Update on research related to CCS potential reservoir at KIGAM (Korea)

2010. 9. 30

Dae Sung Lee

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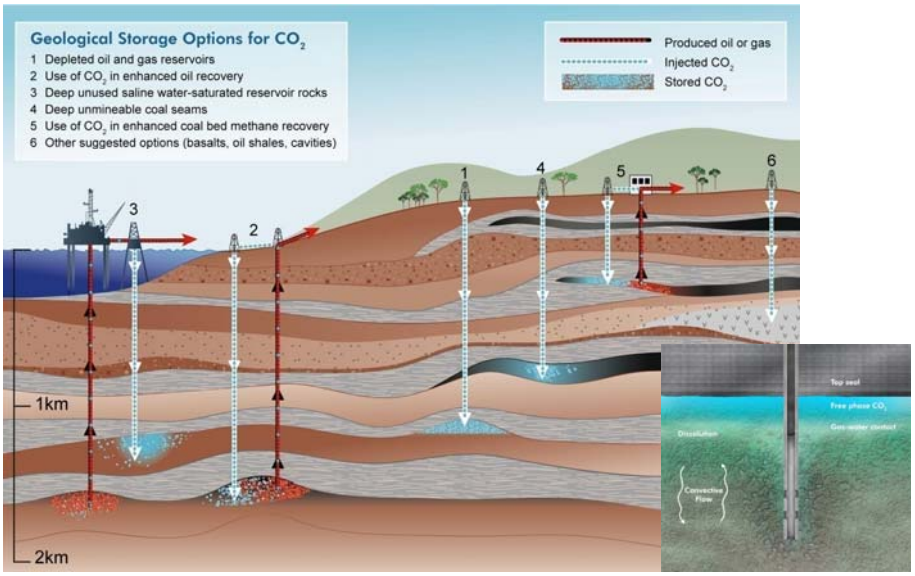
CO2 Geological Sequestration



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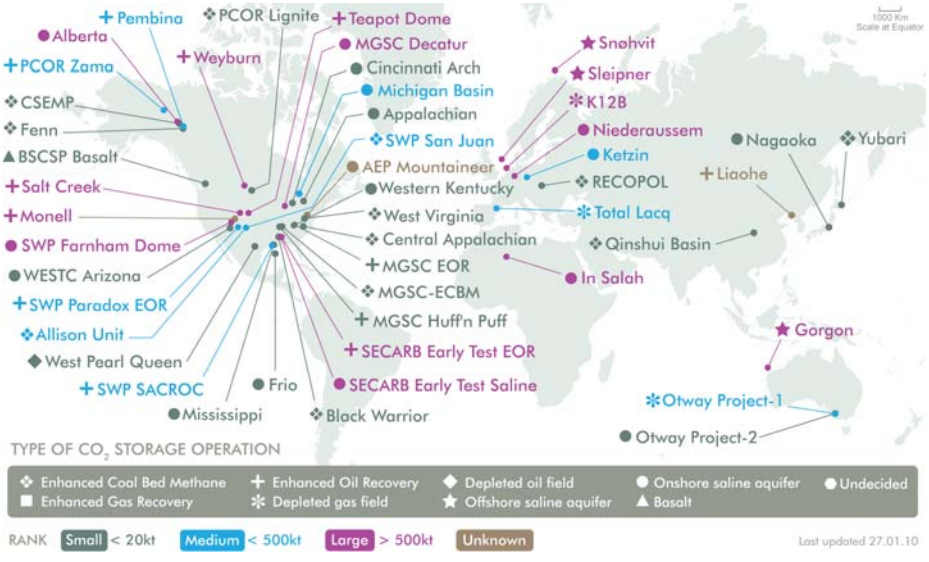
Worldwide CO2 Geological Sequestration Projects



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International Collaboration Project on CCS

Technology Development in Korea

Oversea Advanced Technology

Domestic Policy for CCS
Building Plan for Pilot/Demonstration

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CO2CRC Otway Project

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CO2CRC Otway Project

- **State 1(2003~2009)**
  - Cost: A$40M
  - Target formation: Depleted gas reservoir
  - Injection quantity: 65,000 ton injection
  - Purpose
    - Monitoring and verification a key component
    - Learning include regulation, risk, liability, technology
    - Successful science, ops, communications, community, politics
- **Stage 2(2010~2015)**
  - Estimated Budget: A$20M
  - Target formation: Aquifer
  - Injection quantity: 10,000 ton

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CO2CRC Otway Project Participants (2009. 12 present)

CO2CRC participants

Australian Government Geoscience Australia, CSIRO, Curtin University of Technology, MONASH University, The University of Adelaide, The University of Melbourne, UNSW, Anglo American, bhpbilliton, bp, Chevron, COAL21 Fund, ConocoPhillips, Research Science & Technology, INPEX, 한국지질자원연구원 Korea Institute of Geoscience and Mineral Resources, Mitsui & Co. (Australia) Ltd, NSW Industry & Investment, GNS genesis NZ Resource Consortium, Origin energy, QGR, Queensland Government, RioTinto, sasol, Shell, Solid Energy Coals of New Zealand, Stanwell Corporation Limited, Schlumberger, Total, Victoria Department of Primary Industries, Government of Western Australia Department of Mines and Petroleum, woodside, xstrata coal

Supporting participants: Department of Resources, Energy and Tourism | CANSYD | Meiji University | Process Group | University of Queensland | Newcastle University | U.S. Department of Energy | URS

CRC

Established & supported under the Australian Government's Cooperative Research Centres Program

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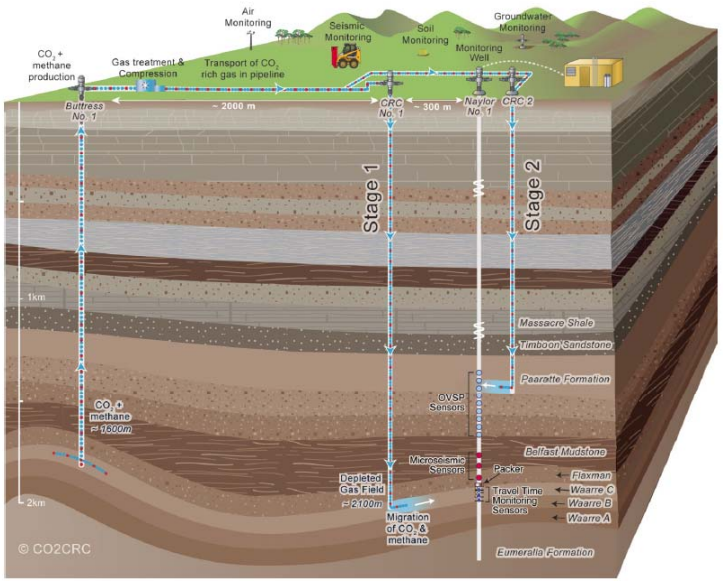
Concept of Otway Project



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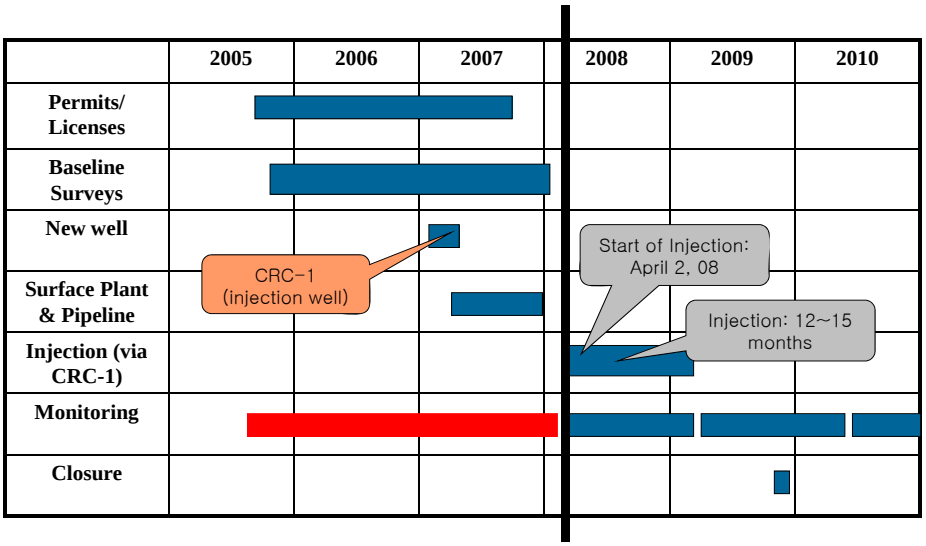
Stage 1 Schedule



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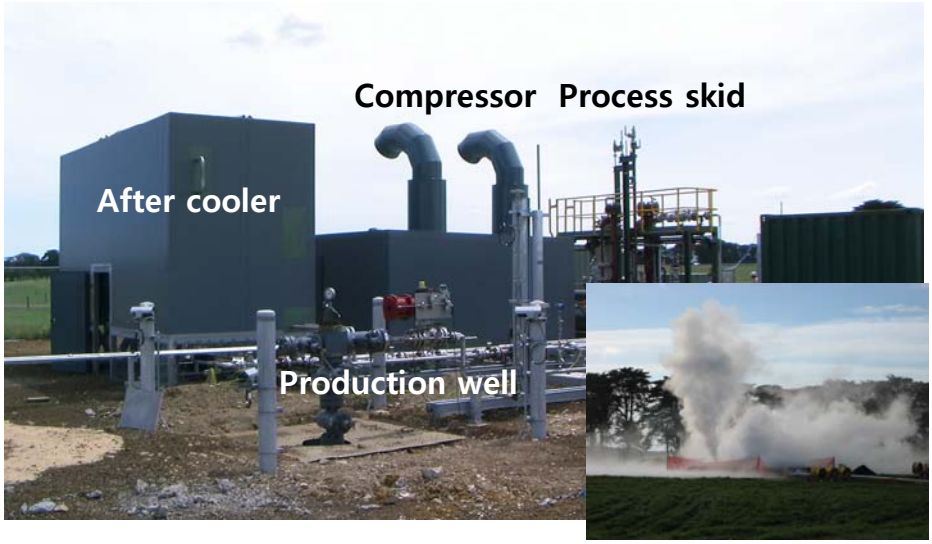
Stage 1 – Buttress 1 (CO2 Production Well) Facilities



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Stage 1 – CRC1 (CO2 Injection Well) Facilities




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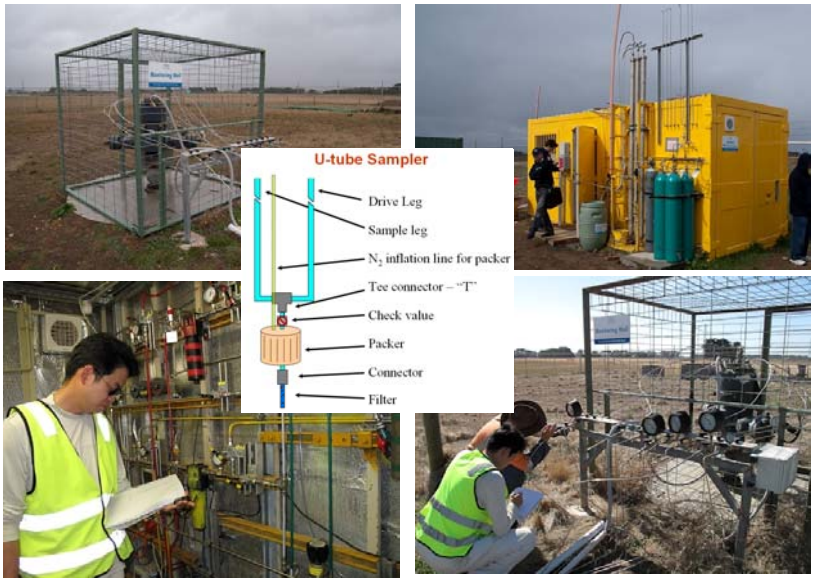
Stage 1 – Naylor 1 (CO2 Monitoring Well) Facilities



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Stage 1 – Core Analysis

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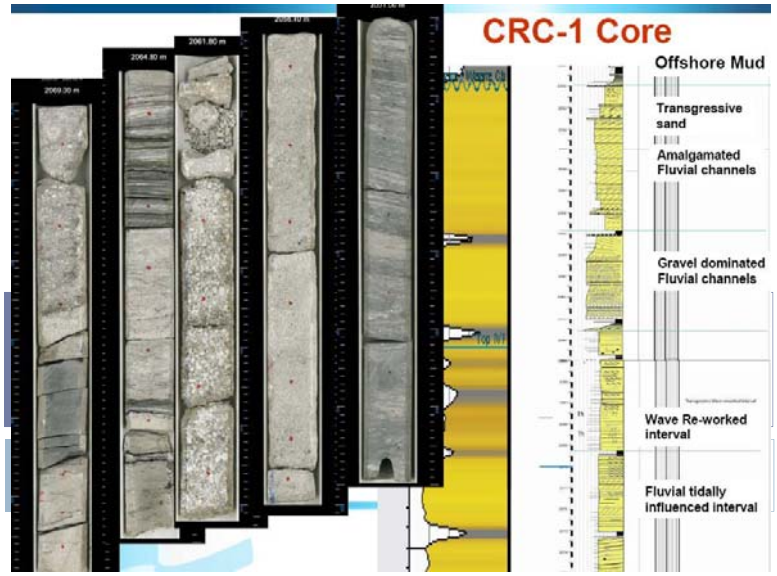
Stage 1 – Core Analysis



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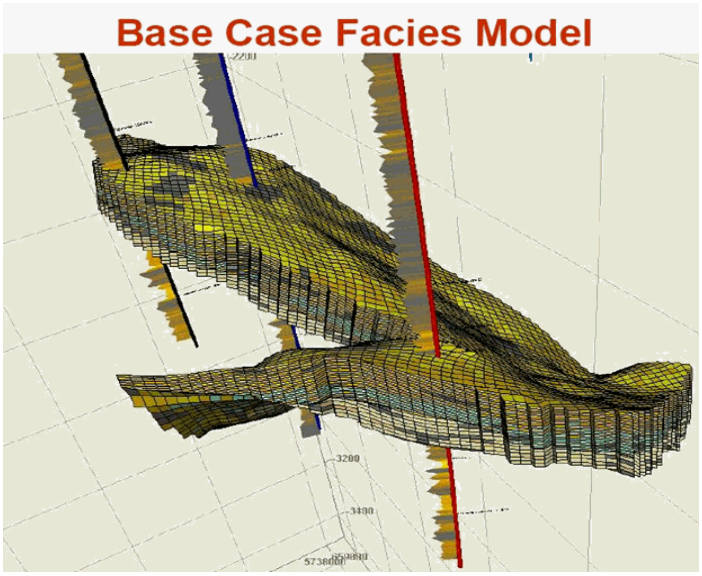
Stage 1 – Static Model Study



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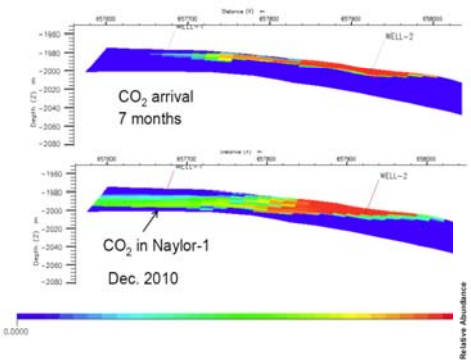
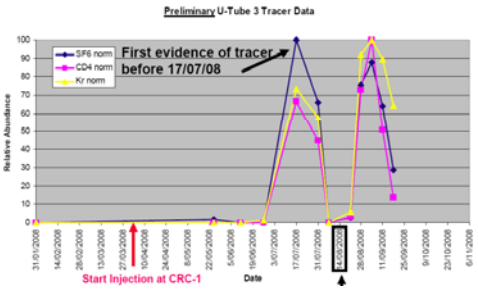
Stage 1 – Dynamic Model Study

Otway Stage 1 (Depleted Gas Field)





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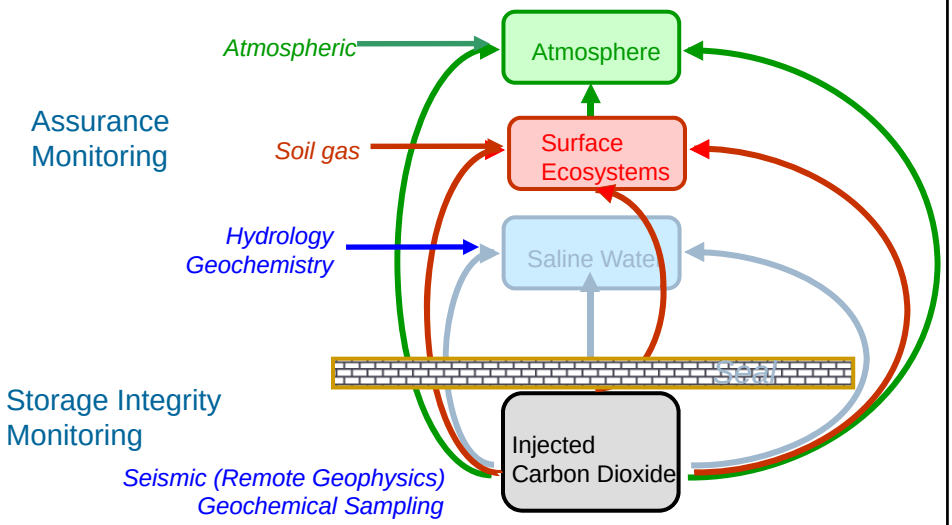
Stage 1 – Monitoring Technology



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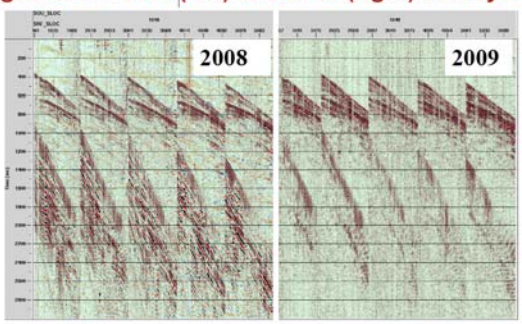
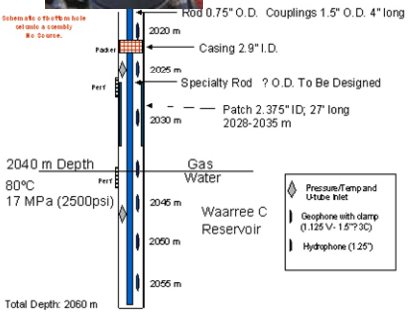
Stage 1 – Monitoring Technology

2009 Participation Seismic Monitoring

Raw data example, the same common shot gather for 2008 (left) and 2009 (right) surveys





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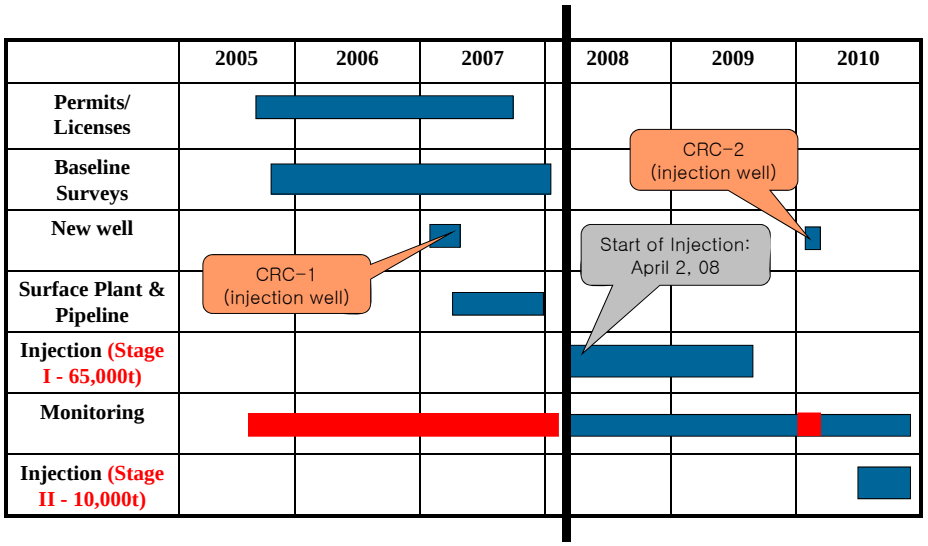
Stage 2 Schedule



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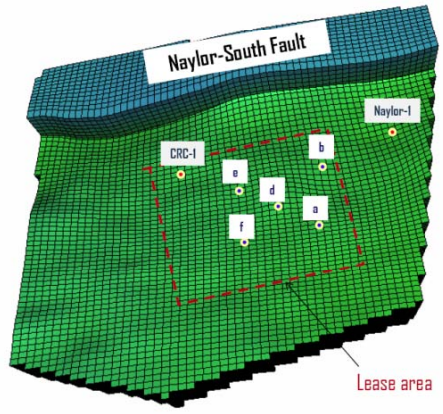
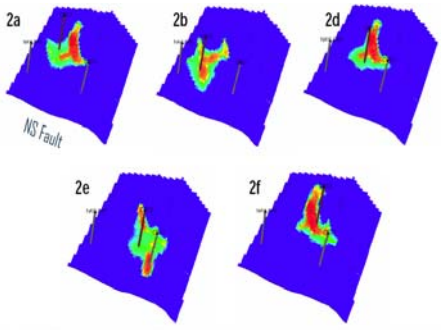
Stage 2 – CRC2 Positioning Drilling Well

Otway Stage 2 (Aquifer)





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Stage 2 – Injection

- Date: 2010.6 ~
- Objective
  - Huff&Puff Test (Residual Trapping)
  - after 1million ton injection

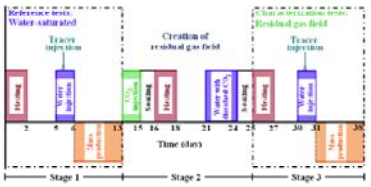
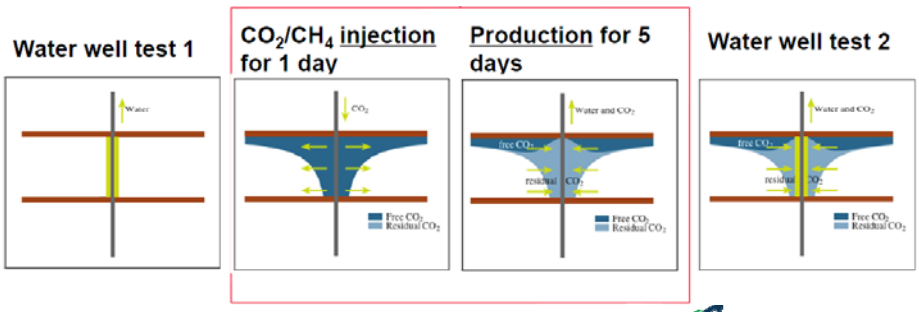


Figure 2. Proposed test sequence (Zhang et al., 2009)



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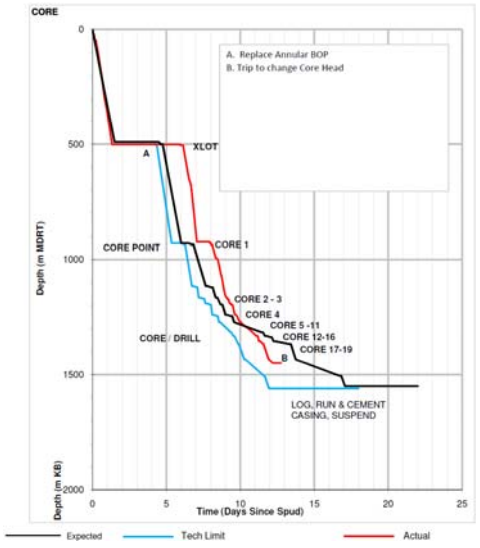
Stage 2 – CRC2 Injection Well Drilling

- Date: 2010.1.28~2.18
- Participants: CO2CRC/KIGAM
- Drilling & Coring
  - ~500 m Drilling/Casing
  - ~929 m Drilling
  - ~1505 m Drilling/Coring
  - ~TD Drilling
  - Logging
  - Casing/Cementing
  - Rig Widrawal



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Stage 2 – Drilling

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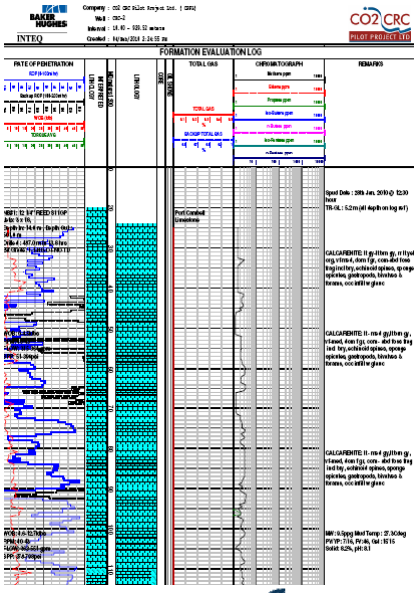
Stage 2 – Mud Logging



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Stage 2 – Coring

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Stage 2 – Well Logging

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Stage 2 – Well Logging

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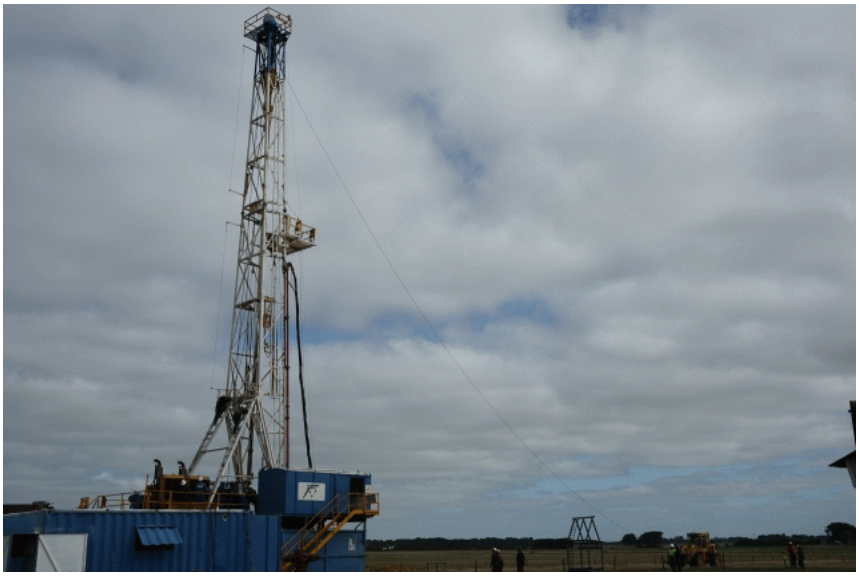
Stage 2 – Rig Withdrawal



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Lessons Learned

- CO2 Geological Sequestration Standardized Selection Criteria
- 4 Stages selection criteria applied
- CO2 underground storage technology, identify key; future promotion pilot experiment
- Drilling, equipment, injection, monitoring, CO2 flow simulation technology, Economic Evaluation

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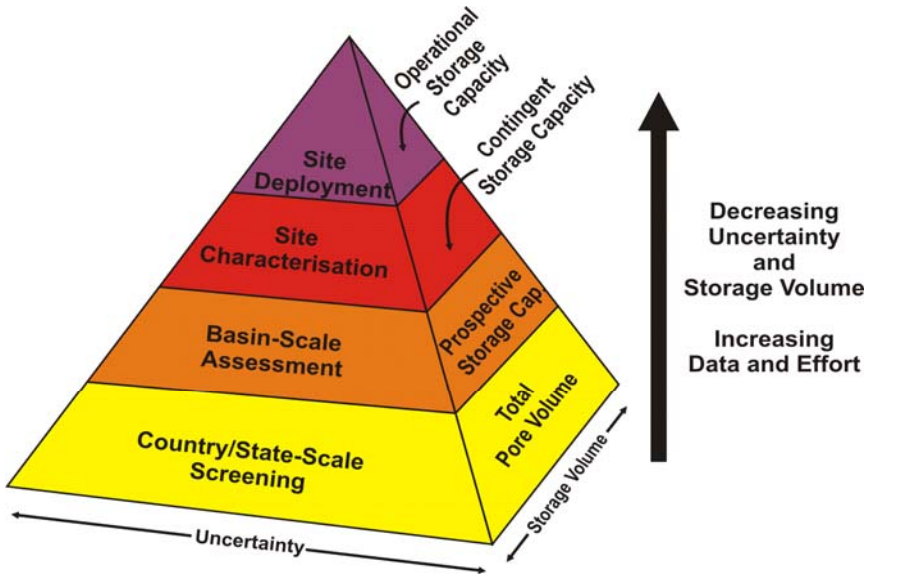
CO2 Storage Selection Criteria: 4 Stages



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Stage 1 Selection Criteria

Criterion		Classes				
		1	2	3	4	5
1	**Tectonic stability**	Very unstable (e.g. subduction)	Unstable (e.g. syn-rift, intermontane, strike-slip)	Intermediate (e.g. foreland)	Mostly stable (e.g. passive margin)	Stable (e.g. cratonic)
2	**Size**	Very small (<1000 km^2)	Small (1000–5000 km^2)	Medium (5000-25000 km^2)	Large (25000–50000 km^2)	Very large (>50000 km^2)
3	**Depth**	Very shallow (<300 m)	Shallow (300–800 m)		Deep (>3500 m)	Intermediate (800–3500 m)
4	**Reservoir-Seal Pairs**	Poor		Intermediate		Excellent
5	**Faulting intensity**	Extensive		Moderate		Limited
6	**Geothermal**	Warm basin (>40°C/km)		Moderate (30–40°C/km)		Cold basin (<30°C/km)
7	**Hydrocarbon potential**	None	Small	Medium	Large	Giant
8	**Maturity**	Unexplored	Exploration	Developing	Mature	Over mature
9	**Coal**	None	Very shallow (<300 m)		Deep (>800 m)	Shallow (300–800 m)
10	**Coal rank**	Anthracite	Lignite		Sub-bituminous	Bituminous
11	**Salts**	None		Domes		Beds
12	**Onshore/ Offshore**	Deep offshore		Shallow offshore		Onshore
13	**Climate**	Artic	Sub-artic	Desert	Tropical	Temperate
14	**Accessibility**	Inaccessible	Difficult		Acceptable	Easy
15	**Infrastructure**	None	Minor		Moderate	Extensive

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Stage 1 – CCS Potential at KOREA

➢ Criteria (Bachu, 2003)

등급 / 기준	5	4	3	2	1
지구조 환경	매우 불안정 <0.000>	불안정 <0.010>	보통 <0.030>	비교적 안정 <0.060>	안정 <0.070>
규모(km²)	<1,000 <0.000>	1,000~5,000 <0.020>	5,000~25,000 <0.030>	25,000~50,000 <0.040>	>50,000 <0.060>
심도(m)	<300 <0.000>	300~800 <0.035>	-	>3,500 <0.055>	800~35,000 <0.070>
저장/덮개 지층조합	없음 <0.000>	거의 없음 <0.013>	보통 <0.039>	발달 <0.065>	매우 발달 <0.090>
암석내 균열	심함 <0.000>	-	보통 <0.027>	-	제한적 <0.080>
수리지질	천부 소규모 유계 혹은 압밀류 <0.000>	-	중간 <0.027>	-	광역 유계, 지형류 혹은 침식류 <0.080>
지온구배 (℃/km)	>40 <0.000>	-	30~40 <0.033>	-	<30 <0.100>
탄화수소 잠재성	없음 <0.000>	작음 <0.006>	중간 <0.018>	큼 <0.036>	매우 큼 <0.060>
(함메탄)탄층 (m)	없음 <0.000>	<300 <0.005>	>3,000 <0.010>	800~3,000 <0.020>	300~800 <0.040>
암염	없음 <0.000>	-	돔형 <0.005>	-	층상형 <0.010>
육상/해양	심해 <0.000>	-	근해 <0.033>	-	육상 <0.100>
기후	극지 <0.000>	아극지 <0.008>	사막 <0.024>	열대 <0.040>	온대 <0.080>
완성도	미 탐사 <0.000>	탐사단계 <0.009>	탐사 <0.027>	개발 단계 <0.062>	개발 <0.080>
접근성	불가 <0.000>	어려움 <0.007>	-	가능함 <0.017>	용이 <0.030>
인프라 기반	없음 <0.000>	약간 <0.011>	보통 <0.033>	좋음 <0.050>	매우 양호 <0.050>

➢ Screening of Onshore Basin

Criteria(max.)	Pohang	Gyungsang	Baekak	Chungnam
지구조 환경(0.070)	3	2	2	2
규모(0.060)	4	2	4	2
심도(0.070)	4	1	1	1
저장/덮개 조합(0.090)	4	4	3	1
암석내 균열(0.080)	3	1	3	4
수리지질(0.080)	3	3	3	3
지온구배(0.010)	5	1	1	1
탄화수소 잠재성(0.060)	4	5	5	5
(함메탄) 탄층(0.040)	4	5	5	4
암염(0.010)	5	5	5	5
육상/해양(0.100)	1	1	1	1
기후(0.080)	1	1	1	1
완성도(0.080)	4	4	5	5
접근성(0.030)	1	1	1	1
인프라 기반(0.050)	1	1	1	1
등급점수합계(1.000)	**0.423**	**0.659**	**0.603**	**0.662**

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Stage 2 Selection Criteria

	Factor	Chance being assessed	Considerations
1	Storage Capacity	will meet the volume requirements of neighboring CO2 sources	Temperature, pressure, area, pore volume
2	Injectivity Potential	Reservoir conditions viable for injection	Porosity, permeability, thickness
3	Site Logistics	Site s economically and Technically viable	Distance from CO2 source, water depth, reservoir depth, overpressure
4	Containment	Seal and trap will work for CO2	Seal capacity and thickness, trap, faults
5	Existing Natural Resources	No viable natural resources in the site that may be compromised	Proven or potential petroleum system, groundwater, coal or other natural resource

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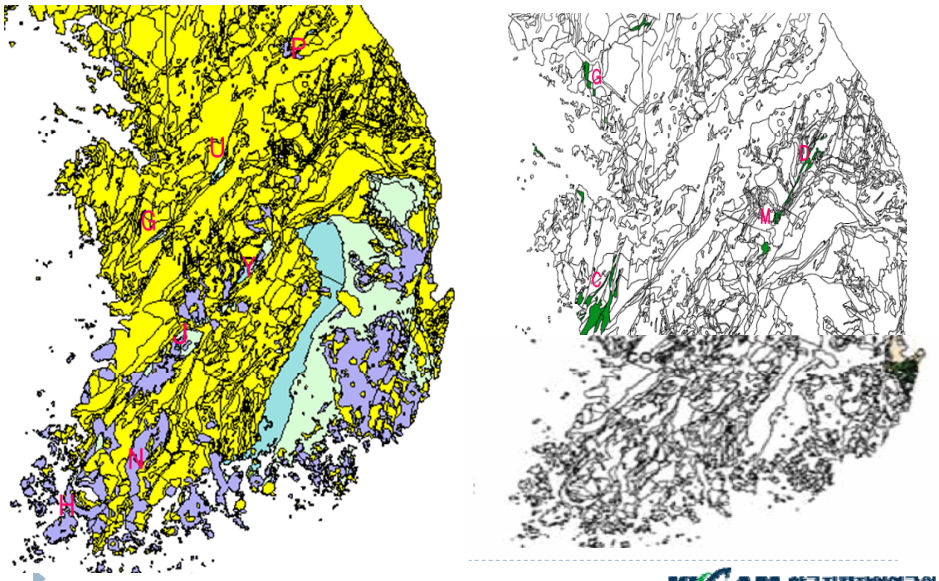
Stage 2



Stage 3 Site Characterization

	Data Needed
1	Maps; structure, hydrology, topography
2	Seismic
3	Well Logs
4	Core Analysis; mineralogy, rock strength
5	Subsurface History; production history, water chemistry
6	Pore Pressure; formation test, leak test
7	Reservoir Characterization; stratigraphy, tectonic, models

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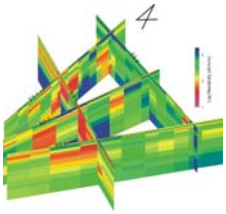
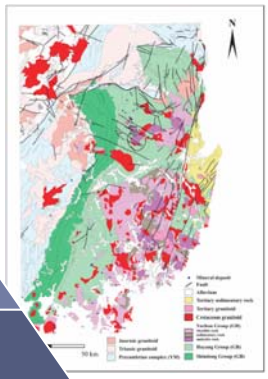
Stage 3

Pilot Test of Geological Storage in Korea

- **Status**
  - No hydrocarbon reservoir on land
  - Presently no possible site that consists of porous reservoir and cap rock

- **Site Selection**
  - Based on deep drilling data for hot spring or geothermal energy
  - Approach
    (1) MT/AMT
    (2) 2D/3D Seismic
    (3) Drilling/logging





Gyeong-Sang Basin