

Update on Nagaoka CO2 Storage Project

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Contents

- **Project Overview**
- **Well-based CO₂ Monitoring**
- **Site Safety Assessment in the wake of Two Large Earthquakes**

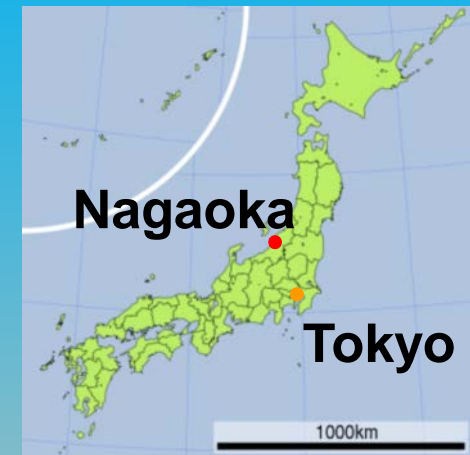
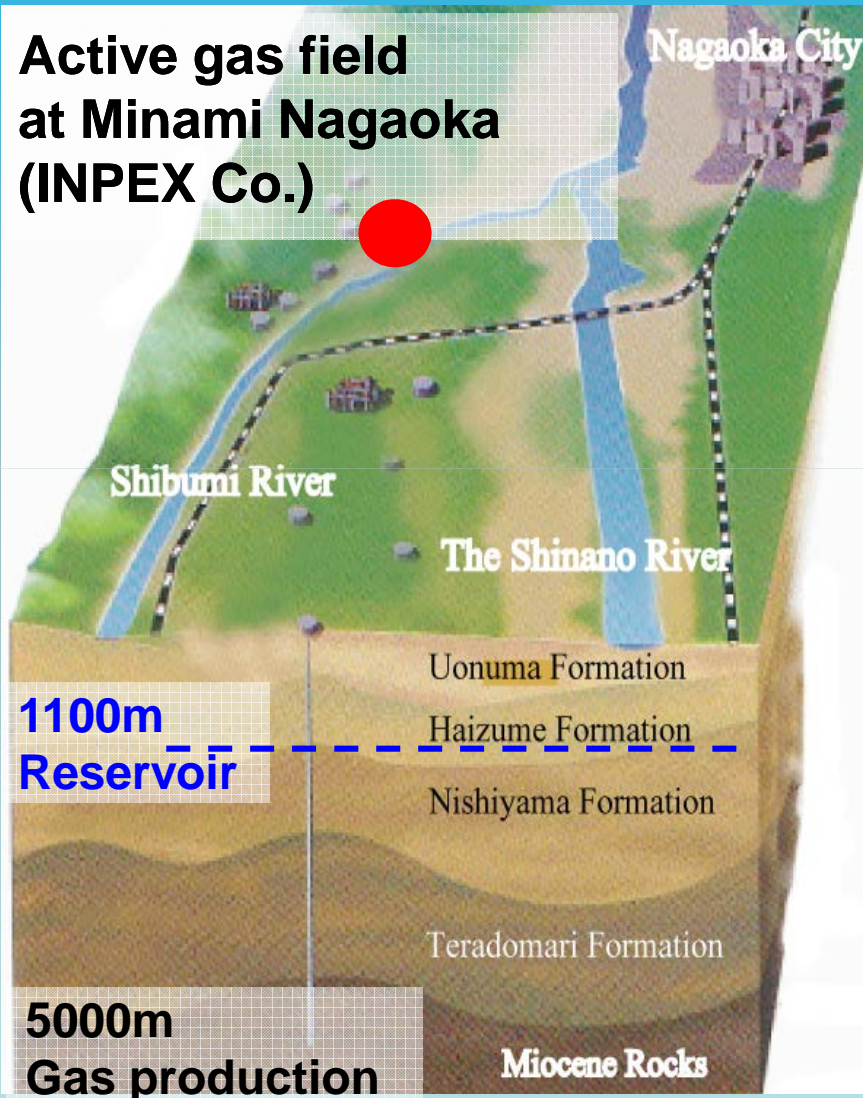
Contents

➤ Project Overview

➤ Well-based CO₂ Monitoring

➤ Site Safety Assessment in the wake of Two Large Earthquakes

Site Selection



Geological Factors

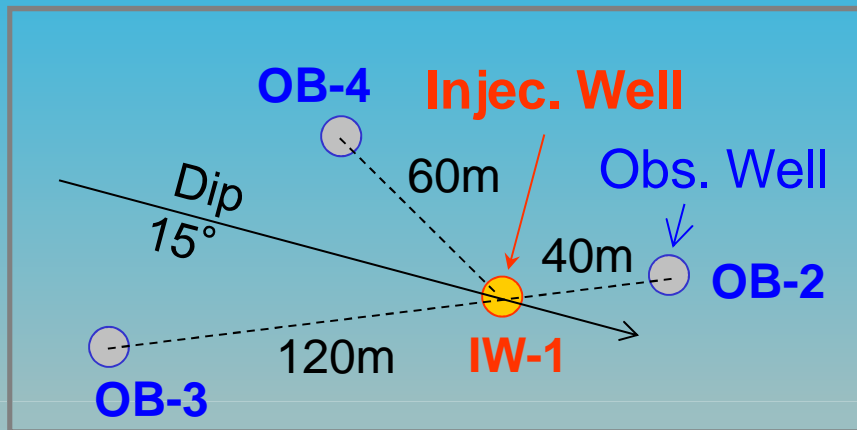
- Continuity of cap rock
- Gentle tilted reservoir
- Depth (800-1200m),
- Thickness (>10m)
- No faults within 1.5km²
- Details data for subsurface

Operational Factors

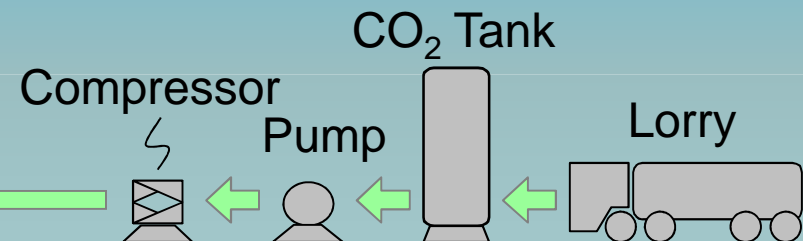
Social Acceptance, Well yard etc.

Overview of the Nagaoka Project

Well Configuration at the Reservoir Depth



- Injec. Period; Jul. 2003~Jan. 2005
- Total amount; 10,400 ton CO₂
- Rate; 20~40 ton/day



- Reservoir; Haizume Formation (Pleistocene Sand)
- Injec. Layer; Zone 2, 12m-thick
- Porosity; 23%
- Permeability; ave. 7mD (Pump-test)
- Conditions; 48°C, 11MPa

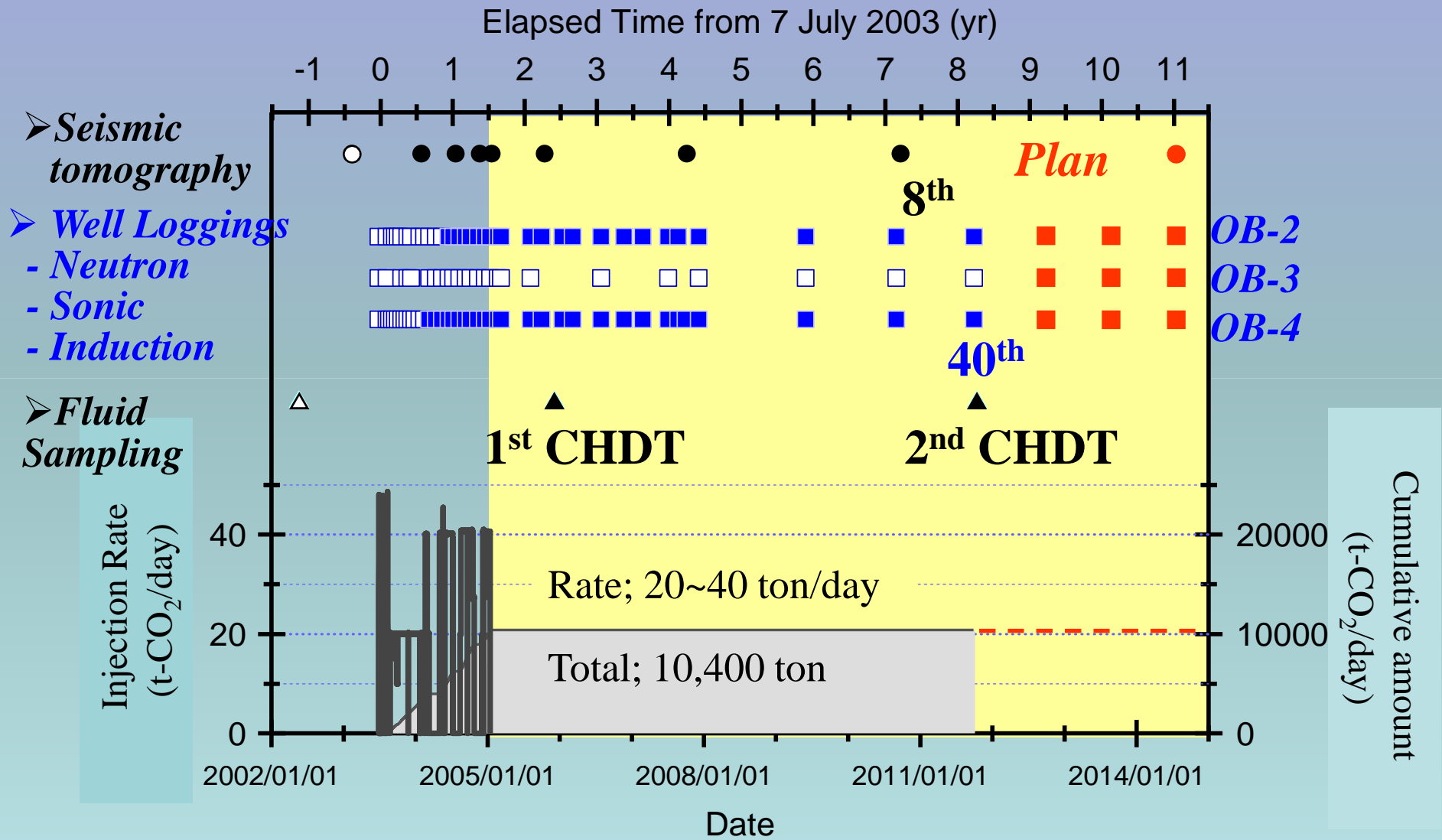
Contents

➤ Project Overview

➤ **Well-based CO₂ Monitoring**

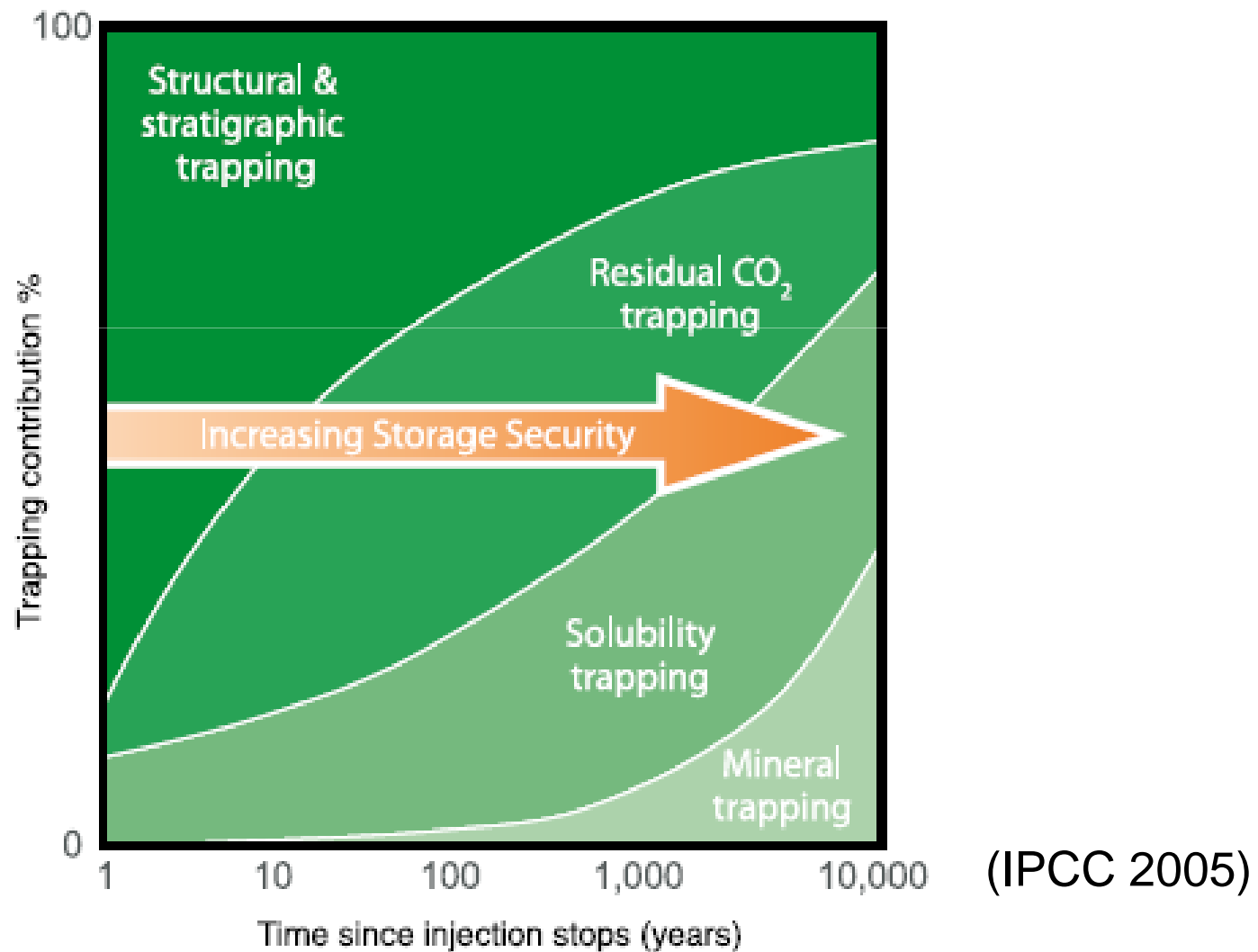
➤ Site Safety Assessment in the
wake of Two Large Earthquakes

Monitoring



Trapping Mechanisms in Nagaoka

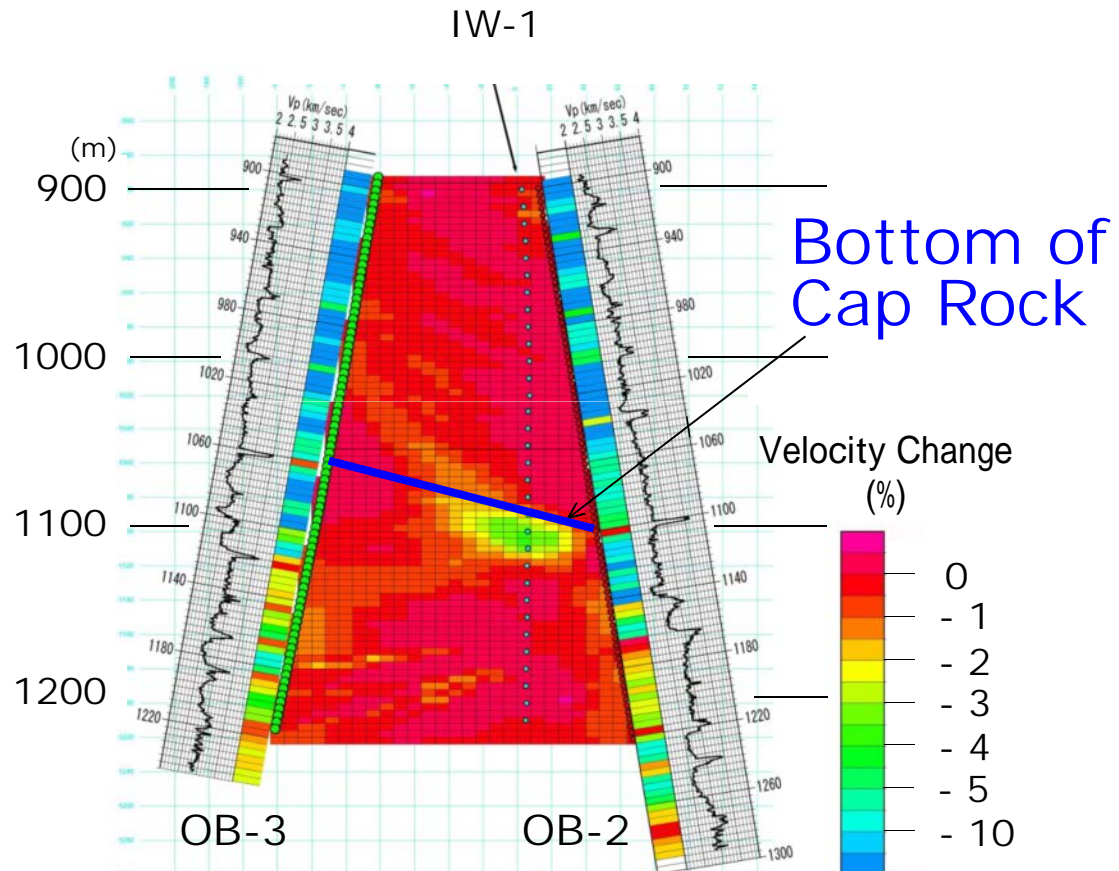
The Nagaoka Project is likely to have already experienced the four trapping mechanisms only in seven years.



Structural Trapping

Seismic tomography → structurally trapped by cap rock

Post-Injection:
10,400t-CO₂

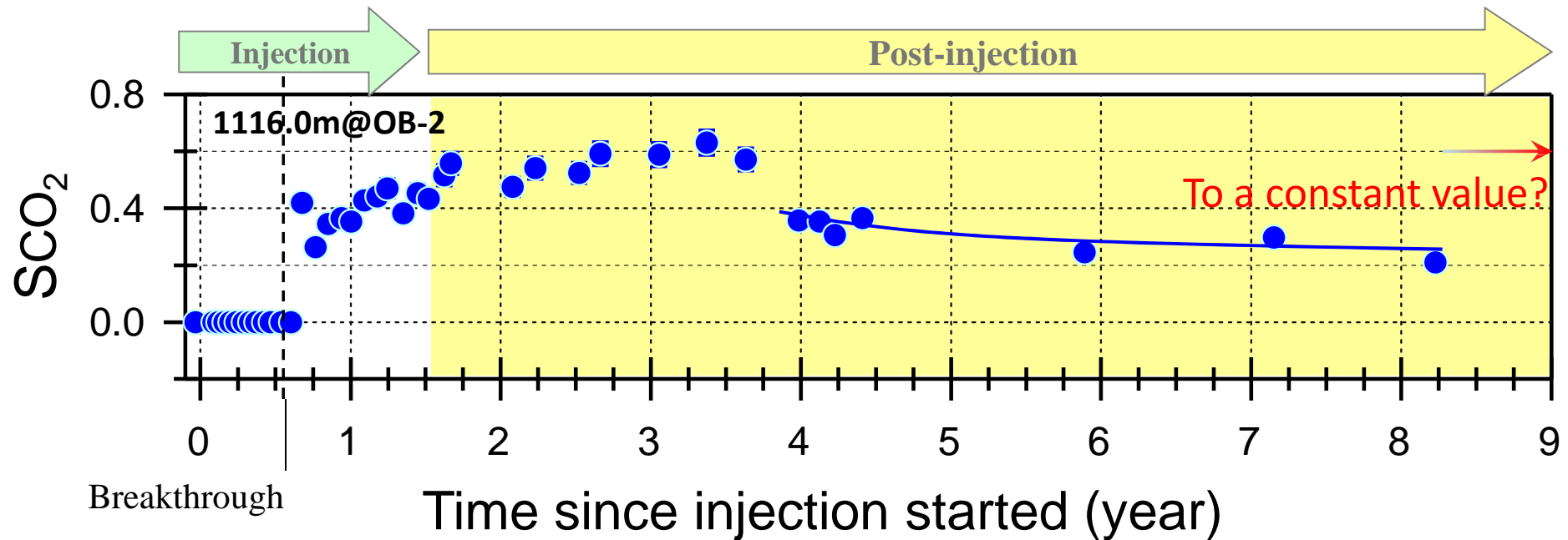


Max. Velocity Change = -3.5%

$$\text{Velocity Change} = (V_{MS4} - V_{BLS}) / V_{BLS}$$

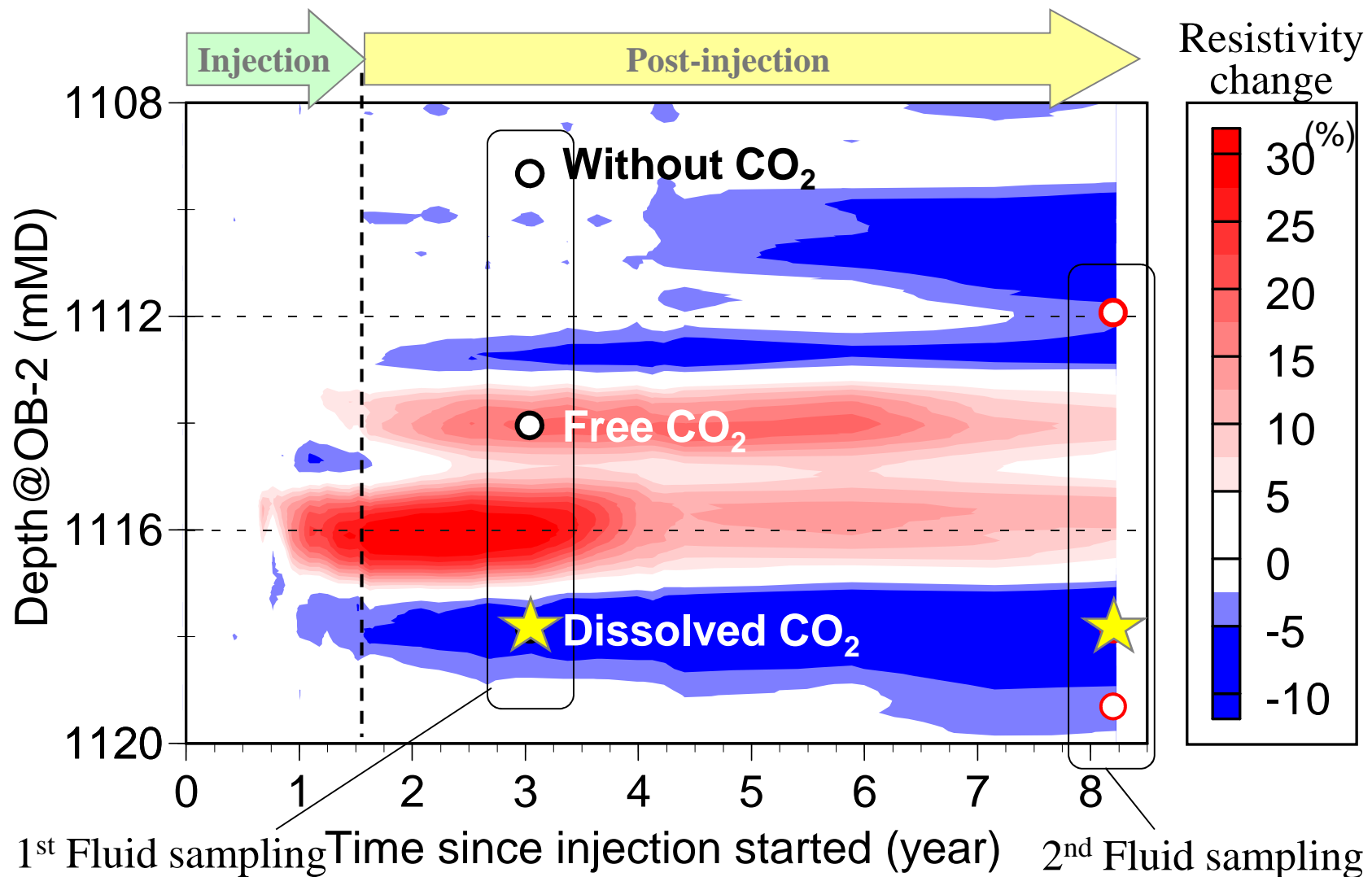
Residual CO₂ Trapping

CO₂ saturation data converging with a constant value
➔ residual gas trapping?



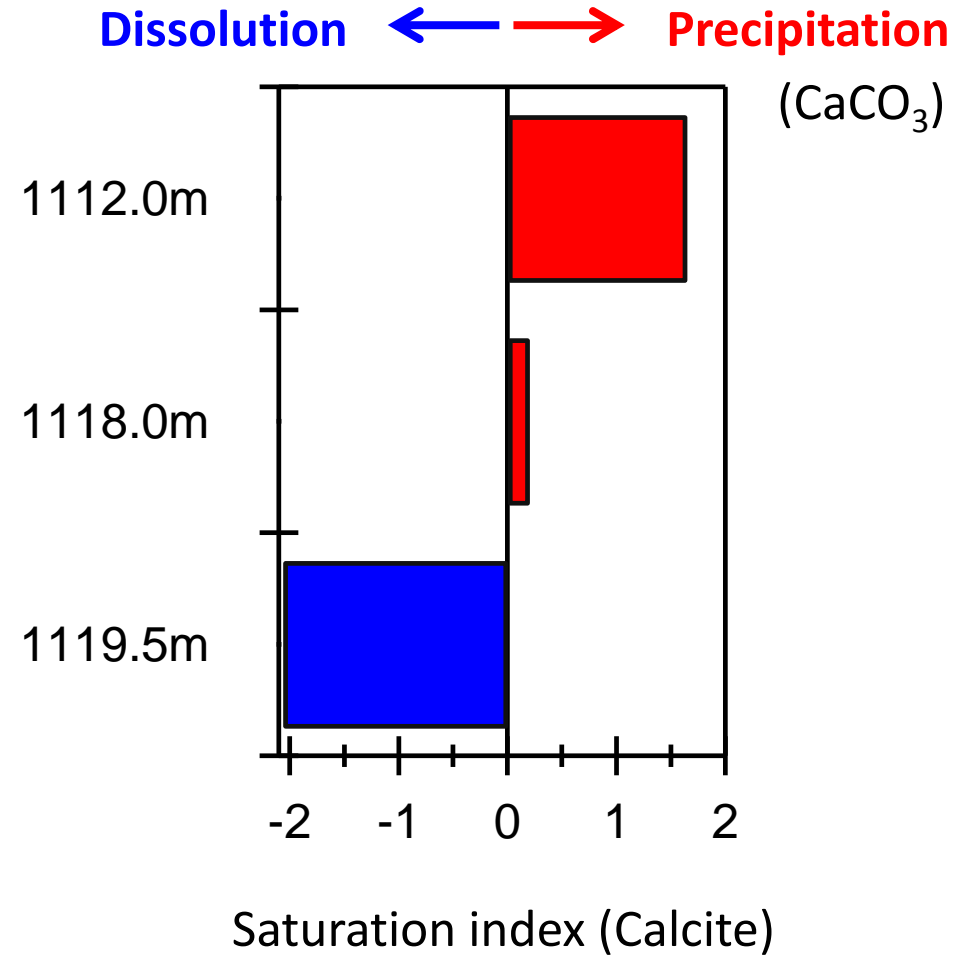
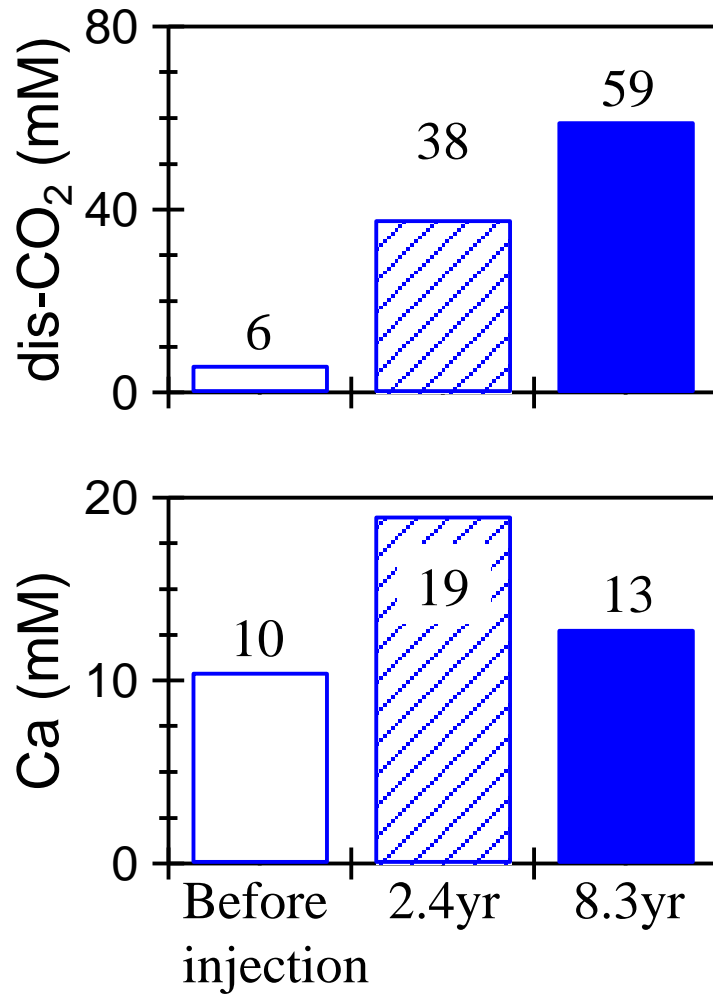
Solubility Trapping

Negative change in resistivity → solubility trapping



Mineral Trapping

Fluid Analyses → Mineral Trapping?



Contents

➤ Project Overview

➤ Well-based CO₂ Monitoring

➤ **Site Safety Assessment in the
wake of Two Large Earthquakes**

Great Earthquakes hit Nagaoka

A large earthquake occurred close to the site during the Injection

(Accumulated CO₂ amounts: 8,950t)

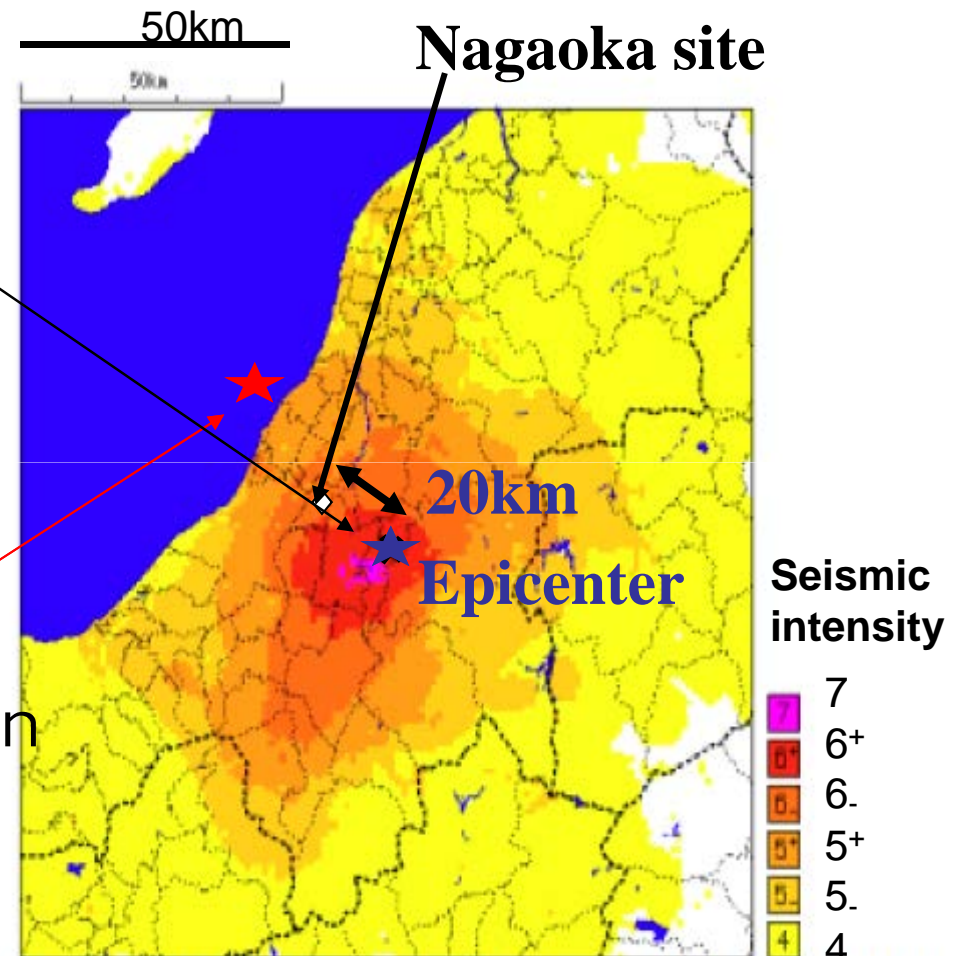
Niigata Chuetsu Earthquake

- Main shock: 23 Oct 2004
- M6.8 at 13km depth

Another earthquake occurred after the Injection

Niigata Chuetsu-oki Earthquake

- 16 July 2007
- M6.8 at 17km depth



(GSJ, 2004 http://www.gsj.jp/jishin/chuetsu_1023/)

Field survey after the 2004 Earthquake (1)



Access Road
to the Site
Damaged



Surface around the
Wells Liquefied



Onsite CO₂ Detector
Detected No Leakage

Field survey after the 2004 Earthquake (2)

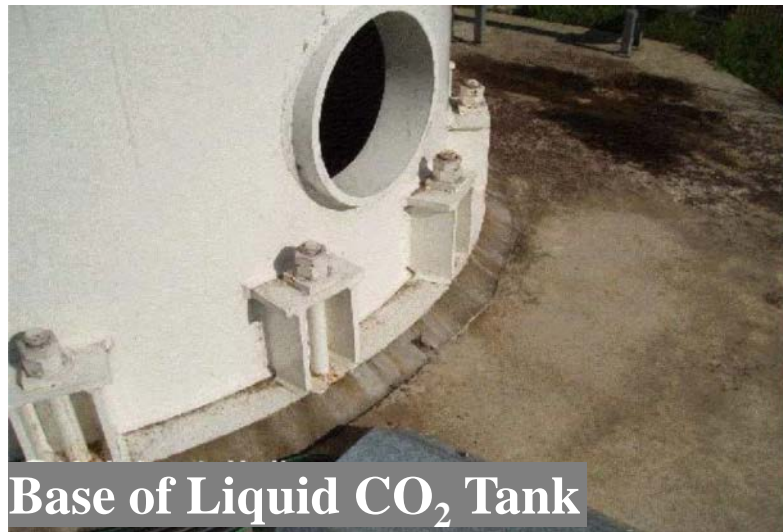
All facilities have no damage identified.



Liquid CO₂ Tank



Injection Well



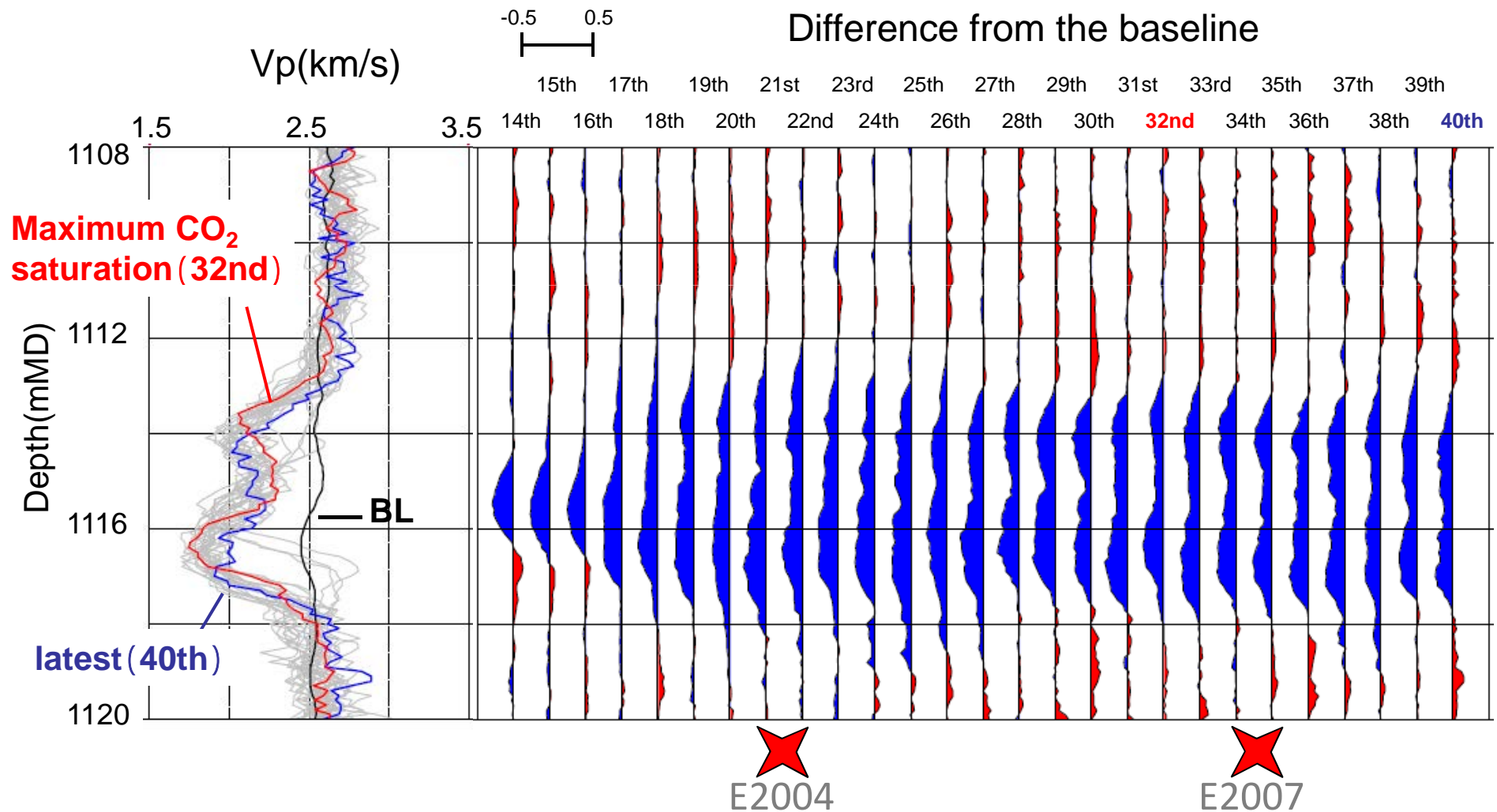
Base of Liquid CO₂ Tank



Observation Wells

Sonic Logging Data at Observation Well 2

Sonic logging data →
No irregular changes before and after the two earthquakes

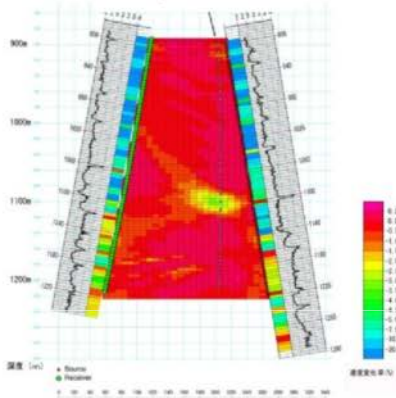


Seismic Tomography Data

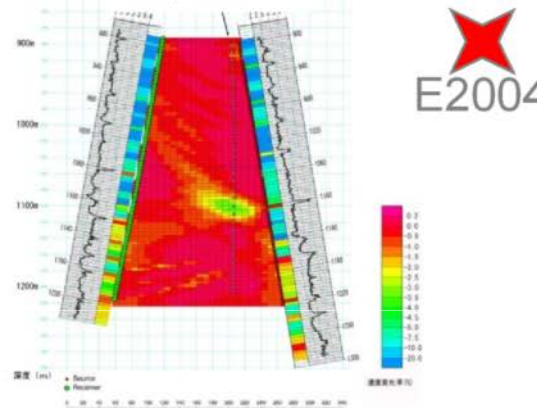
Seismic tomography data →

No irregular changes before and after the two earthquakes.

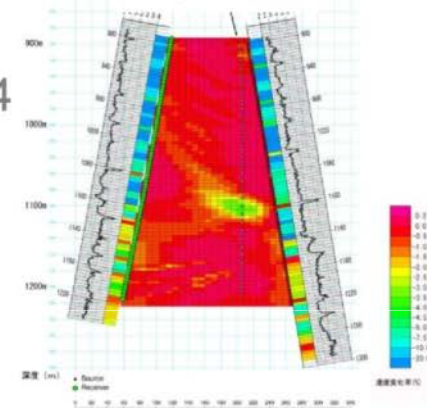
MS1/BL
3,200t



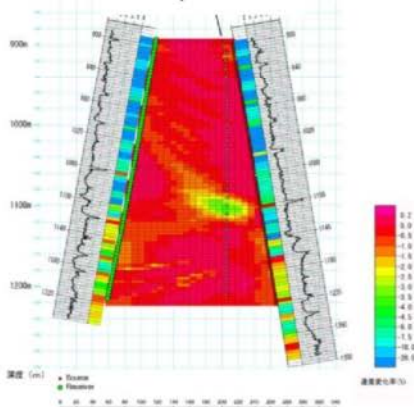
MS2/BL
6,200t



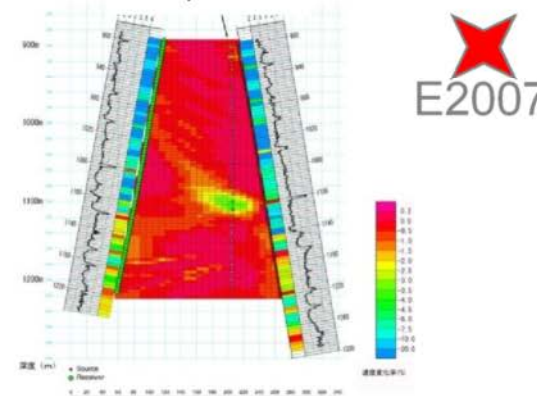
MS3/BL
8,900t



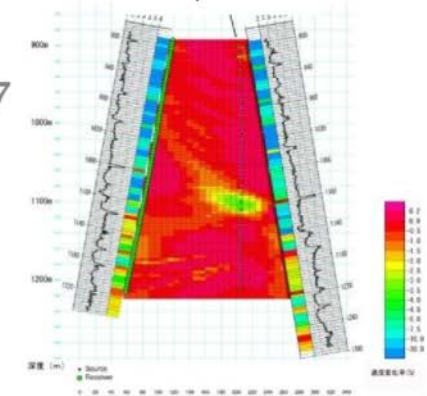
MS4/BL
10,400t



MS5/BL
10,400t



MS6/BL
10,400t



Summary

- All of the four trapping mechanisms are likely to have been observed in the Nagaoka Project. The project, therefore, has a high potential to contribute to advancing R&D on safety of CO₂ storage.
- The field surveys and monitoring data analyses in response to the two large earthquakes identified no sign of leakage from the reservoir and confirmed the safety of CO₂ storage in the Nagaoka Project.