Tomakomai CCS Demonstration Project

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and
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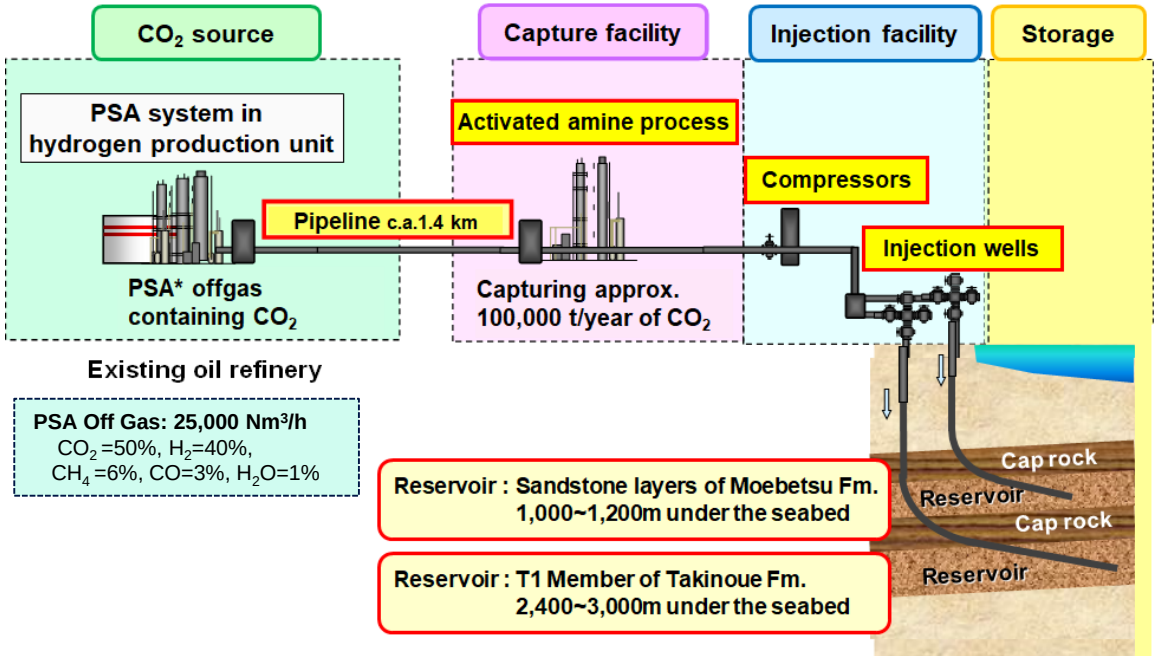
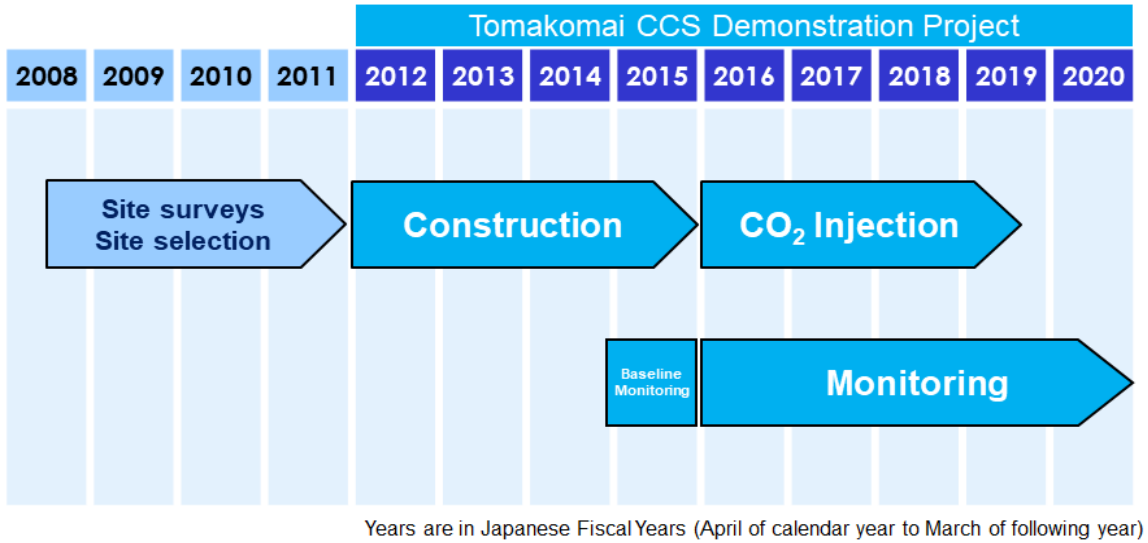
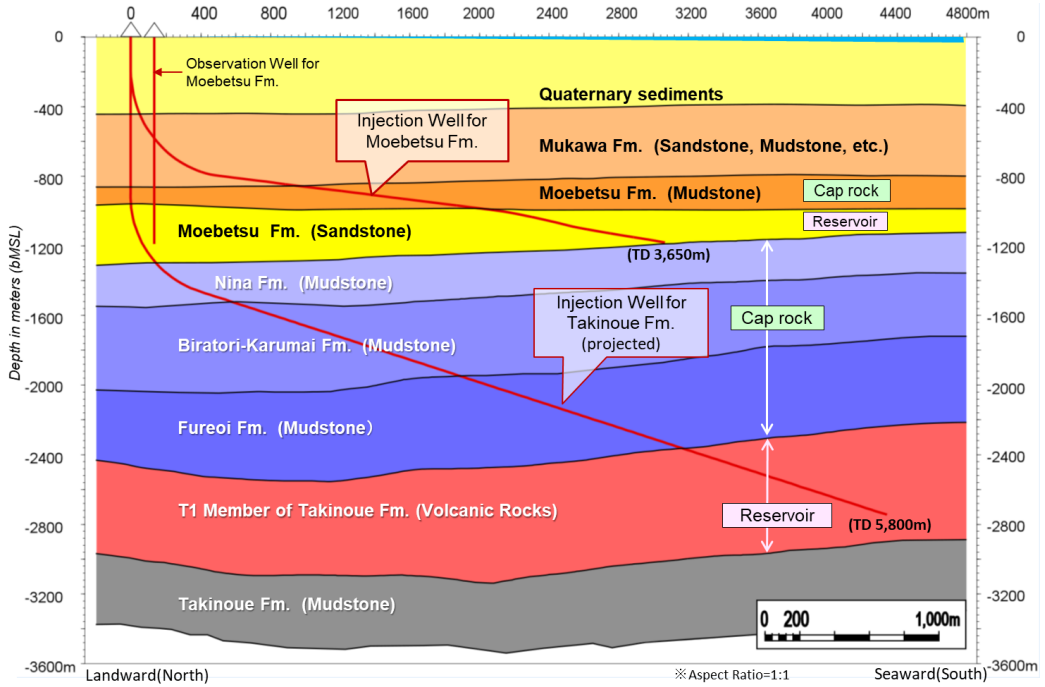
Scheme / Schedule of Tomakomai CCS Demonstration Project





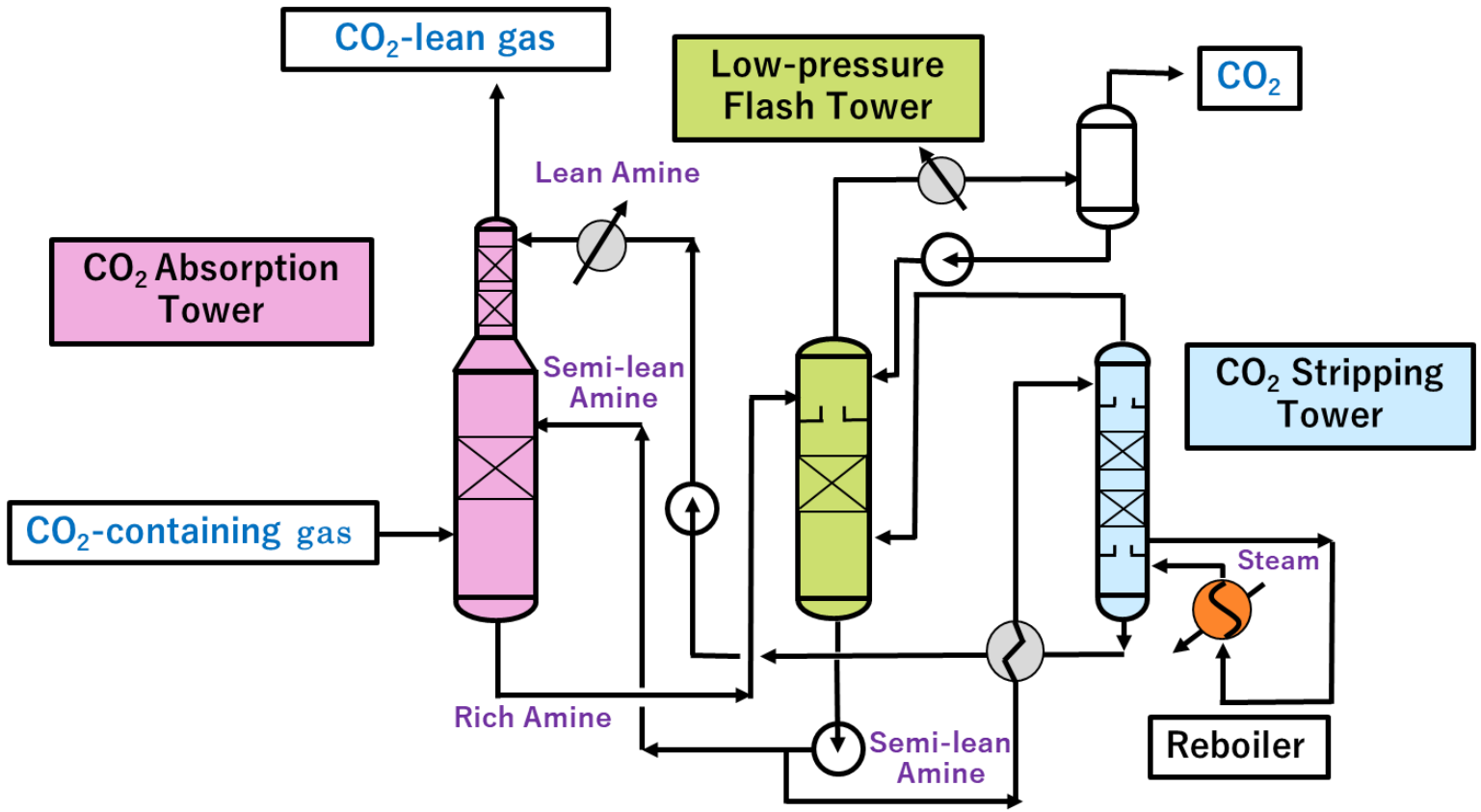
Years are in Japanese Fiscal Years (April of calendar year to March of following year)



Schematic Cross Section

- First full-chain CCS system in Japan from CO_2 capture to storage
- Unique onshore-to-offshore CO_2 injection scheme
- Target of 300,000 tonnes of CO_2 injection achieved on November 22, 2019
- Monitoring operations are being continued

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
- Major part of semi-lean amine solution from LPFT is returned to CO_2 Absorption Tower for CO_2 absorption; as only the remaining minor part of semi-lean amine solution is sent to CO_2 Stripping Tower, reboiler heat required can be reduced

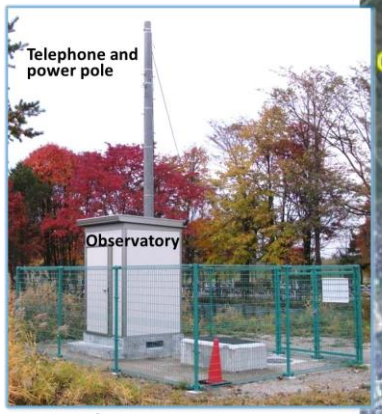
Loading Factor:98% (100%=25.3 t-CO_2/h)

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

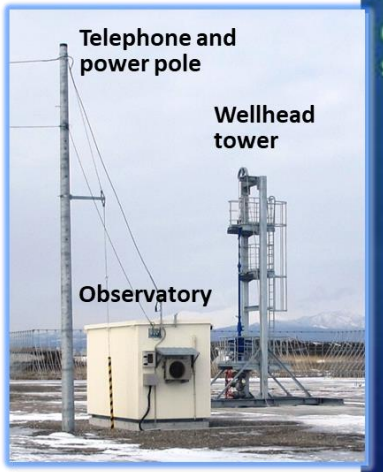
Note 1) : Reboiler duty/steam boiler efficiency
Note 2) : Heat energy + Electric energy

Layout of Monitoring System

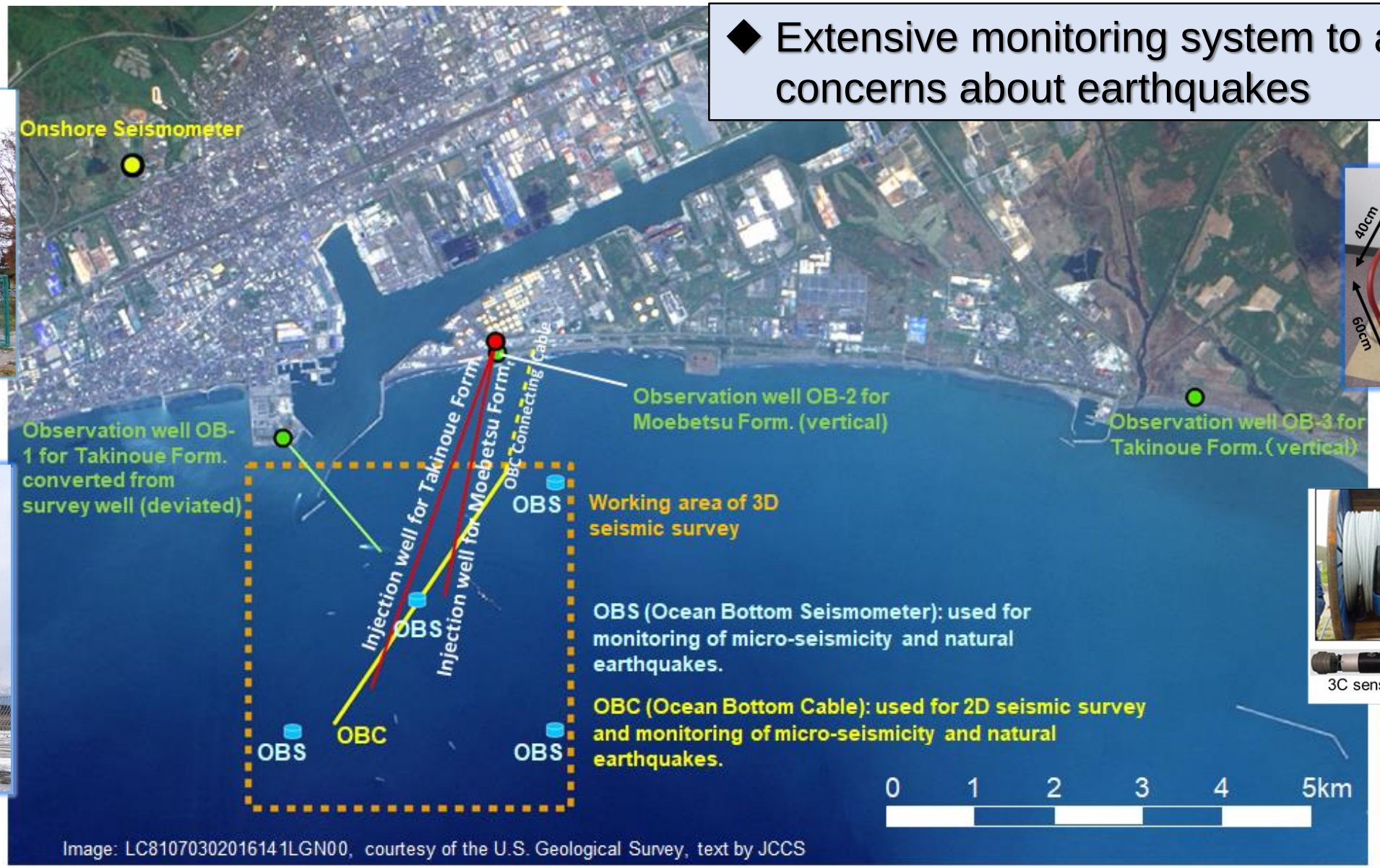
◆ Extensive monitoring system to address concerns about earthquakes



Onshore Seismic Station



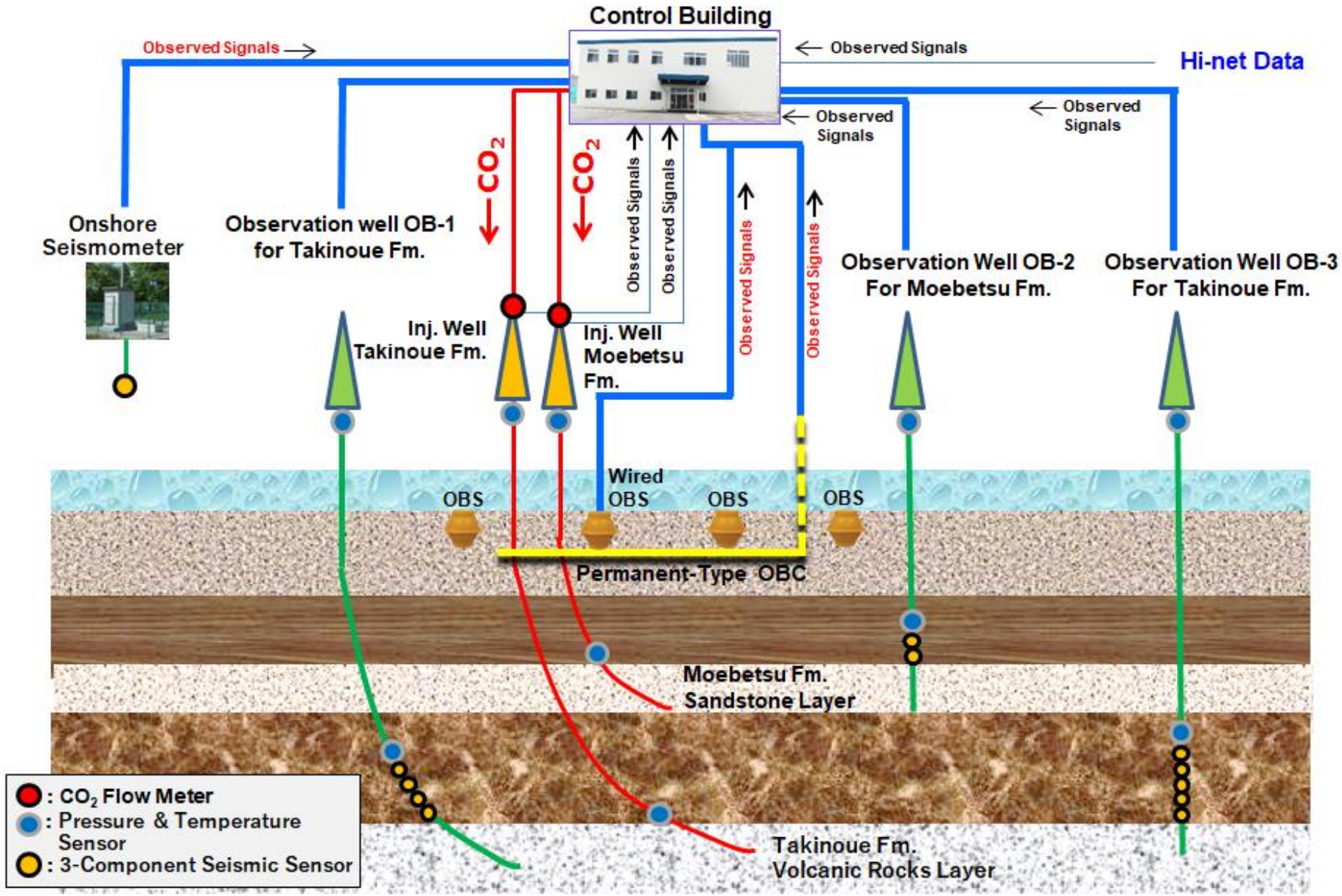
Observation well OB-1



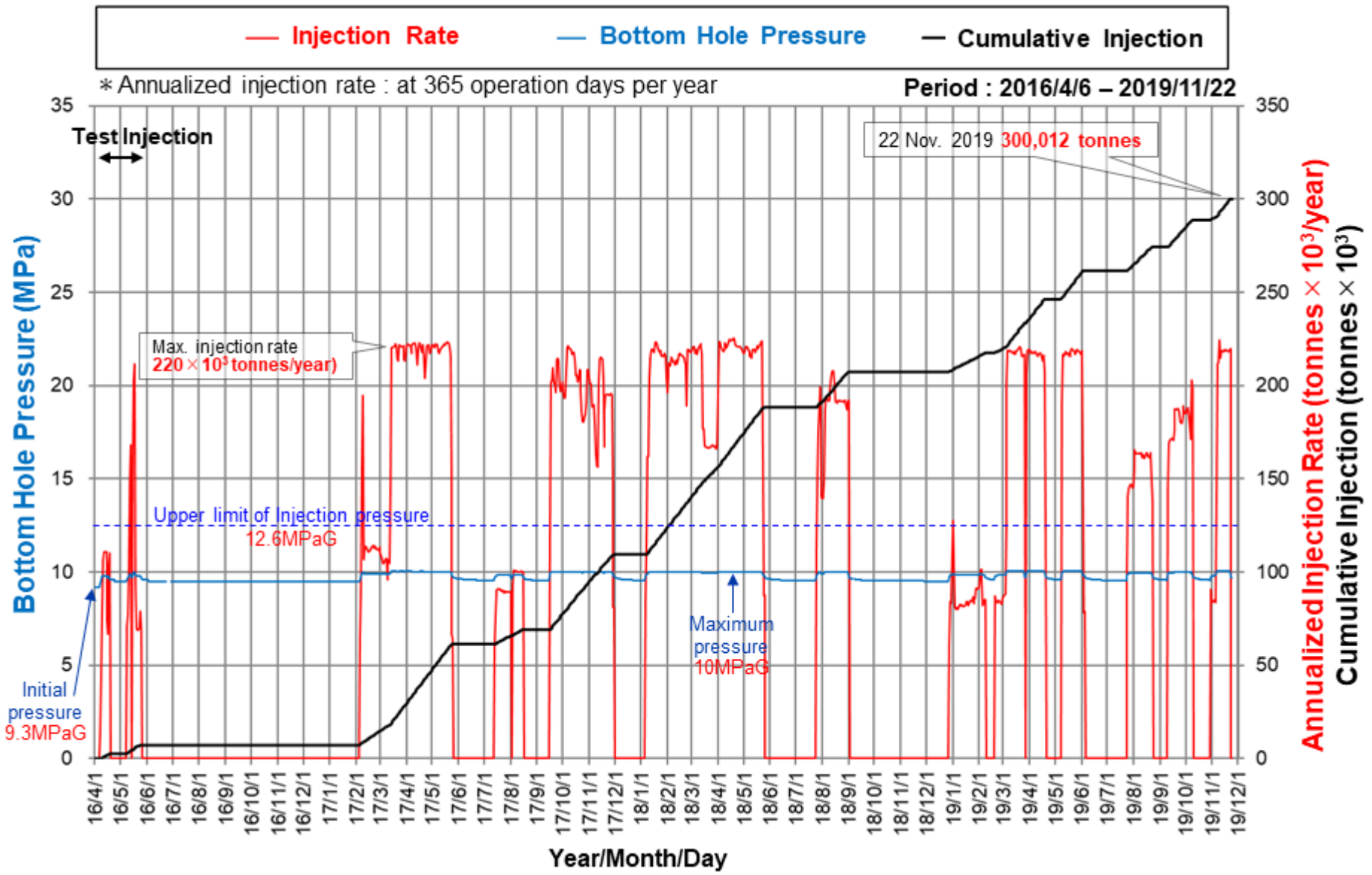
OBS

OBC

Schematic Diagram of Monitoring System



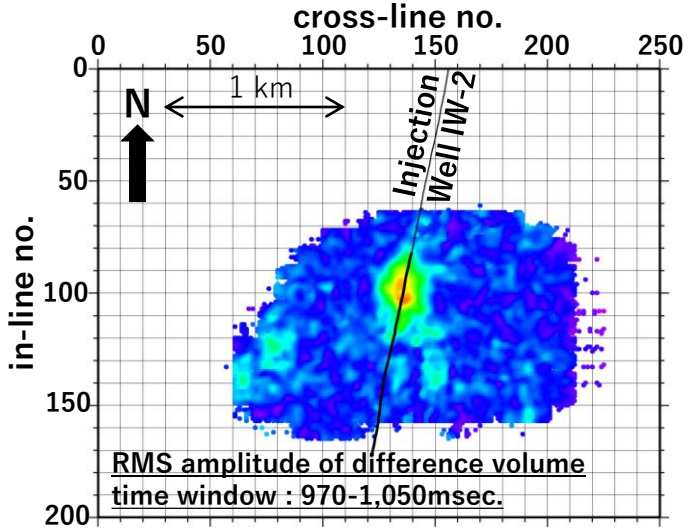
CO_2 Injection Record of Moebetsu Formation

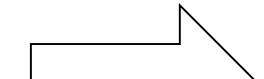


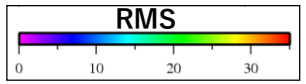
- Injection of 300,012 tonnes of CO_2 into Moebetsu Formation was achieved on Nov. 22, 2019
- Moebetsu Formation demonstrated superior injectivity
- Initial Pressure of Bottom Hole Pressure was 9.3MPaG
- Maximum Pressure of Bottom Hole Pressure was 10MPaG at maximum injection rate
- Maximum pressure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

Results of 2nd & 3rd monitor surveys

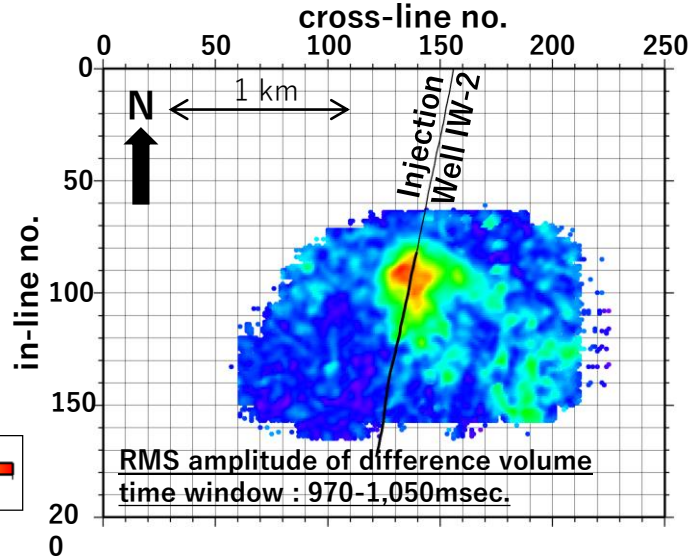
2nd monitor survey (61,239 - 69,070 tonnes; JFY2017)



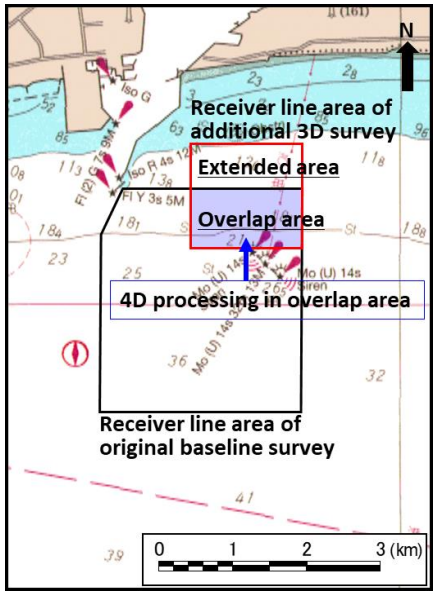




3rd monitor survey (207,209 tonnes; JFY2018)

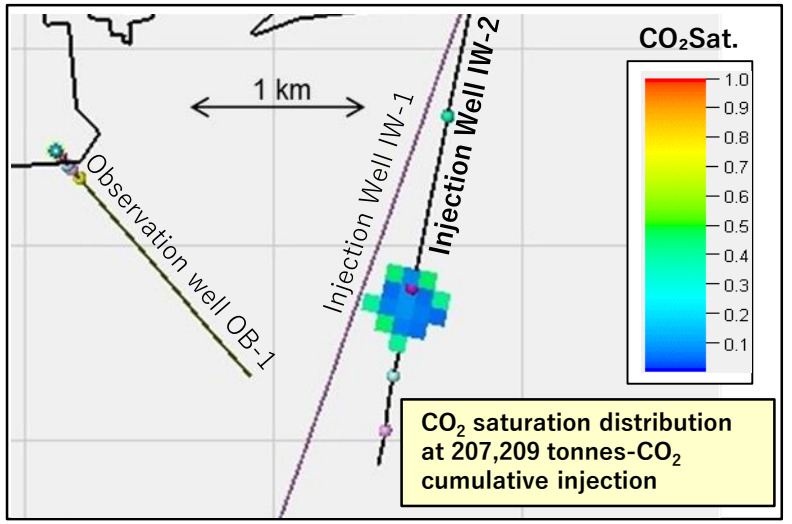


Receiver line area

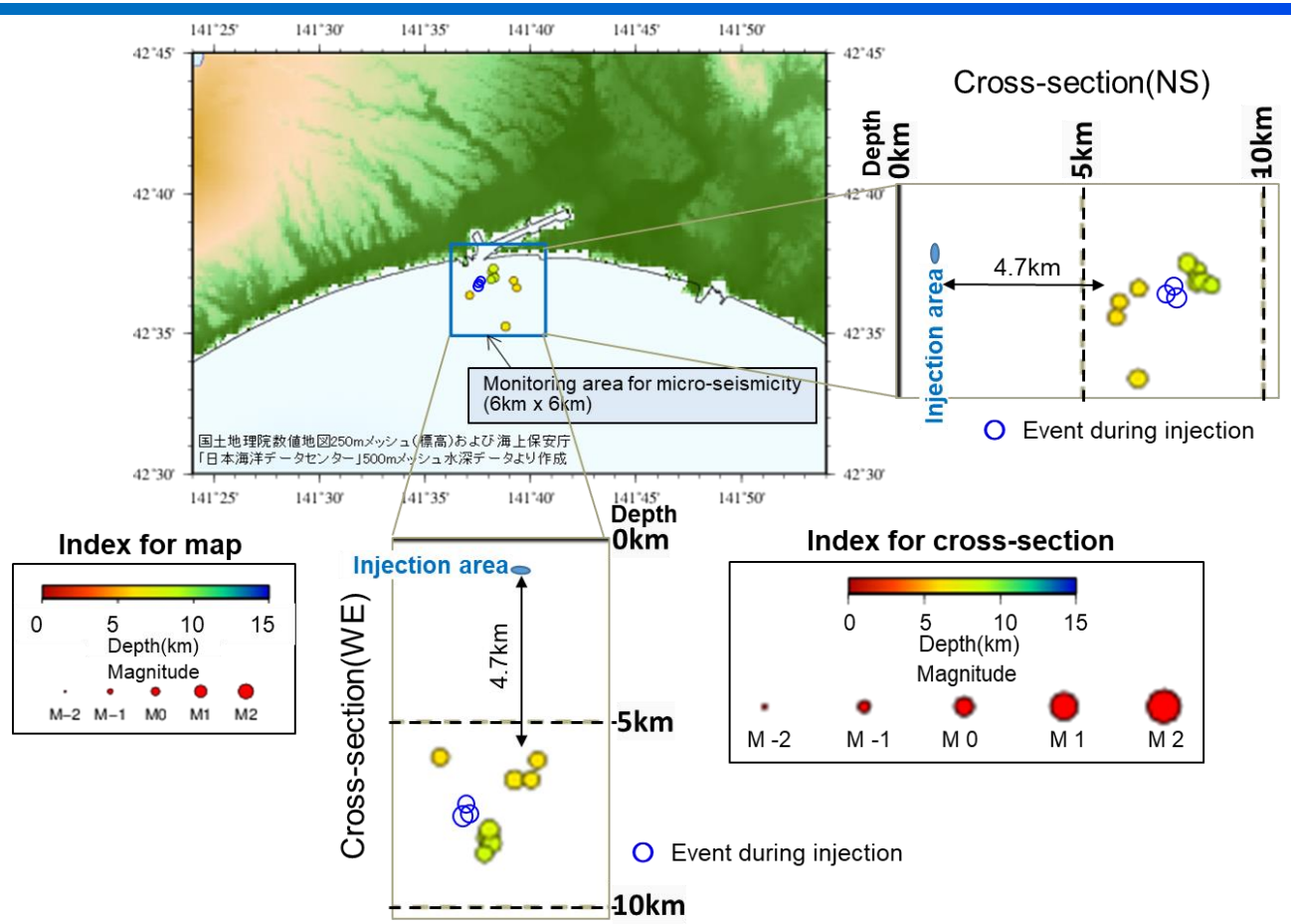


※As only the overlapping portion of the 2009 Baseline Survey and Small-scale 3D Baseline Survey was utilized, the S/N ratio, particularly the peripheral area is low, and the accuracy of the difference calculation is low.

CO_2 saturation prediction by 2018 reservoir model



Results of micro-seismicity monitoring



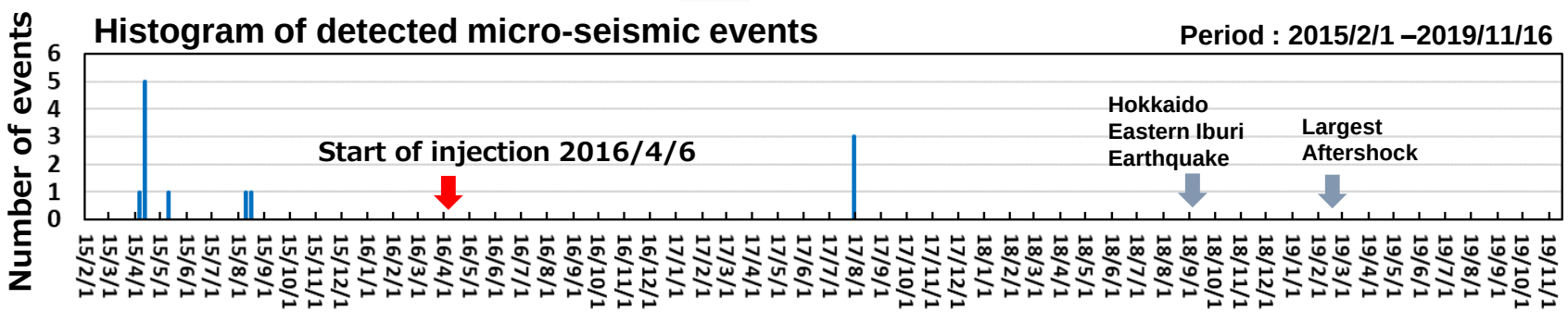
◆ **No micro-seismicity (magnitude > -0.5) in/around the depth range of the reservoirs detected before and during injection**

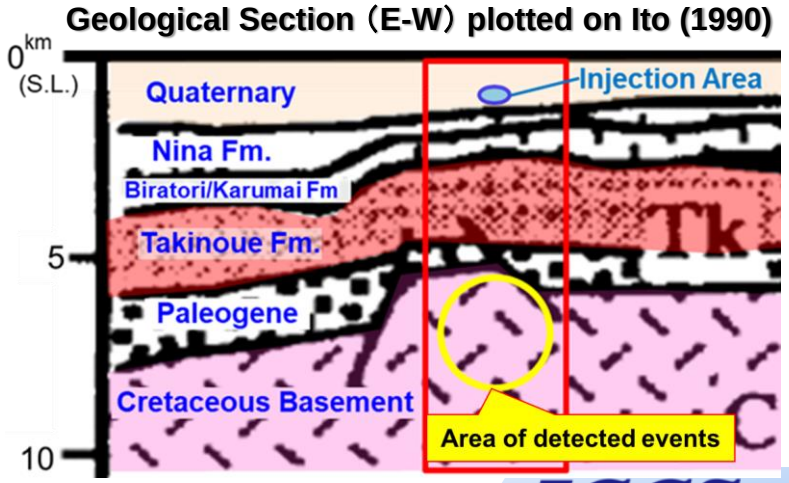
- Before Injection 2015/2/1-2016/4/5

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

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

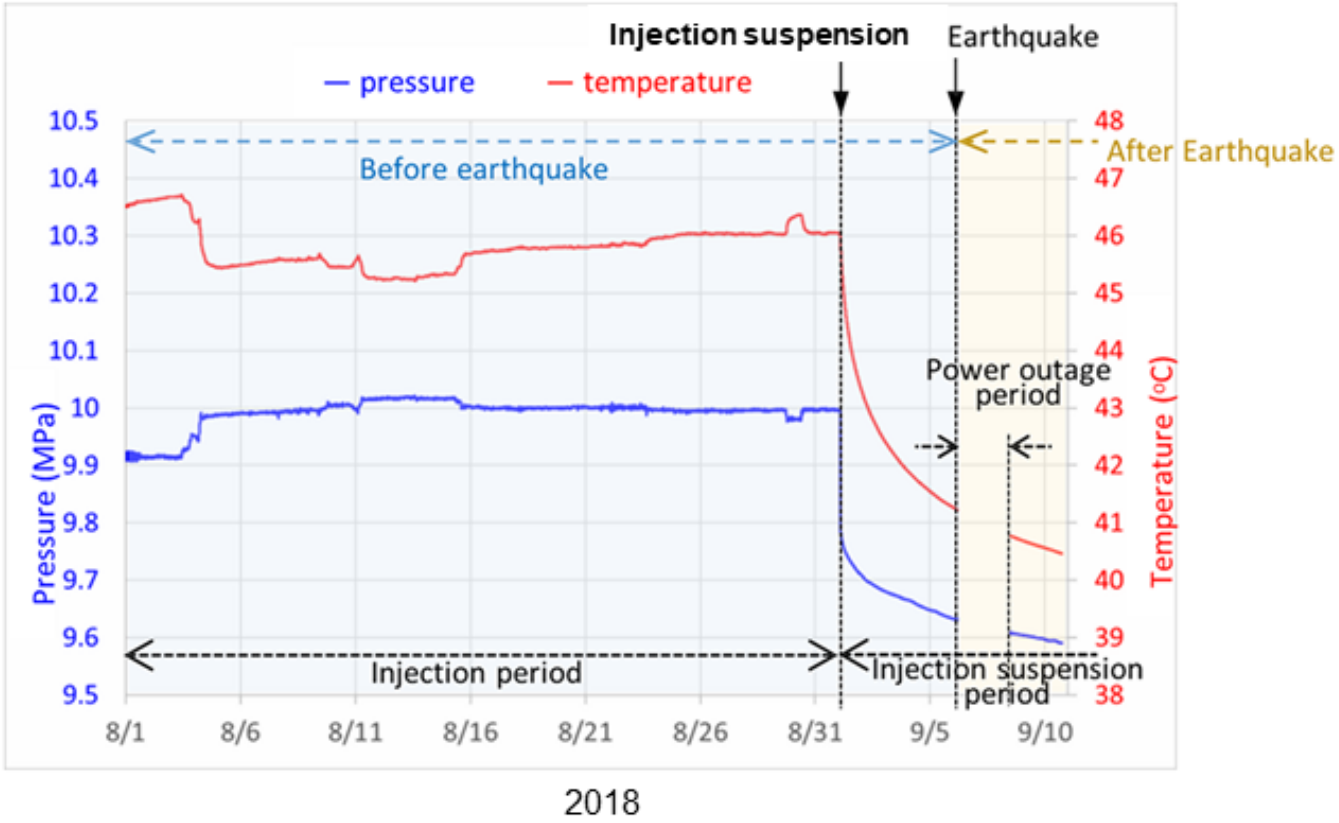
  Total 3 events(blue circle)
  Depth: 7.4km – 7.7km
  M: 0.31～0.52
  Date: Aug. 2, 2017





Hokkaido Eastern Iburi Earthquake: no effect on CO_2 injected reservoir

- Magnitude 6.7 earthquake 30km from site in Sept. 2018 did not affect bottom hole pressure, temperature.
- Expert review found that CO_2 injection area in sedimentary layer is isolated from hypocenter in basement rock, stress change caused by CO_2 injection at hypocenter was negligible, no abnormality of CO_2 reservoir was caused by earthquake, and no leakage of CO_2 was observed.



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 a 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, anomaly detected
- Concerns about earthquakes and induced seismicity have been addressed
  - Natural earthquakes have not caused any damage to reservoirs
  - No seismicity (magnitude > -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/

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).