BỘ TÀI NGUYÊN VÀ MÔI TRƯỜNG
VIỆN KHOA HỌC ĐỊA CHẤT VÀ KHOÁNG SẢN
VIETNAM INSTITUTE OF GEOSCIENCES AND MINERAL RESOURCES

THE POTENTIAL FOR CCS IN THE RED RIVER DELTA BASIN, VIETNAM

Ho Huu Hieu
Vietnam Institute of Geosciences and Mineral Resources

Introduction

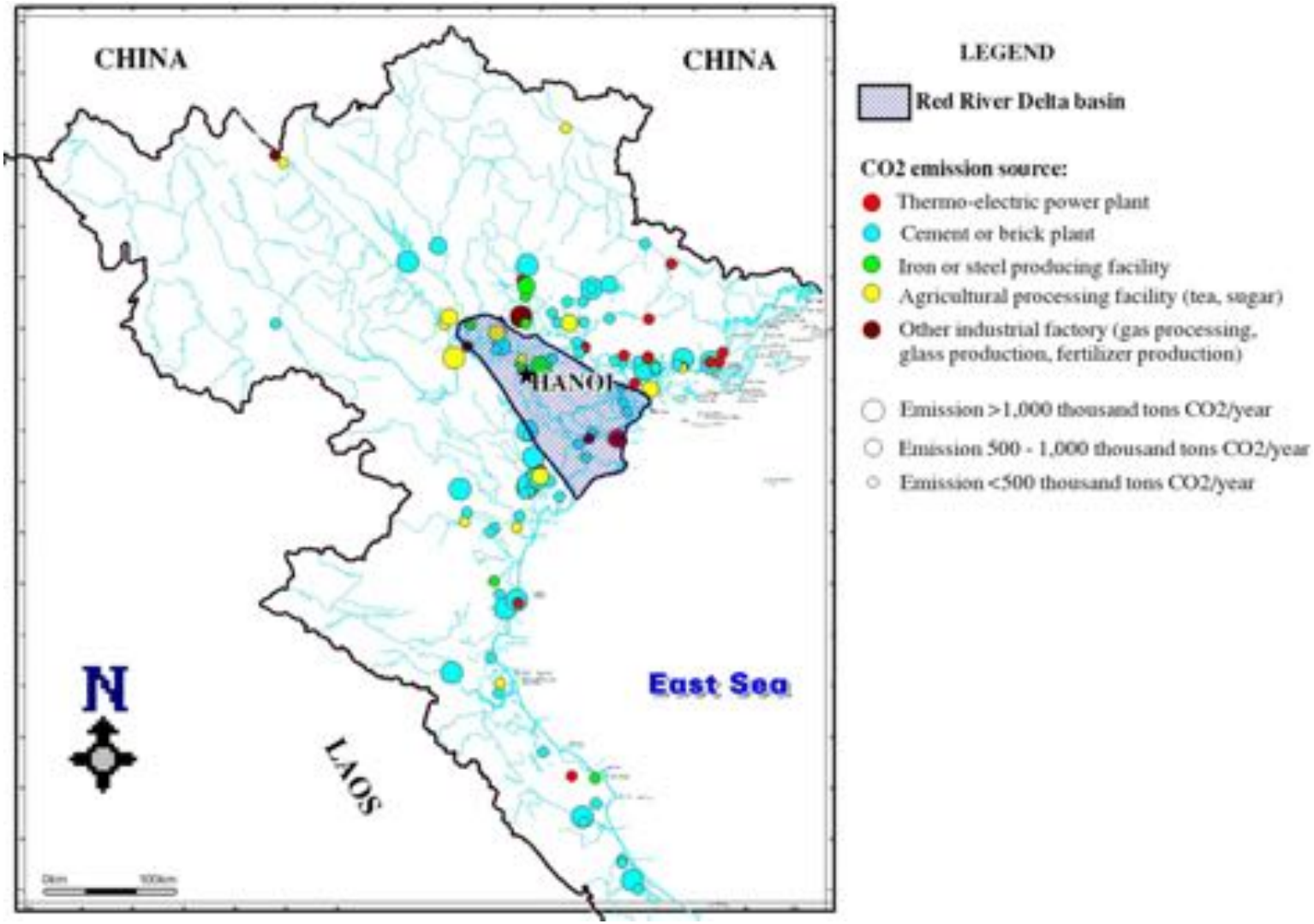

Figure 1. The geographical location of the Red River Delta Basin and CO_2 emission sources in Northern Vietnam

Introduction

Aims of the study: to assess and estimate the capacity of CO_2 storage in 3 options:

- In depleted gas field (EGR)
- In unmineable coal seam (CO2-ECBM)
- In deep saline aquifer

Geological settings

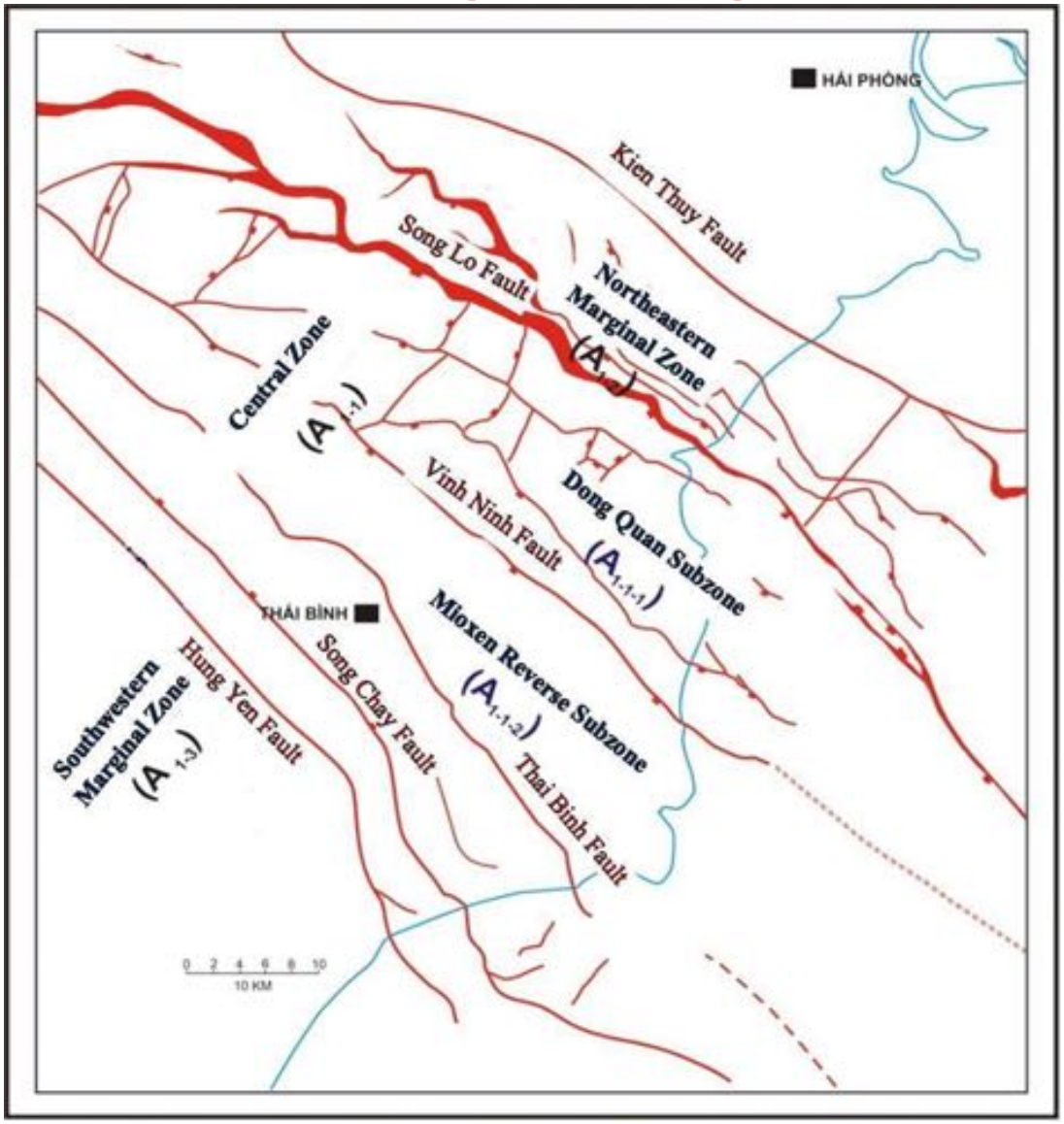

Figure 2. Tectonic-structural map of Red River Delta Basin

Geological settings

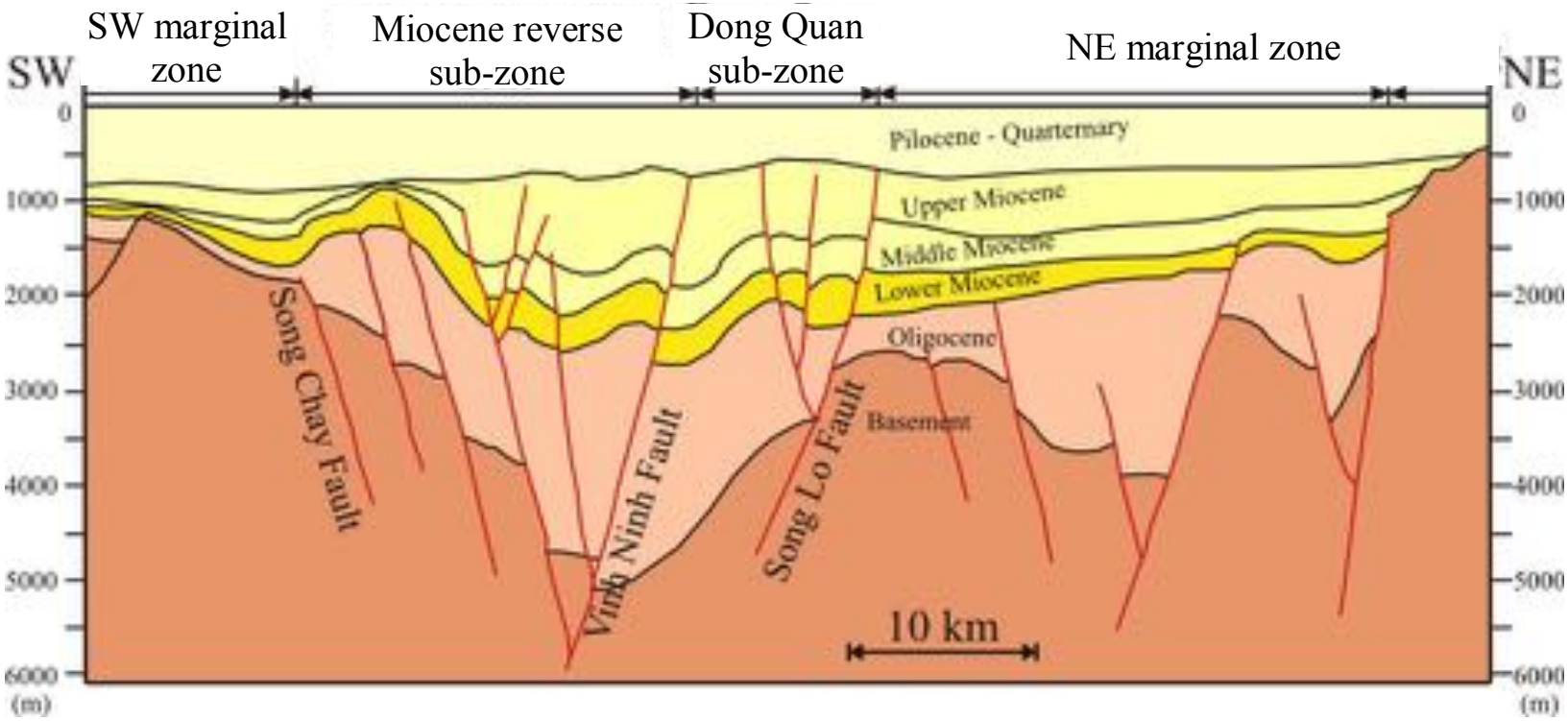

Figure 3. The NE-SW trending geological cross-section over the main structural units of Red River Delta Basin

Reservoir and seal

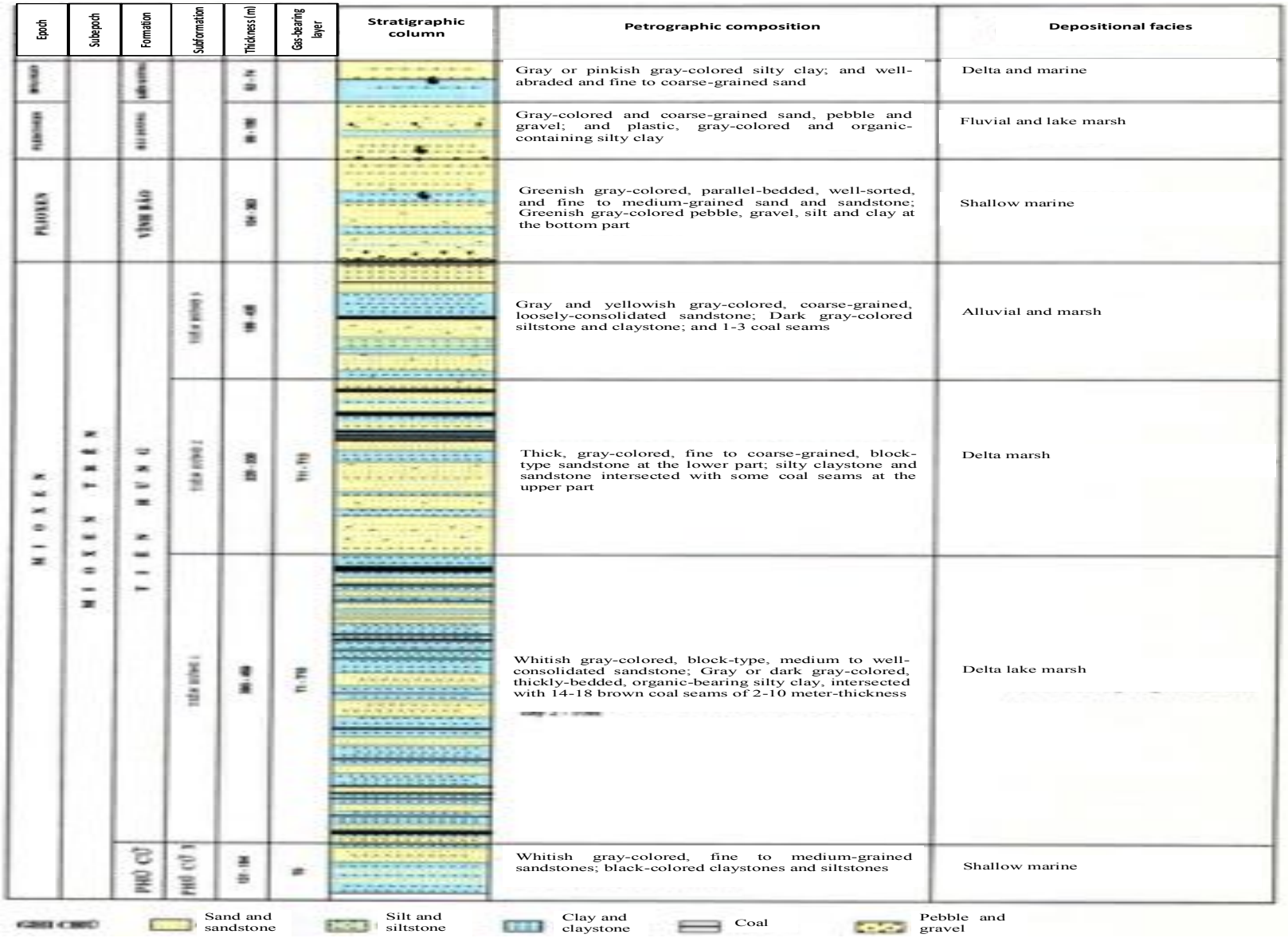

Figure 4. Synthetized stratigraphic column of drillwells in Tien Hai area

Reservoir and seal

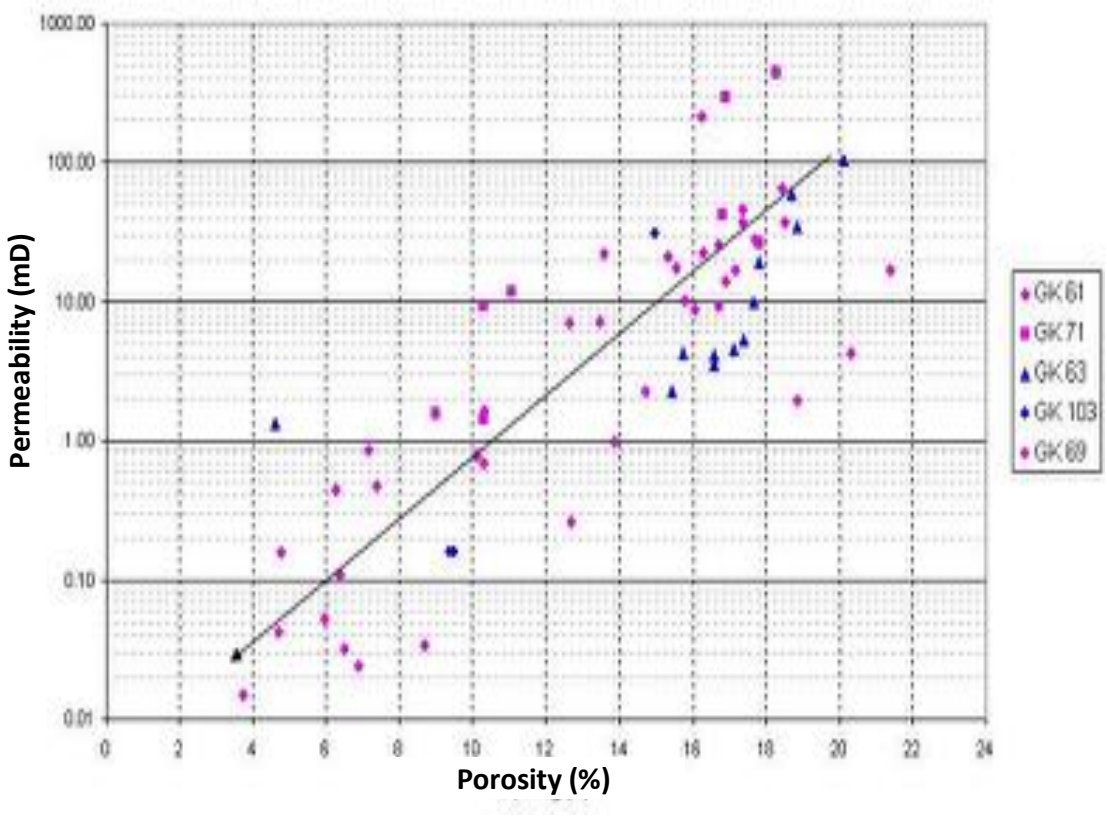

Figure 5. Relationship between porosity and permeability of Miocene sandstones in Red River Delta Basin

Reservoir and seal

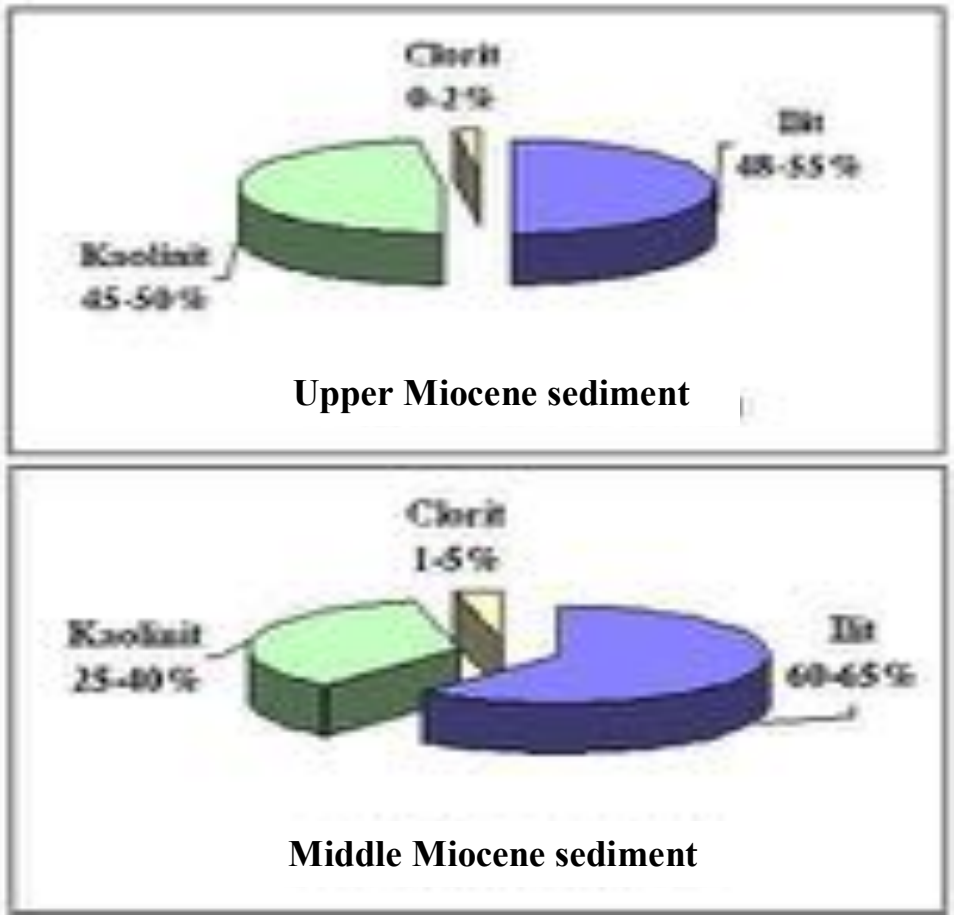

Figure 6. Mineral composition of Middle-Upper Miocene-claystones in Red River Delta Basin

Methodology

a. Depleted Gas Field

$$M_{CO2} = IGIP \times \rho_{CO2}$$

Where:

M_{CO2}: capacity of CO_2 storage (Mton CO_2);

IGIP: initial gas volume in place (million m^3);

ρ_{CO2} : density of CO_2 at reservoir (ρ_{CO2}= 0,7 ton/m^3)

Assumptions:

- CO_2 replaces hydrocarbon in the reservoir

- Migration of water or other processes that reduce the pore volume for CO_2 are negligible

Methodology

b. Unmineable coal seams

$$IGIP = A \times h \times \rho_C \times G_c \times R$$

$$M_{CO2} = IGIP \times ER \times \rho_{CO2}$$

Where:

M_{CO2}: capacity of CO_2 storage (Mton CO_2);

IGIP: the initial gas volume in place (million m^3 stp);

A, h, ρ_c, G_c: area (km^2), thickness (m), density (ton/m^3), gas content (m^3/ton stp) of coal;

R: recovery factor (R= 1-f_a-f_m where f_a and f_m are ash content and water-saturation of coal);

ER: exchange ratio between CO_2 and CH_4;

ρ_{CO2}: density of CO_2 at standard condition (0.0018 ton/m^3).

Methodology

c. Deep saline aquifer

$$M_{CO2} = A \times h \times \varphi \times \rho \times E$$

Where:

M_{CO2}: capacity of CO_2 storage (Mton CO_2)

A, h, φ, ρ: area (km^2), thickness (m), porosity of sandstone, and CO_2 density in reservoir (ton/m^3);

E: efficiency factor of CO_2 storage (E= 4%).

Results and discussion

A. CO_2 storage in gas fields

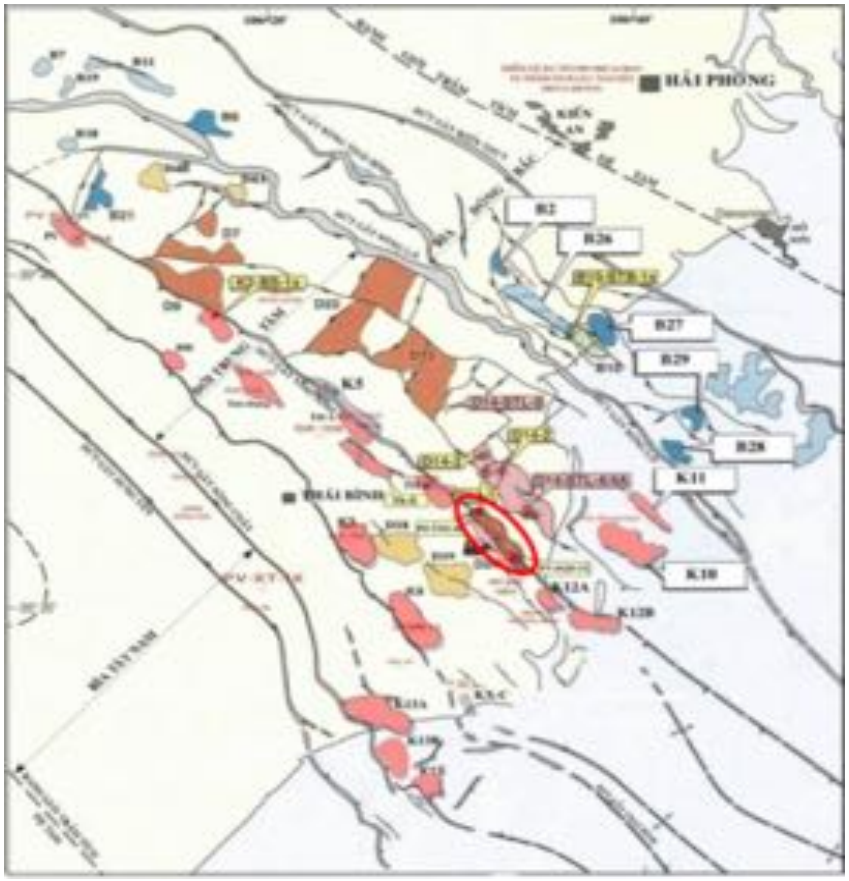

Figure 7. The location of Tien Hai Gas Field in Red River Delta Basin

Results and discussion

A. CO2 storage in gas fields

Table 1. Calculated capacity of CO_2 storage in the Tien Hai Gas Field

	Initial Gas Volume (Million m^3 at STP)	Produced Gas Volume (Million m^3 at STP)	Temp. at reservoir (°K)	Pressure at reservoir (atm)	Volume at reservoir (Million m^3)		Capacity of CO_2 storage (Mton CO_2)	
					Initial Gas Volume	Produced Gas Volume	After Initial Gas Volume	After Produced Gas Volume
Tien Hai Gas Field	1,300	850	343	90	18.1	11.9	**12.7**	**8.3**

Results and discussion

B. CO_2 storage in unmineable coal seams

- Lignite to sub-bitumen type;
- Water saturation: 1 - 21%, average: 11%;
- Ash content: 7 - 22%, average: 14%;
- Gas (CH_4) content: 0 - 4 m^3/ton at shallow depth; and 10 - 15 m^3/ton at high depth, average: 3 m^3/ton;
- No data on porosity and permeability.

Results and discussion

B. CO_2 storage in unmineable coal seams

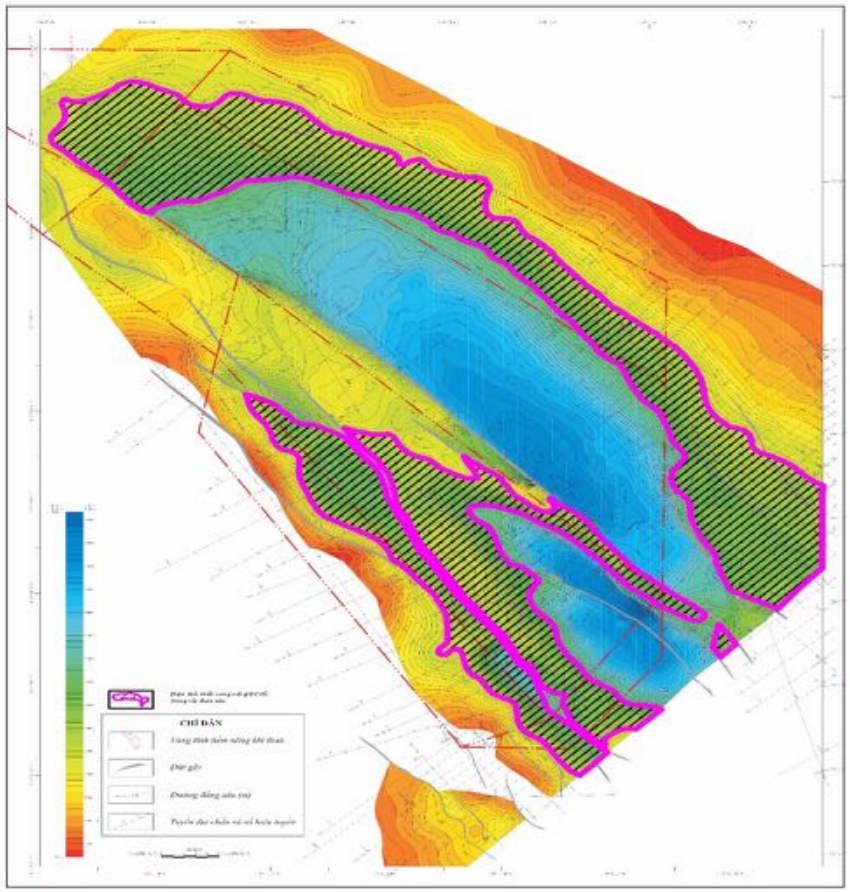

Figure 8. Prospective areas for CO2-ECBM on the depth-contour map of the top of Lower Tien Hung Subformation *($N_1^3th_1$)*

Results and discussion

B. CO_2 storage in unmineable coal seams

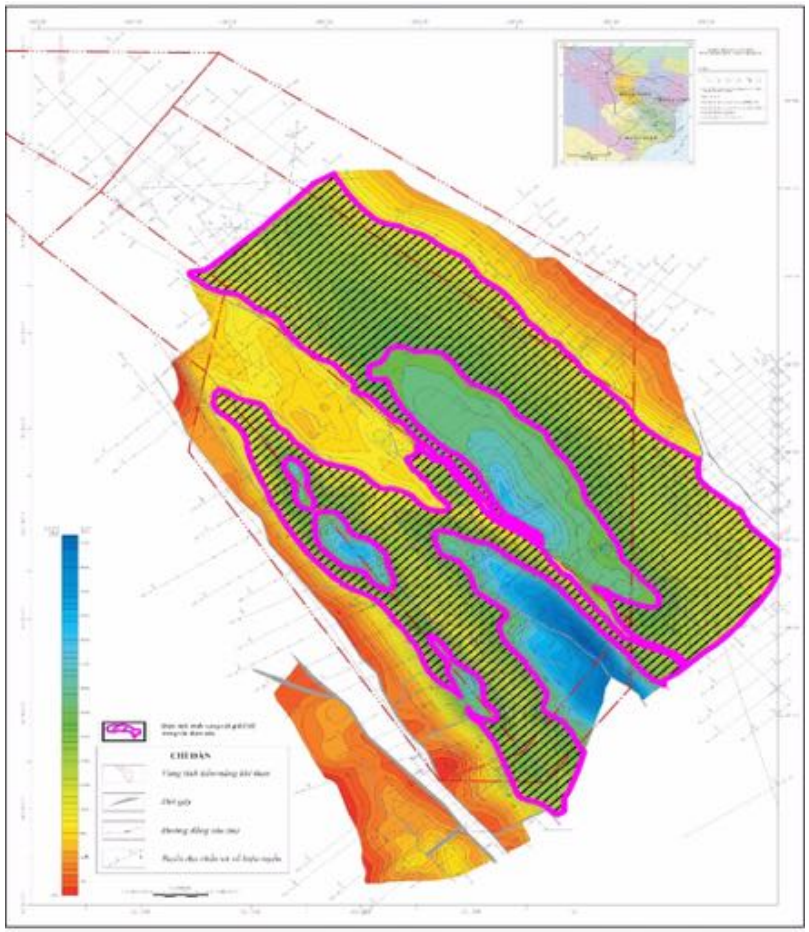

Figure 9. Prospective areas for CO2-ECBM on the depth-contour map of the top of Middle Tien Hung Subformation *($N_1^3th_2$)*

Results and discussion

B. CO_2 storage in unmineable coal seams

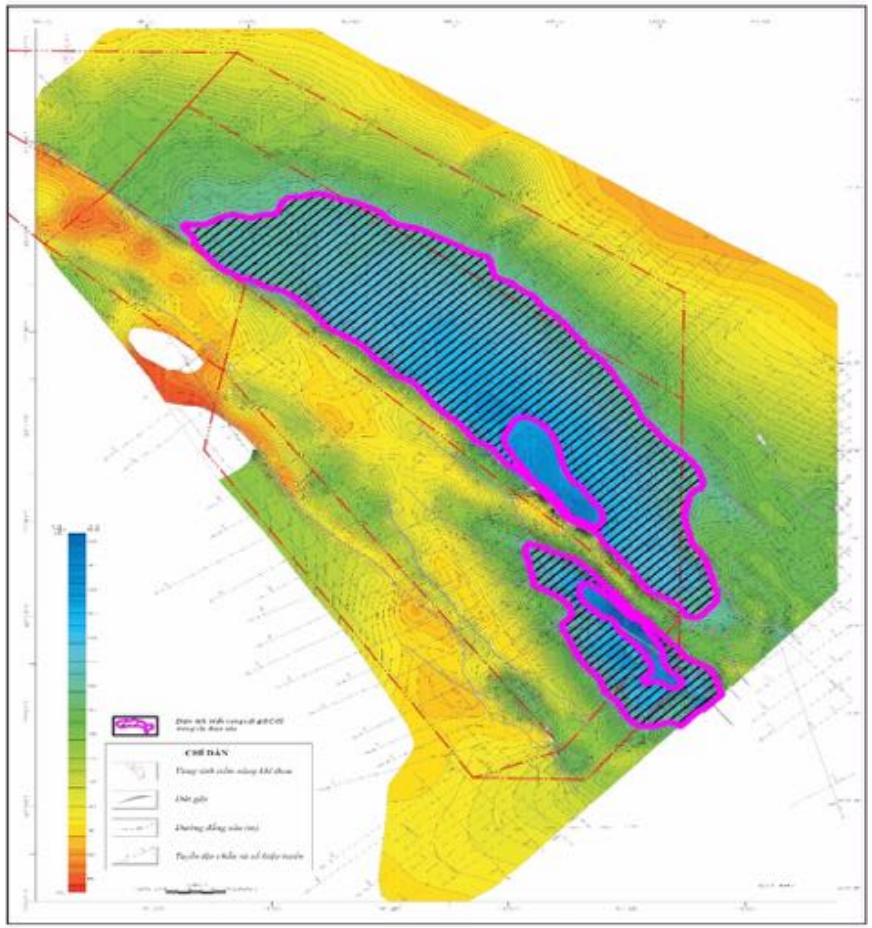

Figure 10. Prospective areas for CO2-ECBM on the depth-contour map of the top of Upper Tien Hung Subformation *($N_1^3 th_3$)*

Results and discussion

B. CO_2 storage in unmineable coal seams

Table 2. The calculated recoverable gas volume and capacity of CO_2 storage in coal seams from 1,000 to 1,500 m depth in Red River Delta Basin

	Area (km^2)	Thickness of the formation (m)	Coal-bearing factor	Coal density (ton/m^3)	Gas content (m^3/ton)	Ash content	Water saturation	Initial gas volume (million m^3 STP)	Exchange ratio (CO_2:CH_4)	CO_2 density at STP (ton/m^3)	Capacity of CO_2 storage (Mton CO_2)
Lower Tien Hung sub-formation	1,026	443	0.06	1.34	3	0.142	0.111	81,893	4	0.0018	590
Middle Tien Hung sub-formation	1,123	800	0.08	1.34	3	0.142	0.111	215,827	4	0.0018	1.554
Upper Tien Hung sub-formation	721	440	0.04	1.34	3	0.142	0.111	38,106	4	0.0018	274
Total								**335,827**			**2,418**

Results and discussion

C. CO_2 storage in deep saline aquifers

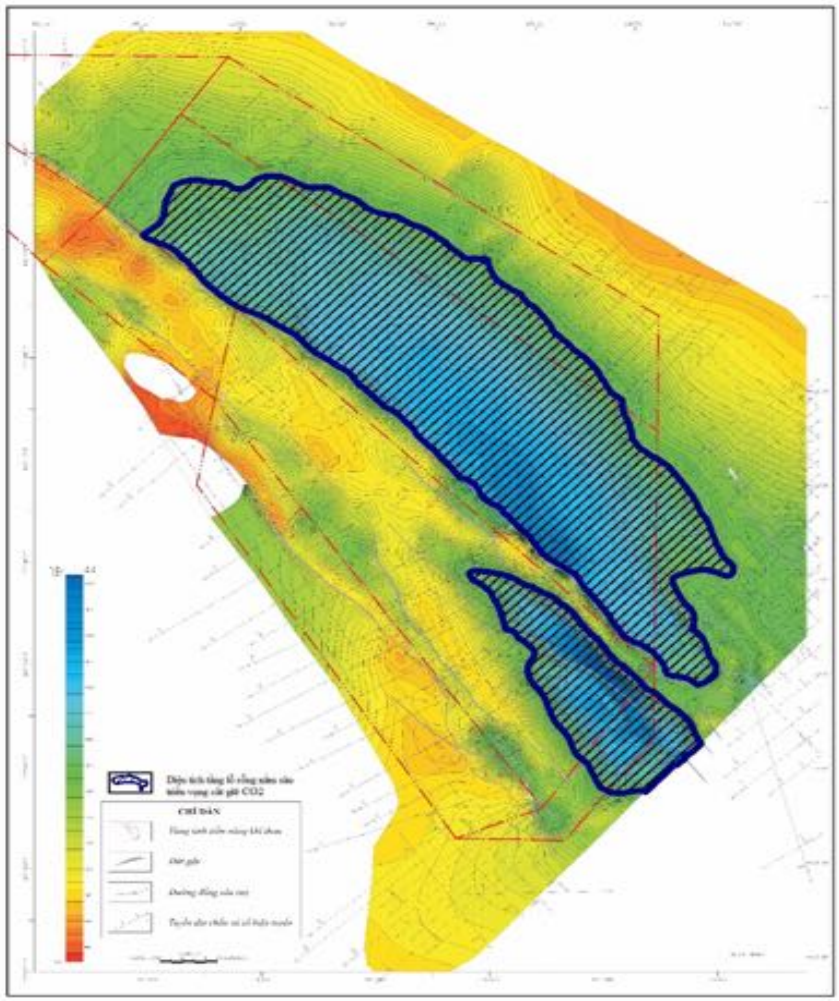

Figure 11. Prospective areas of deep saline aquifers on the depth-contour map of the top of Upper Tien Hung Subformation *($N_1^3 th_3$)*

Results and discussion

C. CO_2 storage in deep saline aquifers

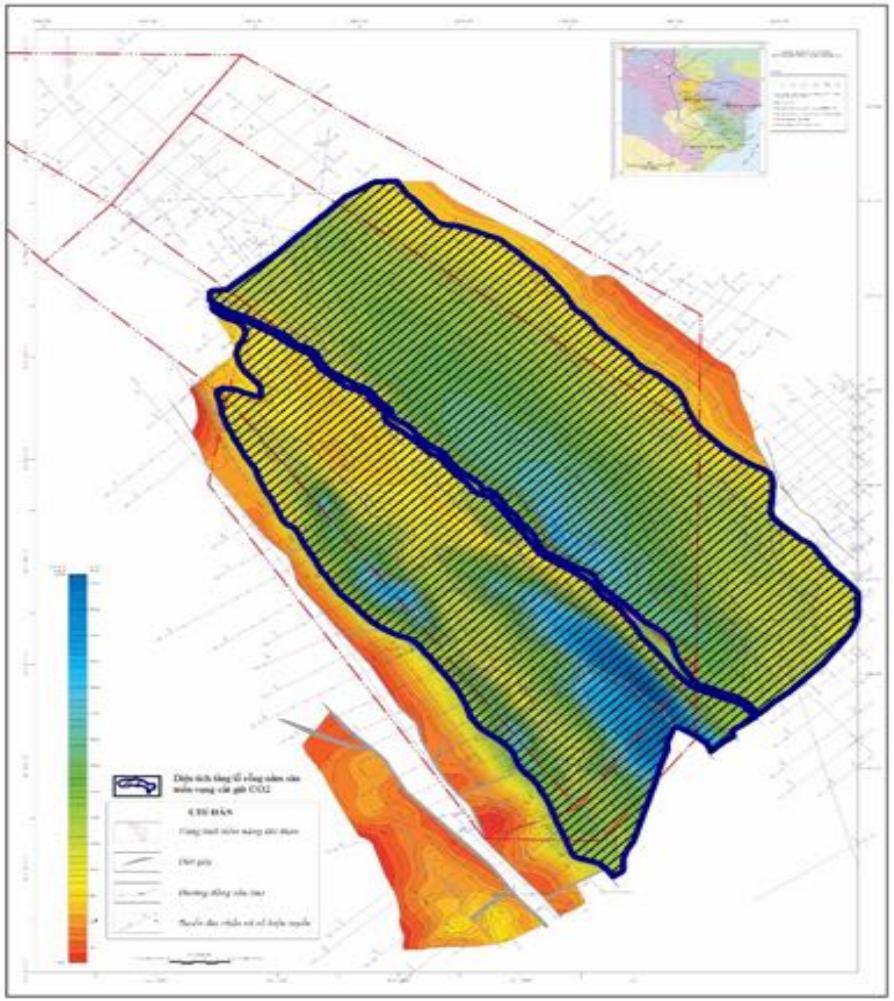

Figure 12. Prospective areas of deep saline aquifers on the depth-contour map of the top of Middle Tien Hung Subformation *($N_1^3th_2$)*

Results and discussion

C. CO_2 storage in deep saline aquifers

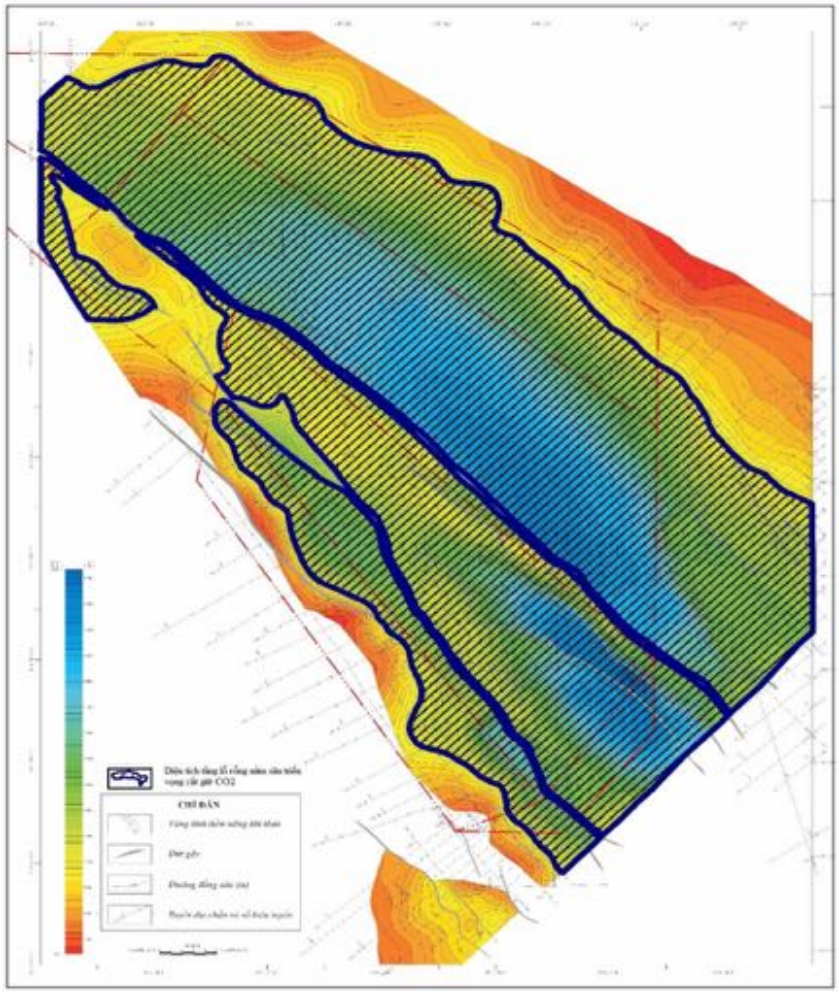

Figure 13. Prospective areas of deep saline aquifers on the depth-contour map of the top of Lower Tien Hung Subformation *($N_1^3 th_3$)*

Results and discussion

C. CO_2 storage in deep saline aquifers

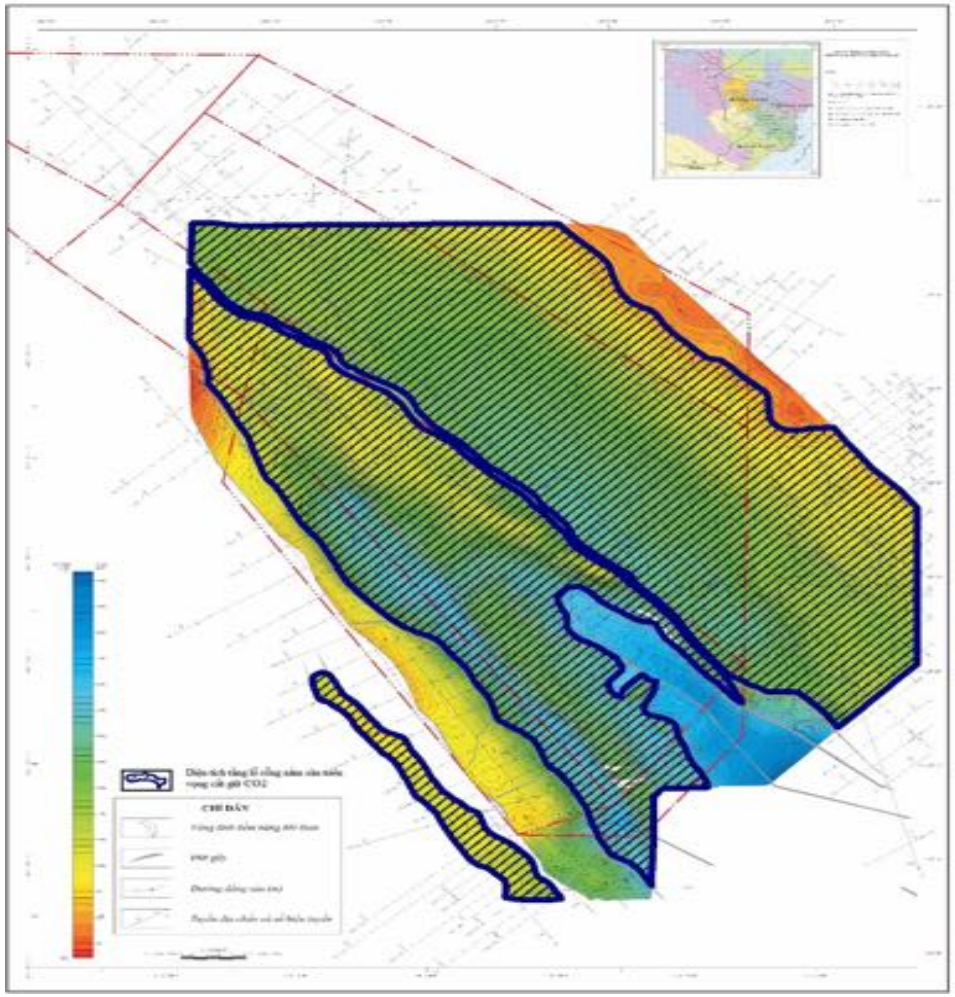

Figure 14. Prospective areas of deep saline aquifers on the depth-contour map of the top of Phu Cu Formation (N_1^2pc)

Results and discussion

C. CO_2 storage in deep saline aquifers

Table 3. Calculated capacity of CO_2 storage for deep saline aquifers in Red River Delta Basin

	Area (km^2)	Thickness of formation (m)	Net/gross of sandstone	Average porosity (φ)	CO_2 density at reservoir (ρ) (ton/m^3)	Efficiency factor (E)	Capacity of CO_2 storage (Mton CO_2)
Upper Tien Hung sub-formation	1,031	440	0.52	0.19	0.5	0.04	2,159
Middle Tien Hung sub-formation	1,796	800	0.7	0.18	0.6	0.04	4,345
Lower Tien Hung sub-formation	2,483	443	0.33	0.17	0.7	0.04	1,728
Upper Phu Cu sub-formation	1,973	300	0.29	0.15	0.7	0.04	721
Total							**8,952**

Conclusion

- The Red River Delta Basin has high potential for CCS based on the socio-economic and geological criteria.
- The capacity for CO_2 storage in combination with enhanced gas recovery in Tien Hai Gas field is small (12.7 Mton CO_2). However, it is an easy and economically feasible option that can be implemented in near future.
- The capacity of CO_2 storage in unmineable coal seams and deep saline aquifers are high (2.4 and 8.9 Gton CO_2 respectively). However, these options need to be invested for further studies and assessment.
- In future, the uncertainties of CO_2 storage including risk of fault or well-along leakage, security of seal, reactivation of faults, or porosity and permeability of coal seams, exchange ratio of CO_2/CH_4, etc… need to be further studied.

THANK YOU VERY MUCH FOR YOUR ATTENTION !