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CCS R&D and regulation in Japan

Shinsuke NAKAO

Geological Survey of Japan, AIST

EPPM Program
Workshop on Regulatory Framework for CCS: with focus on storage into geological formations, HSE, CDM and Flaring
29 June – 1 July 2010, Phuket, Thailand

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OUTLINE

- **CO_2 emission in Japan**
- Technical roadmap and framework
- Regulation and Guideline
- AIST R&D programs on Geol. Storage

Japan's GHG Emissions (after MOE)

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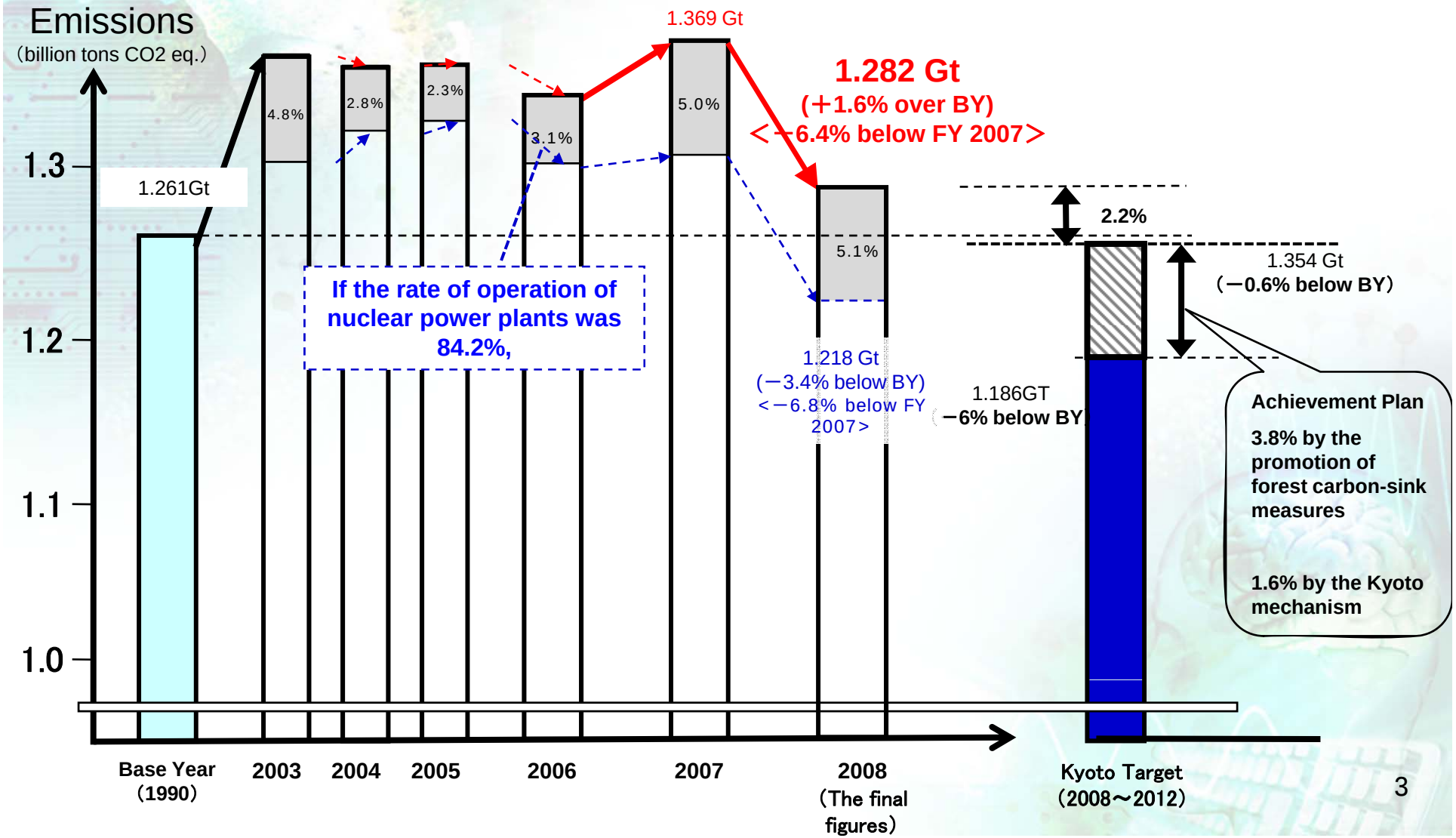
: in FY 2008 were +1.6% over the base year (BY) and -6.4% below FY 2007.

(If the rate of operation of nuclear power plants was 84.2%, -3.4% below BY.)



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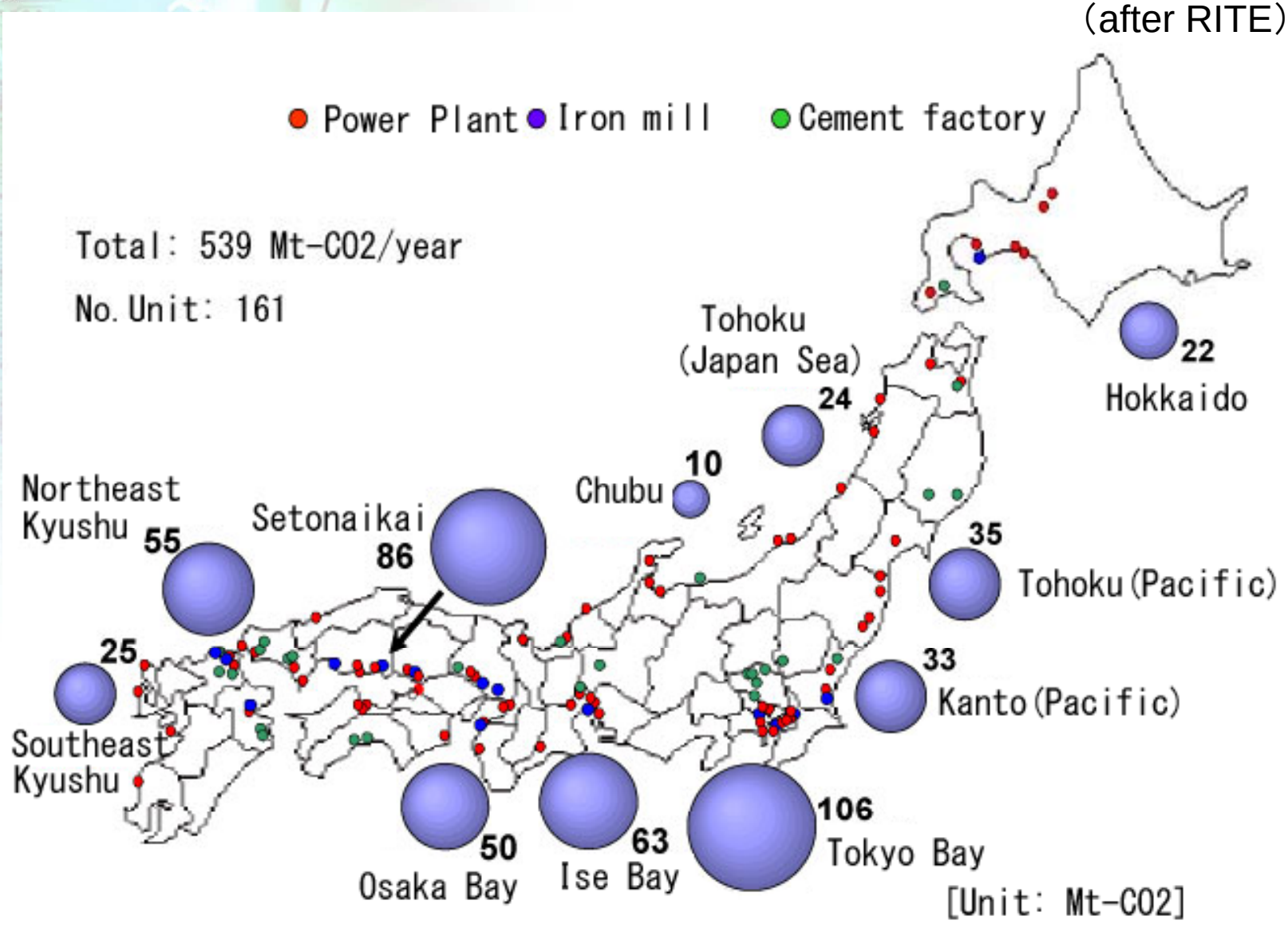
GHG emission sources

(after RITE)



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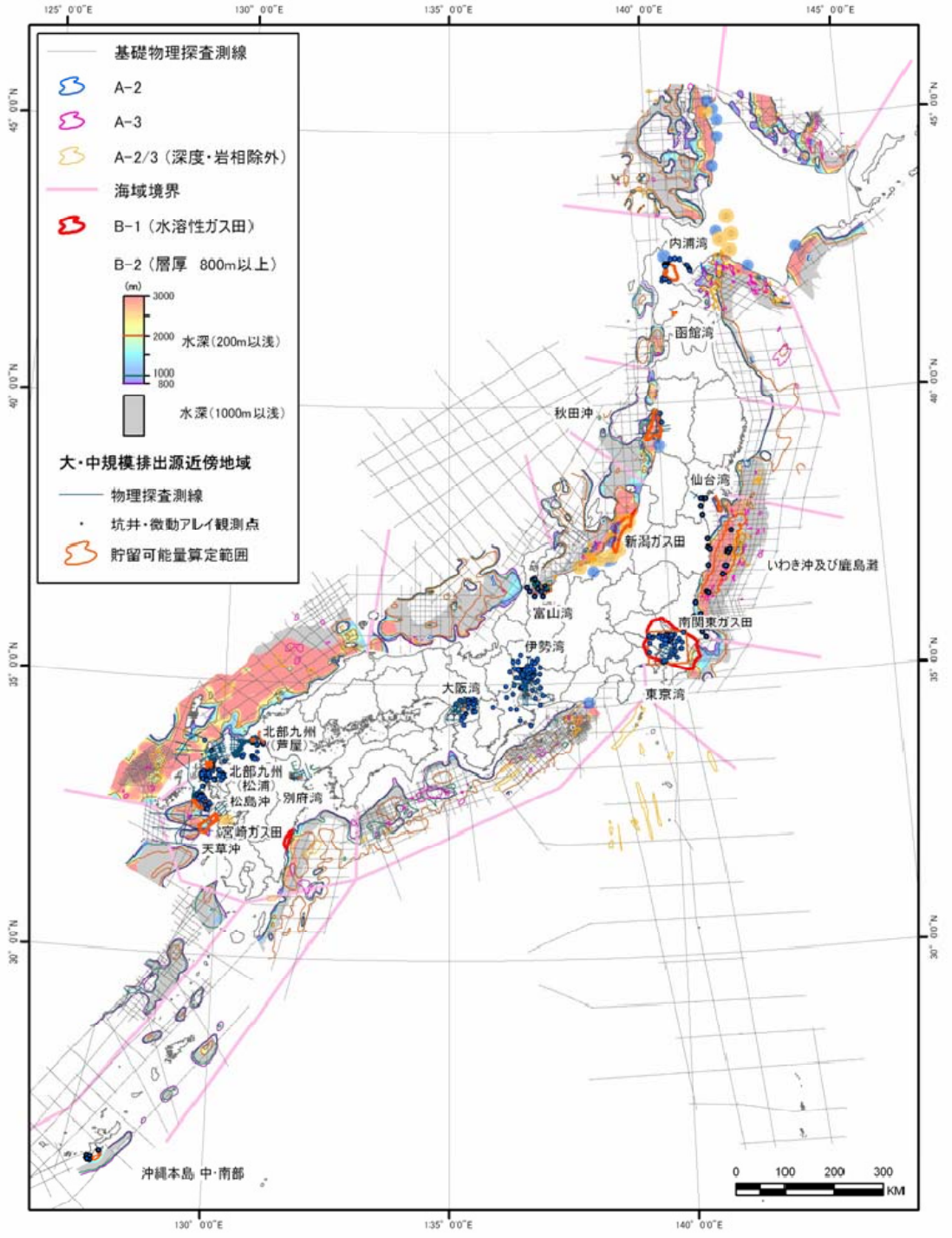
Distribution of Potential Aquifer & Reservoirs for CO_2 Storage



after RITE
(Research Institute of Innovative Technology for the Earth)
(2008)

Total Storage: 141×10^9 (ton)

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Technology Development Roadmap of Japan

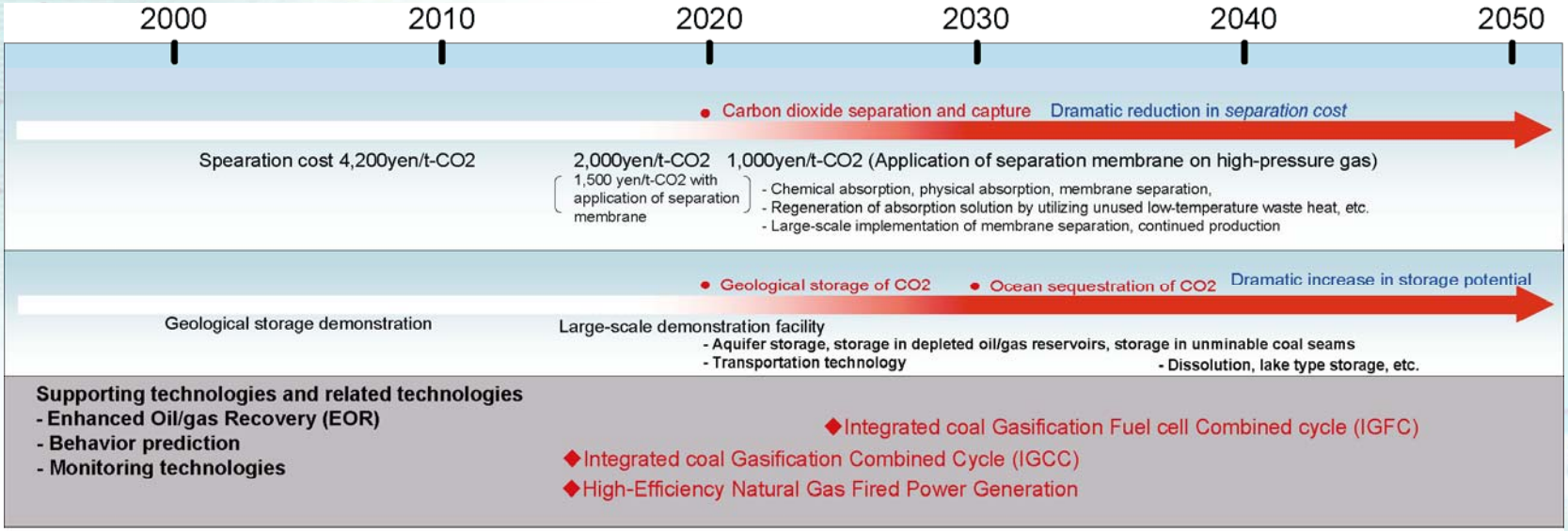
<Current technology> *Mapped out by METI*

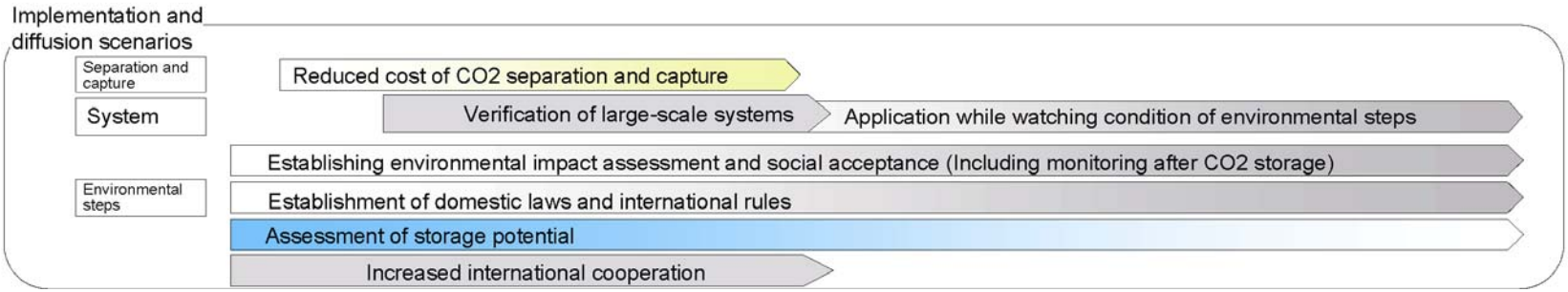
◯ Cost for capture is currently about 4,200 JPY/t-CO2.

＜Technology development roadmap ＞

◯ Target capture cost of 2,000s- JPY by 2015 and 1,000s-level JPY/t-CO2 by 2020s.

◯ Start a large-scale demonstration project as soon as possible after FY2009





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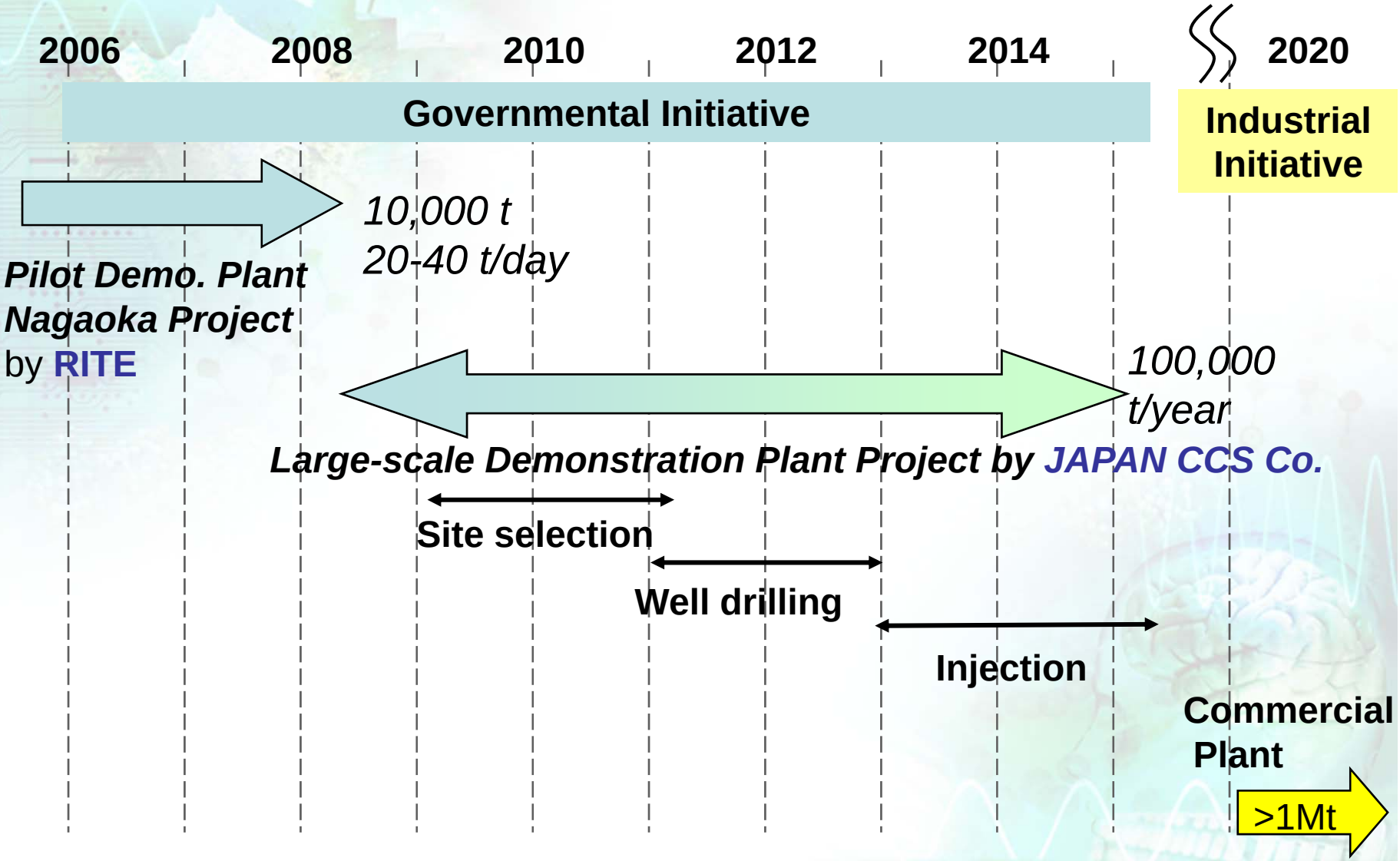
Tentative schedule for CO_2 Geol. Storage Demo. Project in Japan



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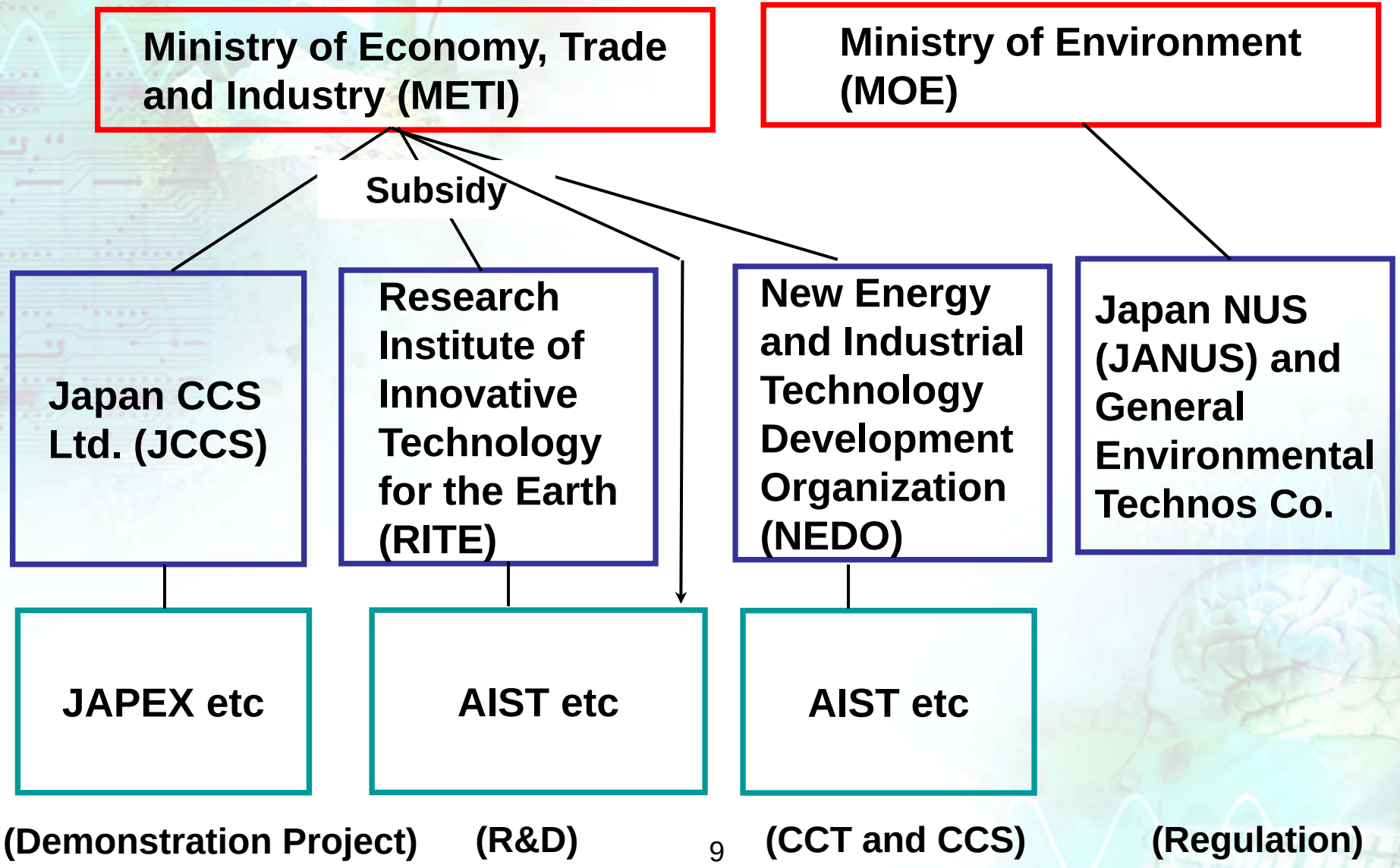
Framework of CCS research in Japan



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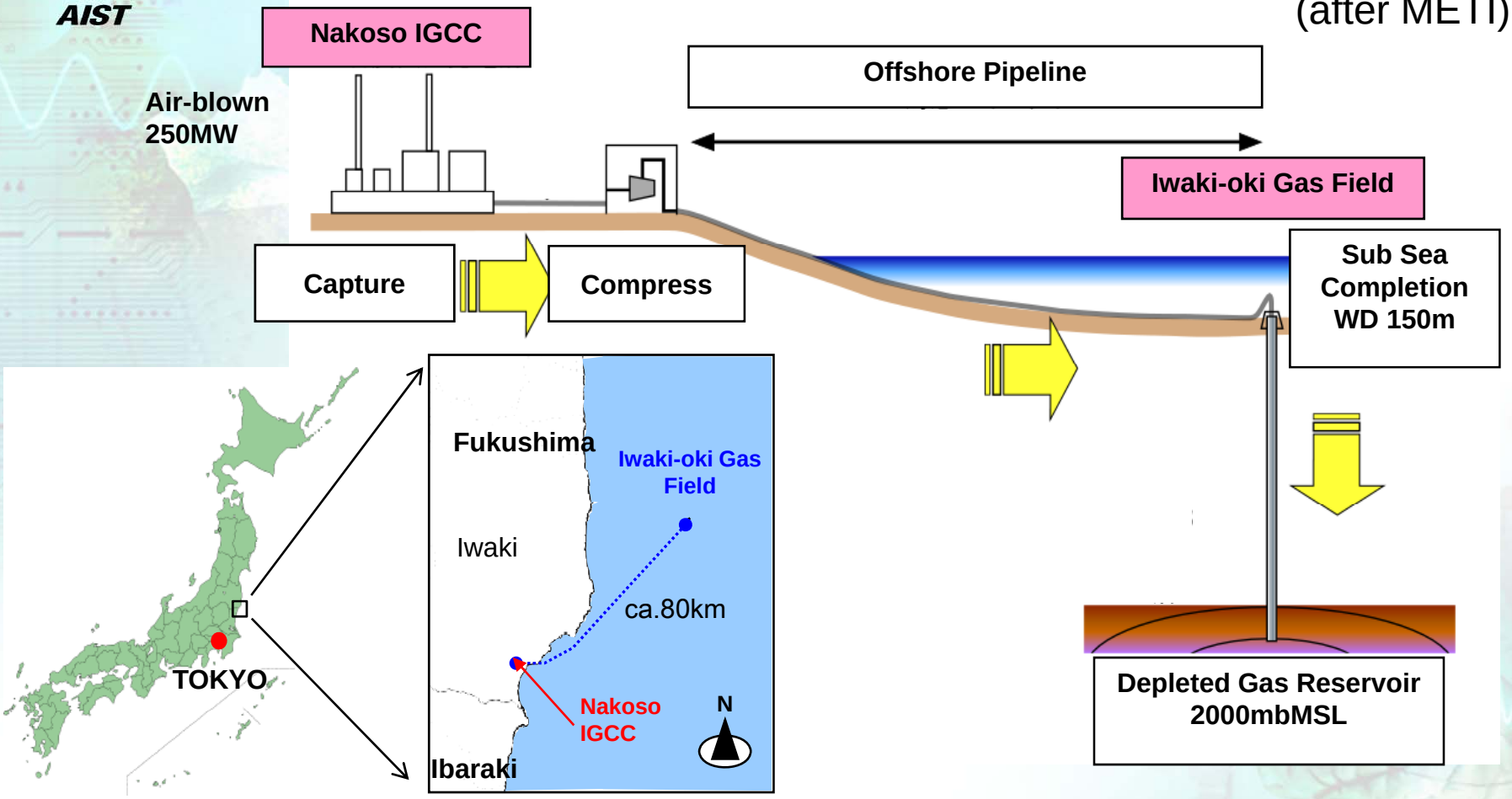
A candidate of the demonstration plant

(after METI)



Offshore sub-sea completion well
CO_2 to be captured at the Nakoso IGCC Demonstration Plant, transported to Iwaki-oki Gas Field and injected into the depleted reservoir

- coal Gasification Combined Cycle, demonstration plant is owned and being operated by Clean Coal Power R&D Co., Ltd. (CCP).
- Iwaki-oki IGCC : Integrated gas field was operated by INPEX (Teikoku Oil).

10

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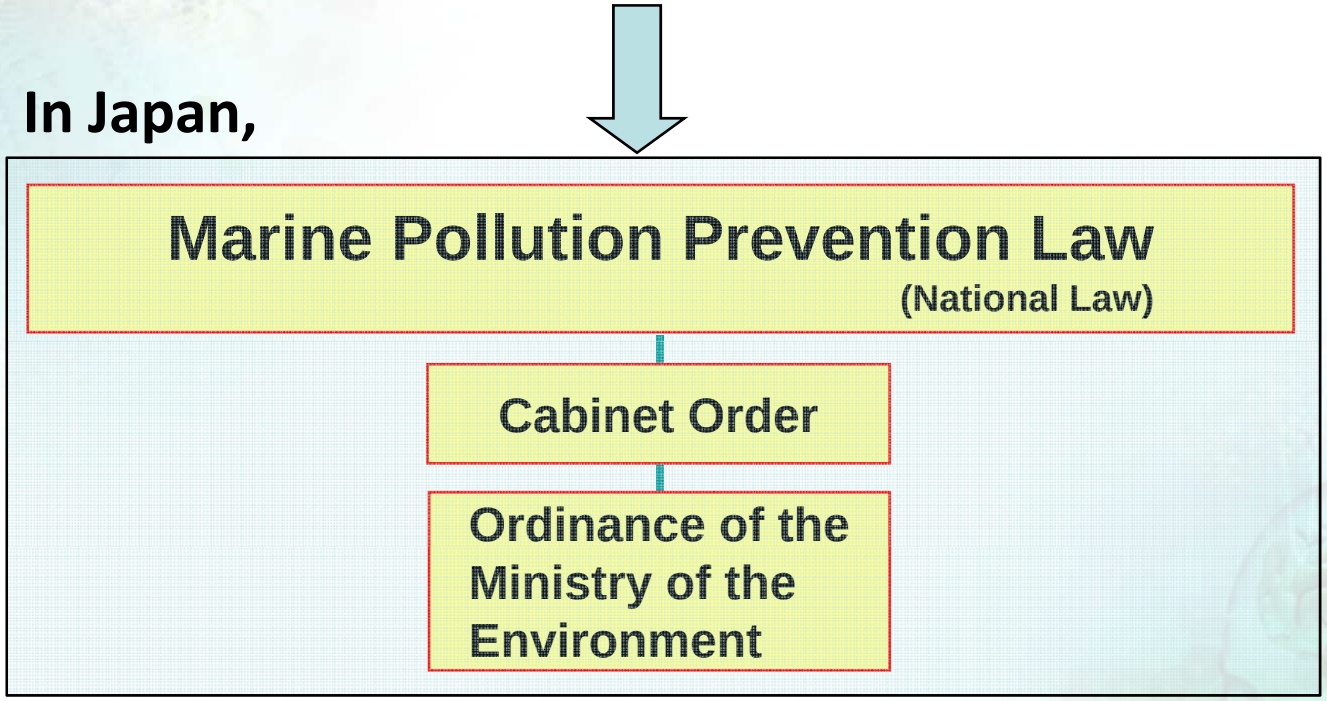
Regulation on CCS

Amendments to the London Protocol 1996

Permission of offshore CO_2 geological storage

In Japan,



Amendment was accepted in the Diet (2007.05.23)

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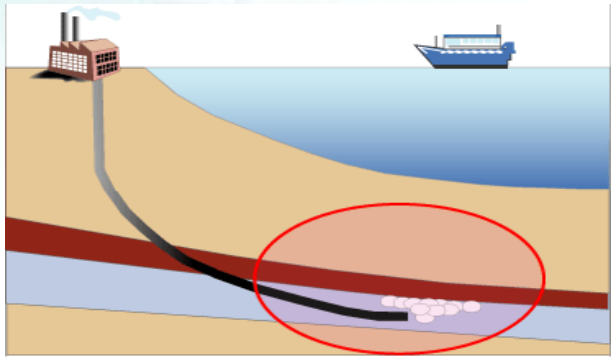
1. Prohibition of disposal of oil, hazardous liquid substances, and wastes under the seabed

No one shall dispose oil, hazardous liquid substances, and wastes under the seabed, except for CO_2 stream storage under the seabed with permit from Minister of the Environment (Article 18.7)

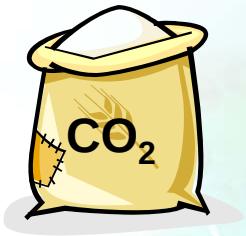


Subsurface under the seabed

Oil

Hazardous Liquid

Wastes



Carbon Dioxide

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2. Provisions for the permit for CO_2 stream storage under the seabed

(1) Anyone intending to dispose CO_2 stream under the seabed must obtain a permit from Minister of the Environment (Article 18.8)

Minister of the Environment

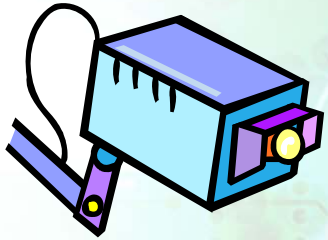
(2) The Minister of the Environment shall not issue a permit for the CO_2 stream storage under the seabed unless it meets all conditions required such as "the storage site under the seabed and the method taken for the storage will not harm marine environmental protection at the storage site" and "there is no other appropriate disposal is available other than storage under the seabed". (Article 18.9)

No impact to marine environment

No other appropriate disposal way

(3) A person holding a permit for CO_2 stream storage under the seabed must monitor status of the pollution at the storage site and report monitoring results to Minister of the Environment. (Article 18.12)

Monitoring and Reporting



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Application for a Permit

Application for a Permit (Ordinance of the MOE, Article 1)

- Project Plan
- Monitoring Plan

Attachments (Ordinance of the MOE, Article 4 and 5)

1. Site selection report
2. Environmental impact assessment report
3. Explanation for no appropriate disposal is available other than sub-seabed storage
4. Financial capability of the applicant
5. Technical capability of the applicant
6. Outline of the entire project (beyond permitting period)

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Guideline
for safe operation of a CCS demonstration project

mapped by METI in August 2009

Contents

1. **Things to be assessed for CO_2 storage from geological aspects**
2. **Transportation Standard**
3. **Safety consideration for placing CCS-related facilities**
4. **Environmental Impact Assessment (EIA)**
5. **Safety consideration for the drilling, completion and P&A (plugging and abandonment) for CO_2 injection and storage wells**
6. **Safety considerations for CO_2 injection and operation**
7. **Concentration standard of CO_2 to be injected**
8. **Monitoring**
9. **Measures to be taken when abnormalities occur**

http://www.meti.go.jp/english/press/data/pdf/090807_02PDF.pdf

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1. Things to be assessed for CO2 storage from geological aspects

1-1. Formulation of hydrogeological and geological structure model

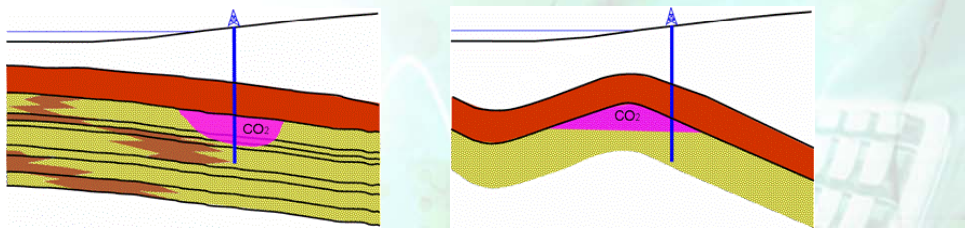
– In order to assess feasibility of a CO2 storage project from geological aspect, following conceptual and detailed models should be formulated.

(1) Formulation of regional (conceptual) model

1) Based on existing materials.
2) A hydrogeological and geological structure model including CO2 reservoir, cap rocks, and their upper section

(2) Formulation of detailed (numerical simulation) model

1) Based on the regional model.
2) To assess the hydrogeological and geological structure of the reservoir region (including cap rocks)
3) To estimate the extent that would be impacted by injection of planned volume of CO2



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1. Things to be assessed for CO2 storage from geological aspects (cont.)

1-2. Things to be assessed to perform large-scale demonstration project

(1) Confirmation of the existence of reservoir and cap rock

1) Storage possibility and reservoir volume
2) Continuity of reservoir and cap rock
3) Characteristics of cap rock
4) Characteristic of artificial structure (ex. wells) and fault, if any

(2) Setting of adequate CO2 injection plan (rate and amount)

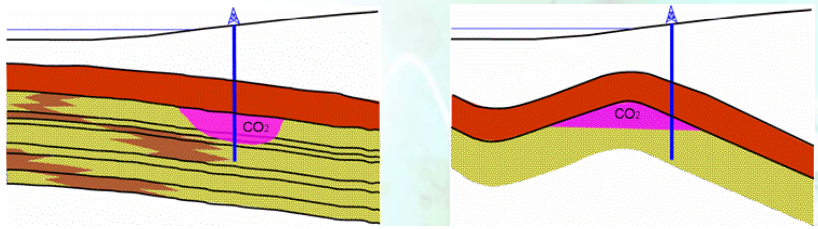
1) Possible CO2 injection rate and total volume of injected CO2.

(3) Sealing property of cap rocks

1) ….should be confirmed to avoid the break down of the cap rock i\under CO2 injection pressure.

(4) Seismic activities occurred in the past near the CO2 injection site

1) In order to identify the seismic activities, background (baseline) data should be acquired



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1. Things to be assessed for CO2 storage from geological aspects (cont.)

1-3. Data to be acquired, acquisition methods and time-frame for acquisition

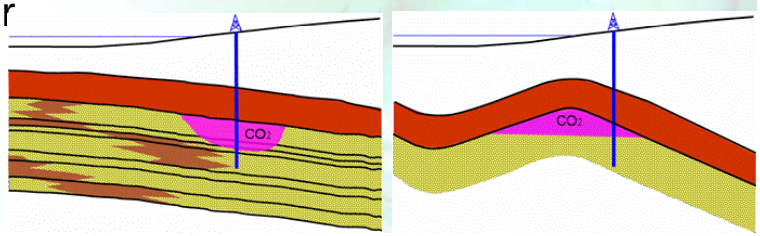
(1) Data to be acquired before drilling the exploration well

1) Public information and existing data related to geological condition
2) Implementation of seismic survey.

(2) Data to be acquired before CO2 injection

1) Formation data obtained by various loggings
2) Stratigraphy and lithofacies
3) Mineral composition, porosity and permeability
4) Capillary pressure of reservoir
5) Threshold pressure of cap rock
6) Breakdown pressure of reservoir and cap rock
7) Downhole temperature and pressure
8) Chemical components of formation water

http://www.meti.go.jp/english/press/data/pdf/090807_02PDF.pdf



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R&D subjects in AIST, GREEN

h) Estimate of Env. effect to Seabed formations

e) Long-term prediction of CO2 by simulation

i) Risk analysis

f) Effect of underground water flow

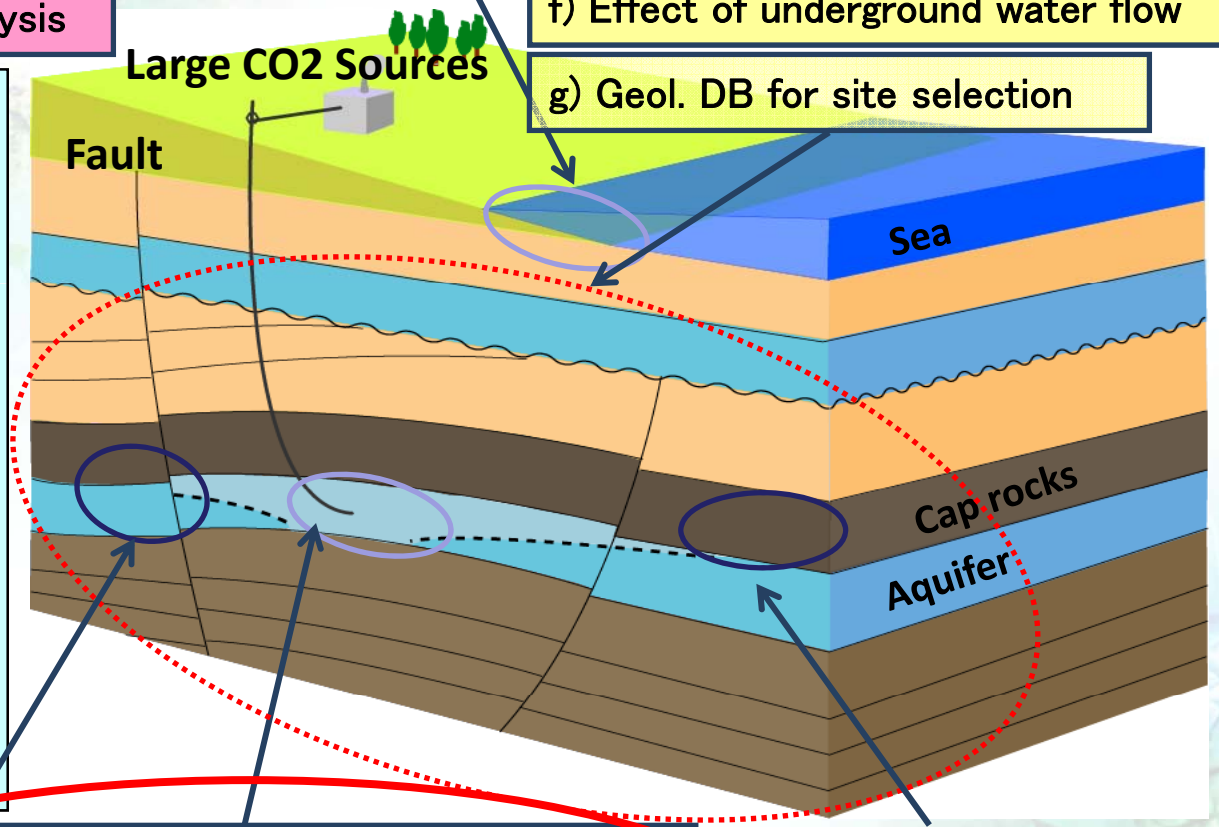
g) Geol. DB for site selection

Key Issues

How CO_2 is stored in a saline aquifer? (mechanism)

How to detect CO_2 ? (monitoring and modeling)

How to obtain the reliability? PA? (risk analysis)



a) CO_2-Water-Rock interaction

b) Monitoring tools for CO_2behavior

c) Estimate of Sealing ability of cap rocks and faults against CO_2

d) Geomechanical stability estimate of cap rocks against CO_2

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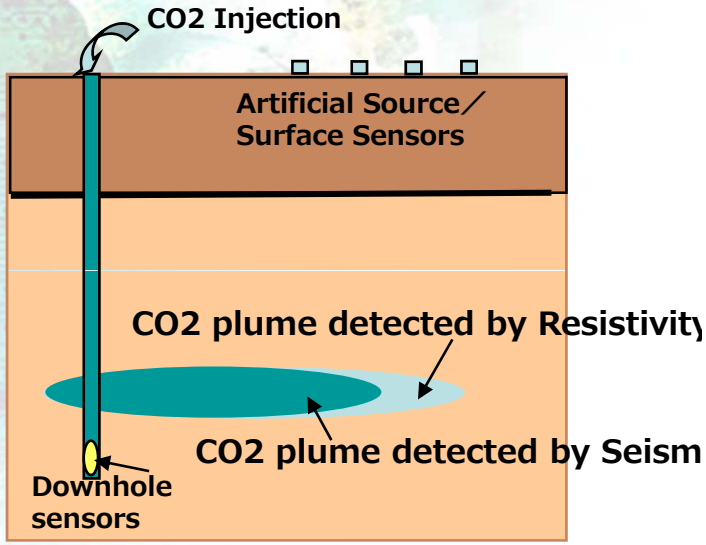
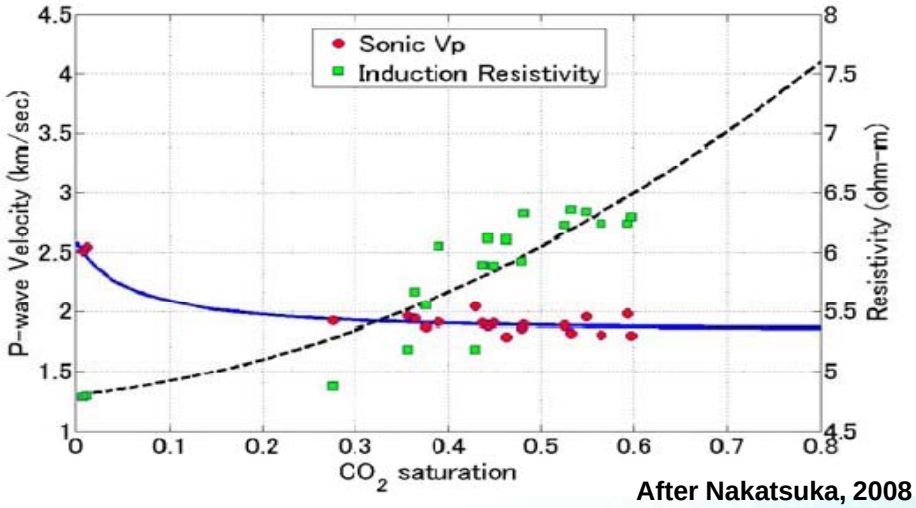
1) Development of Combined CO_2 Monitoring Tools

Objective

- To detect CO2 movement precisely, such as distribution of CO2 saturation
- To monitor dissolved CO2





After Nakatsuka, 2008

Seismic velocity and resistivity changes due to CO2 saturation

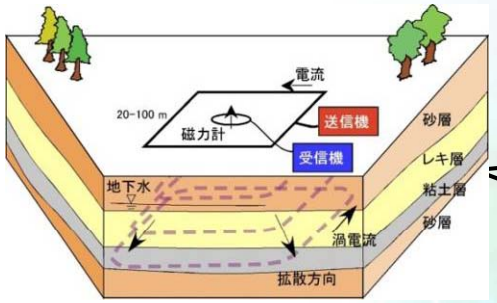
Difficult to detect dissolved CO2 only by seismics

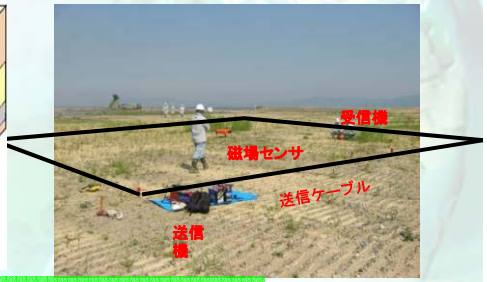
⇩

Combine both of seismic and resistivity methods

Research Items

- ✓Optimal Data Acquisition
- ✓Joint Inversion analysis of Seismic and Resist.





（TEM method：example）

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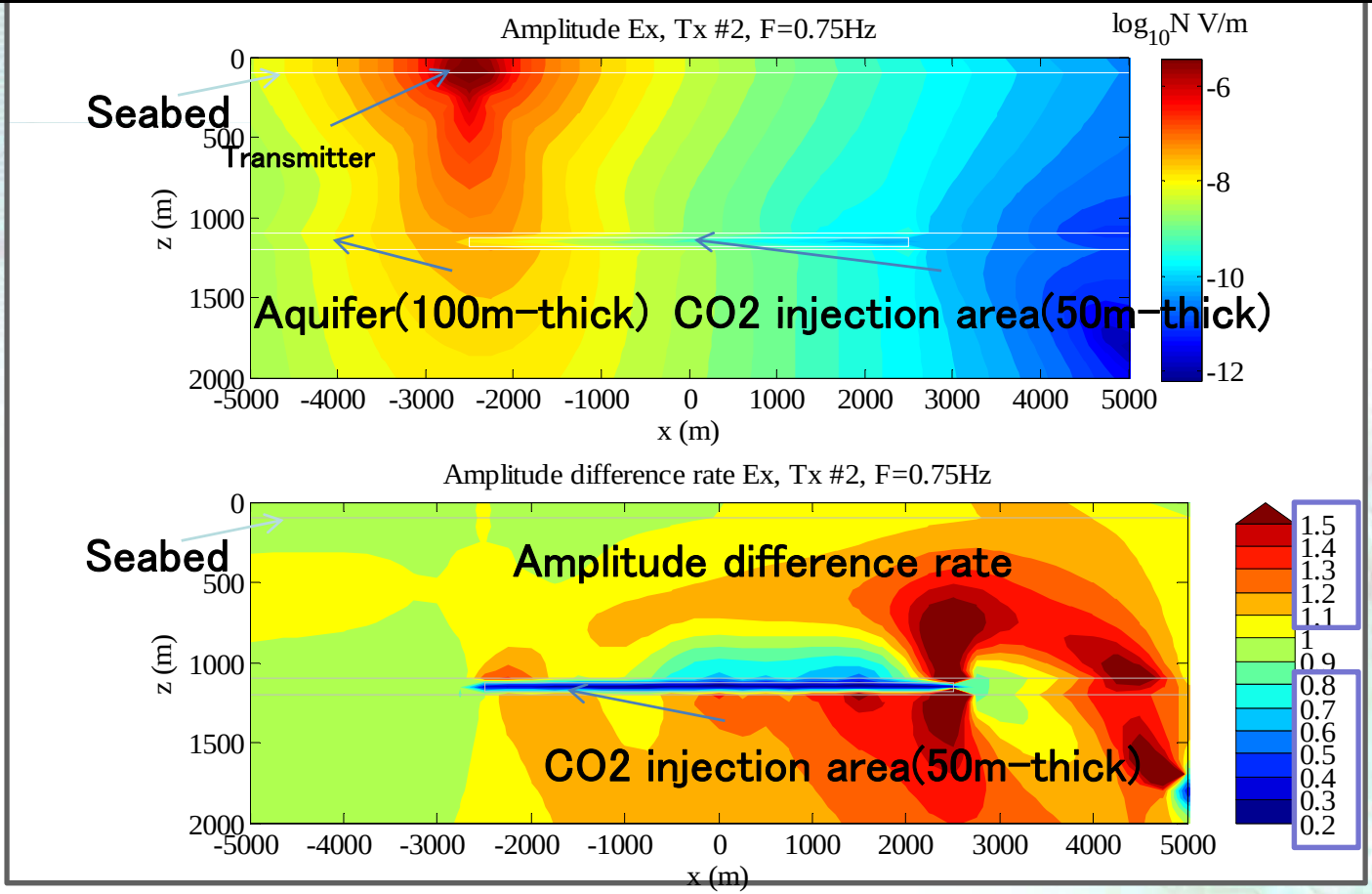
1) Development of Combined CO_2 Monitoring Tools

FY2009:

Data acquisition of both seismic and resistivity methods during CO2 injection into shallow well (50-m depth) , located in AIST, Tsukuba.

Example of calculated Electromagnetic response in offshore



検知可能？

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2) Development of Optimal Modeling Technologies

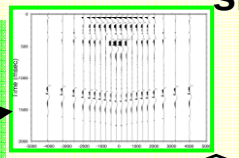
Objective

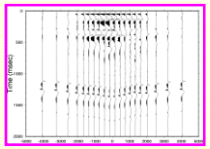
- To obtain a reliable reservoir simulation model to predict long-term CO2 movement behavior
- To utilize geophysical monitoring data, such as seismic, resistivity, SP and gravity methods, for history matching purpose
- We need to develop post-processors calculating observable geophysical data from output (CO2 saturation, T and P changes) of reservoir simulation

Monitoring (Observation data)

Well data
- Downhole pressure
- Downhole Temp. etc.

Geophy. Mon. data
- Seismic
- Resistivity
- Gravity
- SP changes etc.





Direct history-matching is possible

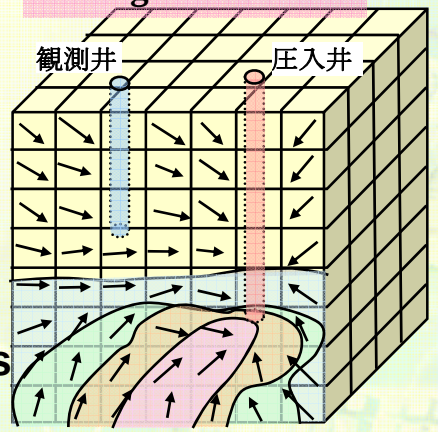
Revision of the simulation model

In order to conduct History-matching

We need Post-processors

Simulation of CO2 injection

P., T.
CO2 saturation
Chemical Contents
Changes



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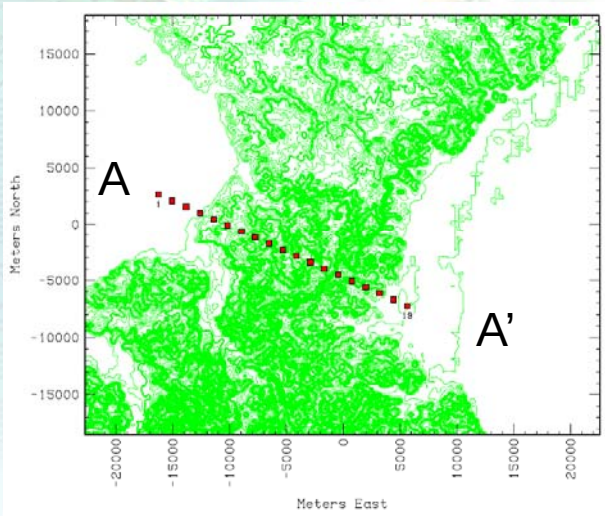
2) Development of Optimal Modeling Technologies (Post-Processors)

FY2009:

Development of Post-processor for Seismic Reflection method



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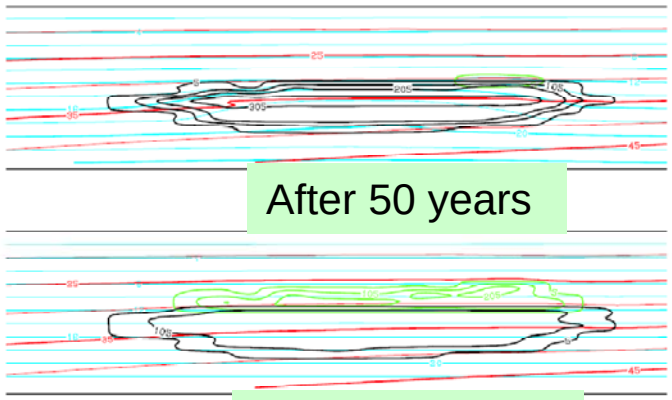
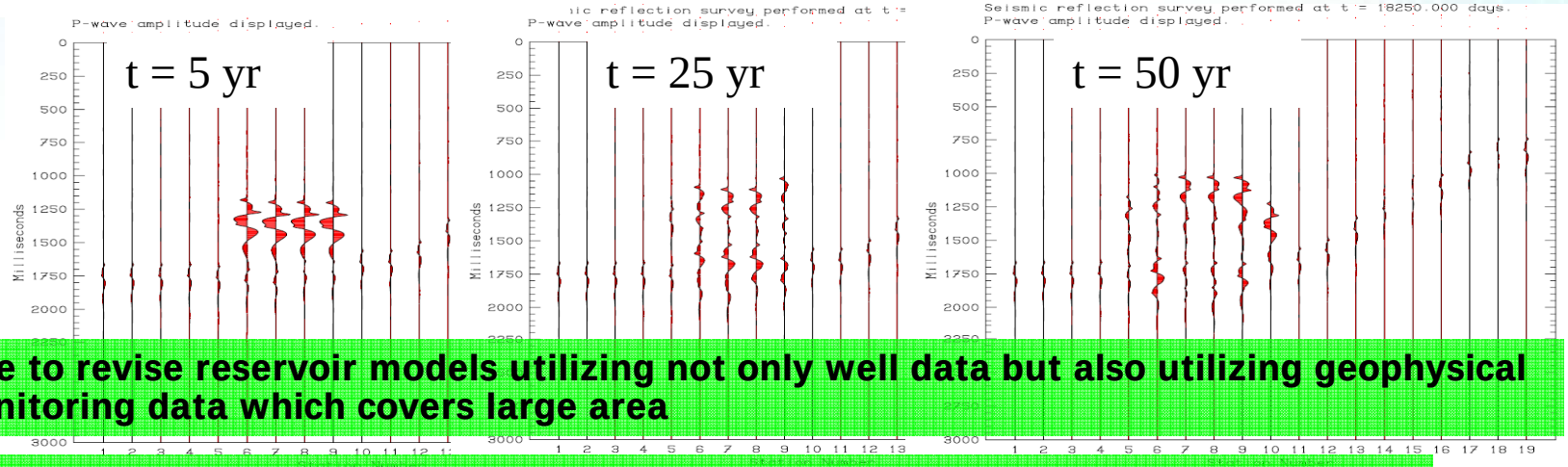


After 50 years

After 1050 years

Prediction of CO2 distribution



Able to revise reservoir models utilizing not only well data but also utilizing geophysical monitoring data which covers large area

Able to plan optimal field design before data acquisition

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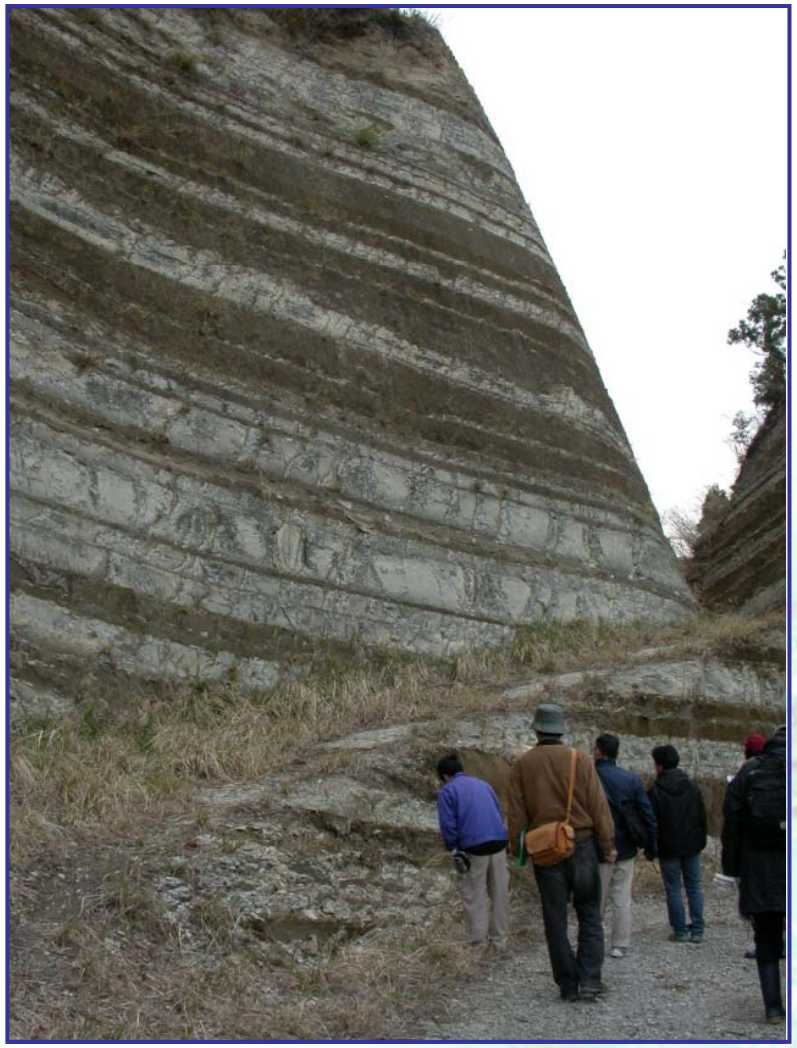
3) CO_2 Trapping Mechanisms in Interbeds of Sandstone and Mudstone

Objective

- To construct hydrological and geological model
- To examine sealing ability of caprocks
- To examine sealing ability and leakage risk of microcracks and faults

Interbeds of Sand- and Mudstone



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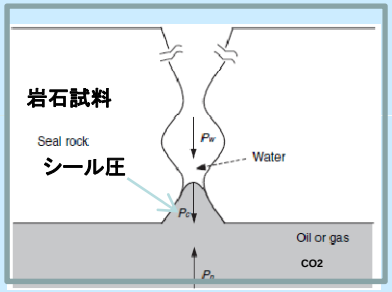
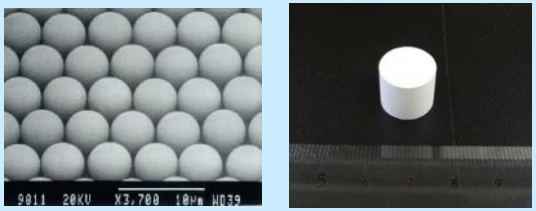
Three research works for the trapping mechanisms

① Measurement of Capillary Pressure





焼結体試料の作製

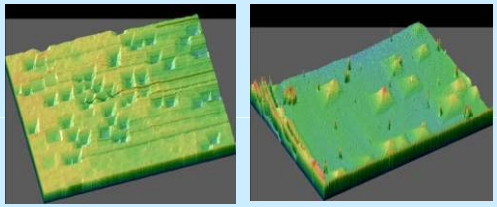
FY2009： Uniform-size artificial specimen

②Measurement of Capillary pressure of Cracks

亀裂なし　亀裂(カッター面)　亀裂(一軸破壊試験)

FY2009： measurement of permeability using specimen including cracks

③ Evaluation of Influence of Chemical Process



鉱物の溶解ー沈殿速度計測

フィールドからの知見取得

FY2009： Evaluation of reaction process of sandstone minerals

Development of Long-term Sealing Ability of individual formation

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Subjects of AIST research works

- ✓ Storage potential estimation around the Japanese Islands
- ✓ Numerical modelling and simulation
- ✓ Laboratory experiments
- ✓ Monitoring tools
- ✓ Ground water data base
- ✓ Geochemical reaction study (Formation water data base)
- ✓ Evaluation of the permeability of micro faults and the seal ability of cap rocks
- ✓ Development of the risk analysis tools.

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Thank you for your attention

We are interested in joint works on CO_2 geological storage in saline aquifer, EOR in oil/gas reservoir and storage in coal seam (ECBM).

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Institute for Geo-Resources and Environment (GREEN)
National Institute of Advanced Industrial Science and Technology(AIST)

View graphs were prepared by
& Shinsuke Nakao and Toshiyuki Tosha,
GREEN