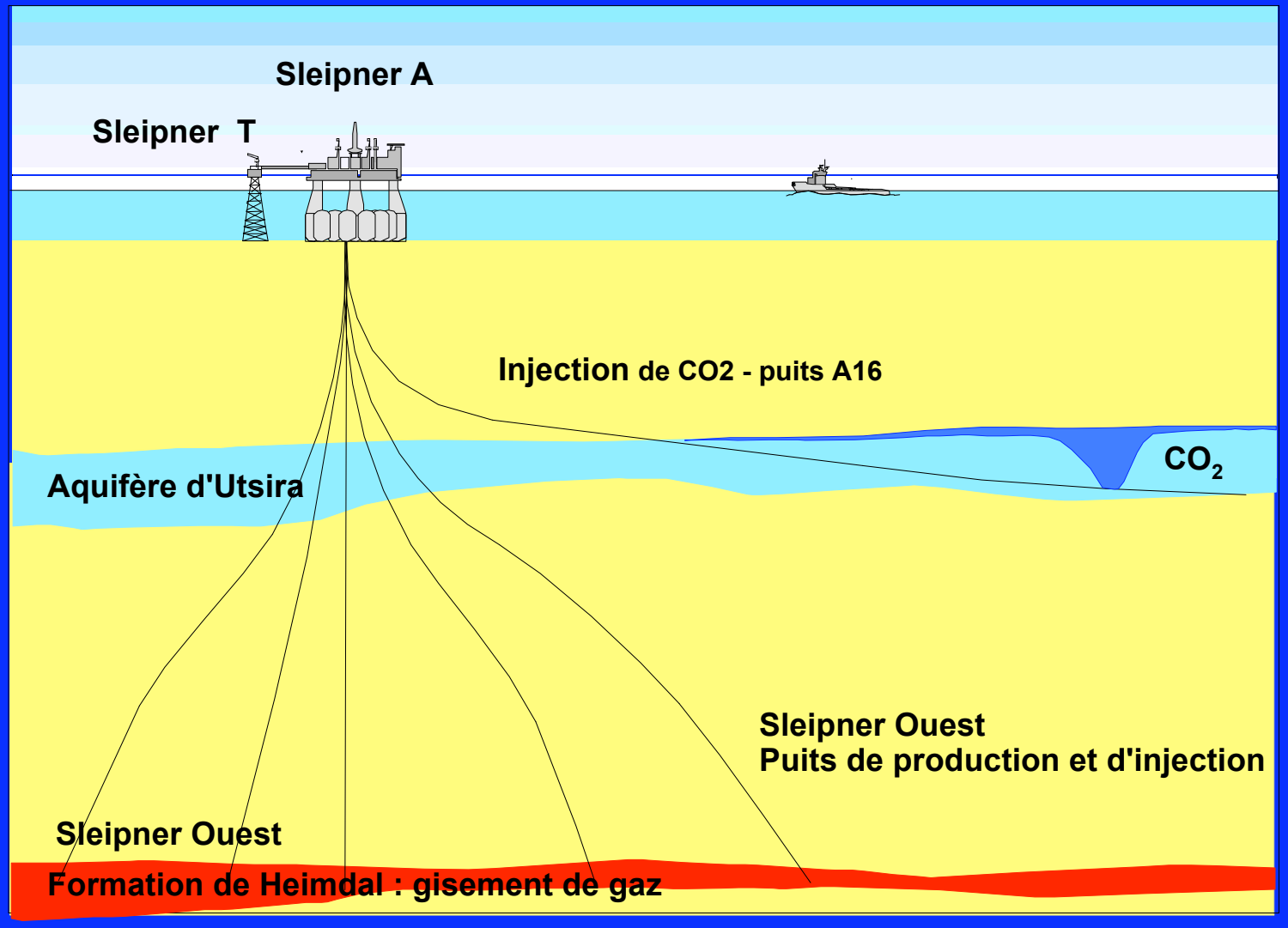
Geological CO_2 storage

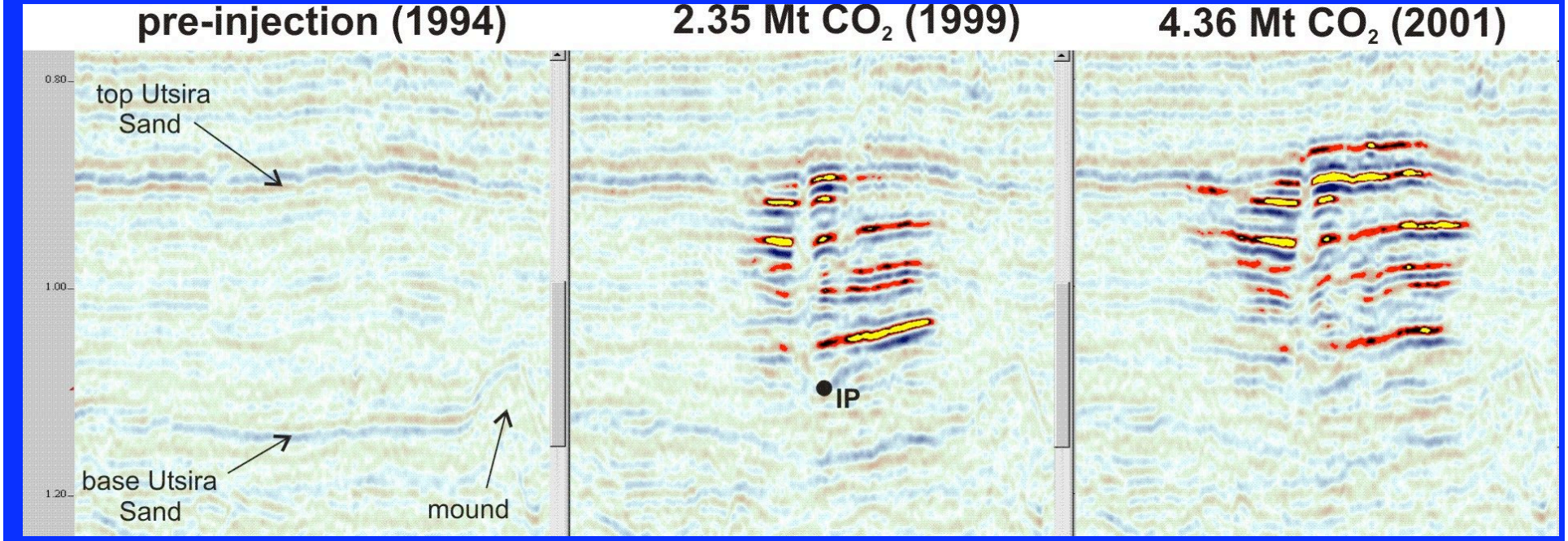
Technological and scientific issues

Sleipner, Norway

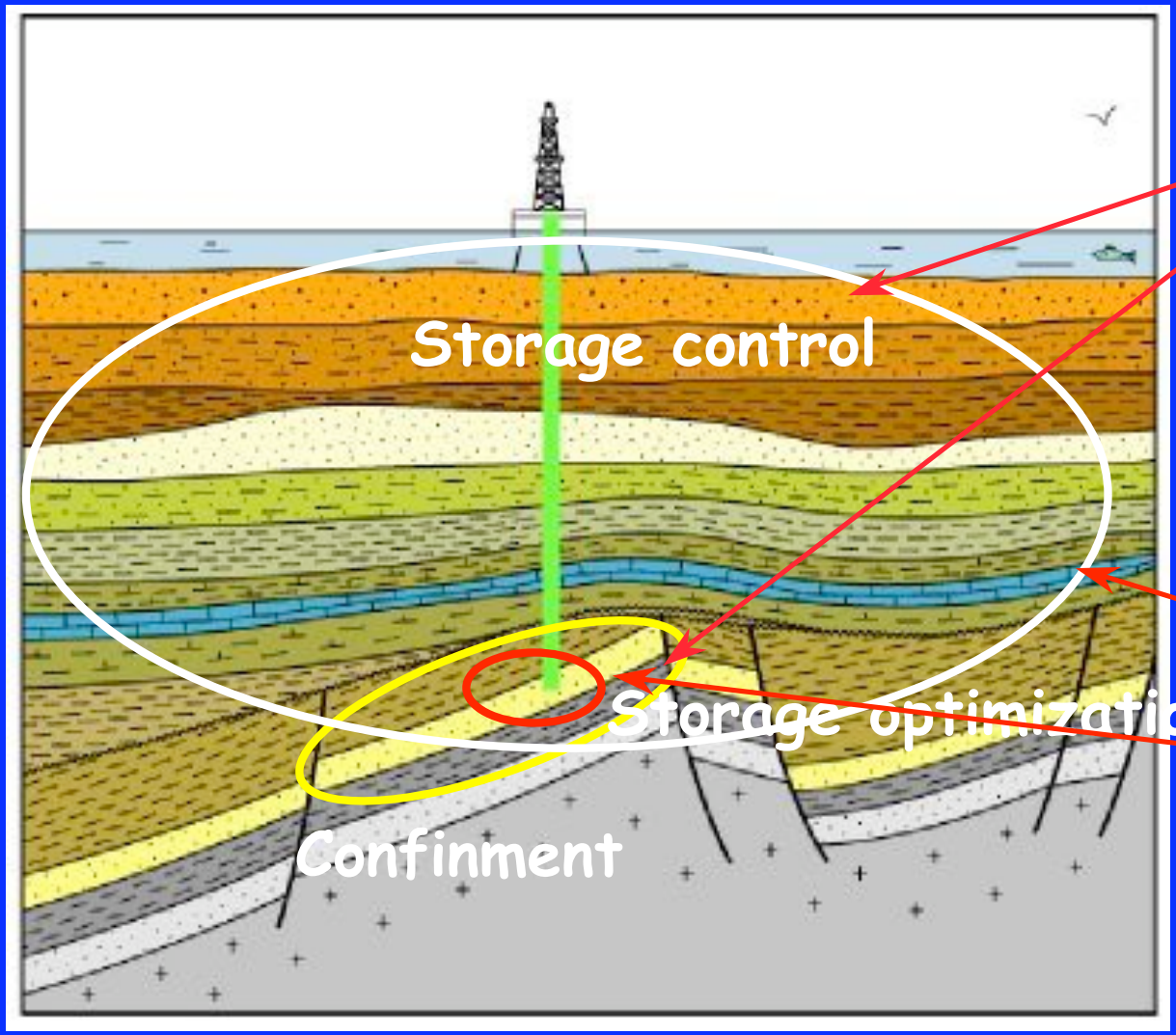
Sleipner. Geological setting



Seismic monitoring



Technological issues



Control technologies :

Geophysical monitoring, Tracers, sensors

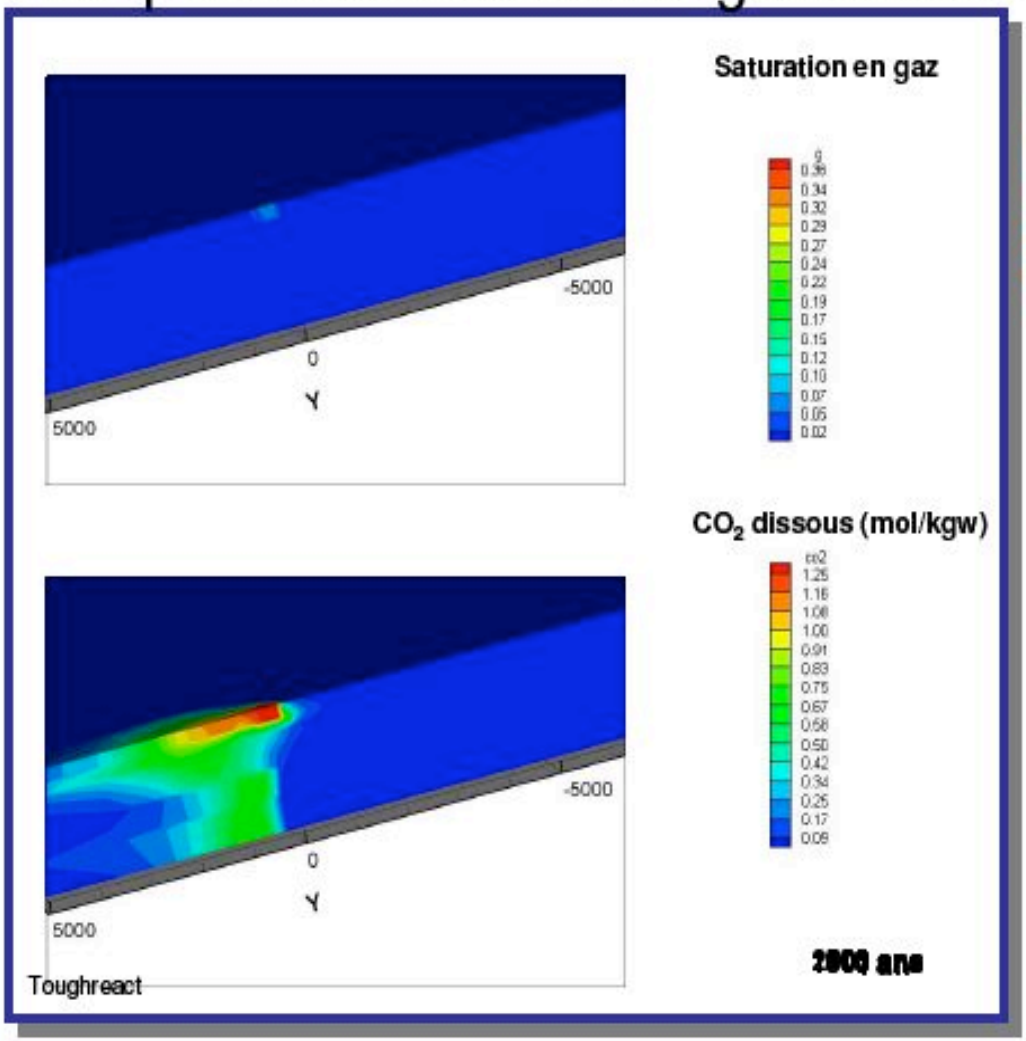
Numerical modeling :

Regional and long Time scale

Local and short time scale (years)

Geochemical modeling

Comportement du stockage à court terme



Impact des interactions chimiques induites par l'injection

- **Comportement de la bulle de CO2 supercritique**
- **Évolution des teneurs en CO2 dissous**
- **Impact sur les minéraux du réservoir**

Profondeur : 1500 m
Pression : 165 bars
Température : 70°C
$C0_2$ injecté : 150.000 tCO2 / an
Durée d'injection : 4 ans

Géosciences pour une Terre durable
brgm

Post-injection fate of CO_2

- CO_2 --> supercritical CO_2
- CO_2 --> dissolution H_2CO_3
- CO_2 --> dissolution/neutralization HCO_3^-
- CO_2 --> solid carbonates MCO_3
- CO_2 --> Reduction « organic » carbon

New scientific questions regarding CO_2 geological storage

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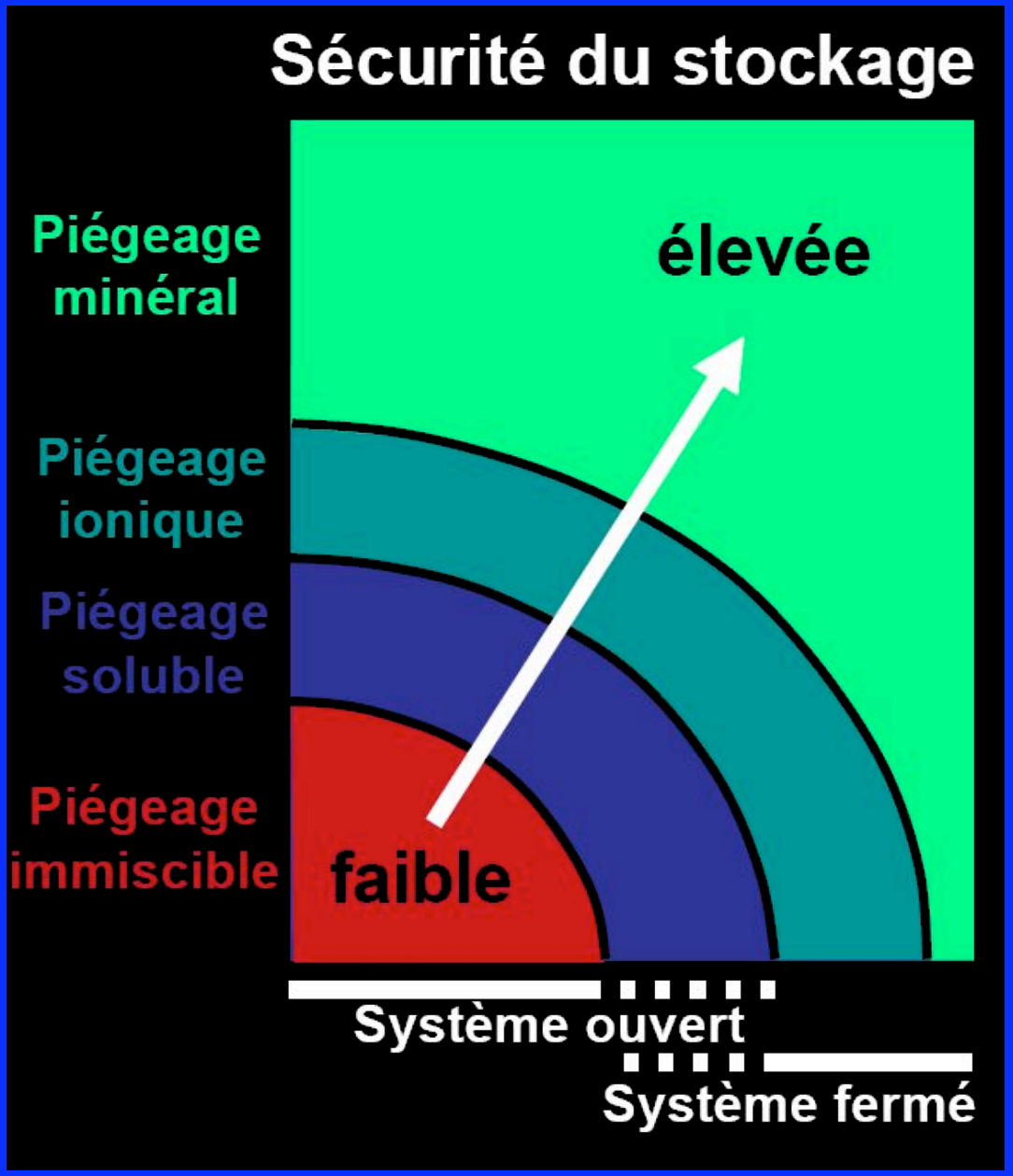
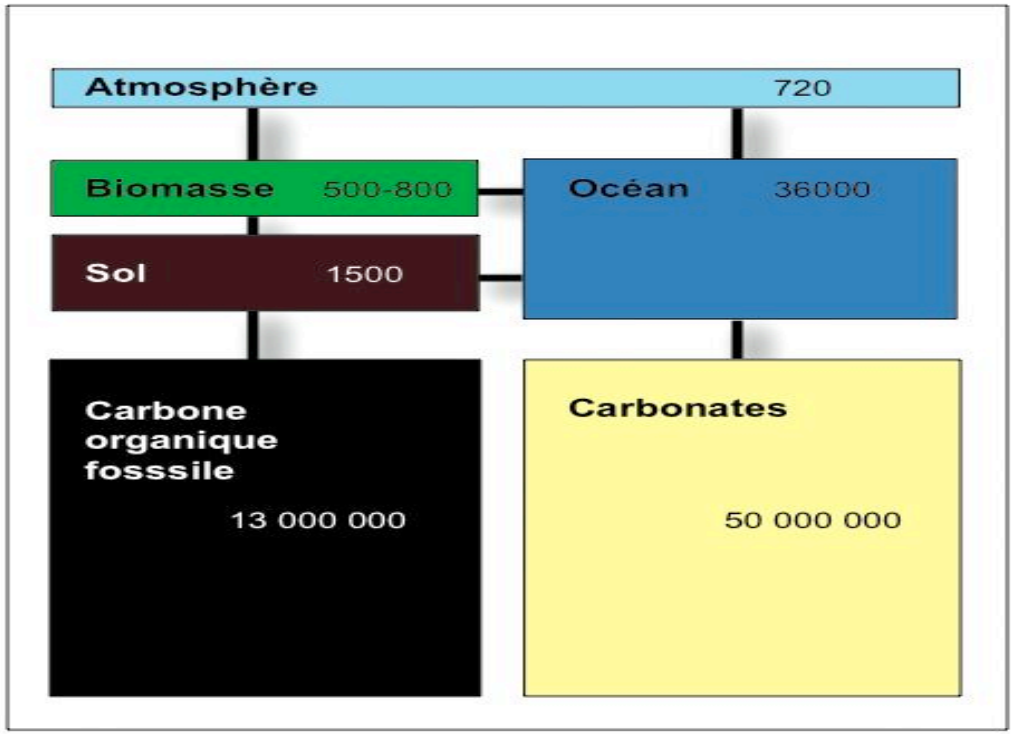
- CO_2 --> solid carbonates MCO_3
- CO_2 --> Reduction « organic » carbon

Safety of storage



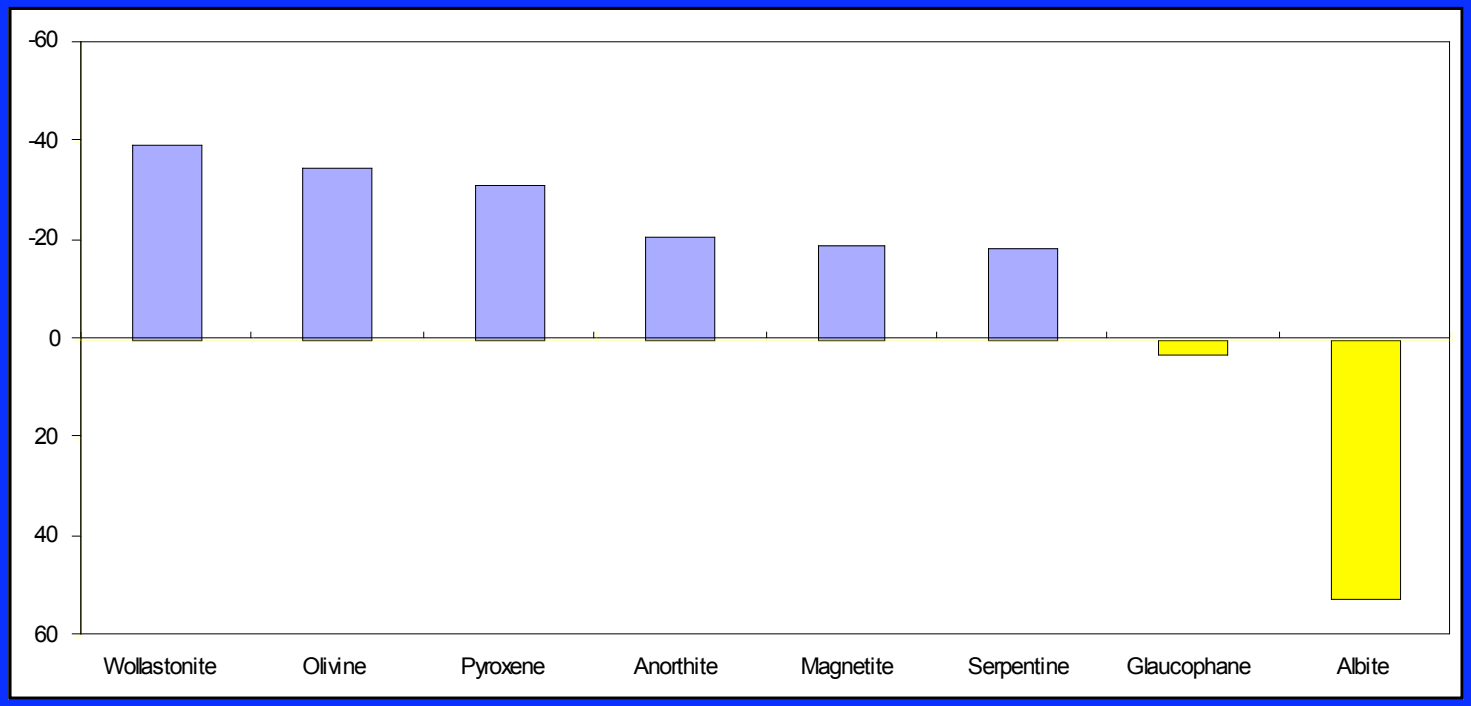
Natural CO_2 storage

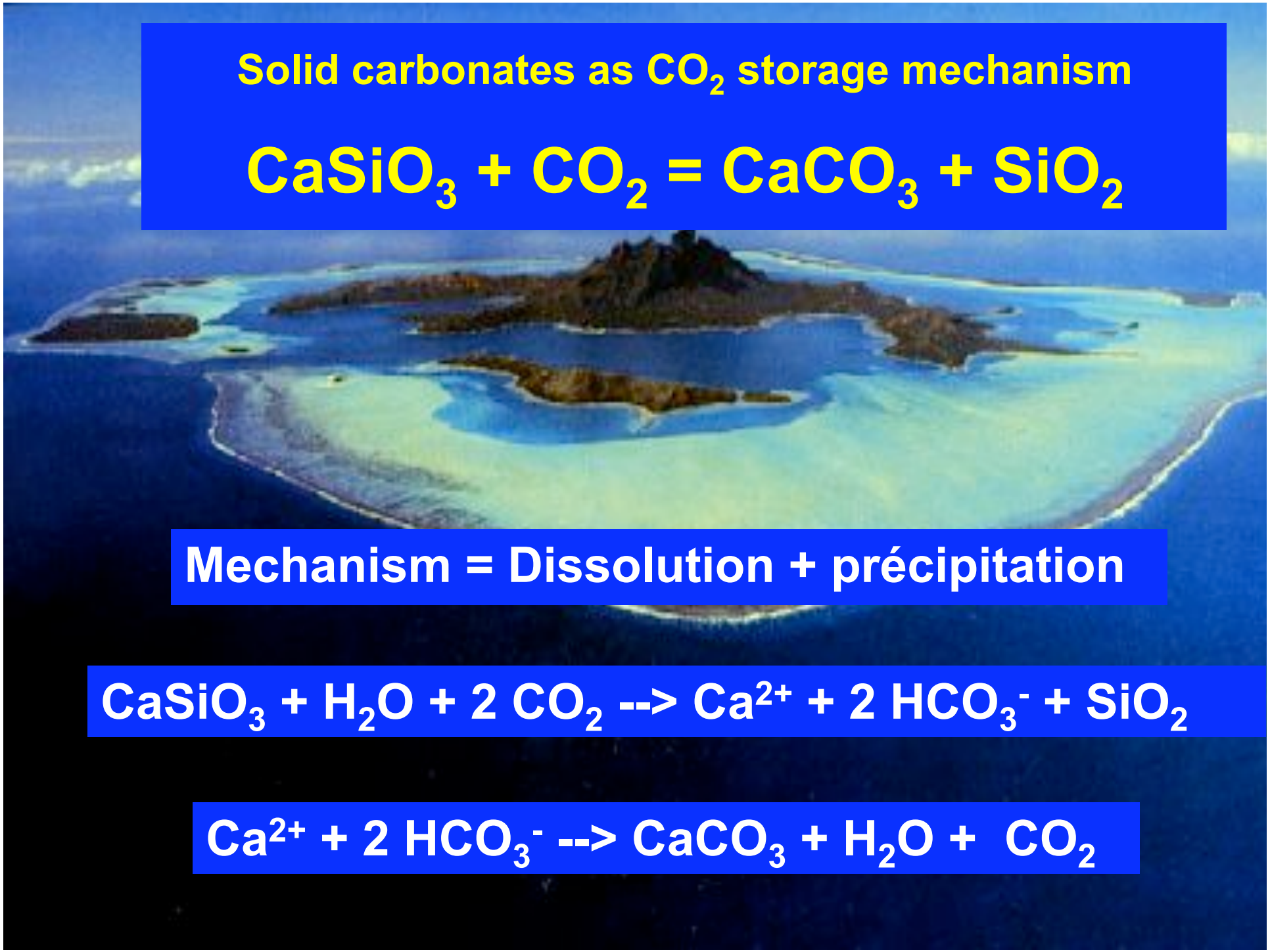


Thermodynamic affinity for carbonatation

$$M_xSi_yO_{x+2y-t}(OH)_{2t} + x\ CO_2 \leftrightarrows x\ MCO_3 + y\ SiO_2 + t\ H_2O$$

- M = Ca or Mg





Solid carbonates as CO_2 storage mechanism

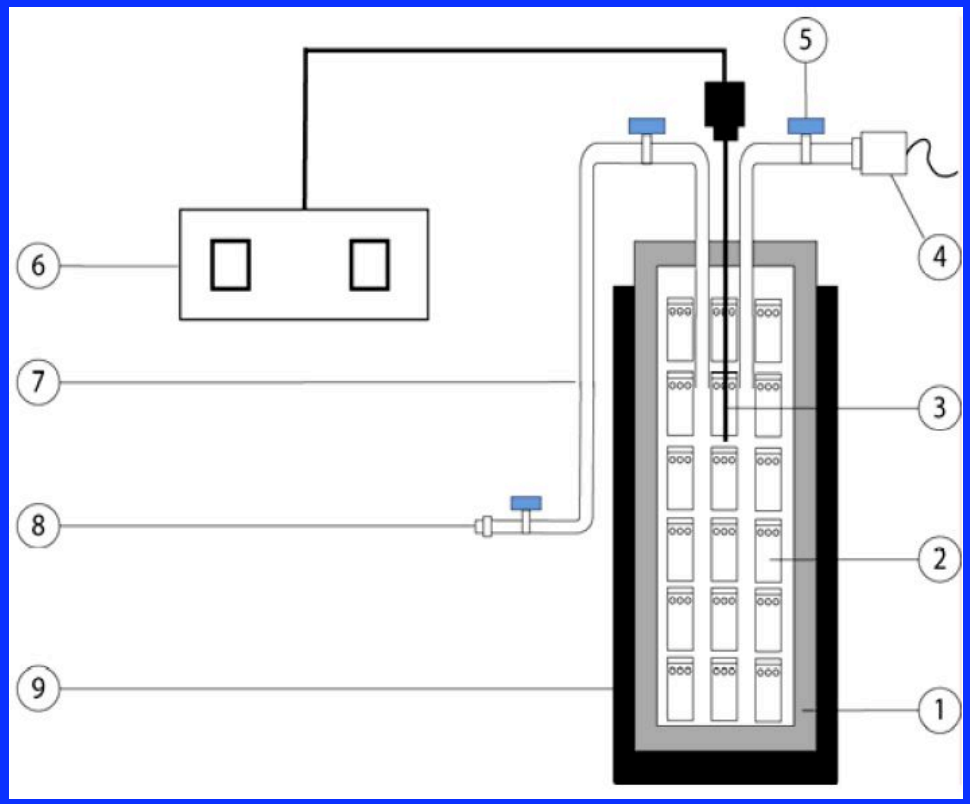
$$CaSiO_3 + CO_2 = CaCO_3 + SiO_2$$

Mechanism = Dissolution + précipitation

$$CaSiO_3 + H_2O + 2\ CO_2 \rightarrow Ca^{2+} + 2\ HCO_3^- + SiO_2$$

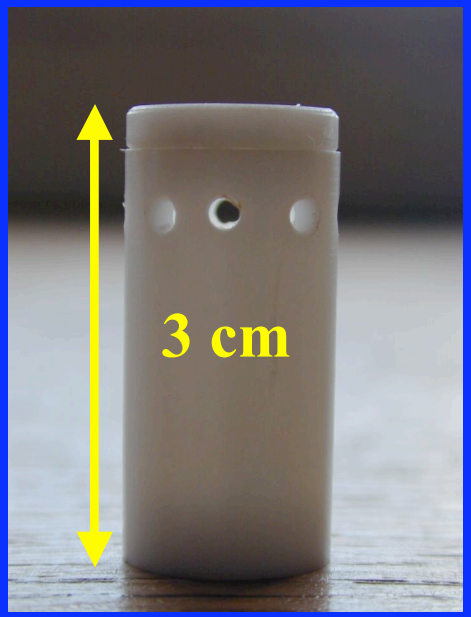
$$Ca^{2+} + 2\ HCO_3^- \rightarrow CaCO_3 + H_2O + CO_2$$

Kinetics : example of experimental protocol



T = 90°C

p_{CO2} = 250 bars



Sample analyses

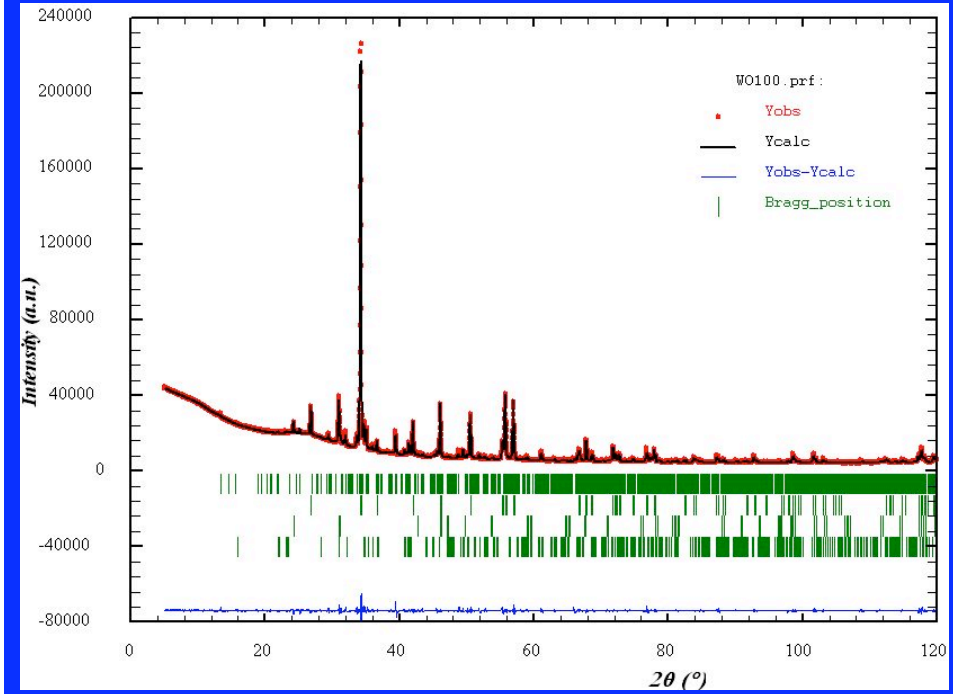
Quantitative

Mass balance

Acid attack

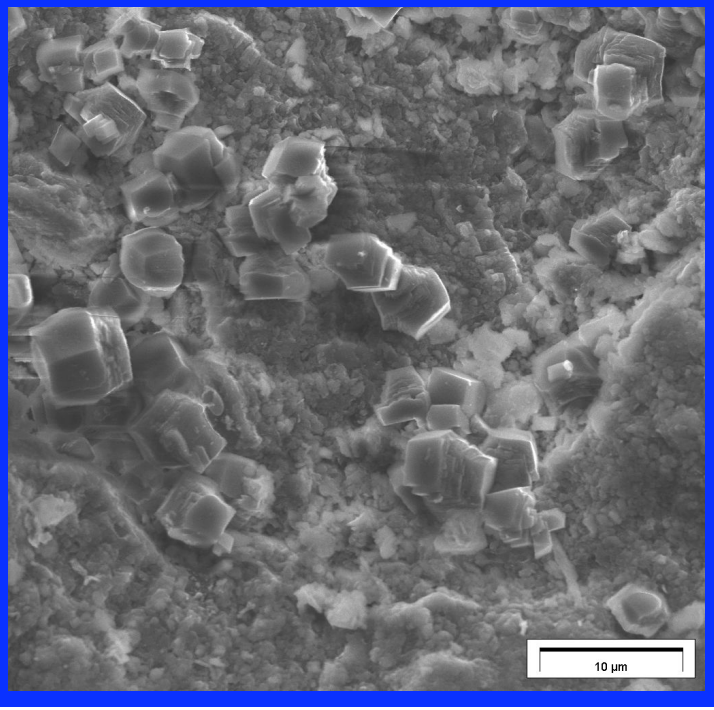
X-ray diffraction +Rietveld

Isotopes

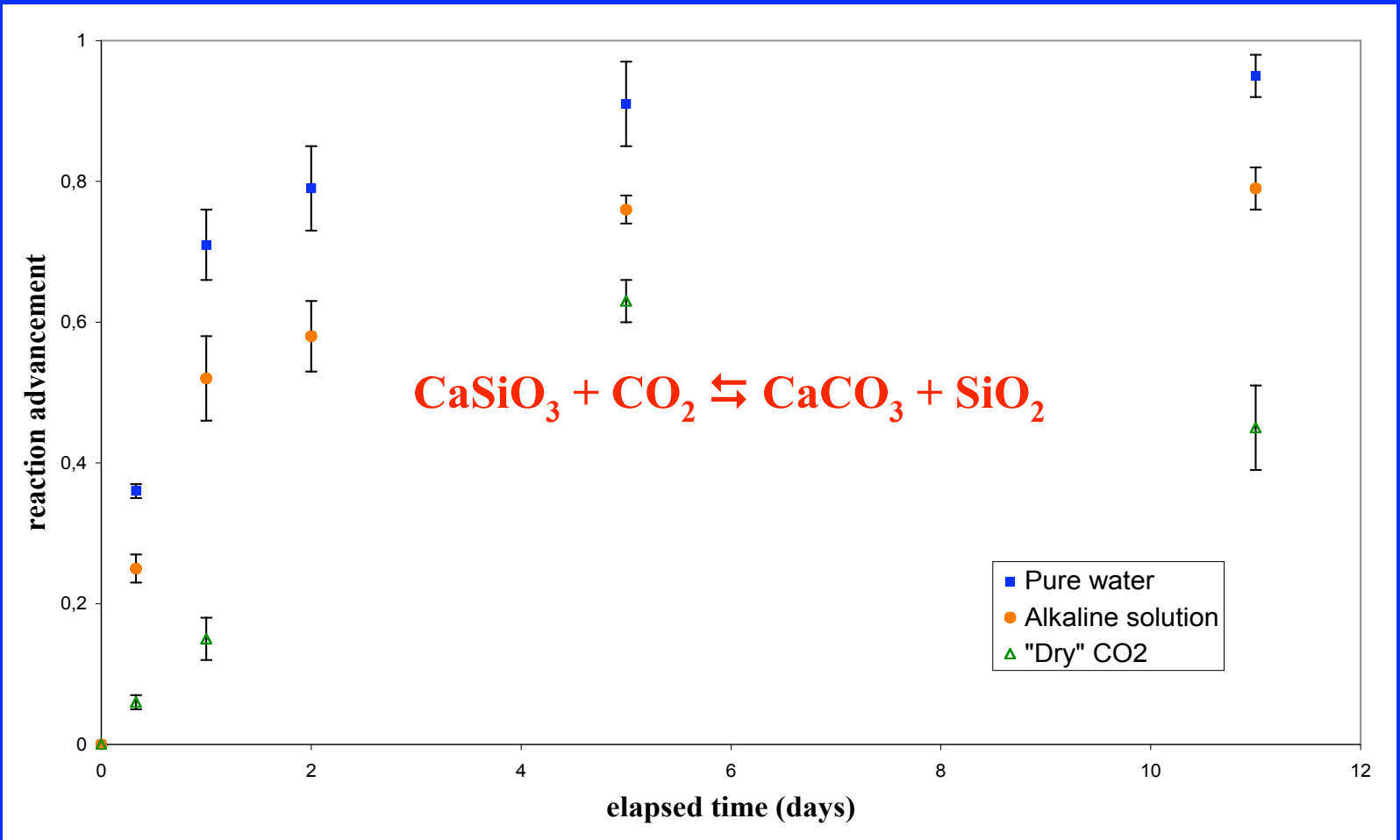


Phases and mechanisms

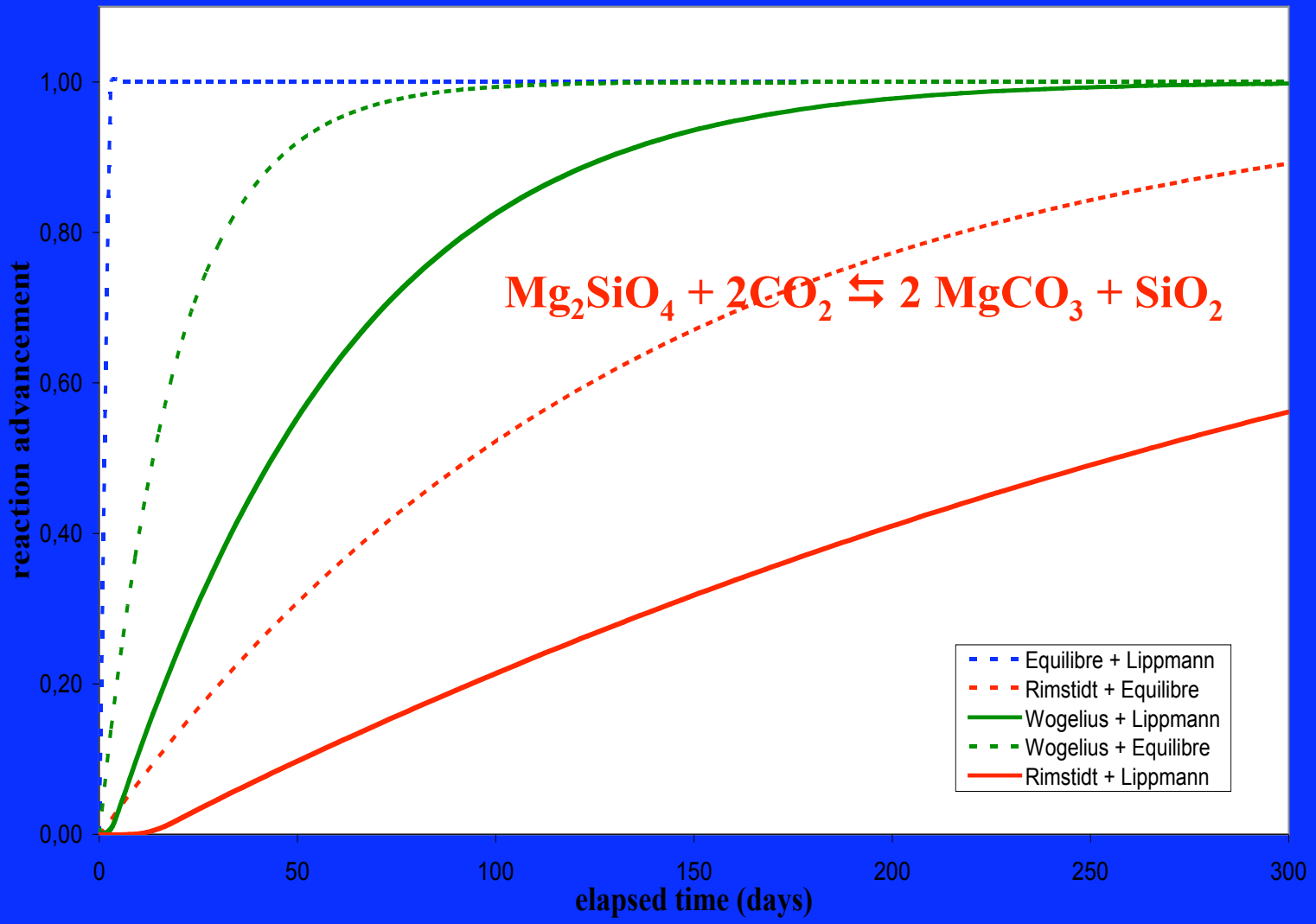
SEM, TEM, Raman, XRD, etc…



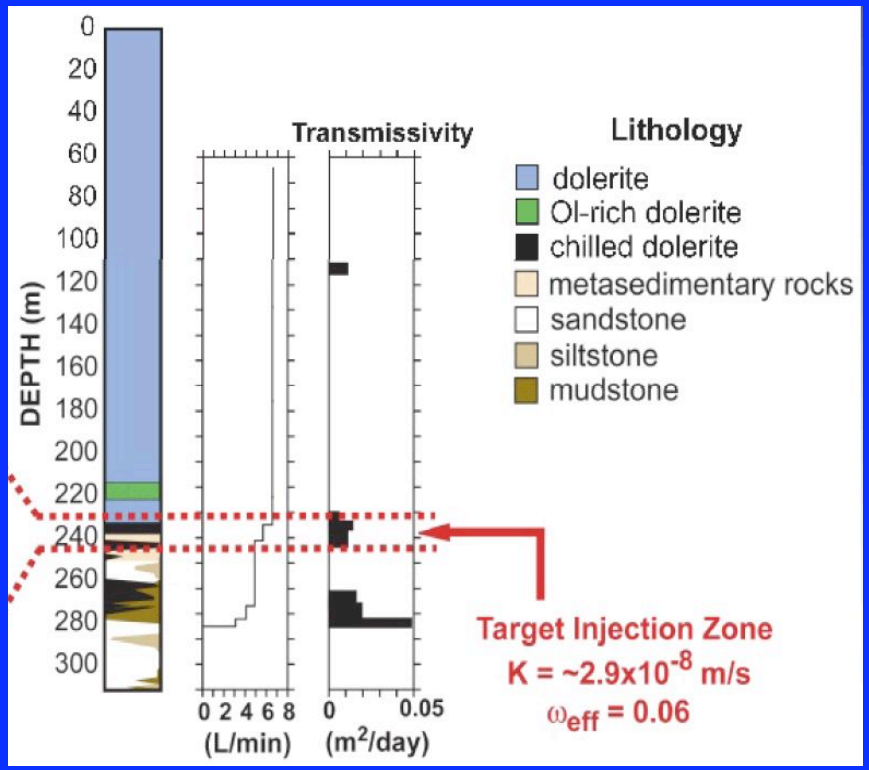
Reaction progress

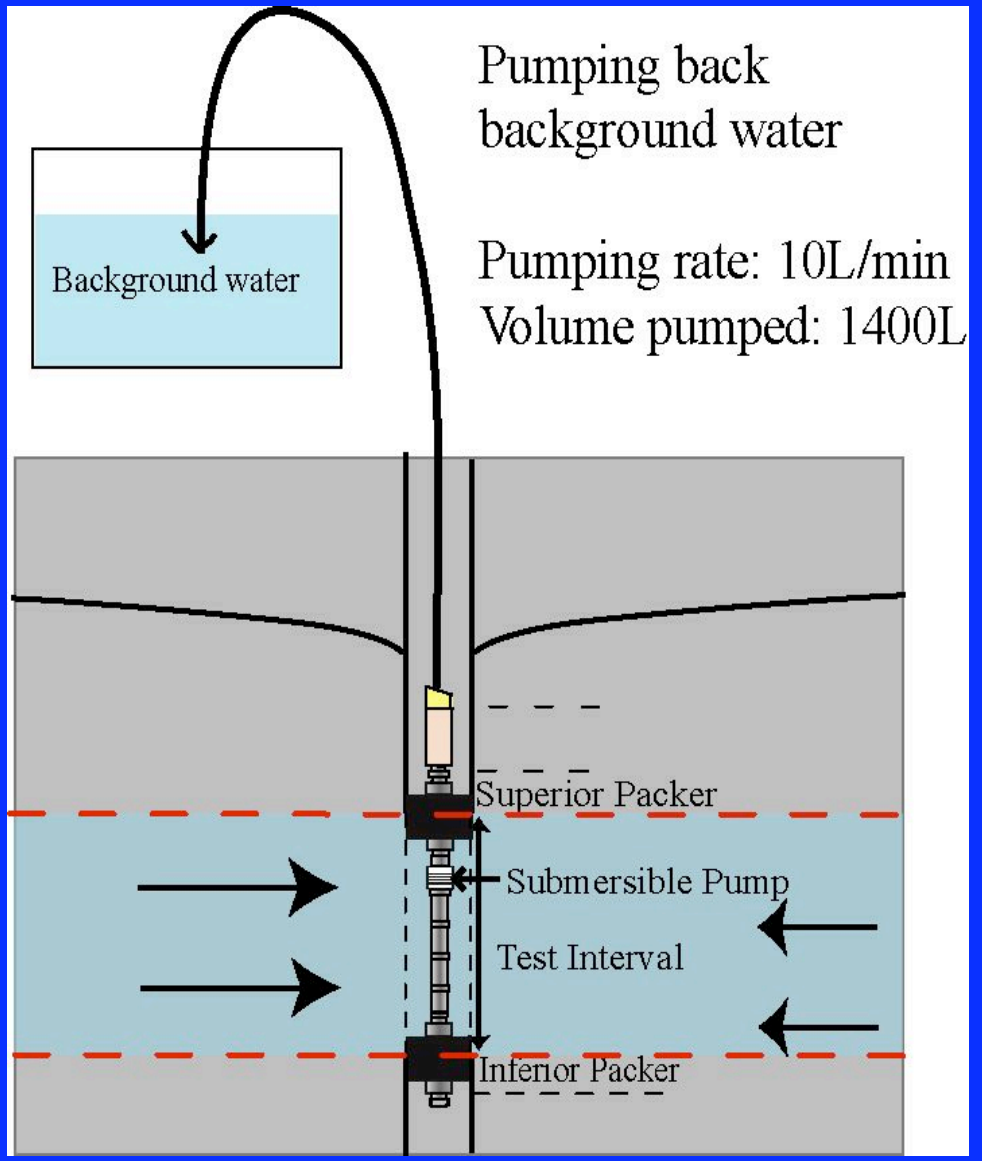


Olivine carbonatation

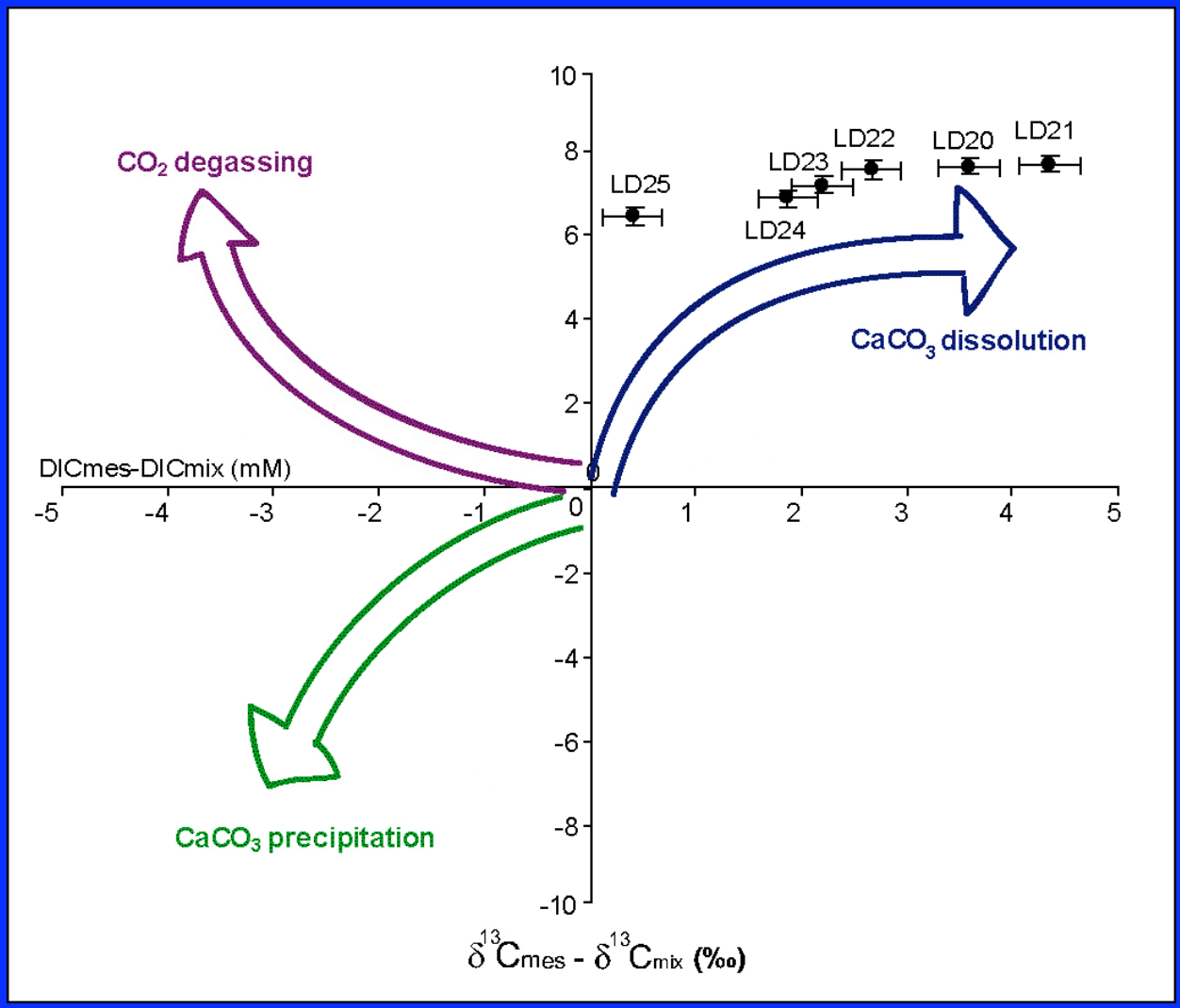


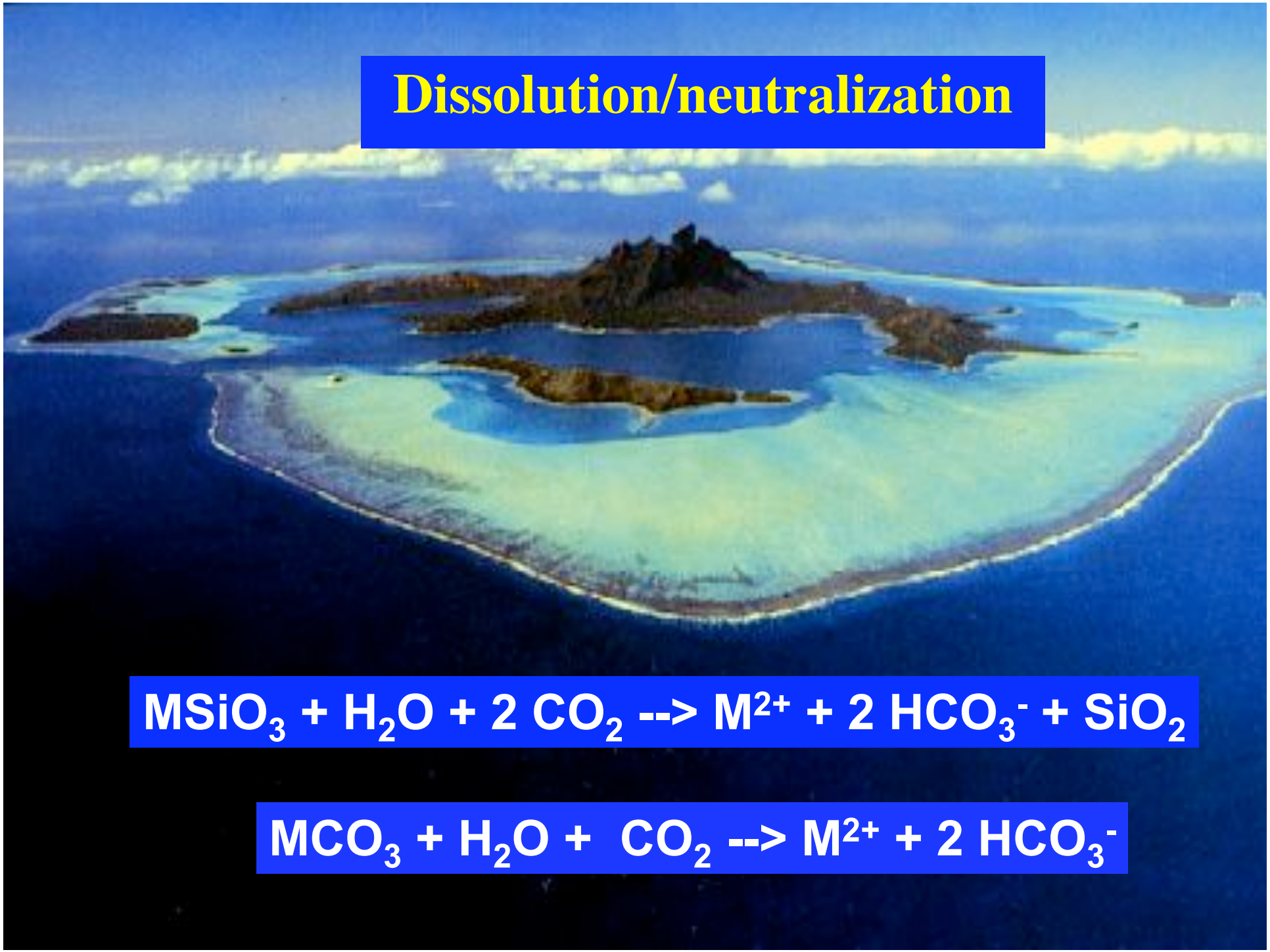
Isotopic monitoring





Carbon isotopic monitoring




Dissolution/neutralization
$MSiO_3 + H_2O + 2\ CO_2 \rightarrow M^{2+} + 2\ HCO_3^- + SiO_2$
$MCO_3 + H_2O + CO_2 \rightarrow M^{2+} + 2\ HCO_3^-$