Un touriste inattendu à Majorque...

Une agriculture développée en plaine

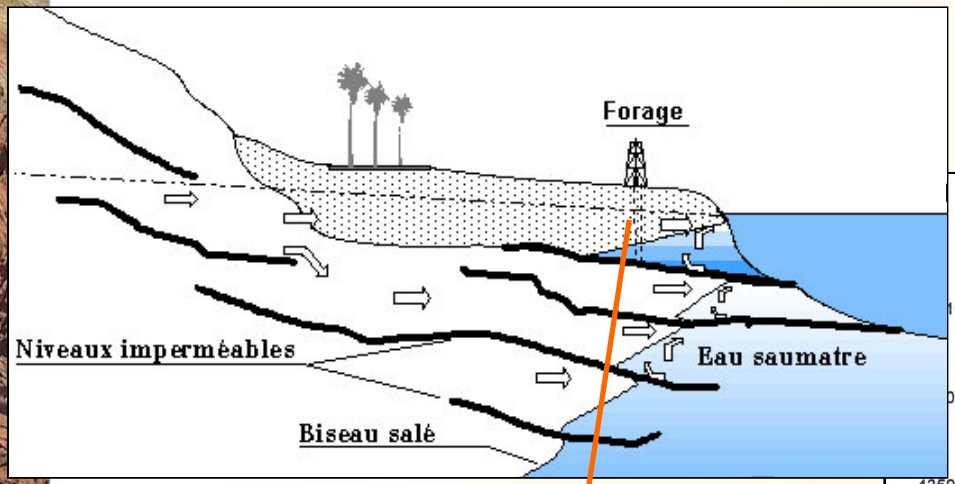
Un développement anarchique du tourisme à partir des années 60

« Baléarisation du littoral »

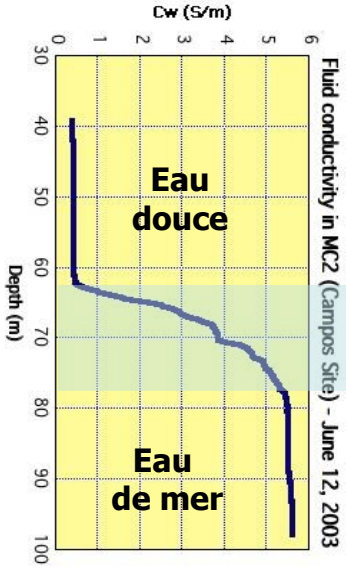
1988
~ 700 000 habitants
Capacité d'accueil: 7,3 millions de touristes!

Intrusion du biseau salé

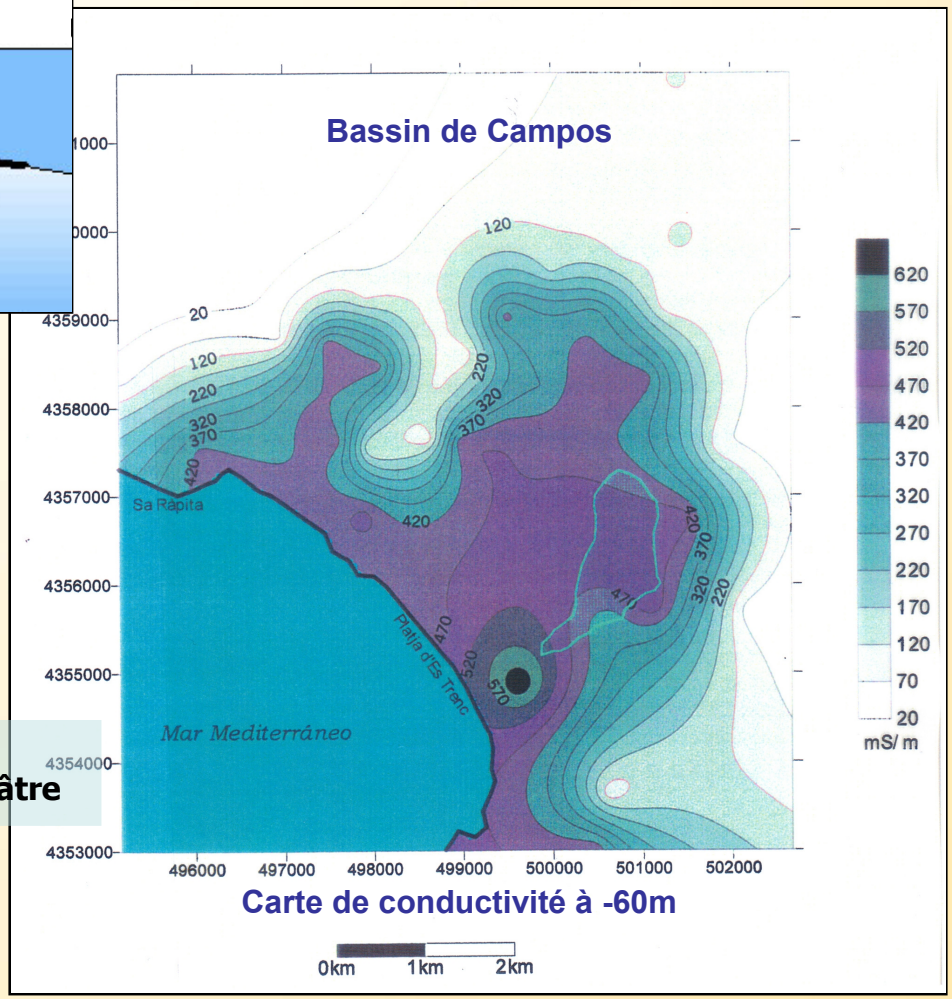
Jusqu'à 20kms à l'intérieur des terres!



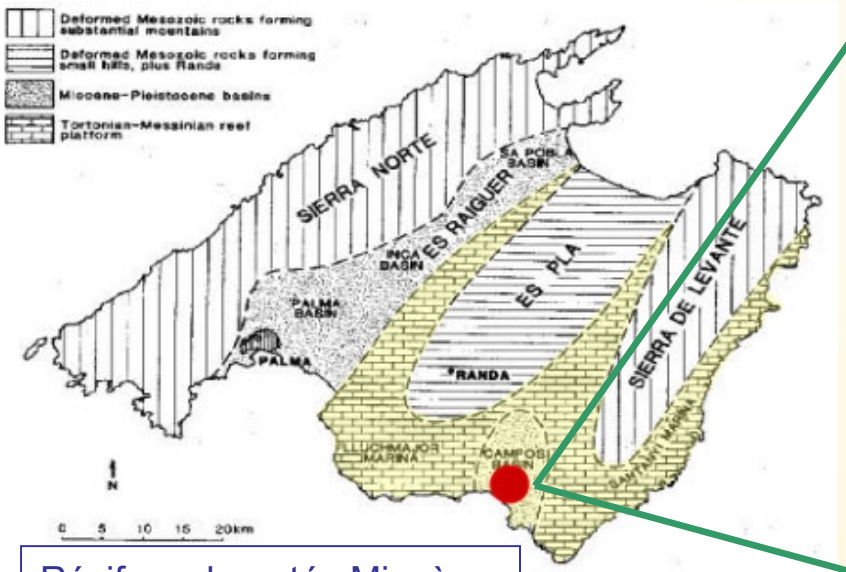
Conductivité du Fluide (S/m)

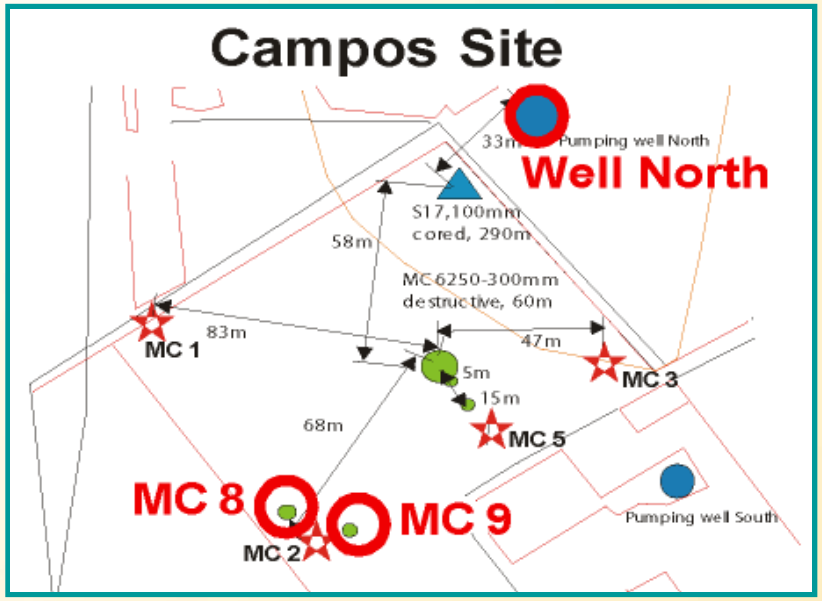


Eau saumâtre

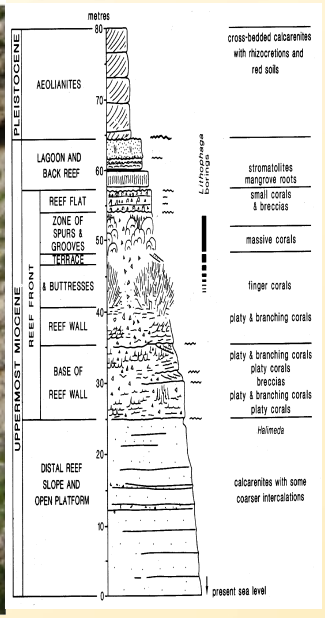


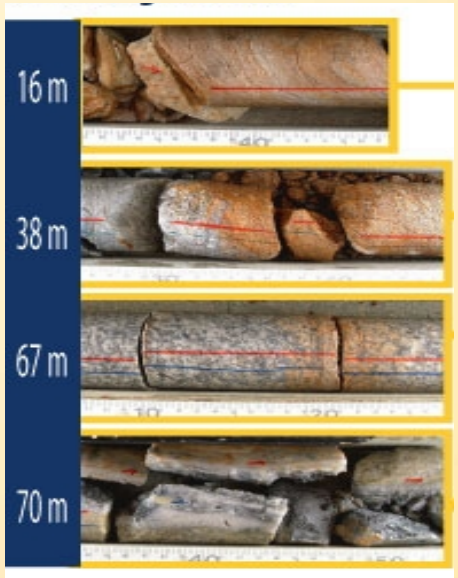
Carte de conductivité à -60m





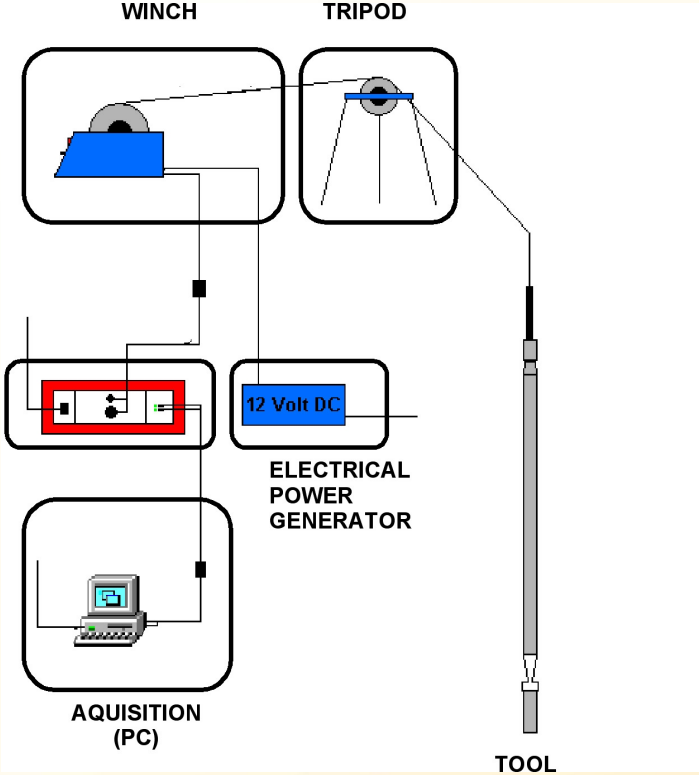
Récifs carbonatés Miocène
(très poreux et perméables)



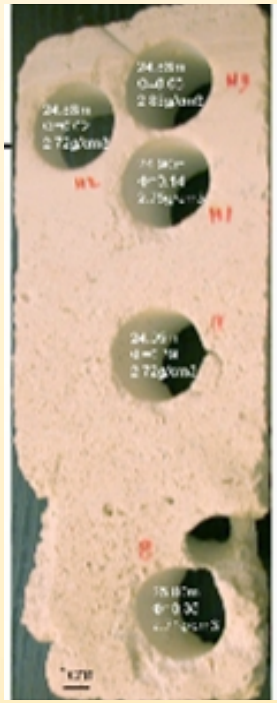


Mesures de paramètres physiques, chimiques, hydrodynamiques

In situ, en forage



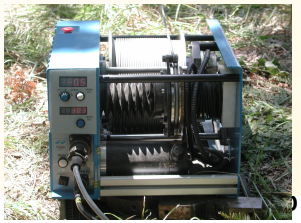
Sur échantillons de fluides ou de roches

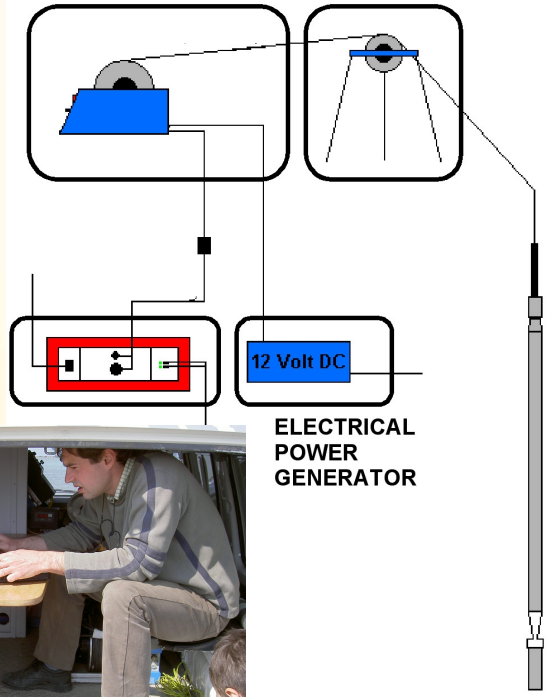


In situ, en forage

Pechelbronn (1927)

200m



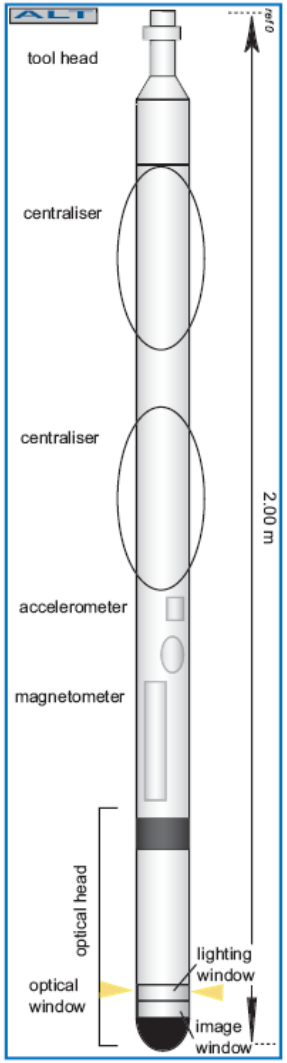


1200m

Camargue (2007)

~ 25 sondes de mesure (09/2007)

OBI40 - Optical Borehole Televiewer



Technical sheet

Tool:
Diameter: 40 *mm*
Length: 2.00 *m*
Measurement point: *1.92m/tool head*
Weight: *7 kg*
Max temperature: *50°C*
Max pressure: *20 MPa*

Cable:
Type: *4 conductors*

Sensor:
Sensor:
CCD 795 x 596 elements
Image:
24 bits RGB

Data characteristics

Horizontal image resolution:
90, 180, 360, or 720 pixels / 360°
Minimum vertical sampling:
2 mm
Hole inclination precision:
0.5°
Hole azimuth precision:
1°

Downhole deployment

Probe: *centralisers (one or two at more than 60 cm from the measuring window)*
Recording speed:
Low resolution: *1.5 m/min*
High resolution: *0.2 m/min*

Deployment restriction

Well filling: *water - air*
Casing: *no (unless for casing inspection)*
Maximum depth: *1500 m*
Borehole diameter: *45 - 300 mm*

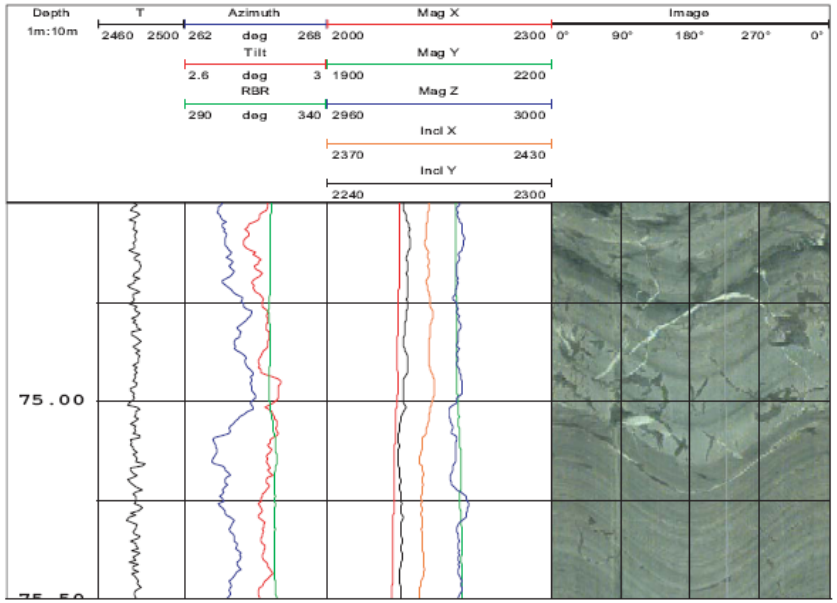
Channels

Image: *RGB borehole wall image (0° corresponding to North)*
T: environment temperature *(in °C)*
Azimuth: *azimuth relative to magnetic north (in degrees)*
Tilt: *inclination relative to the vertical (in degrees)*
Relative bearing: *(in degrees)*
Mag X, Y, Z: *components of Earth's magnetic field (in µT)*
Incl X, Y: *inclination of the tool following x and y (in degrees)*

OBI40 - Optical Borehole Televiewer

Optical imagery is used to gather information when acoustic imagery can't be used (air in the borehole). However overlapping optical and acoustic images makes it possible to gain supplementary details. This imagery provides information on the lithology, the borehole wall and identification of fractures.

Graphical representation of the results



Source : *hole LAV1 (Lavalette - Montpellier)*

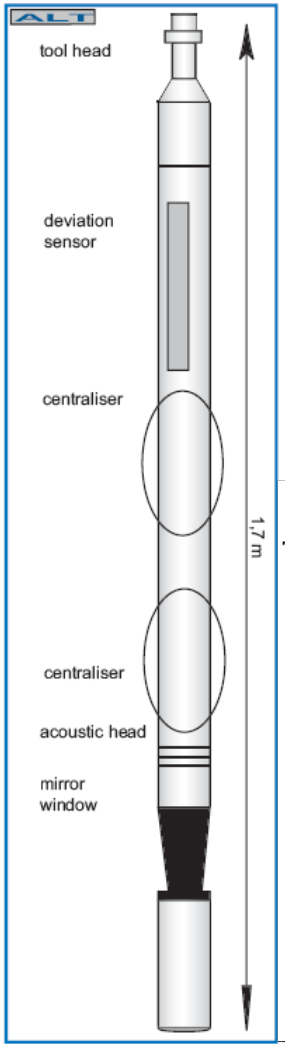
Comments on the results

The 3 left hand columns:
- Graphical representation of the data concerning the probe.

Right hand column:
- Optical imagery representing the borehole wall. It is therefore possible to observe the alternation of stratigraphy, fractures, etc...

Here we can see lithology and fractures, of which some are filled with calcite.

ABI40 - Acoustic Borehole Televiewer



Technical sheet

Tool:
Diameter: *40 mm*
Length: *1.7 m*
Measurement point: *1.55 m*
Weight: *6 kg*
Max temperature: *70°C*
Max pressure: *200 bar*

Cable:
Type: *4 conductors*

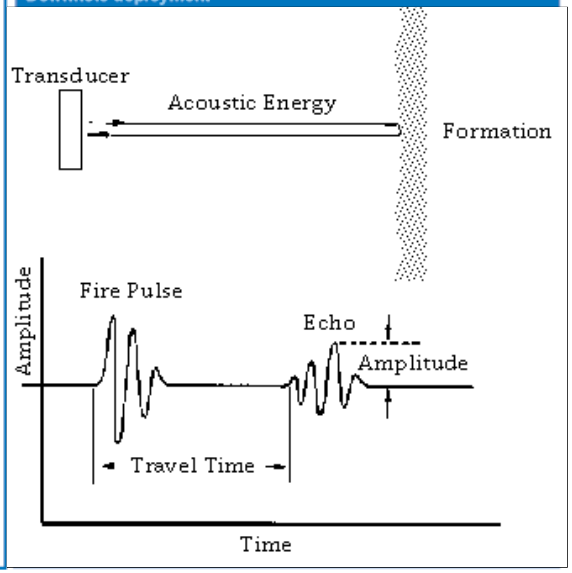
Acoustic sensor:
Sensor:
Sensor: *fixed*
Focal distance: *1,5 mm*
Frequency: *1.2 Mhz*

Rotation speed: *>10 turns/s*
Caliper resolution: *0.08 mm*

Data characteristics

Horizontal resolution:
72, 144, 288 points / 360°
Minimum vertical sampling:
4 mm
Hole inclination:
0.5°
Azimuth accuracy:
1°

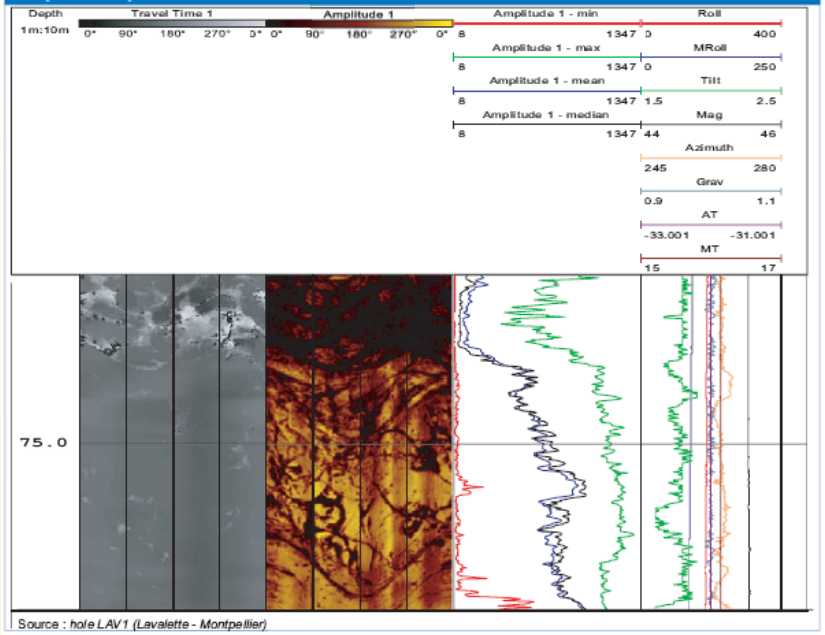
Downhole deployment



ABI40 - Acoustic Borehole Televiewer Tool

Acoustic measurements enable the acquisition of an image of the hole wall depth (distance that seperates the tool from the borehole wall) and an image that represents the capacity of absorption of the formation.

Graphical representation of the results



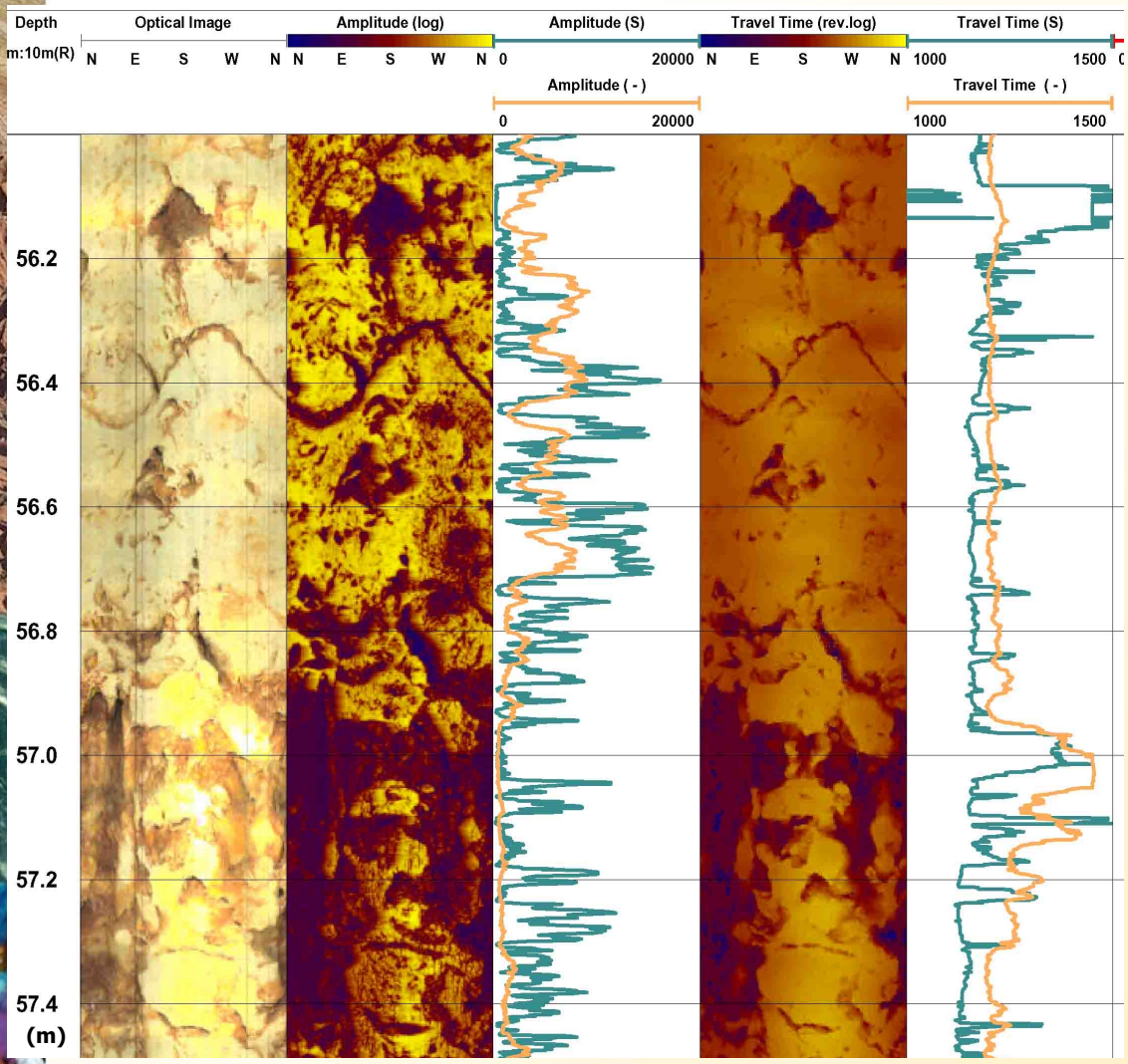
Source : *hole LAV1 (Lavalette - Montpellier)*

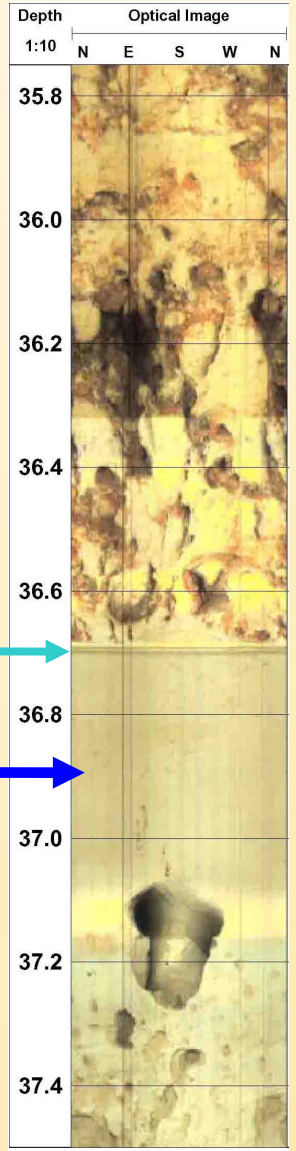
Comments on the results

The two left hand columns:
Acoustic imagery, that includes the Travel Time and the Amplitude of the emitted waves. These two columns enable the visualisation of the formation's structure, fracture analysis, etc...

Right hand columns:

- graphical representation of statistical values extracted from the imagery.
- graphical representation of the syn-measurement data provided by the tool.

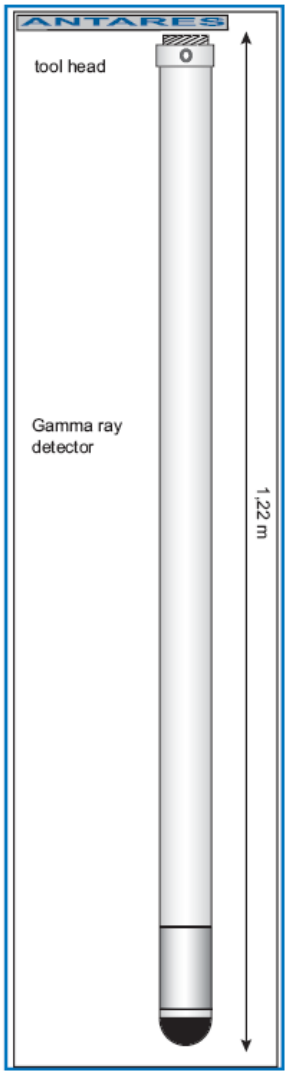




Interface air-eau

Artefact?

ASGR - Spectral Natural Gamma Probe



Technical sheet

Tool:
Diametre: *52 mm*
Length: *1.22 m*
Measurement point: *1.05 m*
Weight: *9 kg*
Max Temp: *75°C*
Max Pressure: *25 Mpa*

Cable:
Type: *4 conductors*

Sensor:
Natural Gamma sensor:
-type: *BGO scintillating crystal*
-diametre: *38 mm*
-length: *150 mm*

Sampling:
256 channels

Data characteristics

Vertical Resolution:
150 mm

Downhole deployment

Probe: *non centered*
Recording speed:
GR: *9 m/min*
Spectral: 3 m/min

Deployment restriction

Well filling: *water - air*
Casing: *not important*
Maximum depth: *2500 m*
Borehole diametre: *75 - 350 mm*

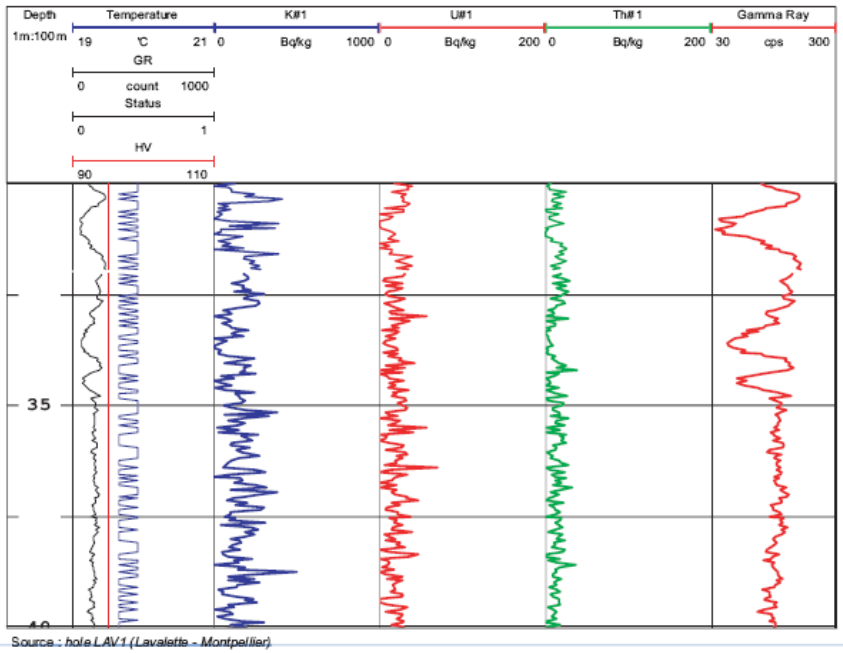
Channels

T: *Tool internal temperature (degrees Celsius)*
GR: *"Gamma Ray" (counts)*
HV: *High Voltage (V)*
K: *Potassium content(Bq/kg)*
U: *Uranium content (Bq/kg)*
Th: *Thorium content (Bq/kg)*

ASGR - Spectral Gamma Ray Tool

Natural radioactivity is caused by rocks and minerals, from various layers in Earth's structure, that are composed of naturally radioactive elements. The content in radioactive elements depends greatly on the type of lithology. In addition to measuring natural gamma rays, the main aim is to be able to differentiate the different radiation emitting elements such as Uranium (U), Thorium (Th) and Potassium (K).

Graphical representation of the results



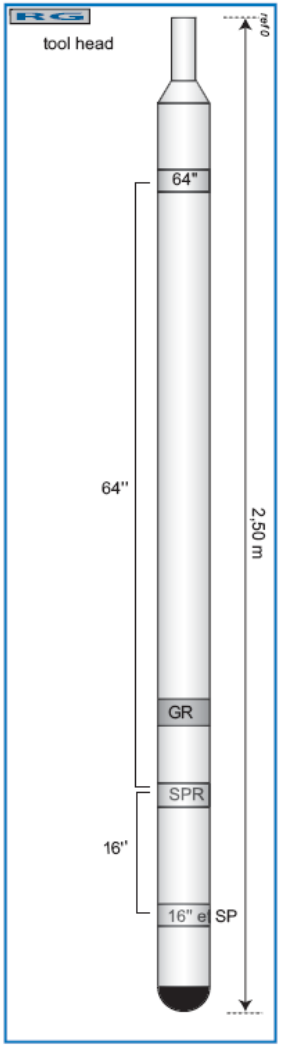
Source : *hole LAV1 (Lavalette - Montpellier)*

Comments on the results

The 3 main elements that emit γ are: Potassium, Uranium and Thorium.

The natural radioactivity curve represents the amount of total natural gamma ray hits received per second (sum of the three elements).
The high points correspond to a zone of high radioactivity (clays, because they are rich in K,U and Th). The low points correspond to a zone of low radioactivity (limestones or sandstones).

ELXG - Normal Electrical Probe



Technical Sheet

Tool :
Diametre : 44 *mm*
Length : *2,55 m*
Measurement point :
LNR : *1,13 m*
NG : *1,74 m*
SPR : *1,94 m*
SNR : *2,14 m*
SP : *2,35 m*
Weight : *9,8 kg*
Max temp : 70°C
Max pressure : *20 Mpa*

Cable :
Type : *4 conducteurs*

Sensor :
Natural Gamma Ray Detector :
50 mm X 25 mm NaI(Tl) scintilating crystal

Result Caracteristics

Usage

Probe : *non centred*
Recording Speed : *+ de 15 m/min*
Cable insulation: *sur 10 m*

Usage restrictions

Well filling : *water*
Casing : *no casing or strongly screened casing*
Maximum Depth : *2000 m*
Borehole diametre: *45 - 300 mm*

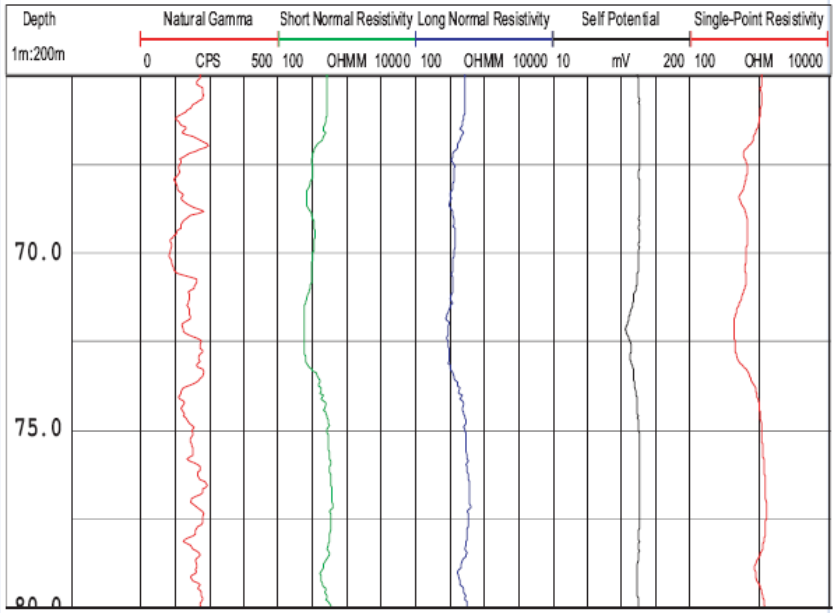
Output

NG : *"Natural Gamma" value of emitted Natural Gamma Rays (in API Cs)*
SNR (16") : *"Short normal resistivity" resistivity between the SPR electrode and the 16" electrode (in ohm.m)*
LNR (64") : *"Long normal resistivity" rresistivity between the SPR electrode and the 64" electrode (in ohm.m)*
SP : *"Self Potential" electrode linked to a surface electrode. Measures a potential (in mV)*
SPR : *"Single Point Resistance" (en ohm)*

ELXG - Normal Electrical Tool

This tool records the resistivity of the rock and its natural radioactivity.
These resistivities are used to determine the lithology and porosity of the formation.

Graphical representation of the results



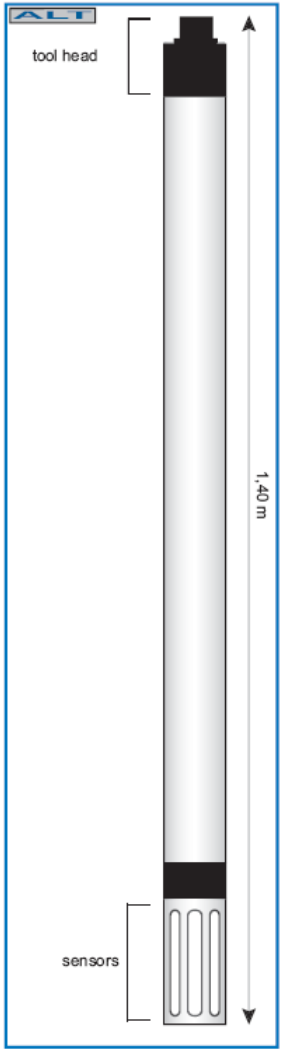
Source :hole *B1 (Ploemeur)*

Comments on the results

The Natural Gamma Ray curve represents a variation of the amount of hits of total gamma rays received by the tool in a second.
The high points correspond to a zone with more of a clay content. The low points correspond to a zone with more of a limestone or sandstone content.

The variations of the SNR, LNR, SP and SPR curves reflect the variation found in the lithology, porosity, etc....

IDRONAUT - Hydrogeological probe



Technical sheet

Tool:
Diametre: 50 *mm*
Length: *1.40 m*
Measurement point: *1.38m/tool head*
Weight: *2.2 kg*
Max Temperature: *50°C*
Max Pressure : *15 Mpa*

Cable:
Type: *4 conductors*

Sensors:
Pressure: *0 - 1500 dbar*
Temperature: *-1 à 49°C*
Conductivity: *0 - 62 mS/cm*
pH: *0 - 14*
Eh: *-1000 à +1000 mV*

Data characteristics

Measurement resolution:
Pressure: *0.01 dbar*
Temperature: *0.004°C*
Conductivity: *0.004 mS/cm*
pH: *0.01 pH*
Eh: *1 mV*

Time constants:
Pressure: *50 ms*
Temperature: *50 ms*
Conductivity: *50 ms*
pH: *3 s*
Eh: *3 s*

Downhole deployment

Tool: *non centered*
Recording speed: *1 à 6 m/min*

Deployment restriction

Well filling: *water*
Casing: *open*
Maximum depth: *1500 m*
Borehole diametre: *> 52 mm*

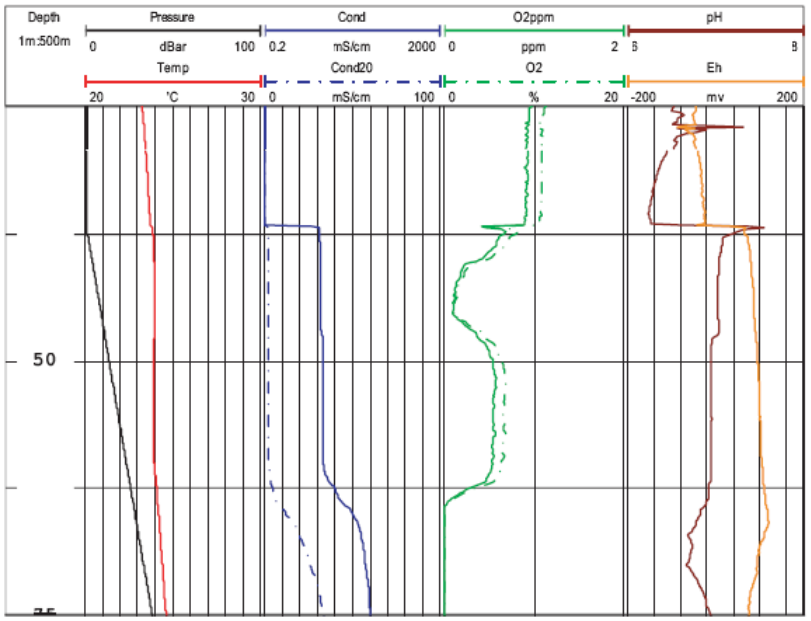
Channels

P: *Environment pressure (in dbar)*
T: *Tool Temperature (in degrees Celscius)*
Cond: *Environment Conductivity at ambiant temperature (in mS/cm)*
Cond20: *Environment Conductivity at 20°C (in mS/cm)*
pH: *Environment pH*
Eh: *Environment oxydoreduction potential (in mV)*

IDRONAUT - Hydrogeological probe

The tool measures the chemistry of the fluids found in the borehole. The measured parametres are pressure, temperature, conductivity, concentratioin in O2, pH and the oxydoreduction potential. This tool is mainly used in the fields of water quality control, contamination studies, aquifer and subterranian flow identification, etc...

Graphical representation of the results



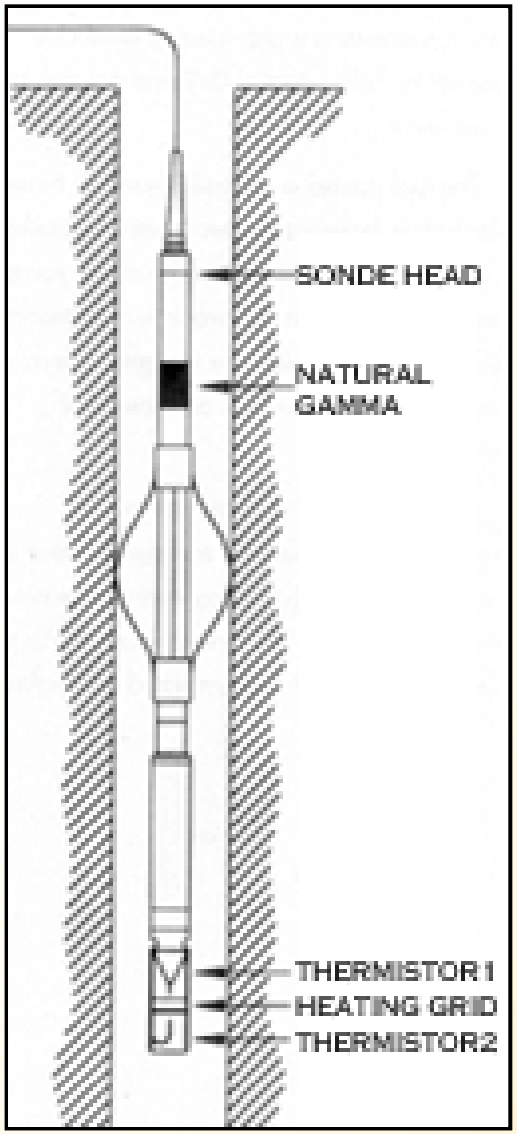
Source : *hole MC8 (Mallorca)*

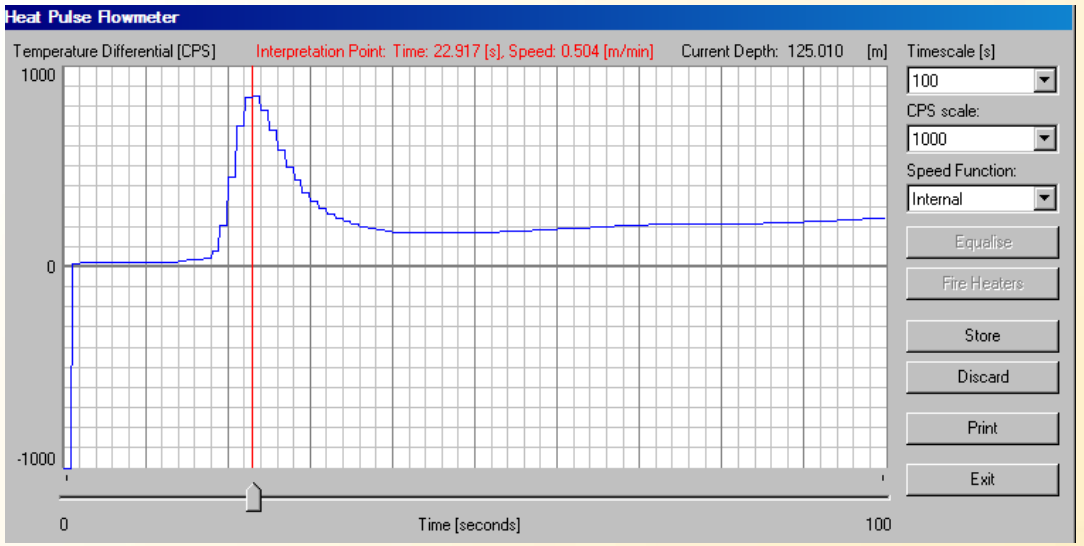
Comments on the results

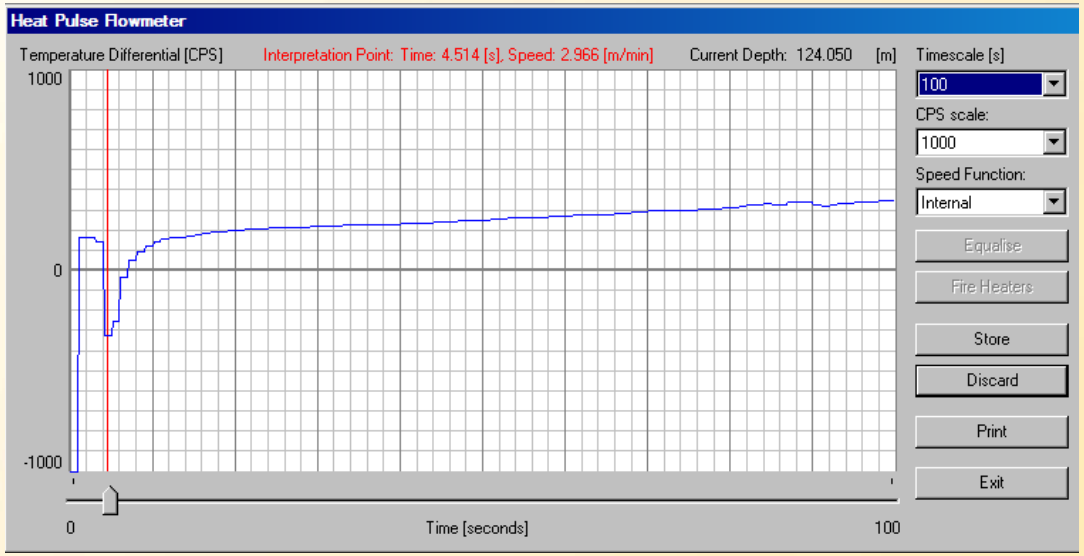
The aquired results are only truly useful when compared. They enable the hydrochemical caracterisation of the fluids found in the borehole. The hydrochemical variations can reveal infiltration of water, the boundary between salt water and fresh water, etc...

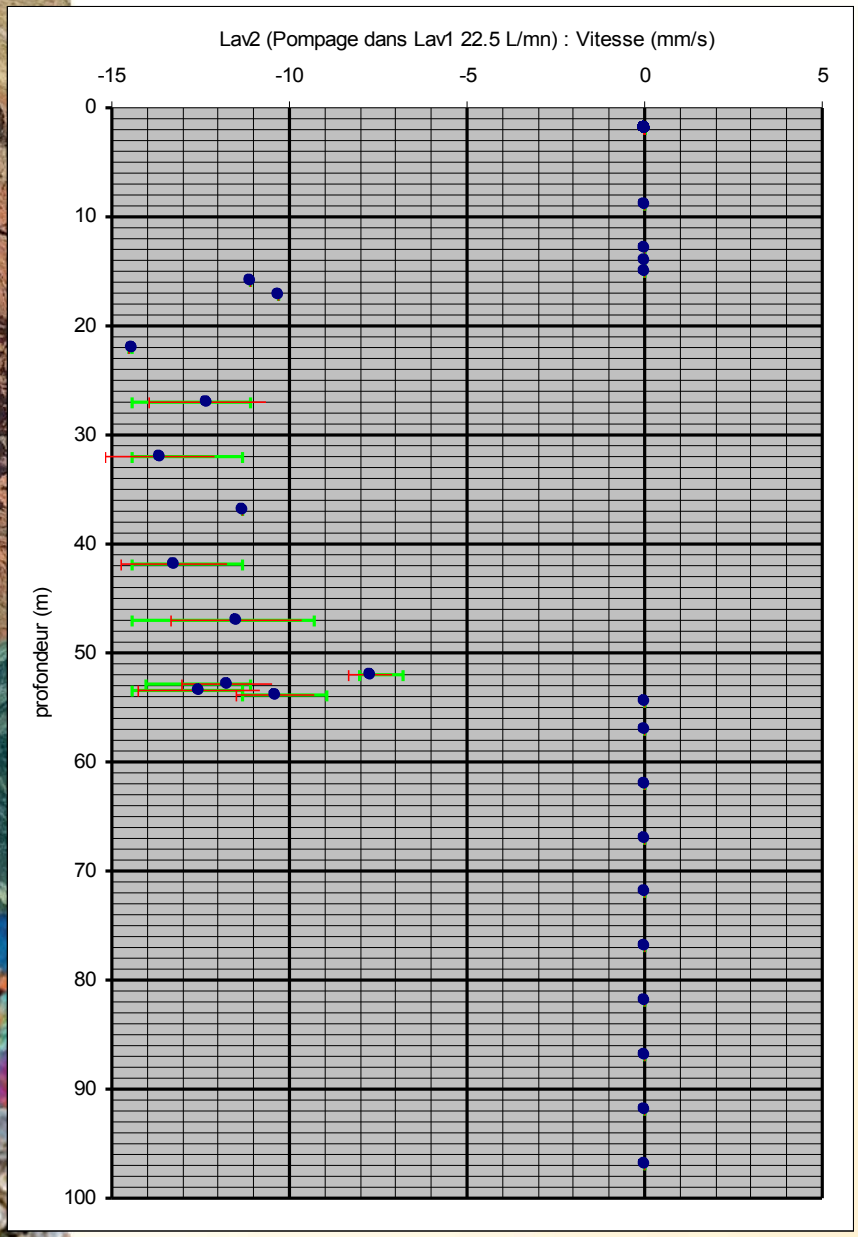
Débitmètre à impulsion thermique

Seuil de détection: 1 mm/s



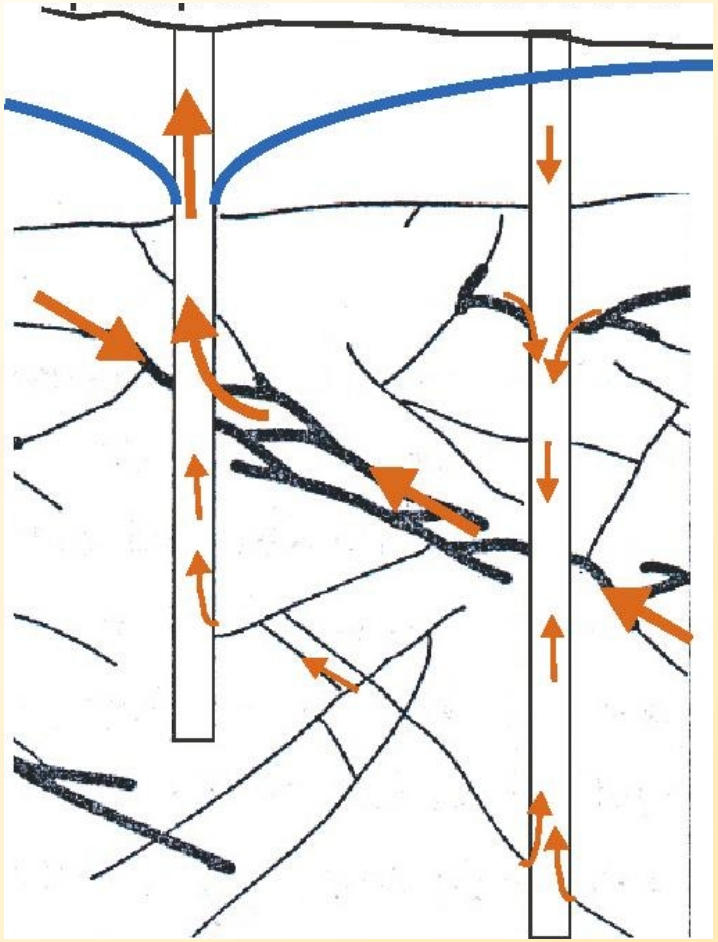




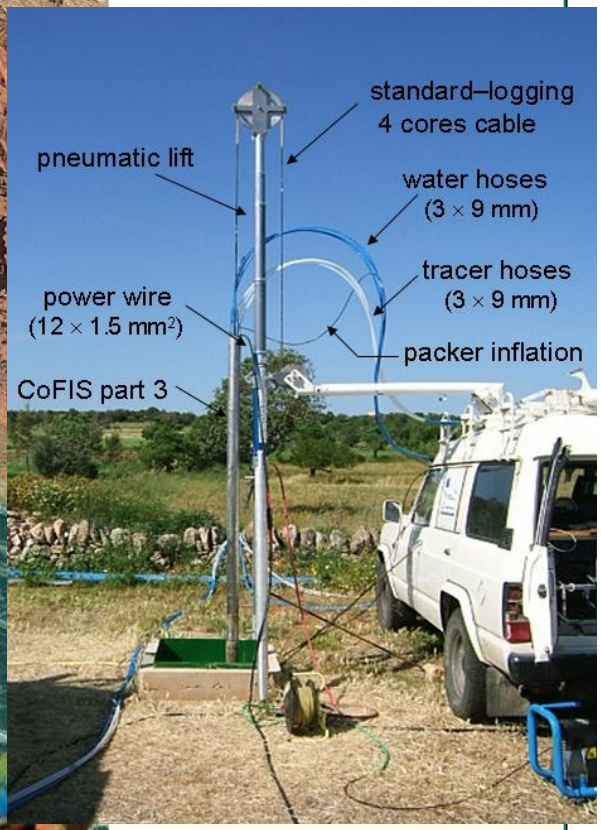


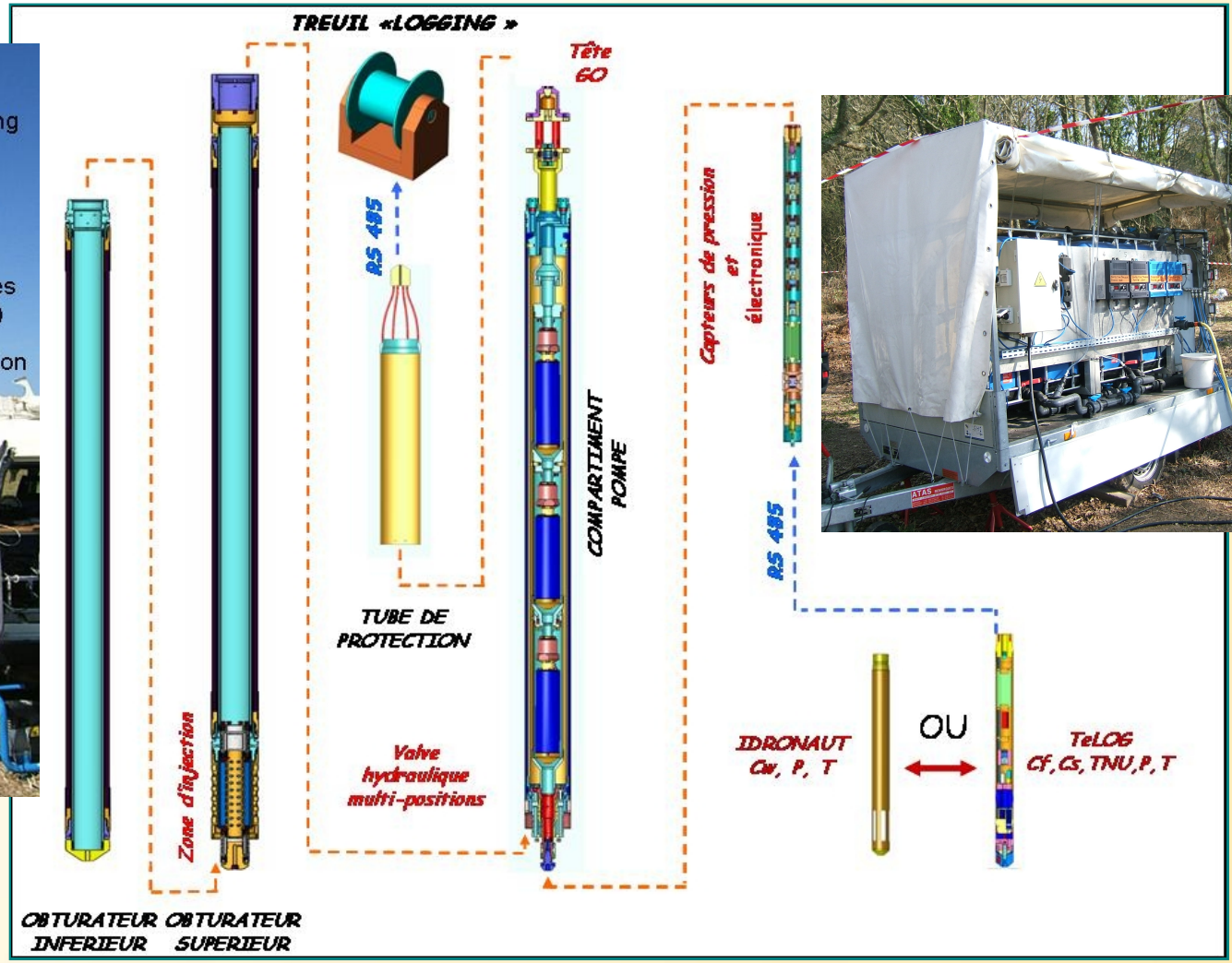
Forage pompé

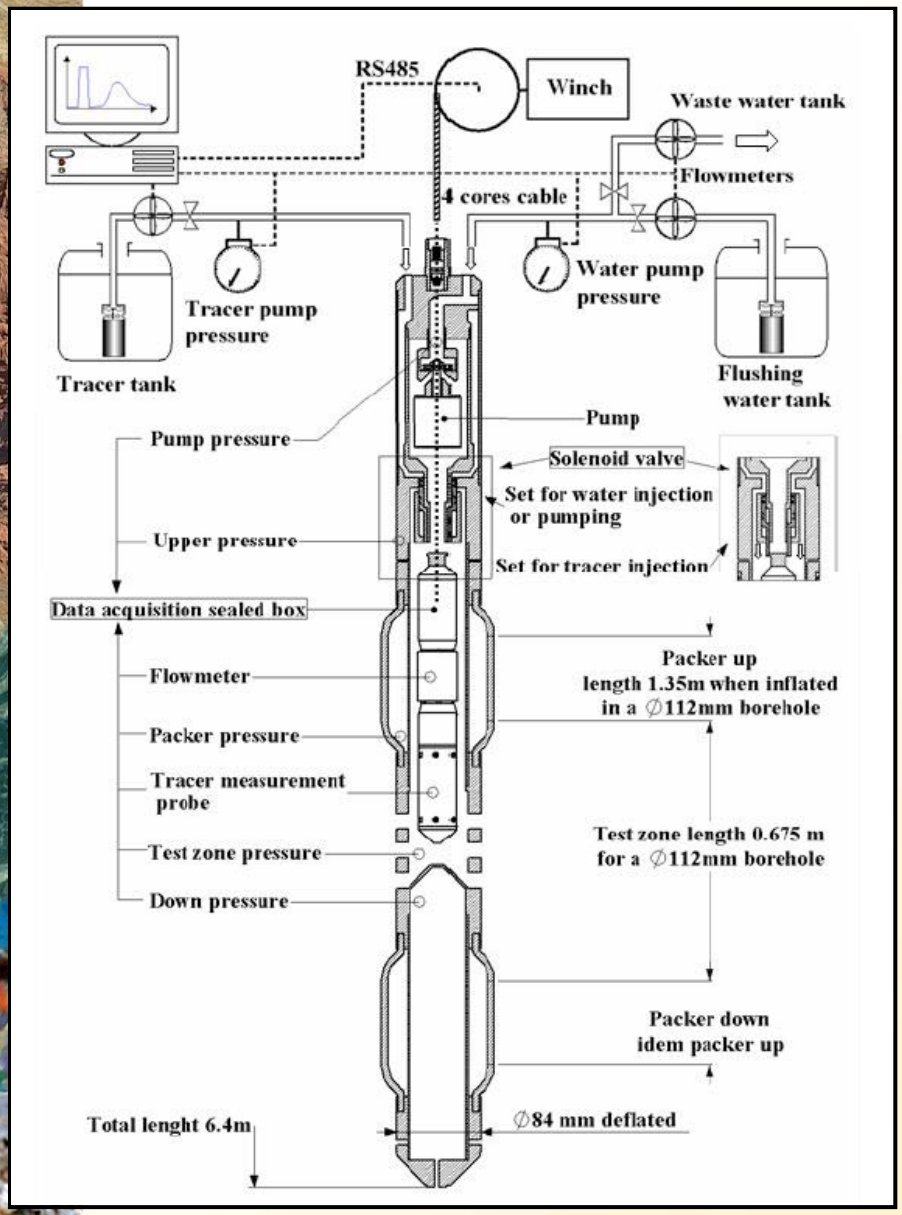
Forage d'observation



Controlled Fluids Injection Sonde

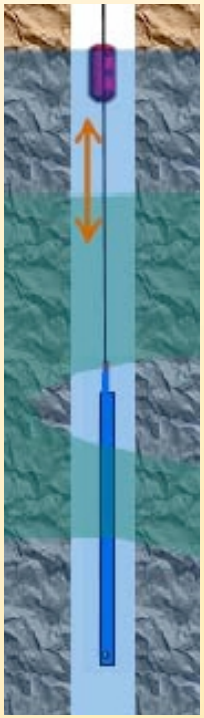


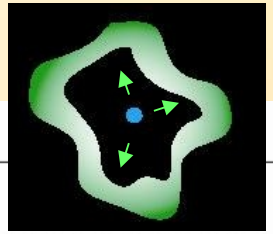




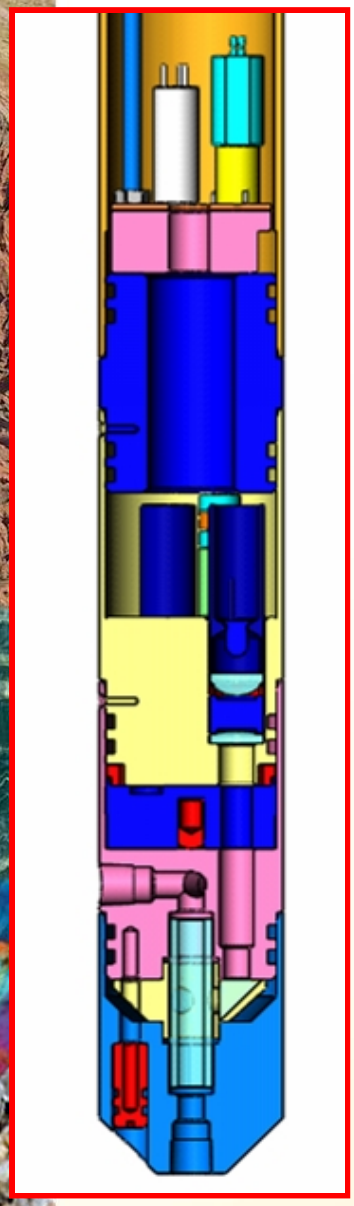
- **Essais de puits « classique »**
- **Mesures de perméabilité:**
  - **En injection**
  - **En pompage**
- **Sollicitations hydrauliques harmoniques.**
- **Mesure de dispersion par traçage:**
  - **Multi puits**
  - **Mono puits**

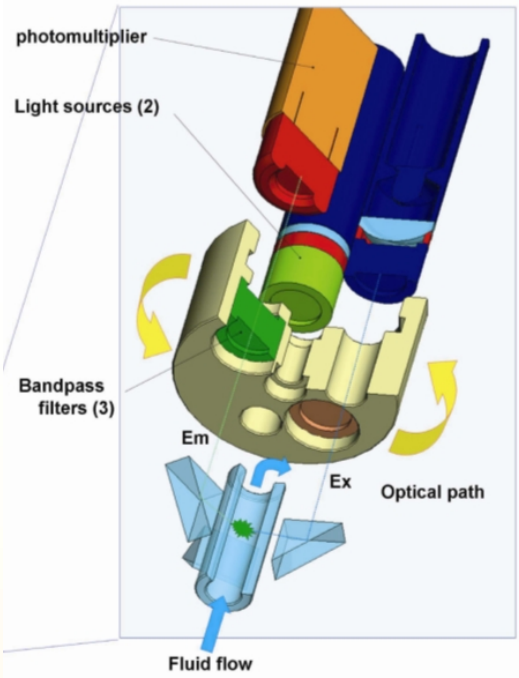
(Taux de récupération du traceur: 90 à 99%)





Traçage fluorescent

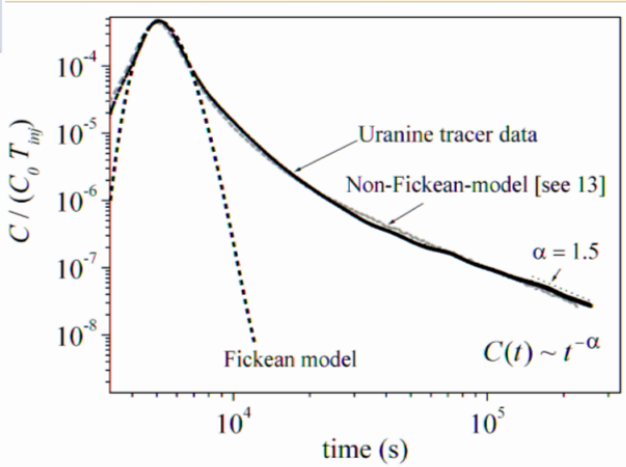




Fluorimètre TloG:

Longueur: 600mm Diamètre: 42 mm
5 paramètres mesurés sur un seul photomultiplicateur:
-C Fluorescéine,
-C sulforhodamine G,
-Turbidité,
-Stabilité source 485nm,
-Stabilité source 525 nm.

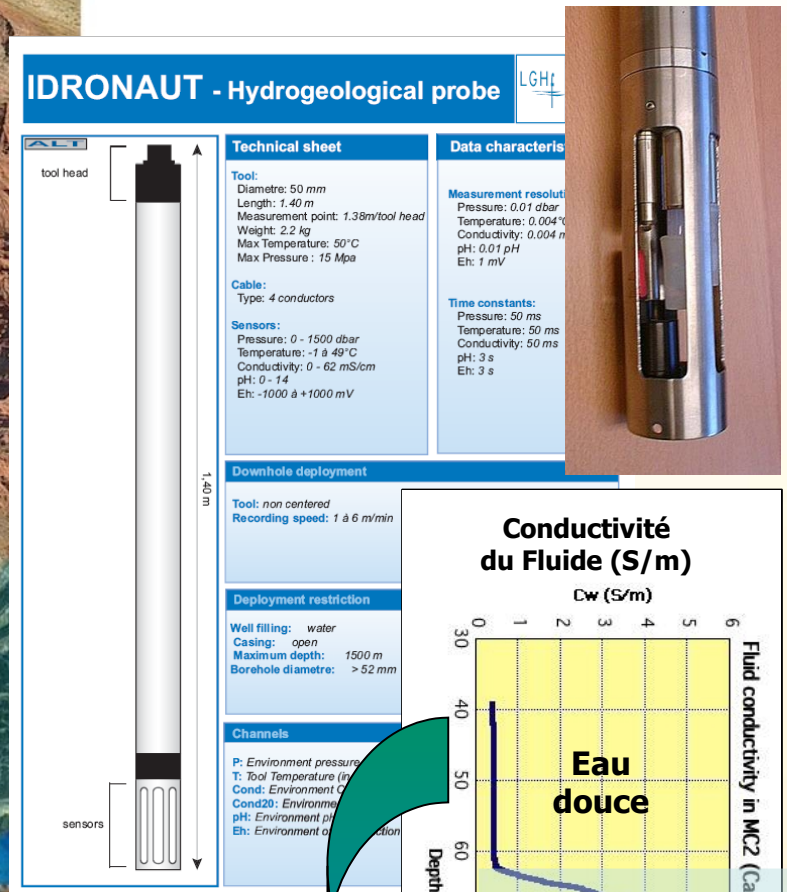
Dynamique en eau claire:
5.10-12 à 10-3 gr/gr

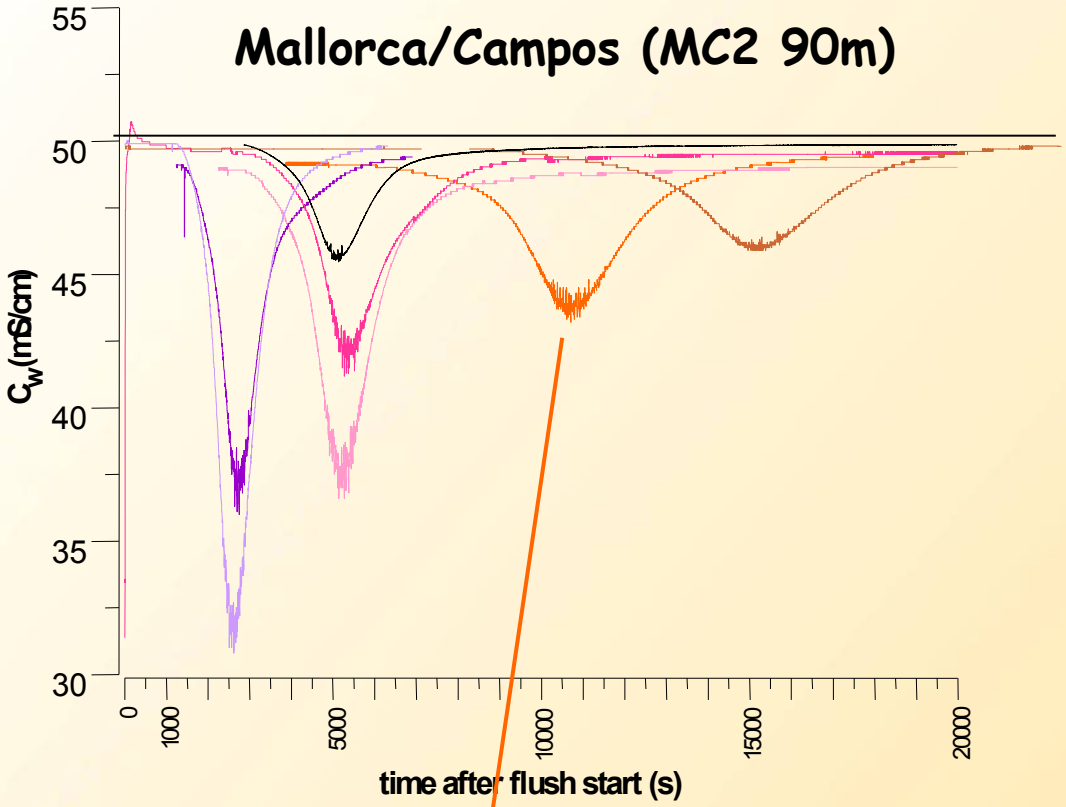


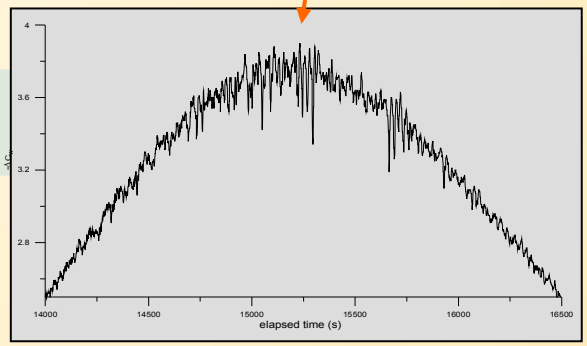
Gouze et al

Fig. 1. Example of BTC normalized by $C_0 \times T_{inj}$ (so that it integrates to 1) measured at the Ses Sitjoles test site showing the power law asymptotic behaviour $C(t) \sim t^{-\alpha}$ at large elapsed time. The dotted curve is the best fit obtained using the standard Fickian dispersion model.

Traçage ionique



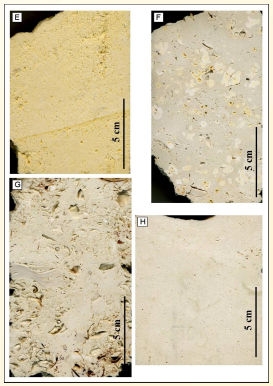


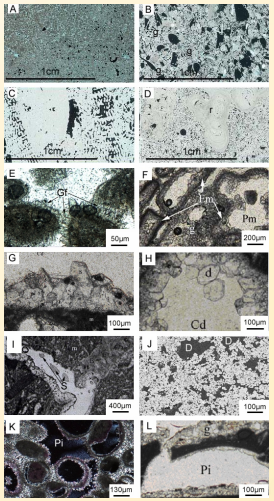


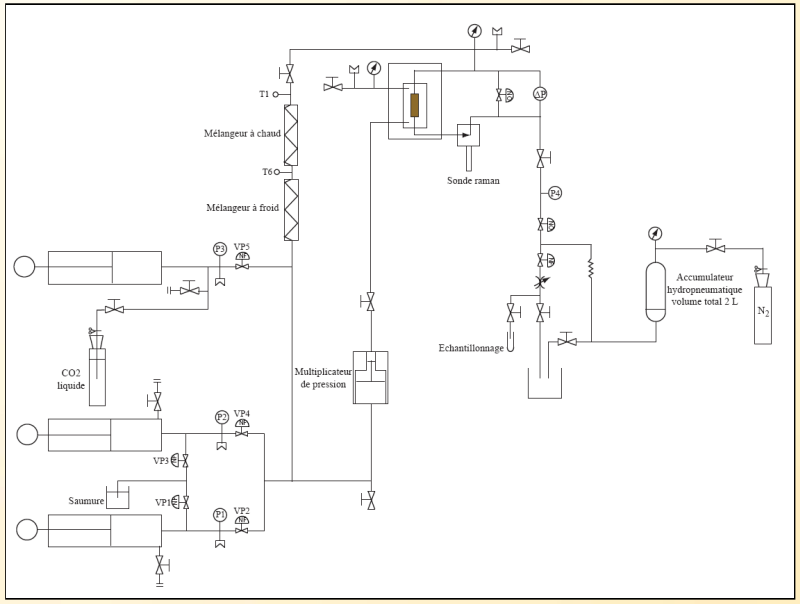
Échanges de gaz dissous à l'interface eau douce/eau salée. CO2? Réactions avec la matrice rocheuse?

Mesures sur carottes en laboratoire

-Analyse des carottes
-Lames minces: Analyses cristallographiques.
-Mesures de perméabilité.
-Mesures de porosité.
-Mesures de conductivité électrique.
-Mesure de dispersion par traçage fluorescent.
-Mesure de dissolution et précipitation sur banc de simulation des processus diagénétiques.







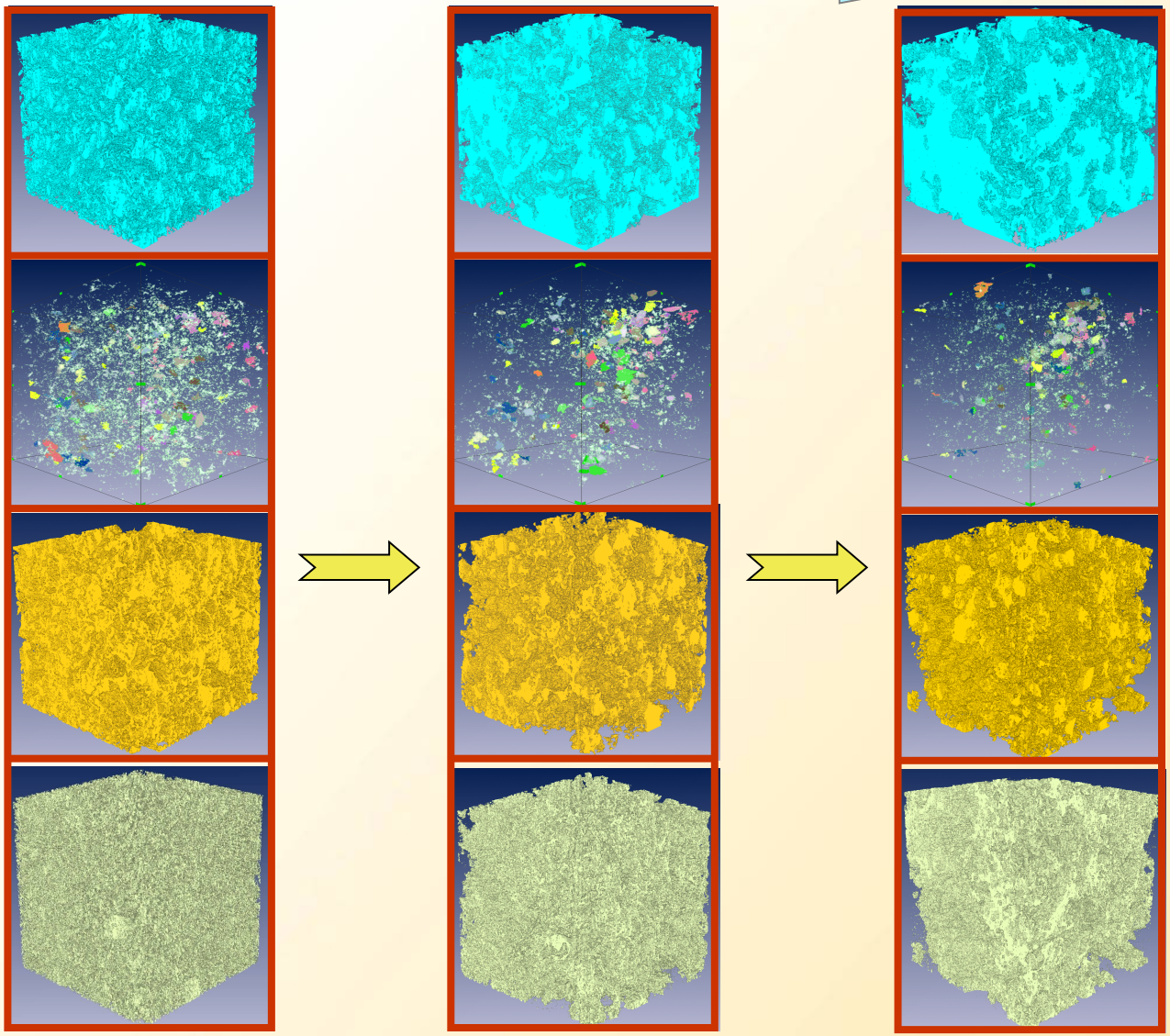
DISSOLUTION

Connected Porosity

Unconnected Porosity

Massive Calcite

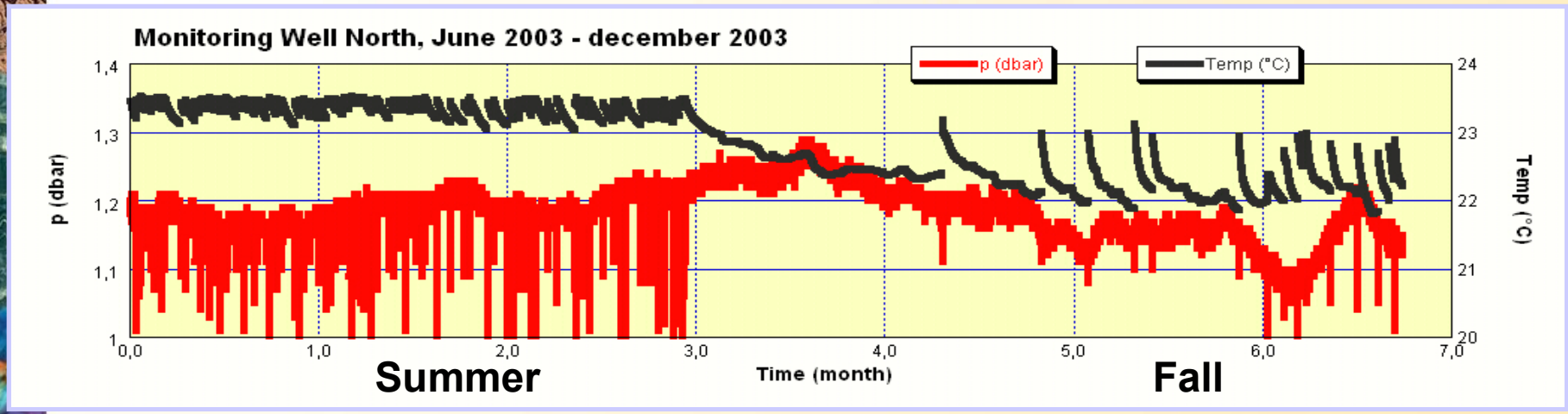
Microporous Calcite



Gouze et al.

→ Influences climatologique et anthropique

Capteurs piézométriques autonomes (P, T°C)



Observatoires de résistivité électrique.

- variabilité de la résistivité en profondeur et au cours du temps