Quantification of the electrical anisotropy in the process of numerical modelling for hydraulic characterization

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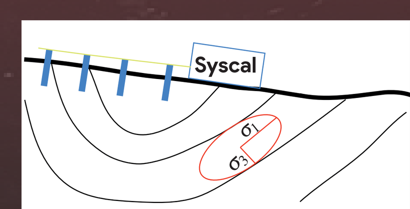
Synthetic case

Anisotropic ERT (AERT): methodological development

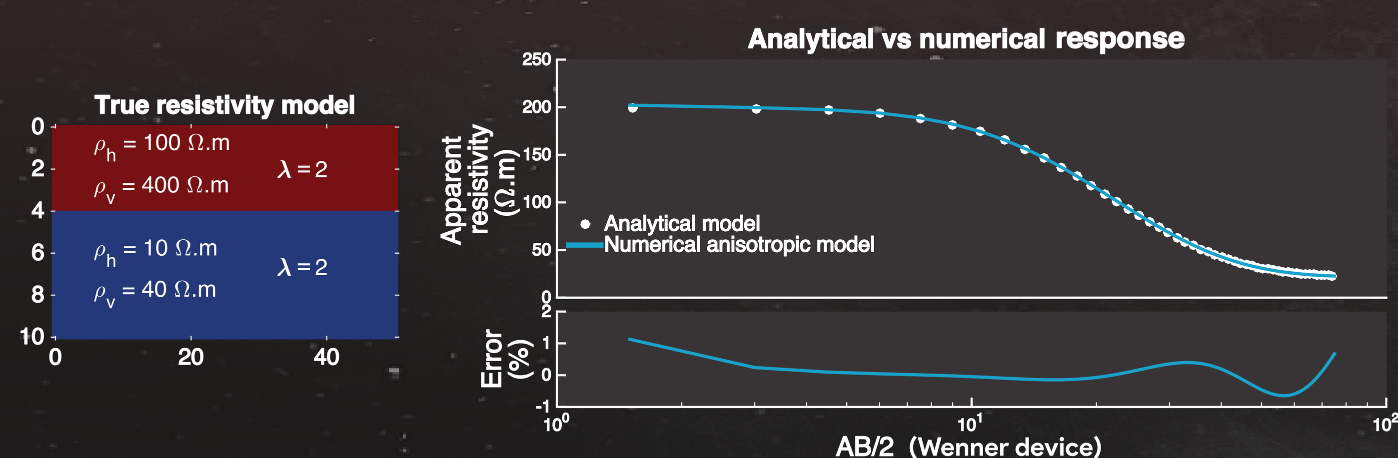
Anisotropic conductivity tensor: $\bar{\bar{\sigma}} = \begin{bmatrix} \sigma_1 & 0 \\ 0 & \sigma_3 \end{bmatrix}$ with $\sigma_1 \geq \sigma_3$

Anisotropic resistivity tensor: $\bar{\bar{\rho}} = \bar{\bar{\sigma}}^{-1}$

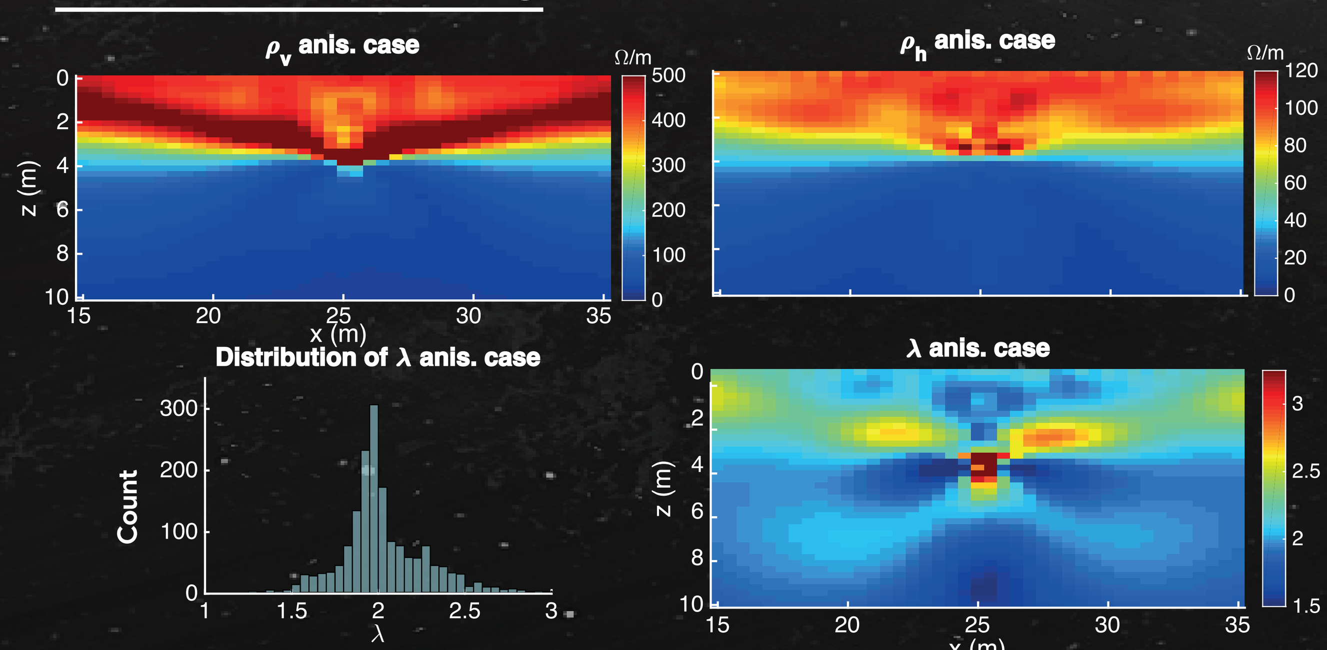
Anisotropic coefficient: $\lambda = \sqrt{\frac{\sigma_1}{\sigma_3}} = \sqrt{\frac{\rho_3}{\rho_1}}$



Forward modelling:



Inverse modelling:

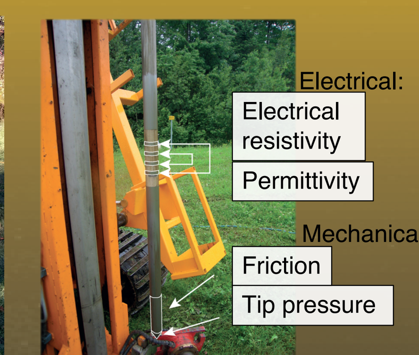


Case study: Saint-Lambert-de-Lauzon

What the electrical methods see:

Setup:

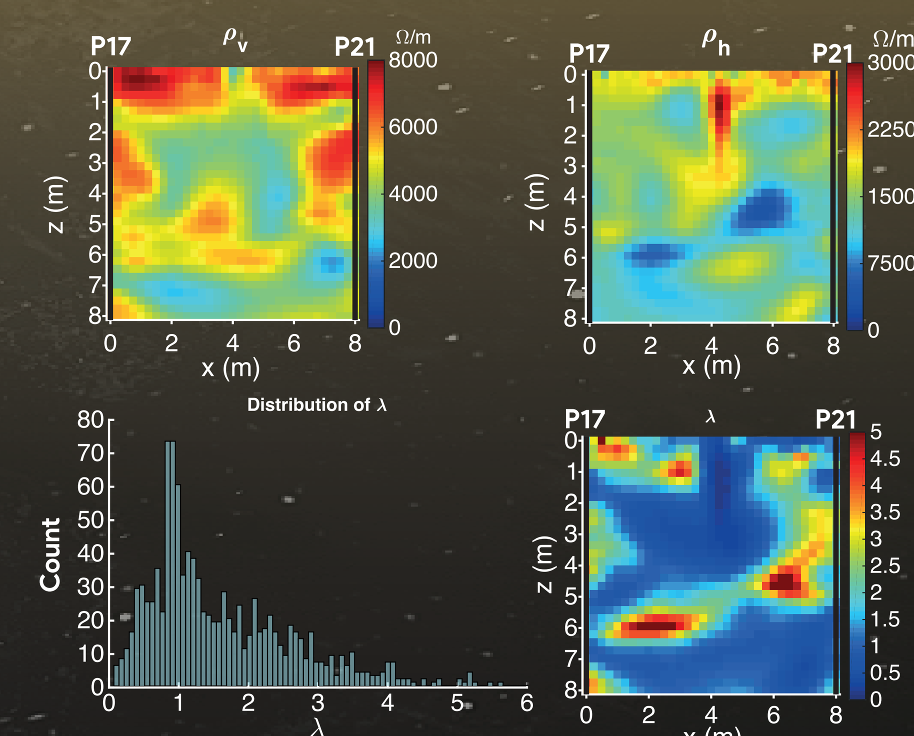
2 wells: P17 at x = 0m & P21 at x = 8m,
1 Syscal Pro,
Surface & borehole electrodes,
2 Cone Penetrometer Tests with a Soil Moisture Resistivity Probe (CPT-SMR, in P17 & P21).



Taken from Paradis (2014)

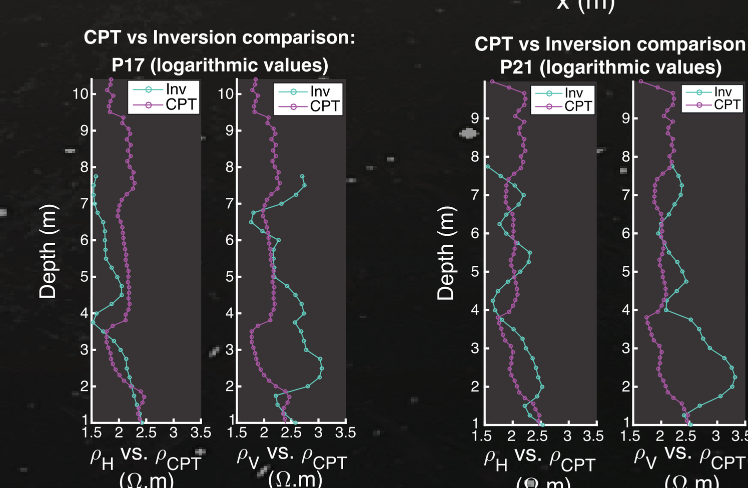
Anisotropic inversion:

A strong anisotropy is seen in the inversed sections, with zones showing a vertical resistivity 10 to 25 times higher than the horizontal resistivity.



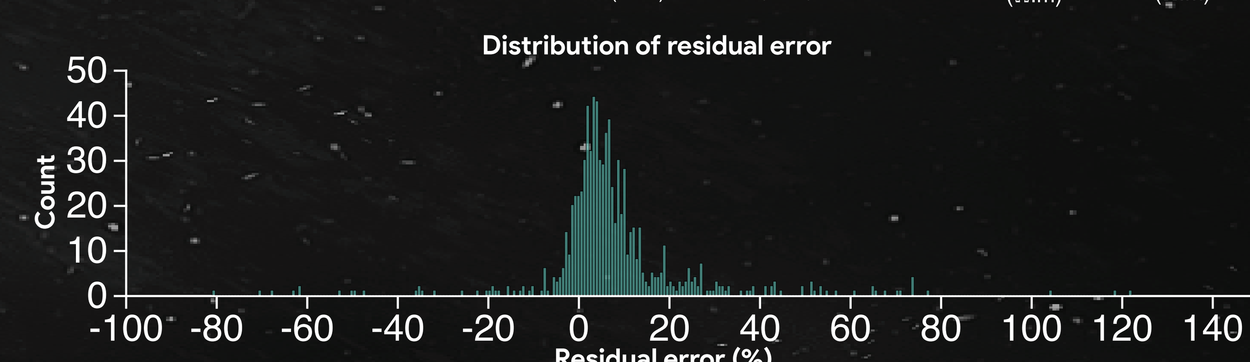
Direct measures:

Direct resistivity measures (CPT) in P17 and P21 versus inversed anisotropic resistivities (Inv).
→ the CPT-SMR resistivity fits well the horizontal component of the total anisotropic resistivity.



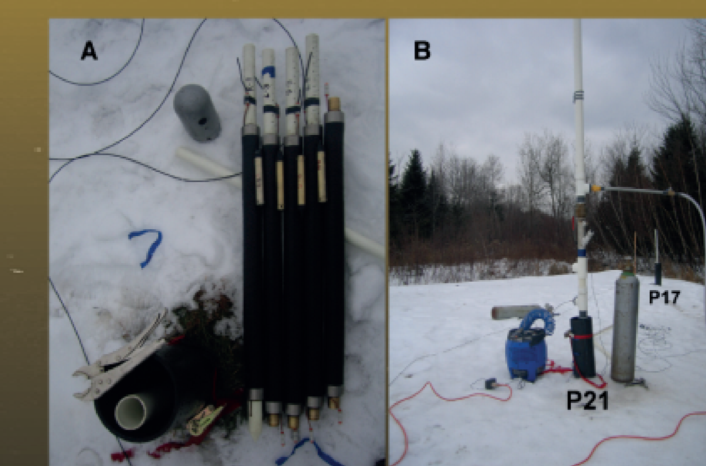
Residual error:

Good fit between the calculated and observed data, with a global error < 20%.

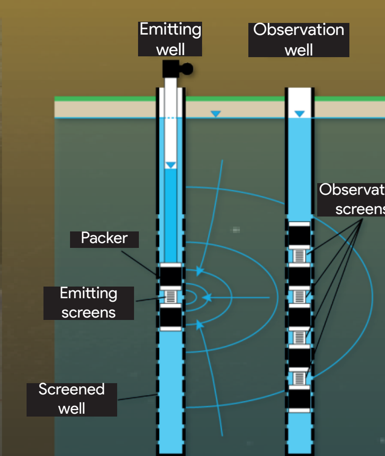


What the hydraulic method sees:

Setup: 2 wells (P17 & P21)
tomography slug tests

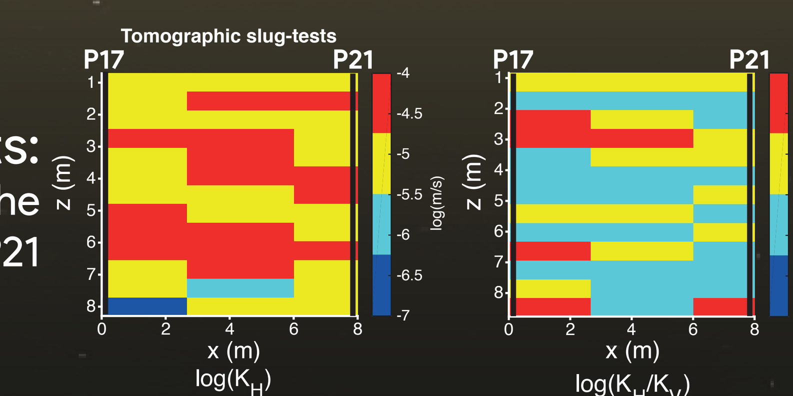


Taken from Paradis (2014)

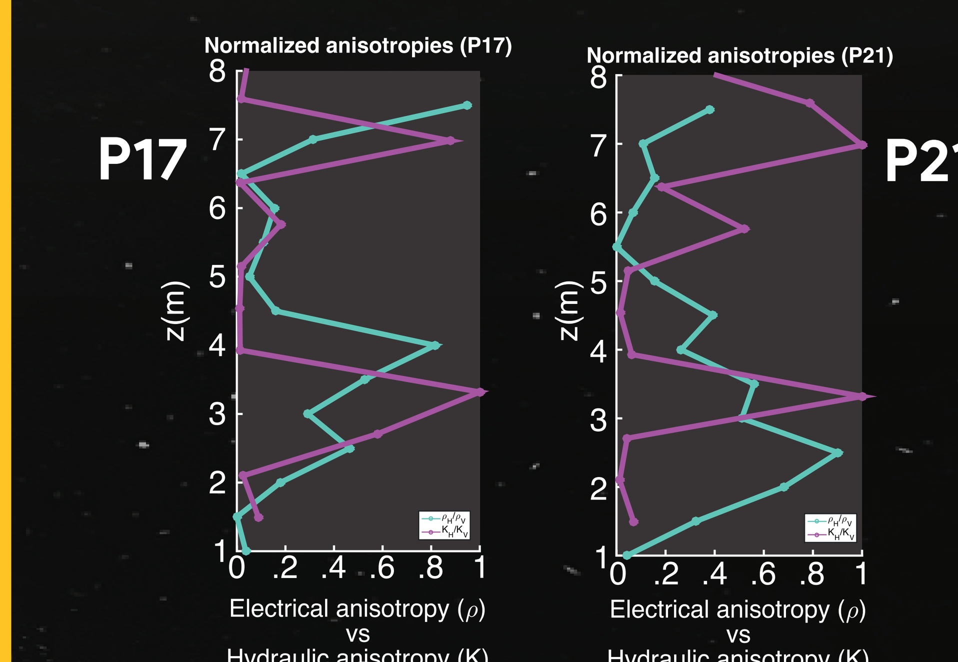


Taken from Paradis (2014)

Tomographic slug tests:
Performed between the same two wells P17 & P21



Comparison of the electrical and hydraulic data:



Normalized amplitudes

Conclusions

AERT and SMR tools do not observe the same phenomenon, and their measures are complementary.
Inversed anisotropic ERT data shows a good fit with the observed data:
→ Our electrical inversed modelling tool allows quantifying the anisotropy of the resistivity field.
Electrical and hydraulic anisotropic models are in good agreement.

Future aim: Quantify regionally the hydraulic conductivity using this new hydrogeophysical approach

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