Monitoring spatio-temporal water redistribution in the subsurface with seismic methods

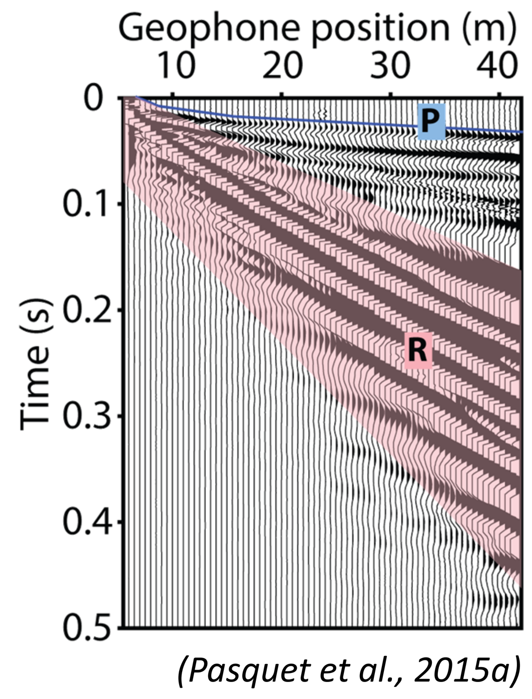
Lara A. Blazevic[1,*], Ludovic Bodet[1], Damien Jougnot[1] and Laurent Longuevergne[2]

[1]METIS UMR 7619, Sorbonne Université, Paris (*lara.blazevic@upmc.fr), [2]Géosciences Rennes UMR 6118, Université de Rennes 1, Rennes

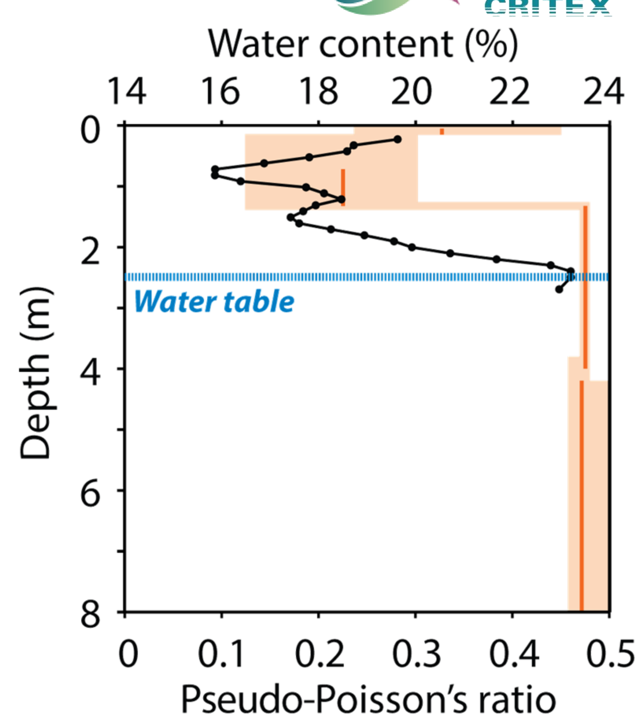
I. INTRODUCTION

The seismic signal is related to mechanical properties that partly depend on porosity and saturation. The behavior of shear (S) and pressure (P) waves in the presence of water is partially decoupled, such that the ratio of their propagation velocities V_P/V_S is strongly linked to water saturation. From seismic data, both V_P and V_S can be recovered by analyzing first arrival and surface waves.

The use of V_P/V_S, Poisson's ratio or derived parameters seems promising for the estimation of water content variability over decametric spatial scales.



(Pasquet et al., 2015a)



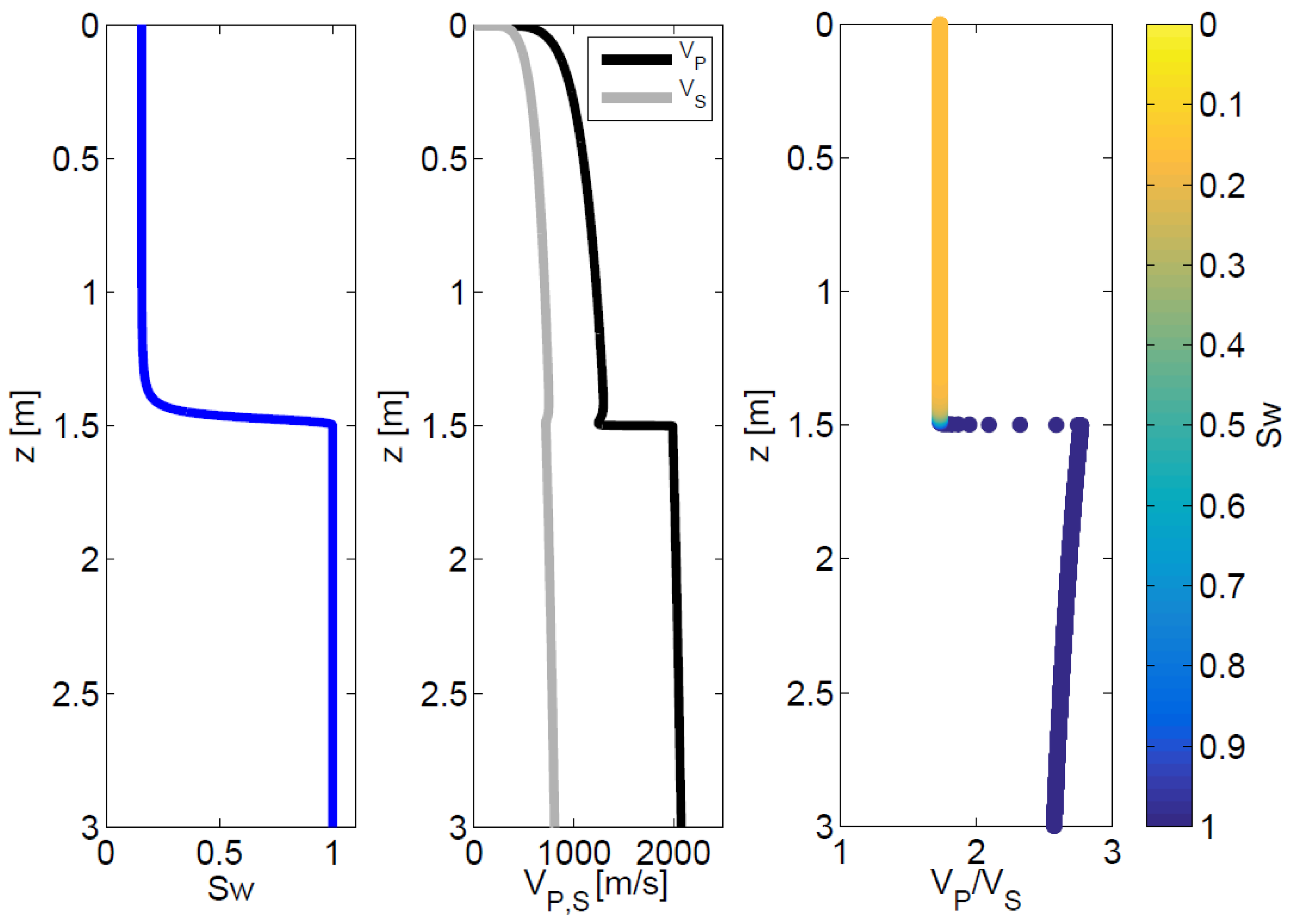
II. OBJECTIVES

- Finding appropriate links between hydrodynamic parameters and seismic properties
- Exploiting the full wealth of active seismic signals and extracting information from temporal variations
- Characterization of a fractured network using seismic methods

III. THEORY AND METHODS

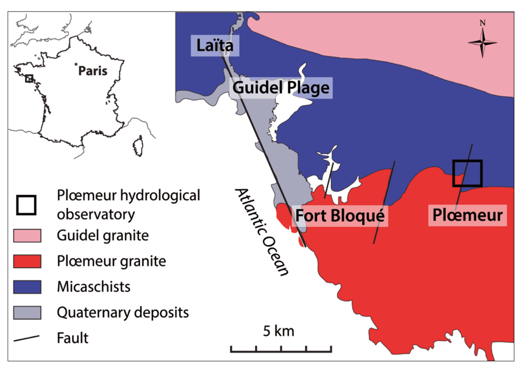
Seismic velocities in rocks or sediments are a function of the effective elastic moduli of the material and its density:

$$V_P(Sw) = \sqrt{\frac{K(Sw) + \frac{4}{3}G}{\rho(Sw)}} \qquad V_S(Sw) = \sqrt{\frac{G}{\rho(Sw)}}$$



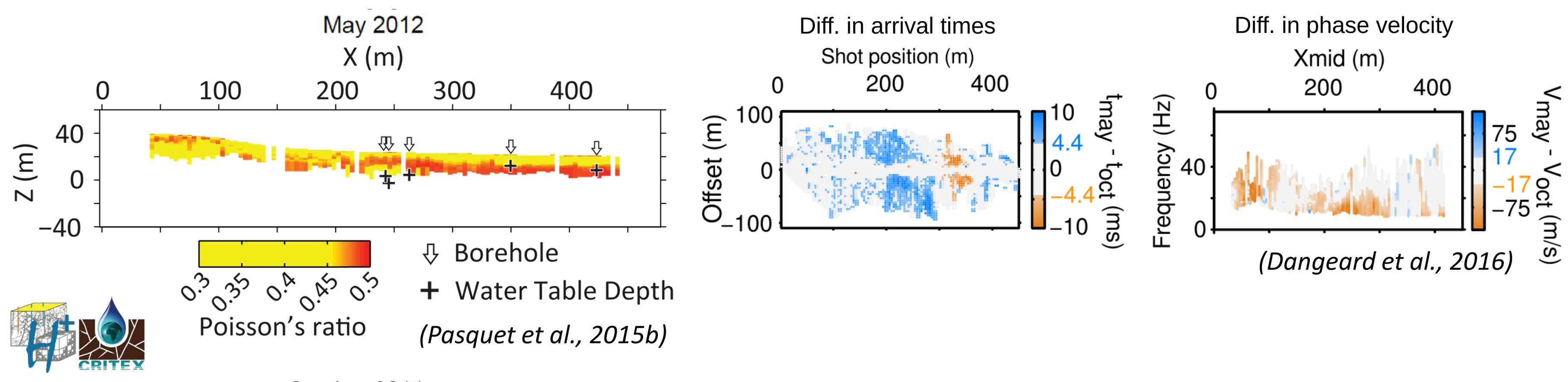
The effective elastic moduli are related to the material's mineralogy, porosity, and to the effective stress. The different responses of *K* and *G* to fluid content (Gassmann, 1951) result in the fluid sensitivity of the V_P/V_S ratio.

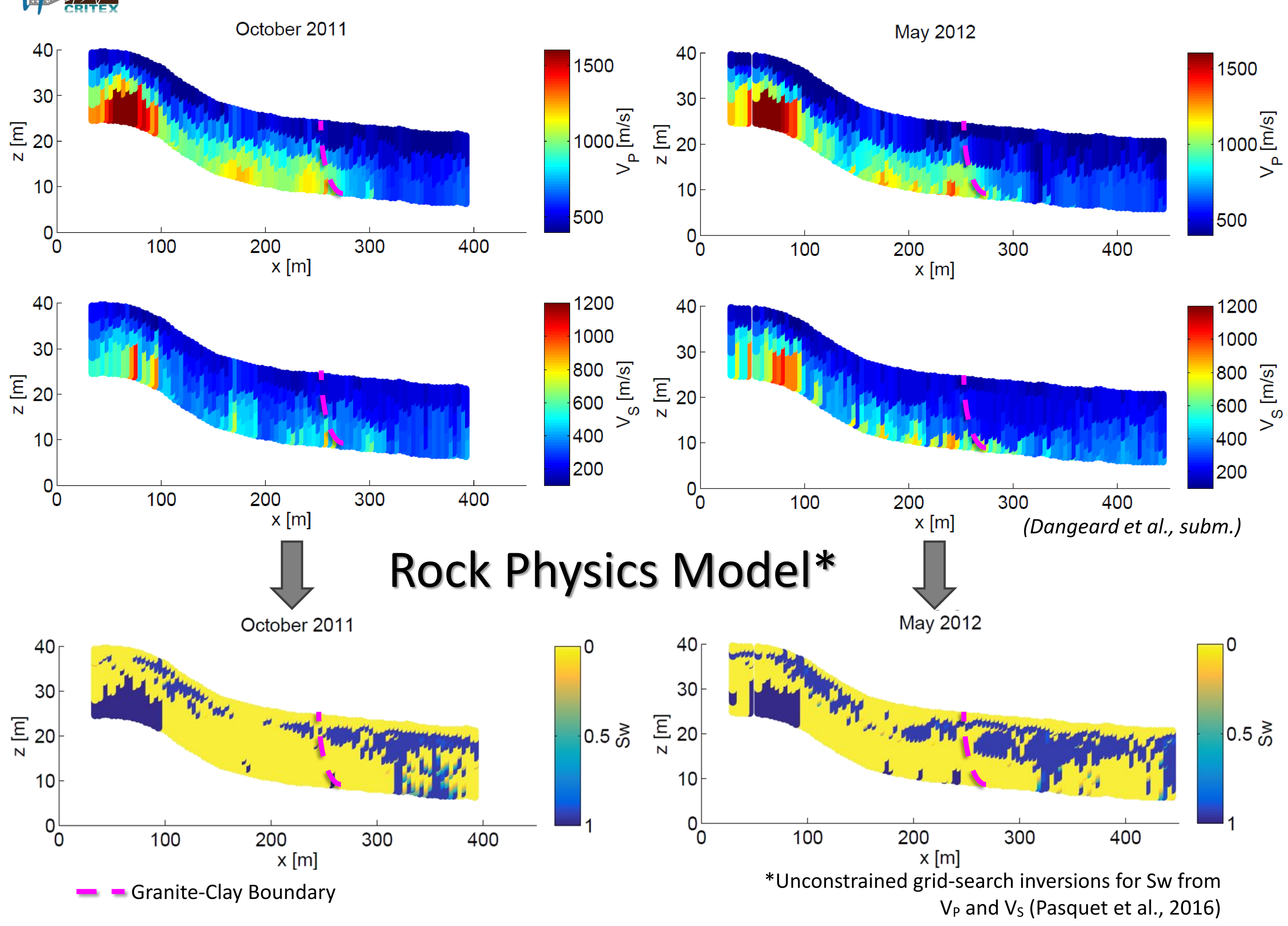
IV. FIELD DATA



***Ploemeur**, Brittany*

- Contact zone between granite (West) and micaschist (East)
- Seismic profile perpendicular to the contact zone





V. DISCUSSION

We observe changes in the data – Can we also observe these changes in the inverted parameters? There is the need to study and test different rock physics relationships that might translate data changes to water saturation variations.

REFERENCES

Dangeard, M., Pasquet, S., Bodet, L., Guérin, R., Longuevergne, L., Thiesson, J., 2016. Temporal variations of near-surface seismic data at the Ploemeur (France) hydrogeological observatory. In: Near Surface Geoscience 2016 – 22nd European Meeting of Environmental and Engineering Geophysics. EAGE, Barcelona, Spain.

Dangeard, M., Bodet, L., Pasquet, S., Thiesson, J., Guérin, R., Jougnot, D., and Longuevergne, L. Estimating picking errors in near-surface seismic data to enable their time-lapse interpretation on hydrosystems, submitted to Near Surface Geophysics.

Gassmann, F., 1951. Elastic waves through a packing of spheres. Geophysics, 16(4), pp.673-685.

Pasquet, S., Bodet, L., Longuevergne, L., Dhemaied, A., Camerlynck, C., Rejiba, F., Guérin, R. 2015b, 2D characterisation of near-surface Vp/Vs: surface-wave profiling versus refraction tomography. Near Surface Geophysics, 13(4), 315–331.

Pasquet, S., L. Bodet, A. Dhemaied, A. Mouhri, Q. Vitale, F. Rejiba, N. Flipo and R. Guérin, 2015a, Detecting different water table levels in a shallow aquifer with combined P-, surface and SH-wave surveys: insights from Vp/Vs or Poisson's ratios, Journal of Applied Geophysics, 113, 38–50.

Pasquet, S., W. S. Holbrook, B. J. Carr, and K. W. W. Sims, 2016, Geophysical imaging of shallow degassing in a Yellowstone hydrothermal system: Geophysical Research Letters, 43, 12027–12035.

ITN Enigma

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie Grant Agreement No 722028.

4th Cargèse Summer School
Flow and Transport in Porous and Fractured Media
June 25th – July 7th 2018