Experience from Tomakomai CCS Demonstration Project

Yoshihiro Sawada
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Japan CCS Co., Ltd.

Outline of Presentation

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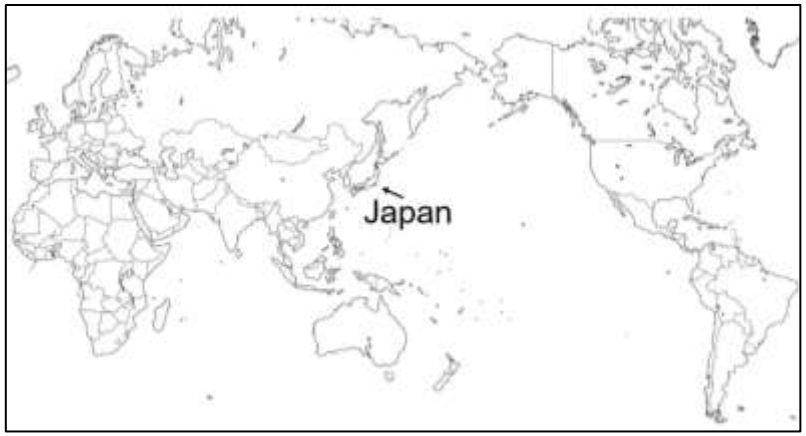
7. Summary

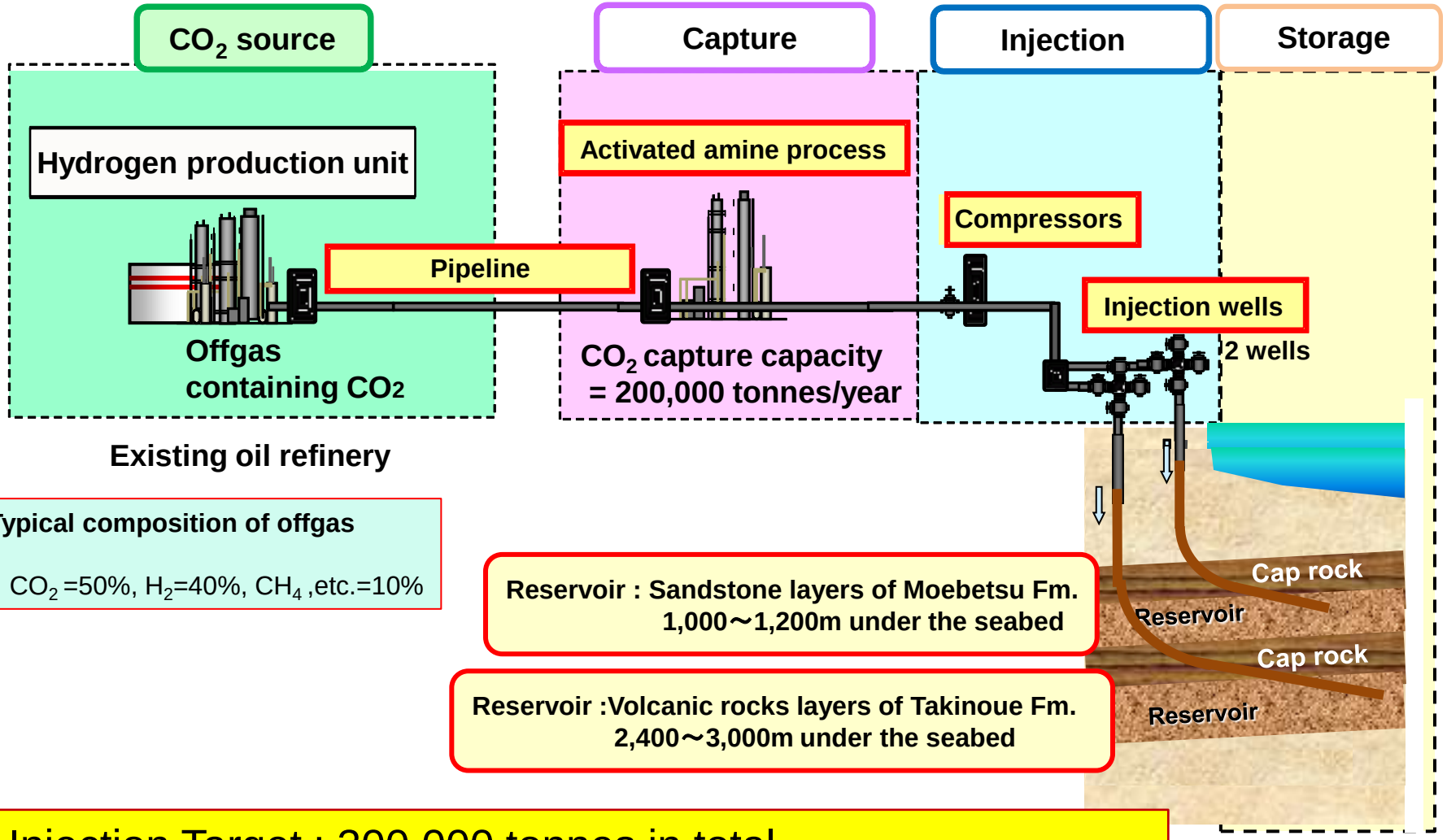


1. Overview of Tomakomai CCS Demonstration Project

Objectives and tasks of Demonstration Project

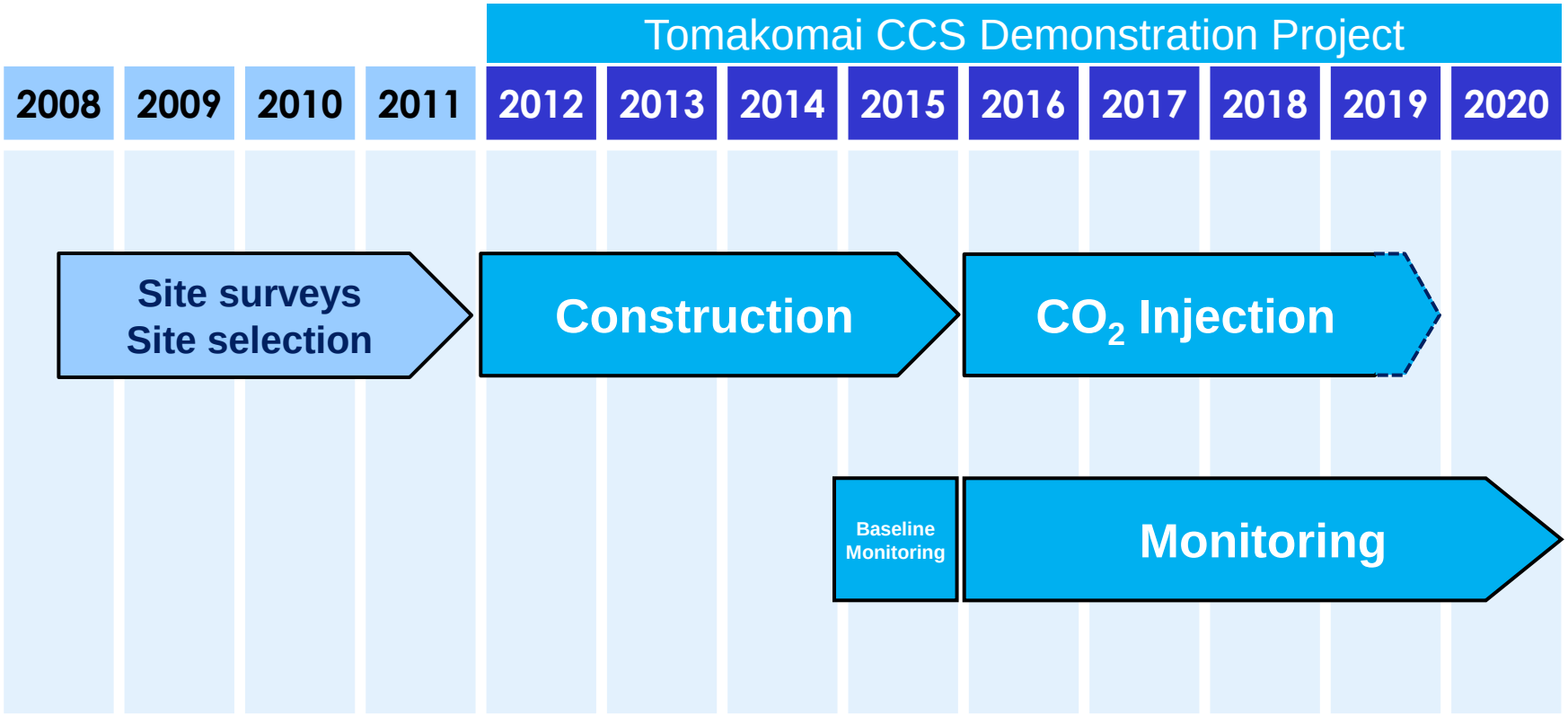
- Demonstrate full-chain CCS system from capture to storage
- Confirm existing technologies adopted in the system work properly and efficiently
- Demonstrate CCS system is safe and reliable
- Remove concerns about earthquakes by the data collected;
  - No influence by natural earthquakes on CO_2 stored
  - 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 Tomakomai CCS Demonstration Project



Injection Target : 300,000 tonnes in total
Injection as of June 4th, 2019 : 261,730 tonnes

Schedule of Tomakomai Project

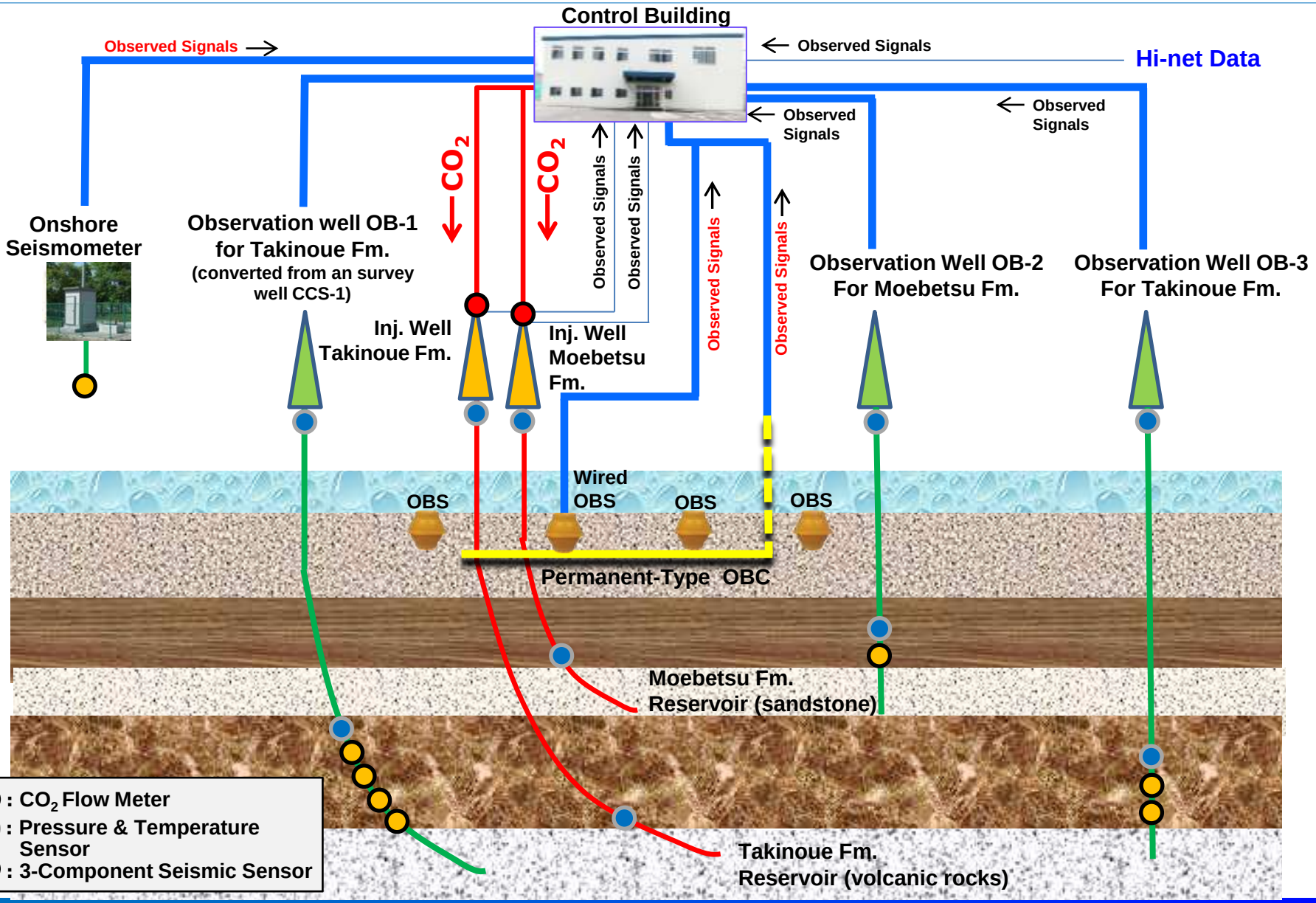


Year are in Japanese Fiscal Years (April of calendar year to March of following year)

Location of Wells and Monitoring Facilities

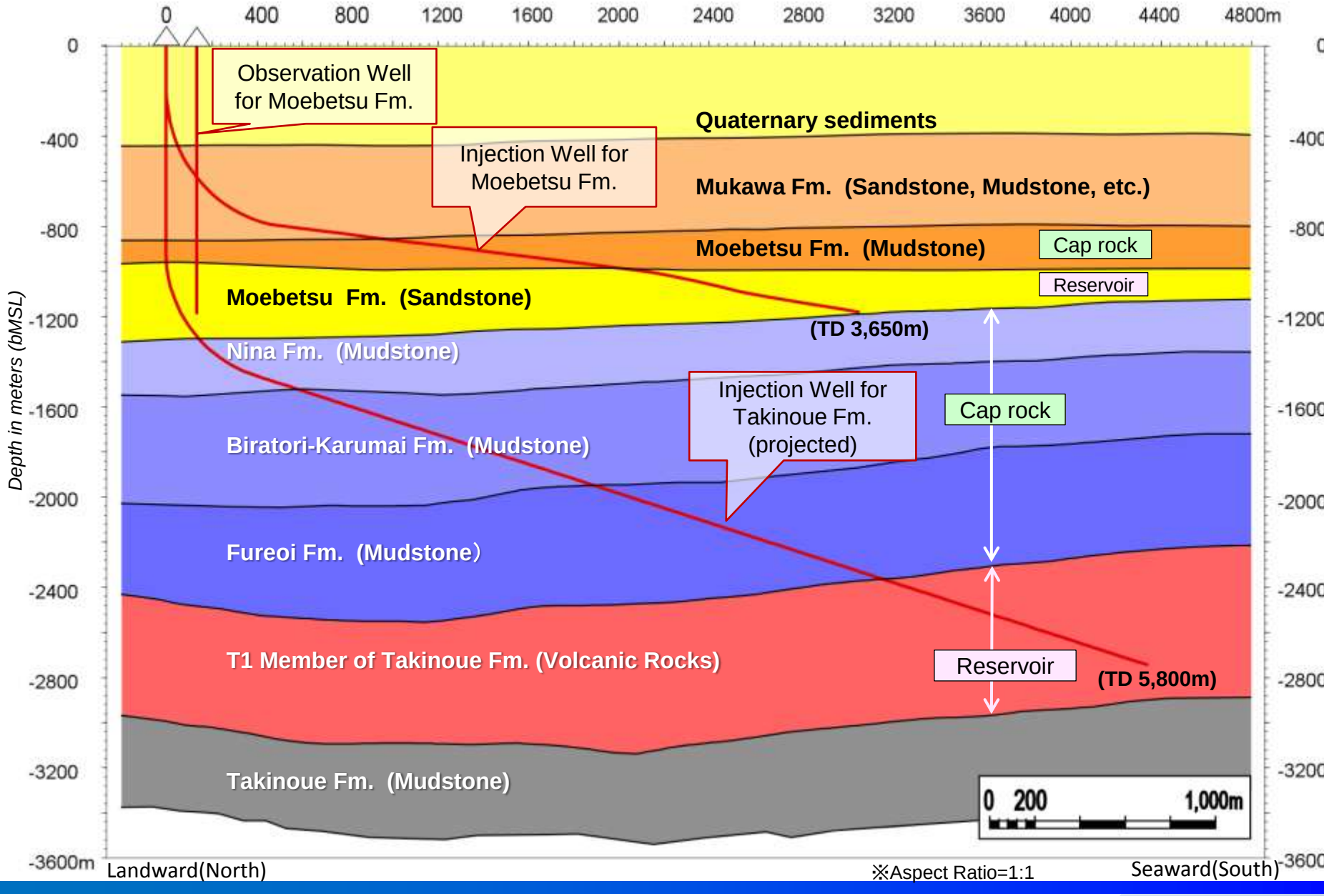
Image: LC81070302016141LGN00, courtesy of the U.S. Geological Survey, text by JCCS

Conceptual Diagram of Monitoring System of Tomakomai Project

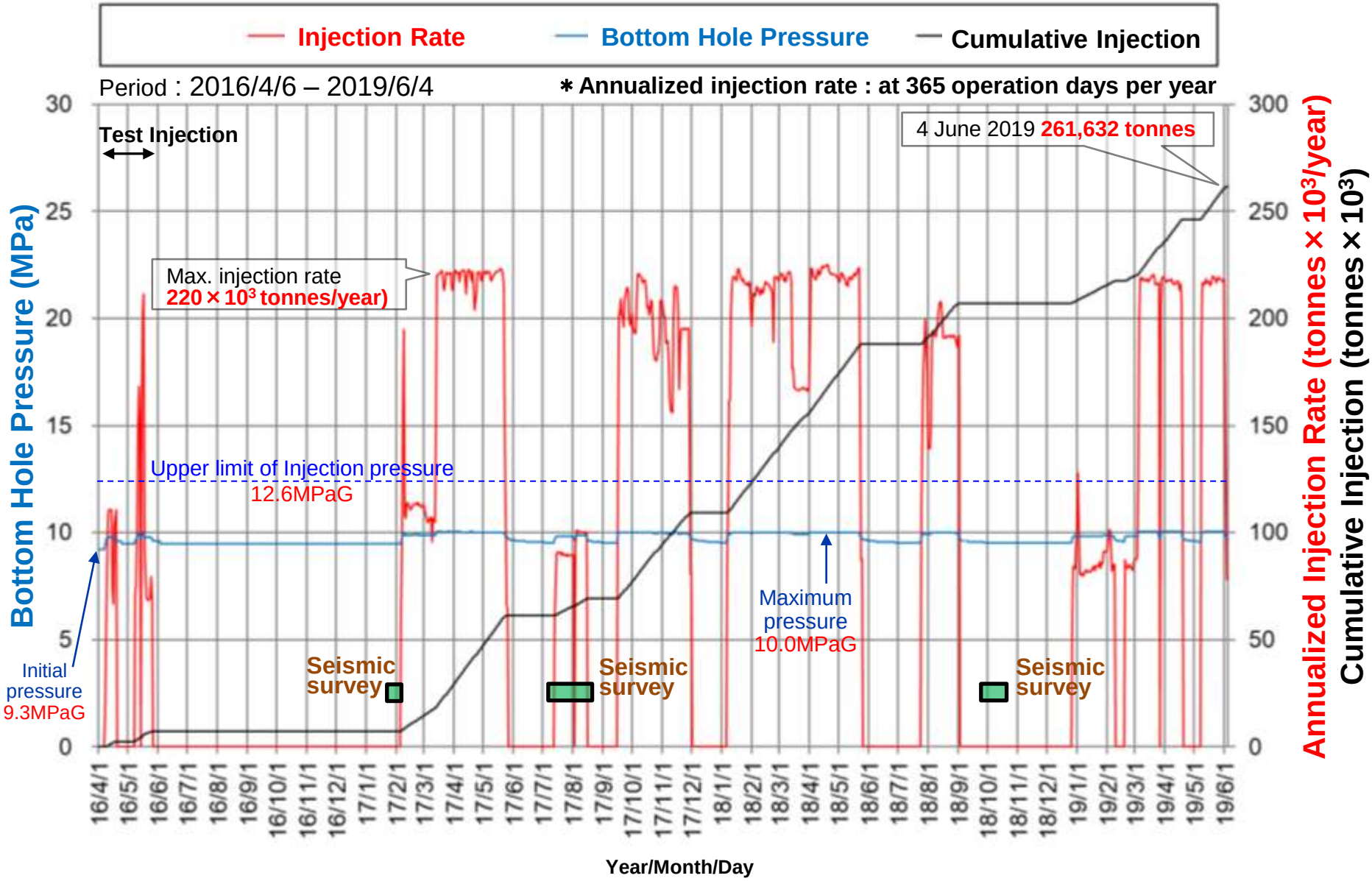


2. Injection Record

Schematic Geological Section



CO_2 injection record of Moebetsu formation



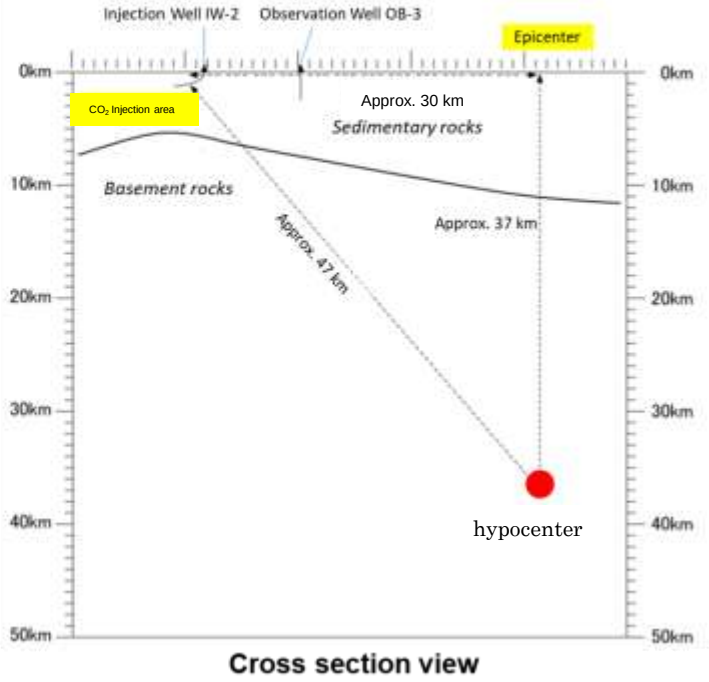
3. Dealing with Earthquakes

Hokkaido Eastern Iburi Earthquake : Location of Epicenter

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

- The epicenter is about 30km in horizontal distance from the CO_2 injection area and the hypocenter is at a depth of about 37km ; the direct distance between the injection area and the hypocenter is about 47km
- Seismic Intensity at Tomakomai was 5 upper

Plan view

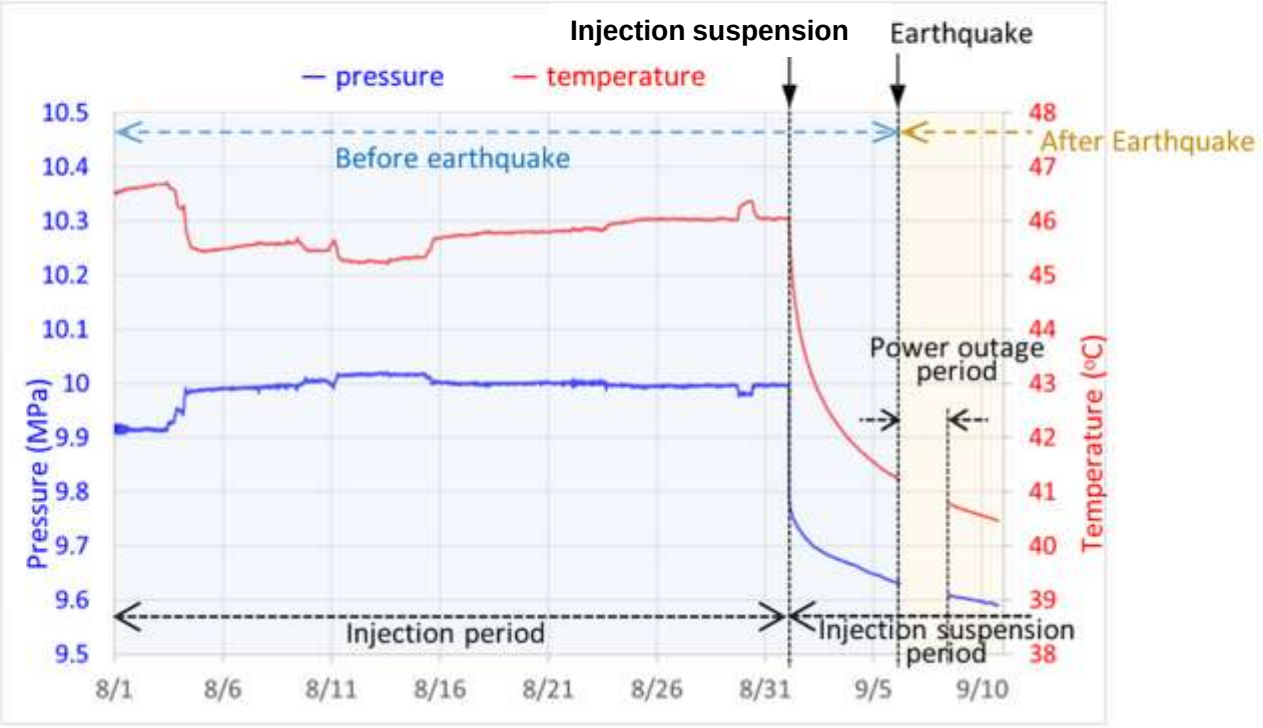


Cross section view

Positional relationship between epicenter (hypocenter) and injection area

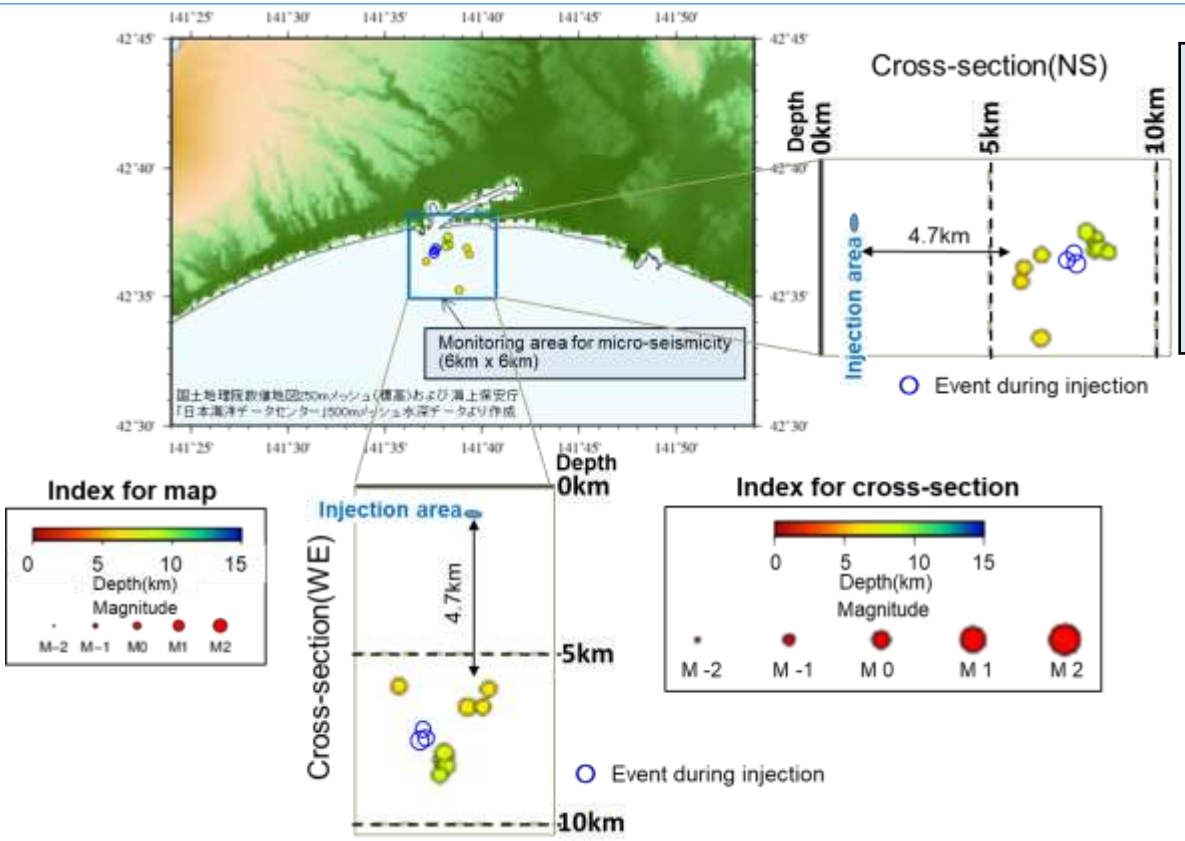
Hokkaido Eastern Iburi Earthquake: Bottom hole pressure and temperature of Moebetsu Fm.

- 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



Bottom hole pressure and temperature of the Moebetsu Formation injection well

Seismic Monitoring Results of Tomakomai Project : Micro-seismicity



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

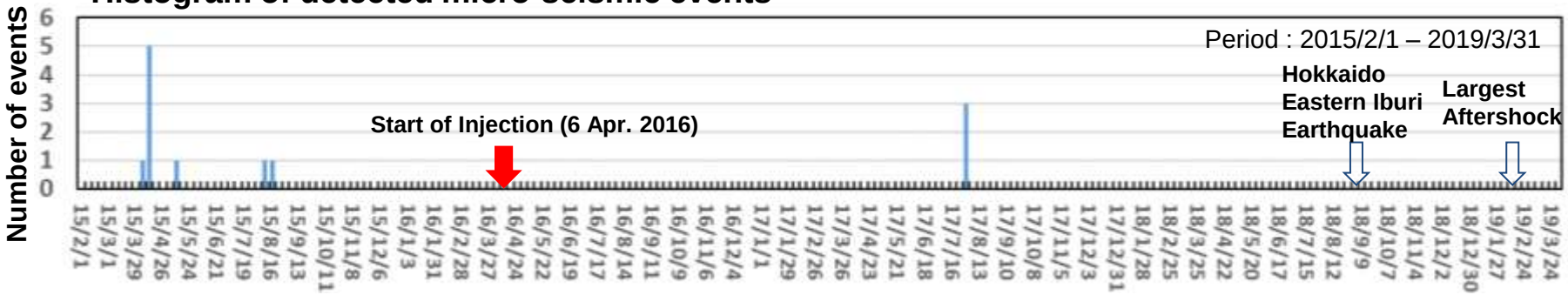
Before Injection period

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

During Injection period

Total 3 events, Mw: 0.31 ~ 0.52
Depth: 7.4km ~ 7.7km
Date: Aug. 2 2017

Histogram of detected micro-seismic events



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 of assessment

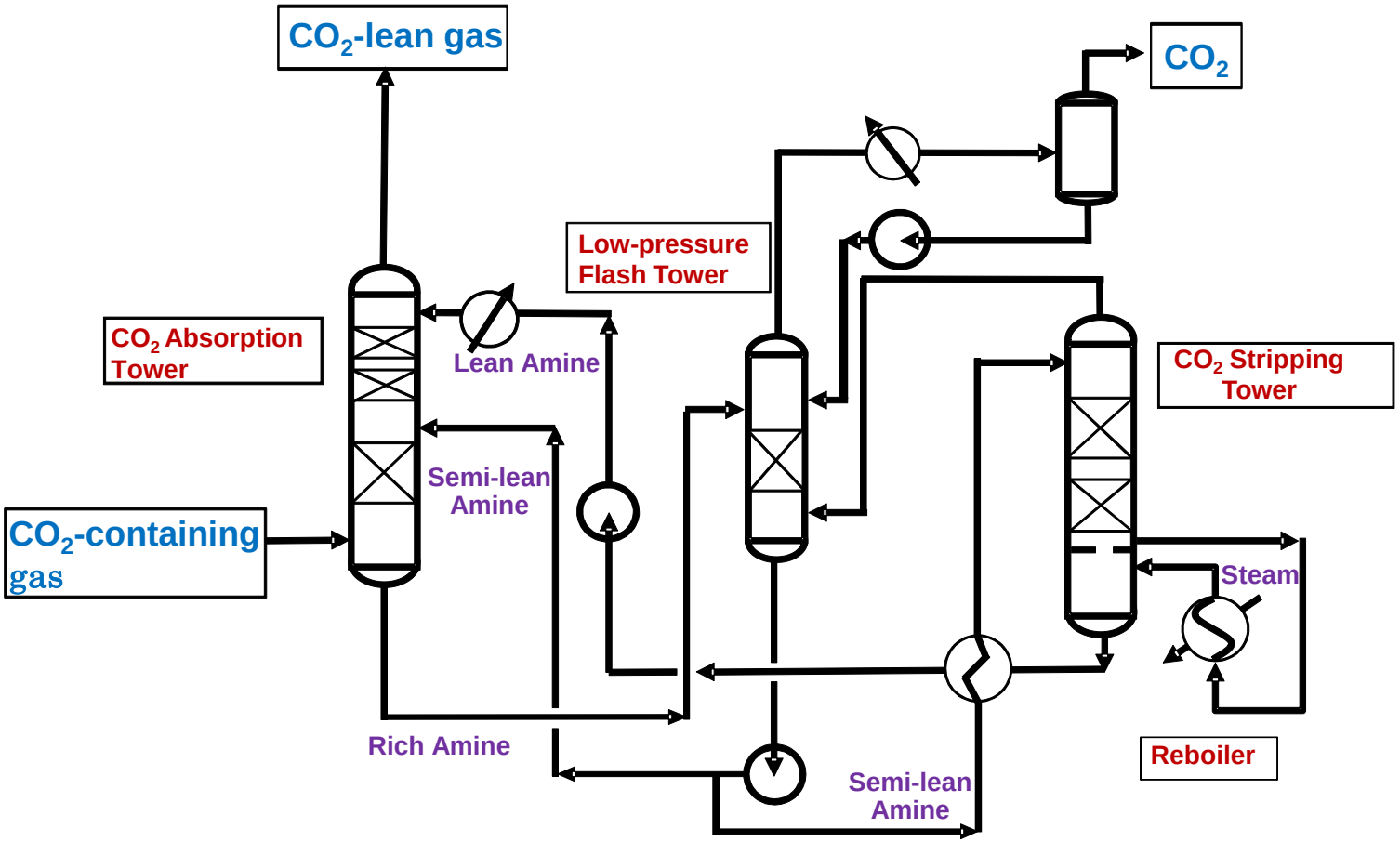
1. No relationship between CO_2 injection and earthquake
2. No CO_2 leakage

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

- Respond quickly
- Include technical explanation

4. CO_2 Capture Process and CO_2 Capture Energy

Tomakomai 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

Relationship between CO_2 Recovery Rate and CO_2 Capture Energy

	Case 1	Case 2	Remarks
CO_2 recovery rate %	99.97	94.8	Loading Factor Case 1: 98%, Case 2: 100%
Reboiler duty (GJ/t-CO_2)	0.88	0.81	
Heat energy (GJ/t-CO_2)	0.98	0.90	Reboiler duty/steam boiler efficiency
Electric energy (GJ/t-CO_2)	0.18	0.19	
CO_2 capture energy (GJ/t-CO_2)	1.16	1.09	Heat energy + Electric energy

Method of test operation at low CO_2 recovery rate (94.8%):

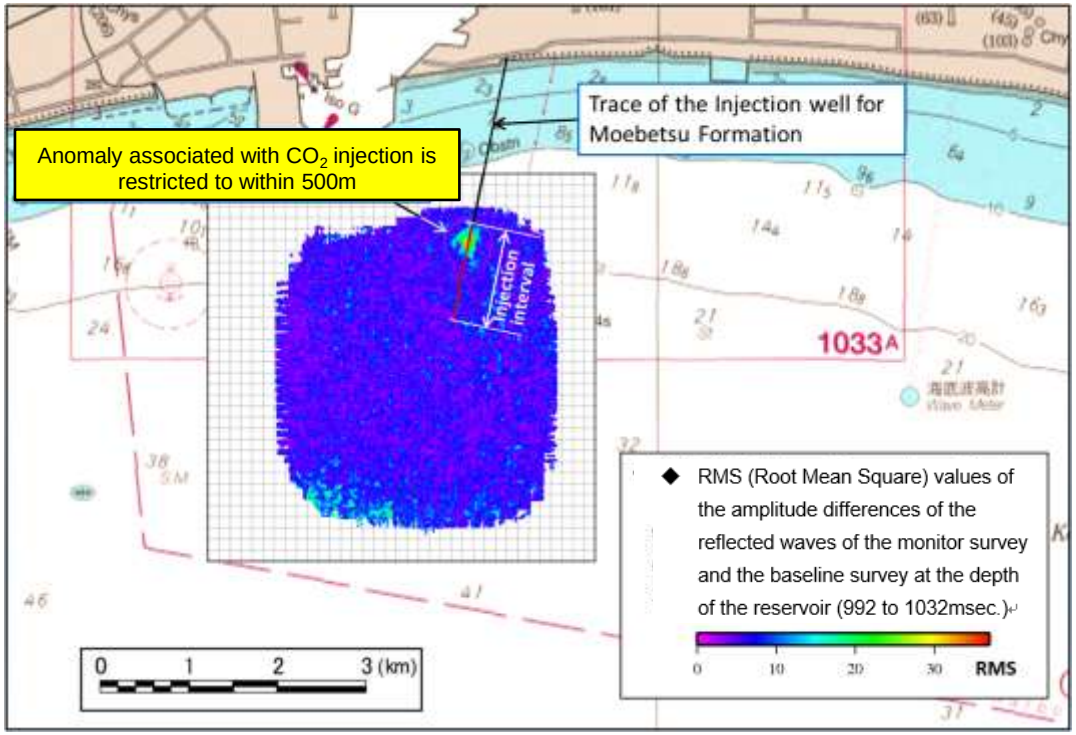
- Reduced flow rate of semi-lean amine solution and steam to CO_2 Stripping Tower
- Maintained flow rate of semi-lean amine solution to CO_2 Absorption Tower

5. Results of Monitor 3D seismic Survey

Results of Monitor 3D Seismic Survey

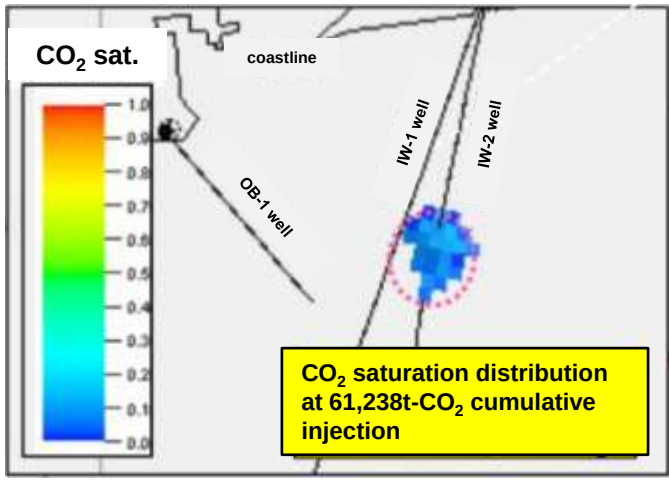
- The first monitor 3D seismic survey at cumulative CO_2 injection of 61,000 to 69,000 tonnes into the Moebetsu Formation detected a clear anomaly along the injection interval, matching simulation results

Result of first monitor 3D survey



Plotted on Japan Coast Guard Nautical Chart

CO_2 saturation prediction by simulation technique



6. Public Outreach Activities

Injection of CO_2 near Urban Area

Population of Tomakomai City : 172,000

https://www.google.co.jp/search?q=%E8%8B%AB%E5%B0%8F%E7%89%A7%E5%B8%82+%E5%86%99%E7%9C%9F&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwiTn_PjpPnXAhWFHpQKHRteB3AQsAQIVw&biw=1536&bih=771

Injection operation in Tomakomai is executed near urban area

⇒Extensive public outreach activities being conducted.

Public Outreach Activities

Voice of Tomakomai Citizens

1) Information Disclosure
- Thorough disclosure should be made
- Want to know more about CCS; should be covered by city newsletter
- Diligent and careful attention to local community is desired

2) Safety/CO_2 leakage
- Need consideration of not only economic benefits but safety
- Want more detailed information on risk of CO_2 leakage

Monitoring & Disclosure Plan

3) Dissemination to Young Generation
- 80% of forum participants over 50; low participation by young people is regrettable
- Should consider other efforts to involve young generation

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, bottomhole 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.




Outreach Activities (JFY2018)

Panel Exhibitions	7 times (Tomakomai and vicinity)	**Site Visitors**	2276 people (331 int'l)
Mini Seminars	22 times (Tomakomai, nationwide)	**Booths in Environmental Exhibitions**	8 times
Kids' lab classes	6 times (Tomakomai)	**CCS Forum**	368 people (Mar 9, 2019)

7. Summary

Summary

- Full chain CCS system from capture to storage is in operation
  - Demonstrate safety and reliability of CCS system
  - Remove concerns about earthquakes and induced seismicity
- 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, matching simulation results
- Project being conducted with understanding and support of local community
- CO_2 injection is progressing smoothly, with cumulative injection at 261,730 tonnes (as of June 4th, 2019), en route to achieving 300,000 tonnes this autumn.

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.