CCS implementation in Japan

February 15th, 2007

Takashi Ohsumi

Research Institute of Innovative Technology for the Earth (RITE)

CCS context in Japan

1988: Investigations on “Direct Ocean Disposal of Carbon Dioxide” started in several laboratories in Japan

1990: Tanaka examined oversea EOR possibilities using CO_2 from Japan

1992: IEA/GHG talks on international ocean experiment of CO_2 injection held in London

1993: Tanana *et al.* ‘s work on estimation of potential capacity for CO_2 aquifer storage in Japan

1994: Japan’s initiative on the ocean experiment started

1996: start of Sleipner

1997: start of the international collaboration (NEDO/RITE) on CO_2 ocean experiment

2000: start of the Nagaoka project

Toward Implementation of CO_2 Geological Storage <AQUIFER>

1990: Tanaka examined oversea EOR possibilities using CO_2 from Japan

1992: Koide *et al.* examined world potential of CO_2 storage with a proposed novel concept of aquifer storage.

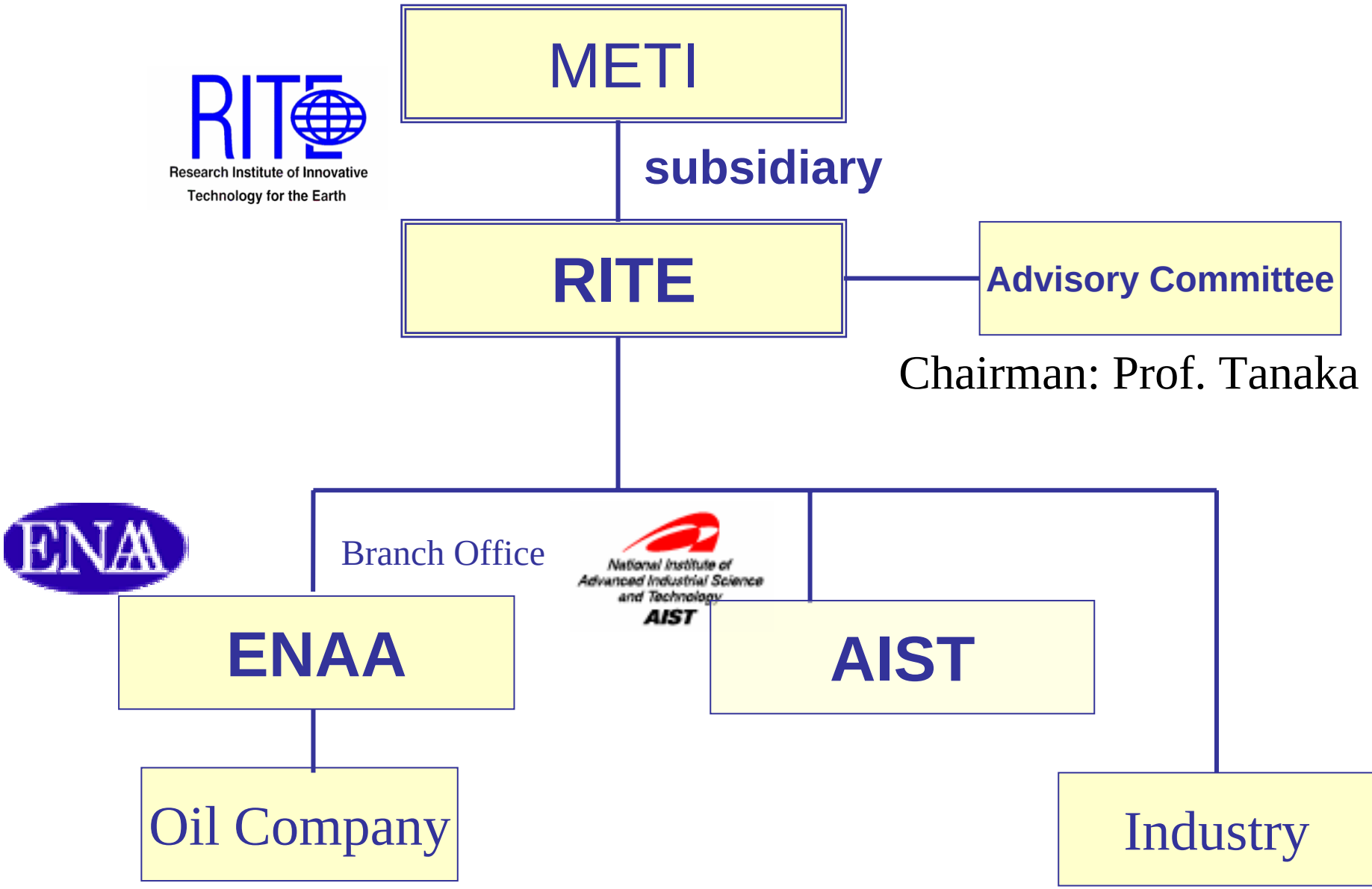
1993: At Oxford meeting, Olav Kaarstad talked to Ohsumi on Statoil's plan of SLEIPNER

1993: Tanaka *et al.* 's work on estimation of potential capacity for CO_2 aquifer storage in Japan.

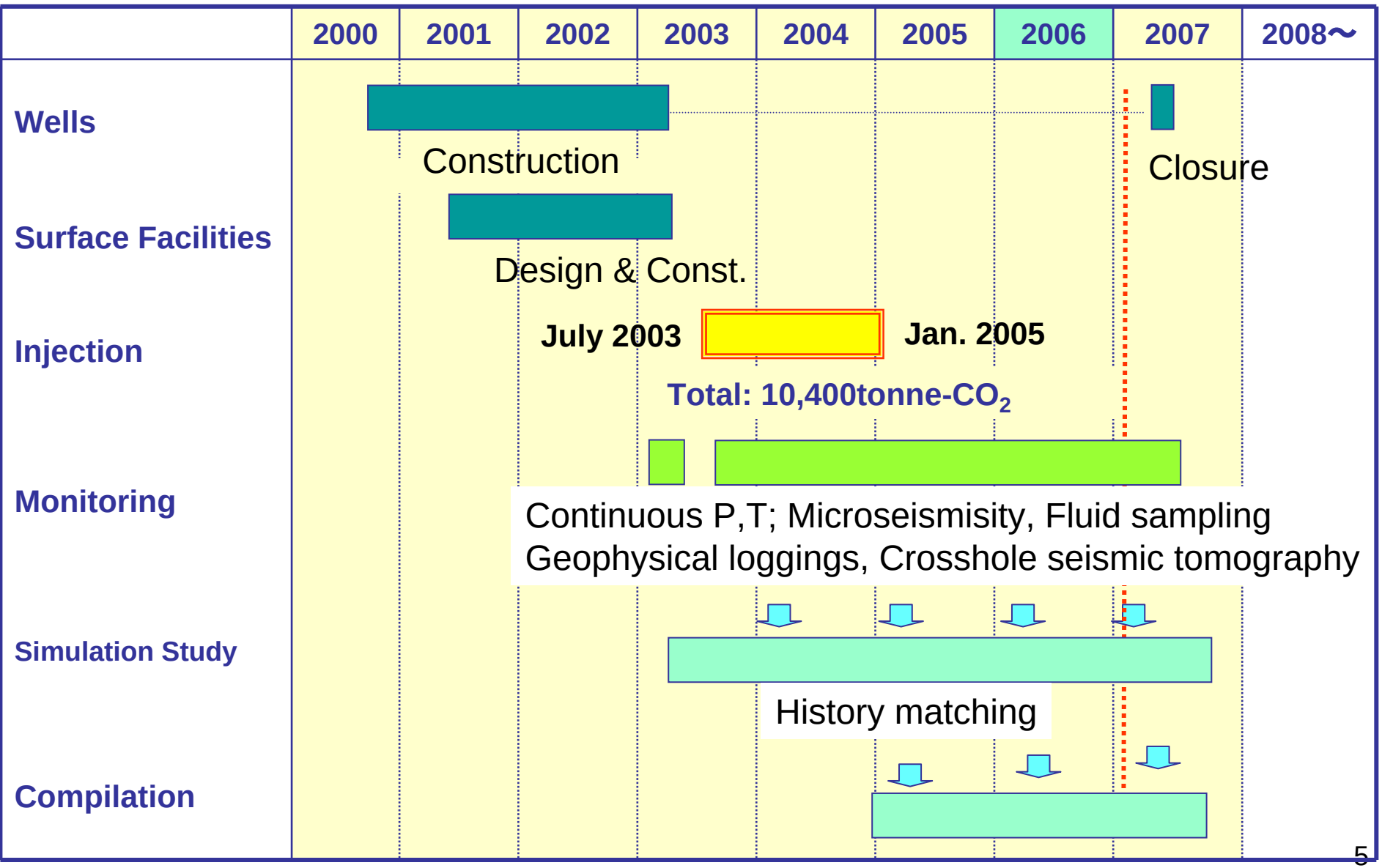
1996: start of Sleipner

2000: start of Nagaoka project

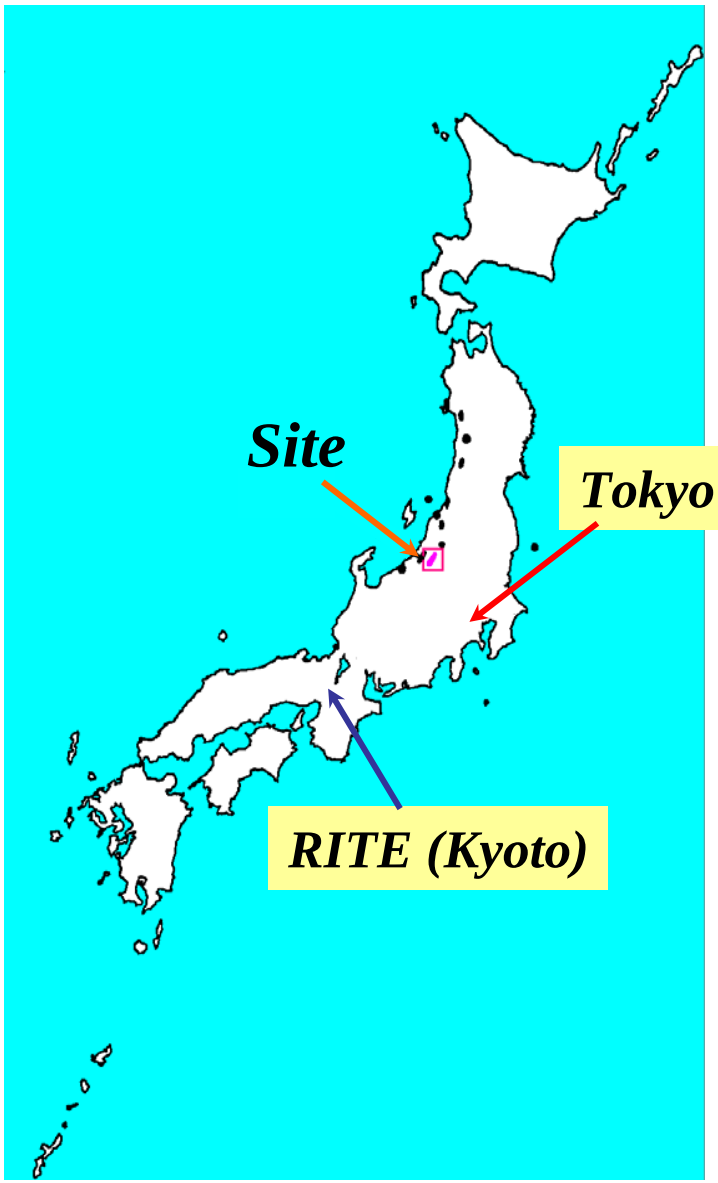
Project Scheme



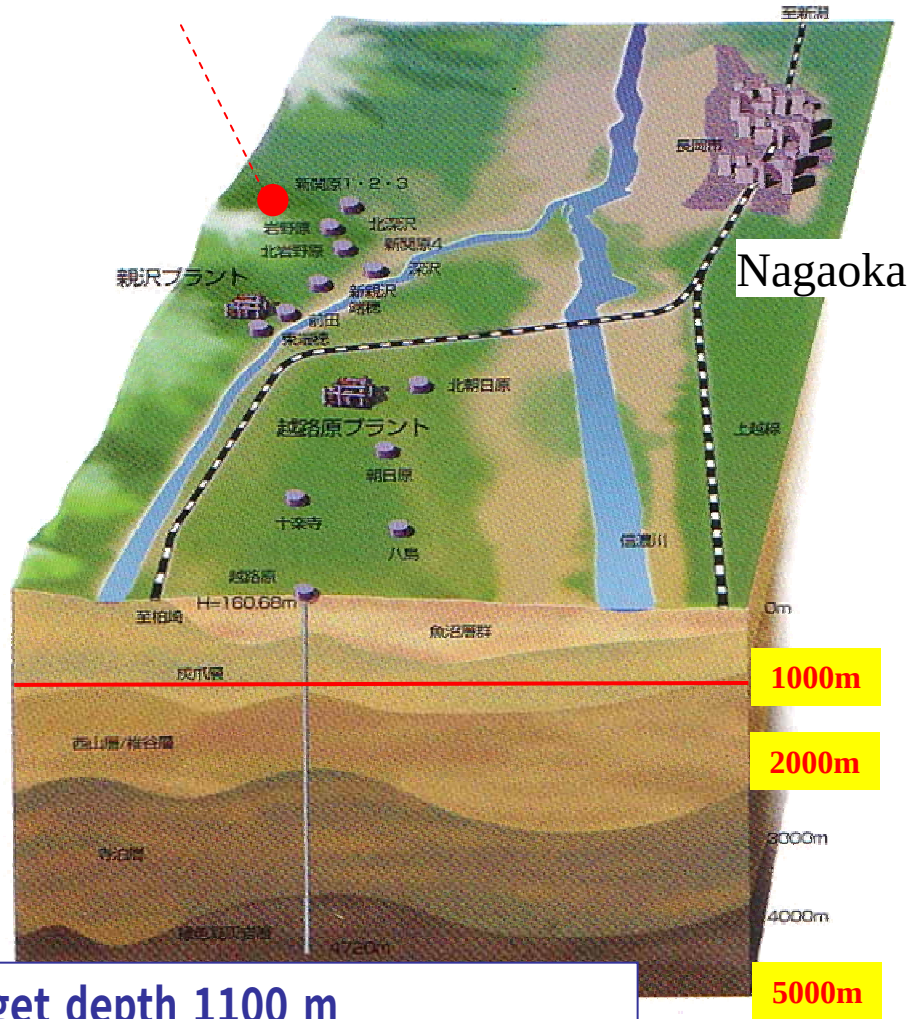
Project timeline



Nagaoka Site



Injection well



Target depth 1100 m

Gas production from 4500 m depth

Feature of Nagaoka Project

1 Injection Test in suburb area of a large city with population of 0.3 million

2 New Injection well for core recovery

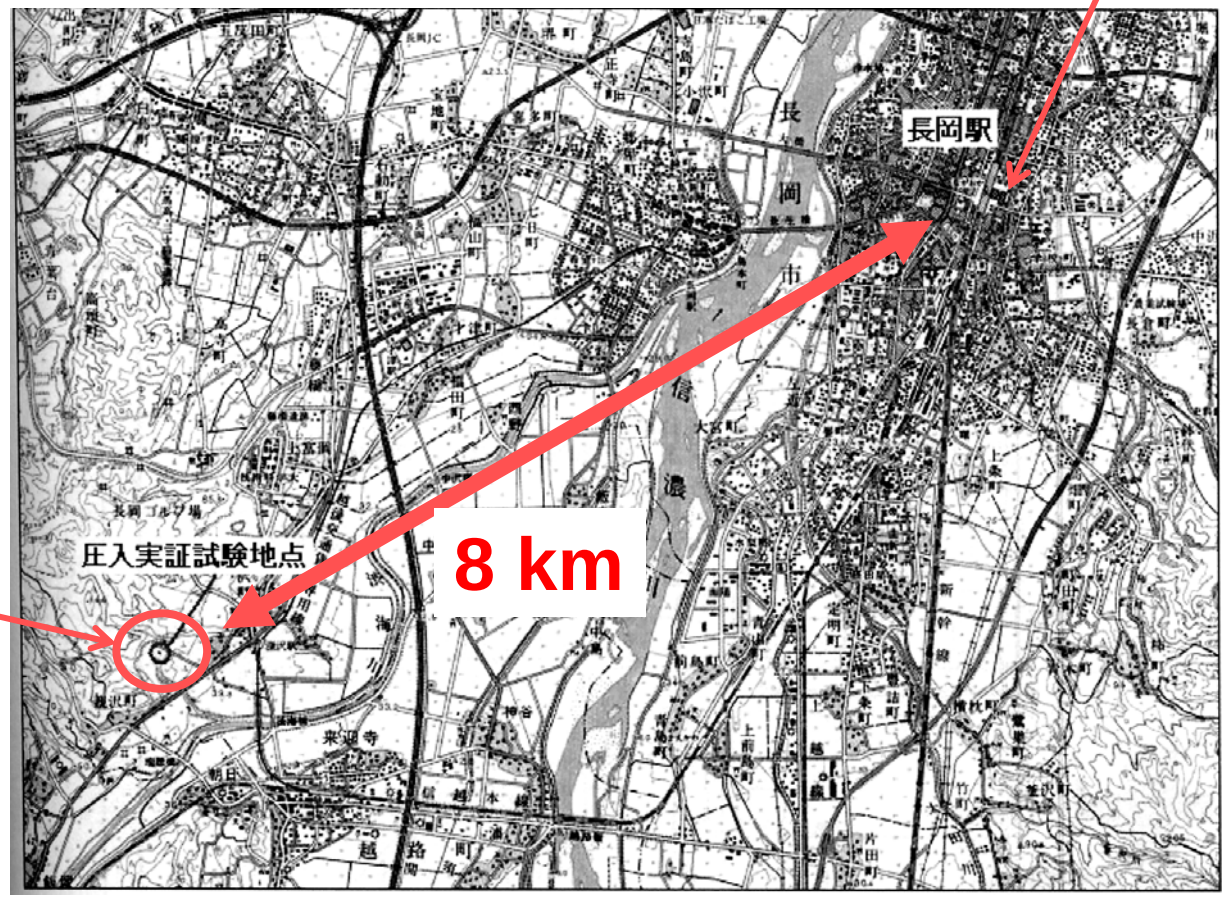
three wells dedicated for observation (with FRP casing at target zone)

3 relatively low permeability:

1.6 ～ 11.2 md （ave. 6.7 md ）

Location of injection well

NAGAOKA Shinkansen Railway Station



Injection site

Completed surface Facilitie in June 2003

Lorry

Storage Tank

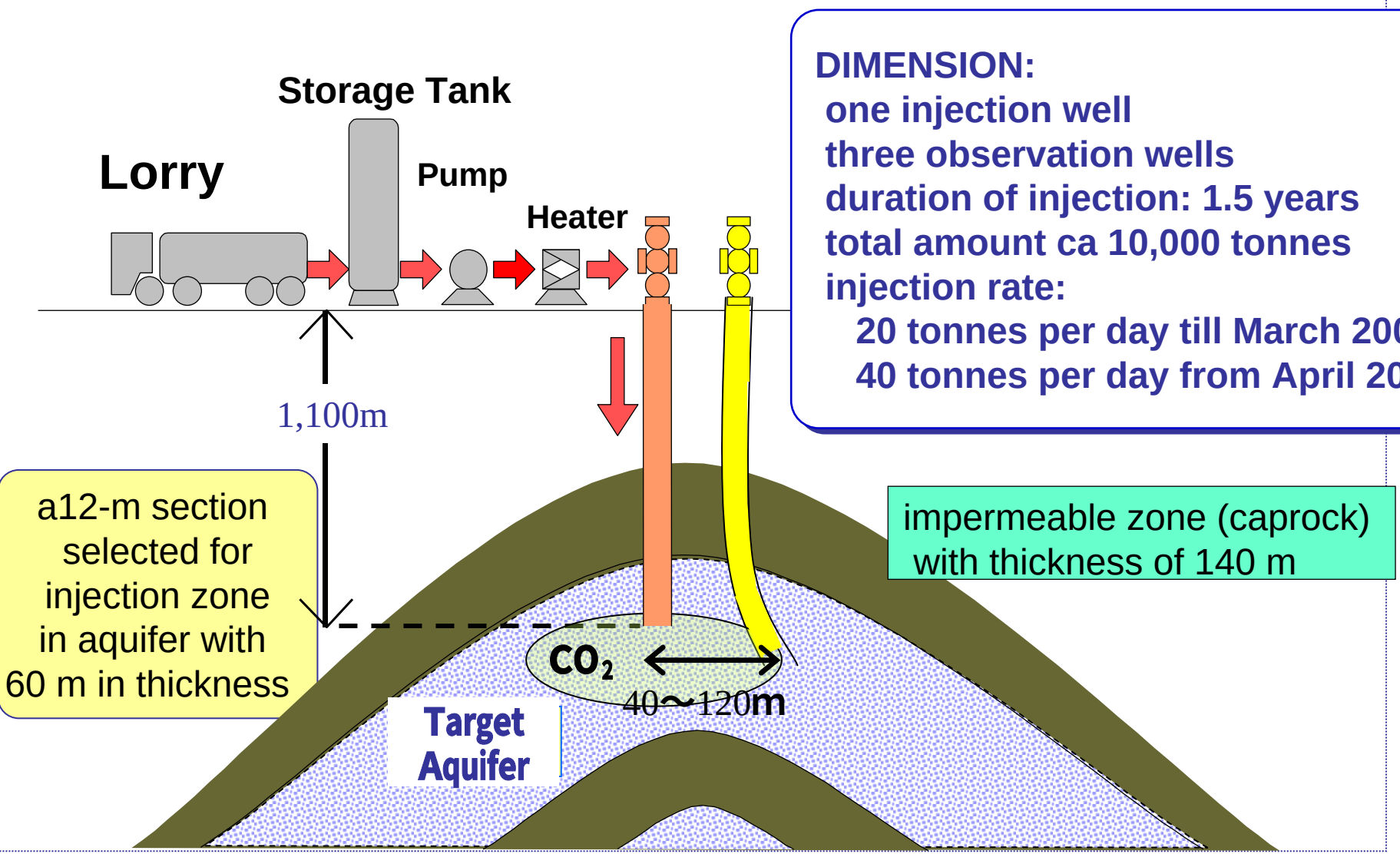
Heater

Pump

Control Rm

Injection. Well

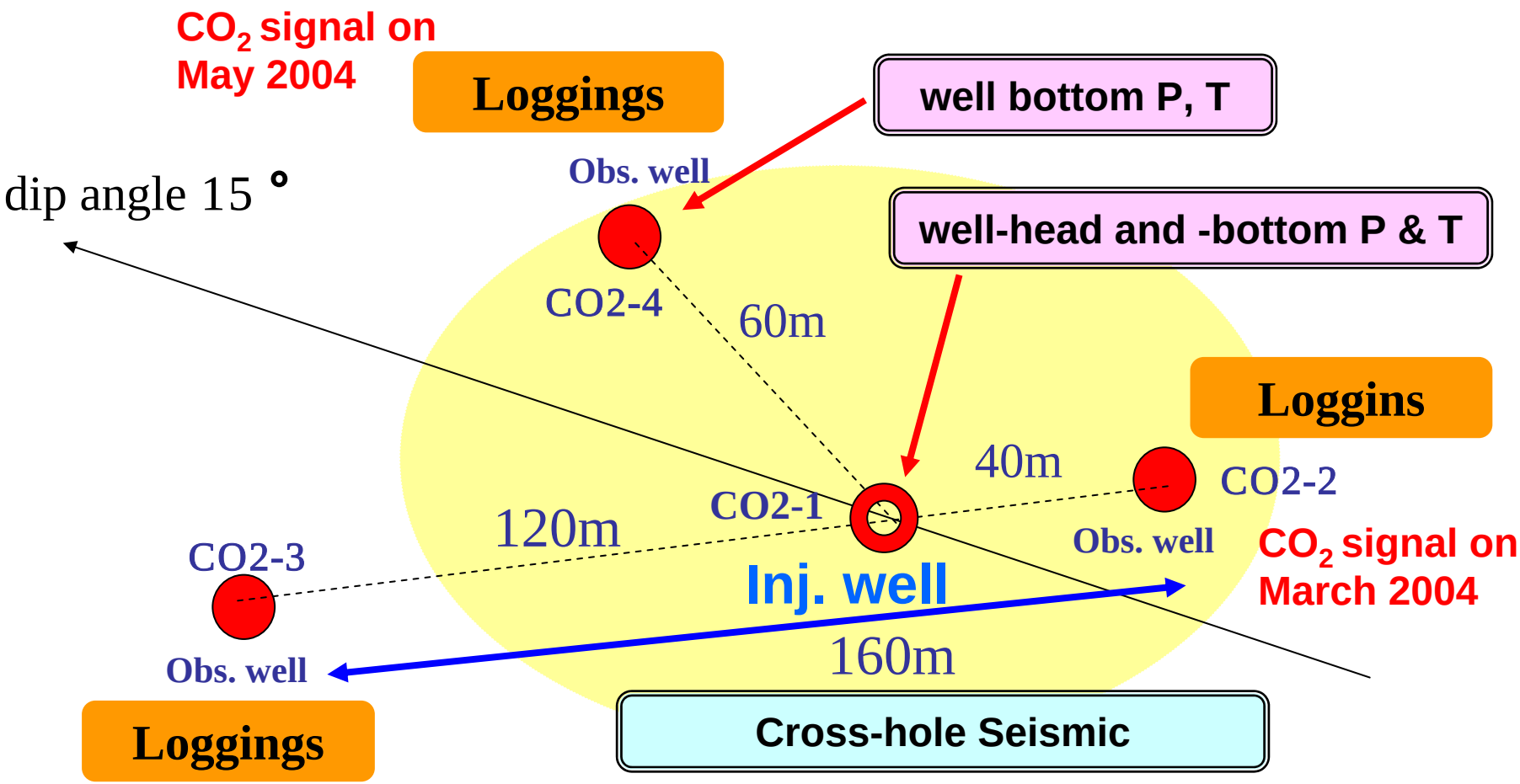
Injection Test



DIMENSION:
- one injection well
- three observation wells
- duration of injection: 1.5 years
- total amount ca 10,000 tonnes
- injection rate:
  - 20 tonnes per day till March 2004
  - 40 tonnes per day from April 2004

Core samples form target aquifer zone recovered from injection well

Monitoring

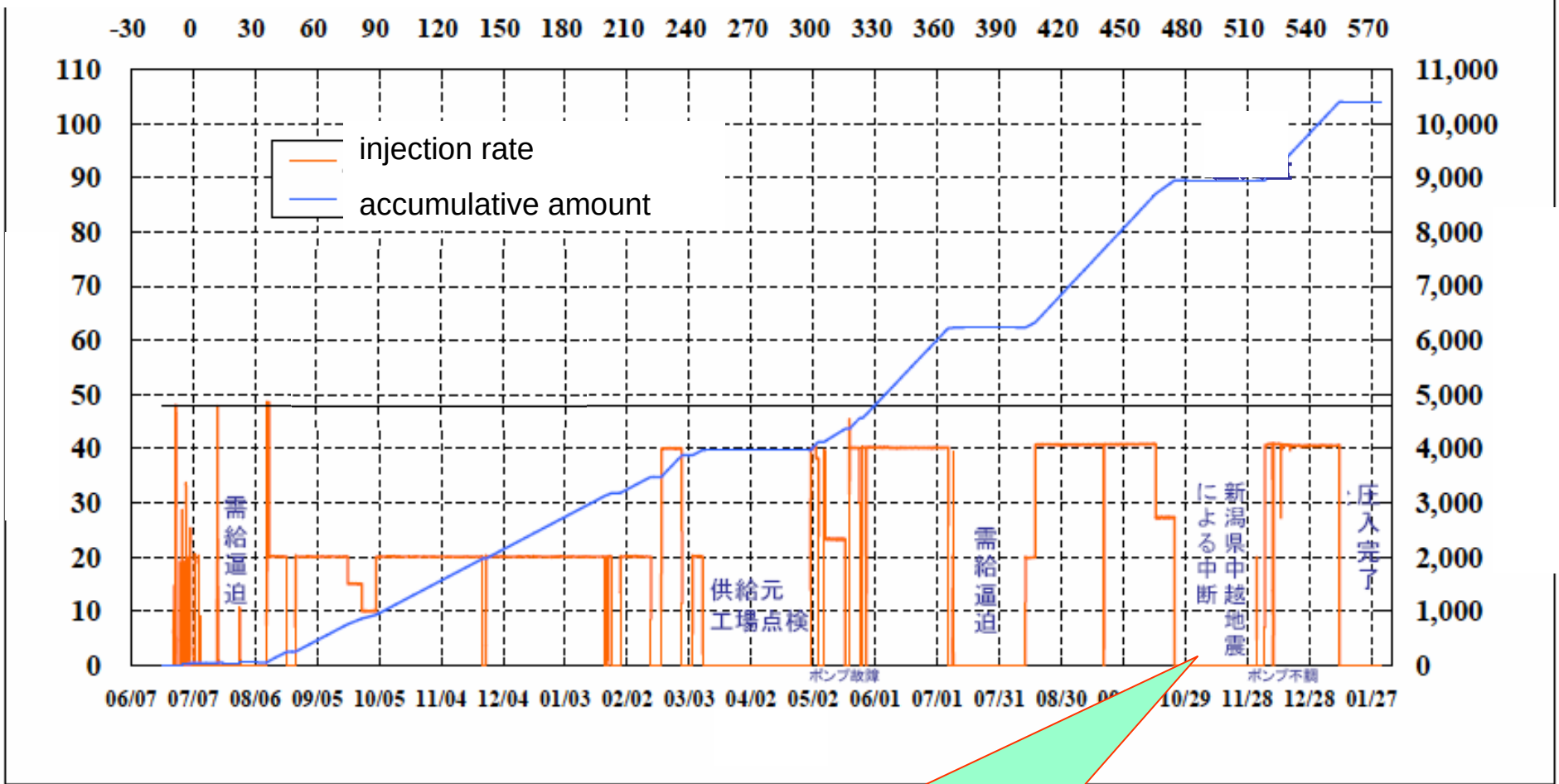

CO_2 signal on May 2004
Loggings
well bottom P, T
dip angle 15 °
Obs. well
well-head and -bottom P & T
CO2-4
60m
Loggins
40m
CO2-2
CO2-1
120m
Obs. well
CO_2 signal on March 2004
CO2-3
Inj. well
160m
Obs. well
Loggings
Cross-hole Seismic

Injection operation

from July 7,2003 through January 11,2005

Rate

Total Amount



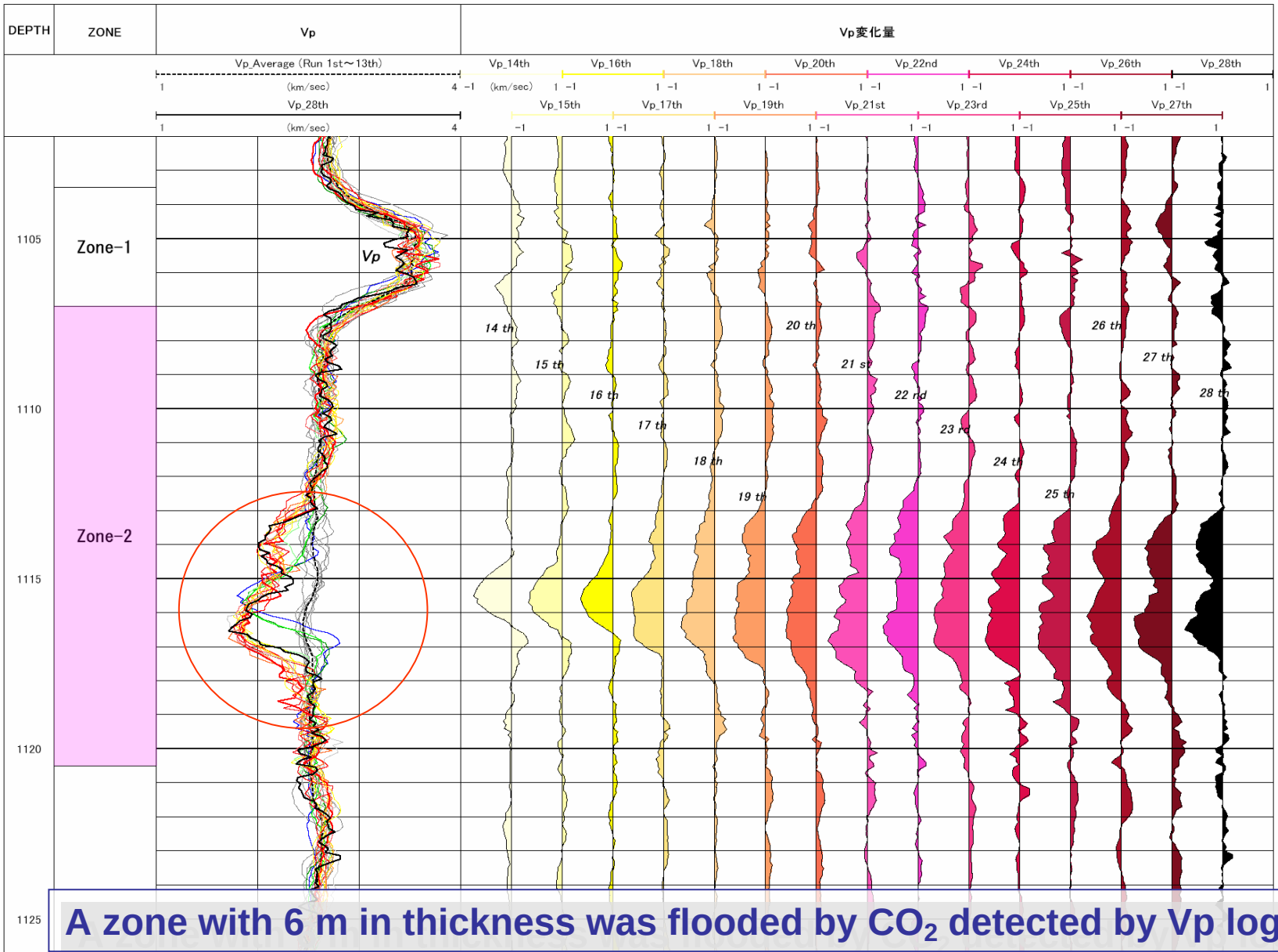
Earthquake

Geophysical Loggings

Lowering a sensor unit

well head of Obs well

V_p log at CO2-2



A zone with 6 m in thickness was flooded by CO_2 detected by Vp log

Cross hole seismic tomography

Receiver array in CO2-3 well
24 ch hydrophones (to 24 bit A/D)

Signal source in CO2-2: 2-m interval

travel time measurement

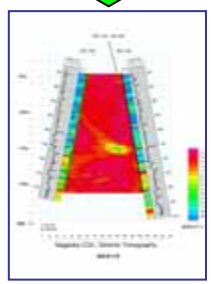
↓

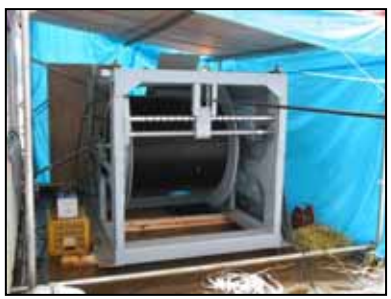
Vp distribution

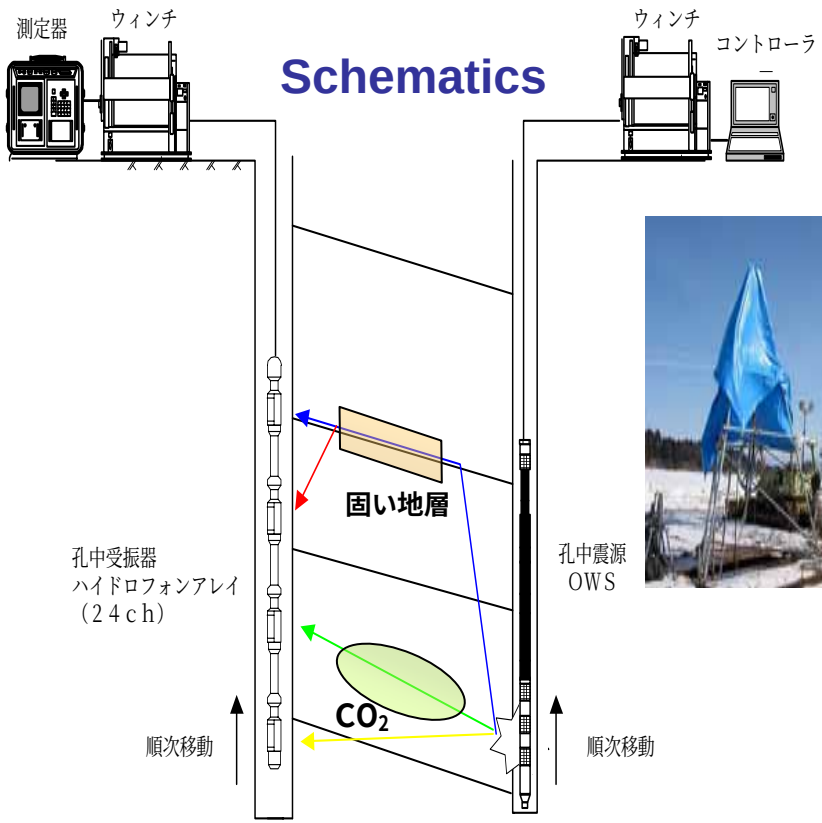
↓

comparison with baseline

↓





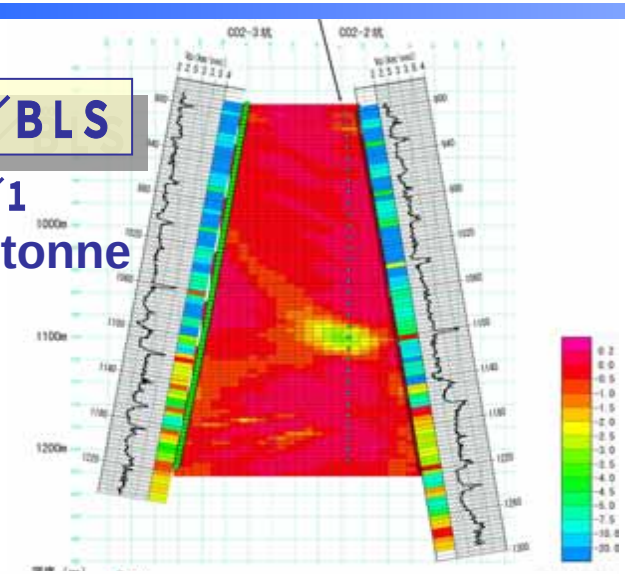


CO_2 imaging by crosshole seismic tomography

MS1／BLS

2004／1

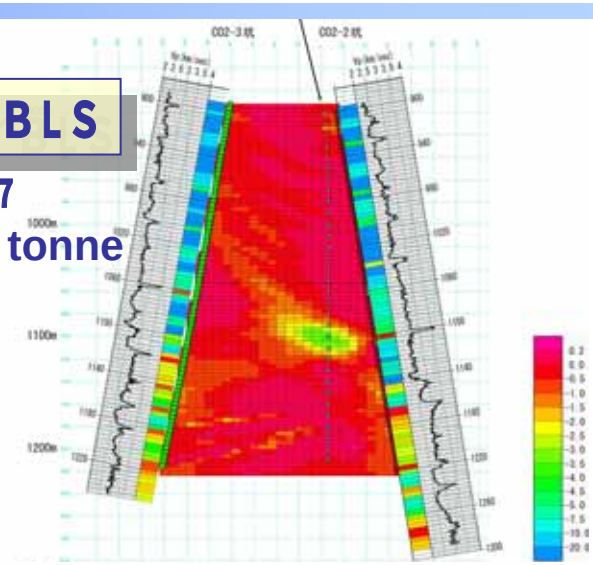
3，200 tonne



MS2／BLS

2004／7

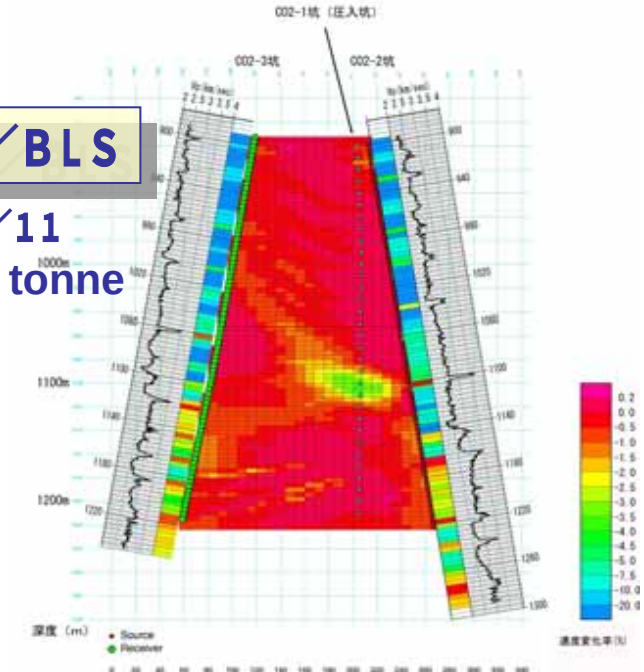
6，200 tonne



MS3／BLS

2004／11

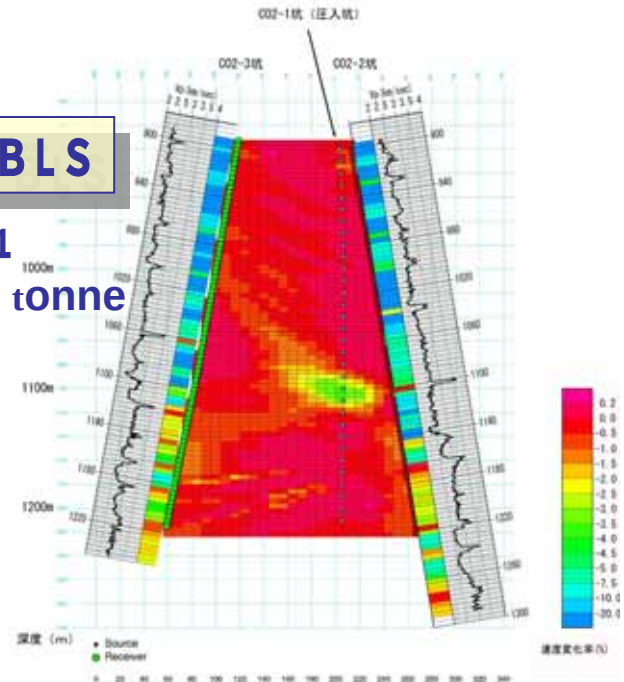
8，900 tonne



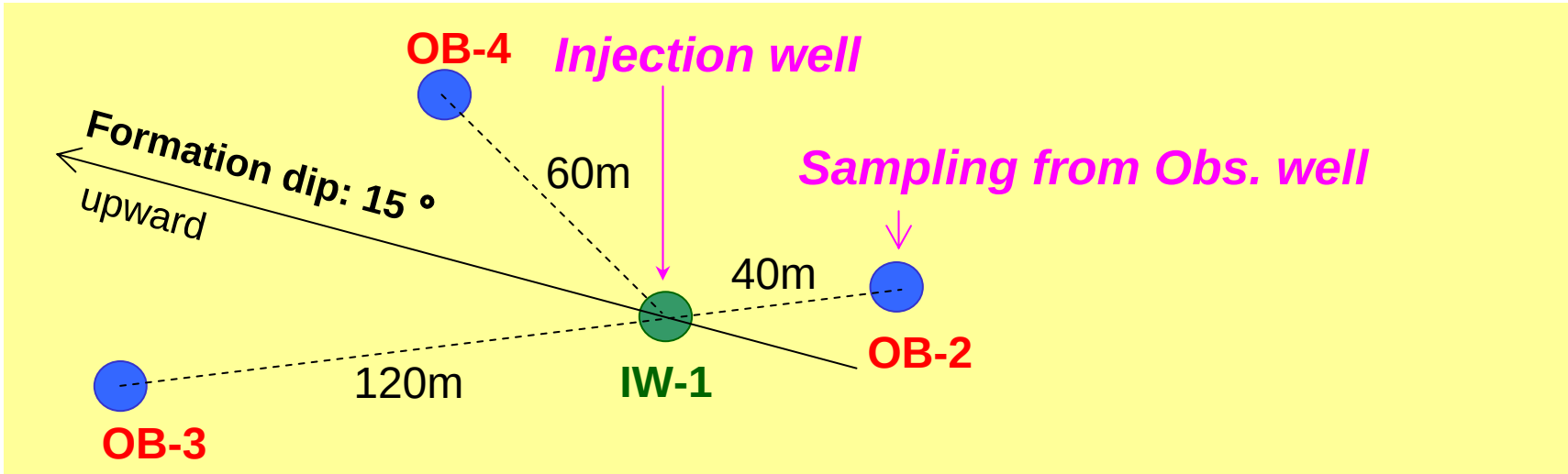
MS4／BLS

2005／1

10，400 tonne



Sampling of fluid in aquifer



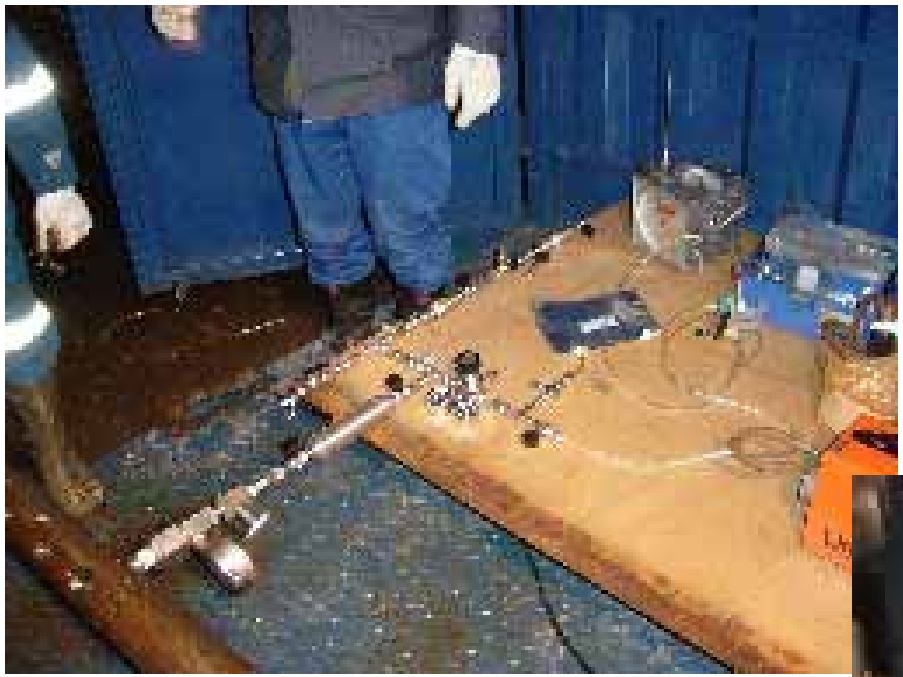
Before injection

- May 2002
- IW-1
- Air Lift

After CO_2 front reaching to obs.well

- Dec. 2005
- OB-2
- CHDT: Cased Hole Dynamics Tester,)

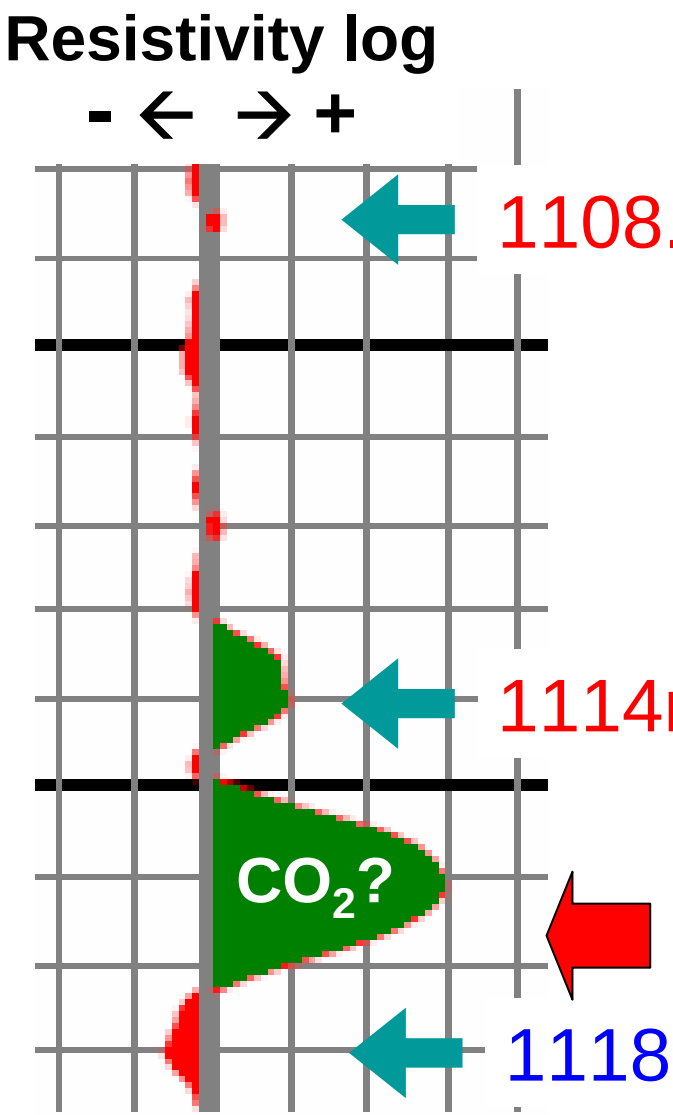
Fluid Sampling by CHDT



Extraction of gas phase

Sampling aqueous phase

Sampling location depth from wellhead



the same composition
as original formation water

overwhelmingly of CO_2 gas

CO_2 have been partly migrating to cause water chemistry change

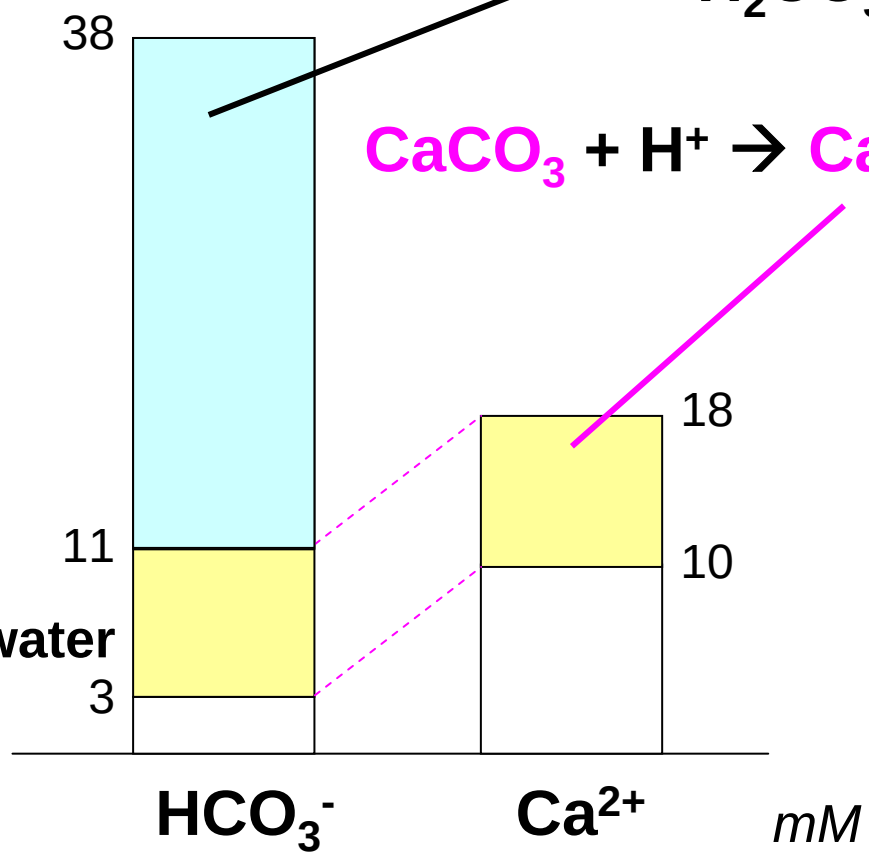
Change of water chemistry affected by migrating CO_2

Blue & Yellow :
Change observed on Dec. 2005

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

$$CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$$

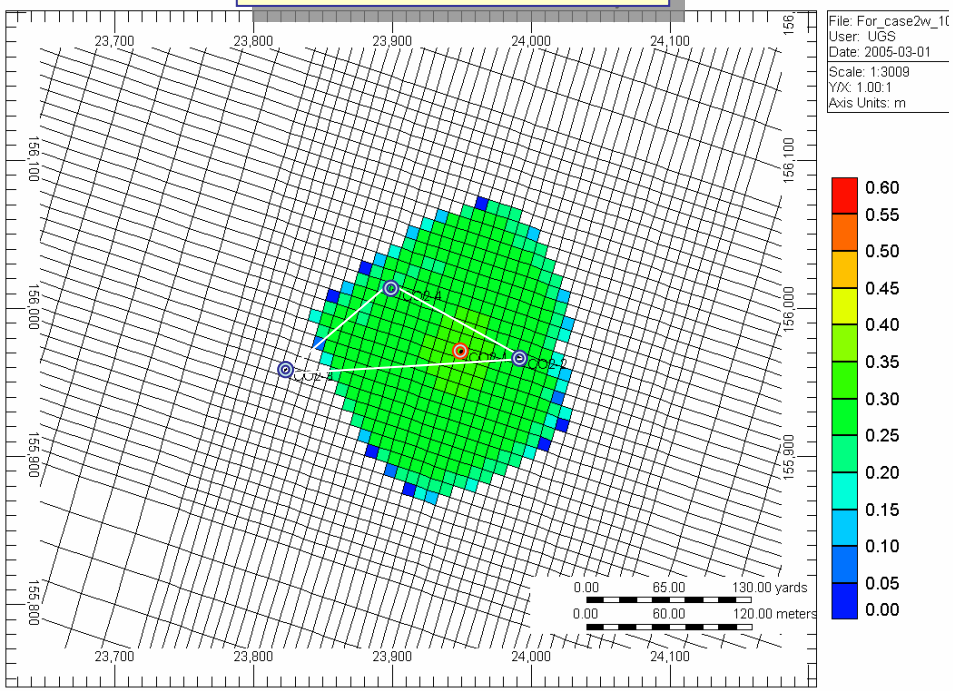


While :
original formation water

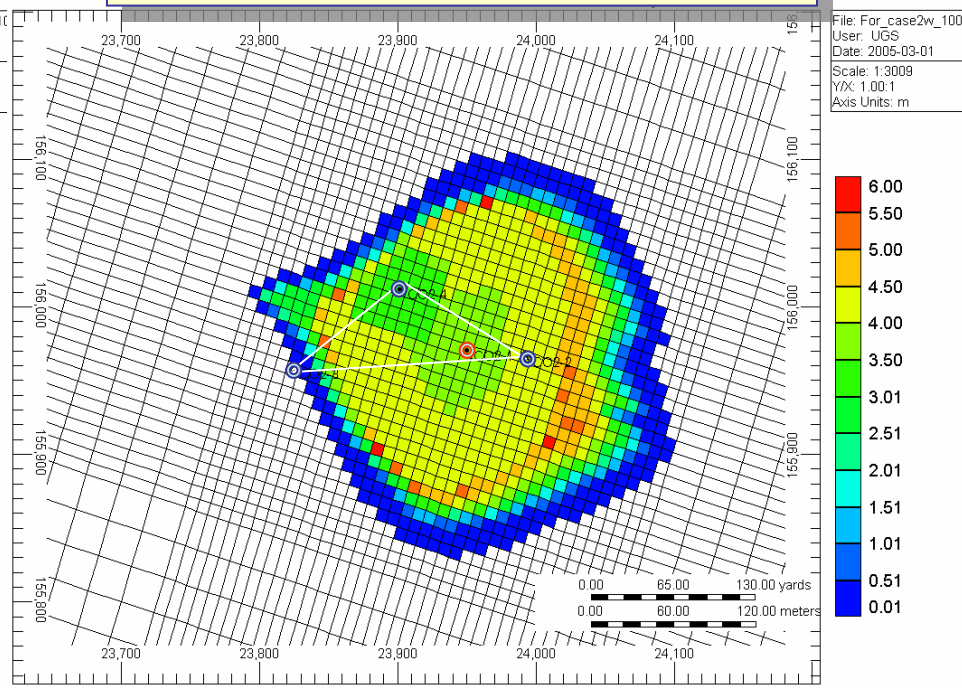
CO_2 simulation

Prediction after 1000 years

Sg、 Fraction



aqueous CO_2 (Sm^3/m^3rock)



Gaseous CO_2 = 63.1 % of total injected

Sgrmax=0.33

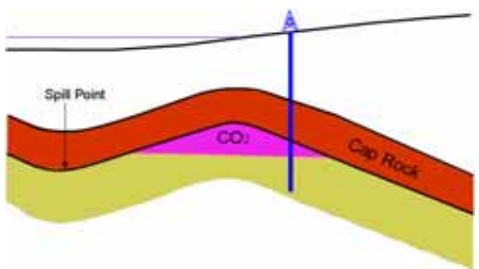
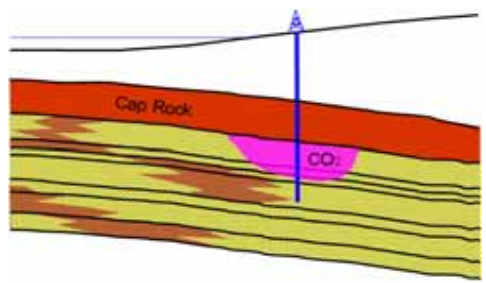
CO_2 in Solution = 36.9 % of total injected

Outcomes of Nagaoka Project

1. successful and meaningful continuous operation of CO_2 injection; 500days and 10 thousand tonnes
2. geophysical logging using observation wells revealed CO_2 migration and distribution
3. imaging by cross-hole seismic tomography]
4. computer simulation of CO_2 migration prediction underground
5. experience of a big earthquake with M6.8: well integrity confirmed
6. pressure test to check for well and seal rock integrity before injection operation: up to 19.2 MPa (compare to the predicted injection pressure of 18.6 MPa)

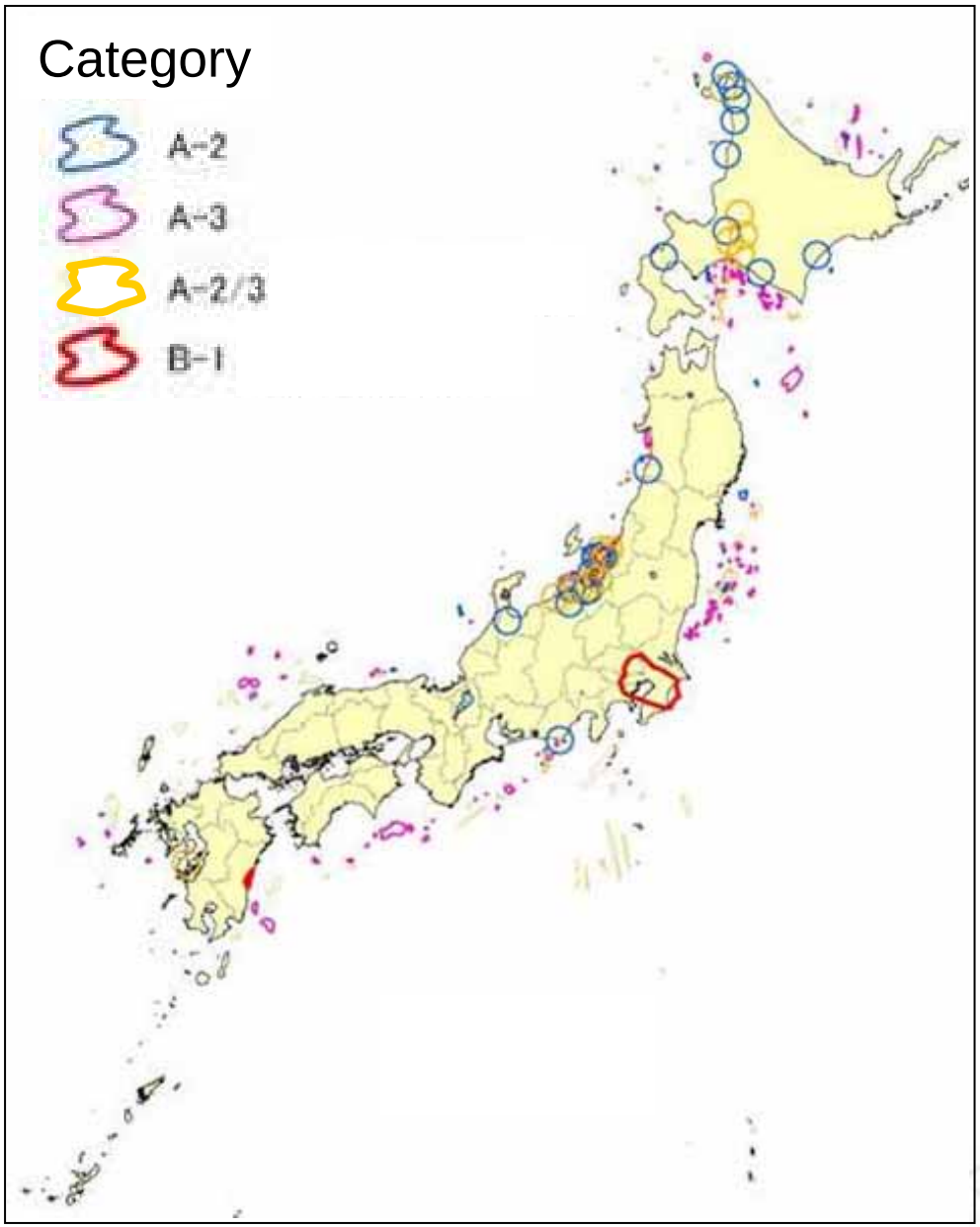
   actual injection pressure of 12.6 MPa for injection rate of 40 tonnes per day

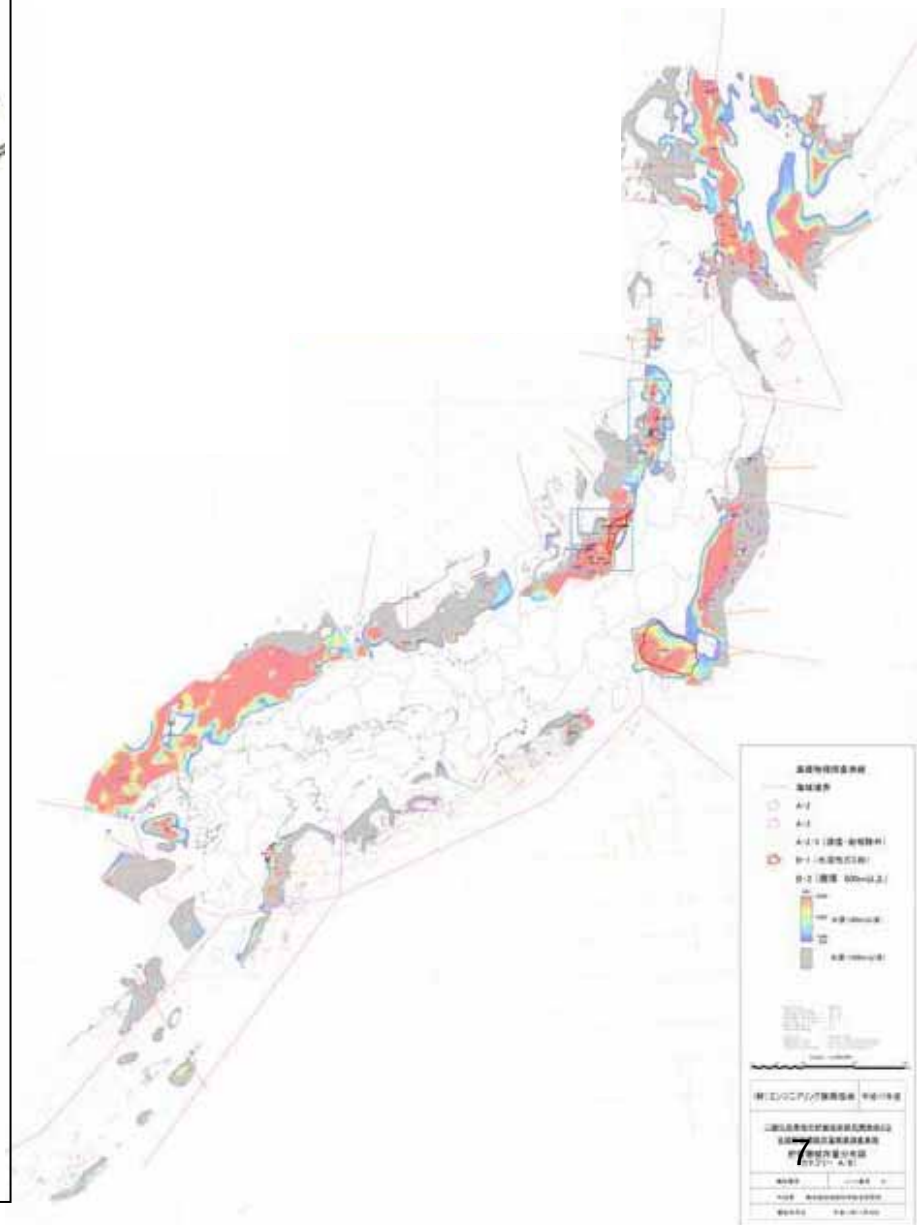
Re-evaluation for Aquifer Storage Potential in Japan

data source		Category A (Aquifer with Closure)	Category B * (Geological formation of stratigraphic trapping)
oil & gas field	data obtained during operation	A1: 3.5 Billion t-CO_2	B1: 27.5 Billion t-CO_2
Basic boring	public domain data by seismic and drillhole	A2: 5.2 Billion t-CO_2	
Basic survey	public domain data by seismic only	A3: 21.4 Billion t-CO_2	B2: 88.5 Billion t-CO_2
scheme			
sum		30.1 Billion t-CO_2	116.0 Billion t-CO_2
total		146.1 Billion t-CO_2	

Inland basins, such as Seto in land sea, Osaka Bay are excluded: based only on Public Domain Oil & Gas Exploring activity. *) deeper than 800m and shallower than 4,000m, located in waters shallower than 200m.

Identification of potential storage sites





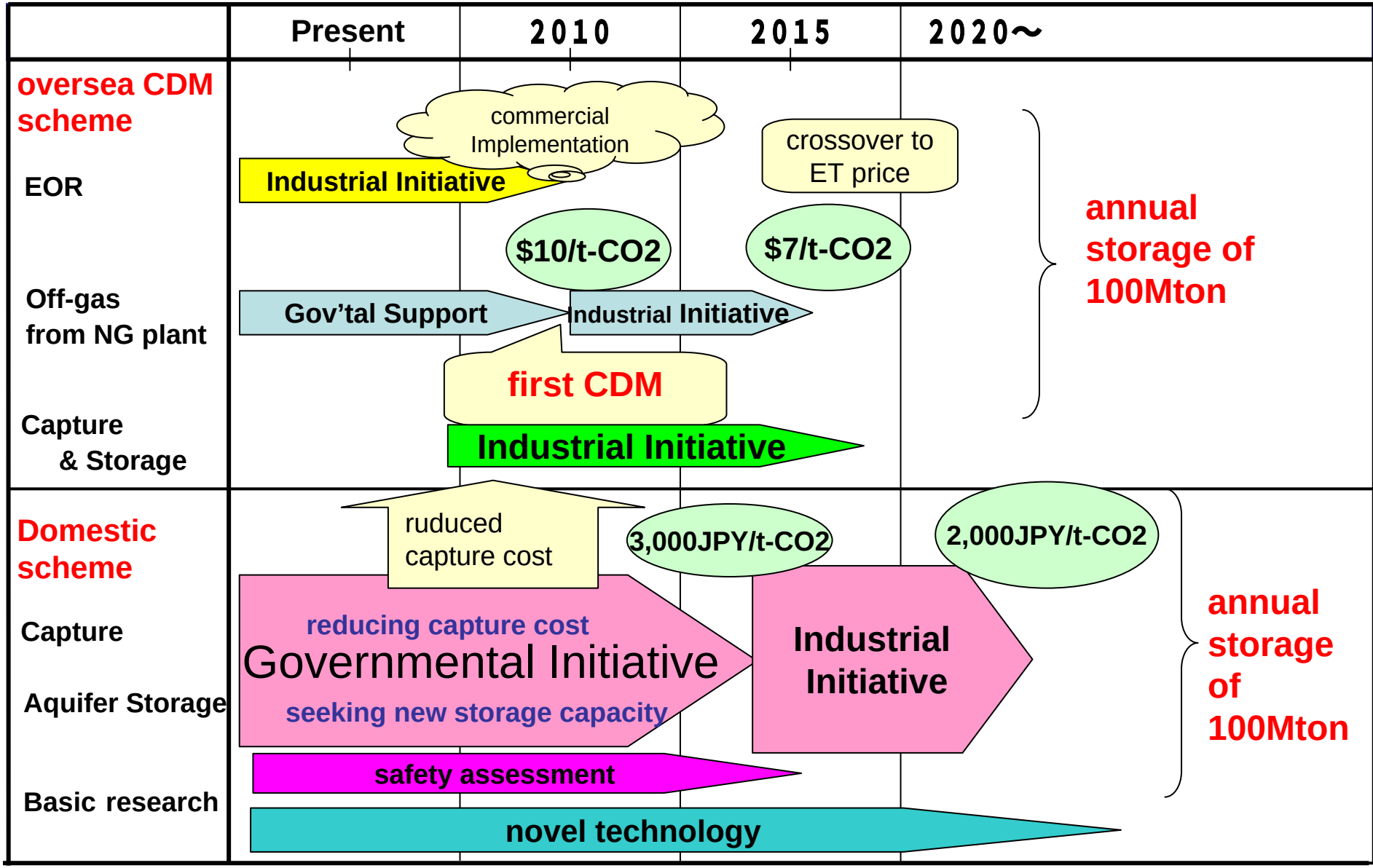
Policy perspective on CCS Implementation

- Governmental Initiative
  - Continued R&DD by full governmental support to reduce CCS cost lower than 1.5 times level for market-in.
  - Followed by encouragement through regulatory measures.

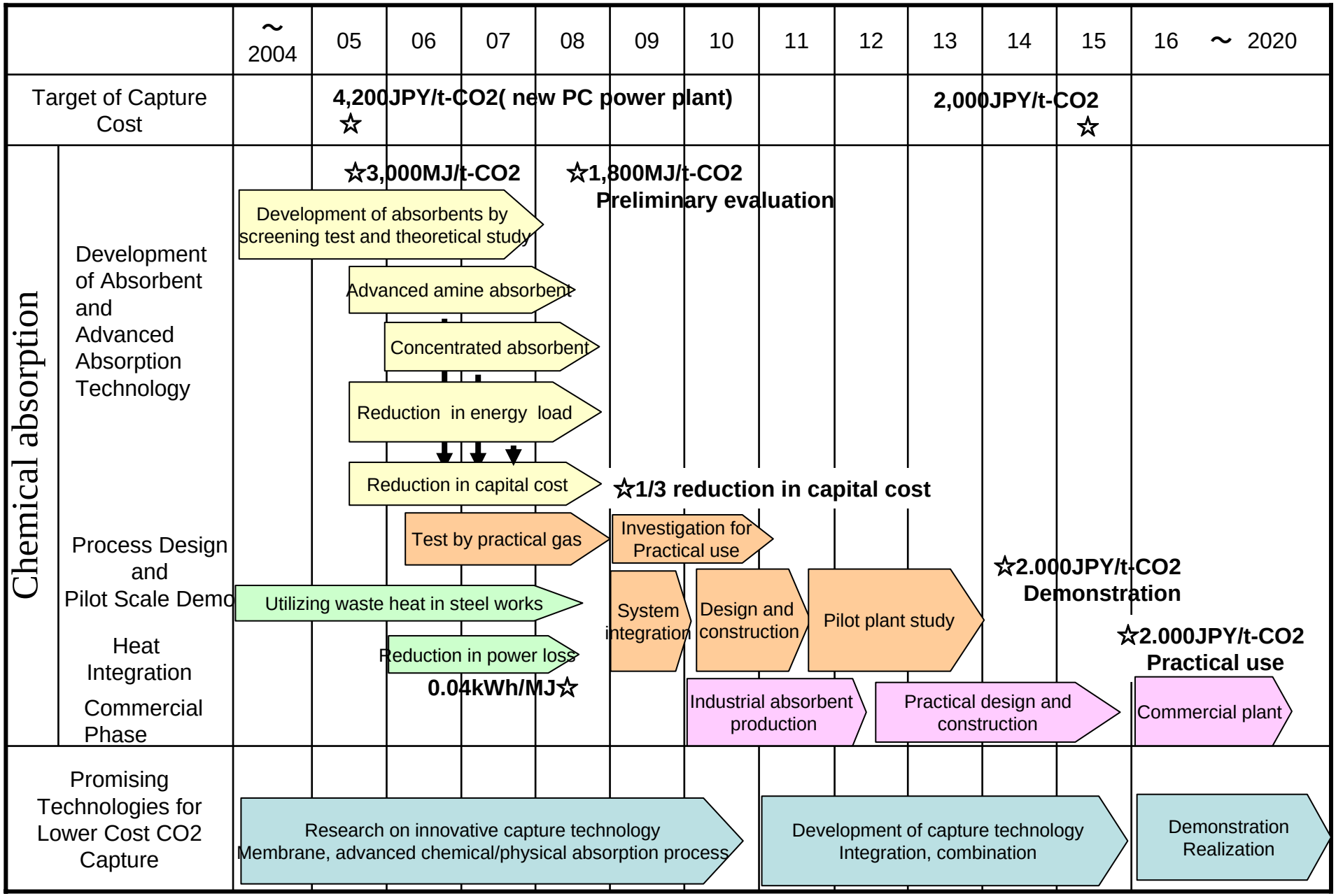
- Overseas Deployment
  - Contribution of CCS to CO_2 concentration level stabilization is the same for those in domestic and overseas deployment.
  - CCS through CDM is regarded as Japan's Commitment to the Kyoto target.

- Stepwise Implementation
  - Early opportunity for storage is encouraged, such as existing streams with high concentration CO_2, where the additional cost is only for compression, transport and injection.
  - Experience in these early opportunities is the key for large scale implementation.

METI's target of Cost and Implemented Storage Rate



CO_2 Capture Roadmap



Recent Discussions on the London Convention and Protocol

- On 10 February 2007, the amendment of London Protocol took into force, allowing CO_2 sequestration in sub-seabed geological formations.

- In the SG Intersessional Technical WG, the framework of risk assessment of CO_2 sequestration in sub-seabed geological formations is now being discussed. Its conclusions will be treated as basic concepts of the CO_2 Waste Assessment Guidelines, which should be the basis for domestic procedures of permitting in each country.

- Japan will be the London Protocol country in mid-2007; the ratification of London Protocol by National Diet is scheduled.

- Domestically, it becomes realised that implementer's views are important to finalize the discussion on the regulation.

Conclusions "towards CCS implementation in Japan"

- <Storage side>

  Demonstration of aquifer storage in sub-seabed geological formation with reliable and/or cost-effective monitoring exercise is probably necessary as a next step.

- <CO_2 sources>

  Early opportunity strategy is still meaningful in view of both industry and government.

- <International collaboration>

  Closer international links are essential:

  lessons from Ocean, IPCC SR CCS, London Protocol, and CDM.