

CO₂ Storage / EOR Projects

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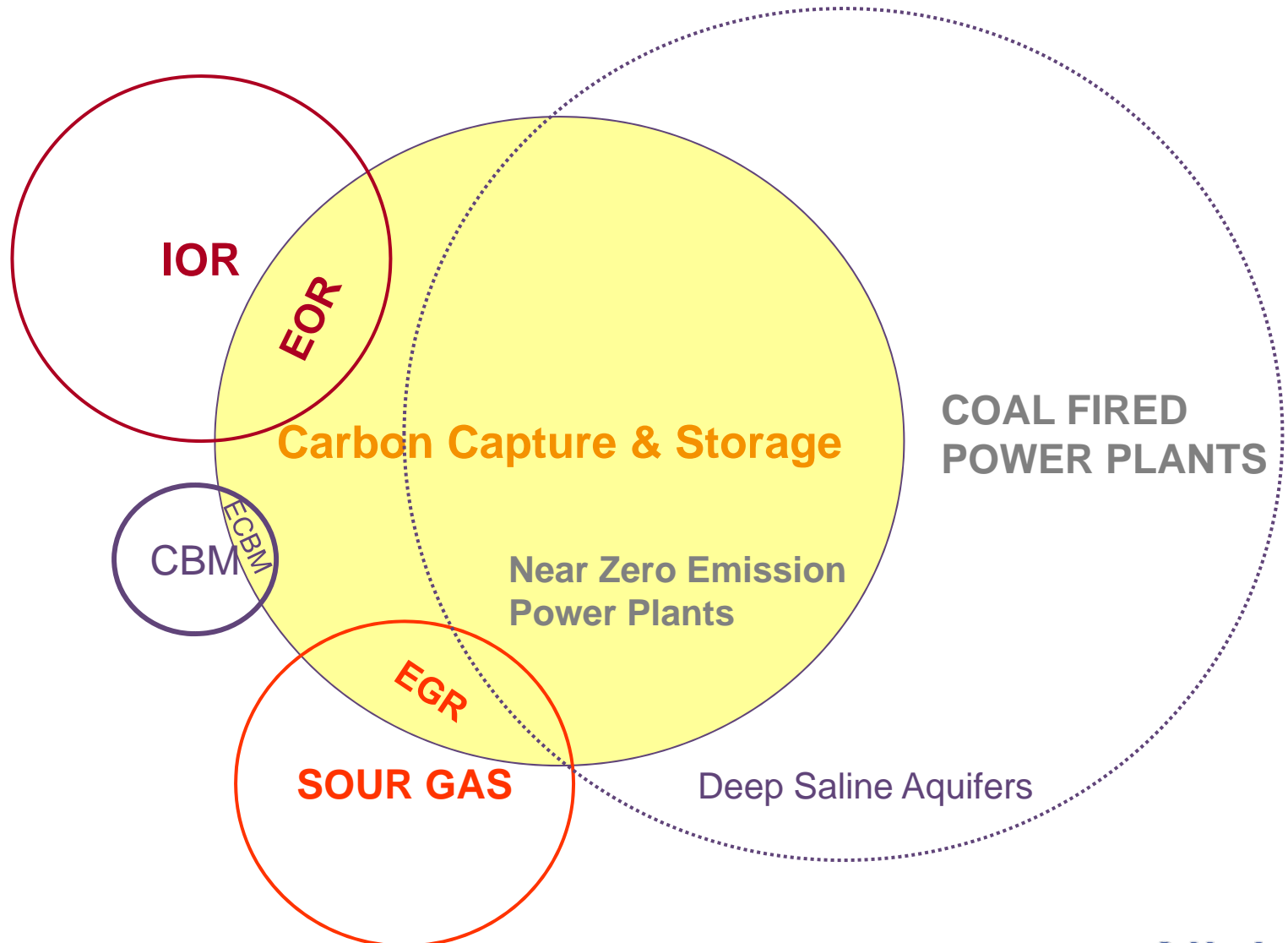


Overview

- Introduction
- CCS Projects, challenges
- CCS in Schlumberger
- Evolution of CO₂ business
- Summary



CCS projects space and value added processes



Key criteria for CO₂ storage site selection

Capacity:

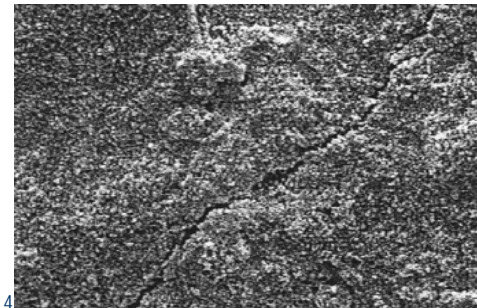
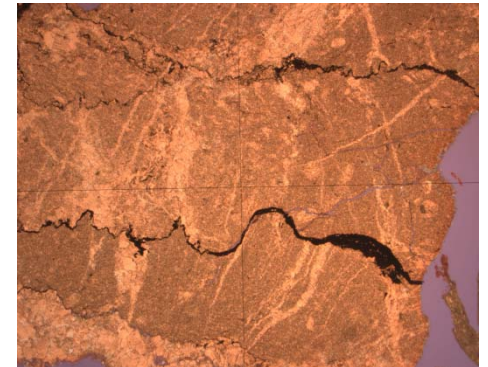
- Total volume available
- Rock, fluid properties

Injectivity

- Capable of injecting design rate
- Sustainable over long time

Effectiveness

- Long term storage stability
- Most difficult to predict



Major uncertainties in CO₂ storage site description

- Nature and distribution of faults
- Rock type scheme
- Areal & vertical distribution of rock types
- Vertical permeability
- High K streaks, baffles/barriers (low K)
- Nature and distribution of fractures
- Permeability dependency on stress changes due to CO₂ injection

Characterization phase needs to provide basic understanding of property distribution (heterogeneity) of reservoir and caprock

CO2 Storage / EOR Technical Challenges

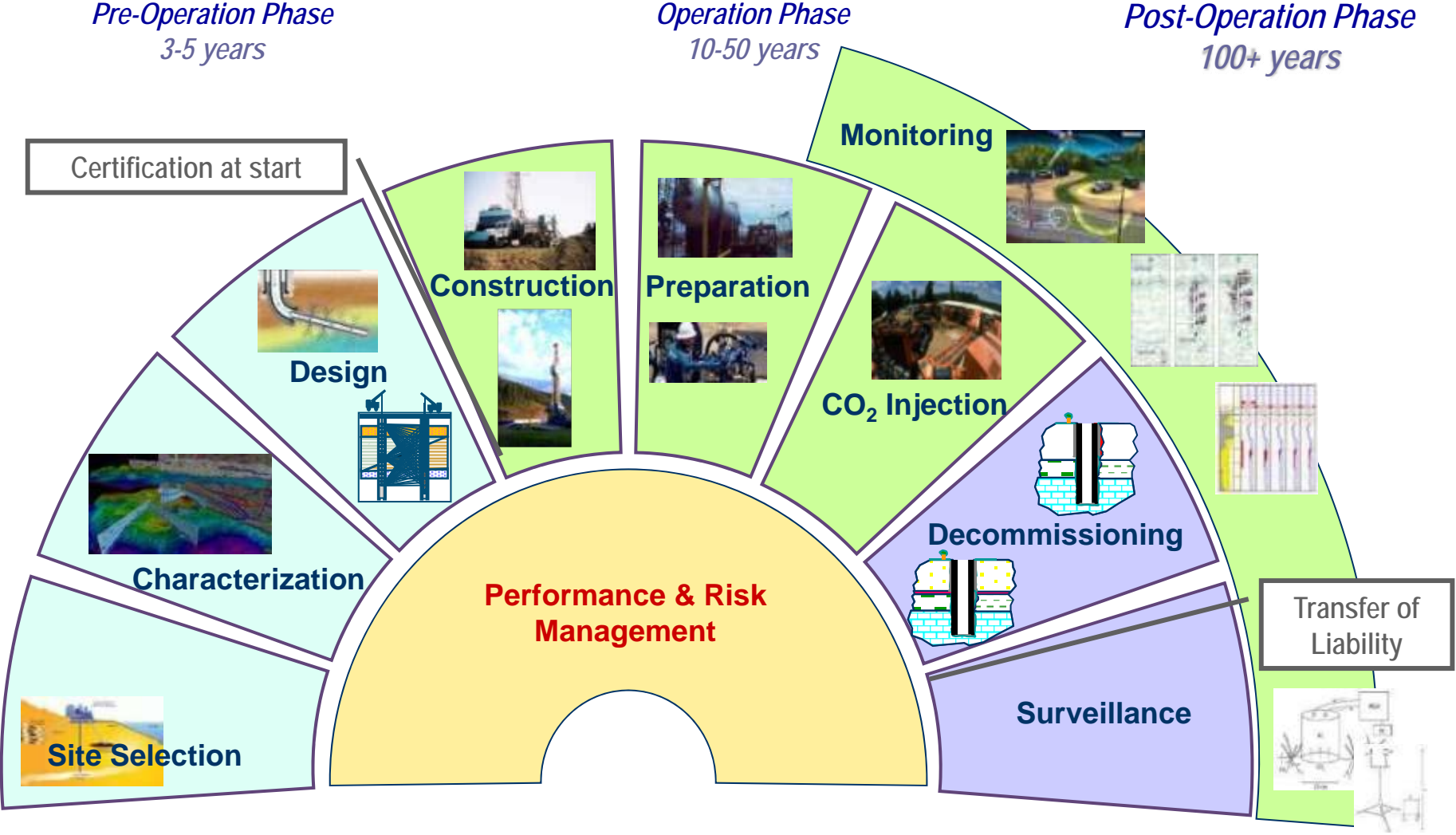
Reservoir

- Injectivity
- EOR response
- WAG
- Conformance control
- CO₂ – Oil interactions
- Wettability alteration
- Asphaltene deposition
- Permeability variations
- Geochemical interactions
- Incremental Oil Potential

Operational

- CO₂ availability, utilization
- Early gas breakthrough
- Asphaltene deposition
- Corrosion
- Completions integrity
- Flow assurance
- Leakage monitoring
- Produced gas handling
- Higher OPEX, CAPEX

CO₂ Storage Project Workflow



Site Characterization – Capacity & Trapping

Ensure that the reservoir can contain all injected CO₂ and that it will be permanently trapped

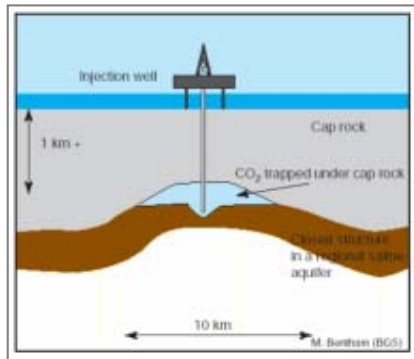
■ Basics

- Structural model
- Available pore volume
- Sweep efficiency ($E_A \cdot E_D$)

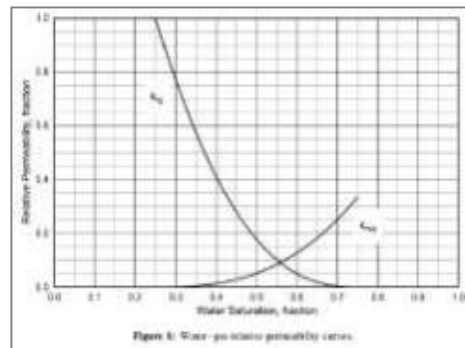
■ Storage Media

- Depleted Reservoir
- Aquifer
- Coal Seams

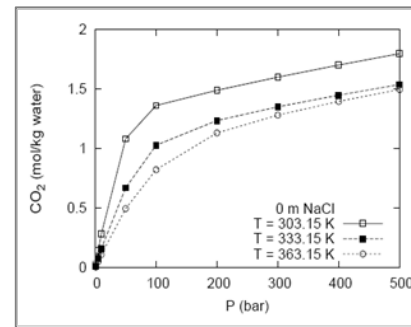
■ Evaluation of the trapping mechanisms efficiency and kinetics



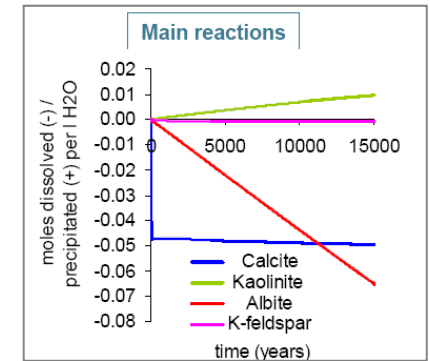
Structural / hydrodynamic



Trapping in residual phase



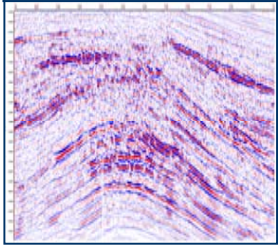
Dissolution



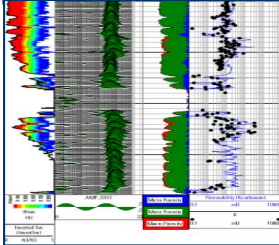
Mineralization

Building a Static Model – Structure & Properties

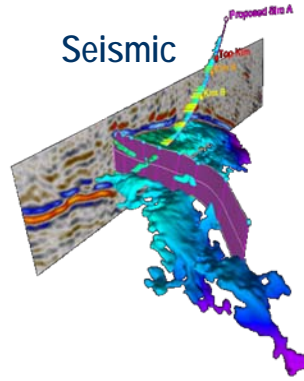
Geophysics



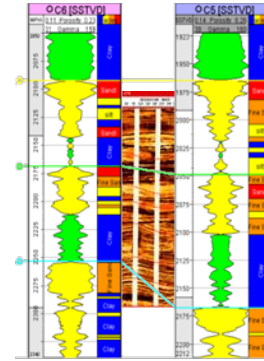
Flow / Transport



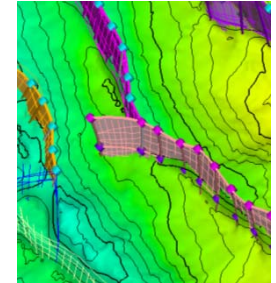
Seismic



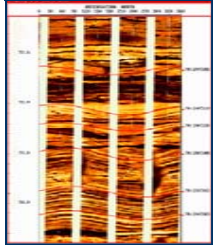
Well Correlation



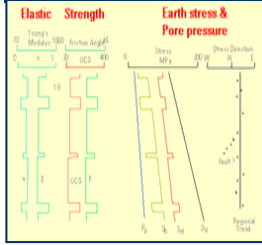
Fault Modeling



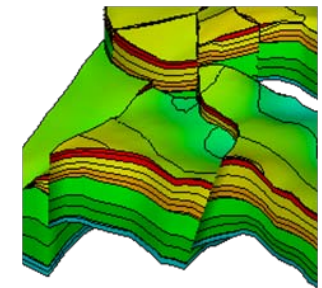
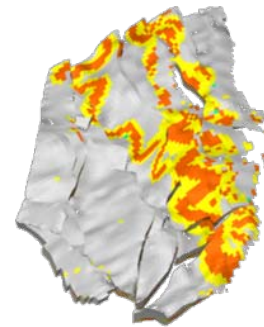
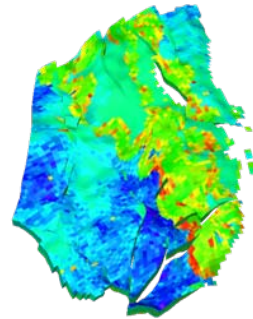
Geology



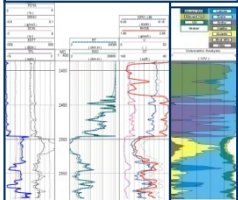
Geomechanics



PETREL



Petrophysics
Mineralogy



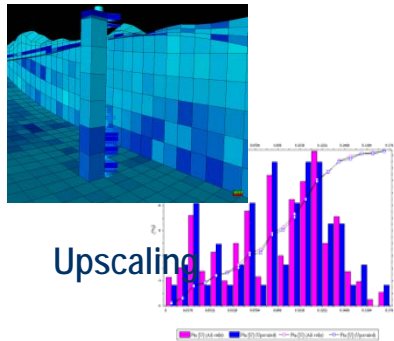
Petrophysical Modeling

Facies Modeling

Zonation and Layering

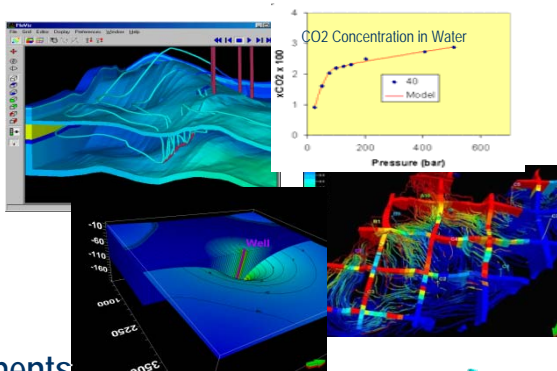
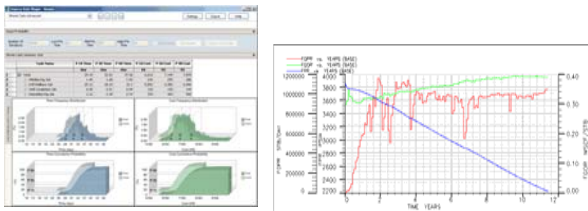
Model should include overburden

CO₂ Injection Dynamic Modeling



ECLIPSE – E300

Calibration on monitoring measurements
(History match)



3D Full Compositional Flow Simulator

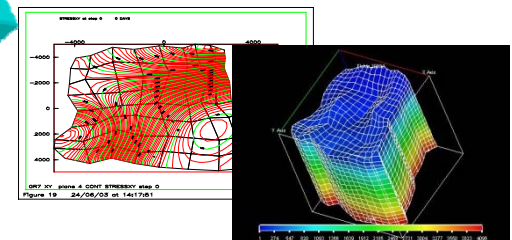
Current status: Improved fluid-fluid / fluid-rock interactions

- Accurate description of mutual solubilities
 - Dry-out / Salting out effect
 - Salt precipitation
- Coal swelling and shrinkage

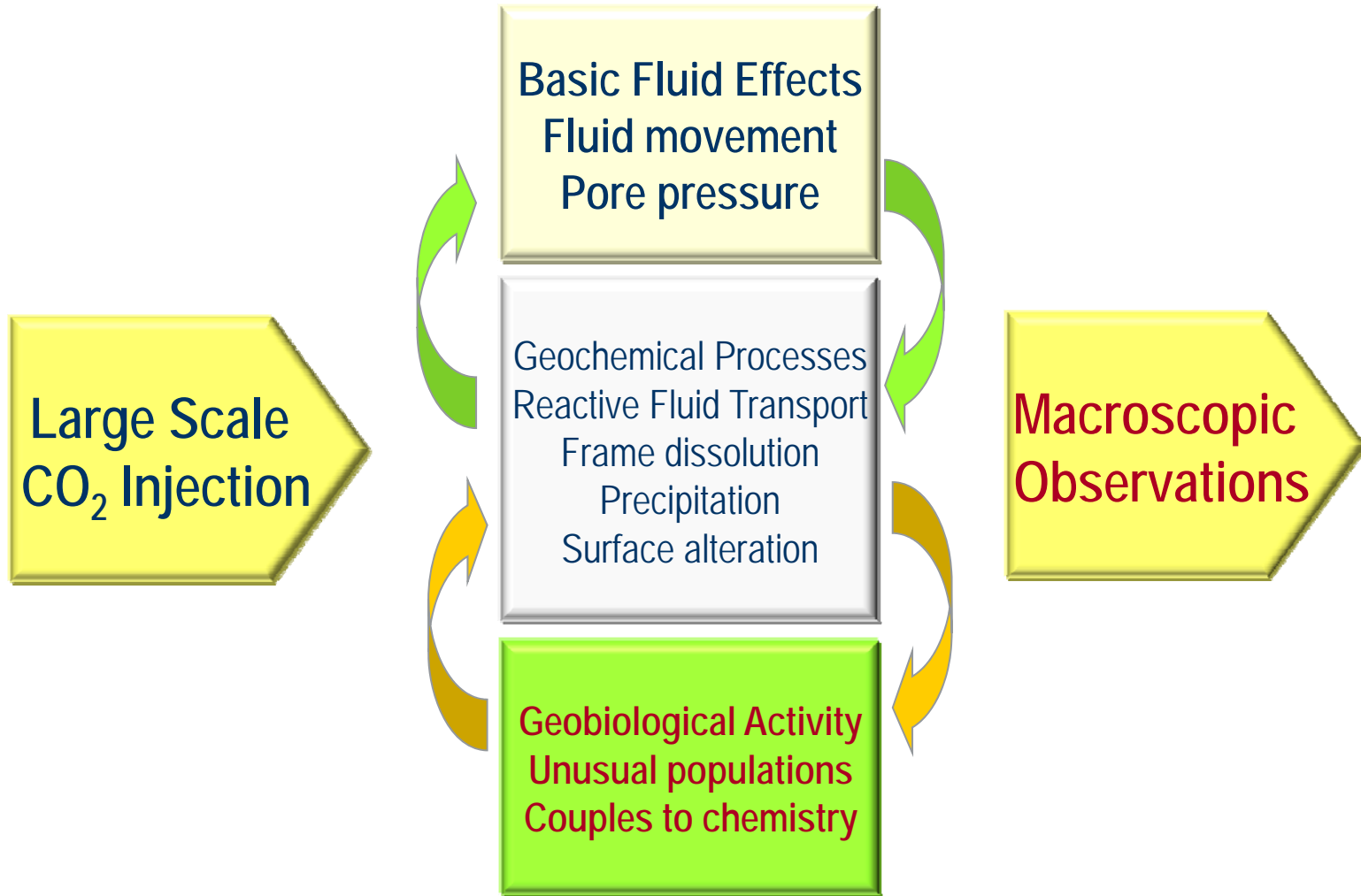
Thermodynamics
Geochemistry

Thermal Modeling

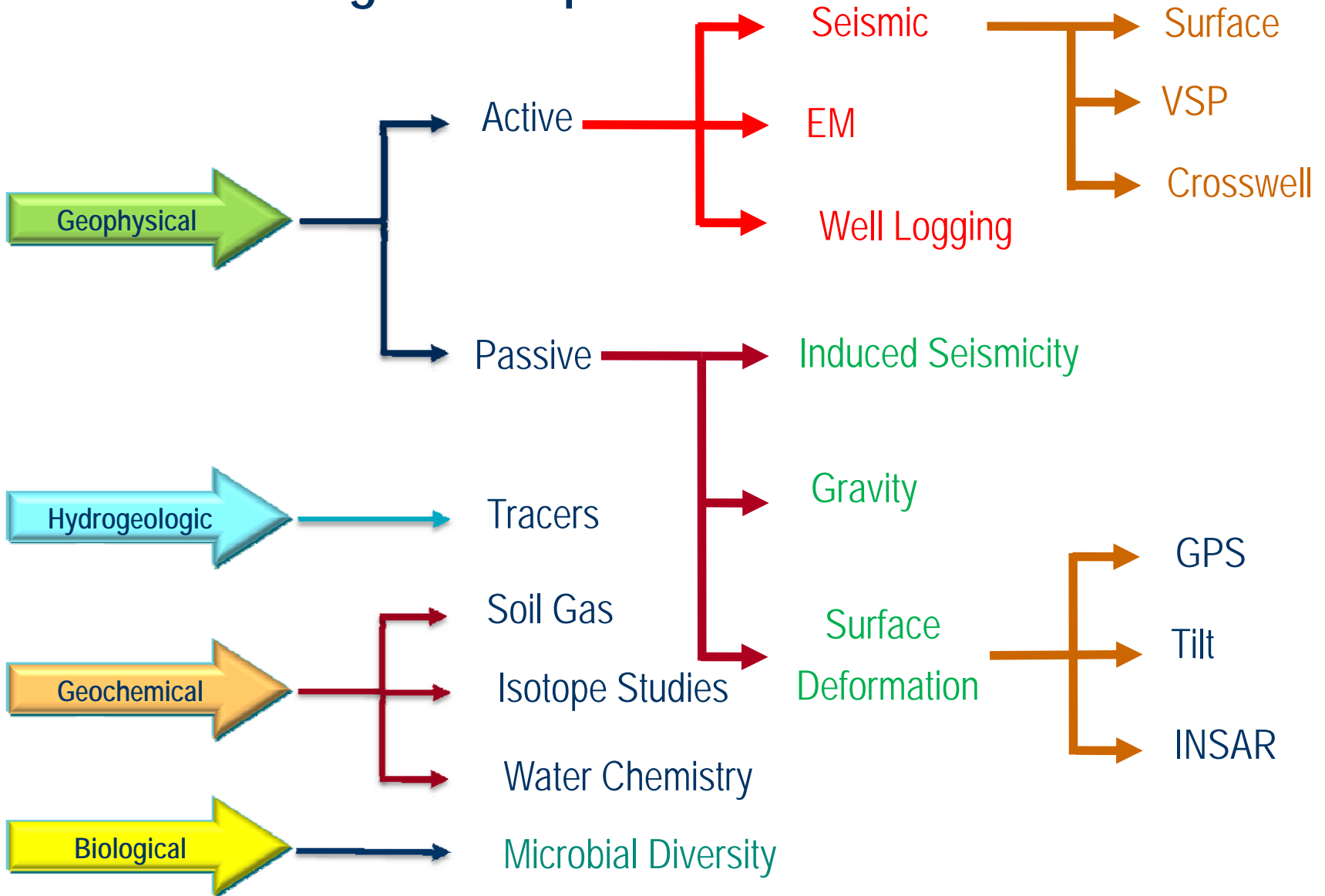
Geomechanics Simulator



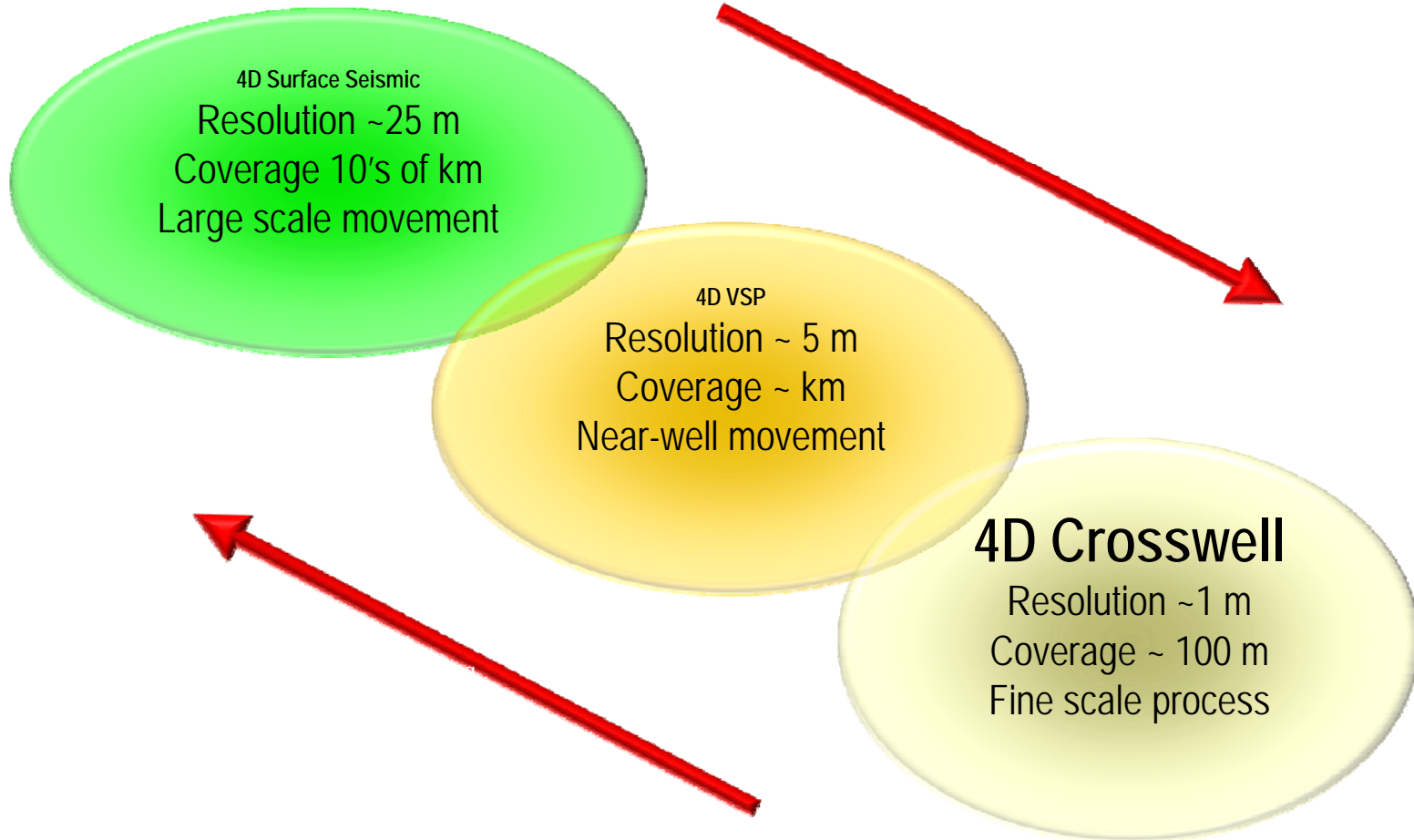
Monitoring Framework

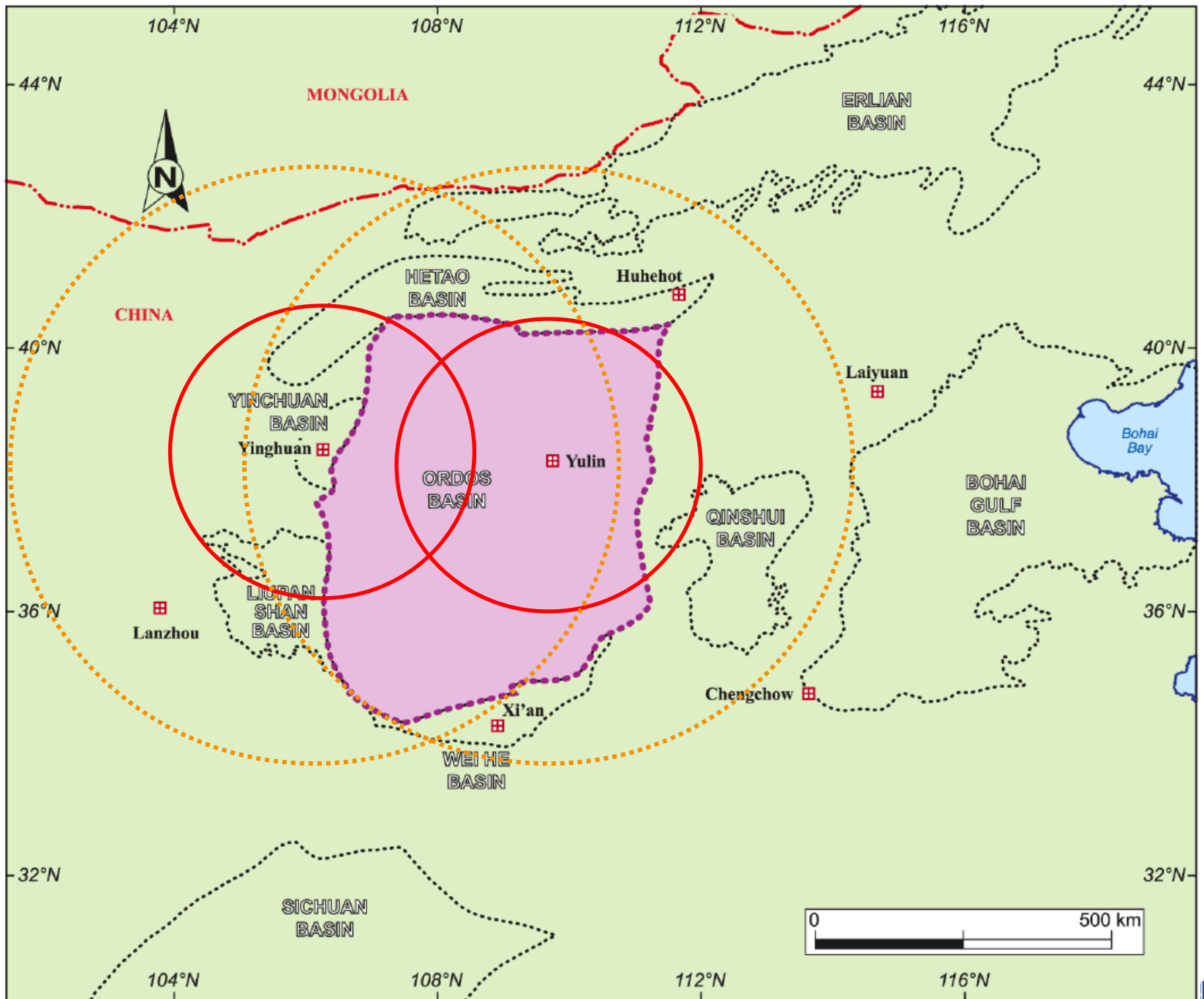


EOR Monitoring Techniques



Three Scales for 4D Seismic Imaging

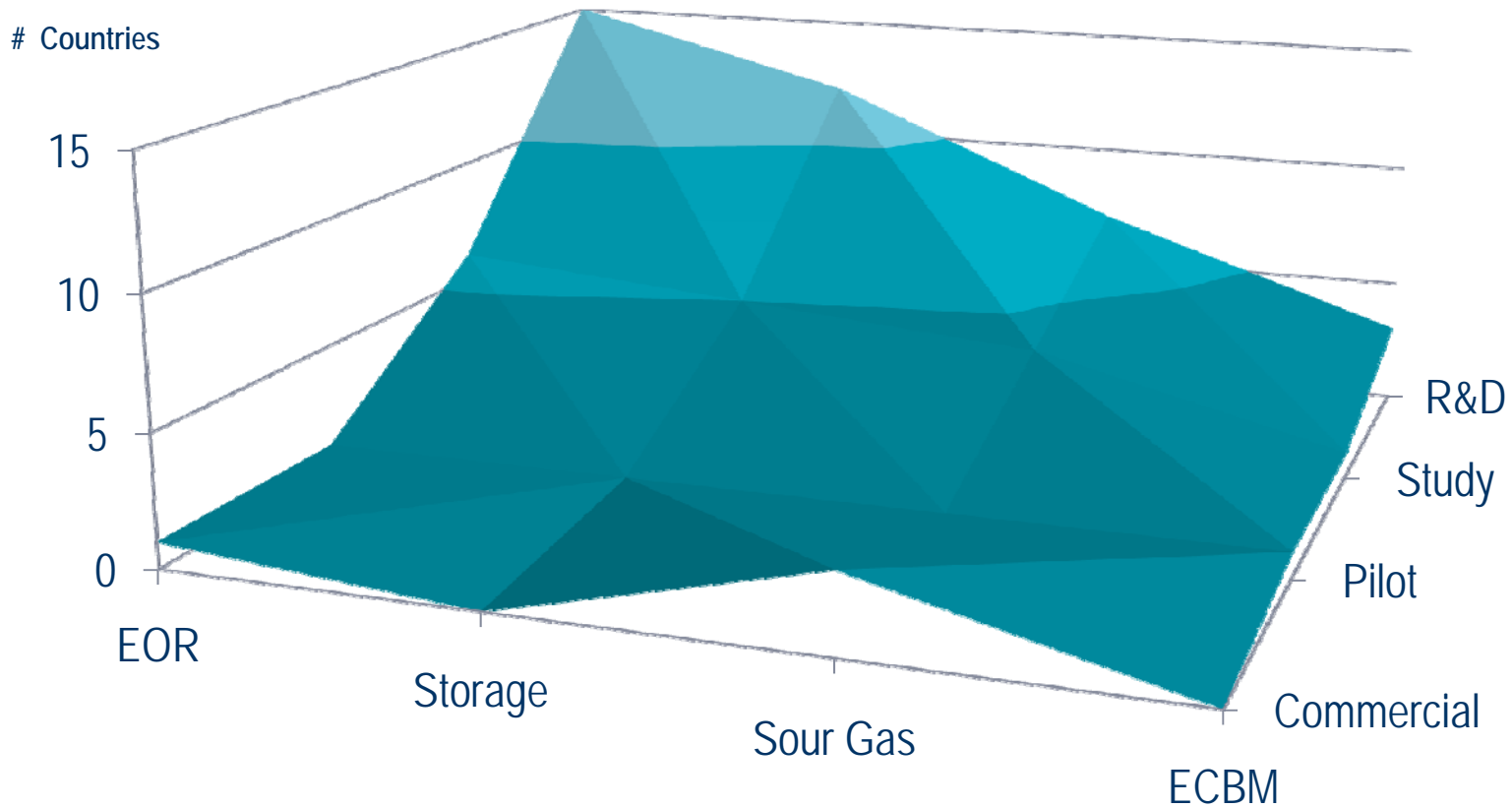




MEA CO₂ Portfolio

Country	CO ₂ EOR	CO ₂ Storage	Sour Gas	ECBM
China	Daqing, Jiangsu, Jilin, Shengli, Zhongyuan (39)	SASOL CTL [*] NZEC [*] , COACH [*] GreenGEN	Pugang Dong Fang Bohai Bay	Qinshui MoveCBM [*]
Japan	-	Nagaoka [*]	Tangga Barat	-
Malaysia	BDO Fields [*]	Bin Tulu -CDM	K-5 [*] , BGT [*]	-
UAE – Abu Dhabi	NEB - Rumaitha	MASDAR	Bab, Shah	-
India	ONGC [*]	Basalt Research	-	-
Kuwait	KOC [*] , KISR, MHI	-	-	-
Qatar	QP, Maersk [*]	-	Acid Gas	-
KSA	R&D [*] , PTRC	KACST [*]	-	-
Thailand	-	BG	BG [*]	-
Vietnam	White Tiger	-	-	-
Indonesia	PERTAMINA	-	Natuna Alpha D	-
Korea / Taiwan	-	TaiPower, KIGAM	-	-

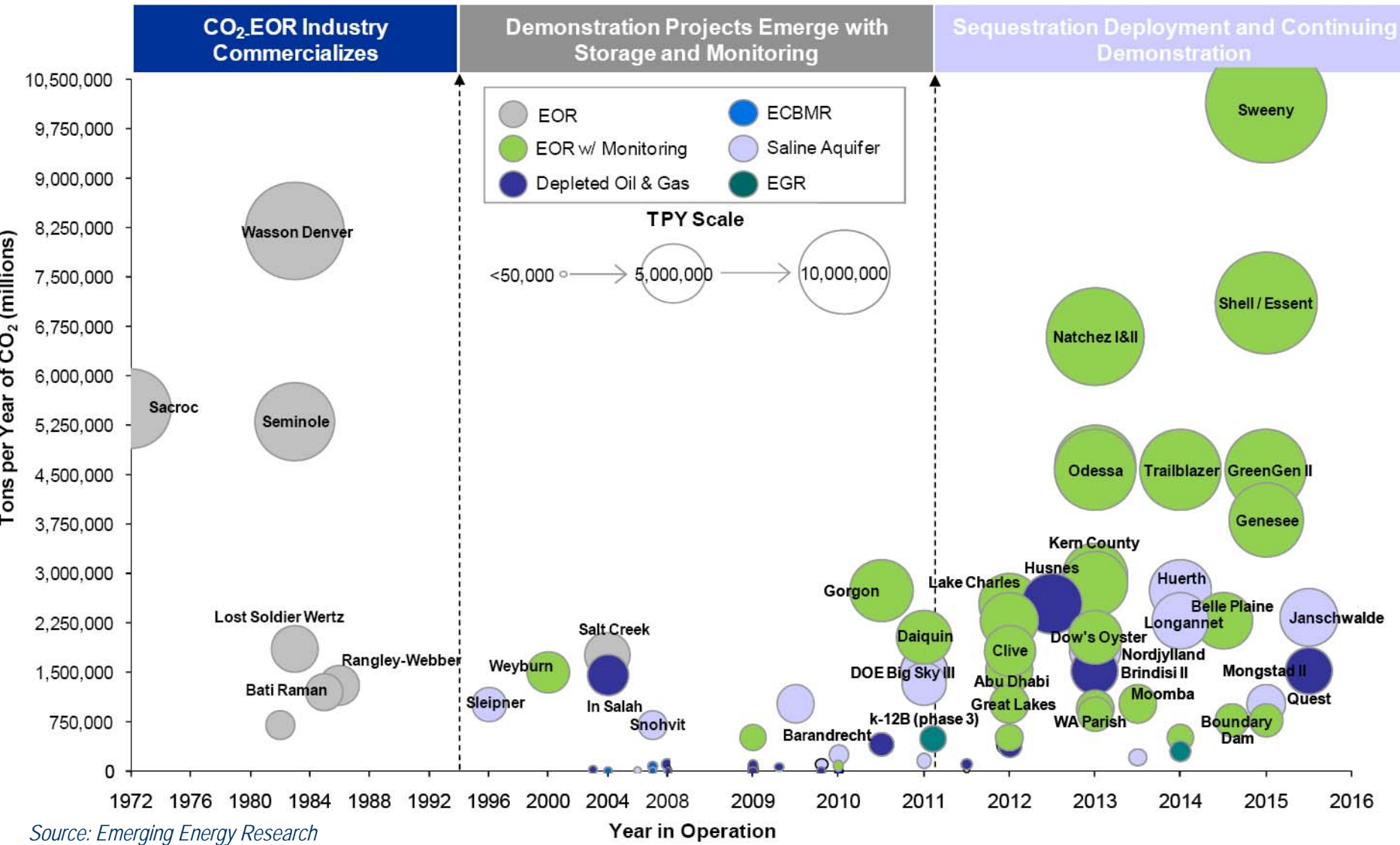
CO₂ Projects Space in MEA



CO₂ Services

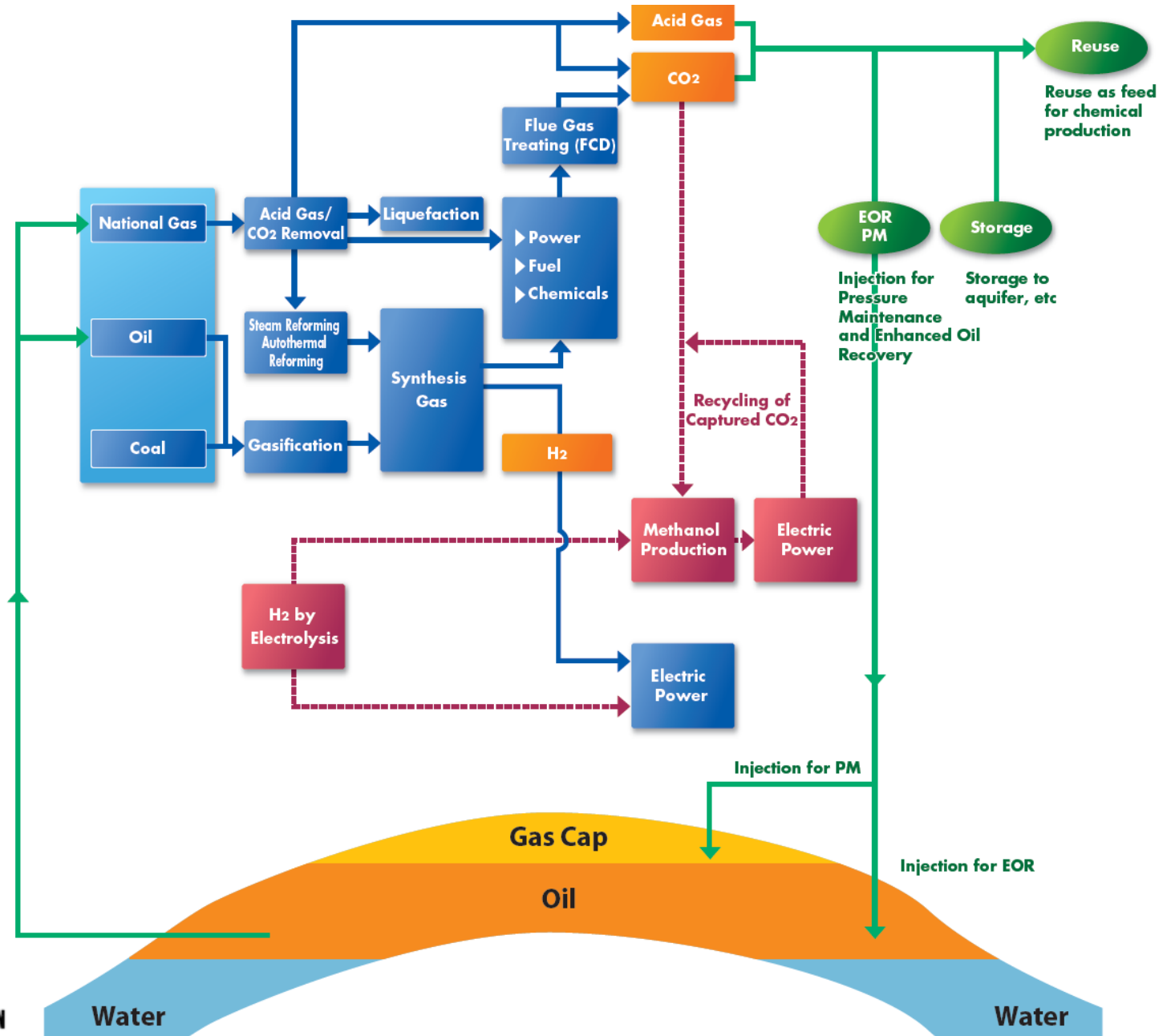
Schlumberger Reservoir		Site Selection		Development		Monitoring		Verification
Characterization	Western Geco	X	X		X	X		
	D&M		X	X				
	Wireline		X	X	X	X	X	
	Testing		X	X			X	
Production	Well Services		X	X	X		X	
	Completions		X	X		X		
	Artificial Lift			X				
	Sand Control			X				
	Fluid Sampling		X	X		X		
	HFM			X		X		
Management	SIS		X					
	DCS	X	X				X	
	SCS	X	X	X	X	X	X	
	SWS	X		X		X		
	SBC							

Existing / Planned CO₂ EOR / Storage Projects

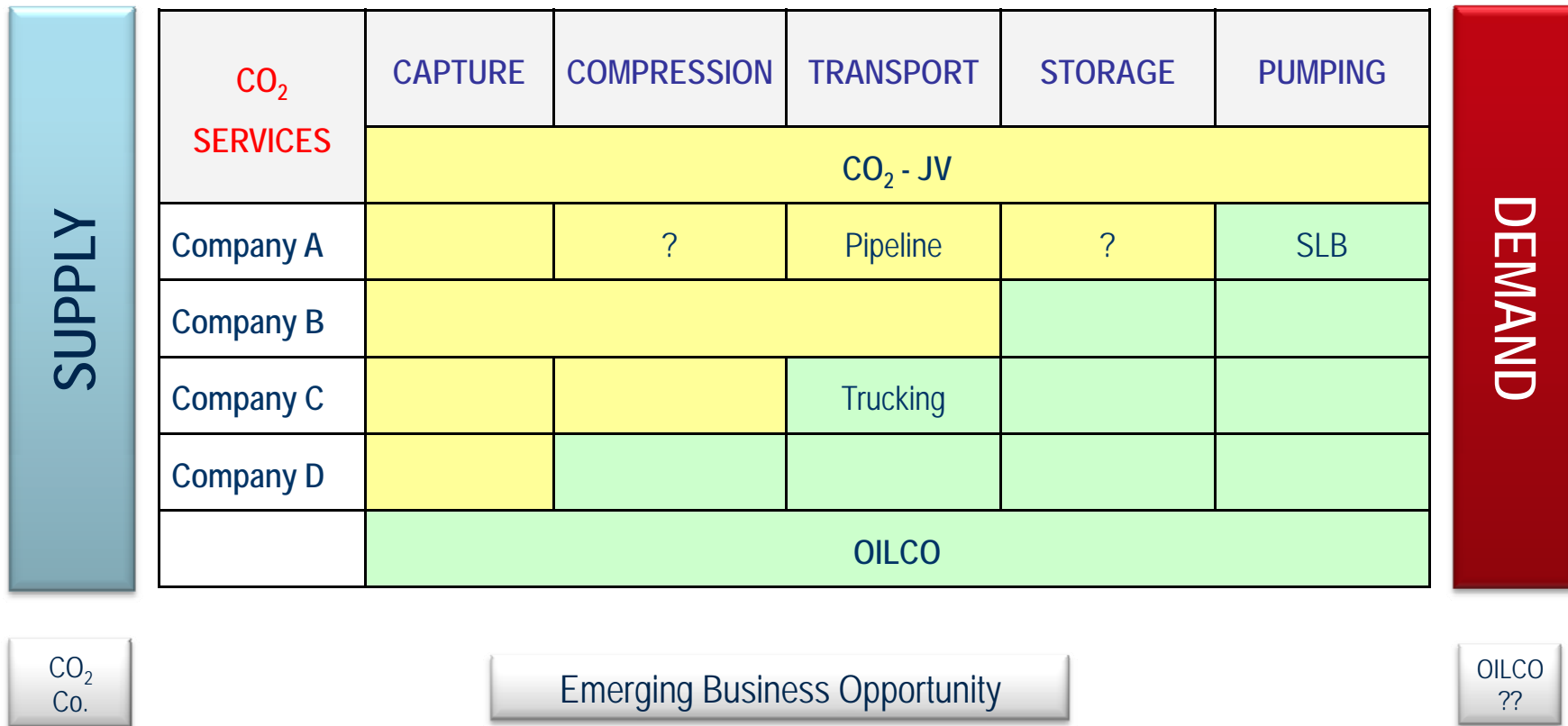


Source: Emerging Energy Research

Power of Integration



CO₂ EOR Business Players



CO₂ EOR Projects;

- Are low return, high cash flow, long life Investments
- Requires large upfront CAPEX / High OPEX
- Are technically demanding projects
- Only a fraction of oil reservoirs are candidates
- Are best placed in a portfolio with low cost / high return projects
- The best waterflood will make an economic CO₂ EOR

Summary



- Engineered site selection for CO₂ storage
- CO₂ Storage in is still in research domain
- Best described subsurface data is only available in E&P
- Develop dual use projects to provide incentive for:
 - CO₂ rich, sour gas reservoirs
 - CO₂ EOR in carbonate reservoirs
 - Coal Bed Methane development
- Need more large scale collaborative field projects

Schlumberger



- Involvement in a majority of CCS projects
- Participation in major collaborative projects (GCEP, European projects, CO2CRC)
- Worldwide development of technologies within SLB encompassing all major sub-surface parts
- Expertise covering storage, depleted fields, CBM, EOR
- Development of site assessment and development workflows
- Creation of a dedicated organization