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Effects of Dip-angle on the CO_2-Enhanced Water Recovery Efficiency and Reservoir Pressure Control Strategies

Zhijie Yang[1,2*], *Zhenxue Dai*[2], *Tianfu Xu*[1], *Fugang Wang*[1], *Sida Jia*[2]

[1]*Key Laboratory of Groundwater Resources and Environment, Ministry of Education, Jilin University, Changchun, 130021, China*

[2]*College of Construction Engineering, Jilin University, Changchun, 130026, China*

corresponding author, yangzhijie@jlu.edu.cn

Outline

- 1. Background
- 2. Geology characterization and Simulation approach
- 3. Enhanced efficiency of injection and production capacity
- 4. Controlling factors of reservoir pressure evolution
- 5. Conclusions

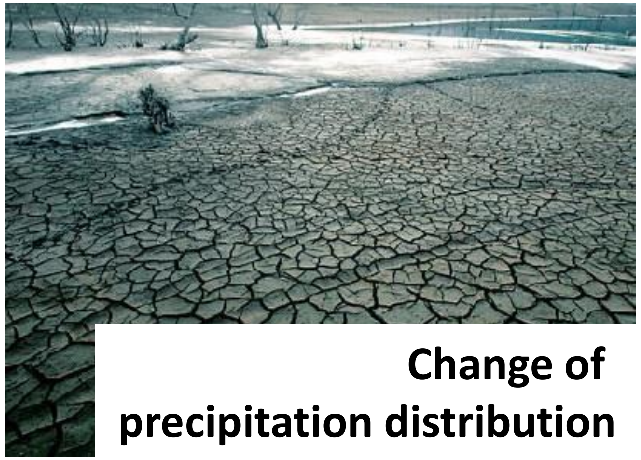
Background

Greenhouse effect

series of environmental problems

rising sea-level

melting ice



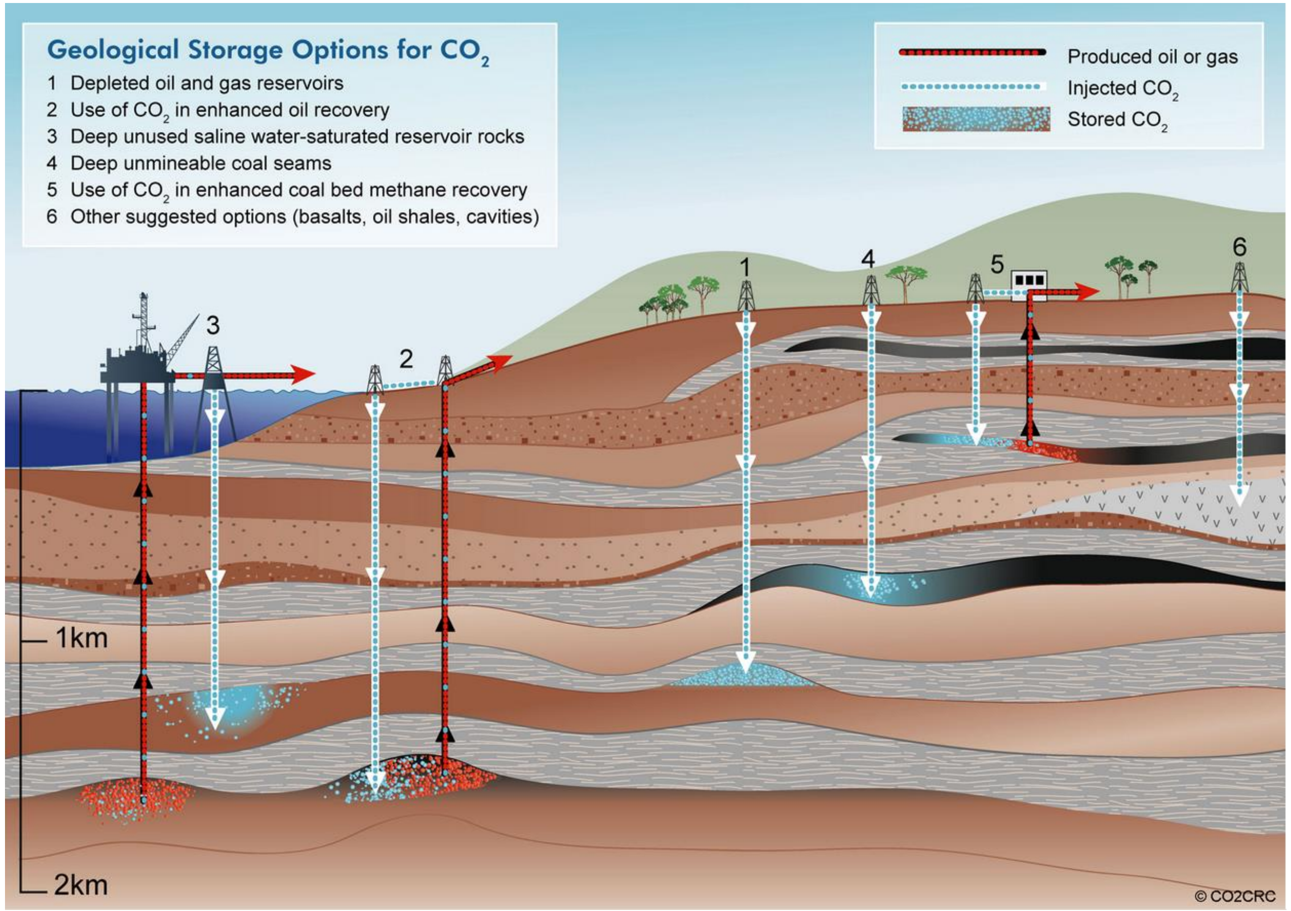
Change of precipitation distribution

● CO_2 geological storage

CCS | Capture → Utilization and Storage → CO_2 Emissions

Possible Site：

- ◆ **Depleted oil and gas fields**
- ◆ **Deep ummineable coal seam**
- ◆ **Deep saline aquifer**
- ◆ **Use of CO_2 in enhanced coal bed methane**



CO_2 geological storage sites

Background

CCS

Utilization and Storage

CCUS

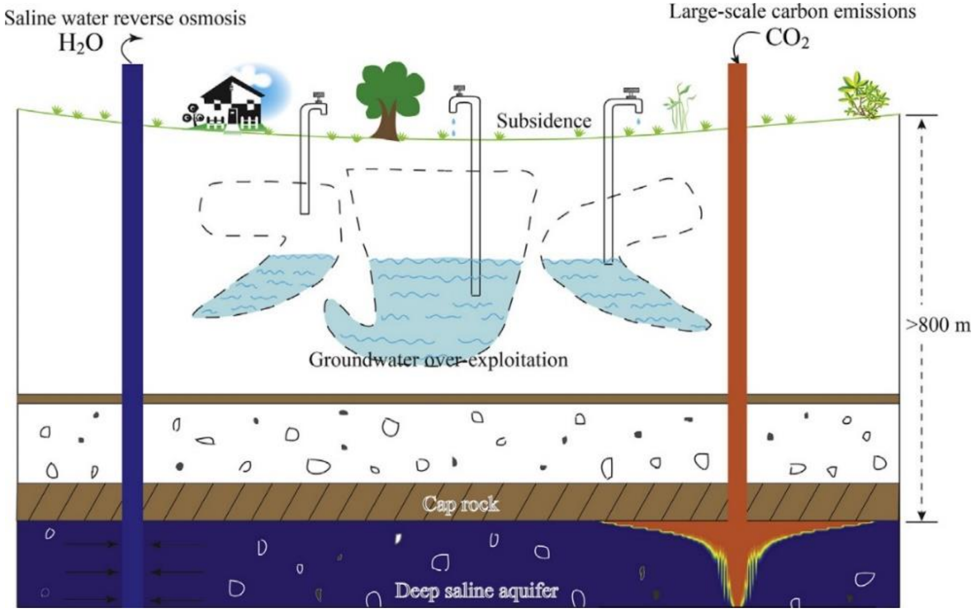
Solo CO_2 injection

Overpressure

- Caprock fracture
- Fault activation
- Induced seismicity

- CO_2 leakage
- Shallow aquifer pollution

limit injection capacity, threat CGS safety



Depiction of the CO_2-EWR technology

Effective method

Junggar Basin

Many coal enterprises

Water shortage

CO_2 Emissions

Demand for more water

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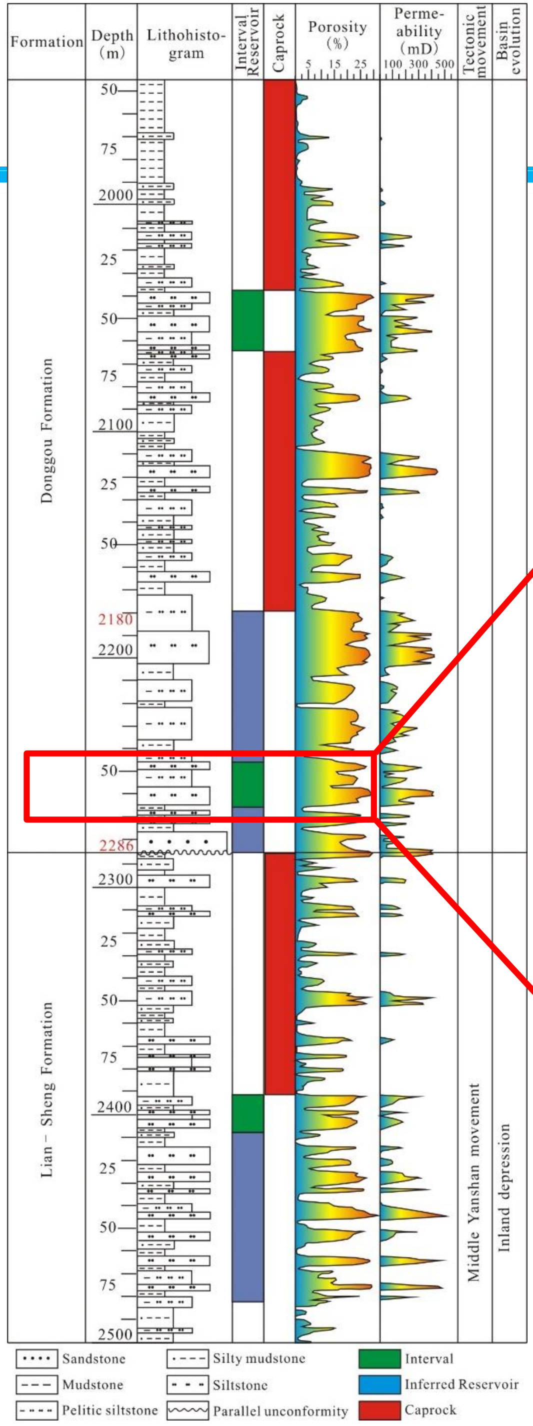
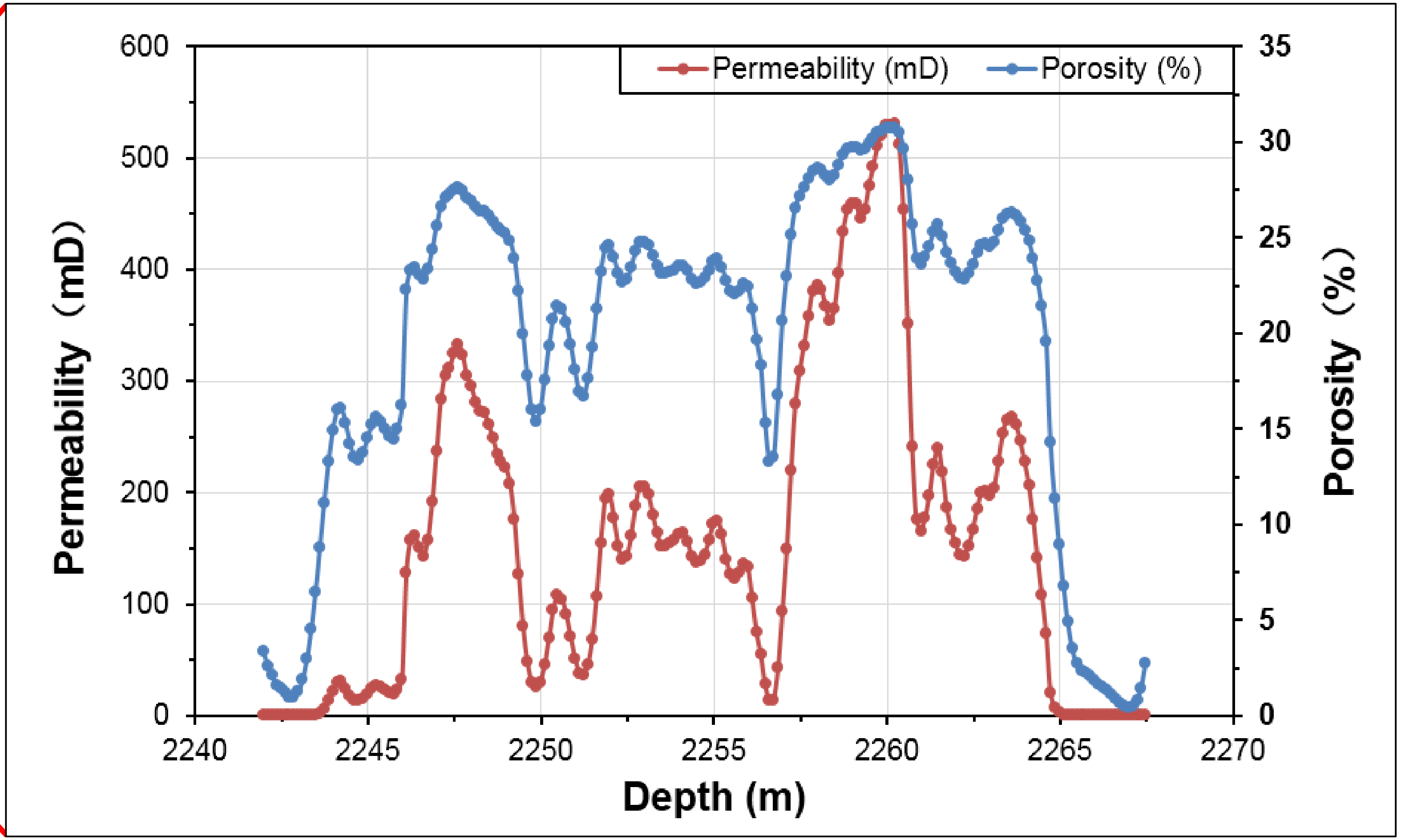
Geology characterization

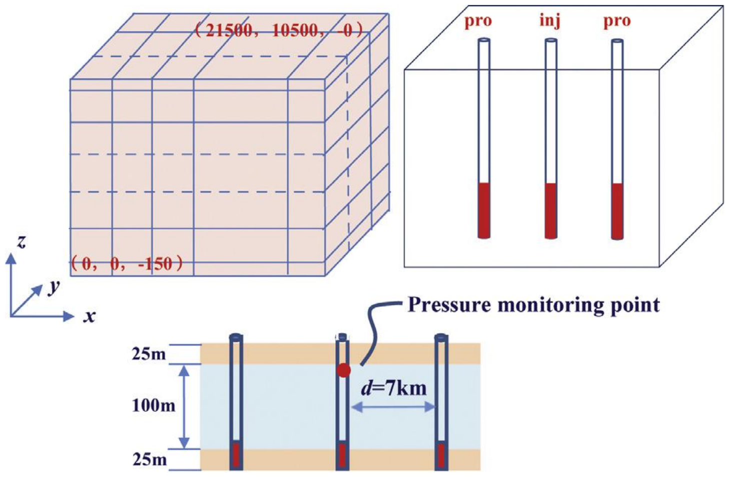


- Vertical **heterogeneity** of porosity & permeability



➢ **Average porosity: 23.83%, average permeability: 207.79mD**

Simulation approach



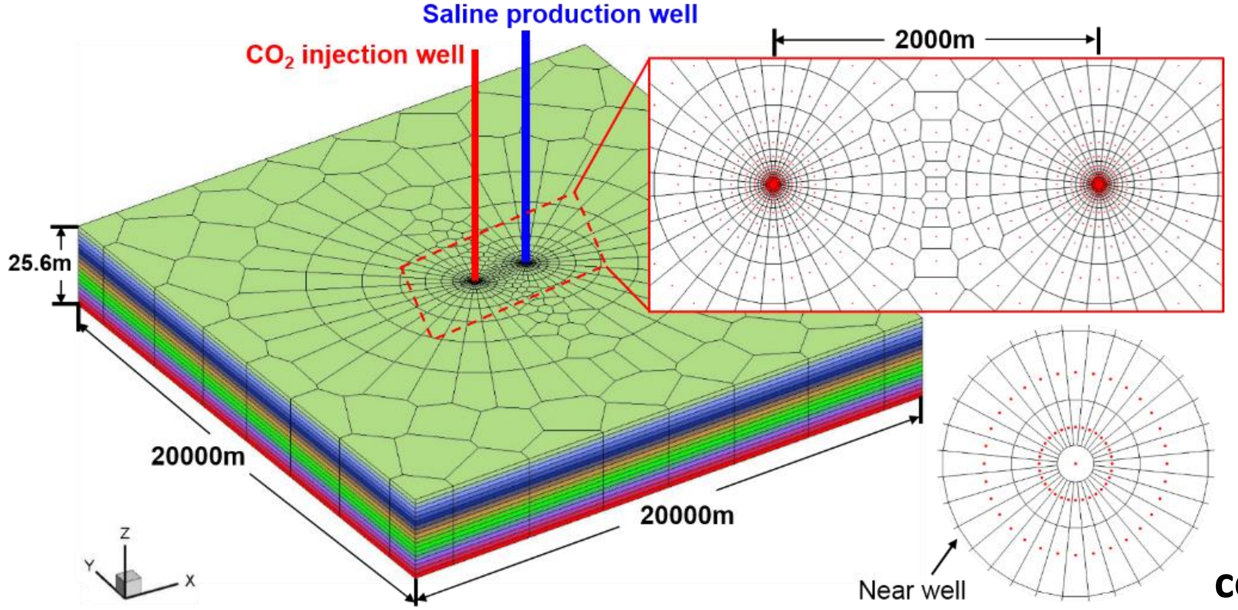
Previous models

(Li et al., 2014; Liu et al., 2016)

Problems in previous studies:

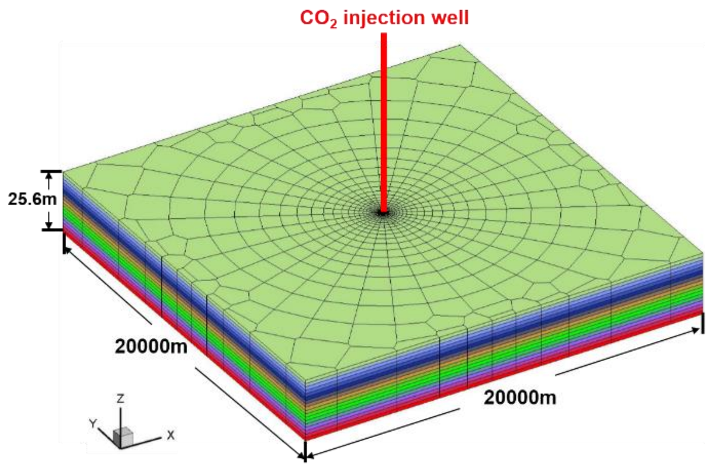
Improvement

- model is too simple
  - Homogeneous isotropy
  - Regular grid: 500m×500m
- Influence of boundary on Model
  - Range: 10km×10km
- Constant rate: injection & production
- Ignore the effect of wellbore

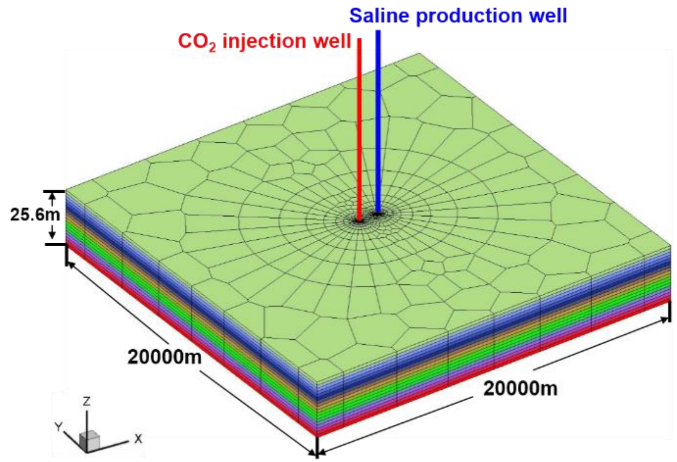


CO_2-EWR model coupled with wellbore

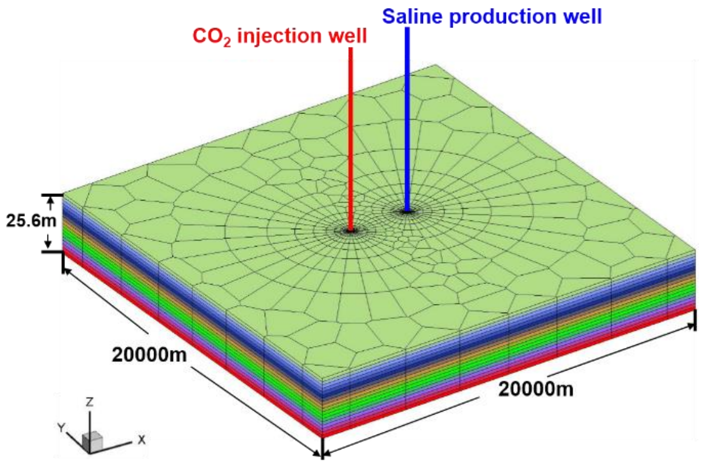
The 3D grid for different simulation scenarios



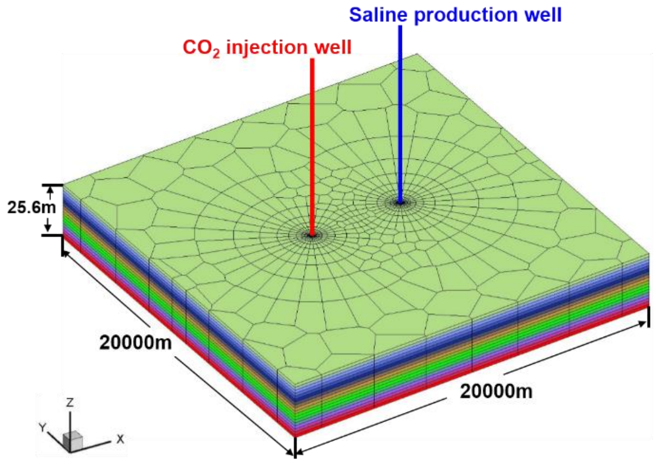
Solo injection/production



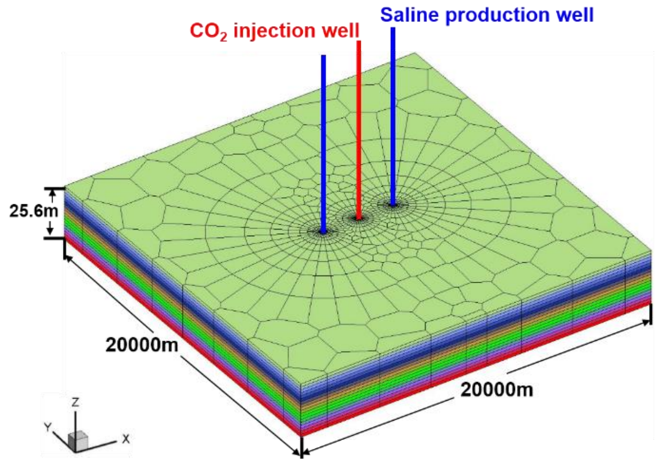
Well spacing of 1km



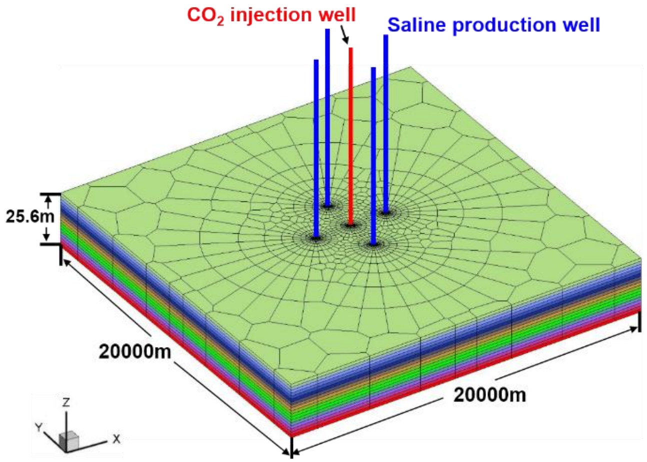
Well spacing of 3km



Well spacing of 5km



2 production wells



4 production well

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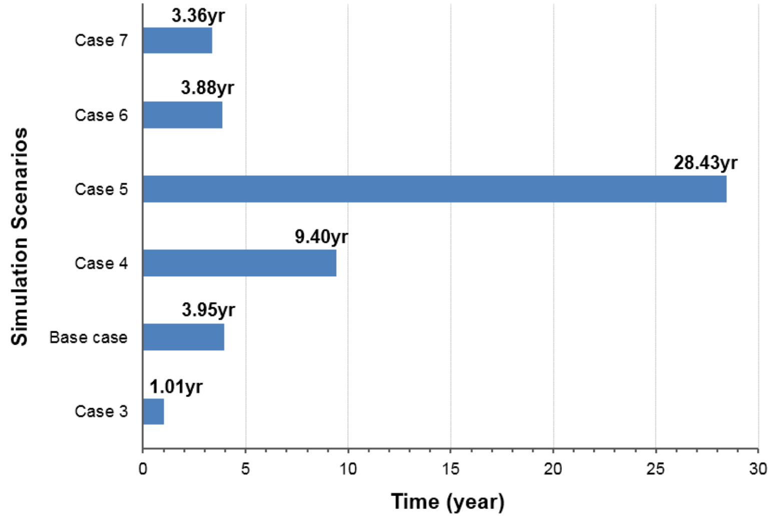
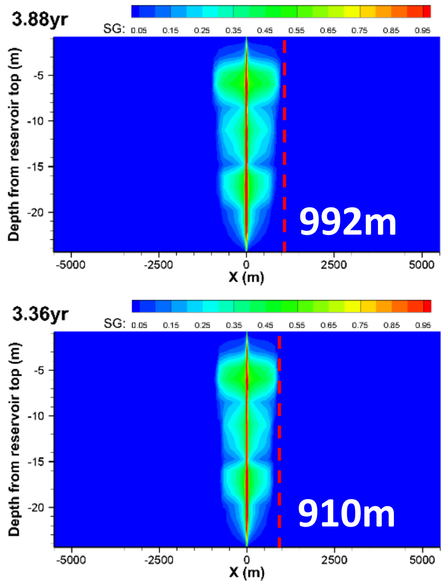
CO_2 migration in reservoirs

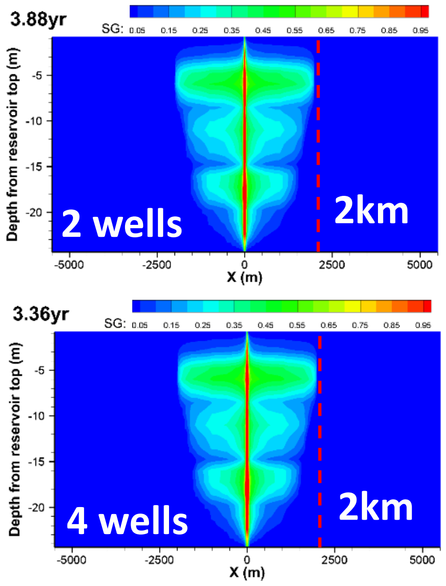


Shut-in time for different scenarios

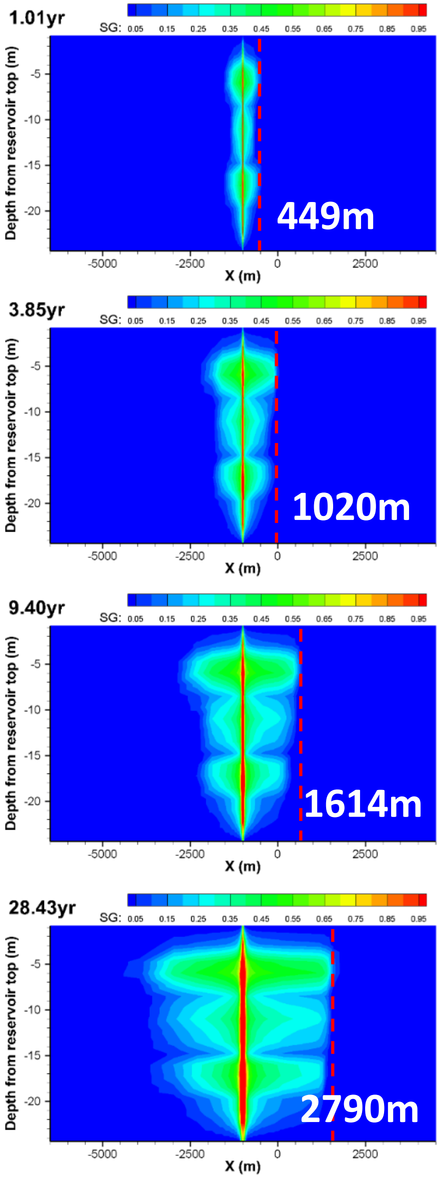
Solo injection



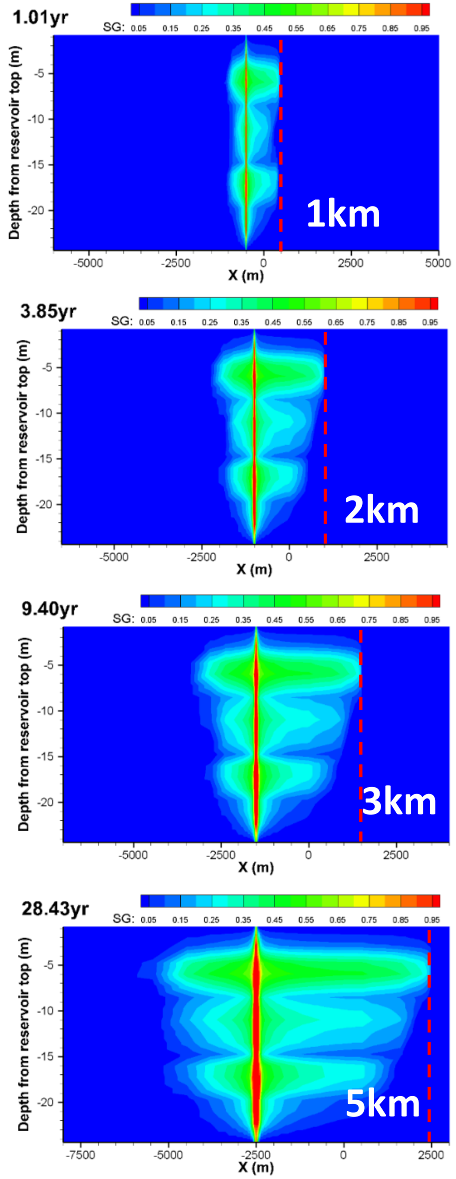
n of production wells



Solo injection

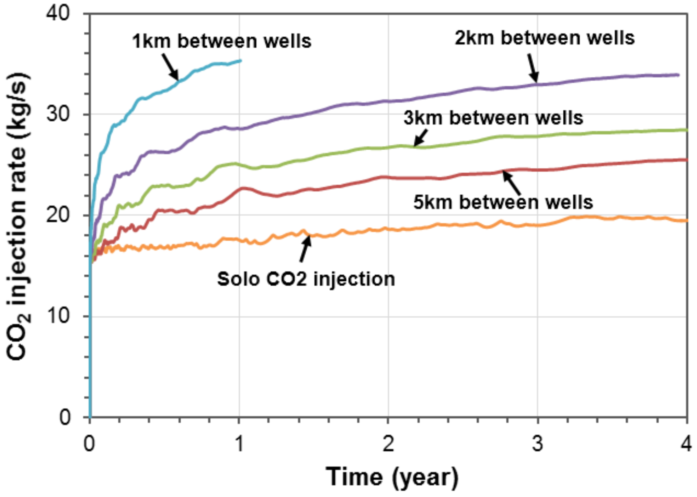


Well spacing

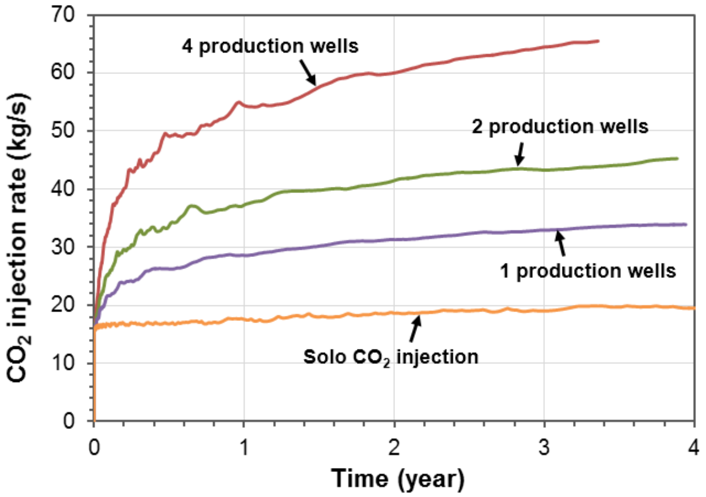


Enhanced efficiency of injection and production rate

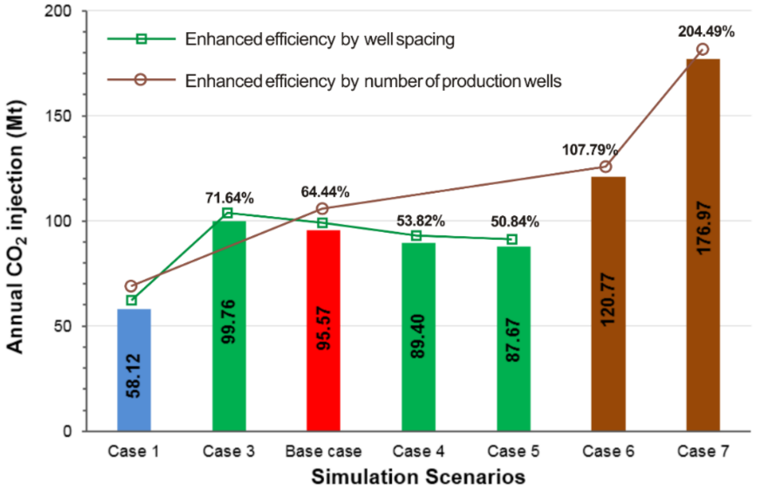
injection rate



Well spacing

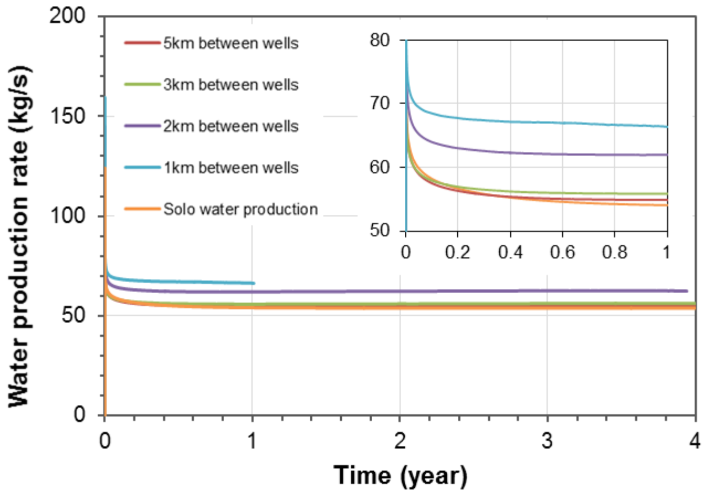


Number of production wells

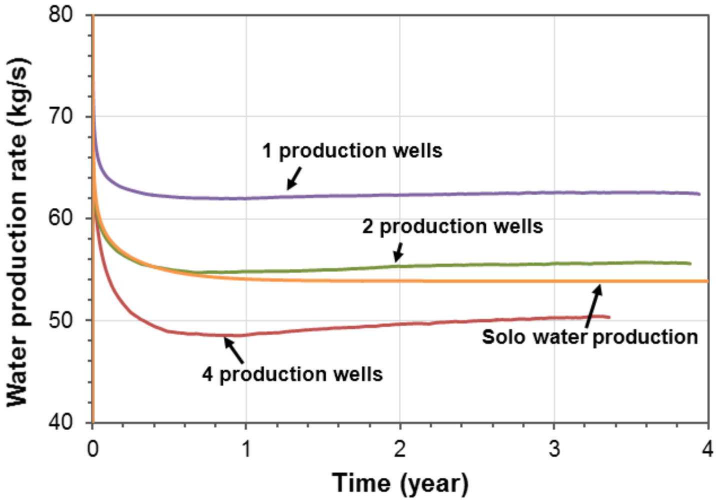


Annual CO_2 injection amount

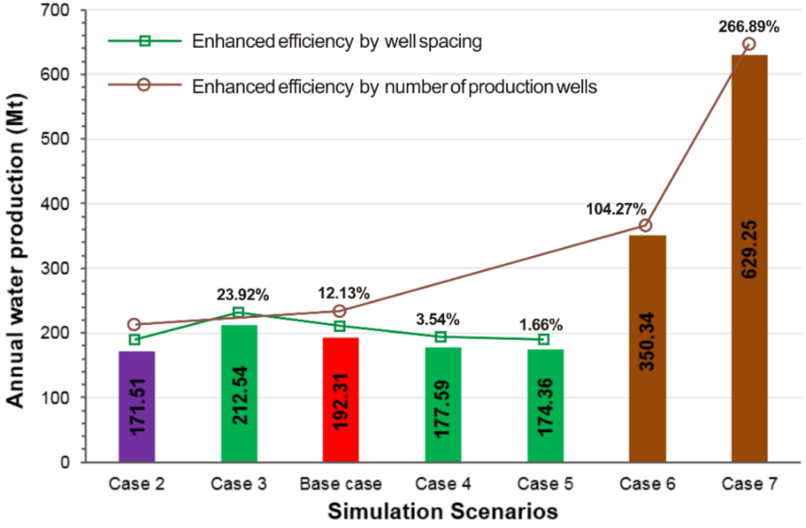
production rate



Well spacing

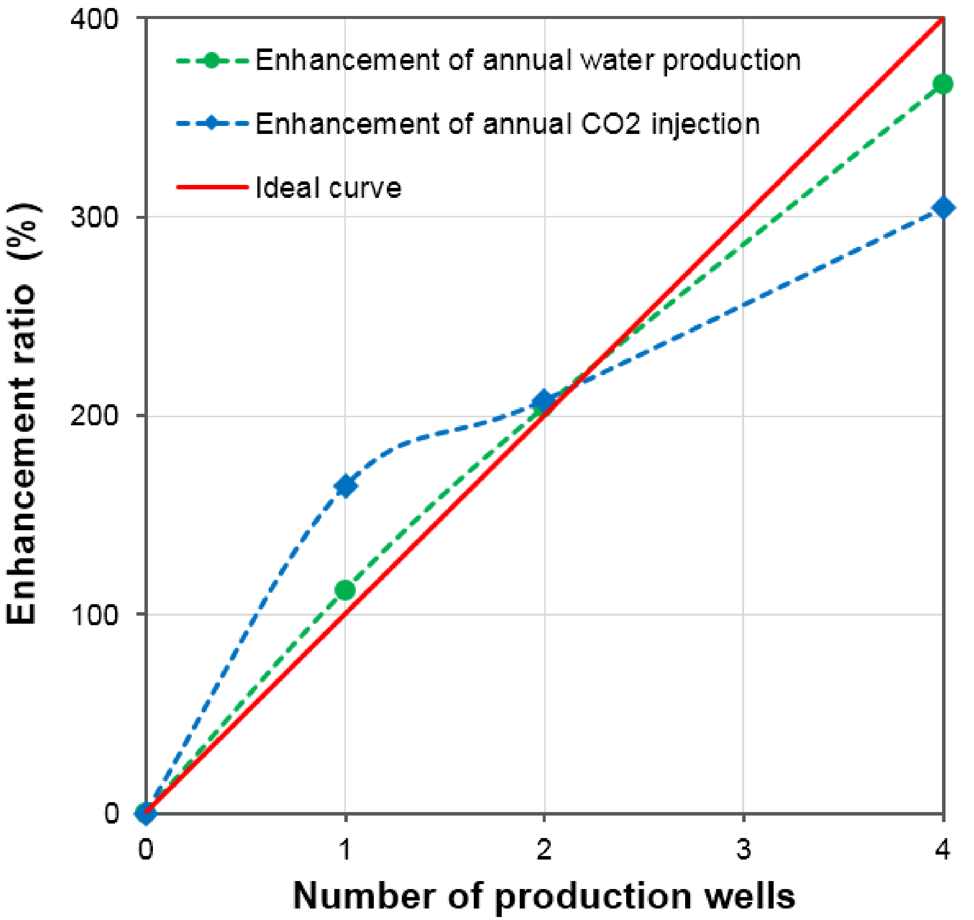


Number of production wells



Annual saline production amount

Number of production wells on enhanced efficiency



enhanced efficiency influenced by n of production wells

- ✓ Well spacing increases, injection and production amount decrease.
- ✓ Well spacing < 1km, premature shut-in time, so 2km well spacing is preferred.
- ✓ n of production wells > 2, low enhanced efficiency
- ✓ economic benefits VS enhanced efficiency, 2 production wells is preferred.

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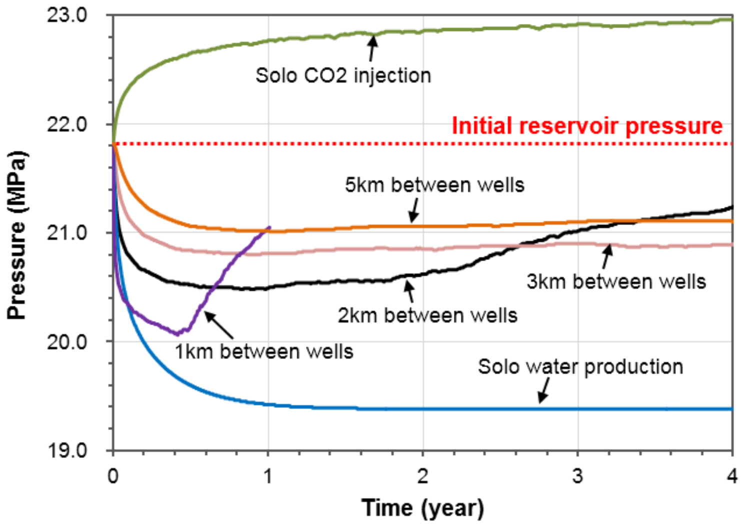
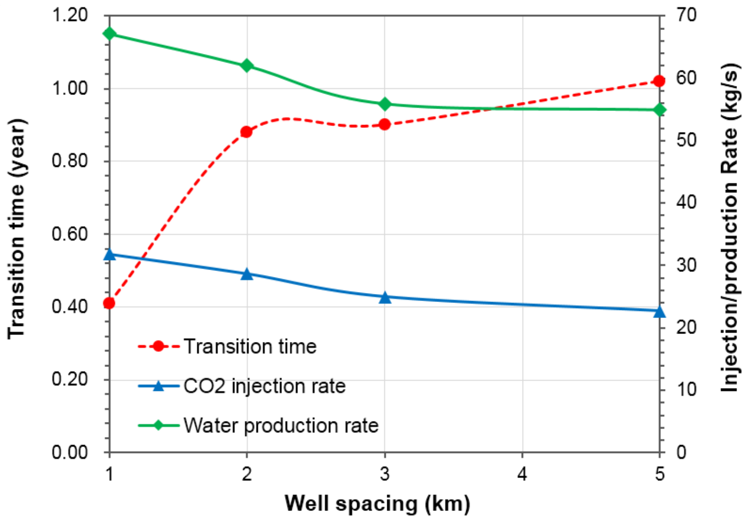
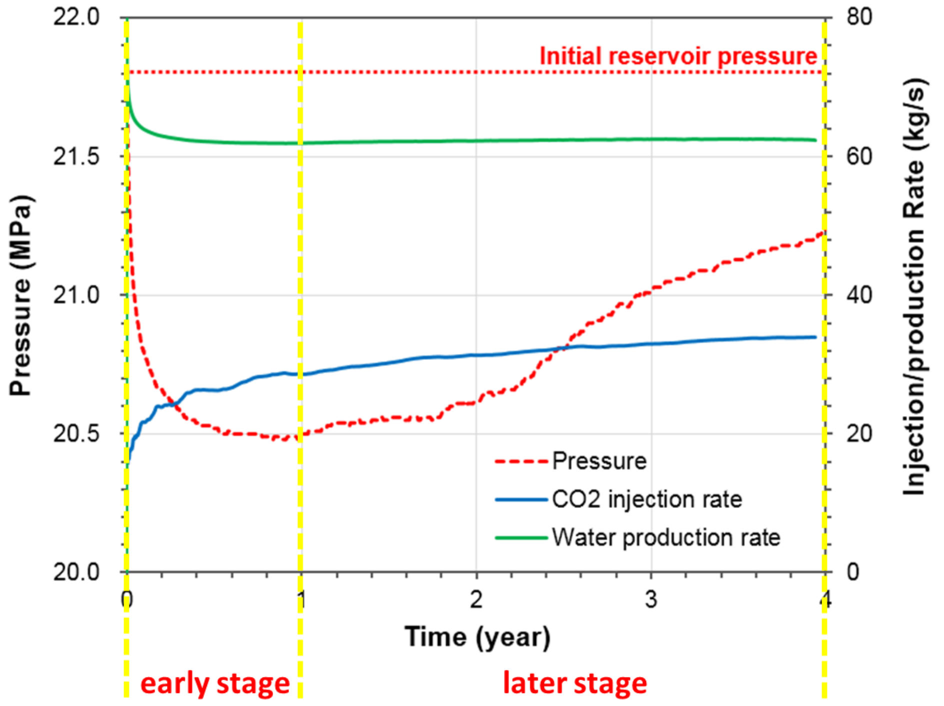
Controlling factors of reservoir pressure evolution



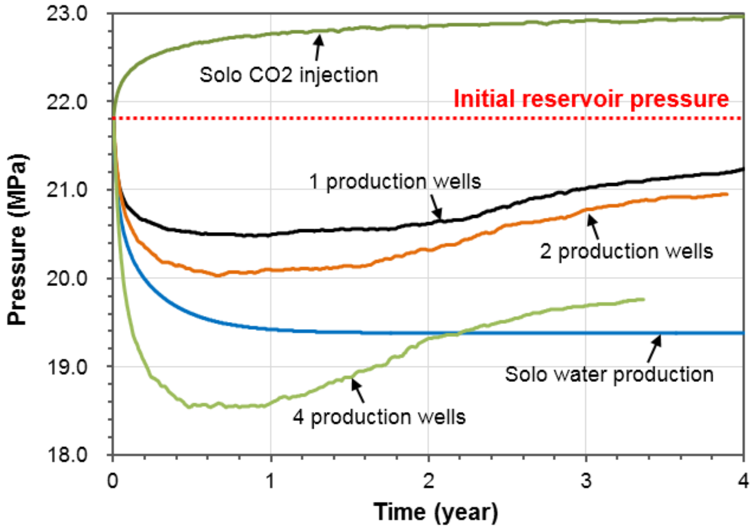
Influence of well spacing on pressure of monitoring points



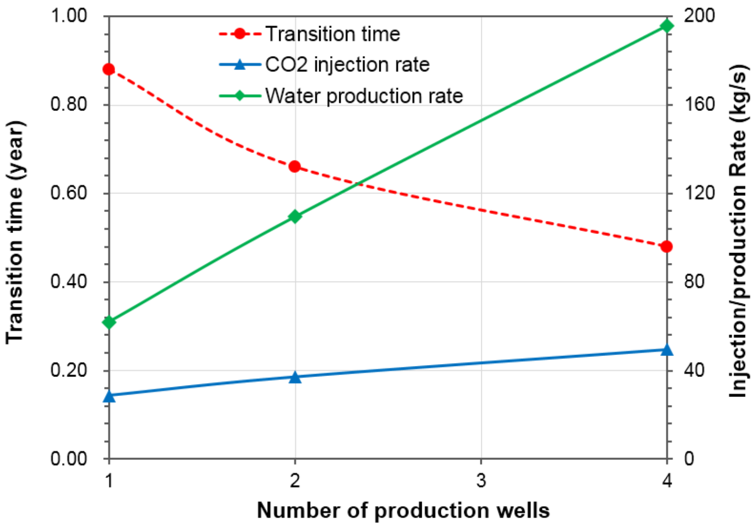
Injection and production rate evolution with well spacing in the transition time point



Temporal variation of the pressure and injection/production rate



Influence of production wells on pressure of monitoring points



Injection and production rate evolution with production wells in the transition time point

- ✓ The main controlling factors of reservoir pressure vary with time.
- ✓ In the early stage: saline production process.
- ✓ In the later stage: CO_2 injection process.

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Conclusions

- CO_2-EWR promote the horizontal migration of CO_2, reducing the accumulation of CO_2 concentration and pressure near the injection wells, which can significantly reduce the risk of CO_2 leakage along the injection wellbore.
- The actual site simulation of Junggar Basin shows that 2 production wells with one injection well and 2 km well spacing is more reasonable.
- The main controlling factor of reservoir pressure evolution is saline production in the early stage and CO_2 injection in the later stage.
- CO_2-EWR technology can effectively control the evolution of reservoir pressure, offset the sharp increase of reservoir pressure caused by CO_2 injection and the sharp decrease of reservoir pressure caused by saline production.

Thank you

Questions ?