

GEOLOGICAL STORAGE OF CO₂ IN KOREA

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Jeong Chan Kim

KIGAM 한국지질자원연구원
Korea Institute of Geoscience and Mineral Resources

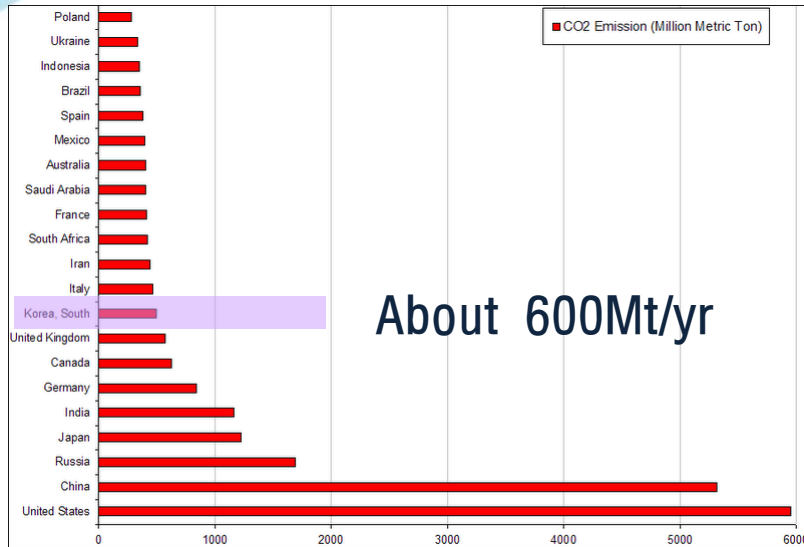


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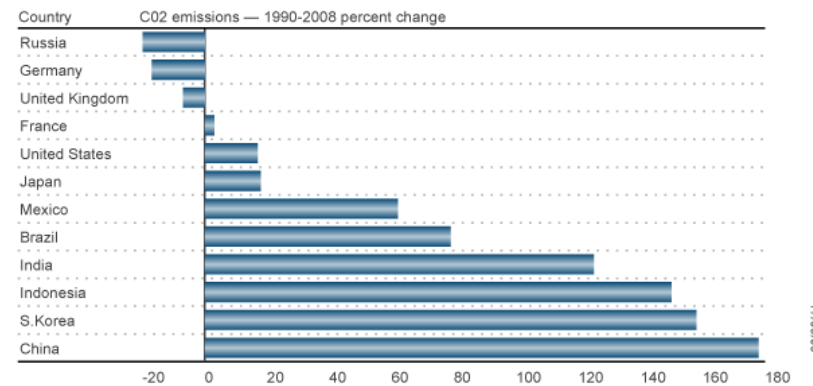
- Introduction
- Current Status of CO₂ Geologic Storage Research
 - Site Screening and Selection
 - Basic Lab. and Field Research
- Future Plans of CO₂ Geological Storage

CO₂ Emission Statistics



Growth in CO₂ emissions — 1990-2008

G5 countries versus world's largest developing economies



Source: IWR

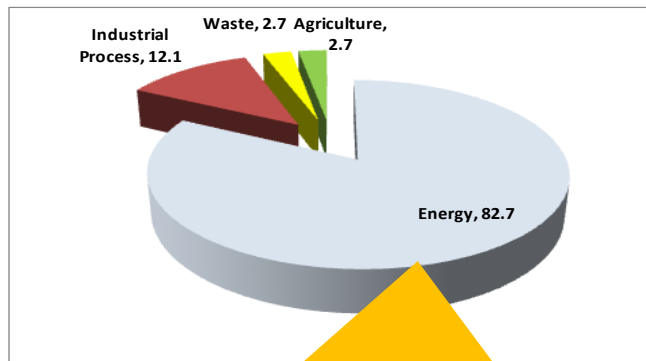
Reuters graphic/Claire Morel

REUTERS

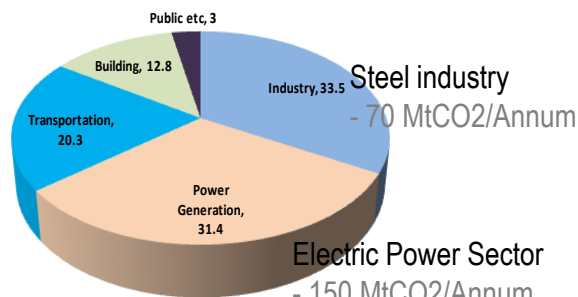
	BAU	2005
Scenario 1	-21%	+8%
Scenario 2	-27%	0
Scenario 3	-30%	-4%

Major CO₂ Emission Sources

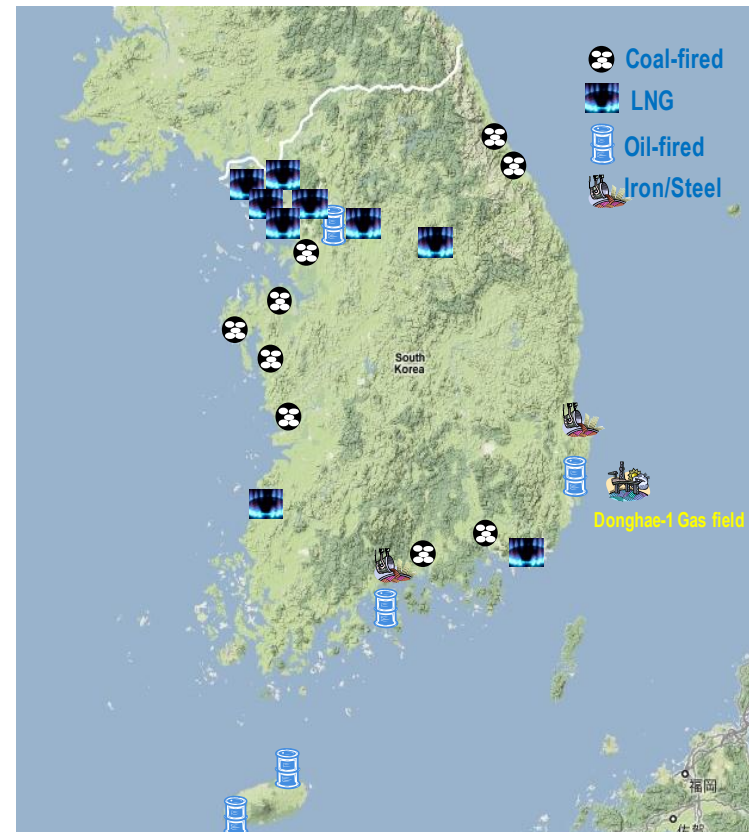
Emission by Sector




Energy Sector

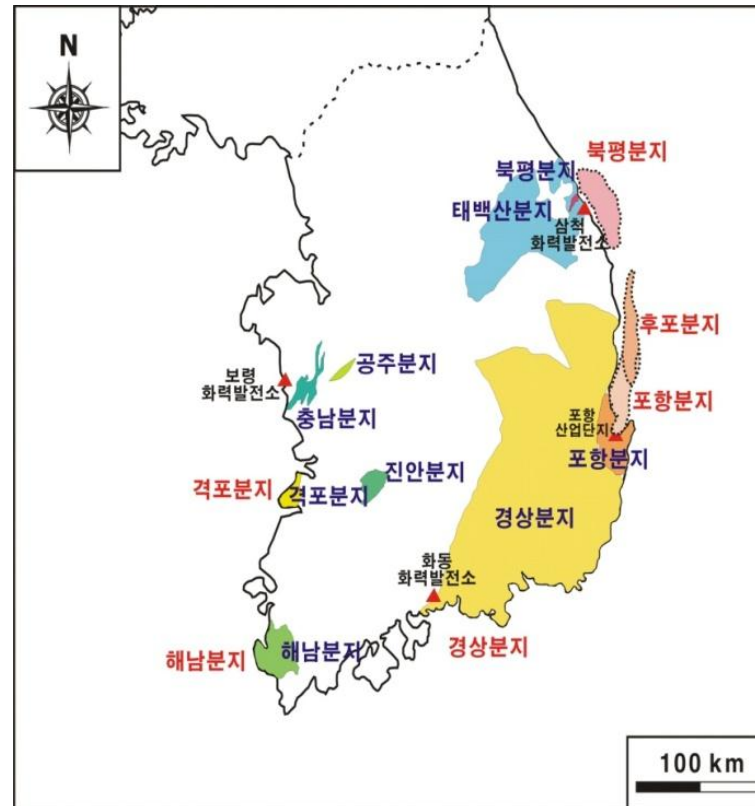


Electric Power Sector
- 150 MtCO₂/Annum
- 25% of GHG Emission
Coal-firing Power
- 115 MtCO₂/Annum

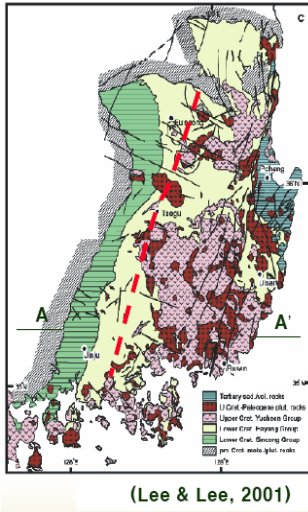


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- In Korea, the most important point for CCS launching is to find suitable storage sites (reservoirs).
 - There is no large-scale (commercial-scale) oil or gas field in the Korean Peninsula, although recently several small-scale gas fields have been found in the offshore region.
 - The Korea Government tries to not only develop CO₂ storage technologies (injection, monitoring etc), but also to find good CO₂ reservoirs.

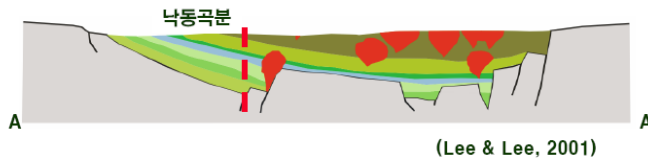
Onshore/nearshore sedimentary basins



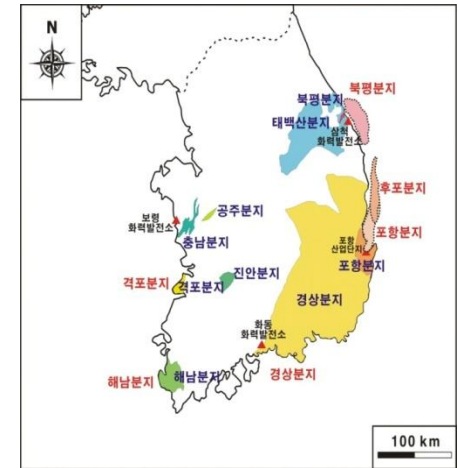
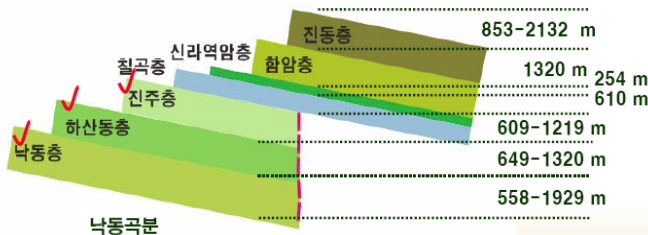
Assessment of Storage Potential (Gyeongsang Basin)



1) 경상분지의 단면도



2) 지층 분포의 단순화

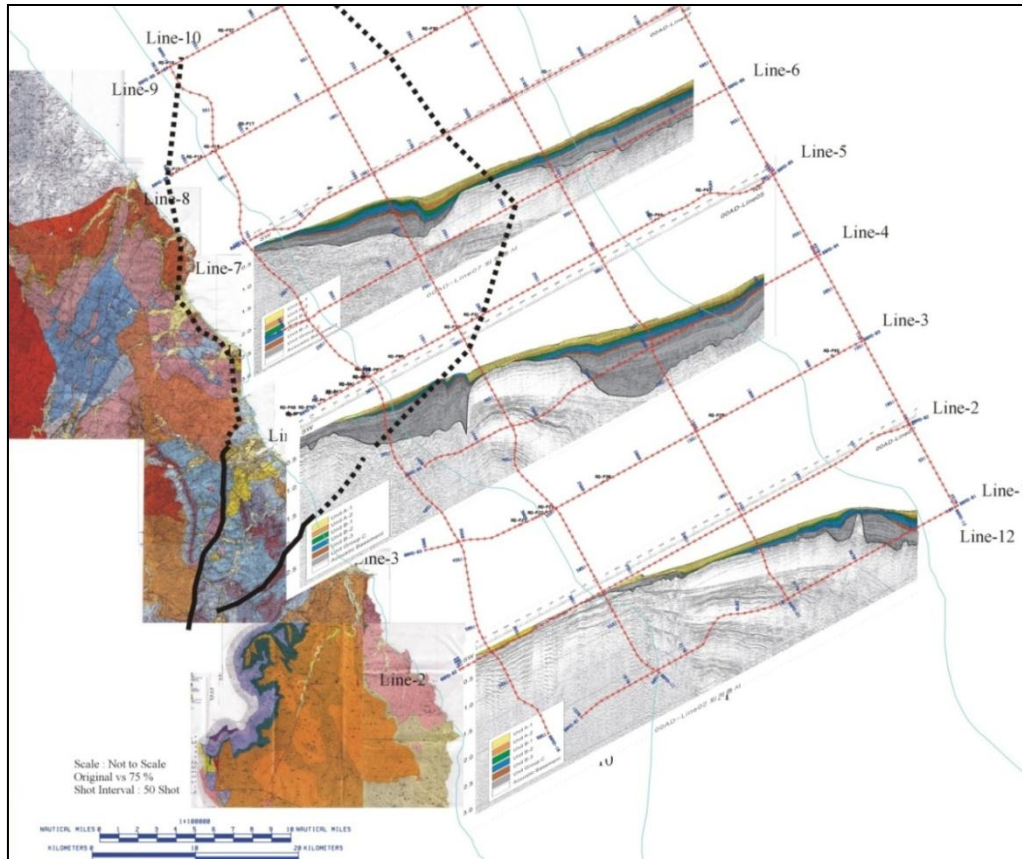


		800 m ~ 예상 최대 심도			800 m - 2000 m		
		잠재 저장암의 부피 (km ³)	잠재 저장 능력 (백만톤)	편차 (백만톤)	잠재 저장암의 부피 (km ³)	잠재 저장 능력 (백만톤)	편차 (백만톤)
신동층단	진주층	1,160	97	635	358	208	146
	하산동층	3,065	2,369	1,677	536	299	212
	낙동층	4,605	2,776	2,136	783	341	262

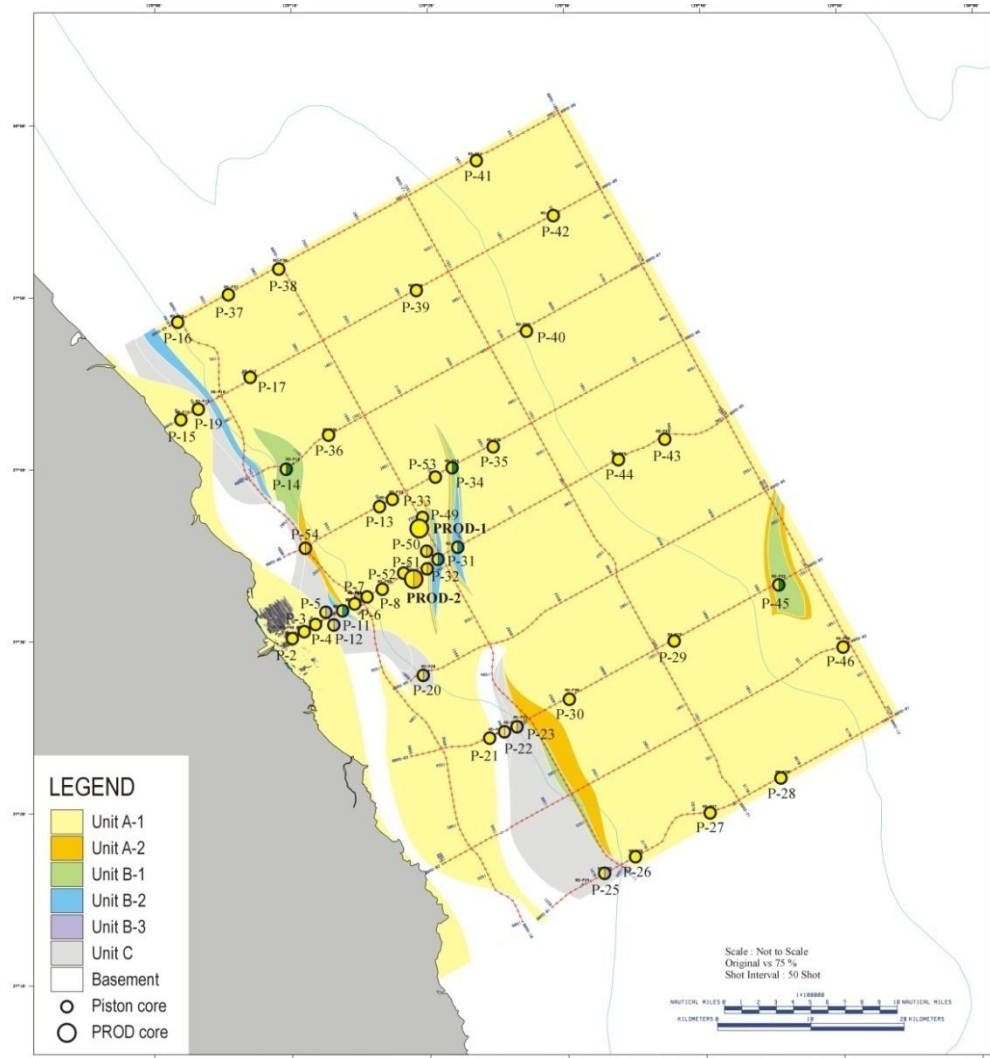
(Source: Lee, SNU)

Bukpyeong Basin

Cenozoic Miocene–Pliocene Deposits



Bukpyeong Basin



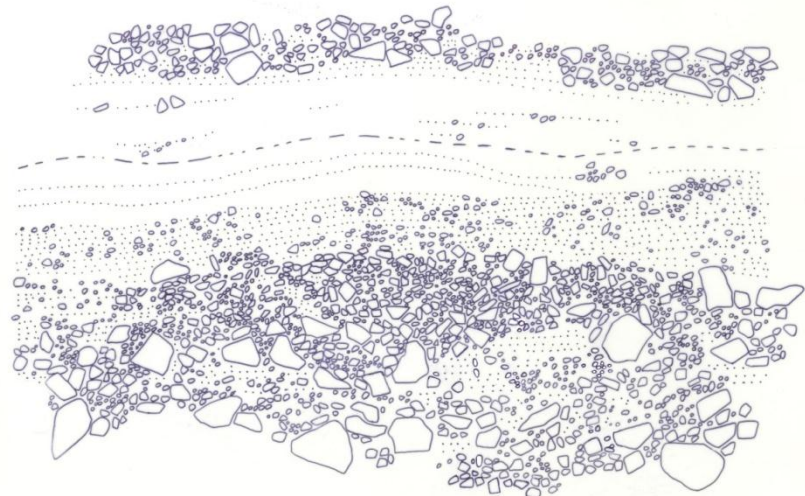
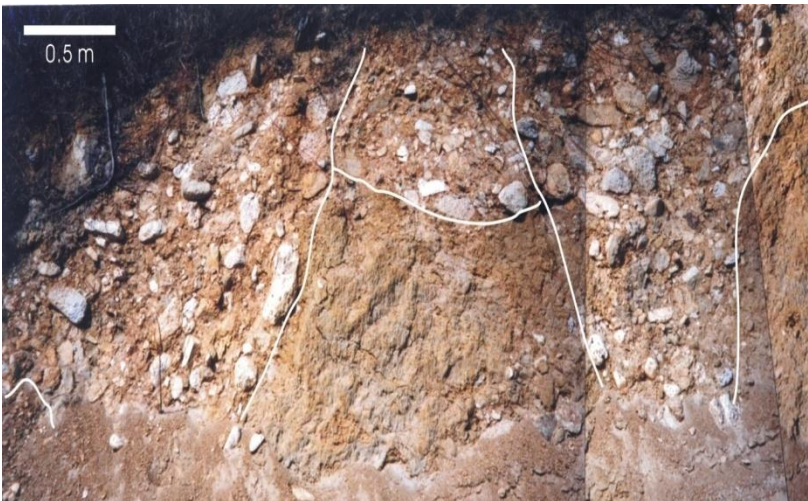
Bukpyeong Basin

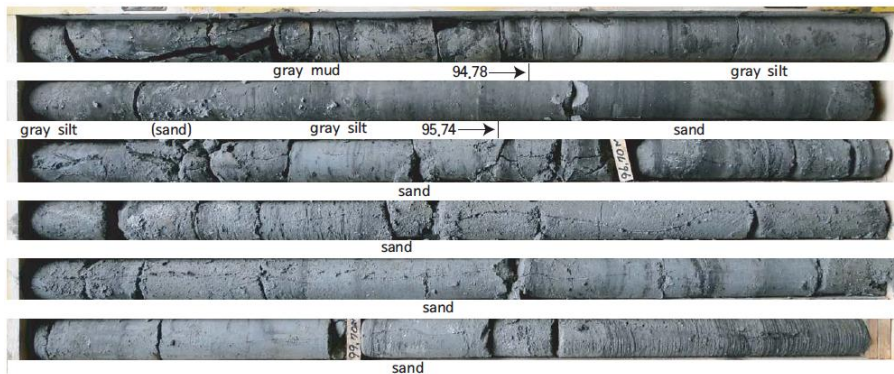
AGE	SEISMIC STRATIGRAPHIC UNIT		CONFIGURATION	CORE	LITHOLOGY	
Quaternary	Unit Group A	Unit A-1	Subunit A-1 a	continuous, high-amplitude, onlap	PROD-1	Mud
			Subunit A-1 b	transparent	PROD-2	Sand
			Subunit A-1 c	continuous, low-amplitude, erosional truncation	PROD-2	Sand/Mud
		Unit A-2	Subunit A-2 a	continuous, low-amplitude, erosional truncation	PROD-2	Sand/Mud
			Subunit A-2 b	continuous, high-amplitude, onlap	00ADP-50, 51, 52	Sand
Tertiary	Unit Group B	Unit B-1	Subunit B-1 a	continuous, intermediate-amplitude, onlap	00ADP-14, 34, 45	Mud
			Subunit B-1 b	continuous, low-amplitude, prograding		Sand/Mud
		Unit B-2	Subunit B-2 a	discontinuous, low-amplitude	00ADP-31, 32	Sand/Mud
			Subunit B-2 b	chaotic, transparent		Sand
		Unit B-3		continuous, low-amplitude, onlap		Sand
	Unit Group C	Unit C-1		continuous, intermediate-amplitude, onlap	00ADP-05, 12, 20, 23, 25	Sand/Mud
		Unit C-2		chaotic, transparent		Conglomerate/Sand
		Unit C-3		continuous, low-amplitude		Sand/Mud
		Unit C-4		continuous, high-amplitude, prograding		Conglomerate/Sand
	Upper Paleozoic	Pyongan Group				Sand/Mud
Lower Paleozoic	Choson Supergroup				Limestone/Shale	
Precambrian					Granitic gneiss	

Bukpyeong Basin

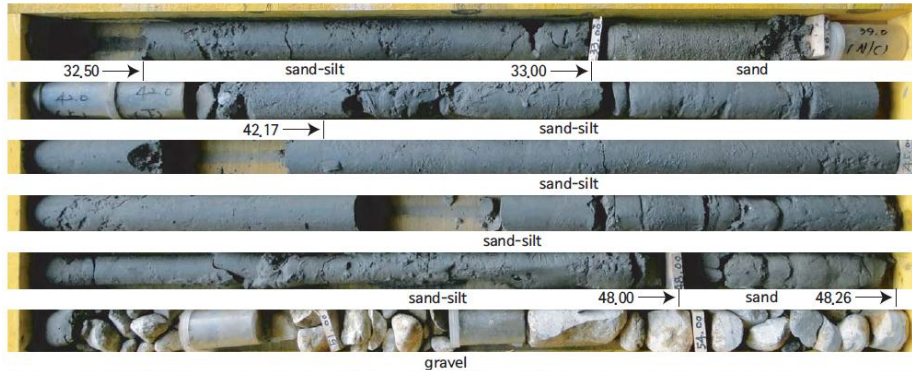
AGE	SEISMIC STRATIGRAPHIC UNIT			PREDICTED LITHOLOGY	SUBBOTTOM UNIT	PREDICTED P-WAVE VELOCITY
Quaternary	Unit Group A	Unit A-1	Subunit A-1a	Mud	Unit a	1500
			Subunit A-1b	Sand	Unit b	1650
			Subunit A-1c	Sand/Mud		
		Unit A-2	Subunit A-2a	Sand/Mud		
			Subunit A-2b	Sand		
Tertiary	Unit Group B	Unit B-1	Subunit B-1a	Mud	Unit c	1550
			Subunit B-1b	Sand/Mud	Unit d	1650
		Unit B-2	Subunit B-2a	Sand/Mud		
			Subunit B-2b	Sand	Unit e	1700
	Unit B-3		Sand			
	Unit Group C	Unit C-1		Sand/Mud	Unit f	1800
		Unit C-2		Conglomerate/Sand		
		Unit C-3		Sand/Mud		
Unit C-4			Conglomerate/Sand	Unit g	1900	
Upper Paleozoic	Pyongan Group			Sand/Mud		4275
Lower Paleozoic	Choson Supergroup			Limestone/Shale		5925
Precambrian				Granitic gneiss		3750

Unconsolidated, coarse-grained sediments – possible reservoir?

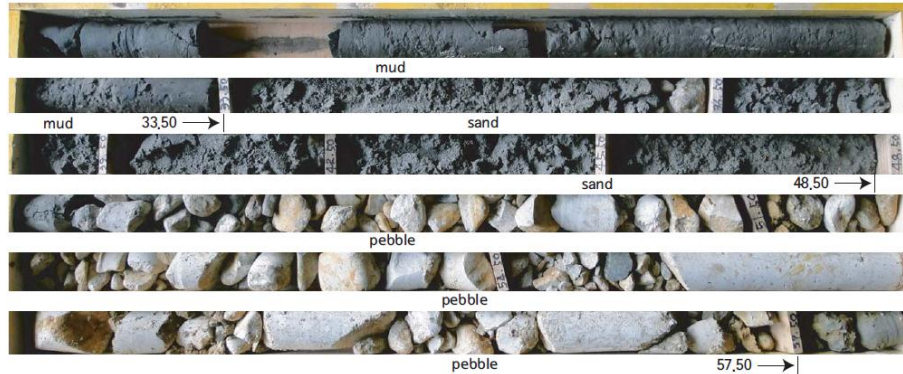




Bukpyeong
Site ID: BH-1
Box #: 9

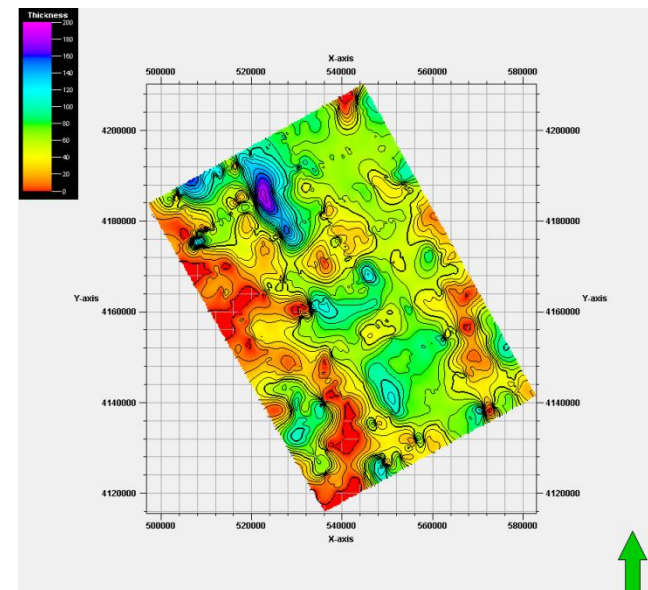
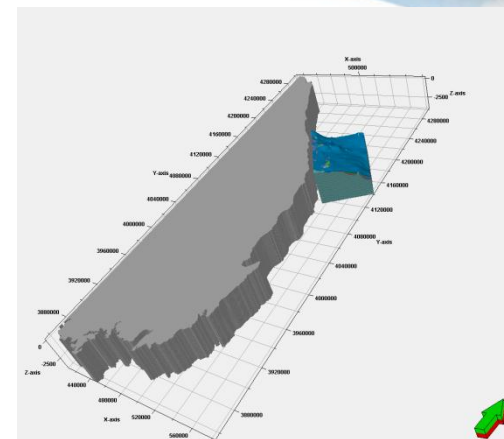
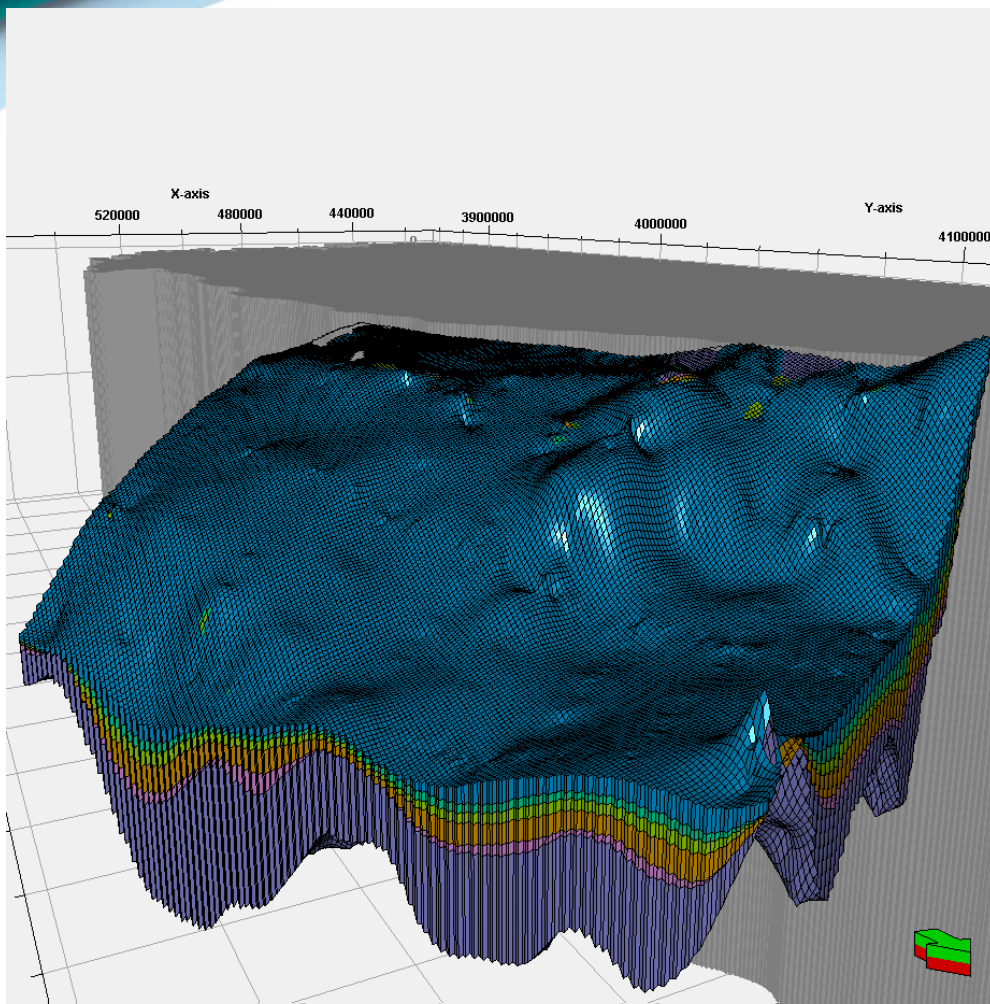


Bukpyeong
Site ID: BH-2
Box #: 2



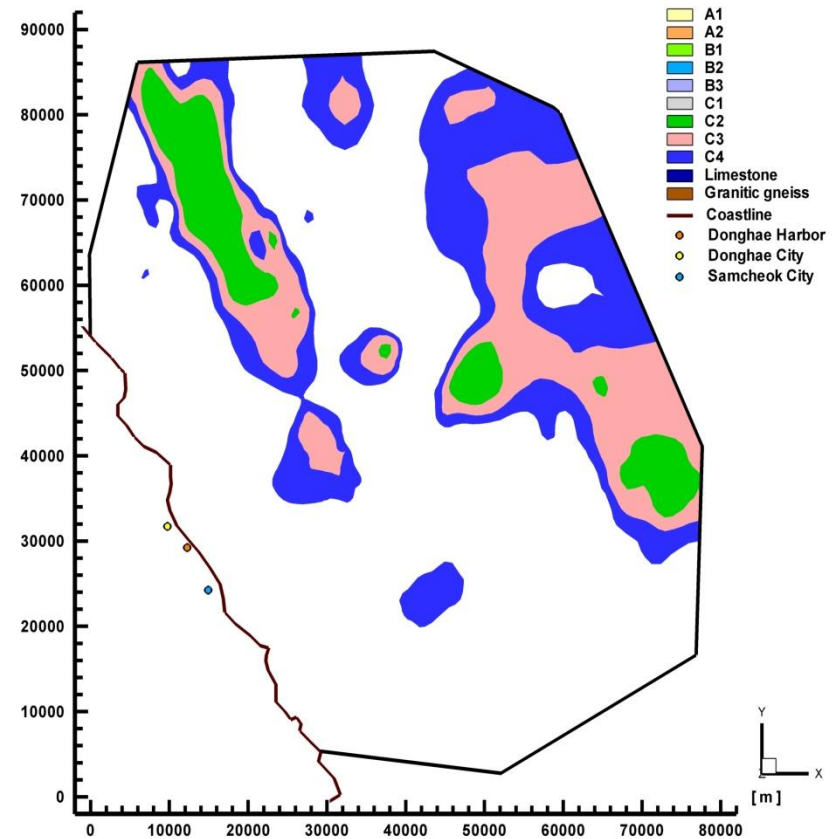
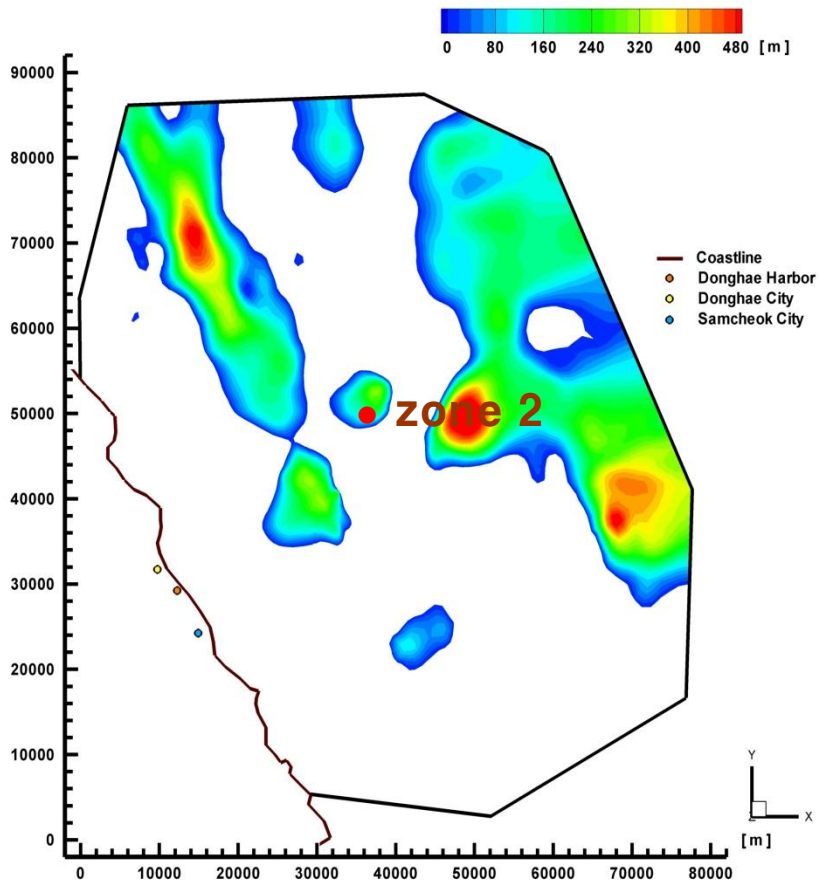
Bukpyeong
Site ID: BH-3
Box #: 2

Bukpyeong Basin



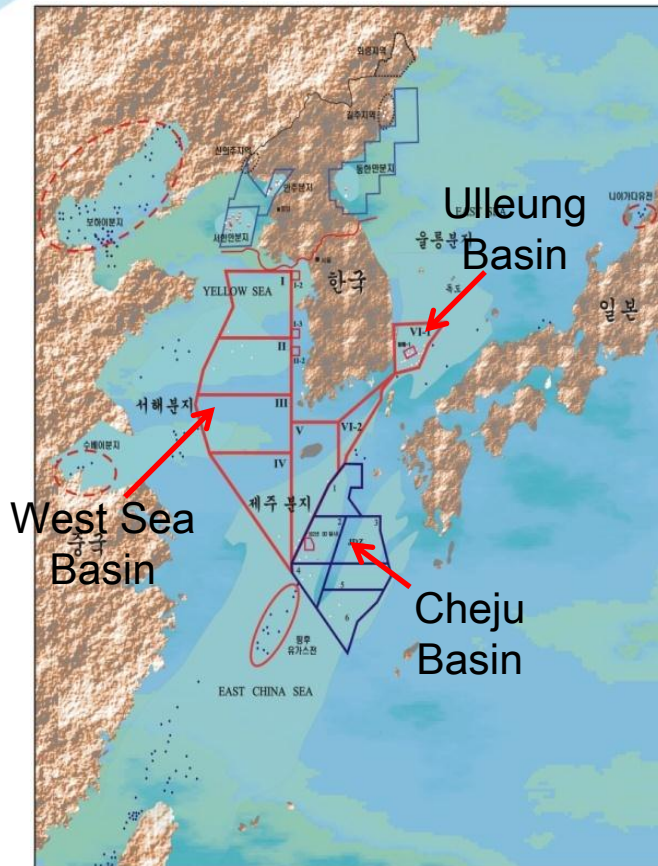
3D Stratigraphic model

Bukpyeong Basin



● Potential CO₂ Storage Capacity: 900 Mton

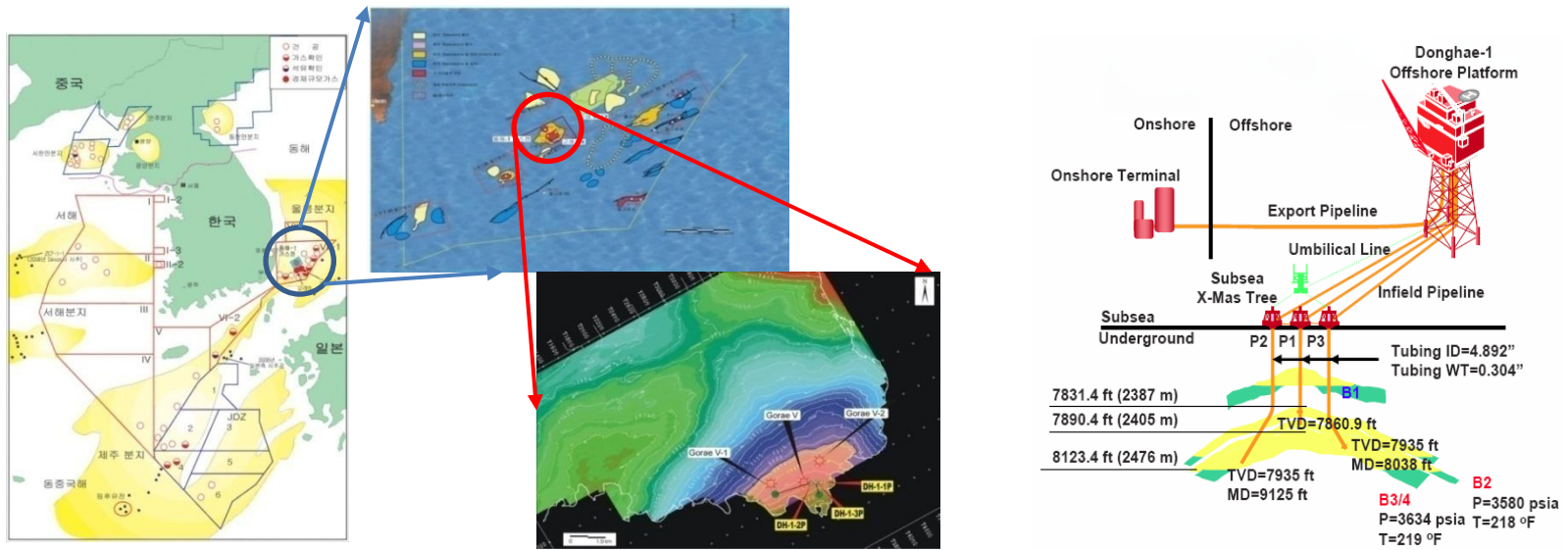
Offshore Sedimentary Basins



- Three offshore sedimentary basins
 - West Sea Basin
 - Cheju Basin
 - Ulleung Basin
- Exploration
 - Partnered with international oil companies (91,079 L-km, 20 exploratory wells since 1969)
 - KNOC (Korea National Oil Corporation) (186,278 L-km, 23 exploratory wells since 1983)
- Production
 - Discovered gas in Ulleung Basin (250 BCF & 1.7 mmbbls condensate)

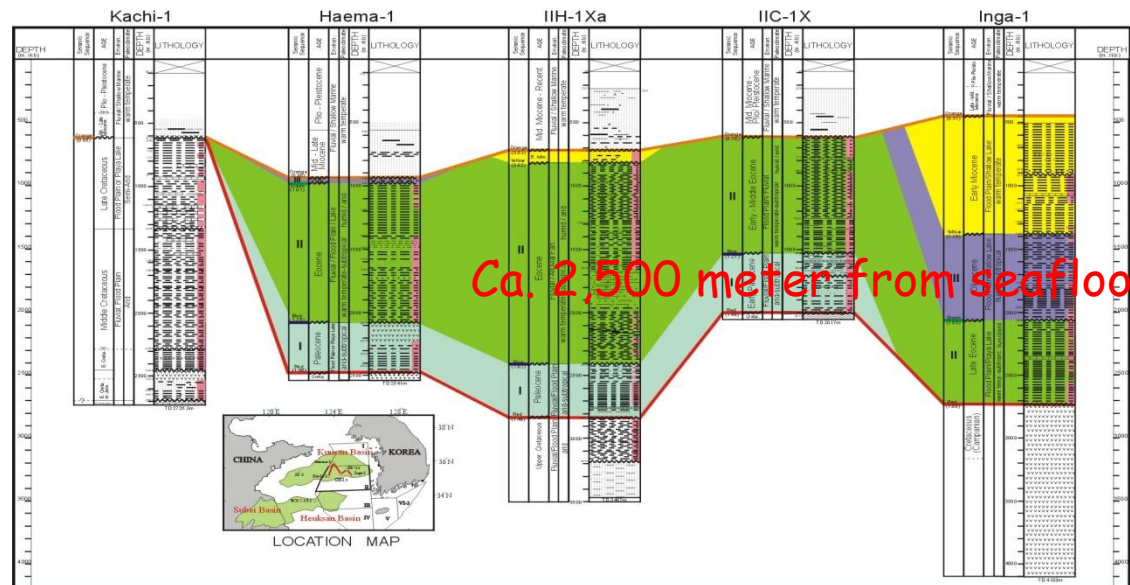
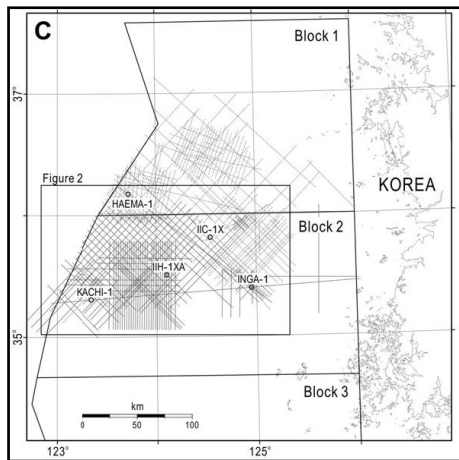
Gorae-V Structure: Potential CO₂ storage site

- Located at the southwest margin of the Ulleung basin
- Subdivided into 5 sandy layers by intervening shale layers
- Storage capacity evaluation by KIGAM
 - - Total pore volume: 1.0 bn m³
 - - Effective capacity: 150 MtCO₂

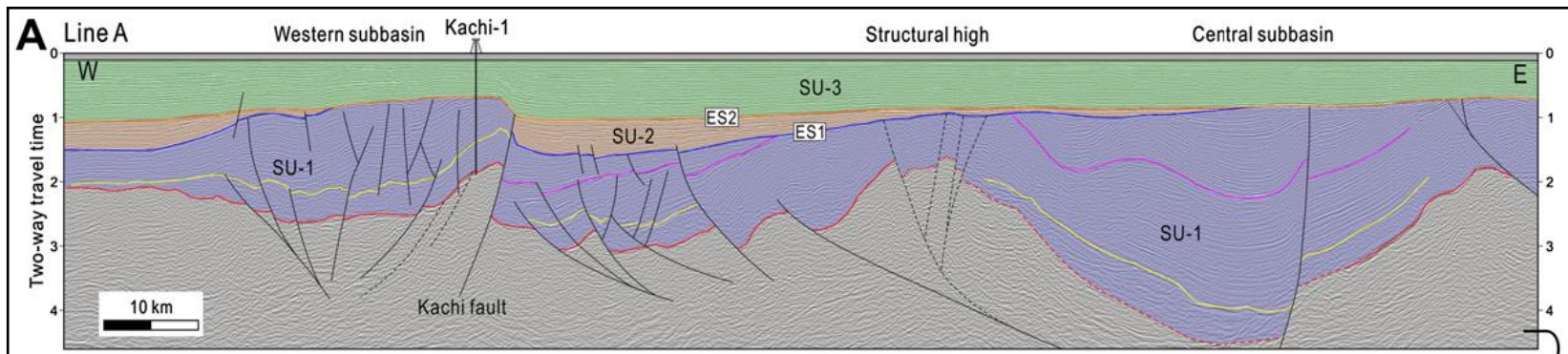


Tertiary Kunsan Basin

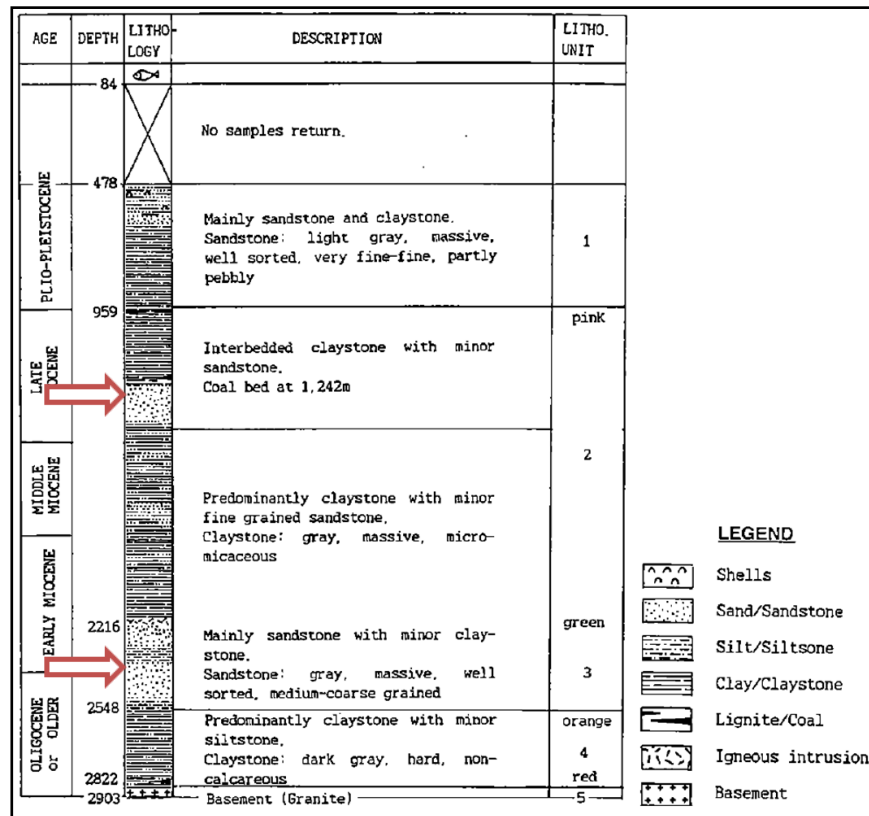
Stratigraphic Correlation of the Tertiary Kunsan Basin



Ca. 2,500 meter from seafloor



Tertiary Jeju Basin

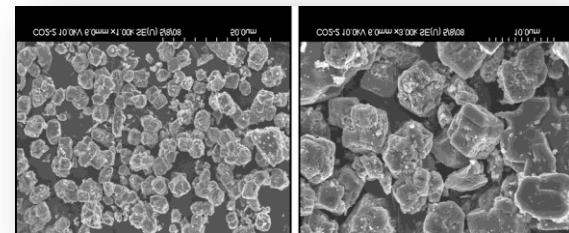
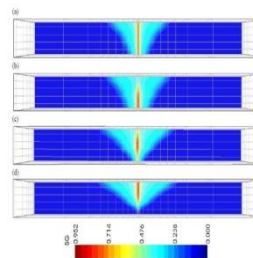
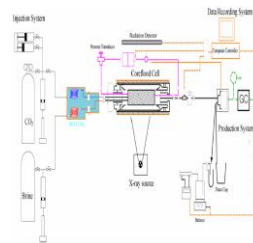
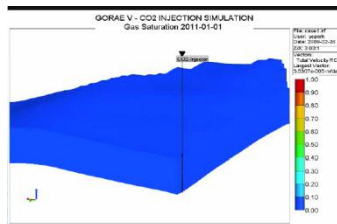


Summary for site screening

- 1. Site screening for onshore/nearshore sedimentary basins is led by KIGAM.**
- 2. Some basins (including Gyeongsang Basin and Bukpyeong Basin) might have enough CO₂ storage potential for pilot tests.**
- 3. Site screening for offshore sedimentary basins is led by KNOC.**
- 4. Offshore sedimentary basins have a relatively good CO₂ storage potentials, but more surveys are needed for accurate CO₂ storage site characterization.**

Basic Research of CO₂ Storage

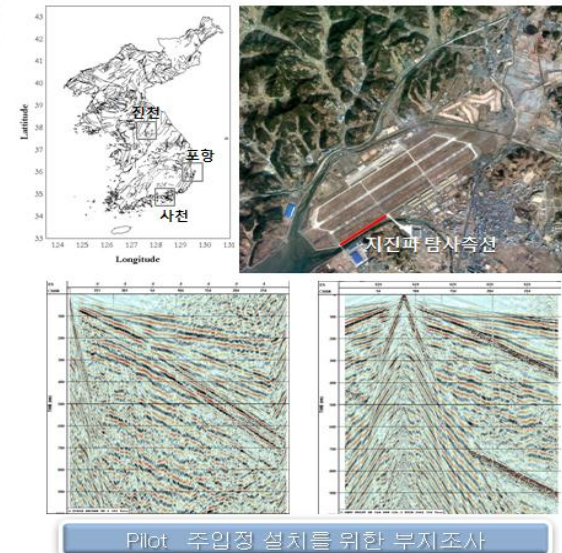
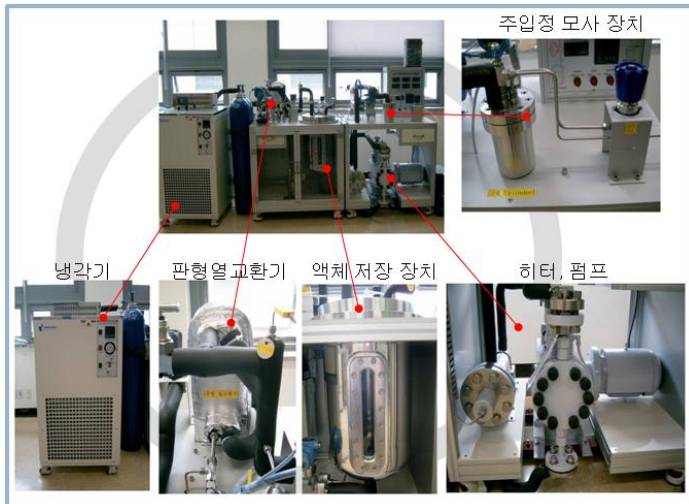
1. Development of CO₂ injection system
2. Pre-injection simulation of CO₂ reaction & migration
3. Geophysical basic research: resistivity & seismic tomography
4. Geochemical basic research: circulation of deep groundwater & survey of carbonated water
5. Mineral carbonation



Development of CO₂ Injection System

- ✓ Design of CO₂ injection pump
- ✓ Design of lab. scale aboveground CO₂ injection system
- ✓ Design of CO₂ injection well
- ✓ Site survey for installment of injection well
- ✓ Planning of pilot injection well operation

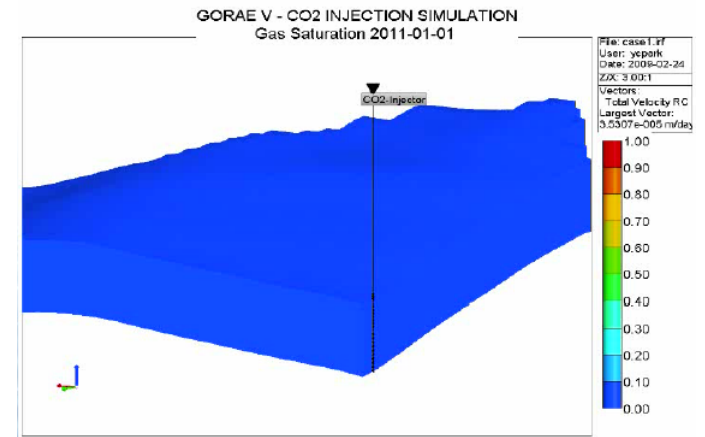
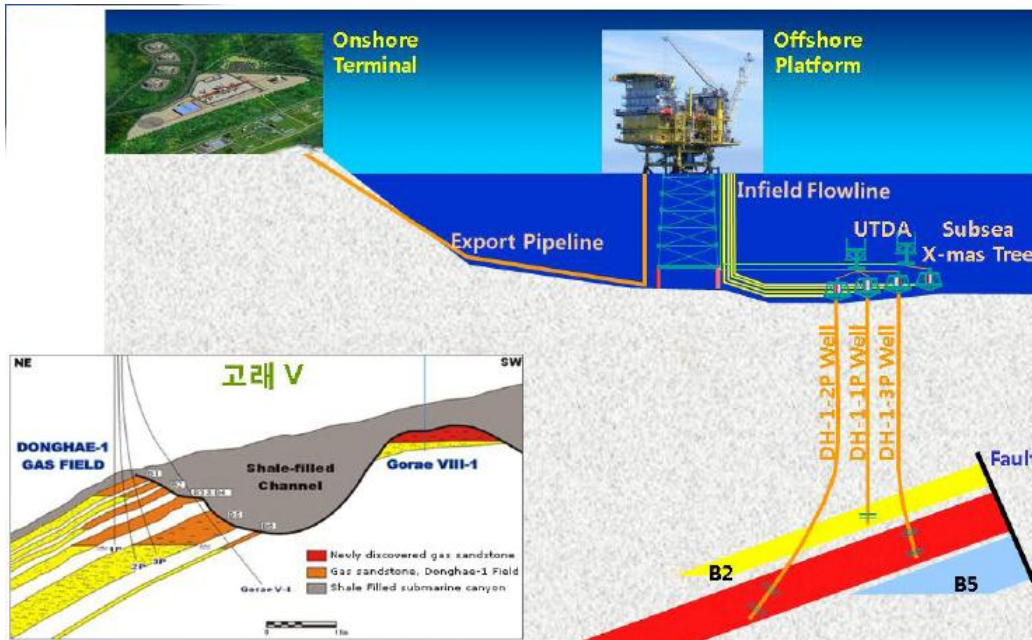
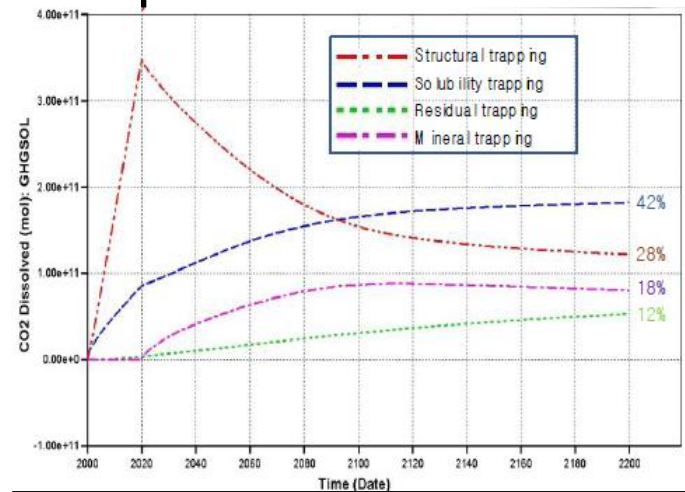
Demonstration of 100,000/yr CO₂ Injection



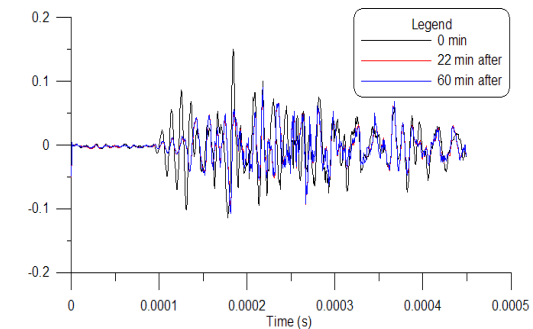
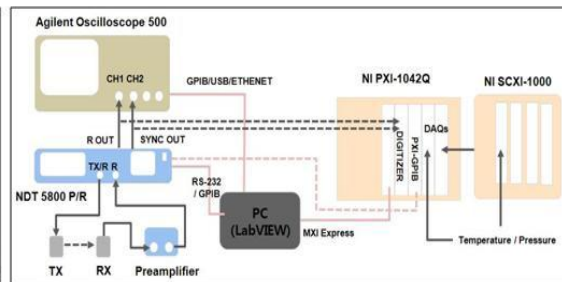
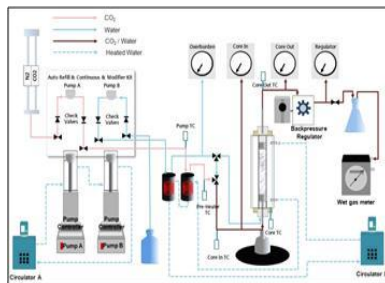
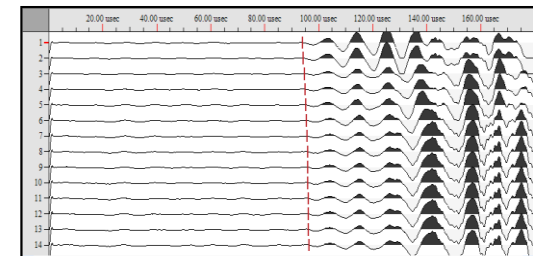


CO₂ Injection Simulation in DOLGORAE Structure

Injection → Monitoring

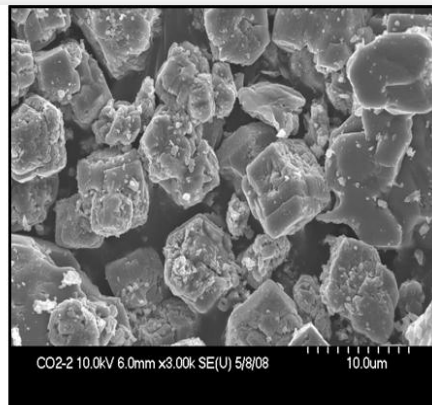
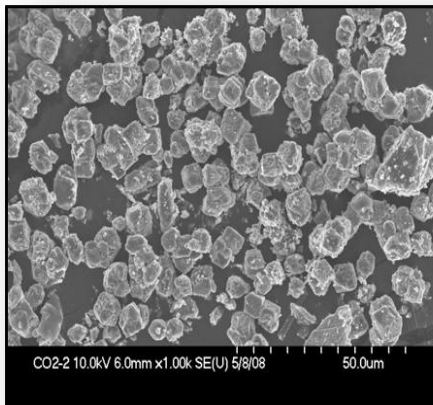


- Seismic P-wave Measurement of core containing CO₂-Water
- Documentation of effects of P, T and CO₂ Saturation on Seismic P&S wave
- Seismic Tomography Simulation



Mineral carbonation

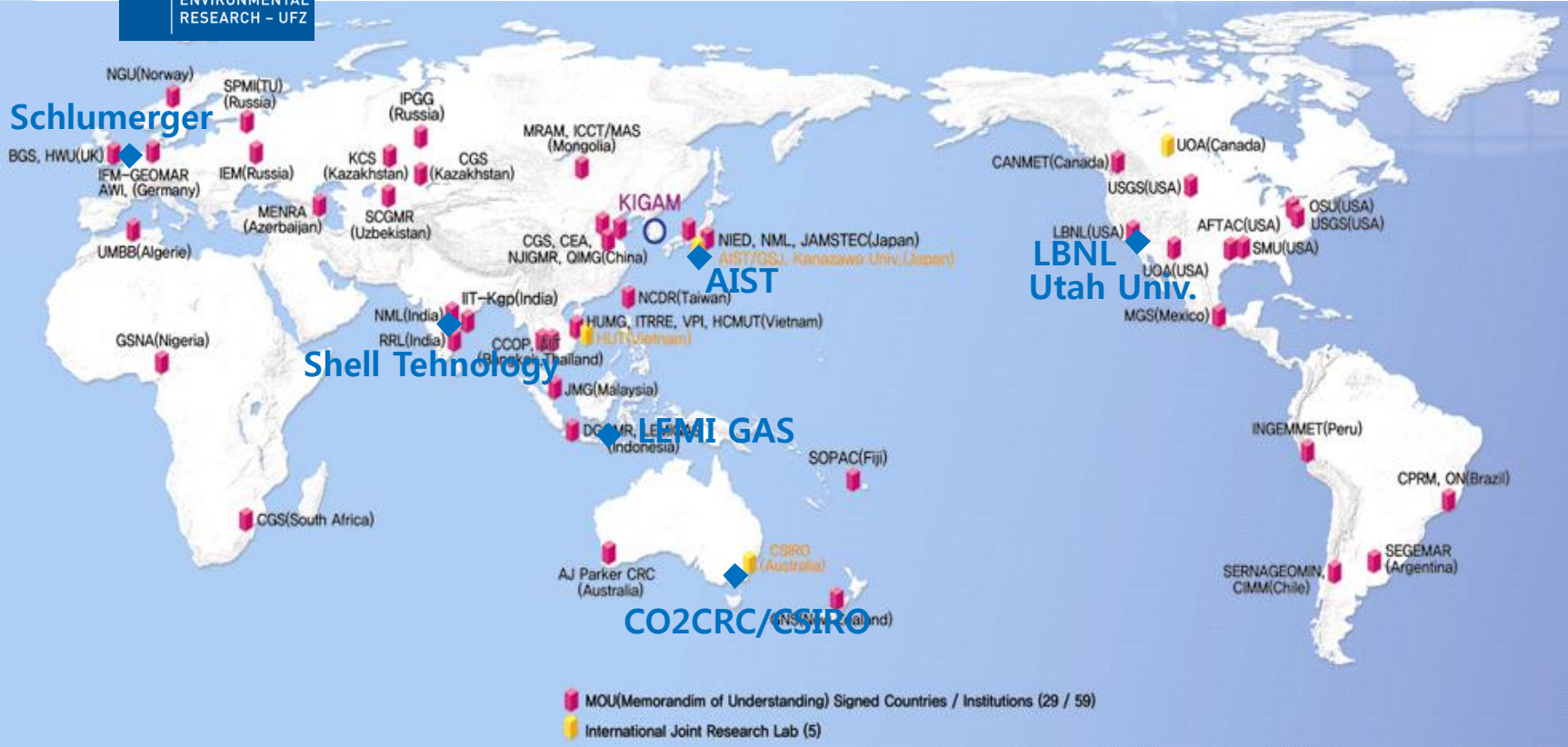
- Mineral carbonation experiment with industrial waste (gypsum, slag, cement and others)
- Mineral carbonate experiment with natural rocks and minerals (anorthosite, serpentine and wollastonite)
- Up-scaling of mineral carbonation plant (~100,000 ton/yr) and optimization of mineral carbonation process (planned)



Calcite formed by mineral carbonation with gypsum waste

Pilot-scale device for mineral carbonation in KIGAM

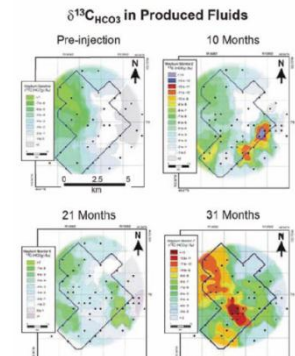
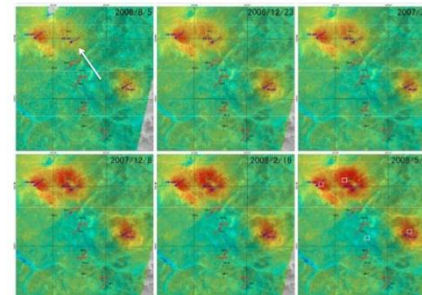
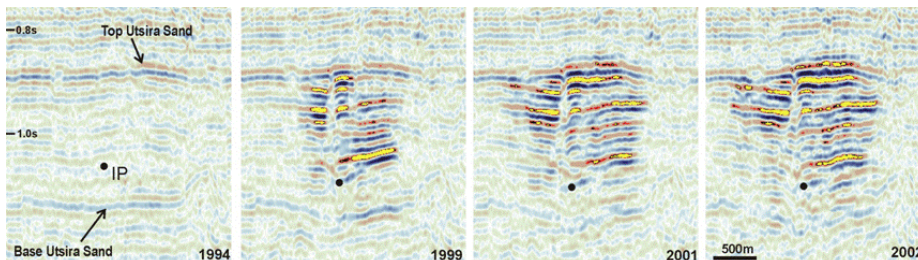
International Collaboration



VISION

Medium Scale Integrated CCS demonstration & Complete preparation for demonstration of commercial scale (> 1MtCO₂) CO₂ storage plant until 2018

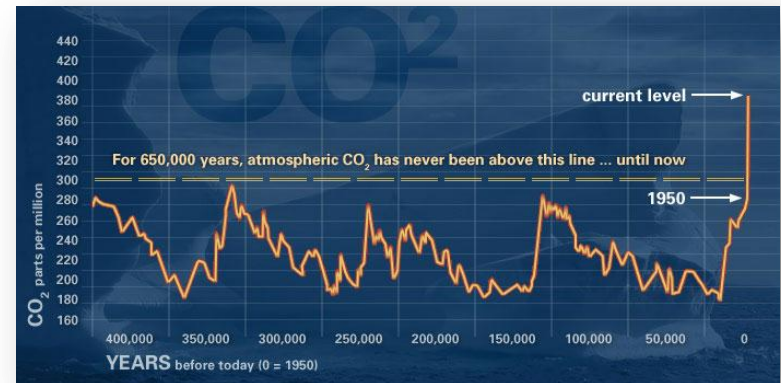
- ✓ Site screening & selection
- ✓ Detailed survey and geological characterization
- ✓ Development of CO₂ injection system
- ✓ Various basic researches
- ✓ Enhancement of MMV(Monitoring, Mitigation and Verification) technologies



Injected CO₂ dissolution (decreasing $\delta^{13}\text{C}$ in produced fluid)
Injected CO₂: $\delta^{13}\text{C} = -34\text{‰}$
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HCO}_3^-$



Thank you!



Source: National Oceanic and Atmospheric Administration (USA)