Progress of Tomakomai CCS Demonstration Project

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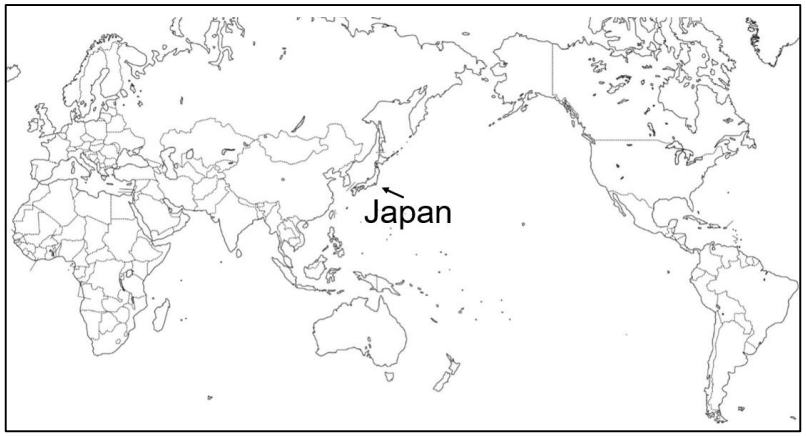
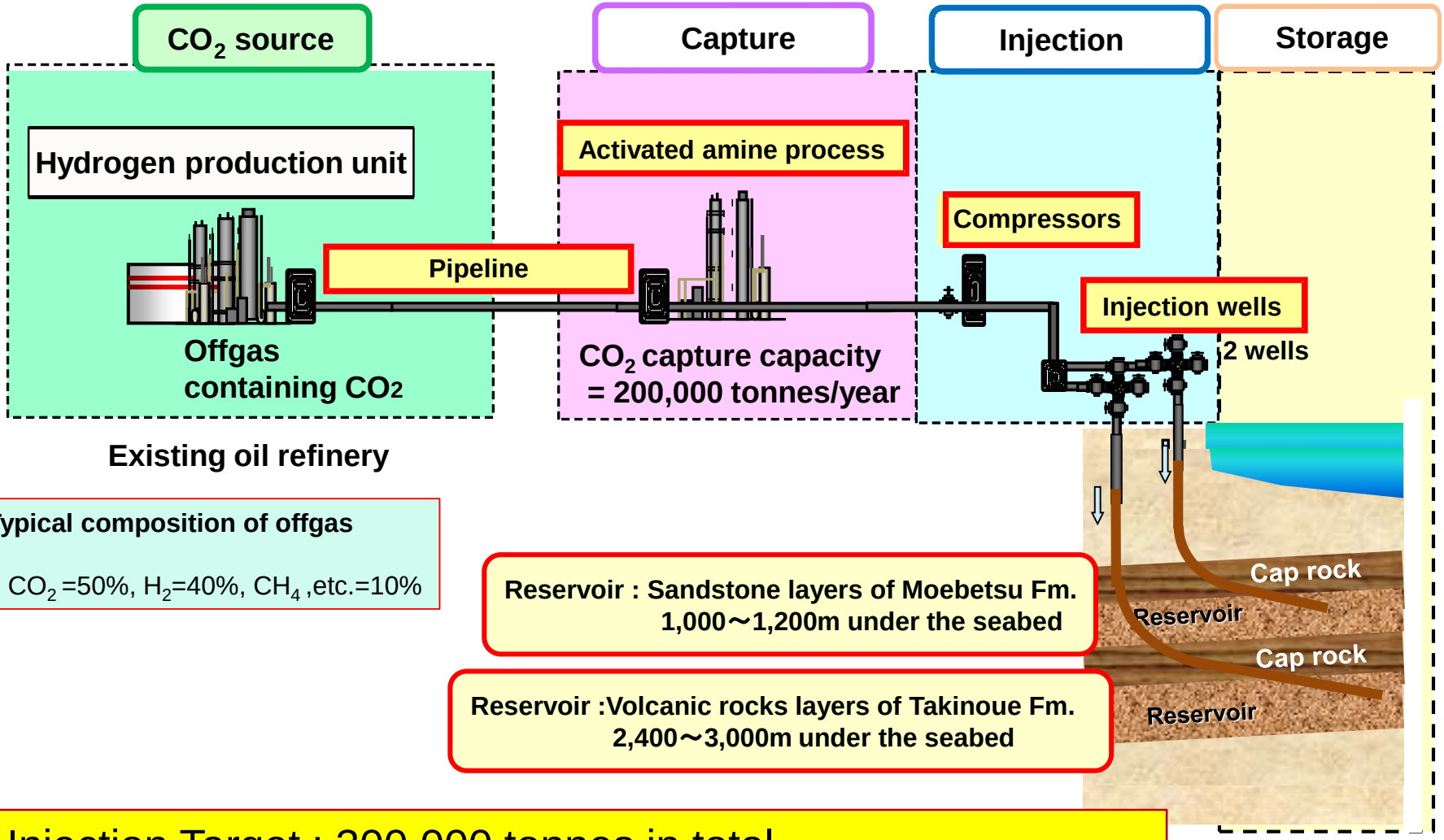
Outline of Presentation

1. Overview of Tomakomai CCS Demonstration Project
2. Injection Record
3. Dealing with Earthquakes
4. CO_2 Capture Process and CO_2 Capture Energy
5. Results of Monitor 3D seismic Survey
6. International Activities



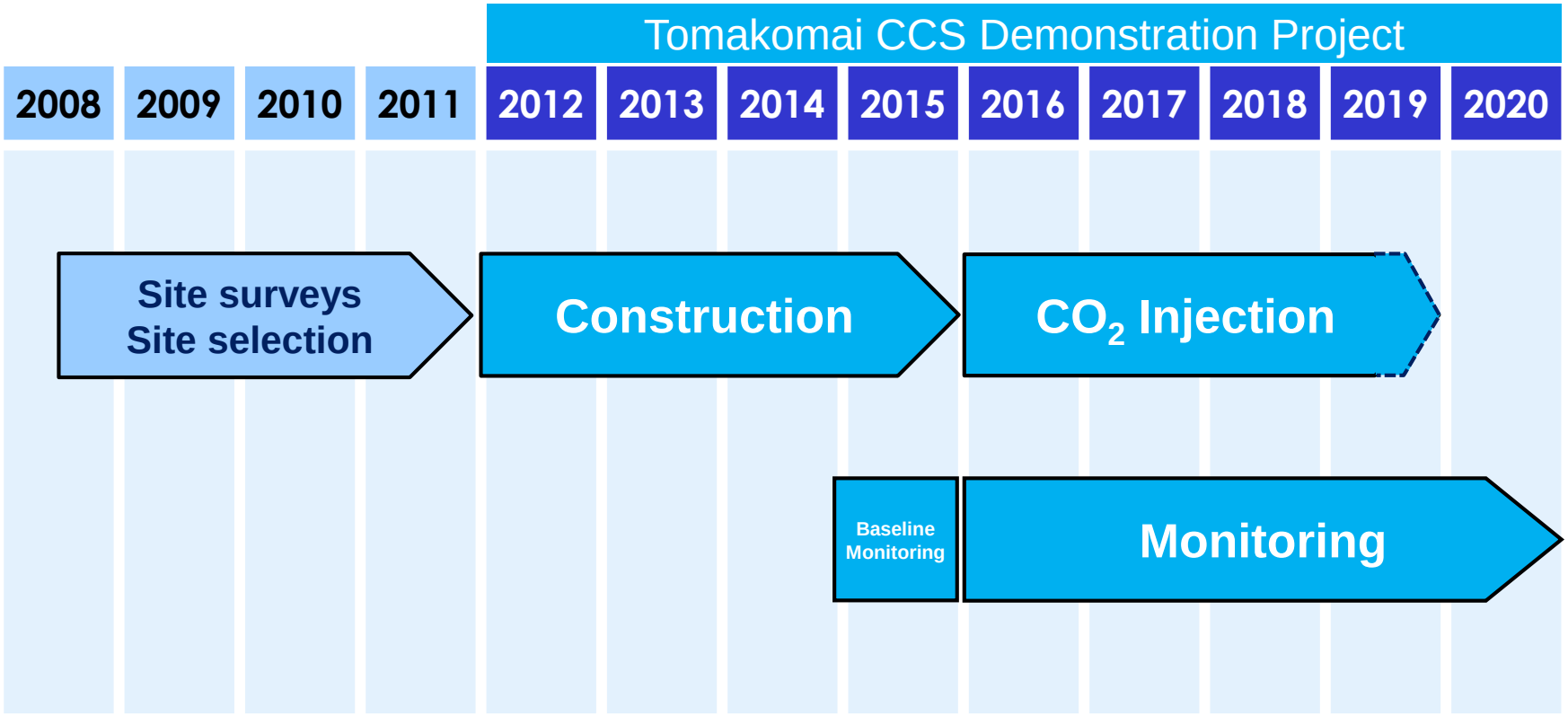
1. Overview of Tomakomai CCS Demonstration Project

Flow Scheme of Tomakomai CCS Demonstration Project



Injection Target : 300,000 tonnes in total
Injection as of May 23rd, 2019 : 255,635 tonnes

Revised 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

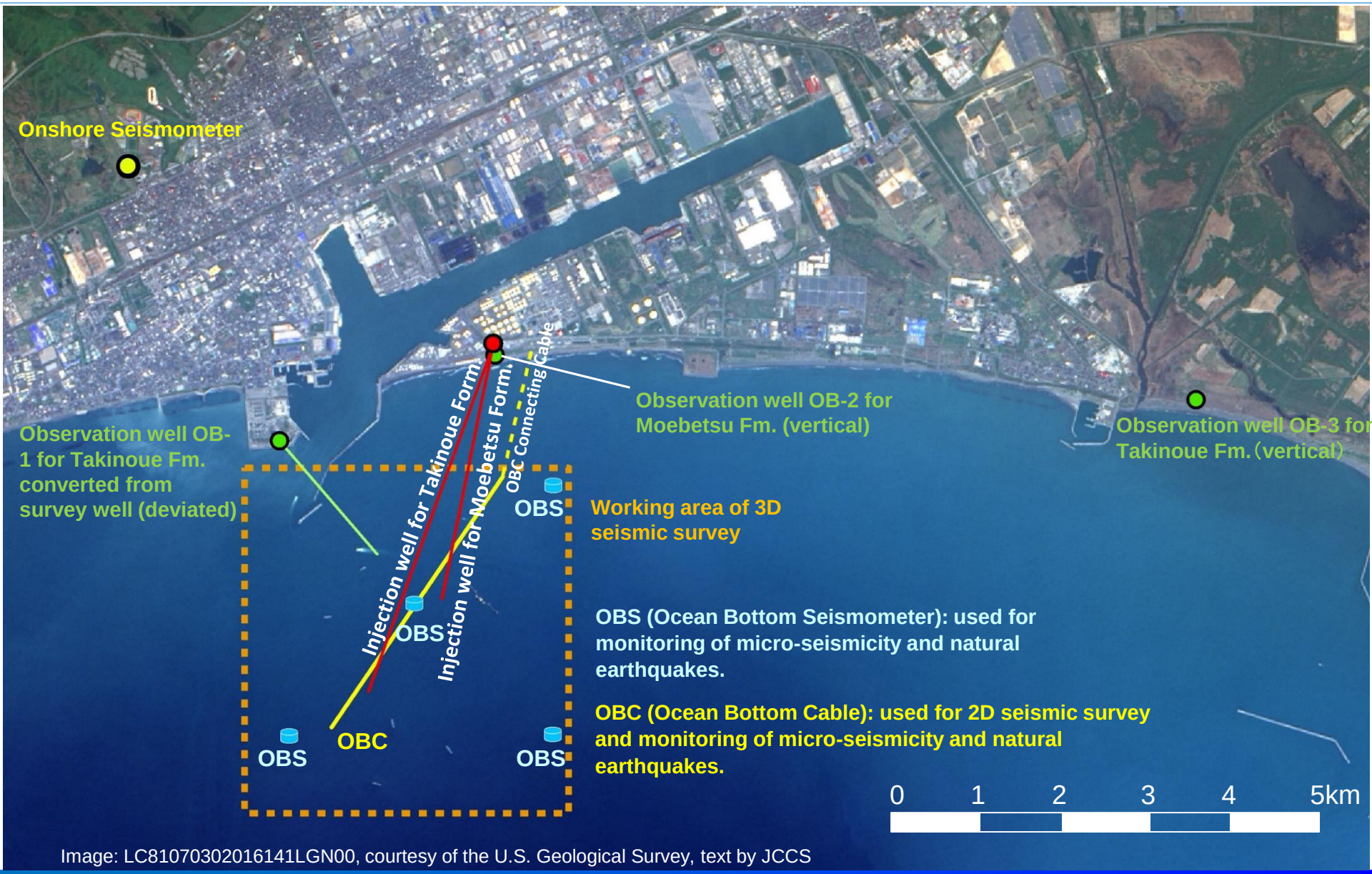
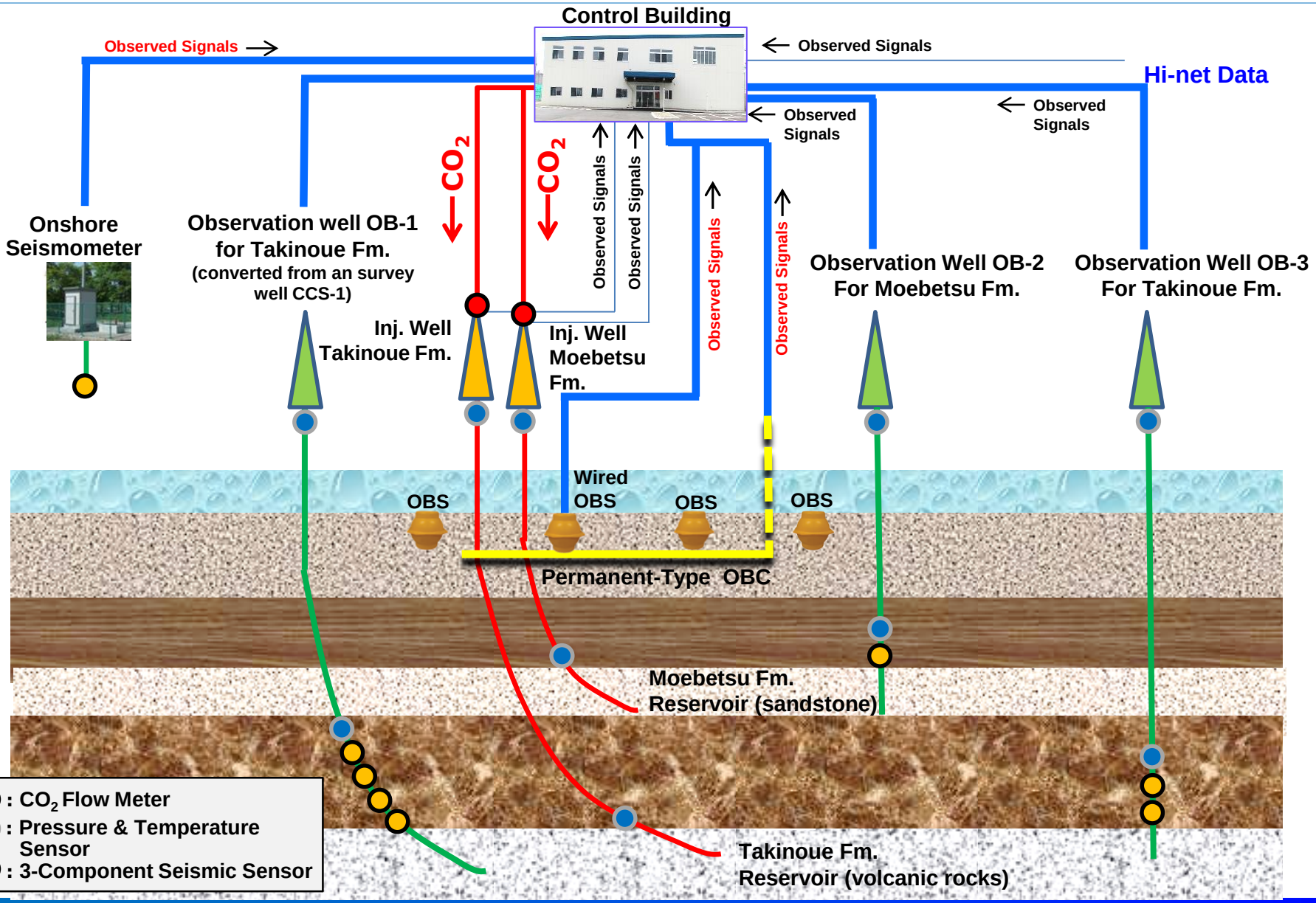


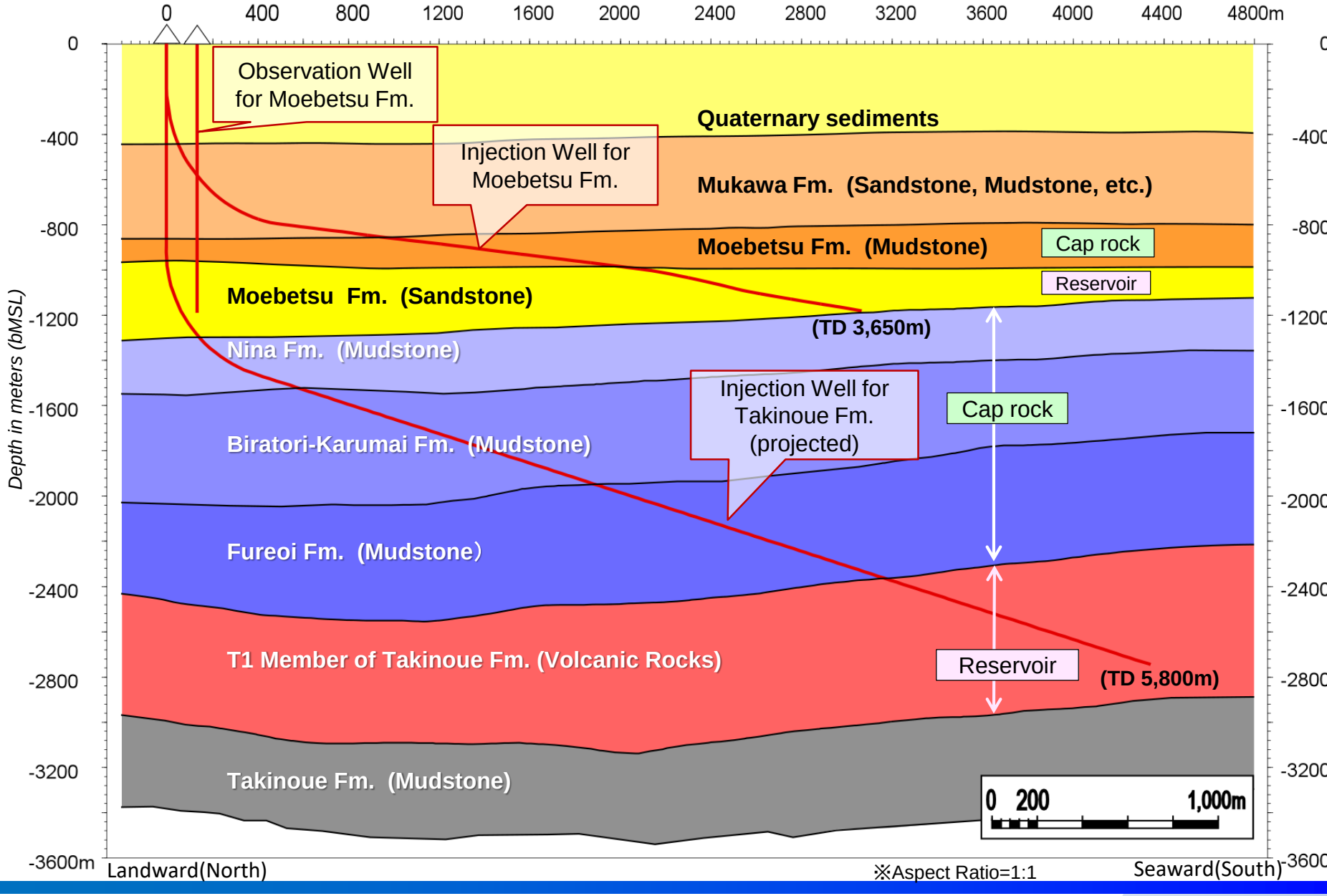
Image: LC81070302016141LGN00, courtesy of the U.S. Geological Survey, text by JCCS

Conceptual Diagram of Monitoring System of Tomakomai Project

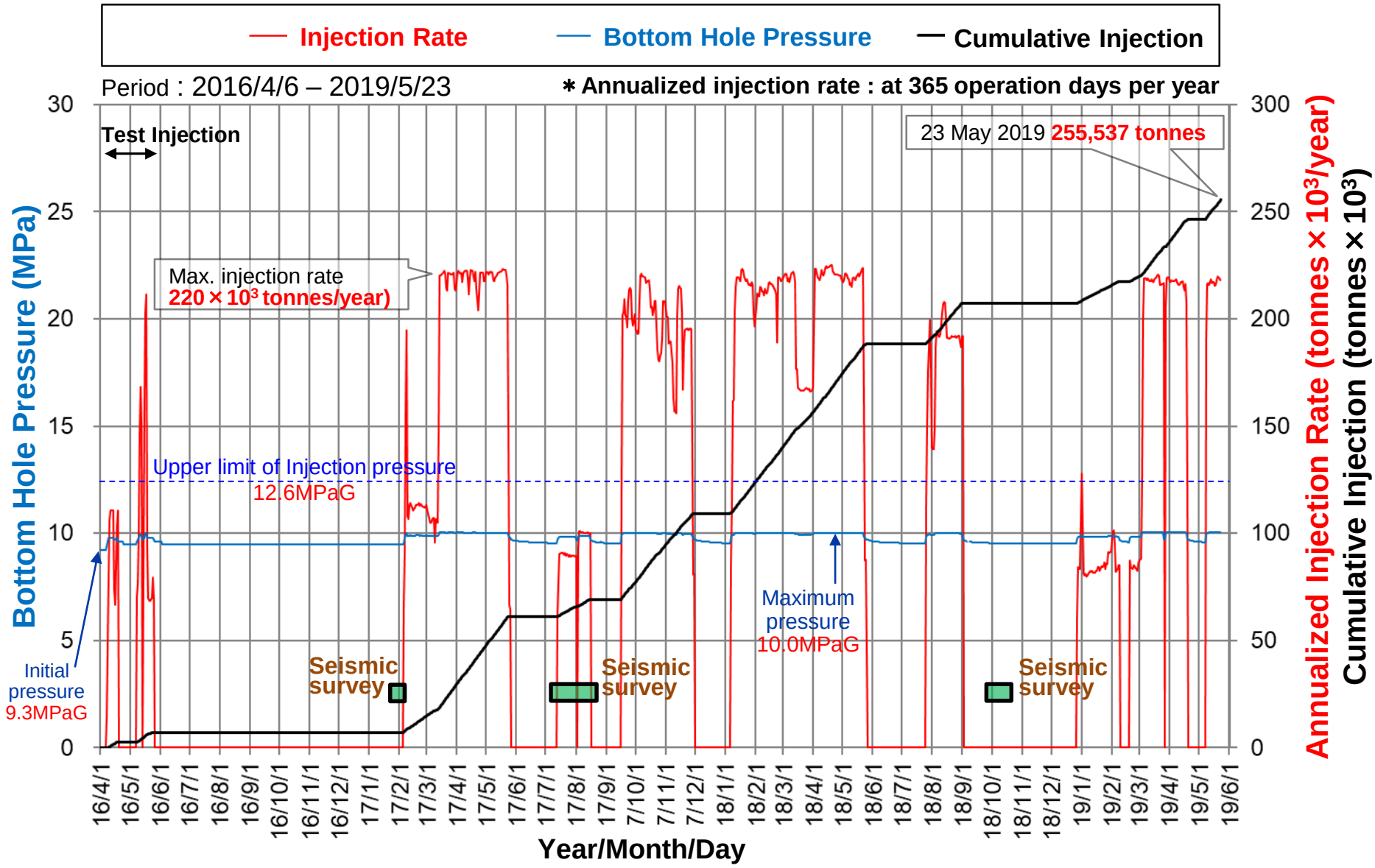


2. Injection Record

Schematic Geological Section



CO_2 injection record of Moebetsu formation



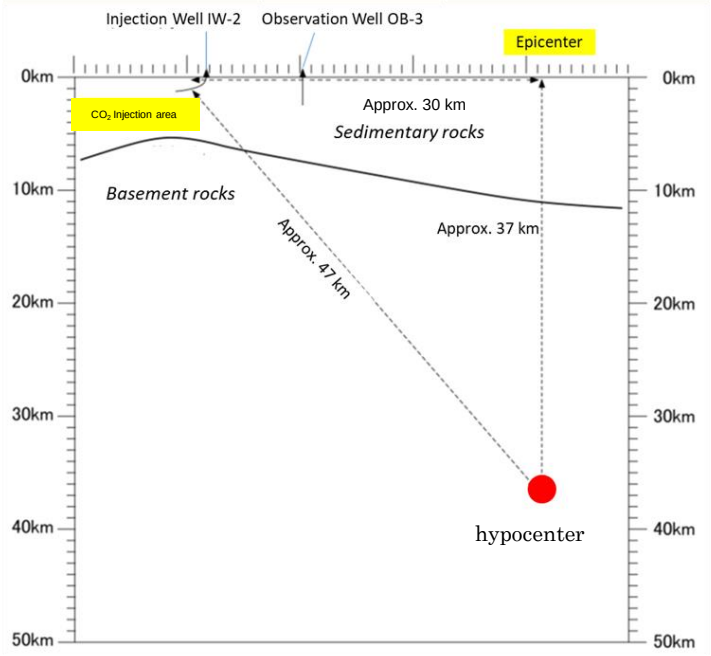
3. Dealing with Earthquakes

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 Tomakomai Project CO_2 storage point 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

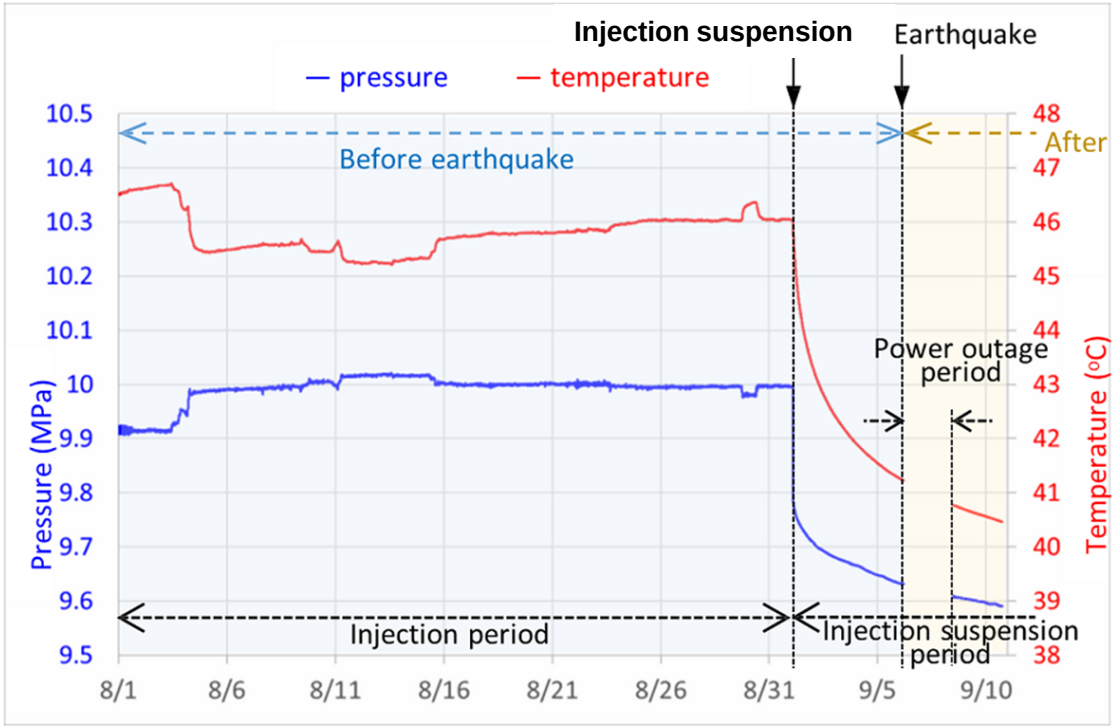


Cross section view

Positional relationship between epicenter (hypocenter) and injection area

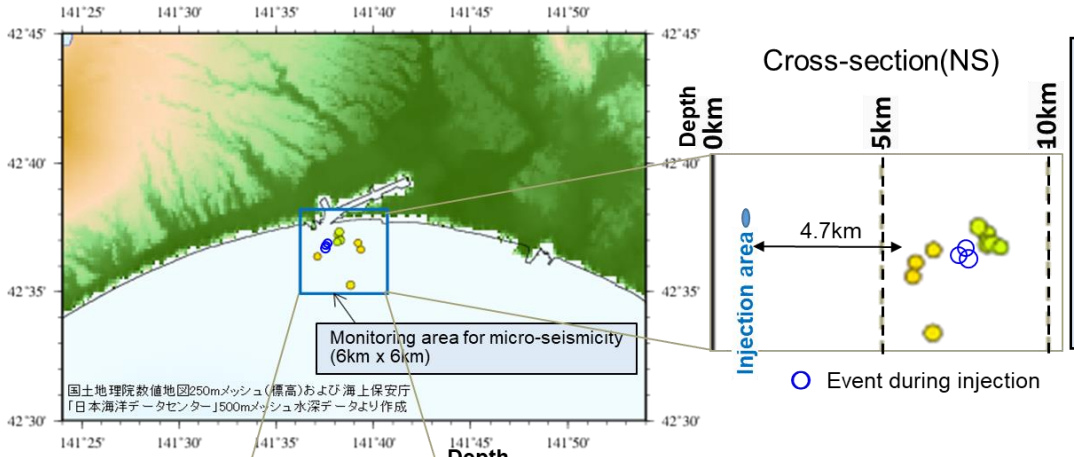
Hokkaido Eastern Iburi Earthquake: Bottom hole pressure and temperature of Moebetsu Fm.

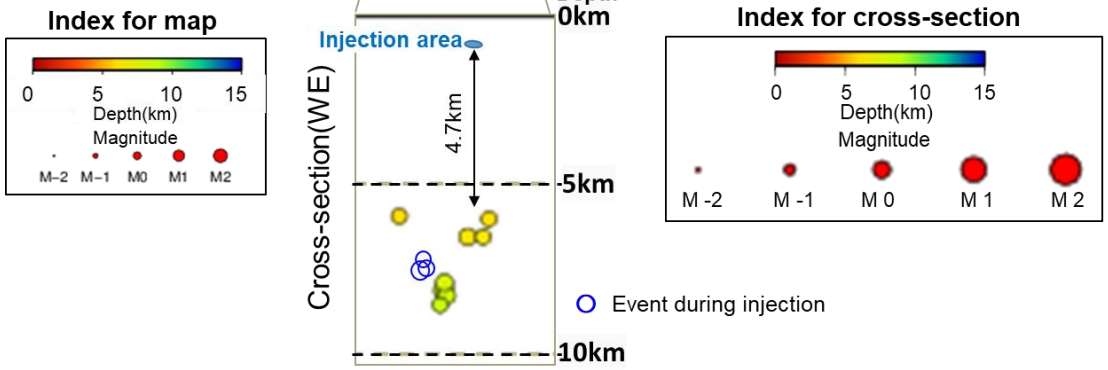
- CO_2 injection was suspended on 1st Sept. 2018 due to supply stop of CO_2-containing gas before the earthquake
- Earthquake occurred on 6th Sept. 2018, during the decline of bottom hole pressure and temperature
- No shift of declining trend of bottom hole pressure and temperature before and after the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

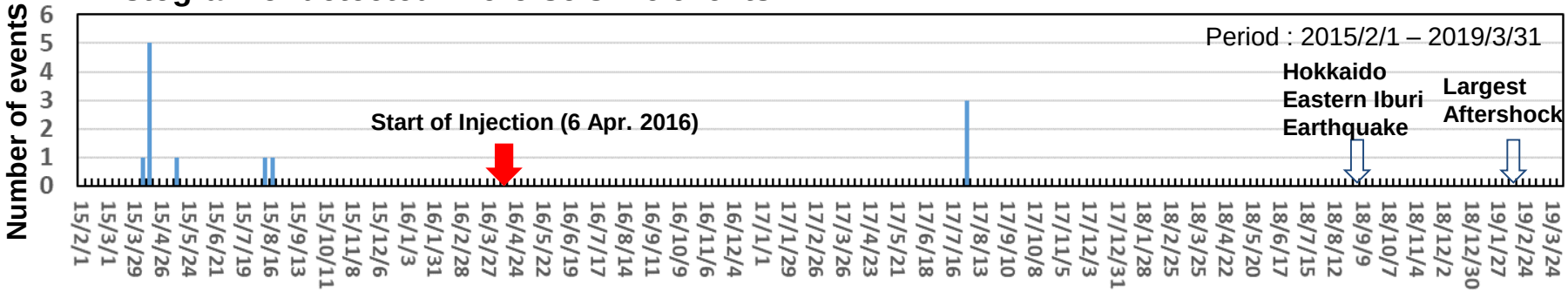
Before Injection period

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

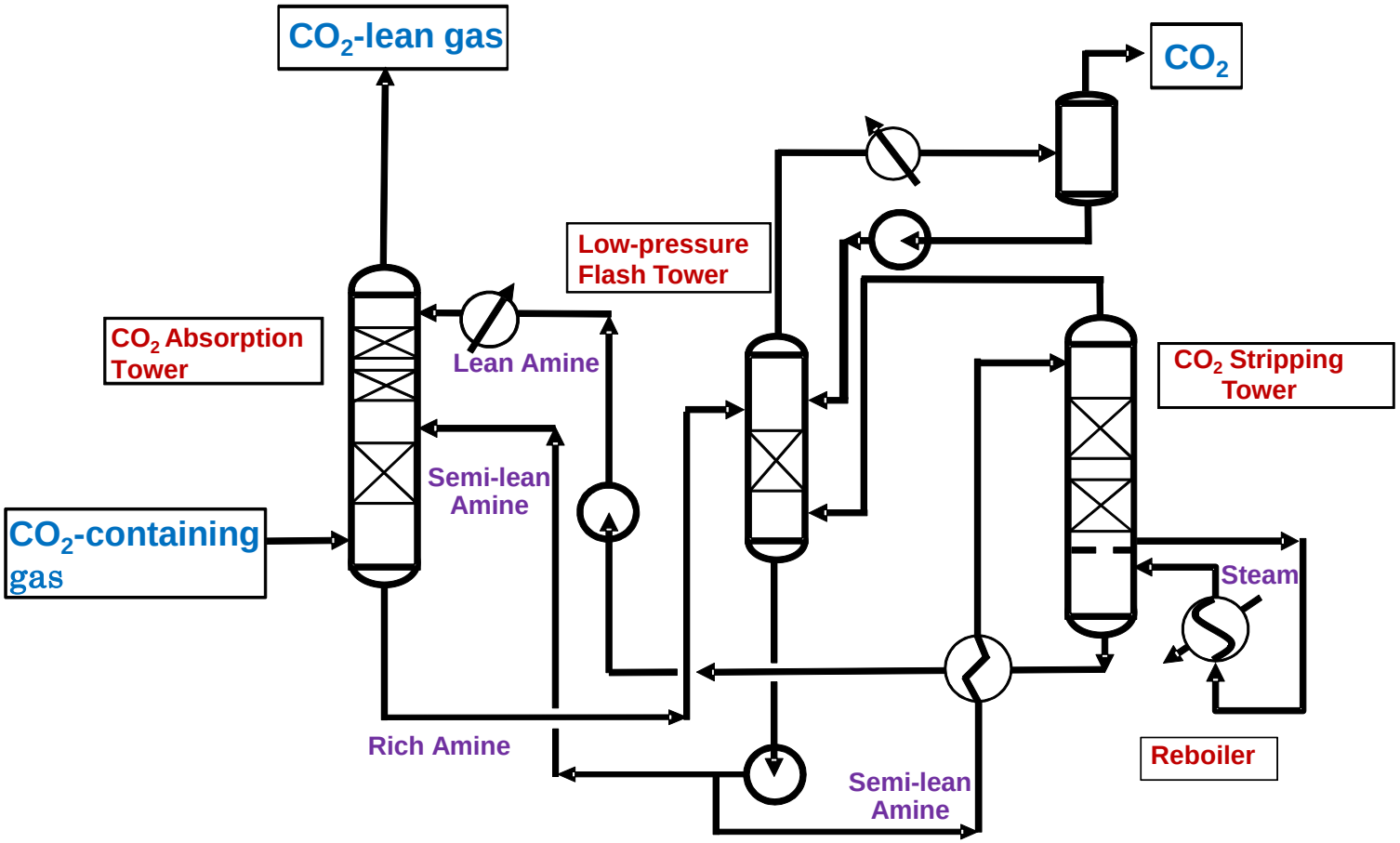
1. No relationship between CO_2 injection and earthquake
2. No CO_2 leakage

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%):

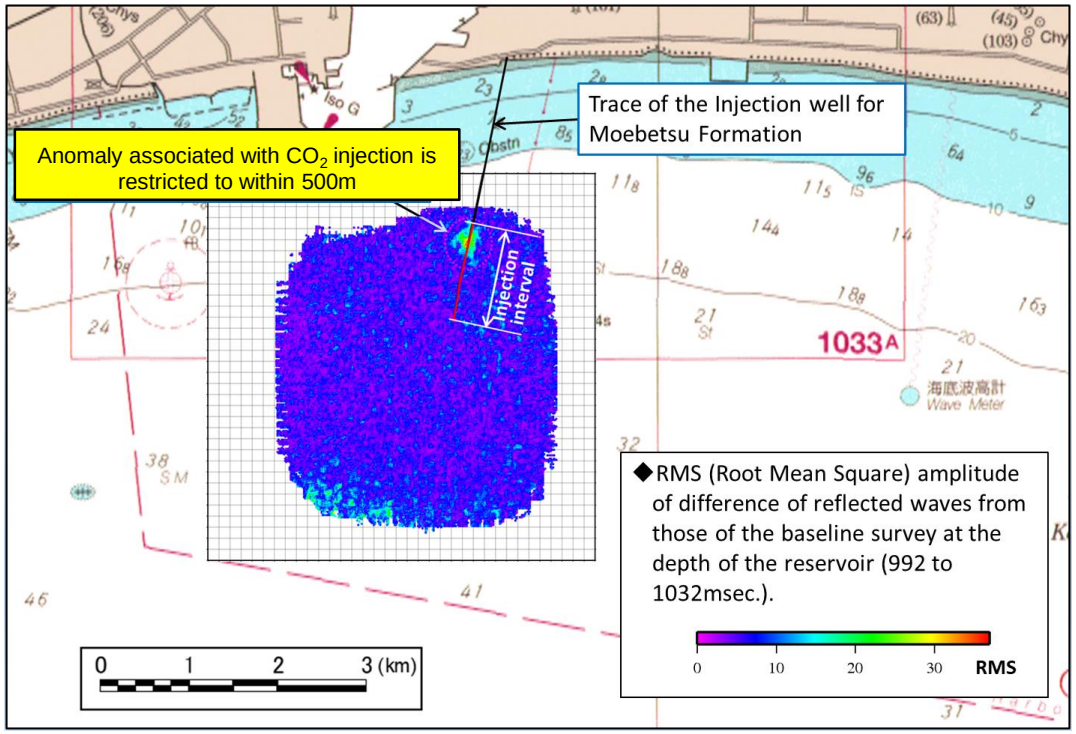
- Reduced flow rate of semi-lean amine solution and steam to CO_2 Stripping Tower
- Maintained flow rate of semi-lean amine solution to CO_2 Absorption Tower

5. Results of Monitor 3D seismic Survey

Results of Monitor 3D Seismic Survey

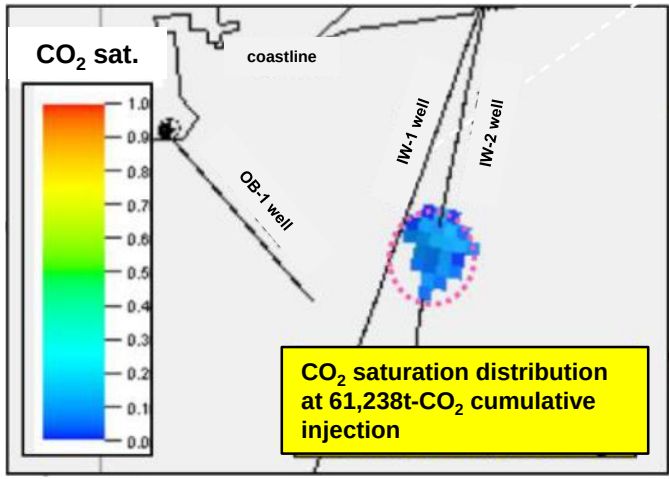
◆ The first monitor 3D seismic survey at cumulative CO_2 injection of 61,000 to 69,000 tonnes into the Moebetsu Formation detected a clear anomaly along the injection interval, matching simulation results

Result of first monitor 3D survey



Plotted on Japan Coast Guard Nautical Chart

CO_2 saturation prediction by simulation technique



6. International Activities

JCCS International Activities

CSLF: Ministerial-level international climate change initiative with 26 CSLF member governments (25 countries plus European Commission) for the development of improved cost-effective technologies for CCS.

2016 Annual Meeting, Tokyo（Oct. 2016)

- **Tomakomai Project was formally certified as a “CSLF-Recognized Project”.**
- **JCCS was nominated Asia-Pacific regional champion for stakeholder engagement and activated collaborative efforts with stakeholders in region.**

Field trip for CSLF delegates

Certificate award ceremony

Certificate

GoMCarb: A regional initiative focusing on the assessment of offshore (sub-seafloor) geologic carbon storage beneath the Gulf of Mexico

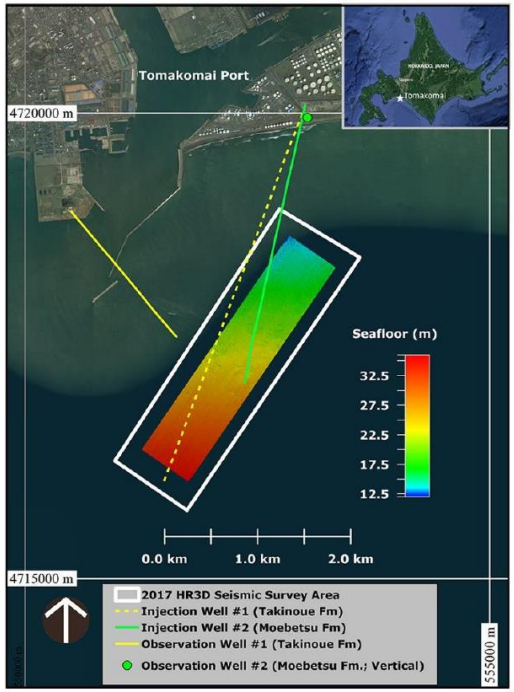
GoMCarb Partnership Meeting, Beaumont, Texas (Feb.2019）

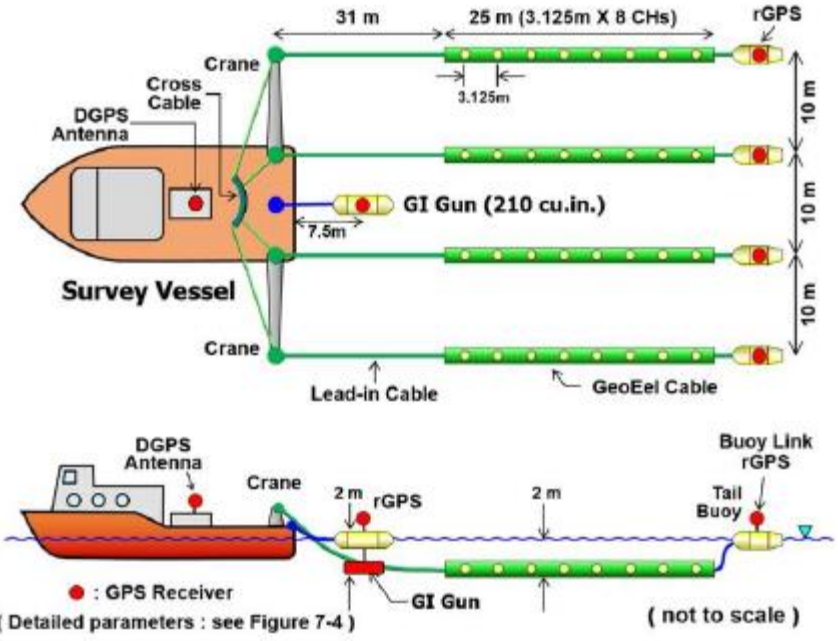
- **JCCS was appointed to serve on the Advisory Committee of the Gulf of Mexico Partnership for Offshore Carbon Storage (GoMCarb)**

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

Ultra High Resolution 3D Seismic Acquisition at Tomakomai

- 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 UHR3D marine seismic data acquisition.
- In August 2017, University of Texas conducted acquisition of UHR3D seismic data at Tomakomai CCS Demonstration Project site.





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)

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
- CO_2 injection is progressing smoothly, with cumulative injection at 255,635 tonnes (as of 23rd May 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.