



**TOTAL**

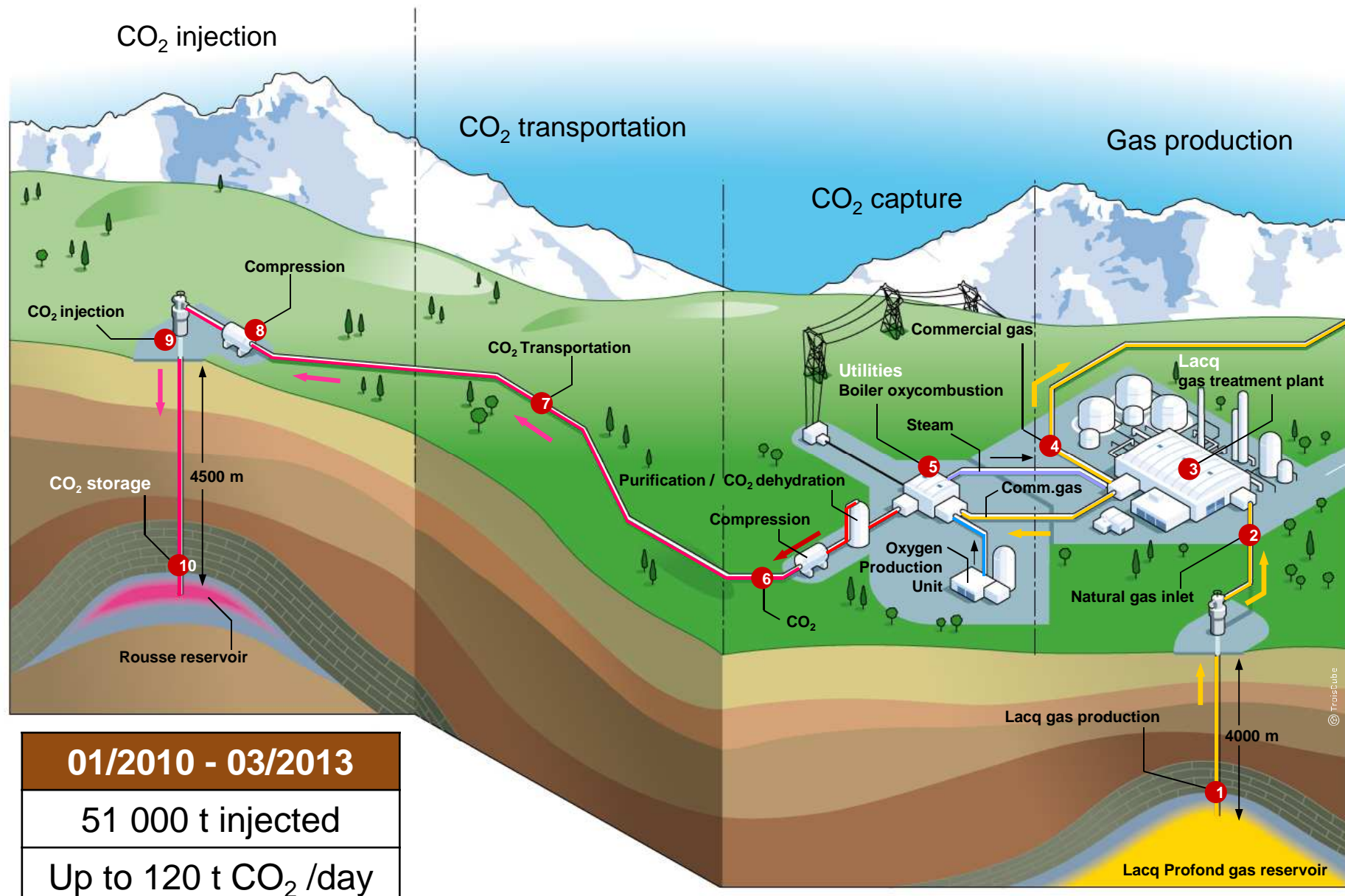
COMMITTED TO BETTER ENERGY

# LACQ CCS DEMO PILOT

Selection, qualification and monitoring of the Rousse reservoir



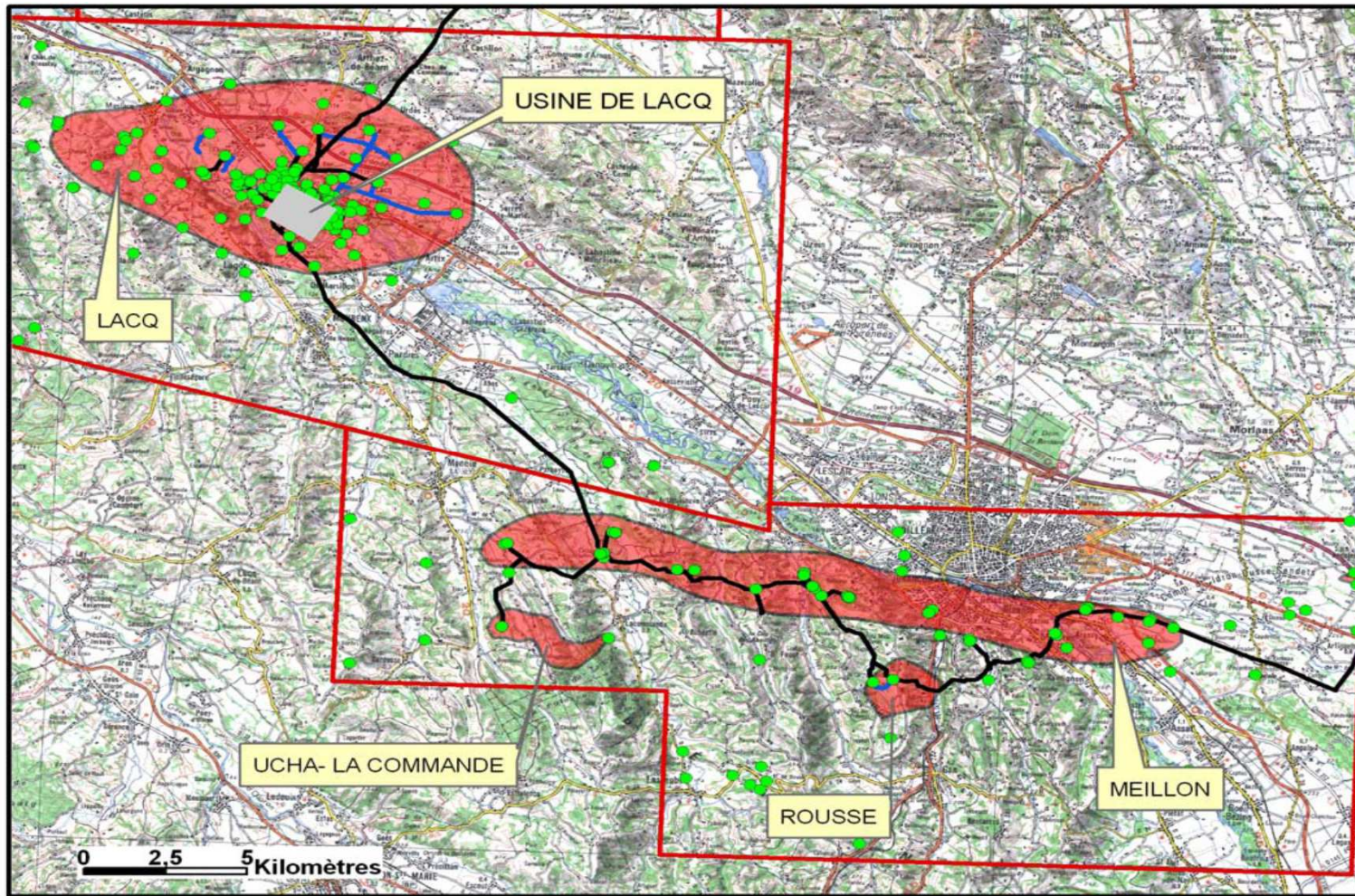
# LACQ-ROUSSE CCS DEMO PILOT





# ROUSSE SITE SELECTION

- Selection amongst the regional gas fields produced by Total



# ROUSSE SITE SELECTION

- Comparison of the gas reservoirs – key screening parameters

	Max Prod MSm <sup>3</sup> /j	Produced GSm <sup>3</sup>	Pressure - bars		Facilities	Production
			Initial	Final		
Lacq	30	250	620	20	Yes	Yes
Meillon Saint Faust	10	58	480	100	Yes	Yes
Ucha-Lacommande	0.3	1.9	470	70	No	No
Rousse-Mano	0.3	0.9	480	30	Yes	No
Rousse-Meillon	1.2	3.7	490	150	Yes	Yes

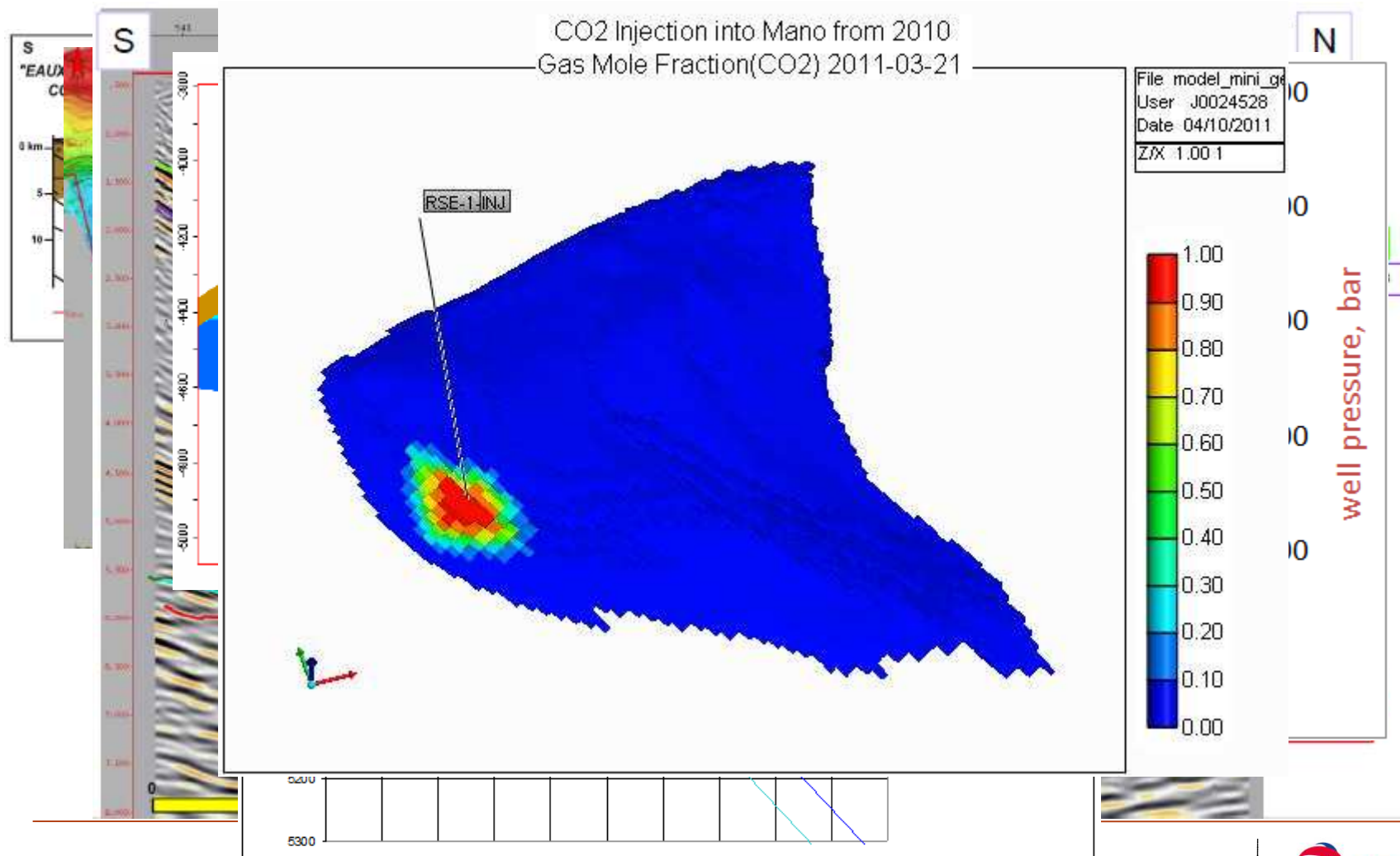
Pilot target	0.06	0.06		100
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- Rousse Mano is an isolated, low pressure structure with existing facilities and no expected remaining production
  - More over there is only one well perforating the Mano reservoir : Rse-1

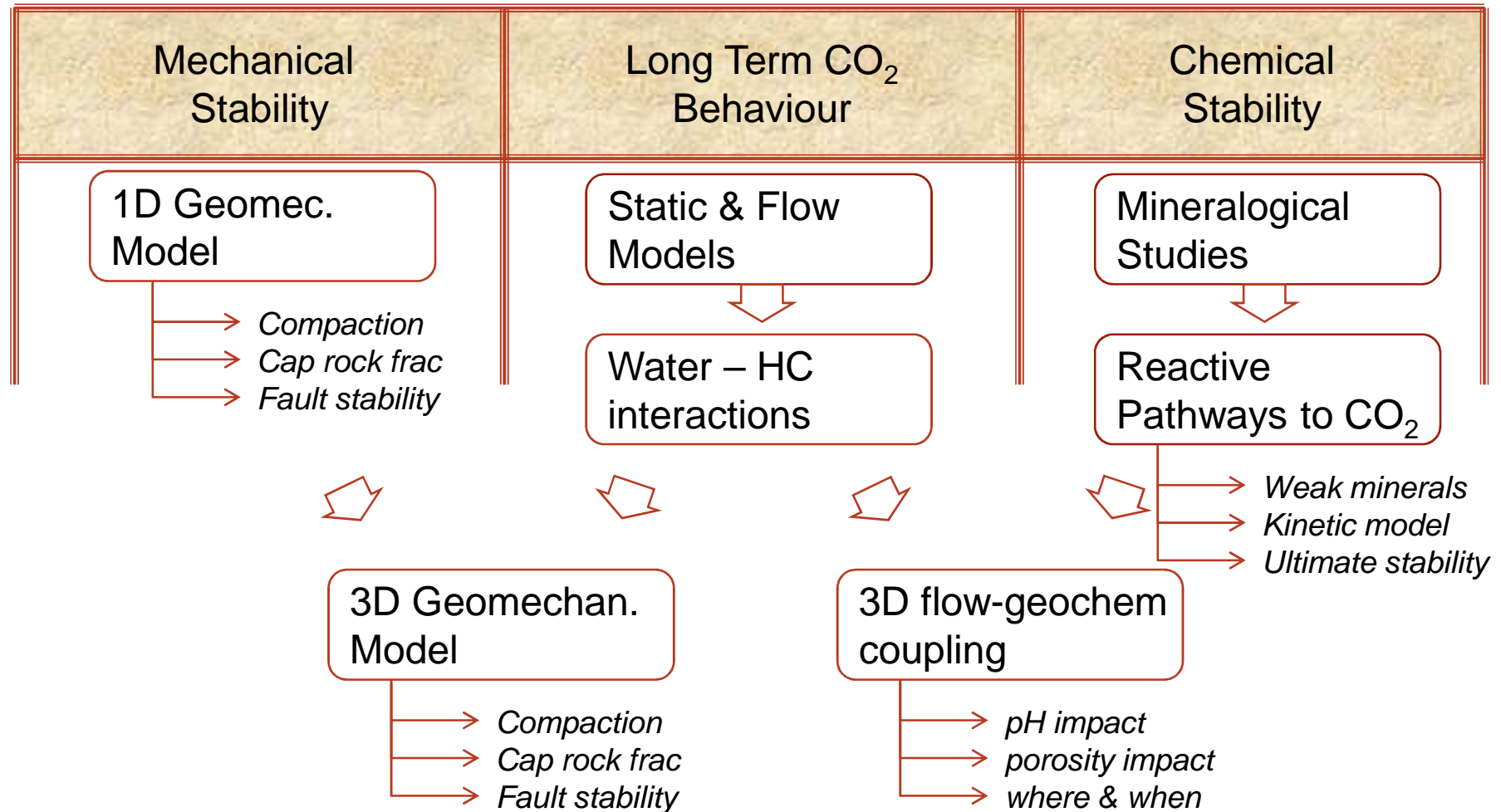


# QUALIFICATION – STANDARD OIL & GAS WORKFLOW

## Dynamic Reservoir Modeling

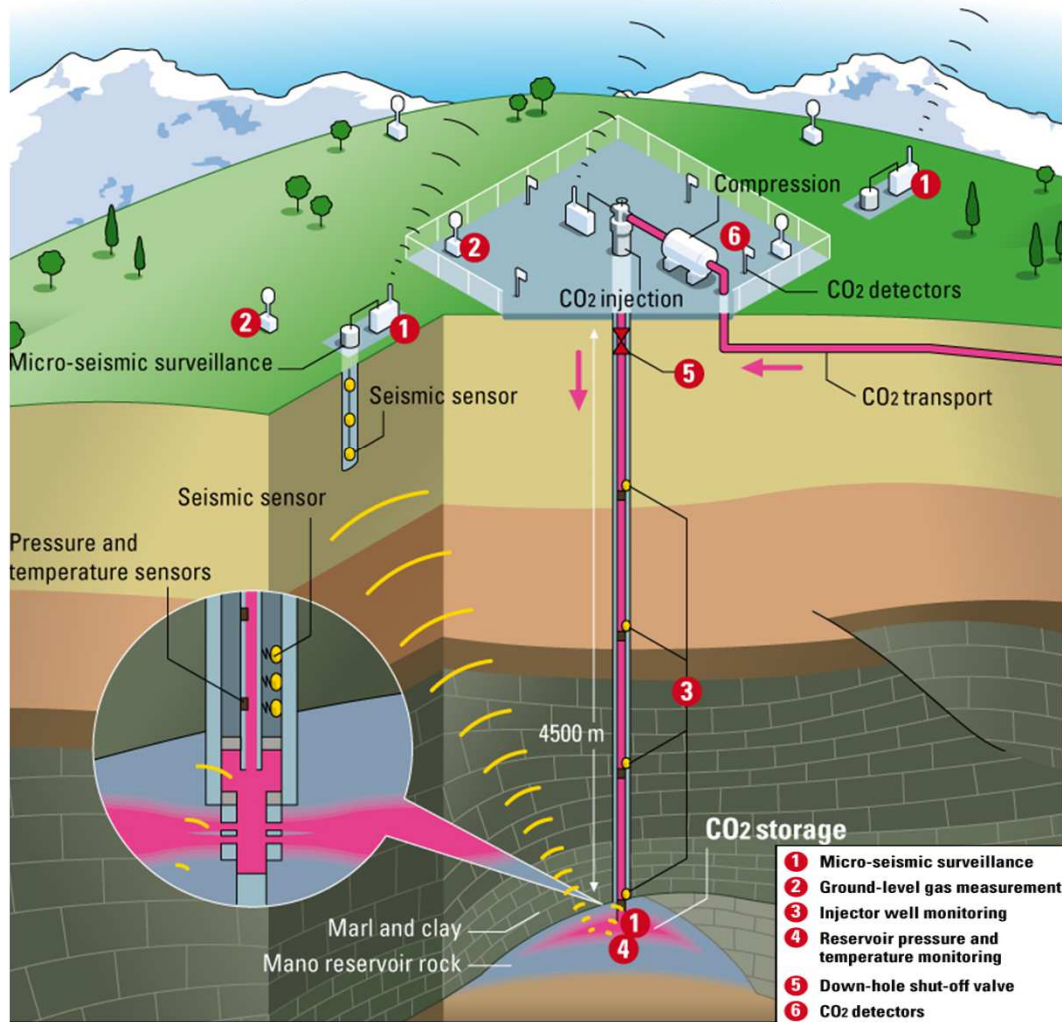


# DEDICATED CO<sub>2</sub> STORAGE WORKFLOWS



# CO<sub>2</sub> STORAGE COMPLEX MONITORING

## Lacq CO<sub>2</sub> pilot CO<sub>2</sub> injection - monitoring system



- Design of various possible monitoring techniques
- Surface monitoring
  - Rates, composition
- Well monitoring
- Deep Subsurface key elements
  - Continuous Pressure & Temperature @4335 m
  - Micro seismic surveillance network
- Completed by an environmental surveillance

# STATUS

- Injection from Jan-2010 until March 2013
- 51 000 tonnes of CO<sub>2</sub> captured, transported and injected
- Demo Pilot performed thanks to the active participation of many institutes
- Ongoing 3 years surveillance period



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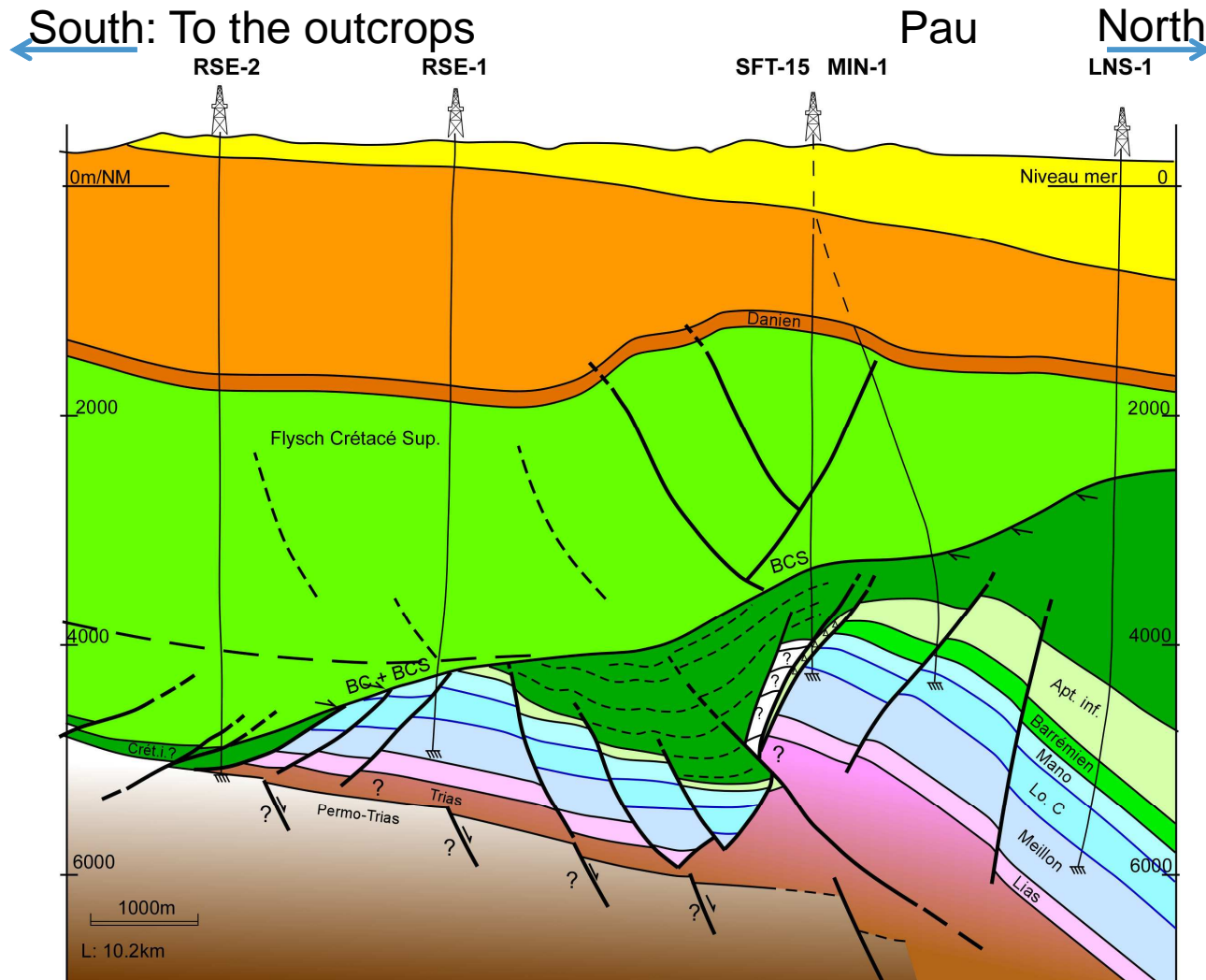
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# ROUSSE-MANO DEPLETED RESERVOIR



## Mano reservoir

Upper Jurassic age

Dolomitic

Fractured

4200 m MSL

3% porosity

$K_m < 1 \text{ mD}$

$K_f \sim 5 \text{ mD}$

150°C

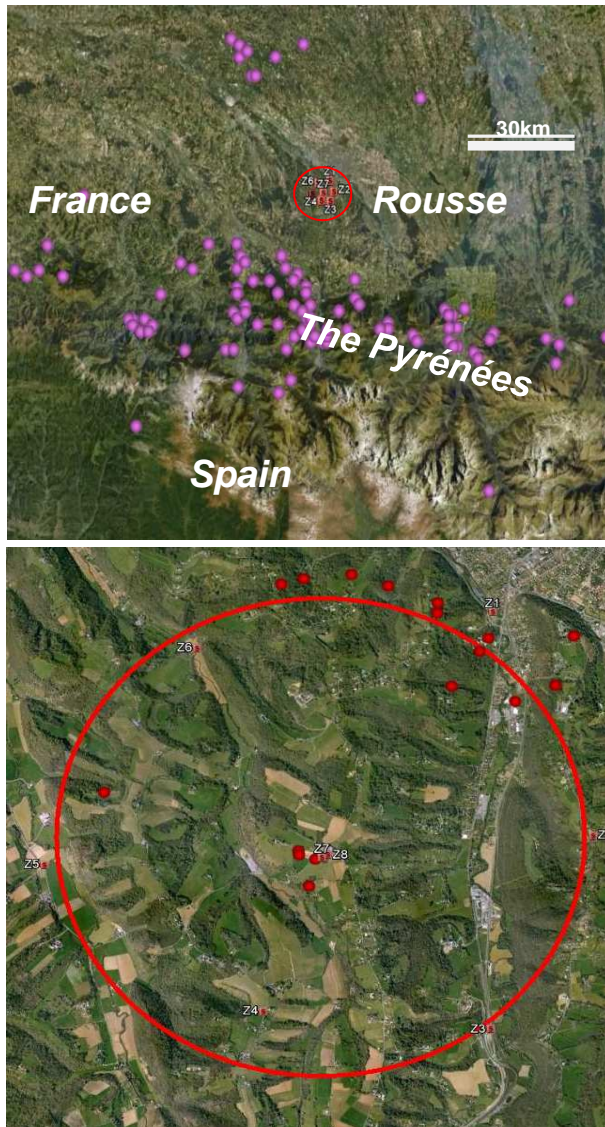
480 ➡ 30 ↗ 80 bar

## QUALIFICATION - SPECIFIC CO<sub>2</sub> STORAGE STUDIES - LEARNINGS

- Difficulty to conclude on cap rock capillary entry pressure based on measurement in heterogeneous samples (*not an issue for the pilot*)
- Geomechanics
  - No plastic deformation during the depletion period
  - Complexity to model fault stability at pressure higher than initial pressure (*situation not encountered during pilot life*)
- Geochemistry
  - CO<sub>2</sub> injection has a very minor impact on the Rousse carbonate reservoir
  - Changes in mineralogy and porosity are expected to be minor
  - Diffusion of CO<sub>2</sub> into the cap rock is slowed down due to chemistry
- Near well bore dehydration
  - Occurs first as a consequence of the production period
- CO<sub>2</sub> migrates down the reservoir due to buoyancy
  - Initial gas accumulates below the cap rock



# MICROSEISMIC MONITORING RESULTS



- Regional seismicity primarily around the Pyrénées and Lacq depleted gas field
- Rousse Local events
  - Integrity objective :
    - Only three events in the Rousse vicinity detected by the surface network
    - Magnitude between -1 and -0.3
  - R&D objective
    - Since march 2011, over 2000 micro seismic events detected by the deep arrays
    - Very low magnitude : between -2.4 and -0.8
    - On-going effort to locate these events

# ENVIRONMENTAL MONITORING

- Soil gas:
  - CO<sub>2</sub>, CH<sub>4</sub> concentration & flux
  - C isotopy
- Perched aquifers (springs) ●
  - Chemical and mineral content
  - pH, conductivity, (bi)carbonates
- Aquifers – drinking water ■
  - Similar monitoring as above
- Surface water
  - Bio indicators
  - Chemical & mineral content
- Fauna & Flora ■
  - Flora ecosystem (33 sites)
  - Amphibians & insects (50 sites)

