An Overview of CCS in China

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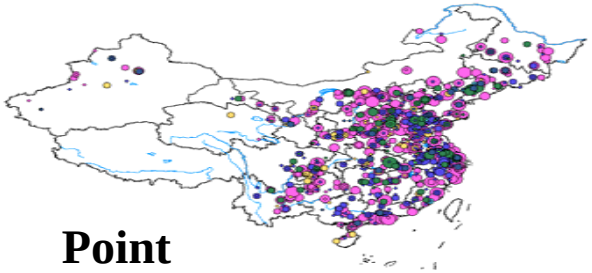
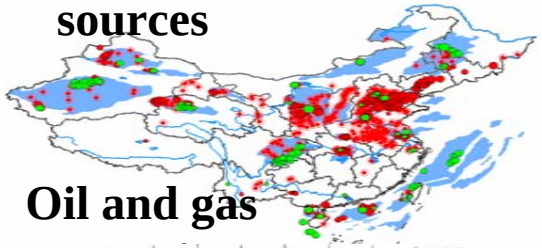
Outline

- CCS potentials
- Mechanical related issues
- Conclusions

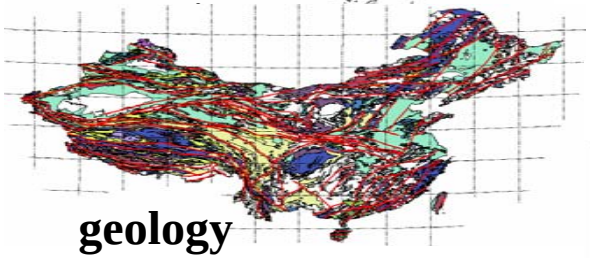
China CCS Database



Point sources

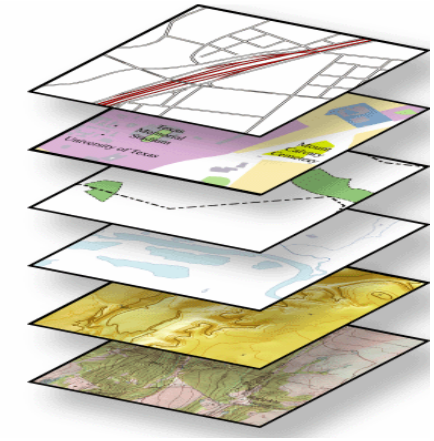


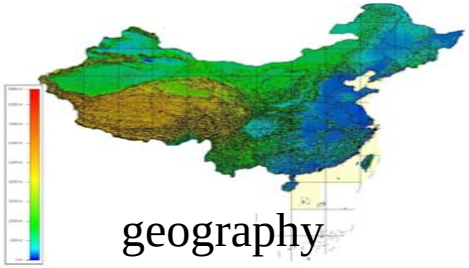
Oil and gas



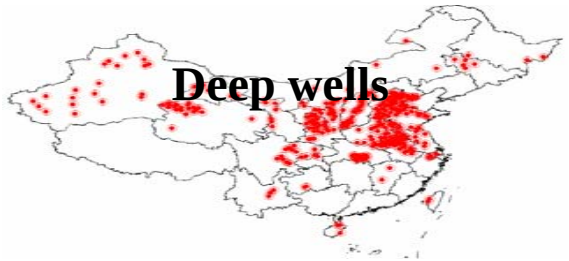
geology

GIS数据库层序结构



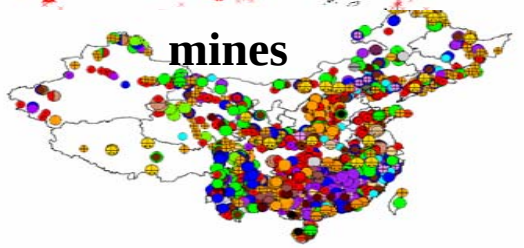


geography



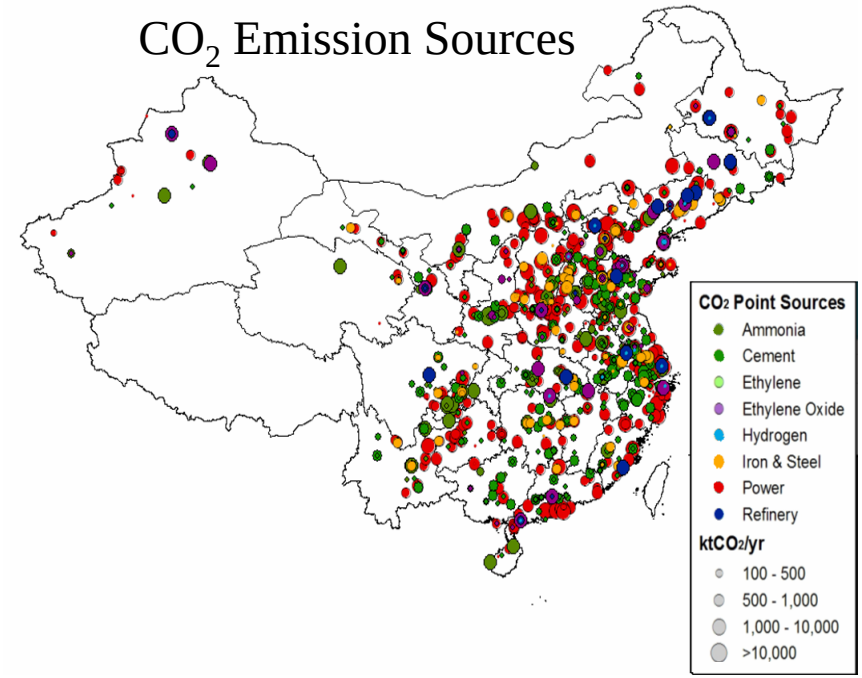
Deep wells

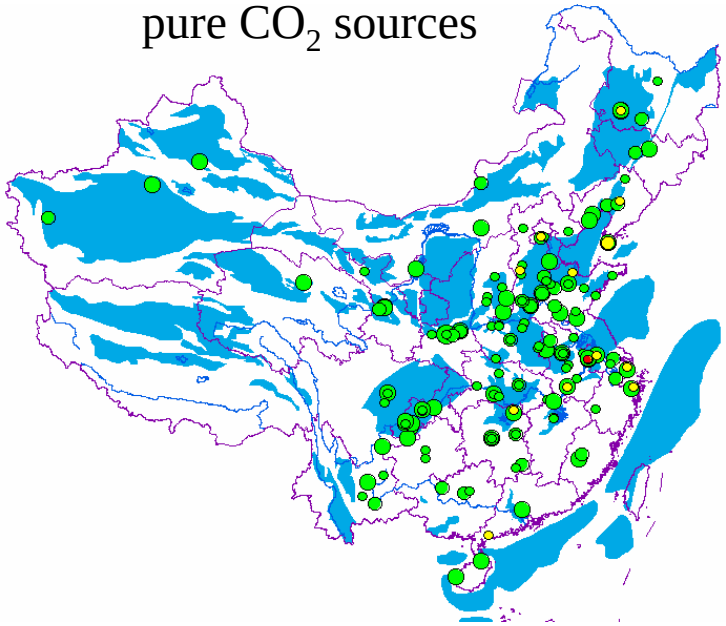
geostresses



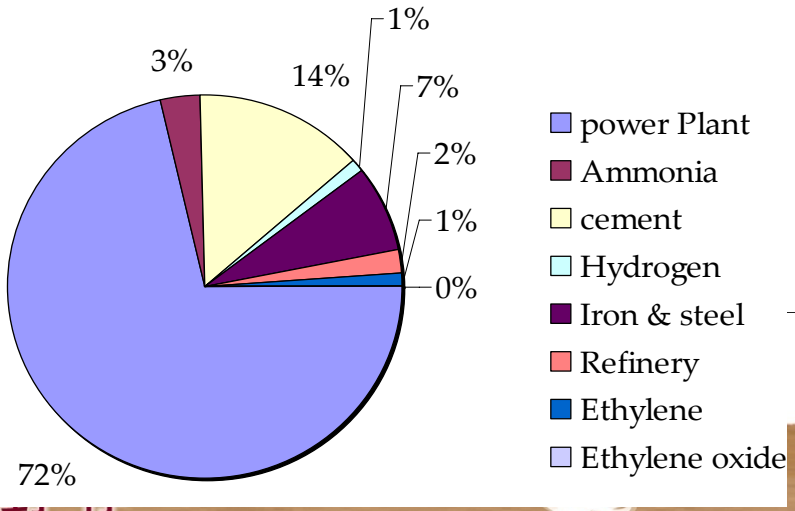
mines

CO_2 Emission Sources

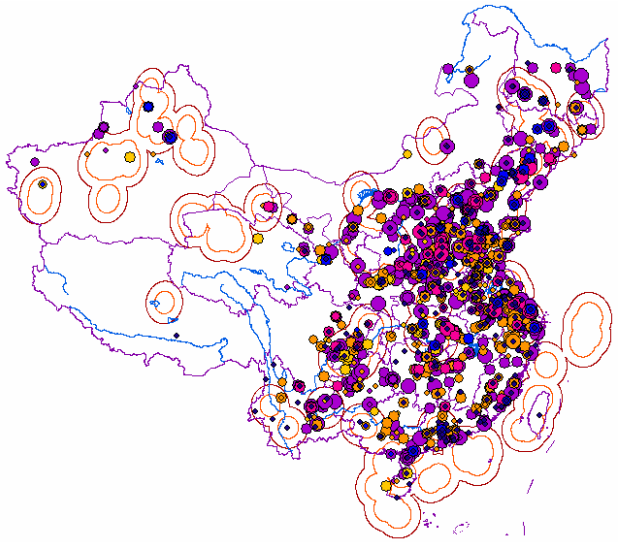


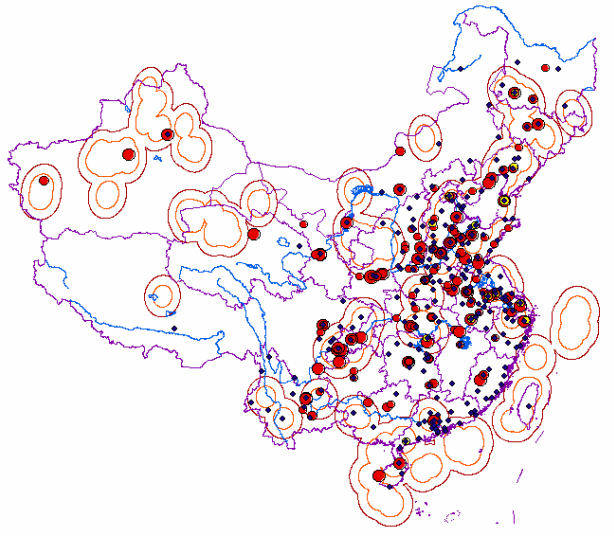


- **1623（>10^5t/a），3.9Gt/a in total（2007）**
- **Emissions from power, cement and iron & steel sectors account for 94%**
- **Average annual emission per sources: 2.73Mt/a**



Source-Site Matching





	All sources	high-con sources
With basin	54%	45%
<80km	83%	75%
<160km	91%	92%

CCS potentials and features in China

- Good potential:
  - Many large sources (1623) and a great annual emission (3.9Gt/a) + big capacity (3Tt) + good proximity (54% with the basins)
- Pure CO_2 source + EOR or EGR provides the early opportunities for CCS demonstrations:
  - 188 pure CO_2 sources in operation and more under construction
- PC plants + DSF will be needed for deep reduction
  - DSF capacity accounts for 99% and PC emission, 72%
  - S&SE China may rely on DSF

China CCS S&T Projects

◆National Key Basic Research Program(973) “Resource utilization and underground sequestration of greenhouse gas for enhancing oil recovery ”(2006-2010), funded MOST

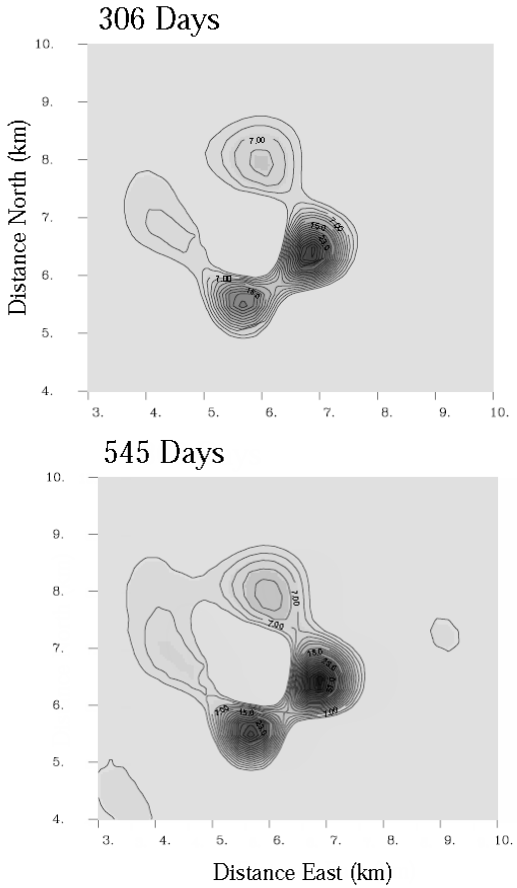
◆Hi-Technology Research and Development Program of China (863) “R&D of CO2 capture and aquifer storage” (2009-2011), funded by MOST

◆Frontier Program Project “Pilot test of impure CO2 capture and aquifer storage”(2009-2010) , funded by CAS

Challenges

- High costs
- Security anxiety
- Financing and regulation: in R&D and implementations
- In lack of practical experiences
- Inter-sector

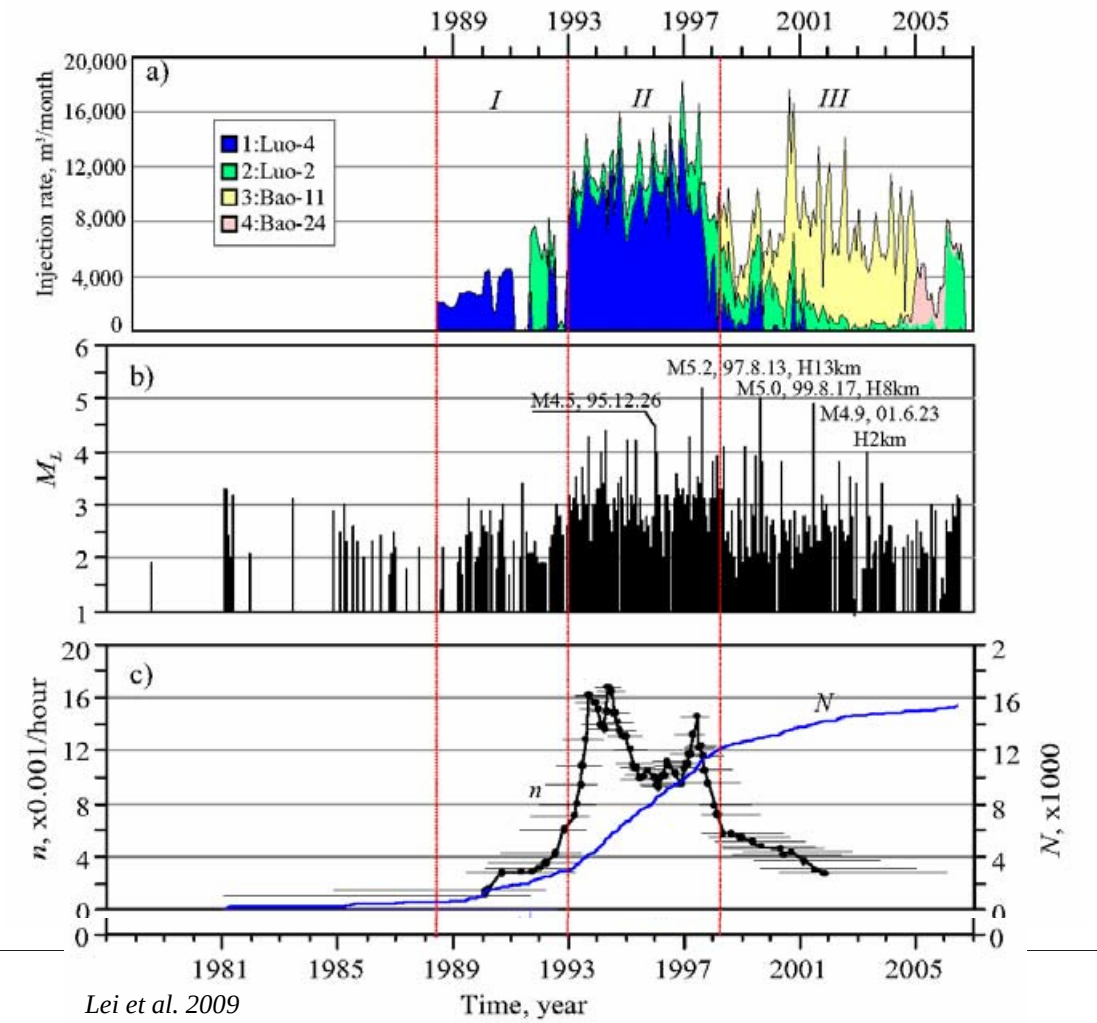
WHY. In Salah CCS in Algeria



- ***InSAR data is used to compare predited uplift at the In Salah sequestration site in central Algeria at one year.***

Vasco et al. 2008

WHY. Water Injection Induced Earthquake



Lei et al. 2009

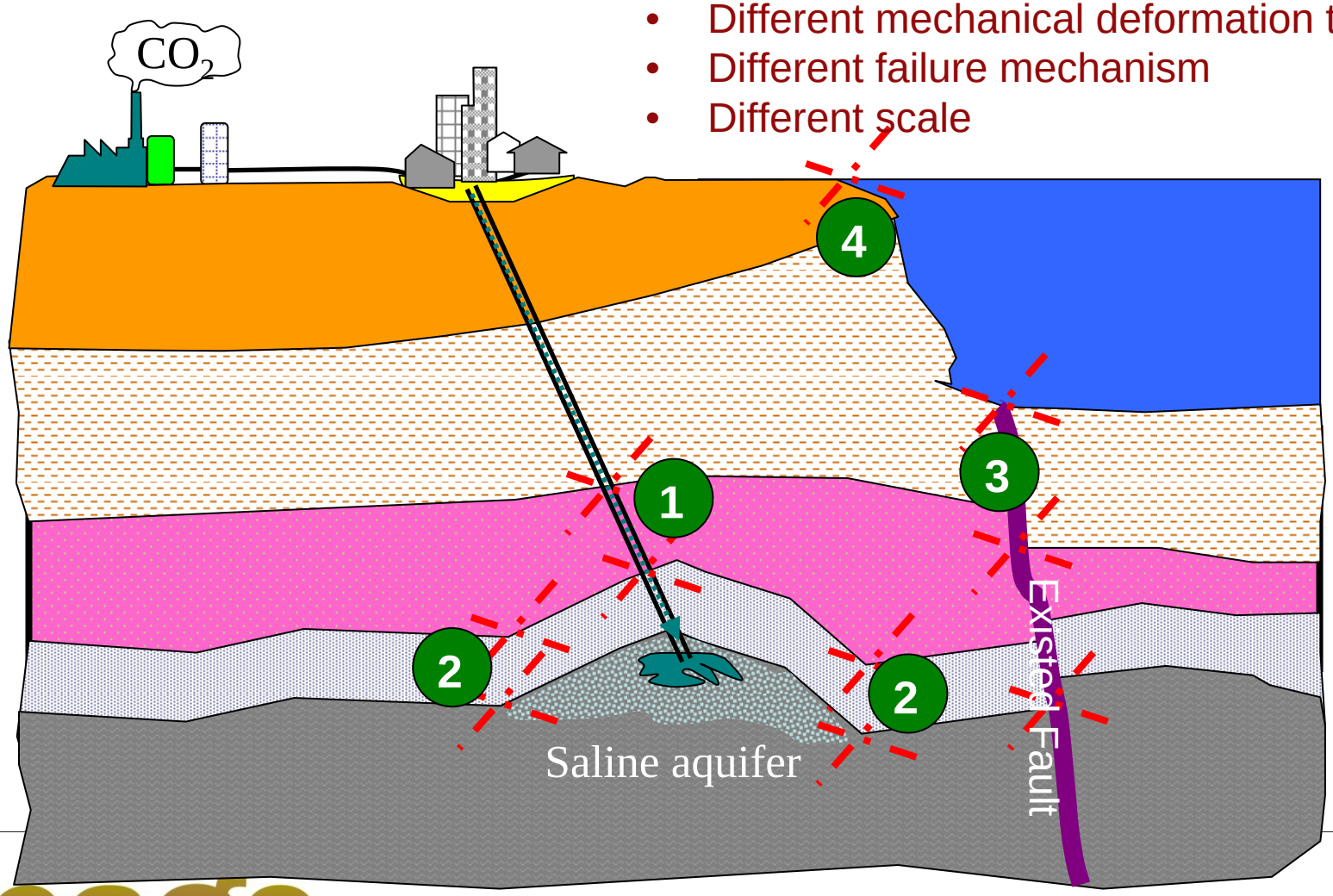
Earthquakes induced by water injection at ~3 km depth within the Rongchang gas field, Chongqing, China.

Largest M=5.2

- Injection MUST induce earthquake, and KEY is magnitude.
- If operating scientifically and systematically, HAZARD may be AVOIDED.

WHAT. Mechanical Stability Issues

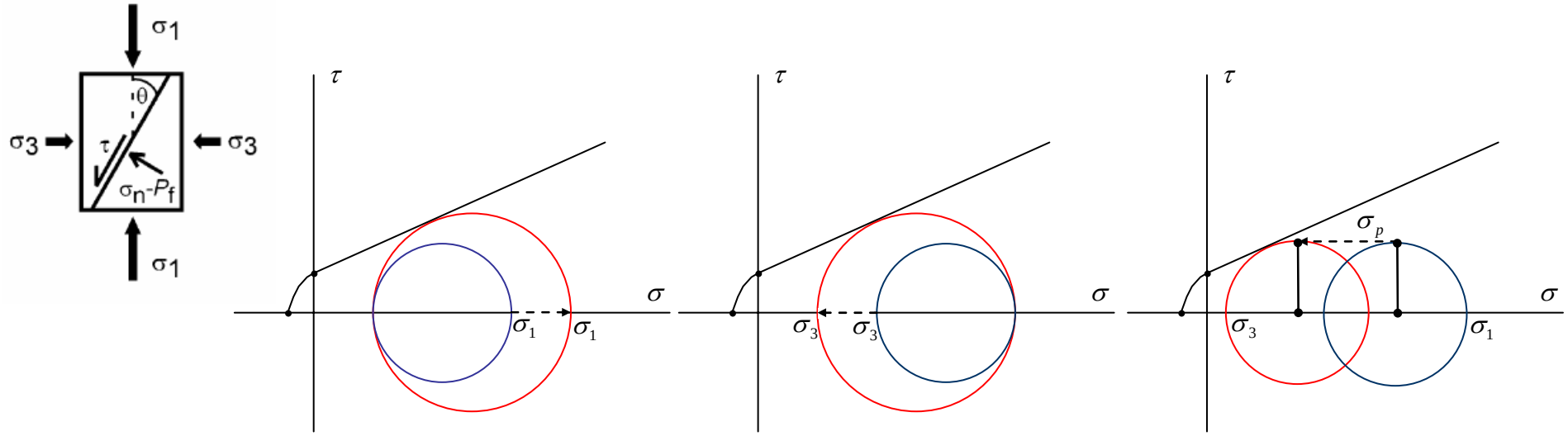
- Different mechanical deformation type
- Different failure mechanism
- Different scale



Li et al. 2006

WHAT. Possible Explanation for Failure Mechanisms

Three major kinds of failure mechanisms of faults around the injected sites are depicted by Mohr's circles.

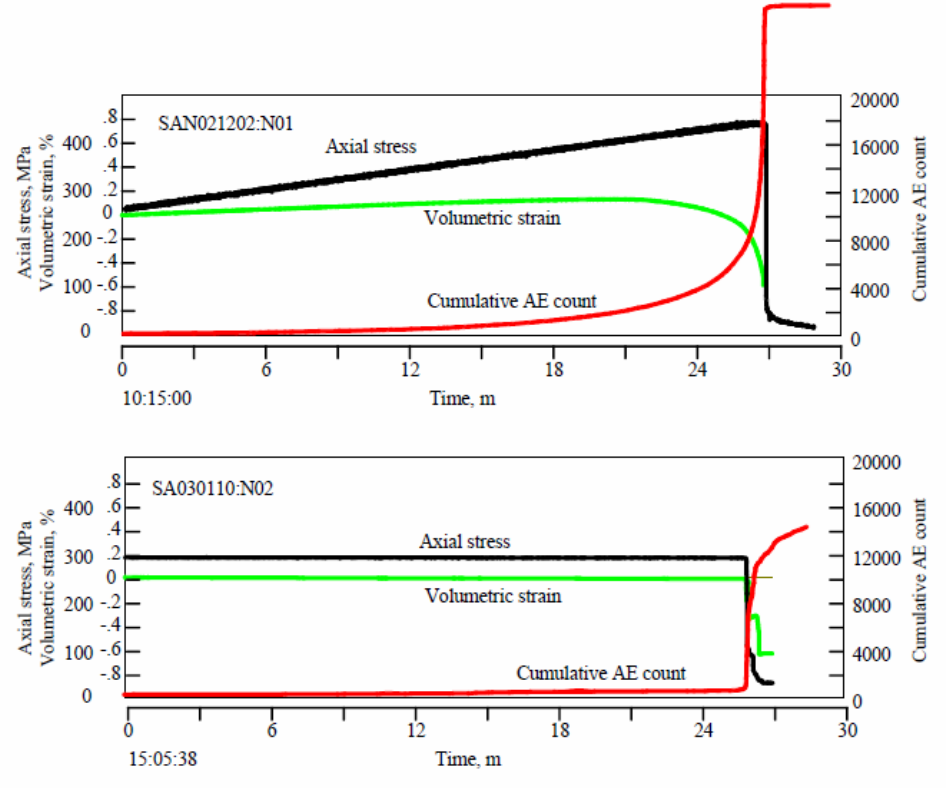


Li et al. 2009

- If Failure may be predicted, it also can be controlled.

HOW. Core level experiment

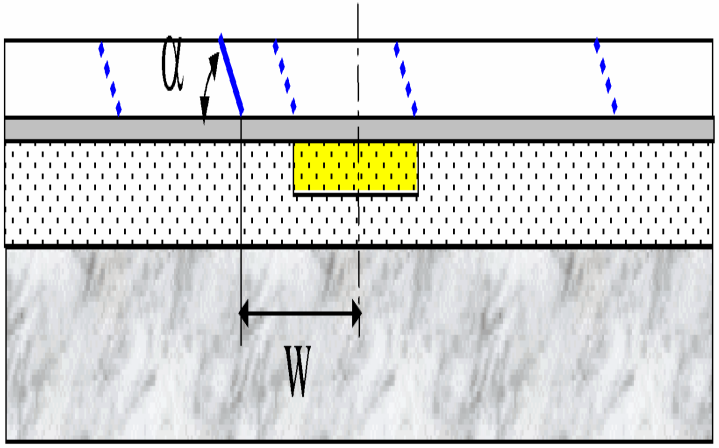
- Failure behavior of sandstone containing pure water or CO2-saturated water
- In case of CO2-saturated water, the failure of specimen exhibited abrupt

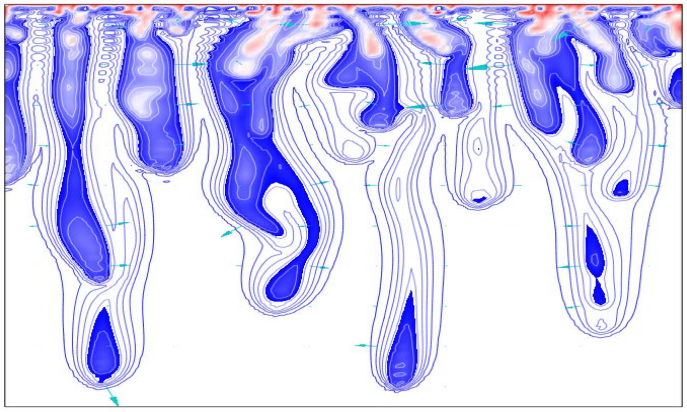


Li et al. 2007

HOW. Fault integration and self-sealing

- The effect of the buoyancy on the fault stability: small and not always negative
- The effect of viscosity on the fault under geothermal gradient during trapping ongoing
- For a relative short term, geochemical trapping may be neglected, but long-term mineralization may cause valve effect of site faults.

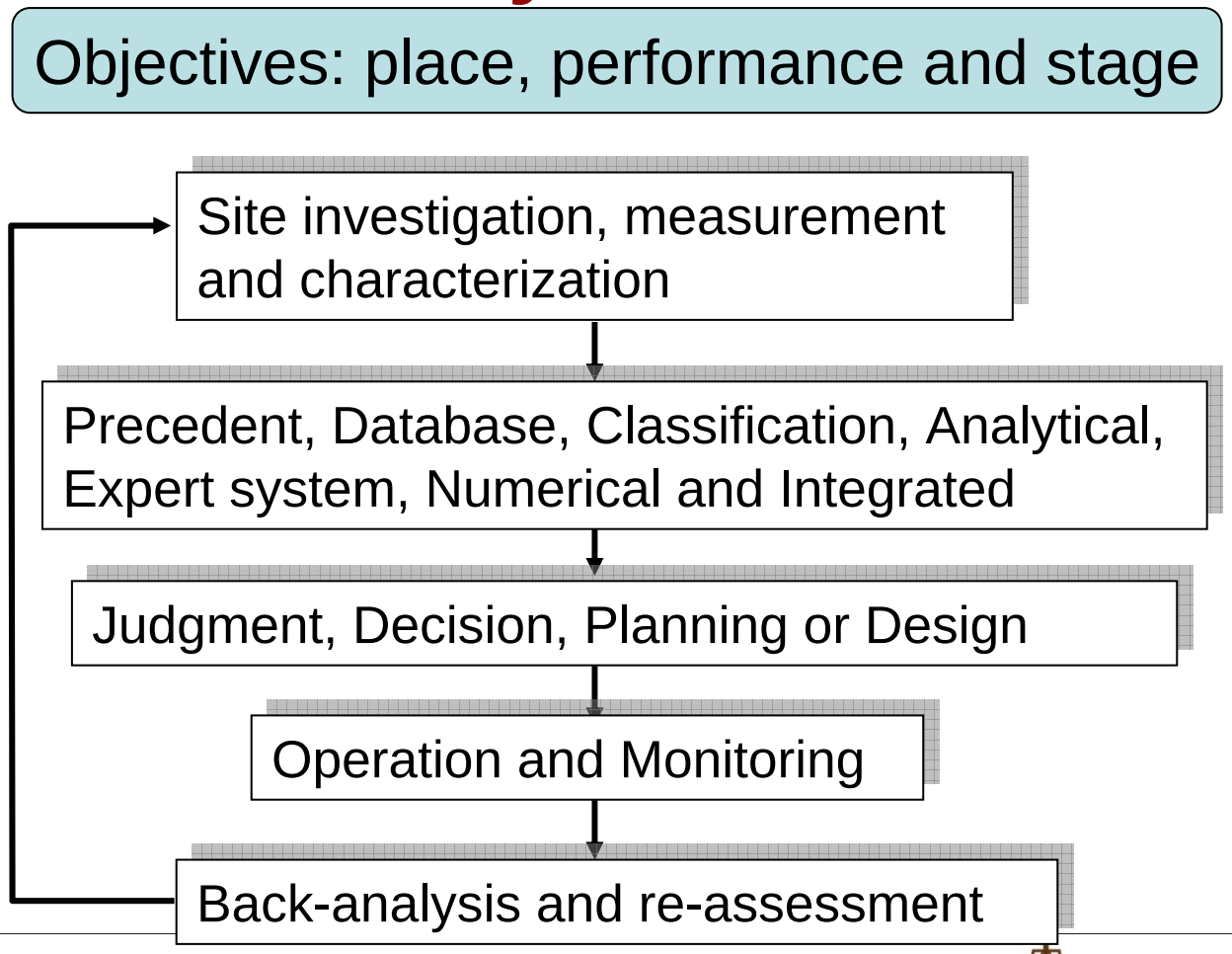




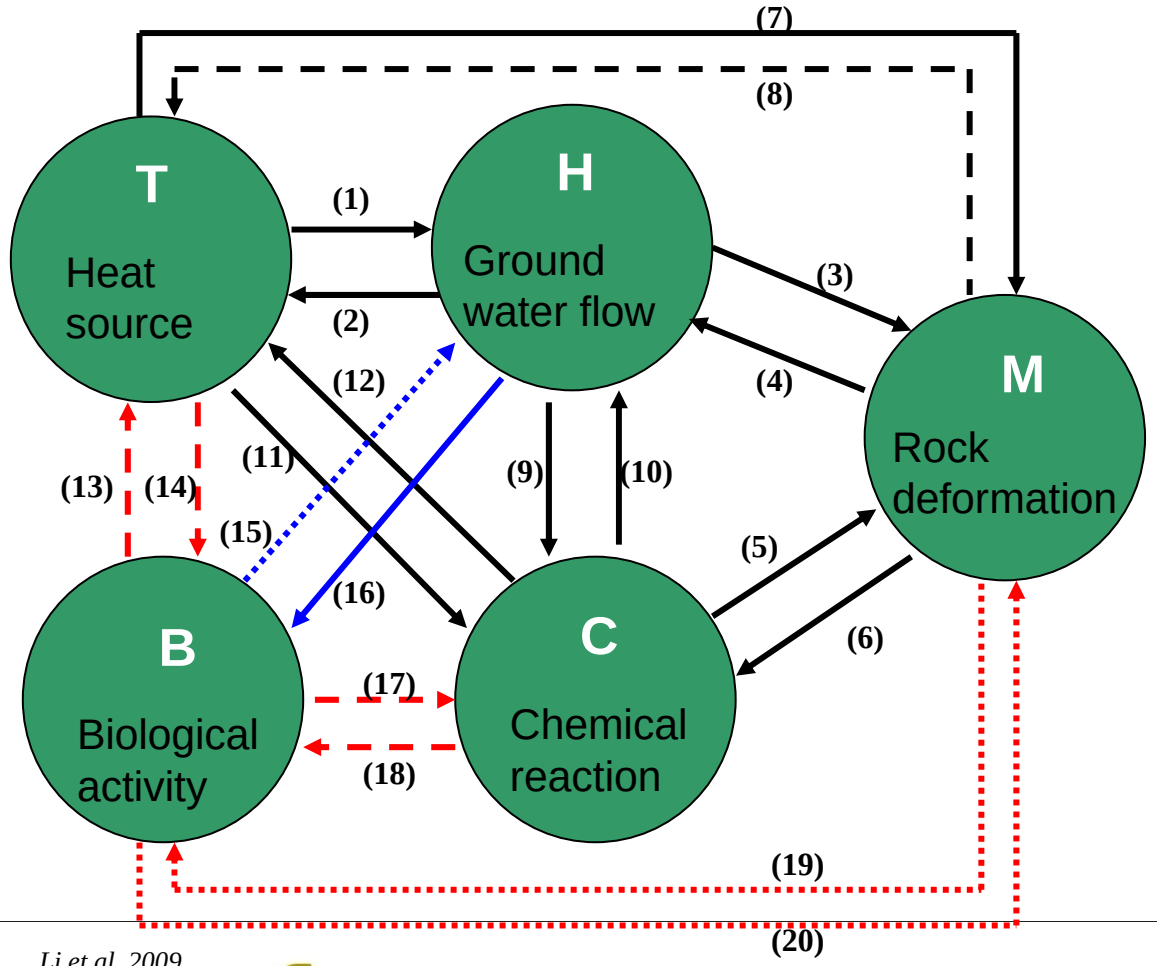
Li et al. 2007

HOW. Systematic Assessment Flow for Mechanical Stability

- Technical index
- Failure criteria
- Platform
- 3M method
- AI Integrated



HOW. Complex Process Couplings Related to Deep Geologic Sequestration



T: Fourier's law for energy balance
H: Darcy's law for mass balance
M: Hooke's law for force equilibrium
C: Fick's law for mass balance
B: Empirical law for mass balanace

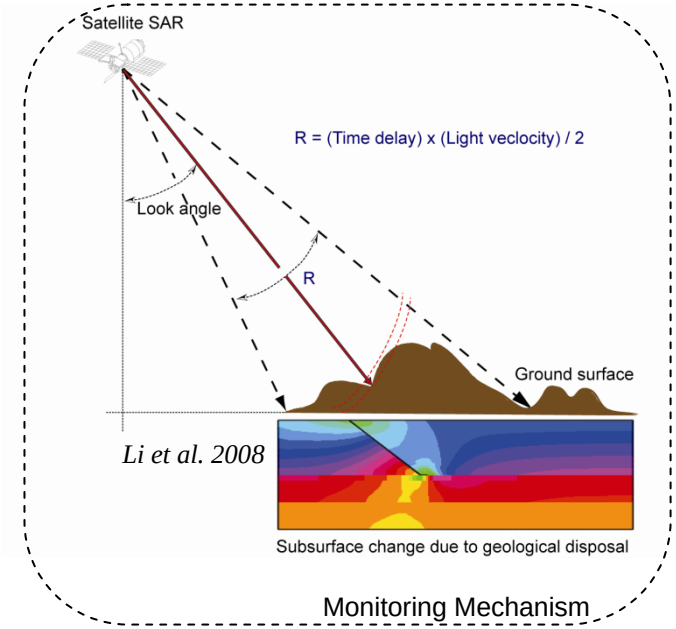
Coupling processes:

(1) Density viscosity
(2) Advective heat transport
(3) Rock stress and strength
(4) Porosity permeability
(5) Porosity
(6) Pressure solution
(7) Thermal expansion
(8) Friction heating
(9) Advective solute transport
(10) Density viscosity
(11) Reaction rates
(12) Exothermic/endothermic processes
…

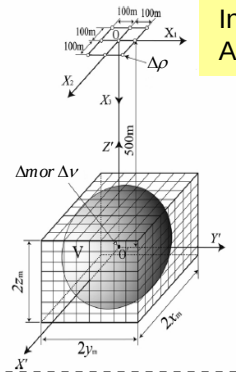
Solid-line: strong coupling
Dash-line: medium coupling
Dot-line: weak coupling
Line-in-black-color: developed
Line-in-blue-color: developing
Line-in-red-color: planning

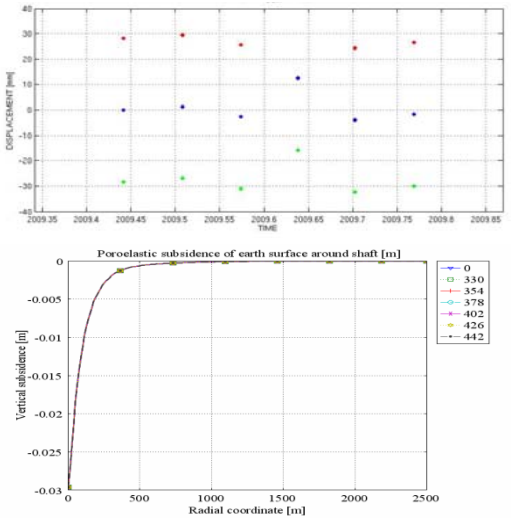
Li et al. 2009

HOW. Coupled Inversion of Subsurface Characterization with CR-PS-InSAR Surface Deformation



Monitoring Mechanism





Comparison:
Monitoring (up) vs. Forward Computation (down)

Li et al. 2009

cags

China Australia Geological Storage of CO_2

中澳二氧化碳地质封存

Concluding Remarks (1)

- Mechanical stability assessment is very necessary during the whole process of CO2 sequestration
- CCS Group, IRSM-CAS has made some progresses in this field, but far from an operative complete solution
- We are calling for more attention and more cooperation on geological mechanical stability issues

Concluding Remarks (2)

- It should be noted that geologic environments are intrinsically complex and heterogeneous, which make the application of general assessment principles and numerical relations difficult and uncertain in any specific situations.
- While the details of the computing models that turn out to be optimal for different problems vary widely, the concepts and fundamental frameworks are at the basis of most important 3M approaches.
- Maybe someday there will be a sequel of new research field titled Zen *and the Art of CCS GeoSystems*.

- Thanks for your attention.
- Enjoy the sights in Wuhan.