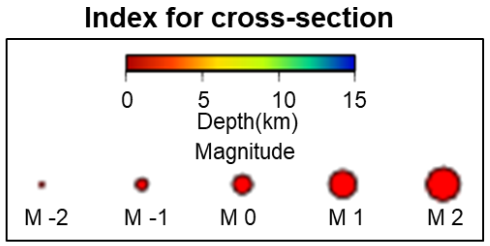
Micro-seismicity









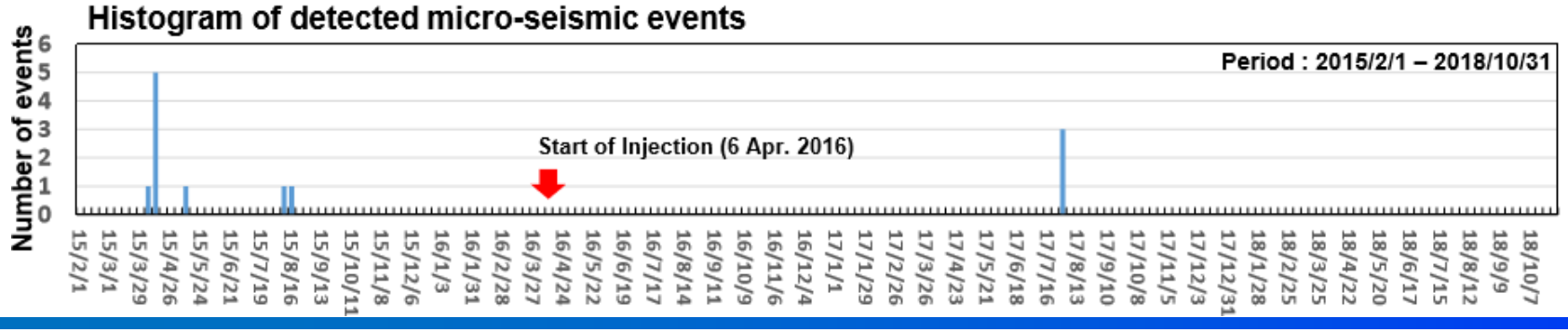
◆ No micro-seismicity (Mw > -0.5) in/around the depth range of the reservoirs before and after the start of injection

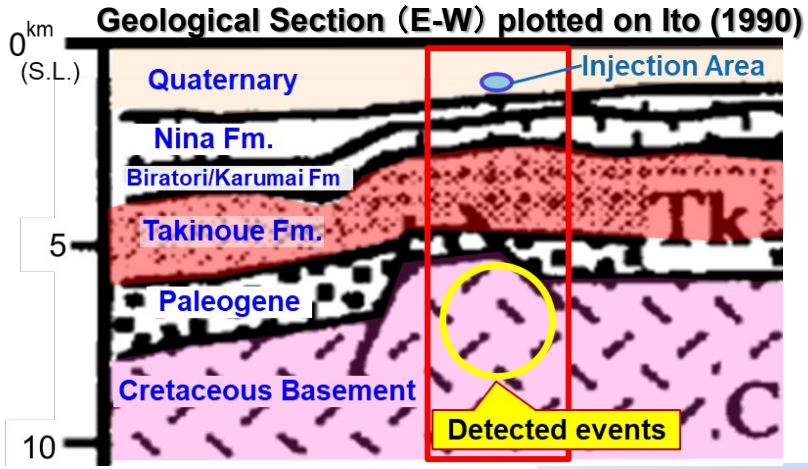
- Before Injection 2015/2/1-2016/4/5

  Total 9 events
  Depth: 5.9km - 8.6km
  Mw: -0.09～0.24

- During Injection 2016/4/6-2018/10/31

  Total 3 events(blue circle)
  Depth: 7.4km – 7.7km
  Mw: 0.31～0.52
  Date: Aug. 2 2017





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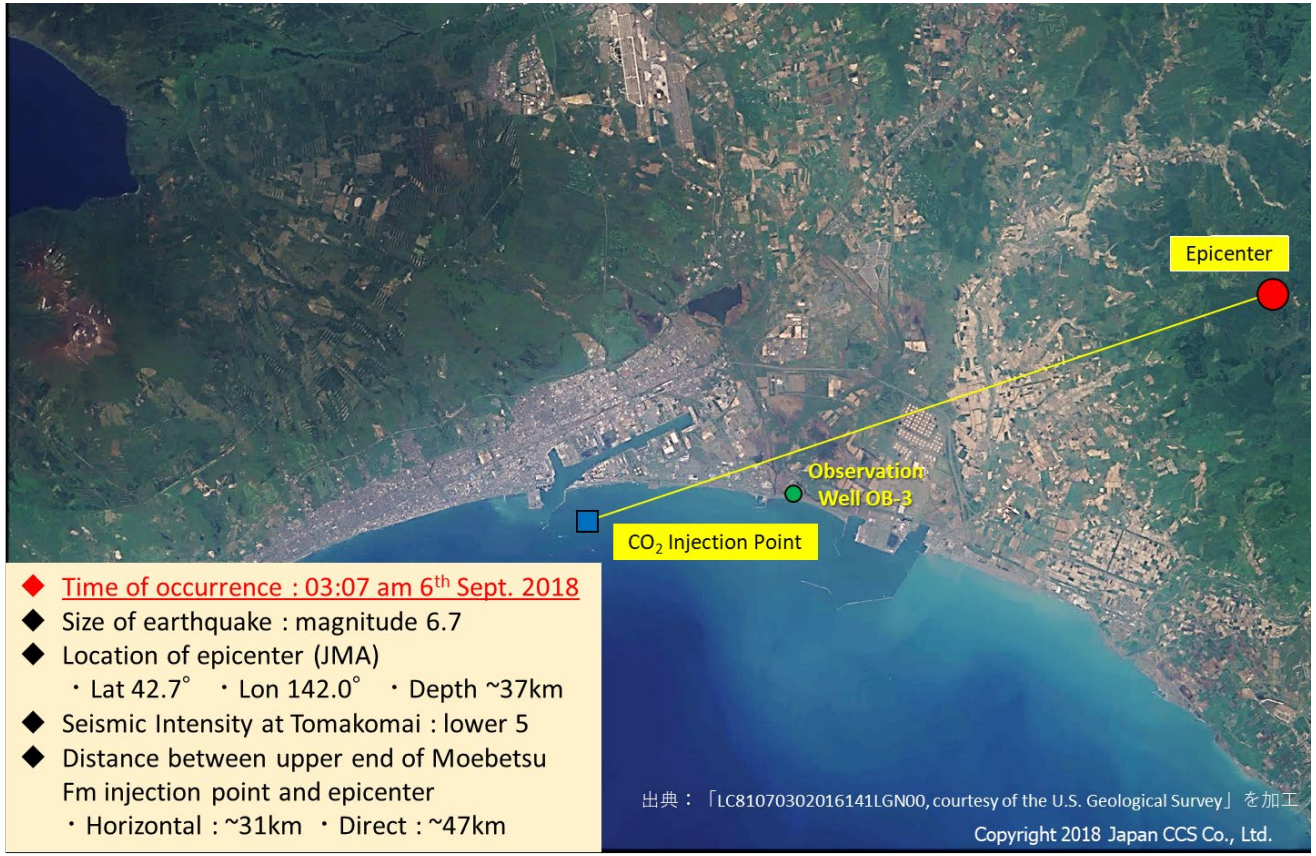
Hokkaido Eastern Iburi Earthquake : Location of epicenter

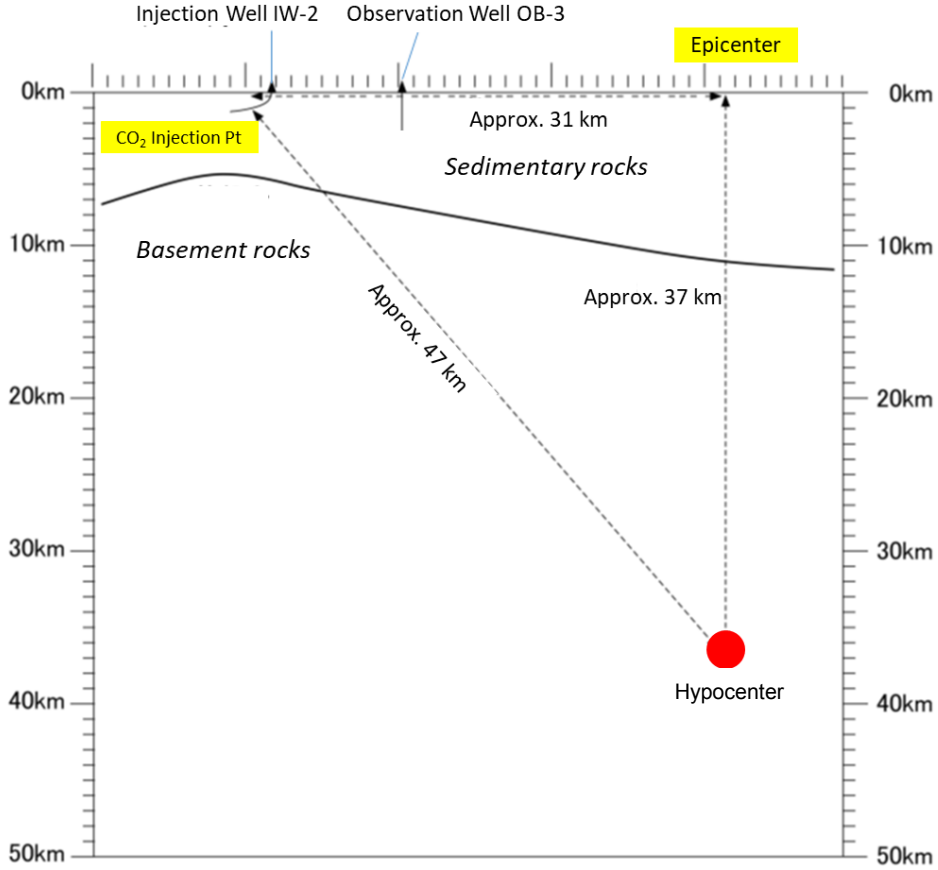
◆ **Magnitude 6.7 at 3:07 am on 6th Sept. 2018**

- ✓ The epicenter is about 31km in horizontal distance from the Tomakomai Project CO_2 storage point and at a depth of about 37km; the direct distance between the storage point and the epicenter is about 47km
- ✓ Acceleration of 158 gal was observed at the capture facility



- ◆ Time of occurrence : 03:07 am 6th Sept. 2018
- ◆ Size of earthquake : magnitude 6.7
- ◆ Location of epicenter (JMA)
  - ・Lat 42.7° ・Lon 142.0° ・Depth ~37km
- ◆ Seismic Intensity at Tomakomai : lower 5
- ◆ Distance between upper end of Moebetsu Fm injection point and epicenter
  - ・Horizontal : ~31km ・Direct : ~47km

Plan view



Cross section view

Positional relationship between epicenter and injection point

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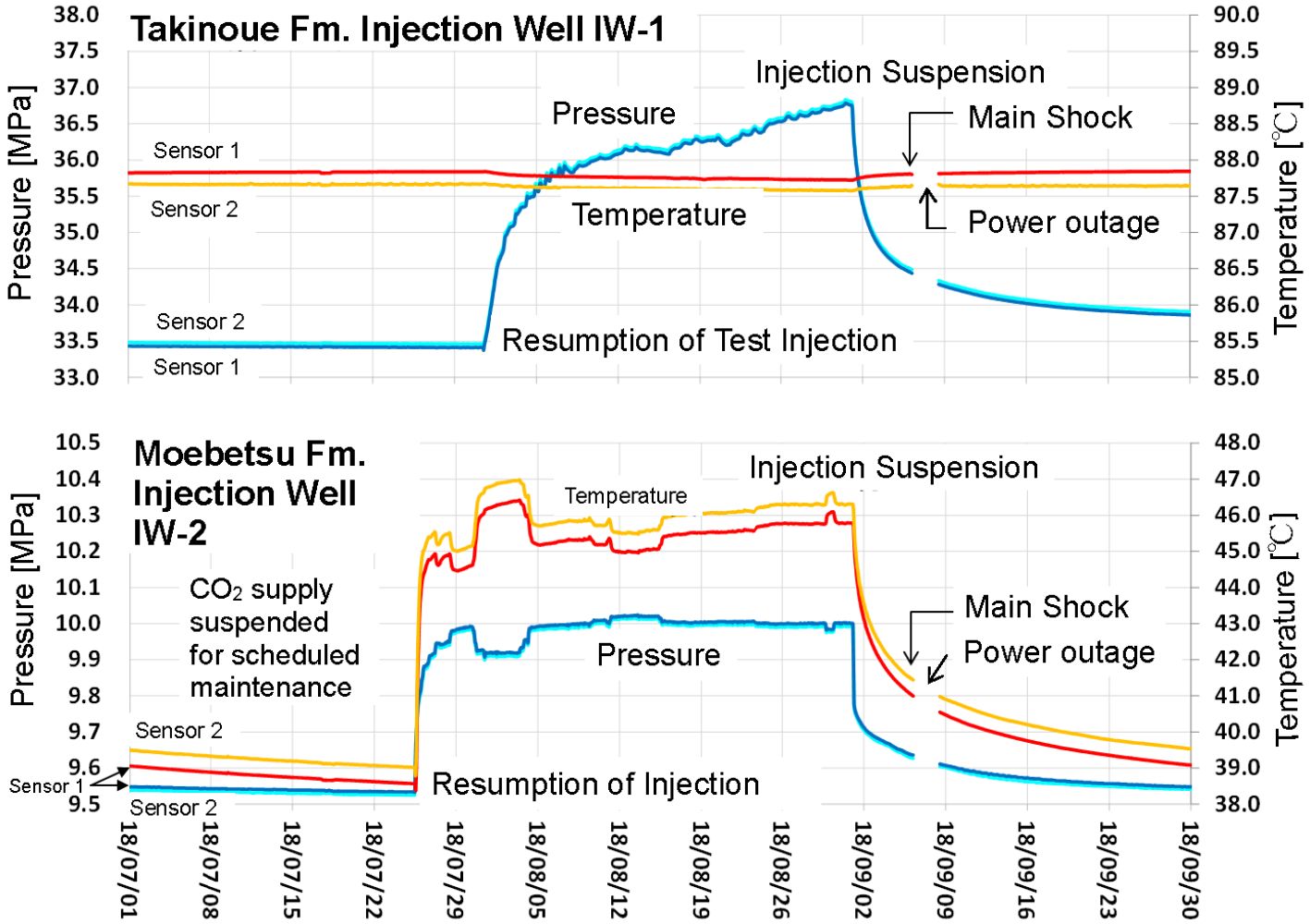
Hokkaido Eastern Iburi Earthquake：Reservoir pressure and temperature

- CO_2 injection was suspended on 1st Sept. 2018 due to the stop of supply of PSA offgas
- Earthquake occurred on 6th Sept. 2018, during the decline of pressure and temperature of the reservoir
- No shift of declining trend of reservoir temperature and pressure before and after the earthquake



Bottom hole pressures and temperatures of the Moebetsu and Takinoue Formation injection wells

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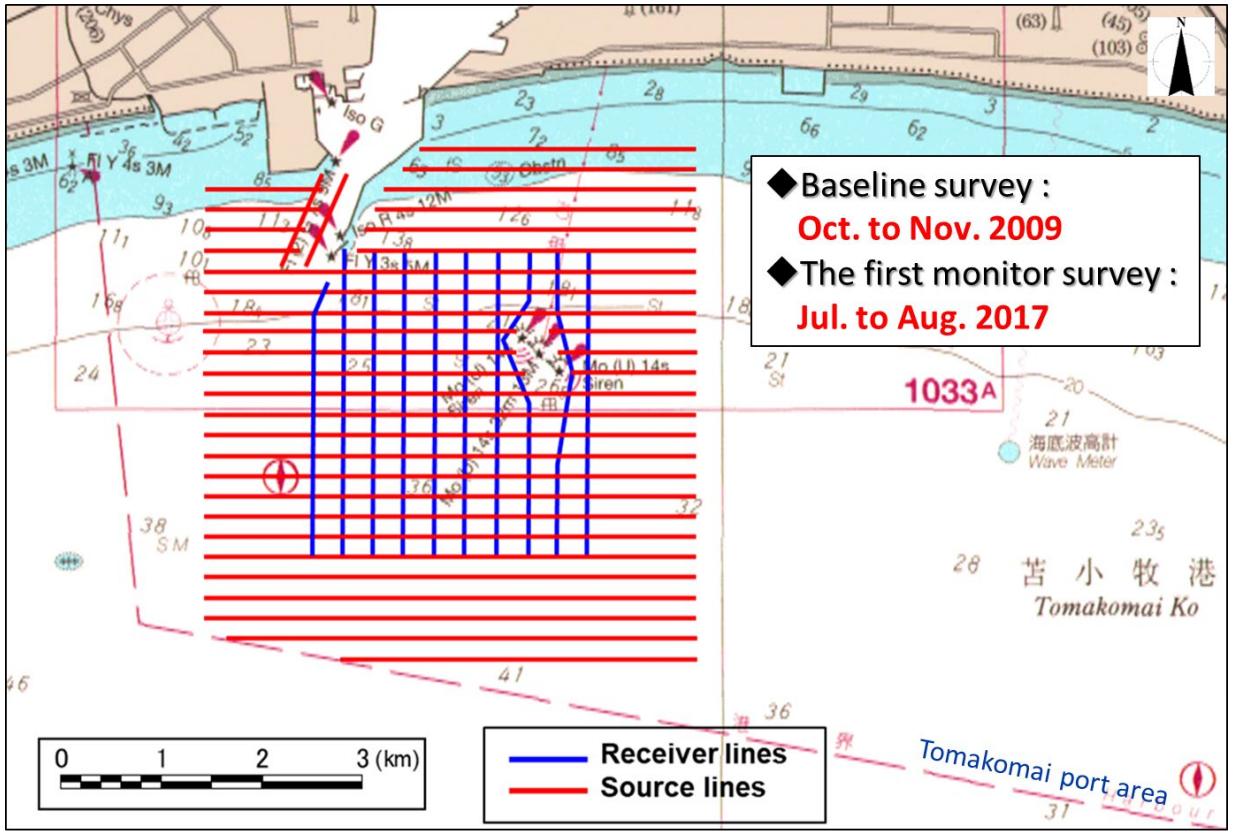
3D seismic survey

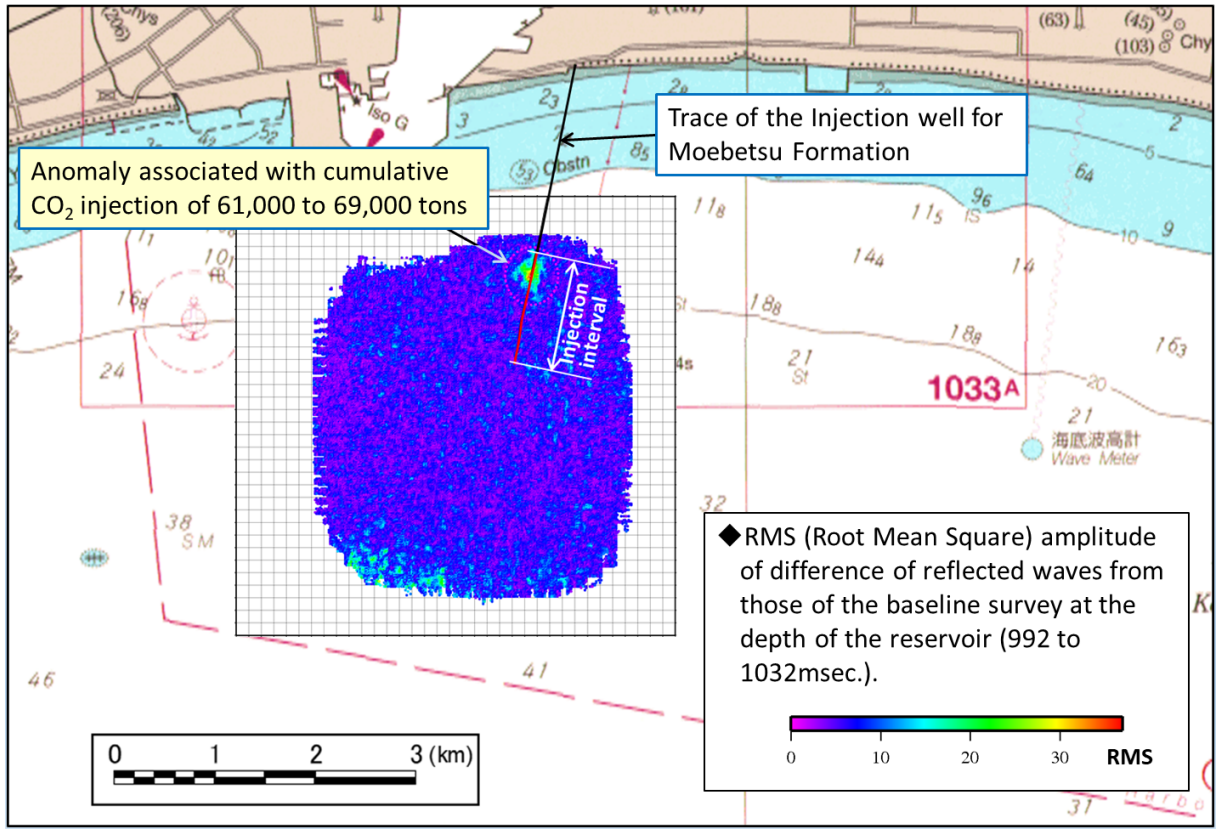
◆ The first monitor 3D seismic survey at cumulative CO_2 injection of 61,000 to 69,000 tonnes into the Moebetsu Formation detected a clear anomaly along the injection interval

Survey lines



Plotted on Japan Coast Guard Nautical Chart

Result of the first monitor survey



Plotted on Japan Coast Guard Nautical Chart

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Marine environmental survey

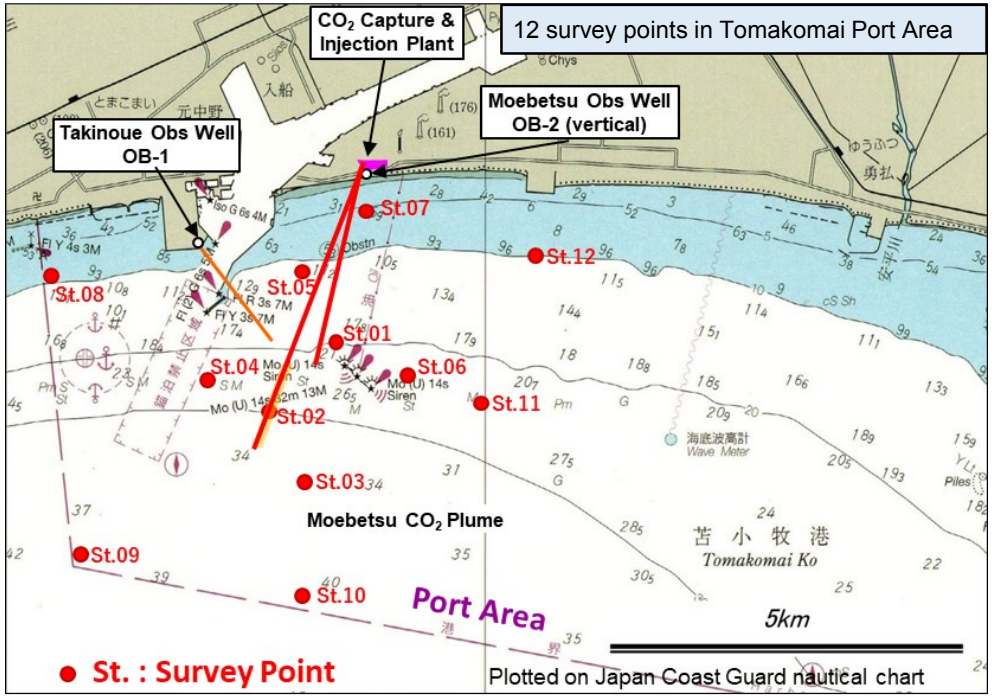
◆ In Japan sub-seabed CO_2 storage is governed by "the Act for the Prevention of Marine Pollution and Maritime Disaster" reflecting the London 1996 Protocol, under the jurisdiction of Ministry of the Environment (MOE)

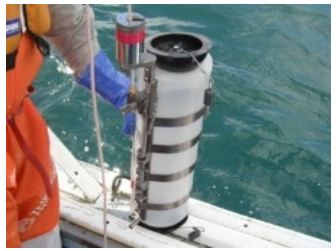
➢ Methods of Survey

- 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

➢ Surveys in Three Stages

- Before Injection: Baseline survey
- During demonstration operation
  - During CO_2 injection
  - After CO_2 injection
- After demonstration operation

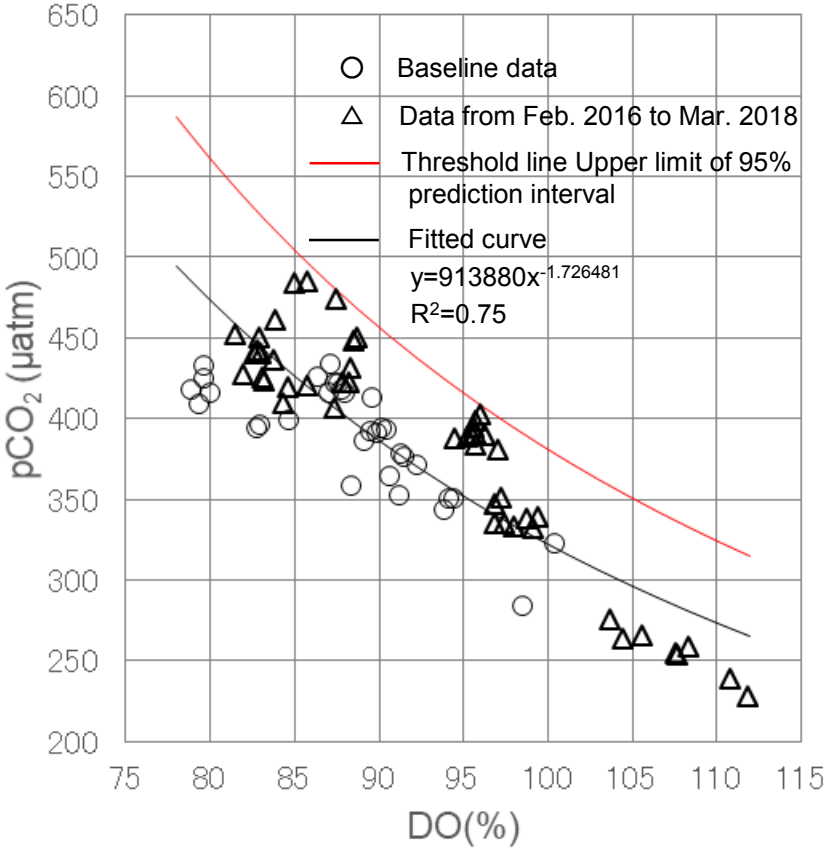




Water Sampler

Bottom Sampler

ROV



pCO_2/DO threshold in the marine environmental survey plan (revised on 31st Aug. 2018)

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Public Engagement

◆ The Tomakomai CCS Demonstration Project is being conducted with the understanding and support of the local government, industries and local community

Tomakomai CCS Promotion Association

Establishment : April 2010 (prior to selection of Tomakomai site)

Activities : 1) Promotion of Tomakomai CCS Demonstration Project
2) Dissemination of information to Tomakomai citizens

Chairman : Tomakomai City Mayor

Members : All major corporations in Tomakomai and industrial associations, Tomakomai Fishery Cooperative

Secretariat : Tomakomai City

Construction site visit by members

Annual publication

Public Outreach Activities

①Panel Exhibitions
Expand exhibition area in accordance with progress of project

②Forum for Tomakomai Citizens
Continue holding forums to maintain understanding of CCS by many people

③Site Tours
Show facilities and observation wells to general public

④Information Disclosure System
Disclosure of CO_2 injection volume, borehole pressure & temperature, seawater CO_2 concentration, earthquake & micro-seismicity data on JCCS website

⑤Mini seminars for students
Held in universities in Hokkaido as well as nationwide

⑥Kids' lab classes/site tours
Held in primary and secondary schools in Tomakomai; enhance understanding of global warming and CCS through CO_2 experiments. Site tours for children.

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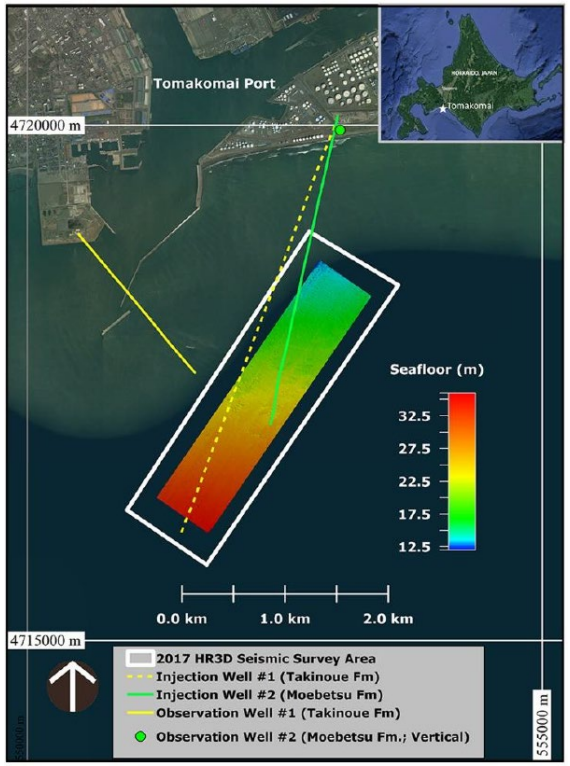
International Collaboration : High Resolution 3D Seismic Acquisition at Tomakomai

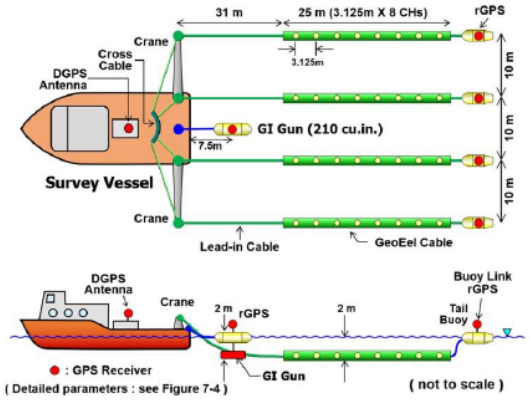
◆ Collaboration with DOE (U.S. Department of Energy)

- **Memorandum of Cooperation (MOC) for collaboration on CCS technology development signed between DOE and Japan Ministry of Economy, Trade and Industry (METI) in April 2015.**
- **In July 2017, as joint research at Tomakomai CCS Demonstration Project site, DOE made decision to provide funding of US$ 2.5 million to Bureau of Economic Geology, University of Texas for implementation of data acquisition and analysis, including HR3D marine seismic data acquisition.**
- **In August 2017, University of Texas conducted acquisition of HR3D seismic data at Tomakomai CCS Demonstration Project site.**



The array design in Tomakomai HR3D survey comprised 4 streamers that are 25 m in length with 10 m inline separation. Each streamer has 8 channels with a 3.125 m group interval, yielding a very small final bin size of 3 x 3 m. Source and receiver positioning were achieved using 5 rGPS units in the water and a DGPS antennae on the vessel.

A 210 cubic inch GI airgun was used as an acoustic source. Over a period of 6 days, approximately 2 square kilometres of data were acquired during daylight hours.



Parameters	Specification
Streamers	4 x 25 m
Channels	8 per streamer = 32 total
Inter-streamer spacing	10 m
Group interval	3.125 m
Source	210 cubic inch GI Airgun
Inline shot spacing	6.25 m
Bin size	3 x 3 m

Source: High-resolution 3D seismic acquisition at the Tomakomai CO_2 storage project, offshore Hokkaido, Japan; T.A. Meckel, Y.E. Feng, R.H. Trevino (Gulf Coast Carbon Center, Bureau of Economic Geology, The University of Texas at Austin)

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Conclusion

- Full chain CCS system from source to storage is in operation; objective is to develop practical CCS technology by around 2020
  - Demonstrate safety and reliability of CCS system
  - Remove concerns about earthquakes and induced seismicity
- Notable features of project
  - Low energy capture system (world-class)
  - Deviated injection wells from onshore site into offshore reservoirs avoiding disturbance of local livelihood
  - Extensive monitoring system for seismicity
- The "Moebetsu Formation" (shallow reservoir) has demonstrated superior injectivity, and CO_2 injection is progressing smoothly with cumulative injection at 215,675,075 tonnes (as of 31st January 2019)
- No seismicity (Mw > -0.5) has been detected in/around the depth range of the reservoirs before and after the start of injection
- Natural earthquakes have not caused any damage to the facilities or reservoirs of the project
- The first monitor 3D survey successfully detected an anomaly at cumulative CO_2 injection of 61,000 to 69,000 tonnes into the Moebetsu Formation
- Project being conducted with understanding and support of local community

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Thank you for your attention.

http://www.japanccs.com/

This presentation is based on results obtained from a project commissioned by Ministry of Economy, Trade and Industry (METI) and the New Energy and Industrial Technology Development Organization (NEDO).

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