



INNOVATIVE IN SITU METHODS FOR VADOSE ZONE CHARACTERIZATION AT INDUSTRIAL CONTAMINATED SITES: THE VADOSE ZONE EXPERIMENTAL SETUP



In situ Remediation 2014 Conference
Natalia Fernandez de Vera

nfdvera@ulg.ac.be

London, 03/09/2014

OUTLINE



- ❖ **Motivation of vadose zone studies**
- ❖ **Vadose Zone experimental setup**
- ❖ **Site description**
- ❖ **Installation**
- ❖ **Results**
- ❖ **Conclusions**

MOTIVATION OF VADOSE ZONE STUDIES

THE PROBLEM

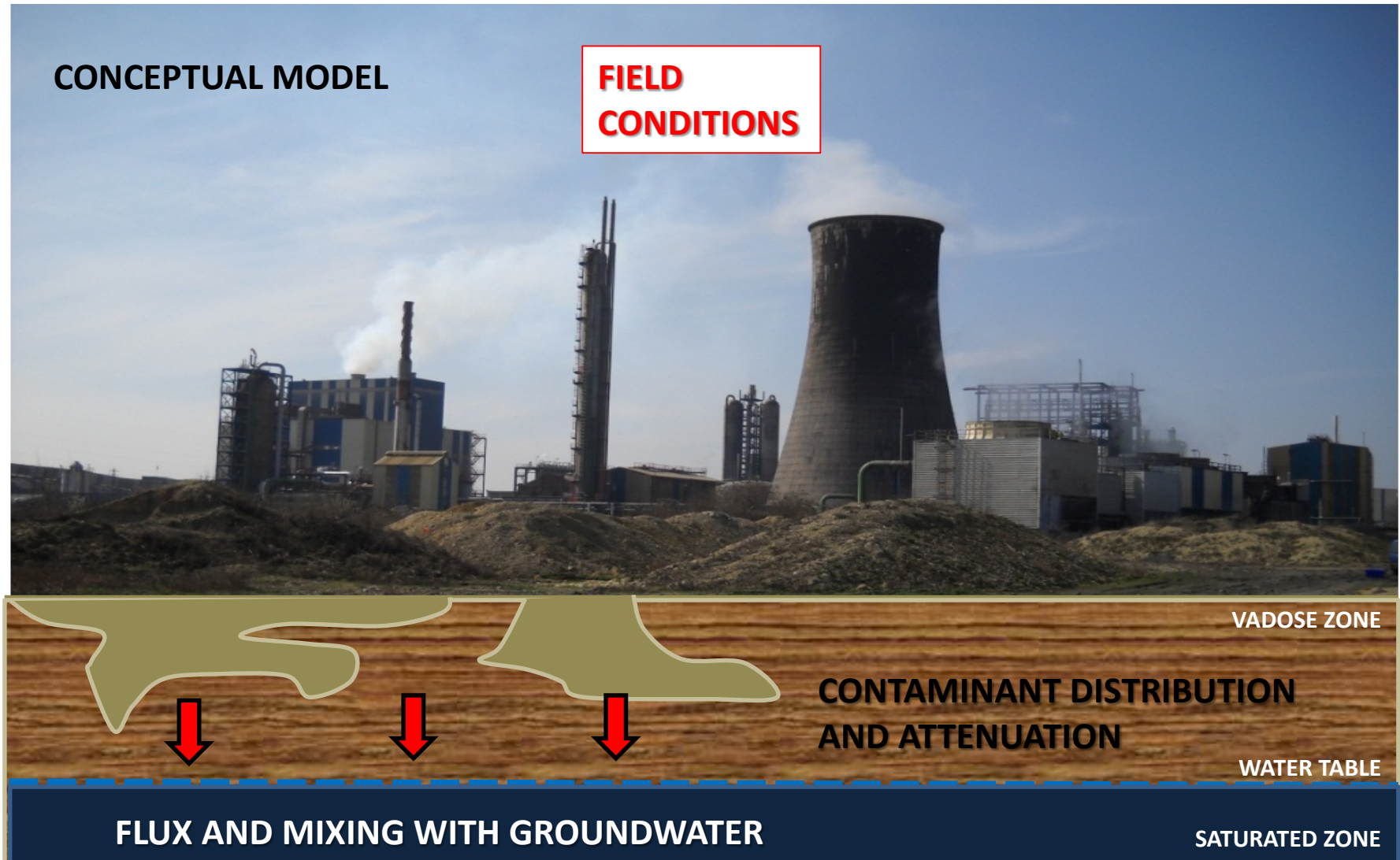
Impact of contamination
in soil and groundwater?

Important for risk assessment
and remediation!



MOTIVATION OF VADOSE ZONE STUDIES

THE AIM



MOTIVATION OF VADOSE ZONE STUDIES

WHY THE VADOSE ZONE EXPERIMENTAL SETUP?

Limited application of contaminant flux measurement techniques at industrial sites



AGRICULTURAL SITES



- SOIL TYPE
- CONTAMINATION
- DEPTH OF INVESTIGATION



INDUSTRIAL SITES

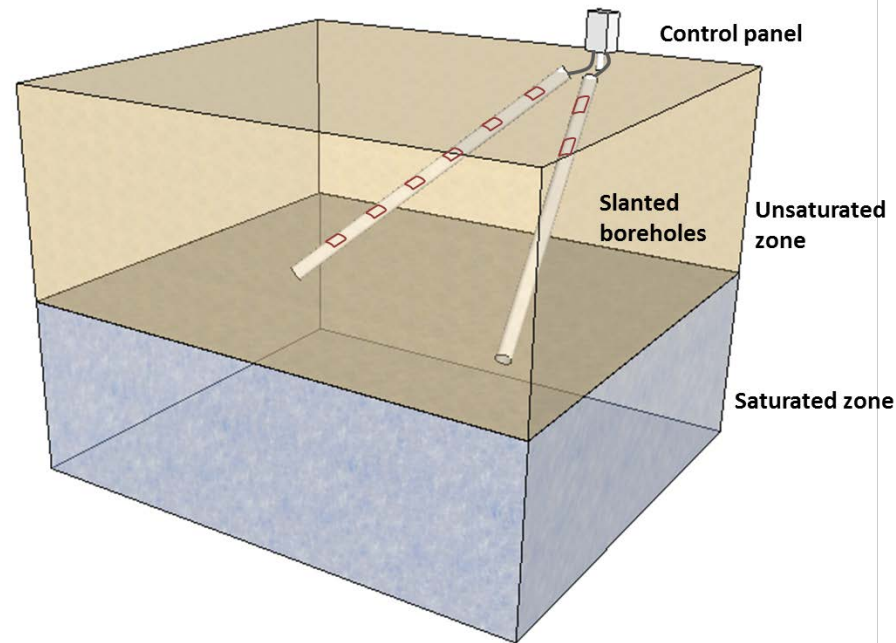
ALTERNATIVE: THE VADOSE ZONE EXPERIMENTAL SETUP

VADOSE ZONE EXPERIMENTAL SETUP

VADOSE ZONE MONITORING SYSTEM (VMS)

SENSORS

Time Domain Transmissometry (TDT)



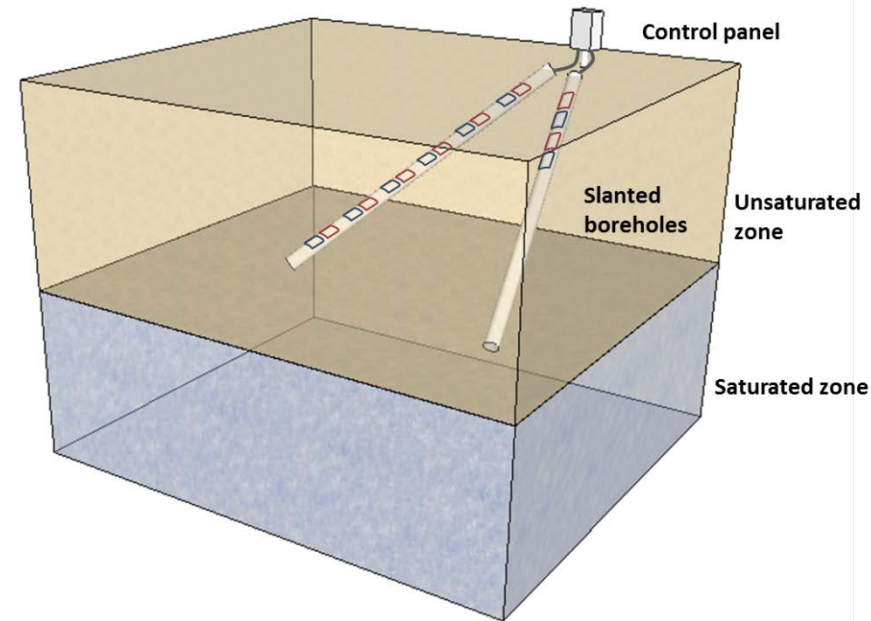
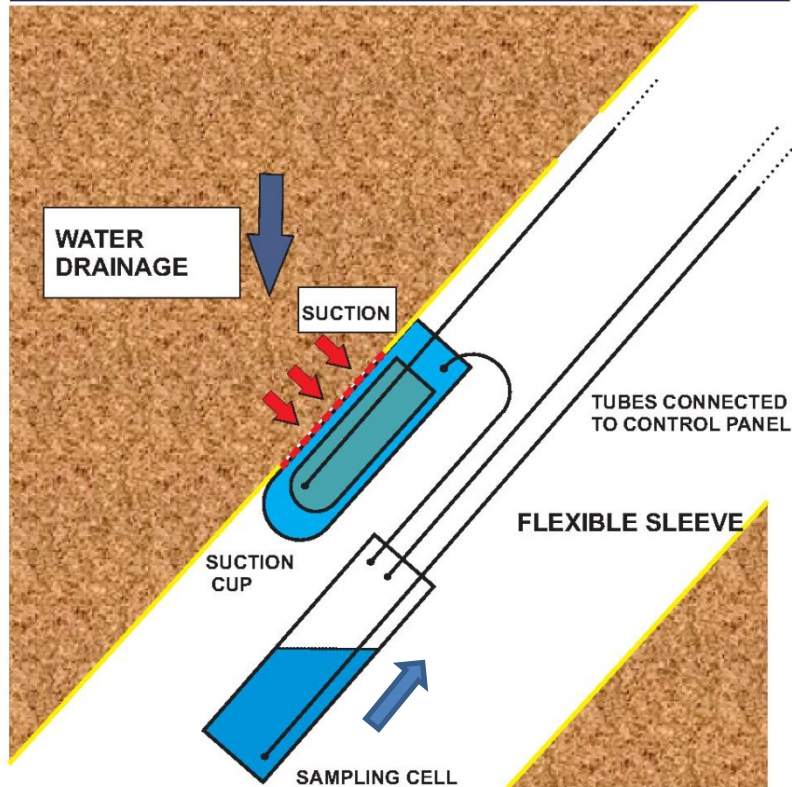
Used for soil moisture content measurements

VADOSE ZONE EXPERIMENTAL SETUP

VADOSE ZONE MONITORING SYSTEM (VMS)

SENSORS

VADOSE SAMPLING PORTS (VSP)

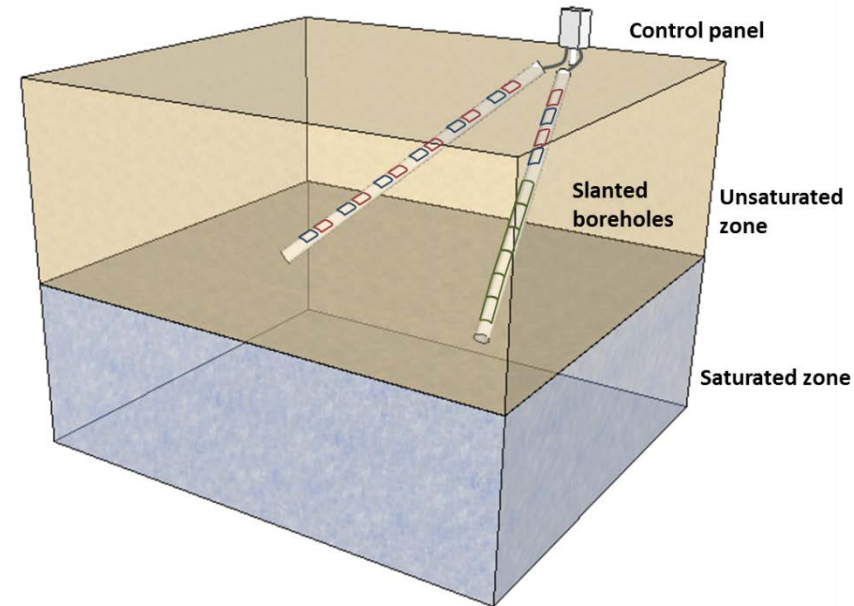
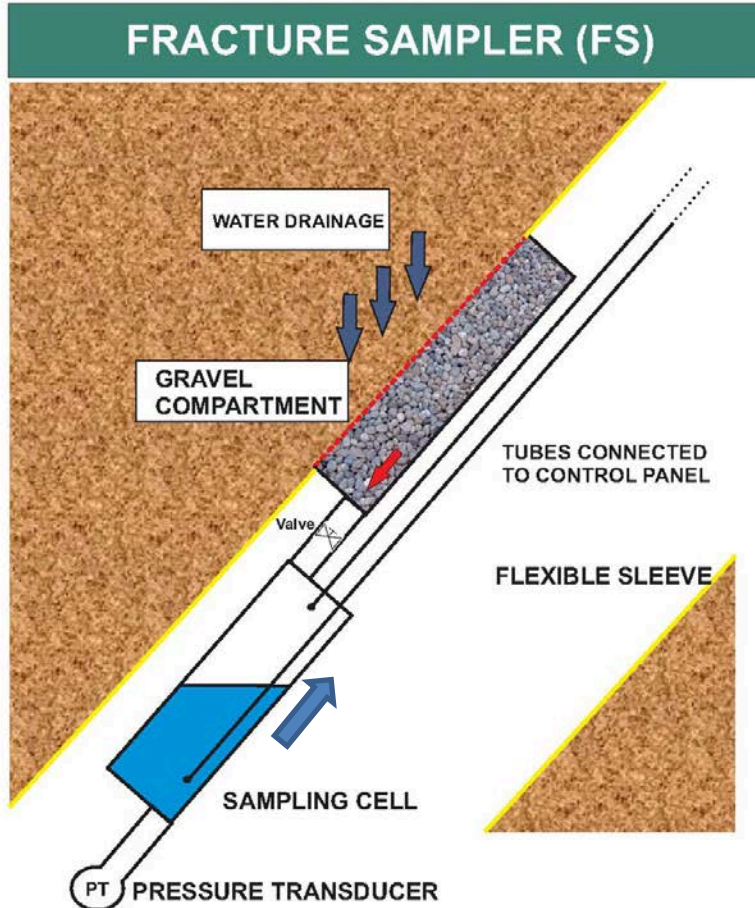


Used for collecting soil water samples from the matrix of undisturbed soil

VADOSE ZONE EXPERIMENTAL SETUP

VADOSE ZONE MONITORING SYSTEM (VMS)

SENSORS

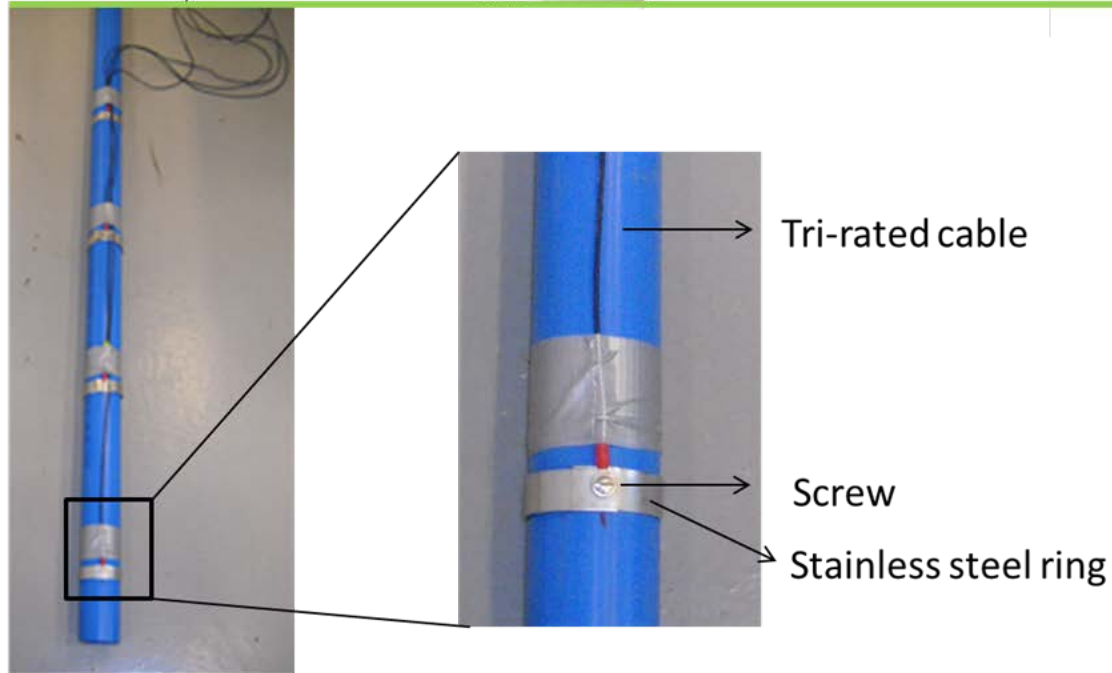
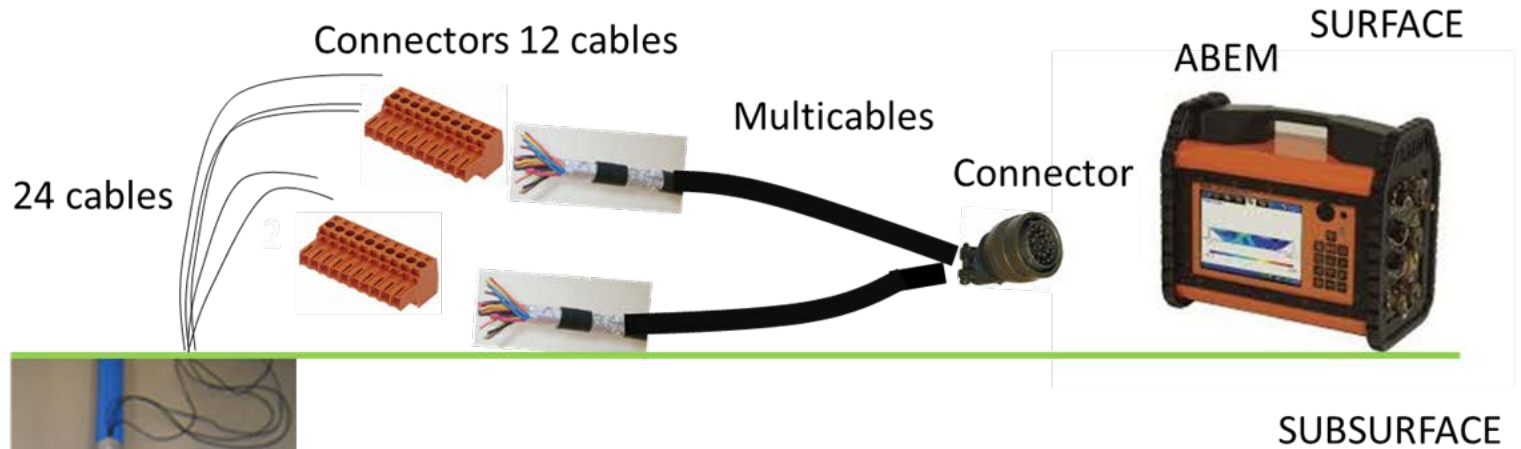


Used for collecting soil water samples from fractures

VADOSE ZONE EXPERIMENTAL SETUP

CROSS-HOLE GEOPHYSICS

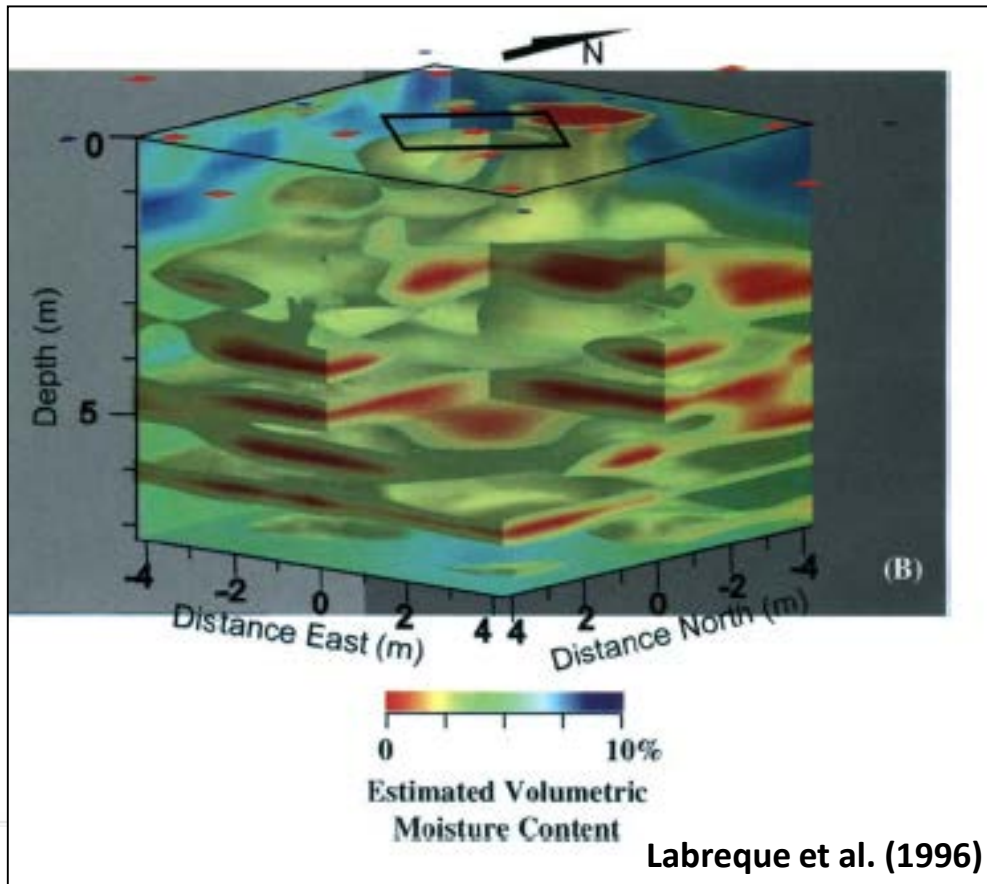
COMPONENTS



2" PVC tube with electrodes

VADOSE ZONE EXPERIMENTAL SETUP

CONCEPTUAL MODEL



STUDIES

- ✓ NATURAL RECHARGE CONDITIONS
- ✓ INFILTRATION TEST

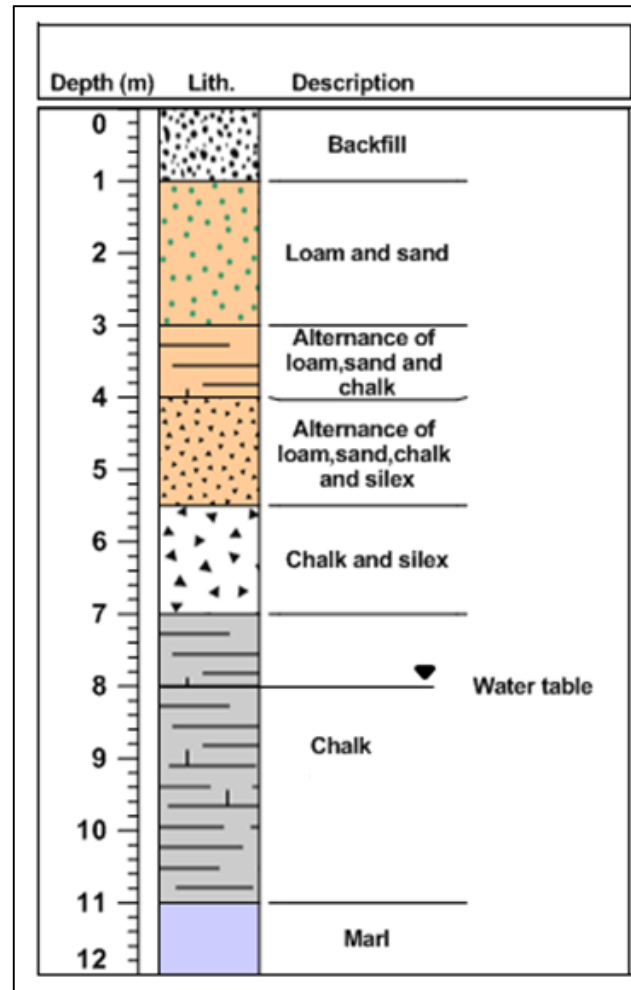
RESULTS

- ✓ 3D IMAGE OF THE SUBSURFACE
- ✓ CALIBRATION WITH VMS DATA
- ✓ VADOSE ZONE CHARACTERIZATION

SITE DESCRIPTION

THE CARCOKE SITE

LITHOLOGIES



INSTALLATION VADOSE ZONE MONITORING SYSTEM (VMS)



INSTALLATION CROSS-HOLE GEOPHYSICS



SUMMARY OF INSTALLATION

BOREHOLE GEOPHYSICS

VMS A

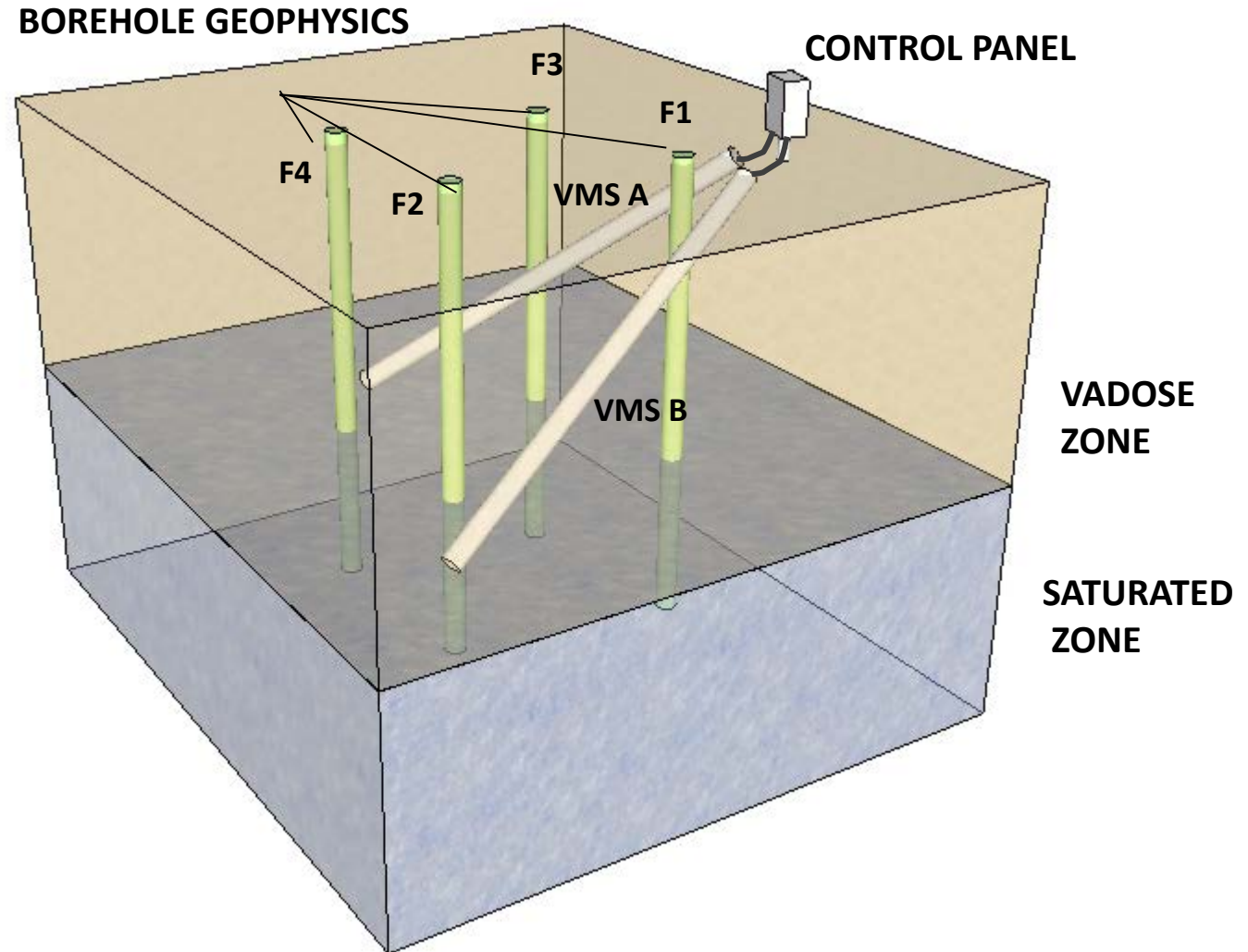
- 350/40
- Length : 9.60 m
- 6 TDTs, 6VSPs

VMS B

- 310/40
- Length : 9.70 m
- 2 TDTs, 2VSPs,
6FS

Cross-hole geophysics

- 4 holes of 15m



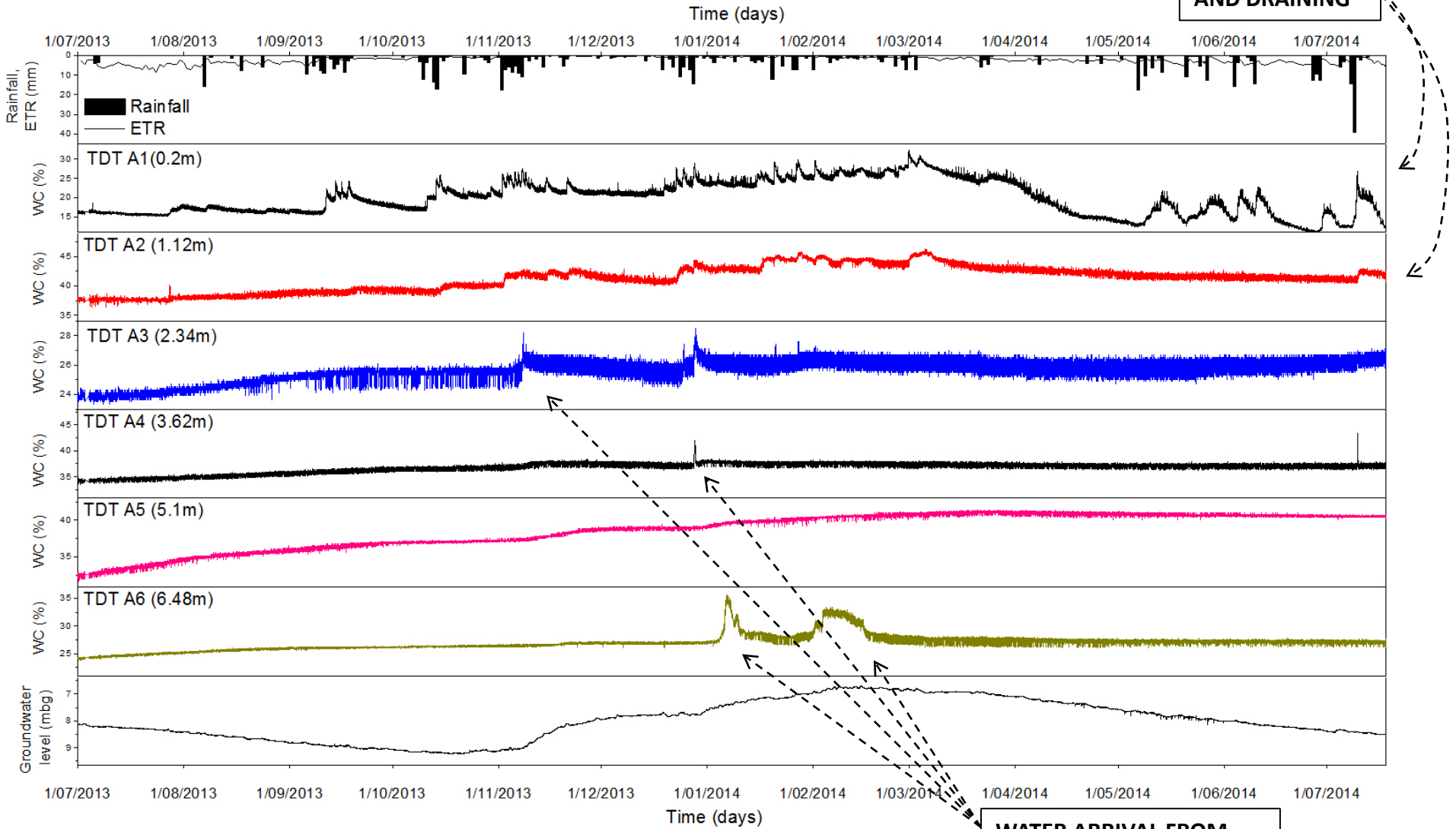
RESULTS

NATURAL RECHARGE CONDITIONS



TDTs SHOW REACTIONS TO RAINFALL AT DIFFERENT SOIL DEPTHS

**FAST WETTING
AND DRAINING**



**WATER ARRIVAL FROM
FRACTURE ACTIVATION**

RESULTS

NATURAL RECHARGE CONDITIONS

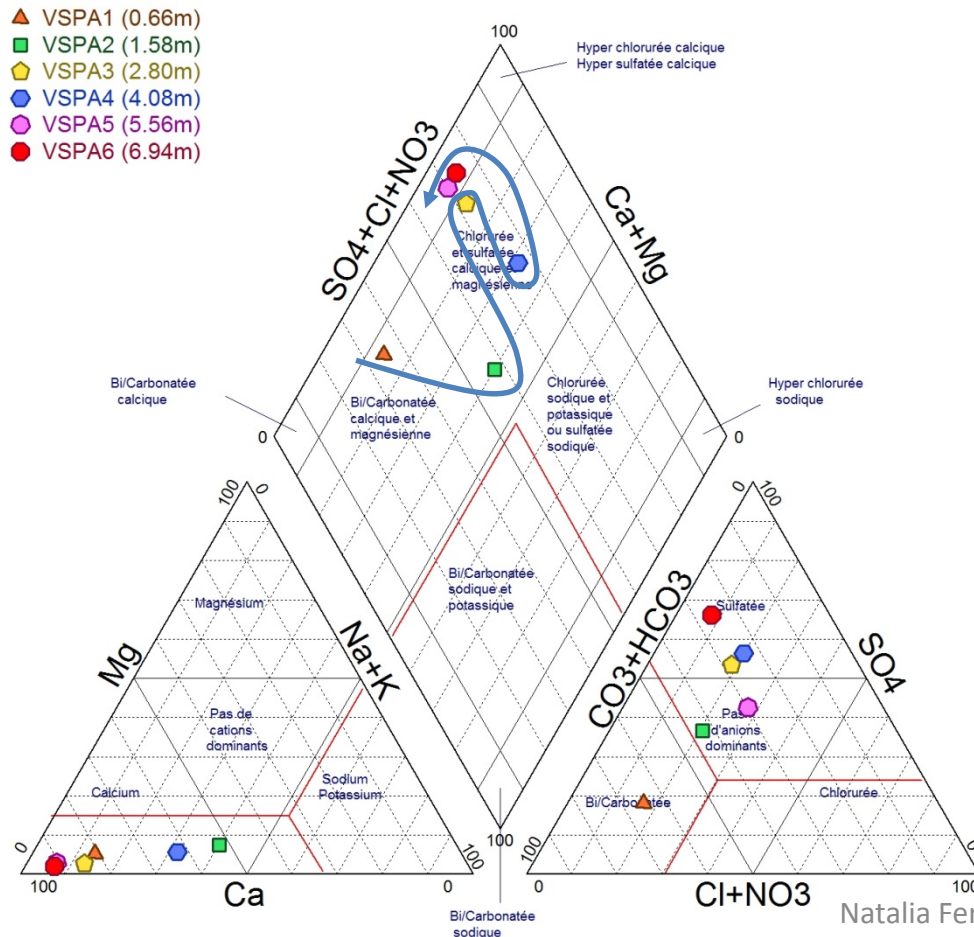


THERE ARE CHANGES IN THE CHEMICAL FACIES OF SOIL WATER

SPRING 2014 (low rainfall period)

APRIL 2014

Diagramme de Piper



THERE IS A TRANSITION OF
CHEMICAL FACIES WITH DEPTH....

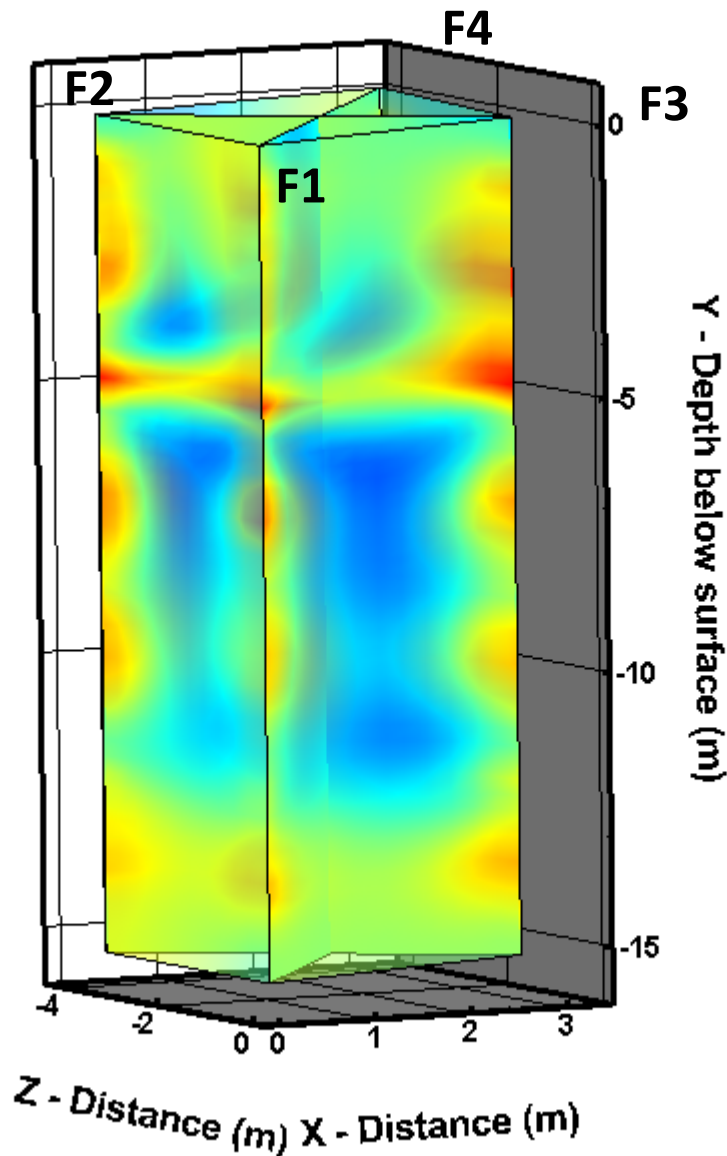
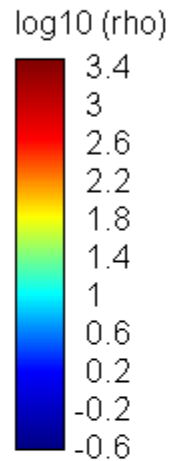
...AND RAIN INFILTRATION!

RESULTS

NATURAL RECHARGE CONDITIONS

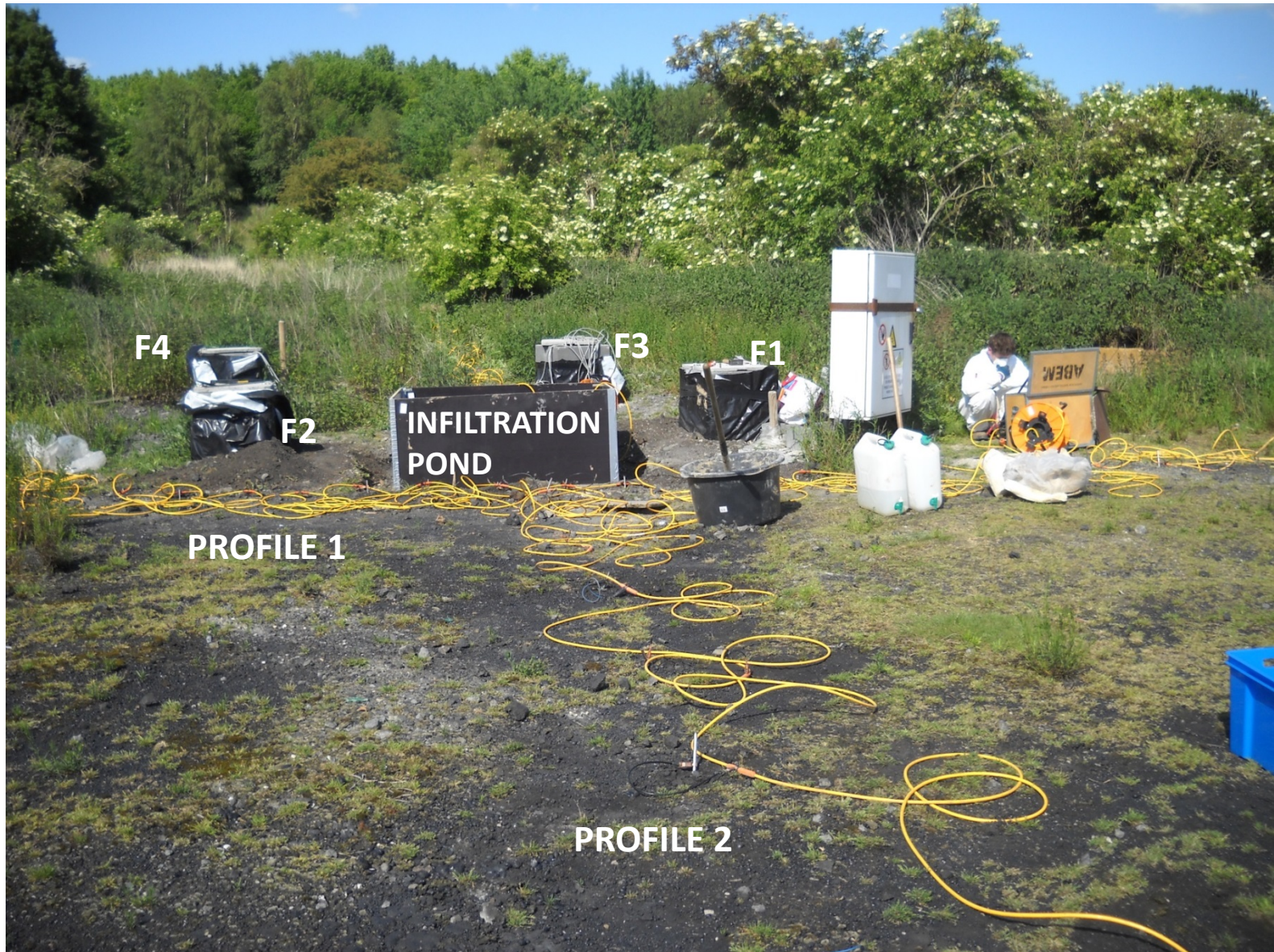
HIGHLY CONDUCTIVE AREAS:

- LITHOLOGY
- HIGH MINERALIZATION OF WATER



RESULTS

INFILTRATION EXPERIMENT



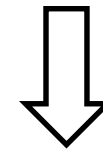
RESULTS

INFILTRATION EXPERIMENT

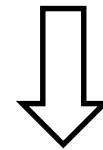


TRACER SELECTION

HIGHEST ELECTRICAL CONDUCTIVITY OF
SAMPLED WATERS: $1787\mu\text{S}/\text{cm}$



50Kg OF CaCl_2 + 2Kg of LiCl IN 600l OF WATER
ELECTRICAL CONDUCTIVITY: $107000\mu\text{S}/\text{cm}$



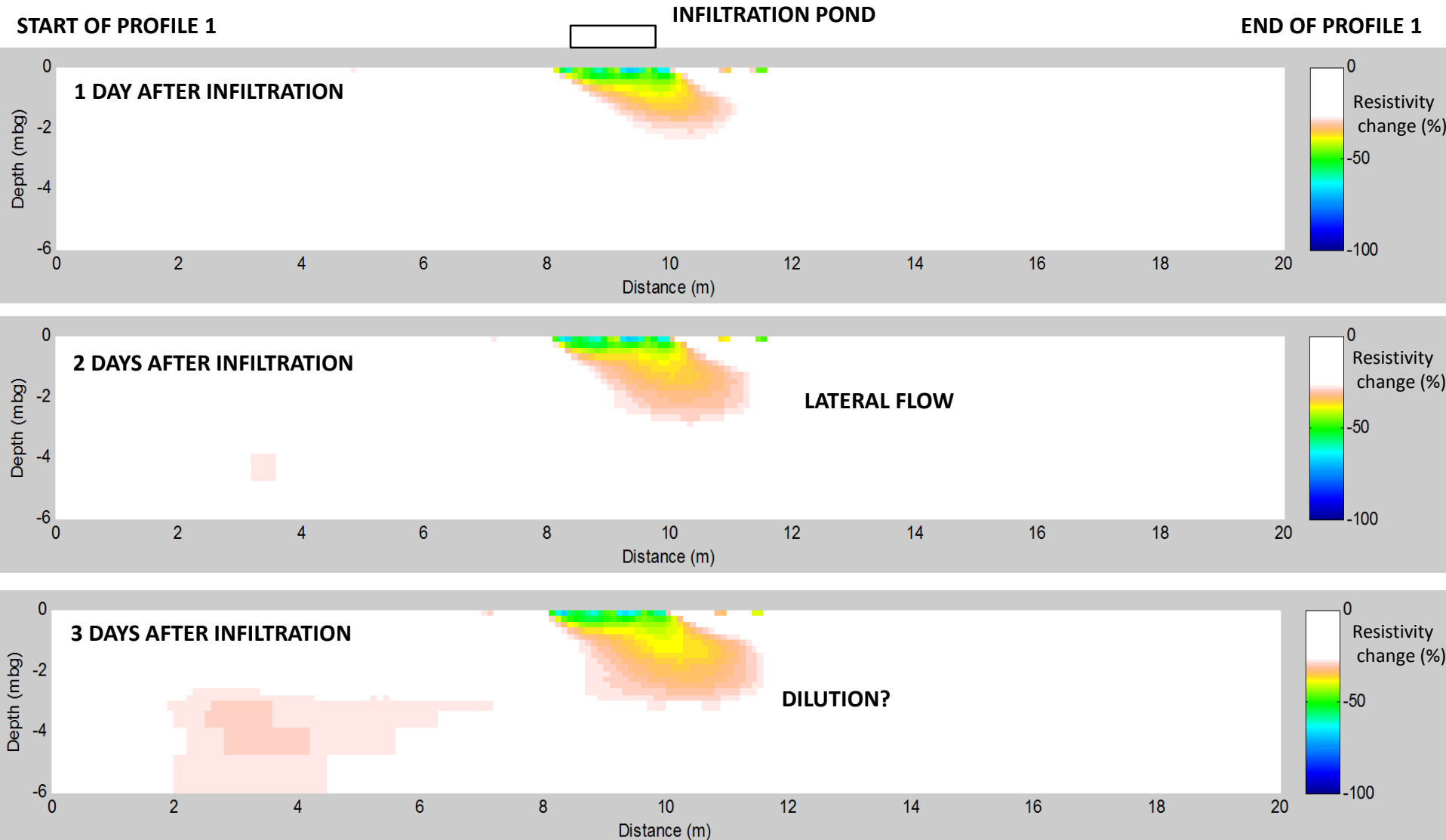
ENOUGH CONTRAST FOR TRACKING THE
TRACER WITH GEOPHYSICS

RESULTS

INFILTRATION EXPERIMENT



TRACKING THE TRACER VIA ERT

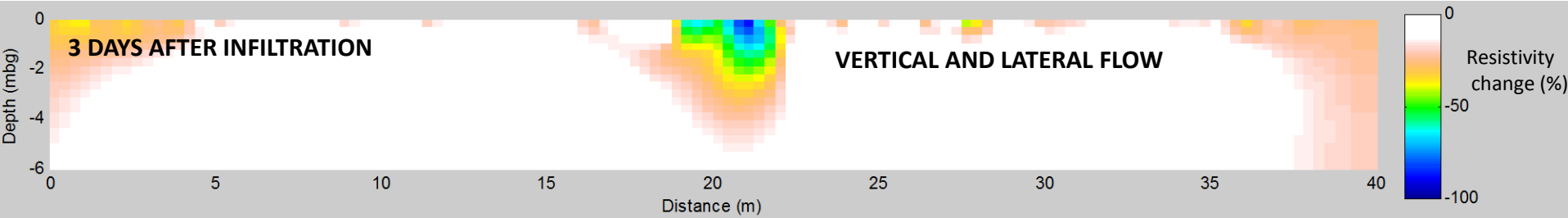
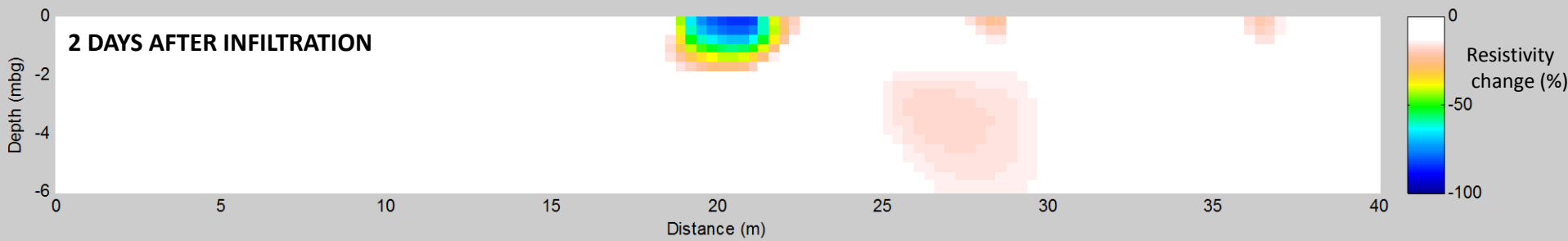
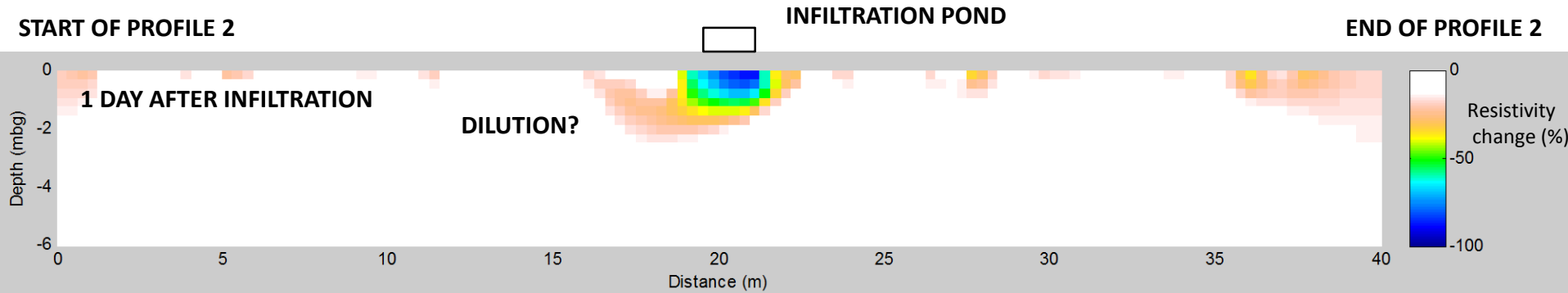


RESULTS

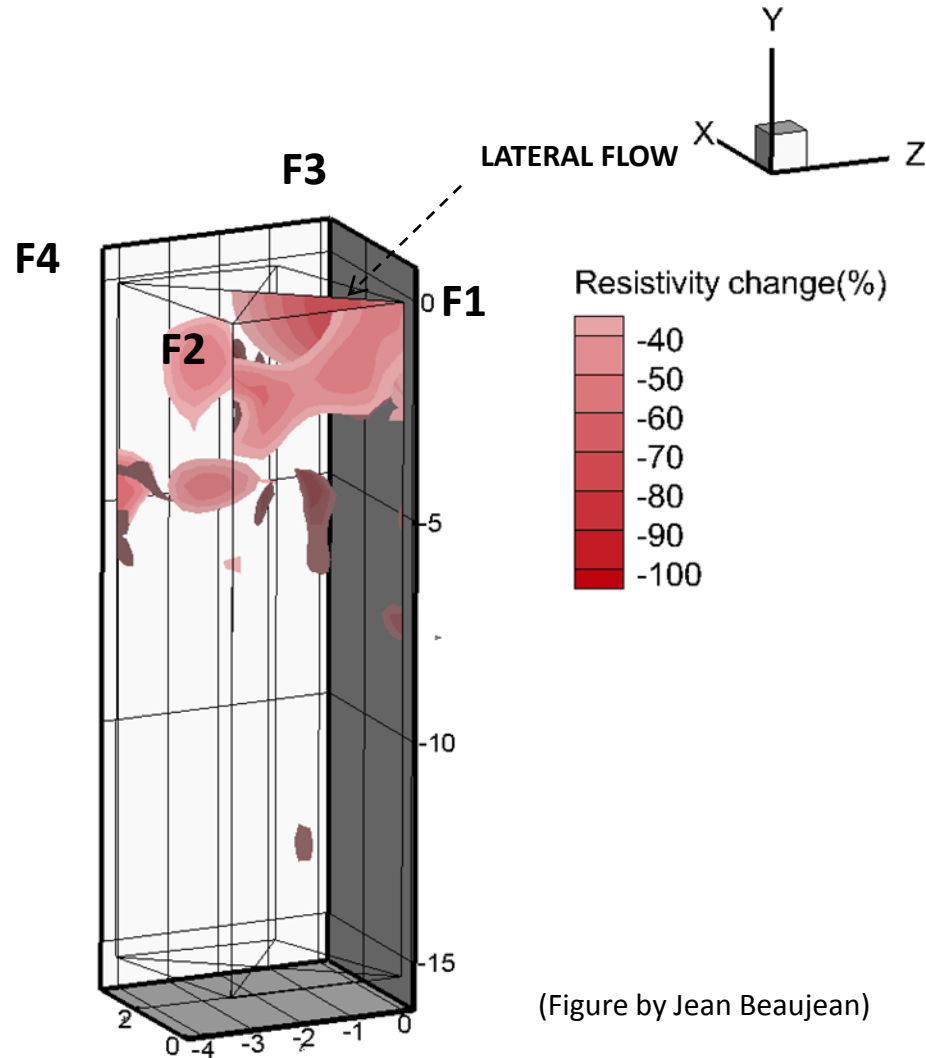
INFILTRATION EXPERIMENT



TRACKING THE TRACER VIA ERT



TRACKING THE PLUME VIA CROSS-HOLE GEOPHYSICS



(Figure by Jean Beaujean)

CONCLUSIONS



The vadose zone experimental setup provides information of:

- ✓ **Water content** in soil at different depths and reactions to rainfall events
- ✓ **Chemical evolution** of soil pore water with depth and rainfall infiltration
- ✓ **Structure** of the subsurface and contaminant transport

THANK YOU

nfdvera@ulg.ac.be

Link to video of the installation

http://www.ulg.ac.be/cms/c_3331470/fr/comprendre-la-pollution-des-eaux-souterraines

Acknowledgements:

Department of Hydrogeology and Environmental Geology (University of Liège)

Department of Applied Geophysics (University of Liège)

