Tomakomai CCS Demonstration Project - Results and Lessons Learned

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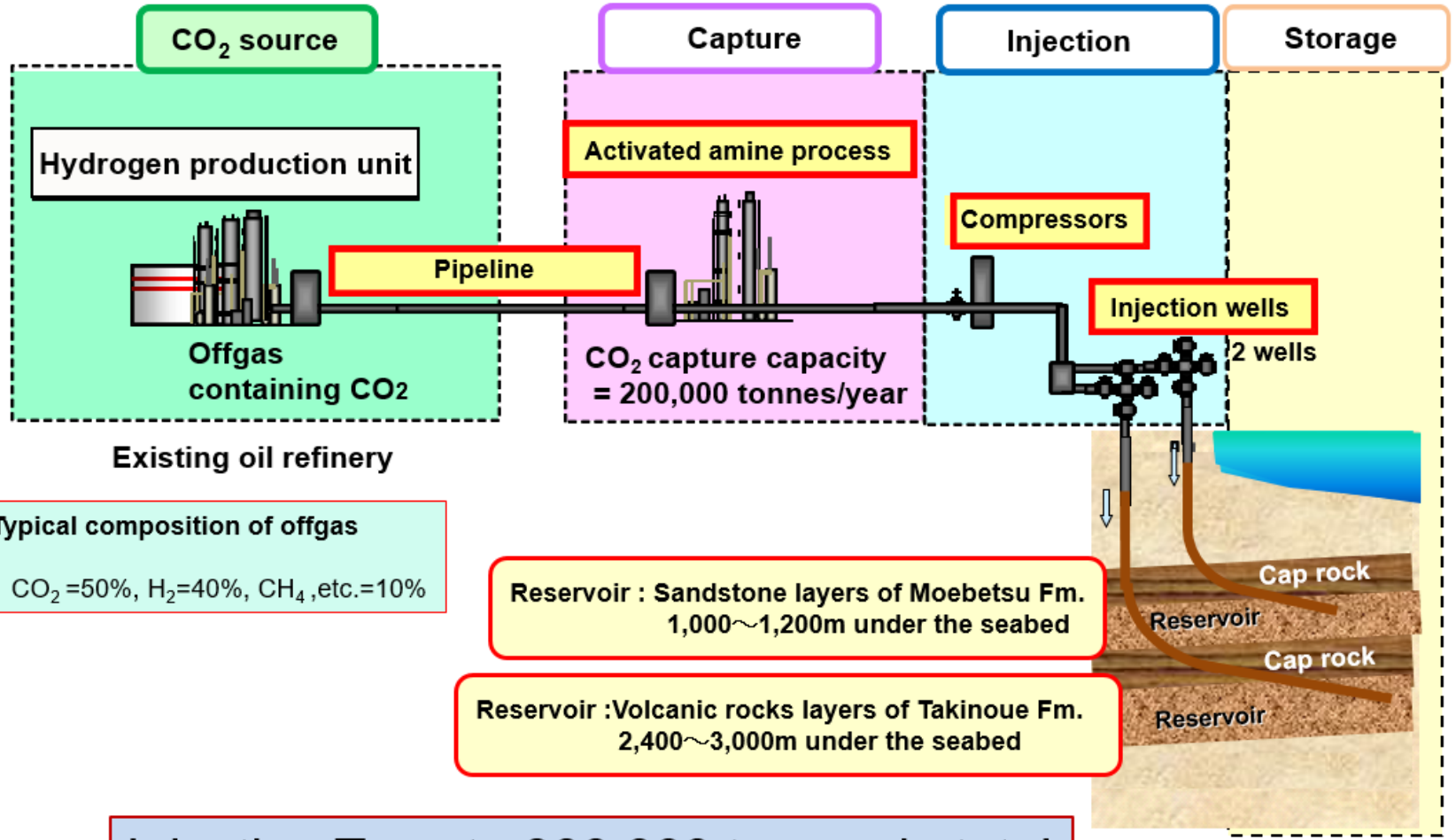
Objectives and tasks of Tomakomai CCS Demonstration Project

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**
- **Demonstrate CCS system is safe and reliable**
- **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**
- **Disclose project information & data and enhance understanding of CCS by local residents**
- **Clearly define areas to be improved or solved toward commercialization**

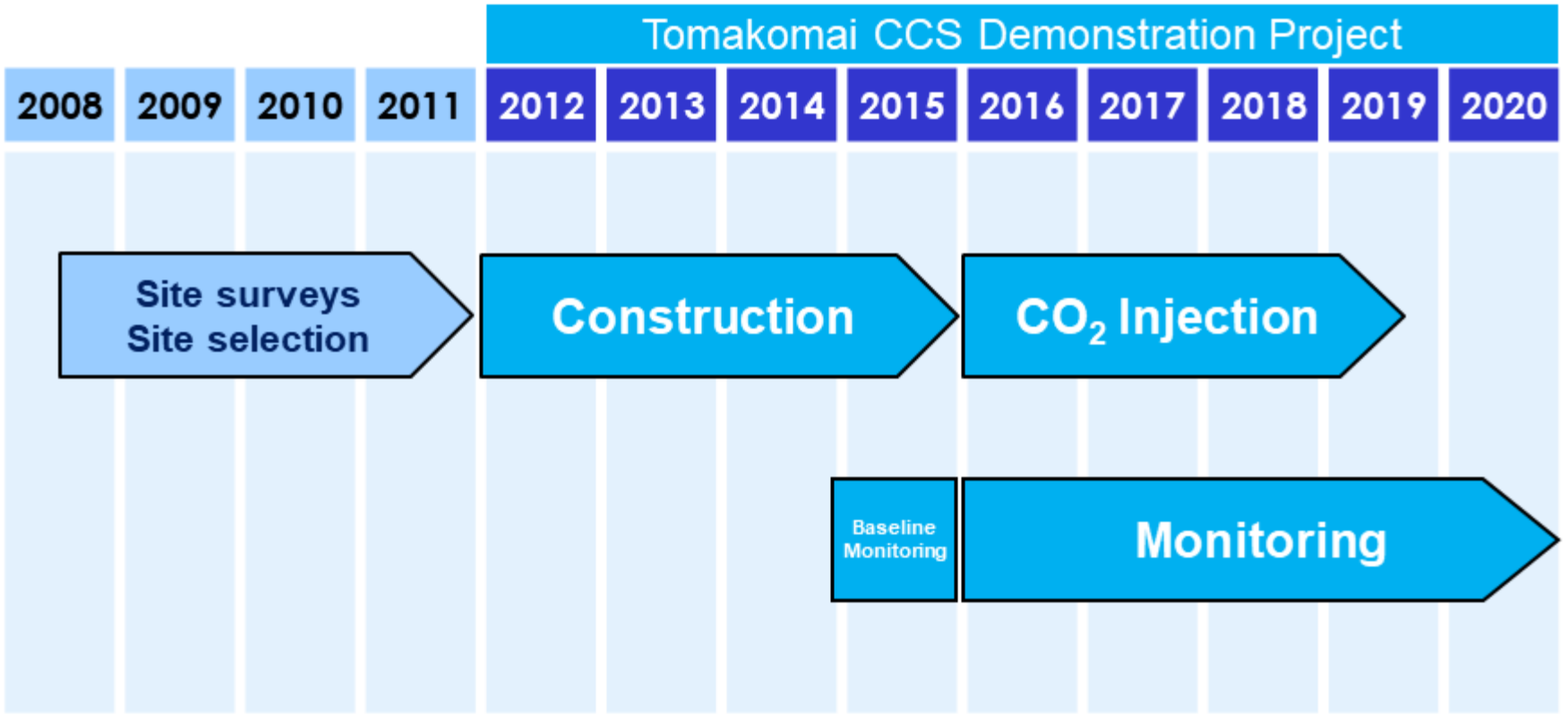
Flow Scheme of Project



Injection Target : 300,000 tonnes in total

First full-chain CCS system in Japan from capture to storage has been conducted successfully

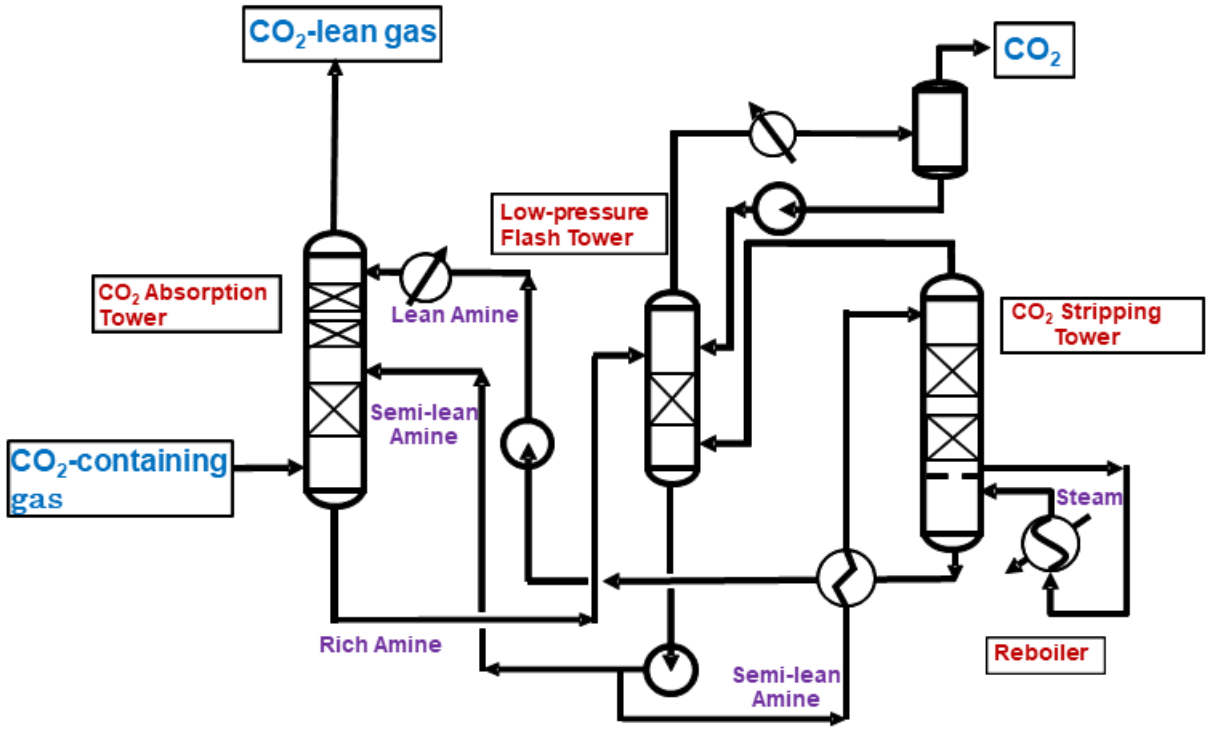
Schedule of Project



- Target of 300,000 tonnes of CO_2 injection achieved on November 22, 2019
- Monitoring operations are being continued

Years are in Japanese Fiscal Years (April of calendar year to March of following year)

CO_2 Capture Process



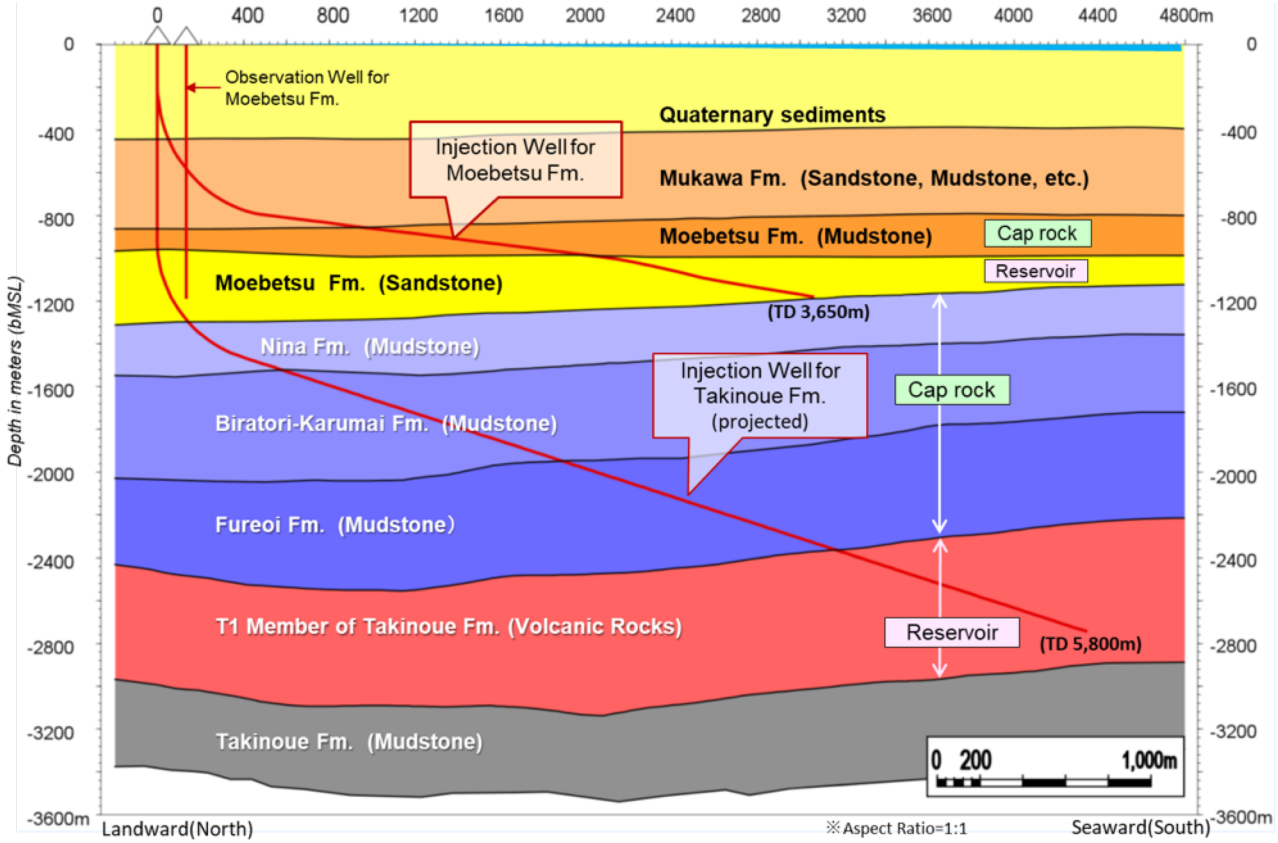
- In LPFT (Low-pressure Flash Tower), CO_2 is stripped by depressurization; thermal energy of steam of CO_2 Stripping Tower is also utilized to strip CO_2
- Greater part of semi-lean amine from LPFT is returned to CO_2 Absorption Tower for CO_2 absorption; as only the remaining smaller portion is sent to CO_2 Stripping Tower, reboiler heat required can be reduced

Loading Factor:98% (100%=25.3 t-CO_2/h)

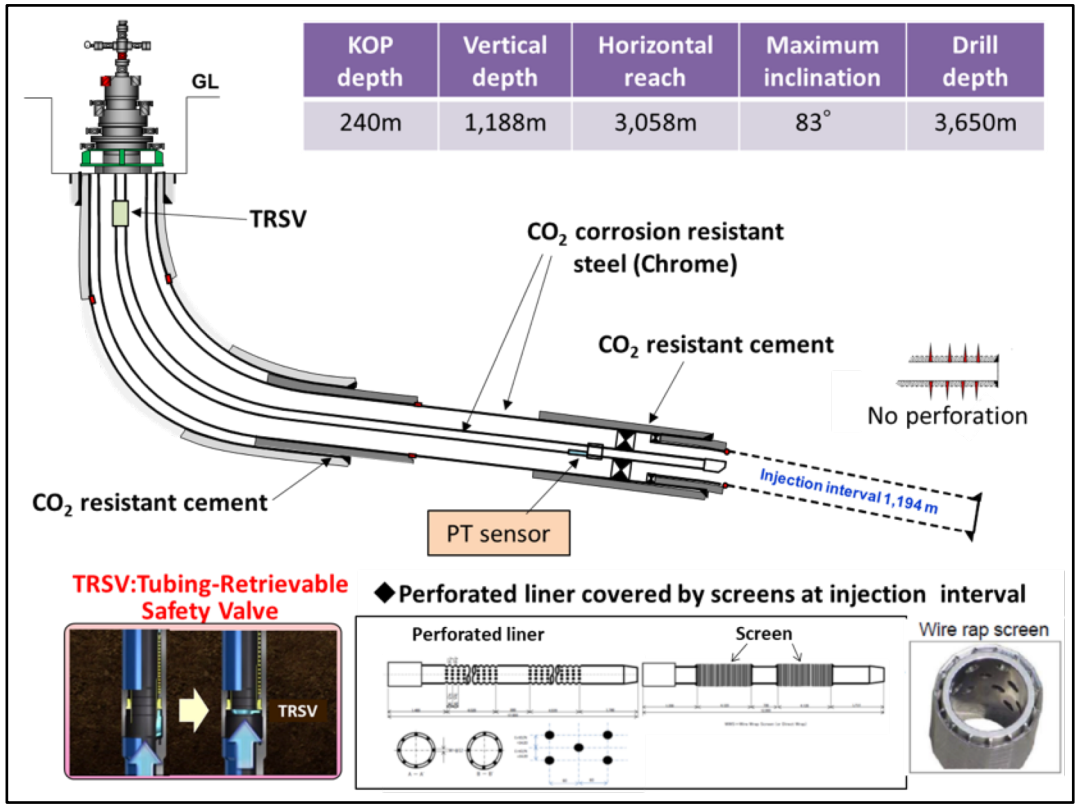
CO_2 recovery rate %	99.97
Reboiler duty (GJ/t-CO_2)	0.88
Heat energy [1] (GJ/t-CO_2)	0.98
Electric energy (GJ/t-CO_2)	0.18
CO_2 capture energy [2] (GJ/t-CO_2)	1.16

Note 1) : Reboiler duty/steam boiler efficiency
Note 2) : Heat energy + Electric energy

Injection Wells

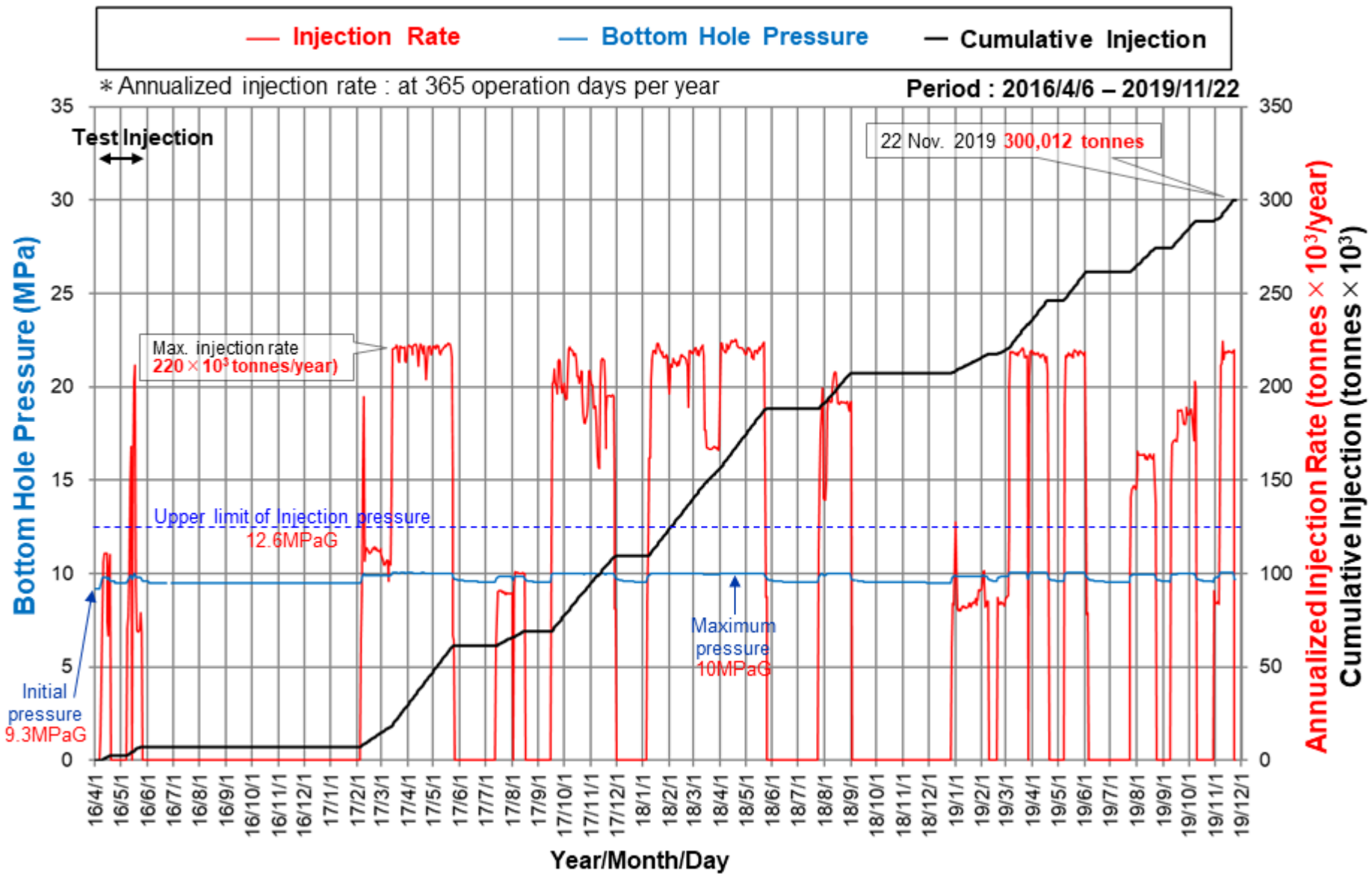


Injection well for Moebetsu Formation



- ◆ 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

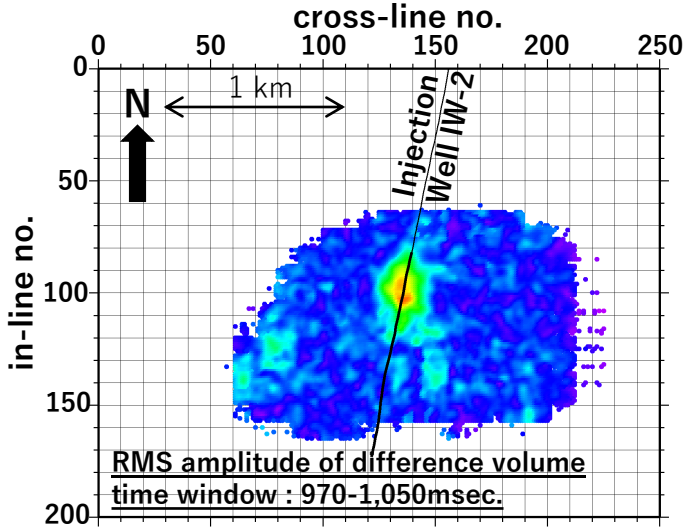
CO_2 Injection Record of Moebetsu Formation



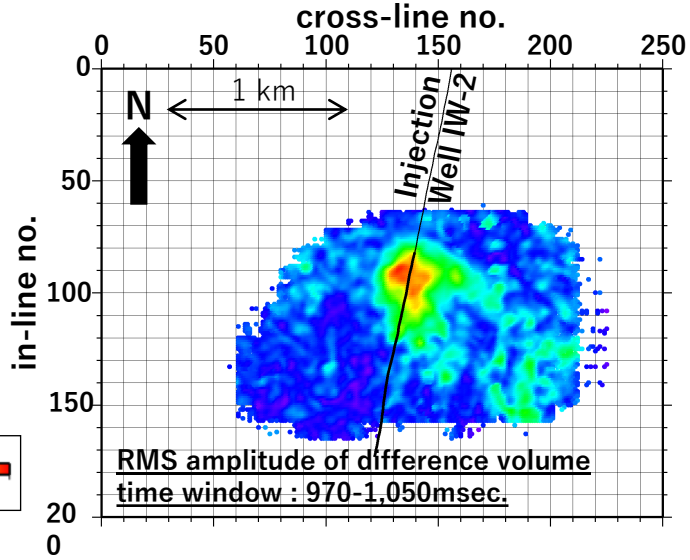
- Injection of 300,012 tonnes of CO_2 to Moebetsu Formation achieved on November 22, 2019
- Initial Pressure of Bottom Hole Pressure was 9.3MPaG
- Maximum Pressure of Bottom Hole Pressure was 10MPaG at maximum injection rate
- Maximum pressure was much lower than upper limit of injection pressure (12.6MPaG)

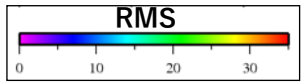
Results of 2nd & 3rd monitor surveys

2nd monitor survey (61,239 - 69,070 tonnes; JFY2017)

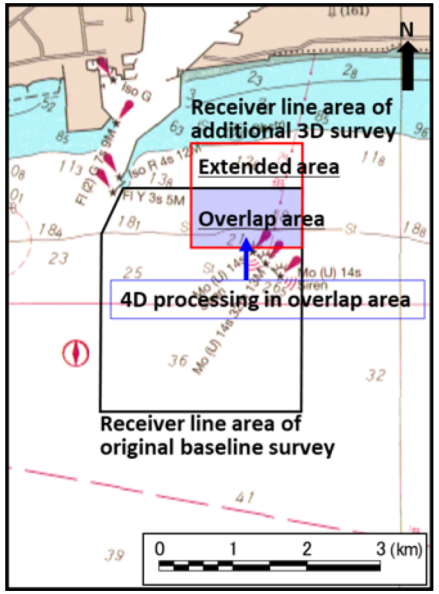


3rd monitor survey (207,209 tonnes; JFY2018)



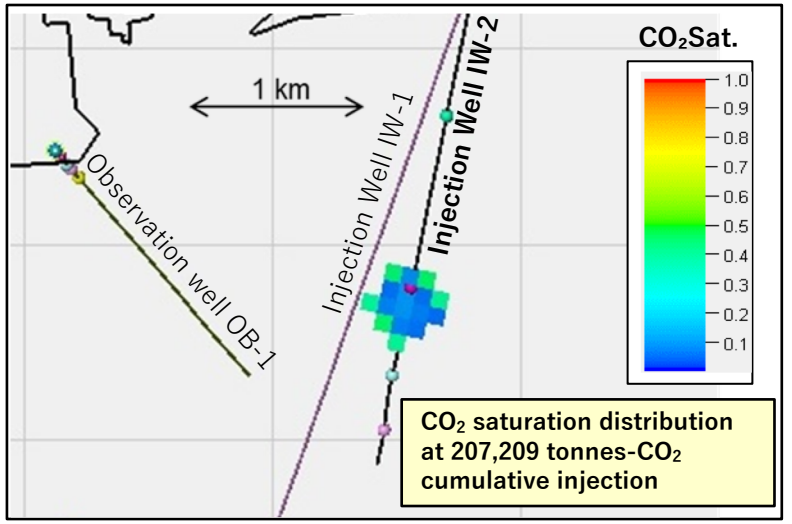


Receiver line area

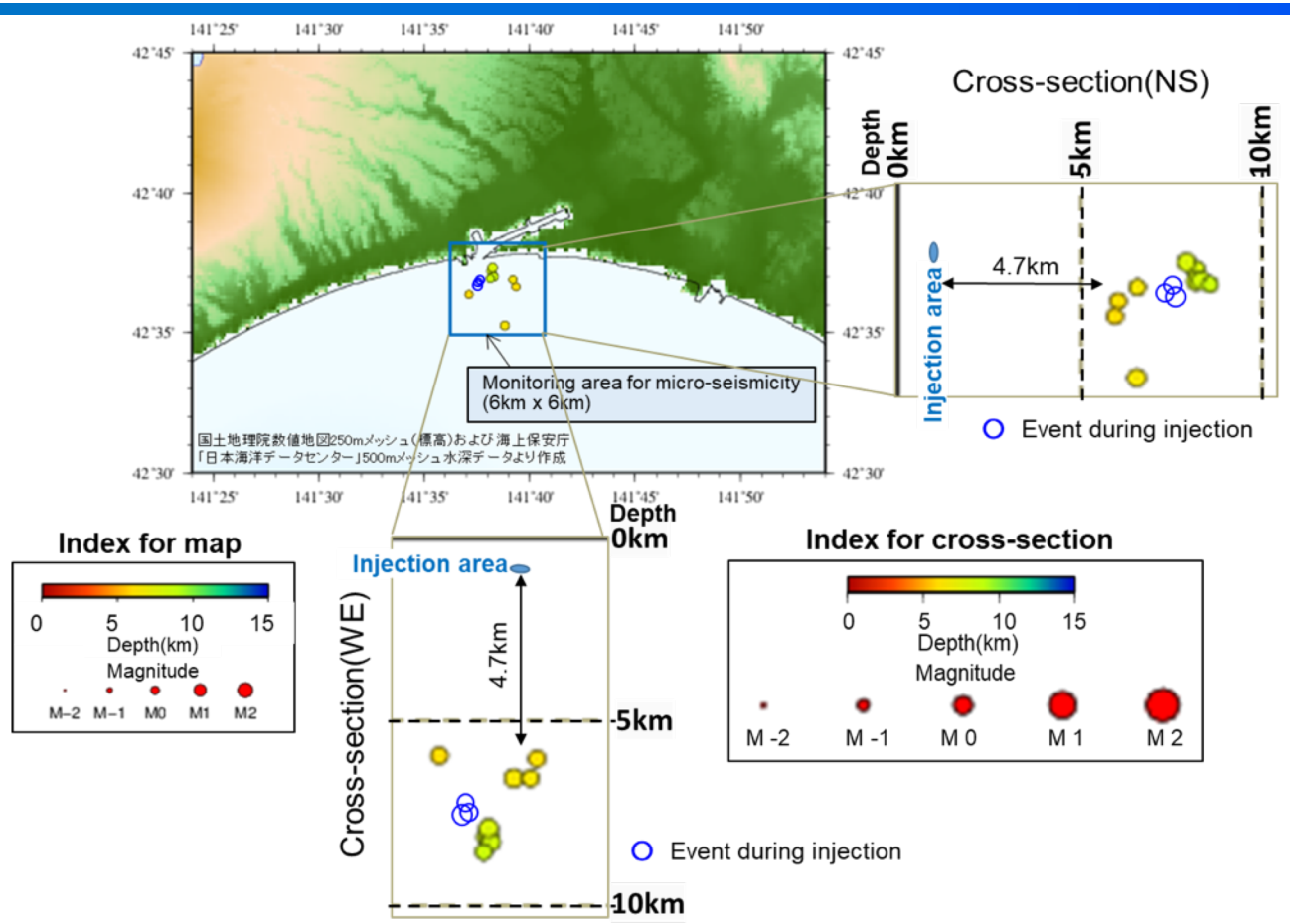


※As only the overlapping portion of the 2009 Baseline Survey and Small-scale 3D Baseline Survey was utilized, the S/N ratio, particularly the peripheral area is low, and the accuracy of the difference calculation is low.

CO_2 saturation prediction by 2018reservoir model



Results of micro-seismicity monitoring



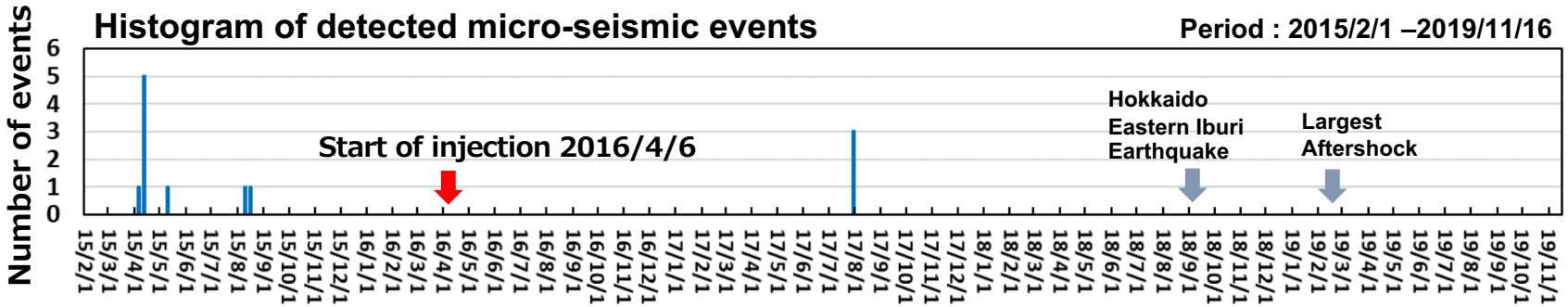
◆ **No micro-seismicity (Mw > -0.5) in/around the depth range of the reservoirs before and during injection**

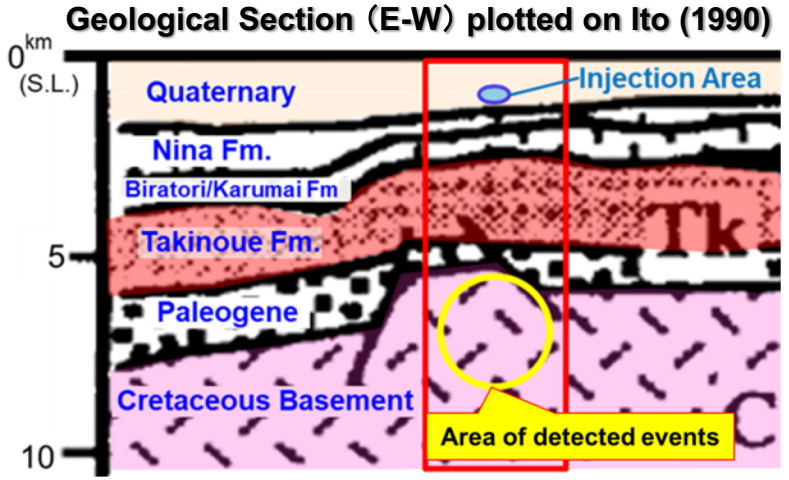
- Before Injection 2015/2/1-2016/4/5

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

- During Injection 2016/4/6-2019/11/16

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

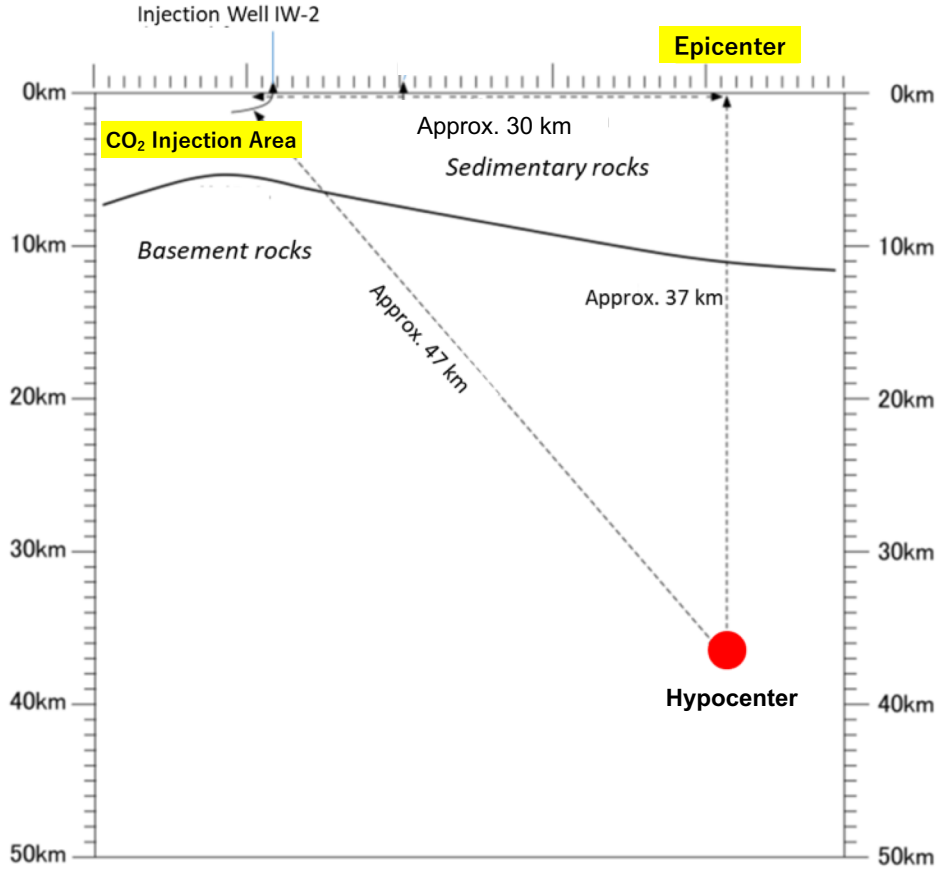




Hokkaido Eastern Iburi Earthquake: location of epicenter

- **Magnitude 6.7 at 3:07am on 6th Sept. 2018**
- The epicenter was about 30km in horizontal distance from the Tomakomai Project CO_2 injection point, and the hypocenter was at a depth of about 37km; the direct distance between the injection point and the hypocenter was about 47km
- Acceleration of 158 gal was observed at the capture facility (no damage to plant facilities)

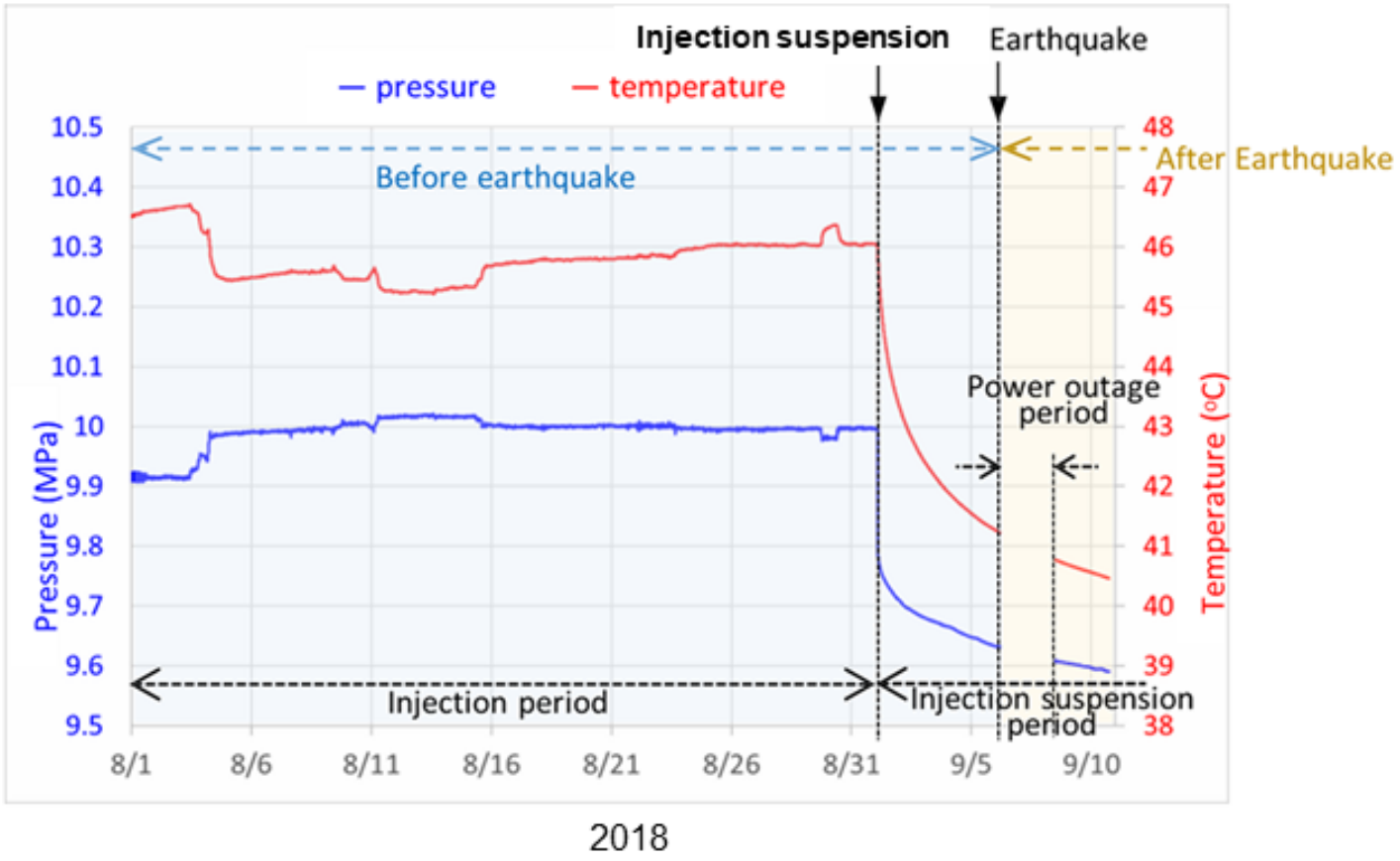
Plan view



Cross section view

Positional relationship between epicenter (hypocenter) and injection point

Hokkaido Eastern Iburi Earthquake：Bottom hole pressure and temperature of Moebetsu Fm.



Bottom hole pressure and temperature of the Moebetsu Formation injection well

- CO_2 injection was suspended on 1st Sept. 2018 due to supply stop of CO_2-containing gas before the earthquake
- Earthquake occurred on 6th Sept. 2018, during the decline of bottom hole pressure and temperature
- No shift of declining trend of bottom hole pressure and temperature before and after the earthquake, and no abnormalities have been found

Measures taken by JCCS after Earthquakes

6th Sept. 2018 : Magnitude 6.7 earthquake occurred

12th Sept. 2018 : Posted JCCS's view on HP

19th Oct. 2018 : Held an expert review meeting

21st Nov. 2018 : Posted summary of a review meeting on HP

21st Feb. 2019 : Magnitude 5.8 earthquake occurred

26th Feb. 2019 : Posted JCCS's view on HP

Key points on JCCS HP :

1. No relationship between CO_2 injection and earthquake
2. No CO_2 leakage

Key principles to minimize concerns of local community and general public :

- Respond quickly
- Include technical explanation

Public Outreach Activities

Voice of Tomakomai Citizens

1) Information Disclosure
- Thorough disclosure should be made

2) Safety/CO_2 leakage
- Want more detailed information on risk of CO_2 leakage

3) Dissemination to Young Generation
- Should consider efforts to involve young generation

Outreach Activities

Monitoring & Disclosure Plan

①Panel Exhibitions

②Forum for Tomakomai Citizens

③Site Tours

④Information Disclosure System

⑤Mini seminars for students

⑥Kids' lab classes/site tours

Outreach Activities (JFY2018)

Site Visitors: 2276 peoples (331 int'l)

Mini seminars: 22 times

Panel Exhibitions: 7 times

Kids' lab classes: 6 times

Booth in Environmental exhibitions: 8 times

CCS Forum: 368 peoples

Project being conducted with understanding and support of local community

A message from Mr. Hirofumi, Iwakura, Tomakomai Mayor

Regarding the achievement of 300,000 tonnes of cumulative CO_2 injection in the Tomakomai large-scale CCS Demonstration Project (November 25, 2019)

Mr. Hirofumi, Iwakura, Tomakomai Mayor

The Tomakomai Project is the first large-scale CCS demonstration project in Japan, and the data and knowledge acquired is certain to play an important role in advancing CCS in Japan.

Tomakomai City will continue supporting this project, with the aim of nurturing understanding for CCS in our region and consciousness of our environment, in order that Tomakomai may play a leading role towards the establishment of a low-carbon society where the global environment and a thriving local economy can co-exist.

Source: Message from Tomakomai Mayor Hirofumi Iwakura: Regarding the achievement of 300k tonnes of cumulative CO2 injection in the Tomakomai large-scale CCS Demonstration Project (November 25, 2019), Tomakomai City website: http://www.city.tomakomai.hokkaido.jp/shisei/shicho/shichoshitsu/comment/comment191125.html
The English version is a translation of the original message in Japanese, translated by JCCS, Courtesy of Tomakomai City

Summary

- Operation of full chain CCS system from capture to storage has been conducted successfully and target of 300,000 tonnes of CO_2 injection has been achieved
- CO_2 capture process comprising a two-stage absorption system with a low-pressure flash tower has achieved significantly lower capture energy than conventional system
- Deviated injection wells from onshore site into offshore reservoirs saved drilling cost and avoided disturbance of local livelihood
- The “Moebetsu Formation” (shallow reservoir) has demonstrated superior injectivity, with only minor pressure buildup
- Concerns about earthquakes and induced seismicity have been addressed
  - Natural earthquakes have not caused any damage to reservoirs
  - No seismicity (Mw > -0.5) has been detected in/around the depth range of the reservoirs before and during injection
- Safety and reliability of CCS system has been demonstrated
- Project is being conducted with understanding and support of local community

Thank you for your attention.

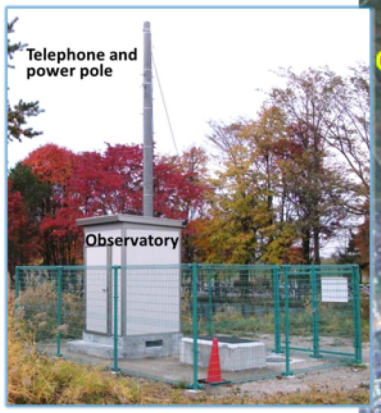
http://www.japanccs.com/

The author would like to express thanks to Ministry of Economy, Trade and Industry (METI), New Energy and Industrial Technology Development Organization (NEDO) for kind permission to disclose information.

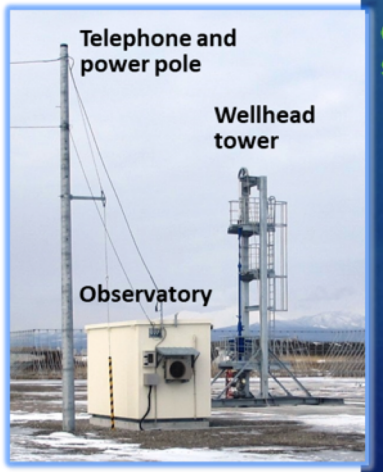
This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

Layout of monitoring system

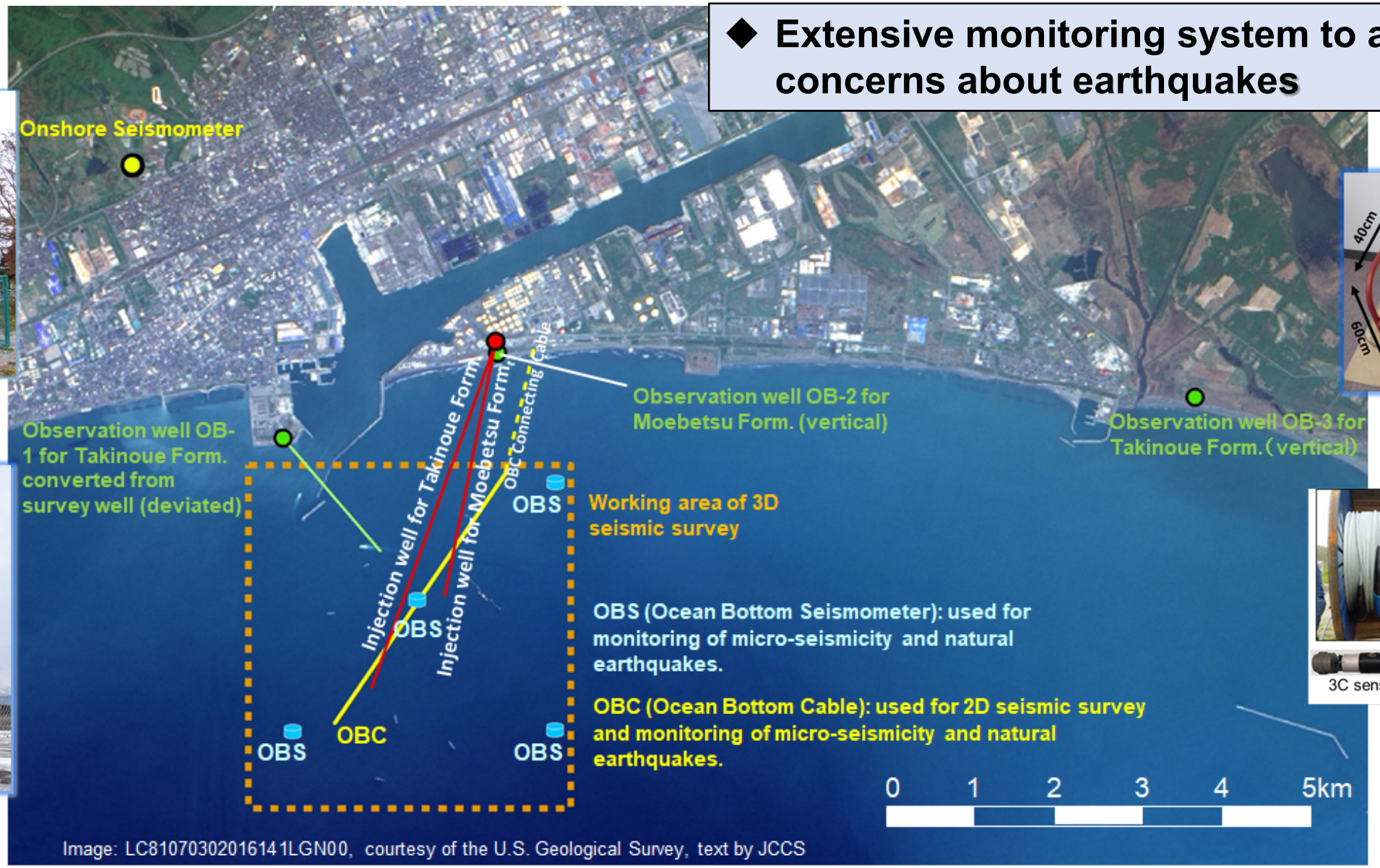
◆ **Extensive monitoring system to address concerns about earthquakes**



Onshore Seismic Station



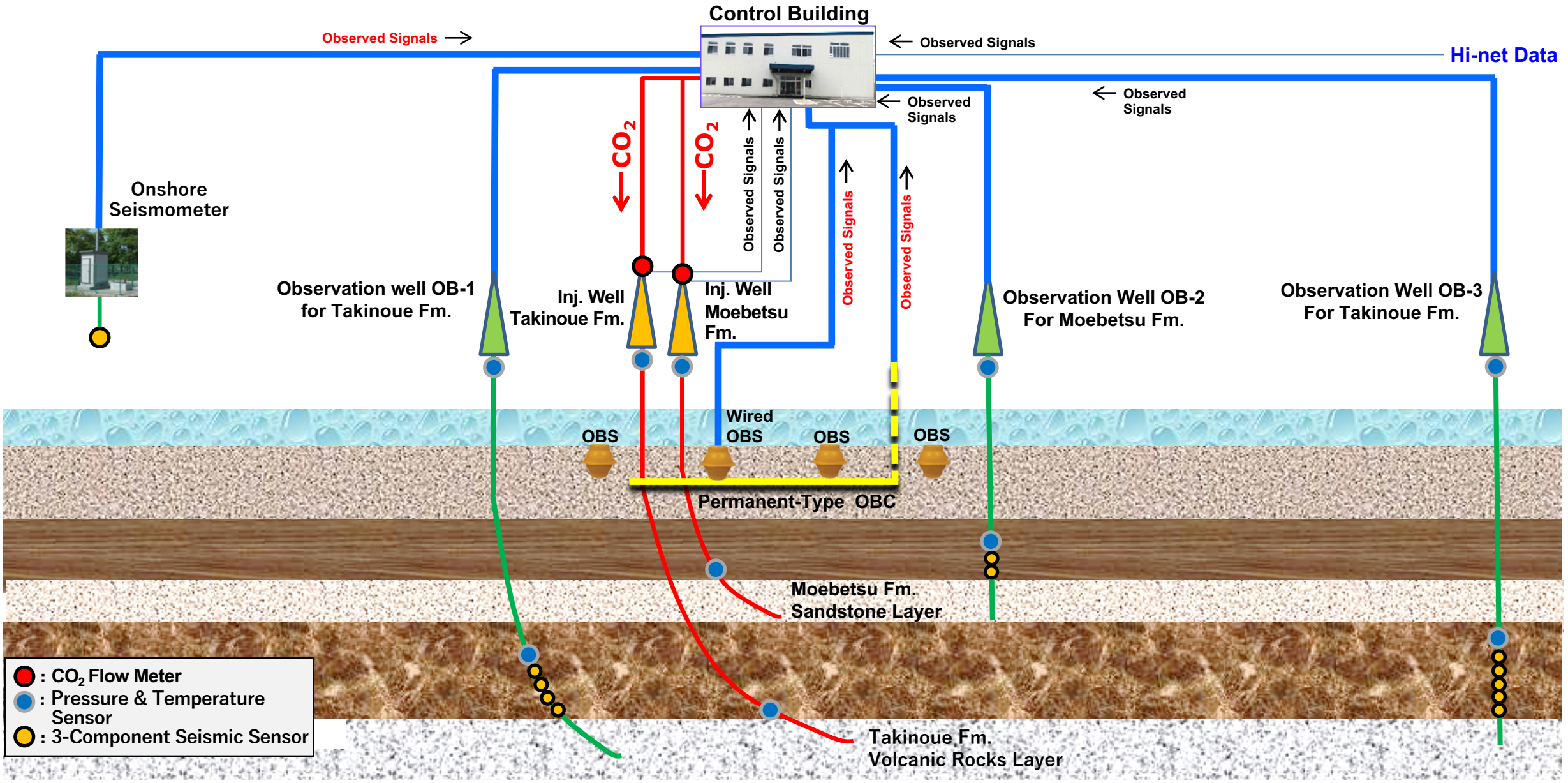
Observation well OB-1



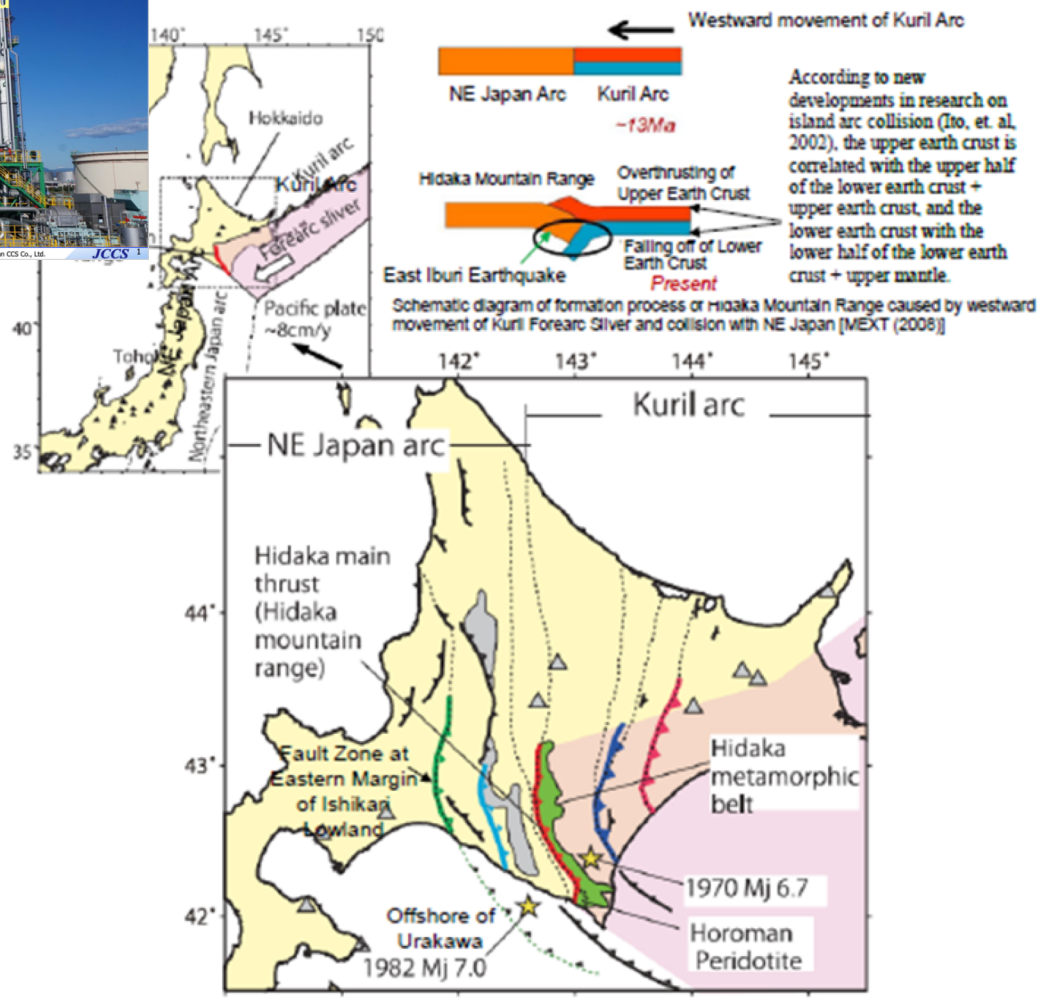
OBS

OBC

Conceptual Diagram of Monitoring System



Hokkaido Eastern Iburi Earthquake : Triggering Mechanism



Tectonic structure image of southern Hokkaido

Source: High-resolution seismic velocity structure beneath the Hokkaido corner, northern Japan (Saeko Kita et al., 2012), Estimation of 3D Inhomogeneous Crustal Structure at Plate Boundaries and Peripheral Regions (MEXT, 2008)

- Regarding the Kuril Arc, it is believed that the upper crust is thrust upwards forming the Hidaka Mountains, whereas the lower crust subducts beneath the NE Japan Arch, dragging the NE Japan Arc downwards as well. As a result, the earth's crust is thicker around the Hidaka Mountains and to the west.
  The Eastern Iburi Earthquake is believed to have occurred near the bend of the crust.
- The Earthquake Research Committee expressed the view on September 6 that "the regions around eastern Iburi, Hidaka to offshore Urakawa are characterized by many earthquakes also occurring in locations deeper than where earthquakes usually occur in the onshore earth crust, and the latest seismic activity occurred in an area having such characteristics."
- The Eastern Iburi Earthquake is not believed to have occurred in an unordinary location; i.e., it occurred within the range of seismic activities expected in the area concerned.

Source : English translation of the "Research Report on Impacts of Hokkaido eastern Iburi Earthquake on CO_2 Reservoir" (in Japanese) published in Nov. 2018. JCCS takes full responsibility for the English translation.