Imaging of hydraulic conductivity from seismic and electrical data in a joint inversion framework

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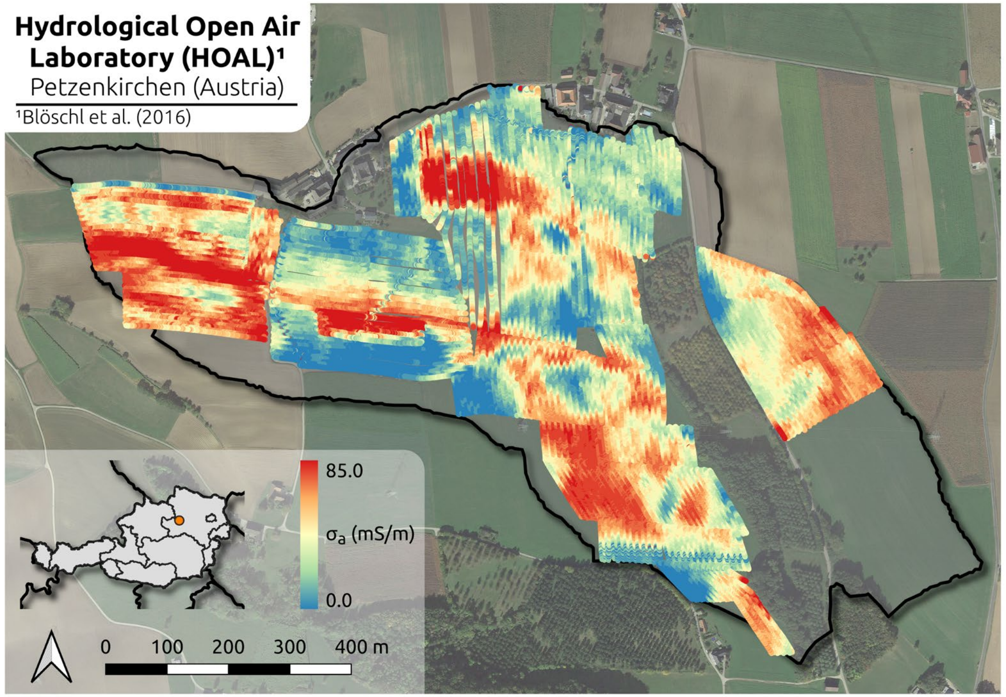
Motivation

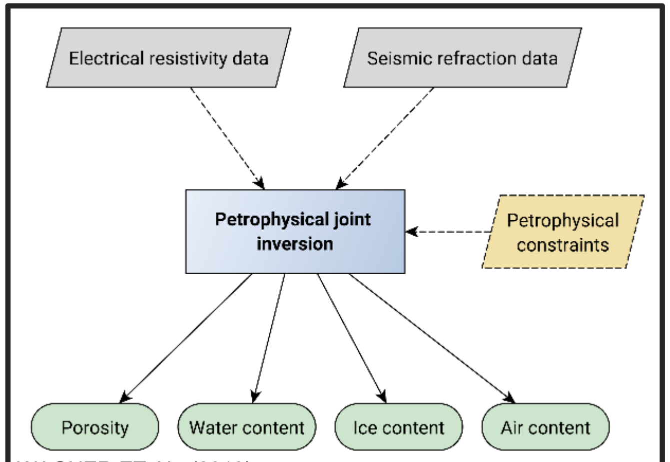


- Extensive information about electrical properties (ERT, IP, EMI)
- Interpretation in terms of hydrological parameters might be ambiguous

- Combine seismic and electrical methods to quantitatively solve for soil parameters

- Provide a tool for hydrological investigations

Consider surface conductivity



WAGNER ET AL. (2019)

$$\sigma^0 = \left(\frac{f_w}{1-f_r}\right)^n (1-f_r)^m \sigma_w + \left(\frac{f_w}{1-f_r}\right)^{n-1} (1-f_r)^{m-1} \rho_g (B-\Lambda)\, CEC$$

REVIL ET AL. (2017)

TARTRAT ET AL. (2019)

$$\sigma^\infty = \left(\frac{f_w}{1-f_r}\right)^n (1-f_r)^m \sigma_w + \left(\frac{f_w}{1-f_r}\right)^{n-1} (1-f_r)^{m-1} \rho_g B\, CEC$$

REVIL ET AL. (2017)

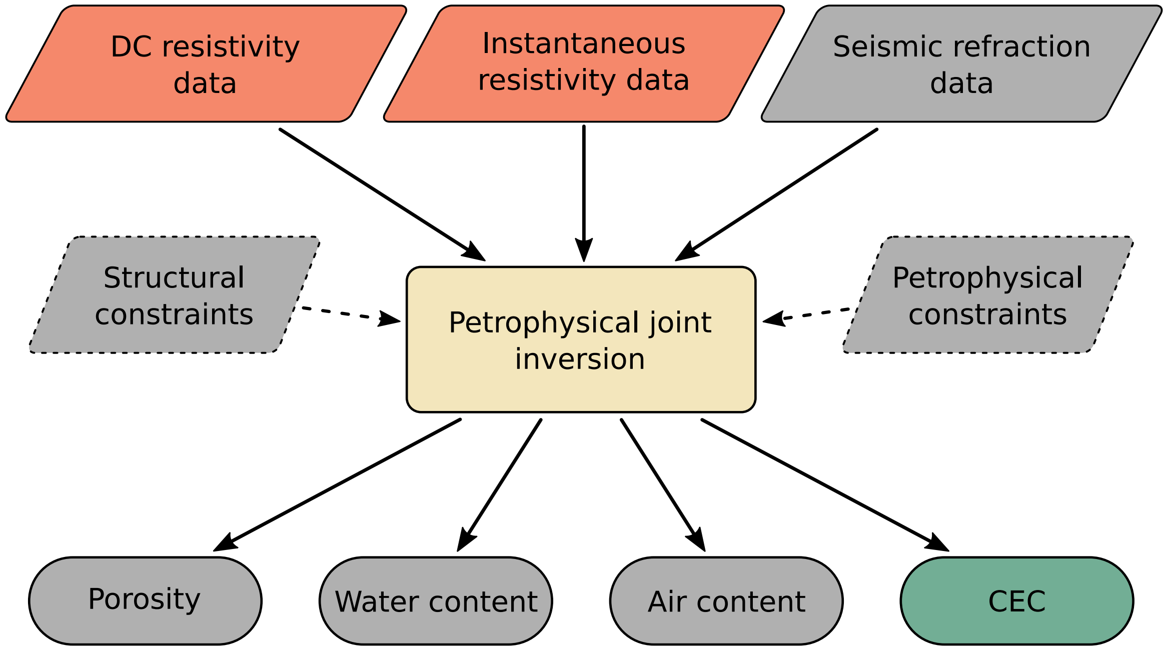
TARTRAT ET AL. (2019)

$$s = \frac{v_f}{\Phi} + \frac{v_s}{1-\Phi}$$

WYLLIE ET AL. (1958)

$$s = \frac{v_w}{f_w} + \frac{v_a}{f_a} + \frac{v_r}{f_r}$$

TIMUR (1968)



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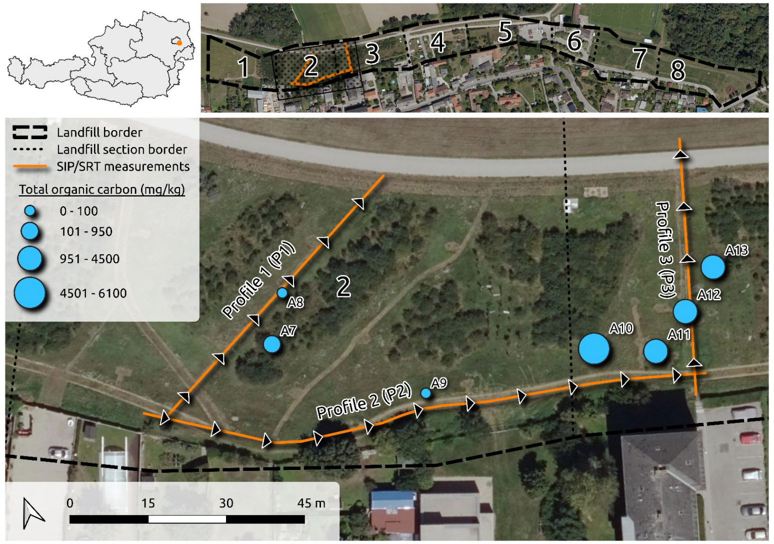
- The resolved model simultaneously explains three different datasets
- Assess the polarization of subsurface materials in terms of the normalized chargeability M_n

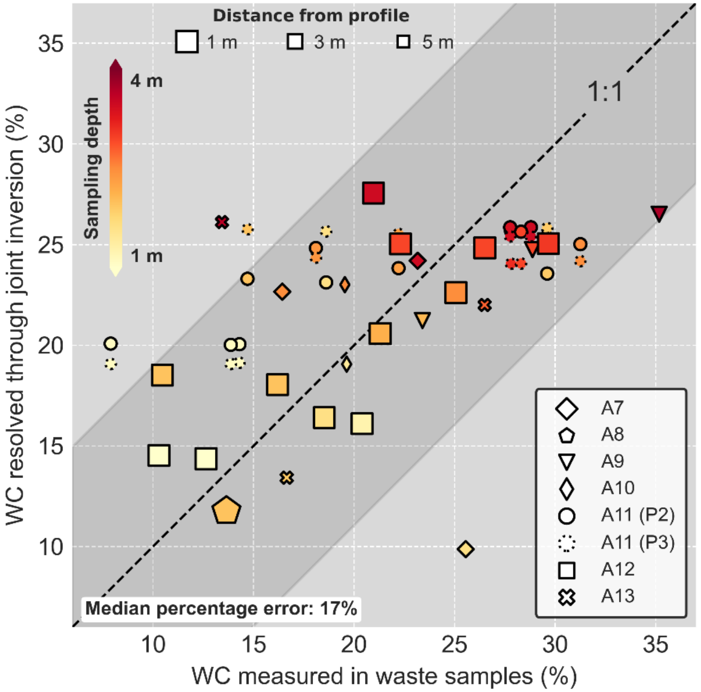
$$M_n = \sigma^\infty - \sigma^0$$

The Heferlbach landfill

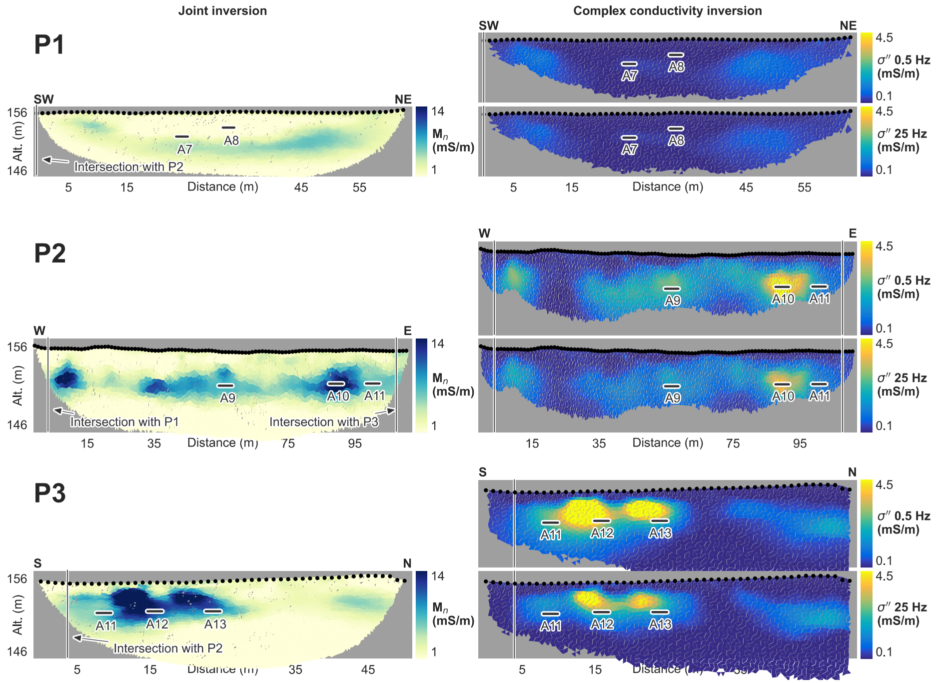
Distinct difference in the electrical properties of host materials and waste



Quantify the water content (WC) within the waste unit



Use models resolved with CRTomo (Kemna, 2000) for evaluation



IN COOPERATION WITH JOHANN FELLNER

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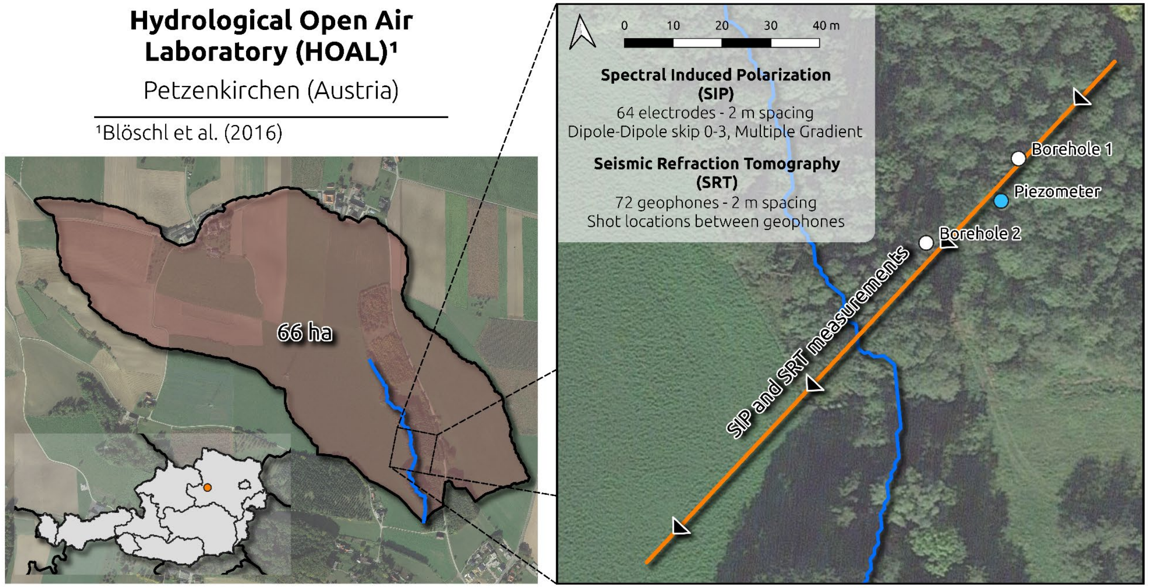
Application to natural soils

Hydrological Open Air Laboratory (HOAL)[1]

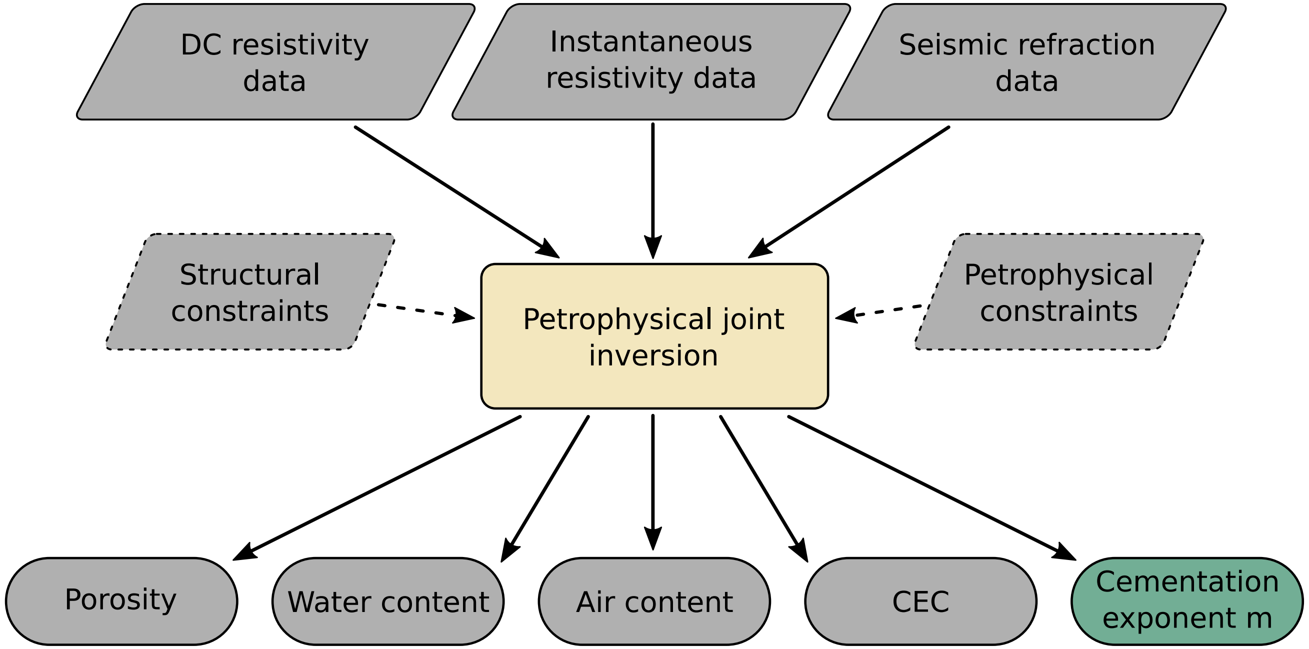
Petzenkirchen (Austria)

[1]Blöschl et al. (2016)

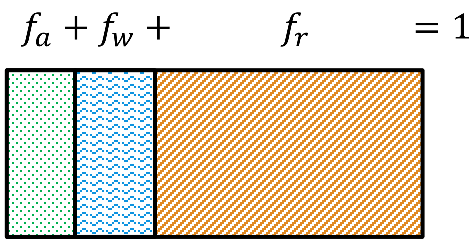


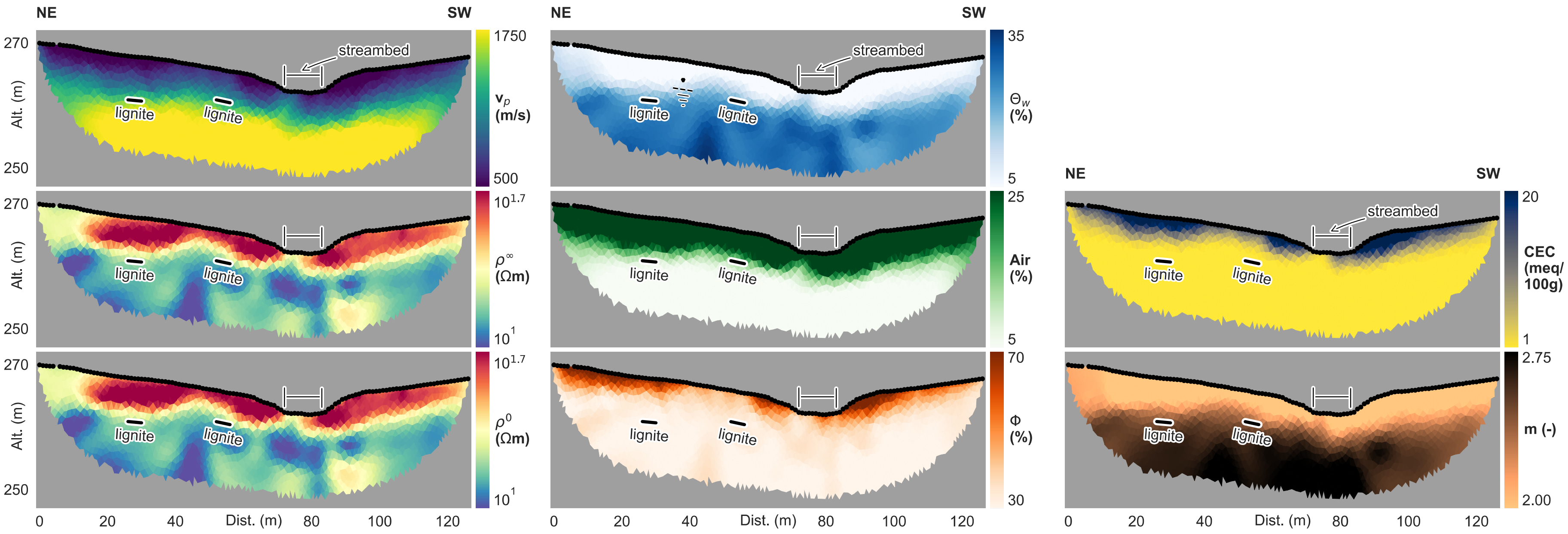
- Identify zones of surface- and groundwater interaction
- Delineate preferential flowpaths for water

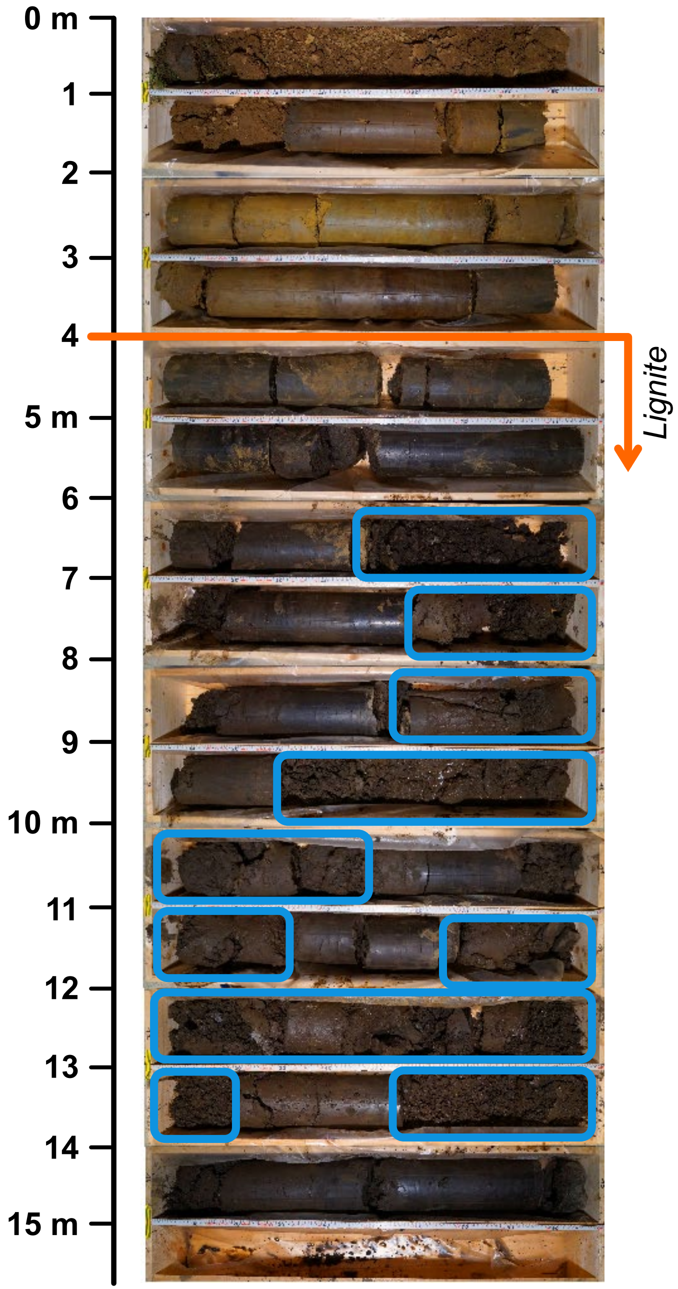
- Solve for the formation factor $F = \Phi^{-m}$, i.e., resolve spatial variations in porosity Φ and cementation exponent m
- Allow for an enhanced estimation of hydrological parameters



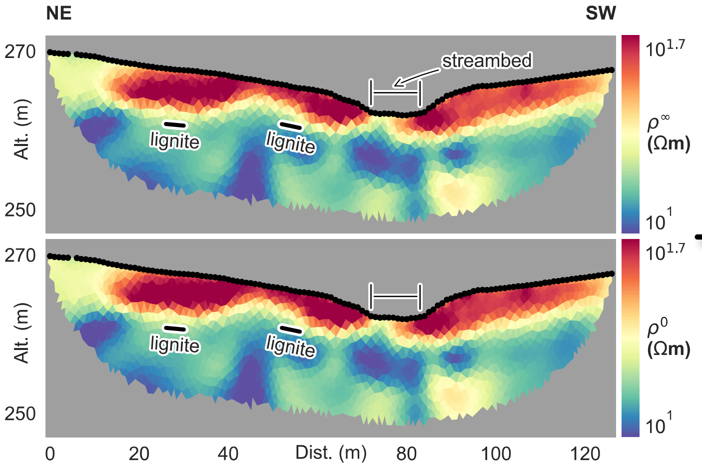
Imaging results

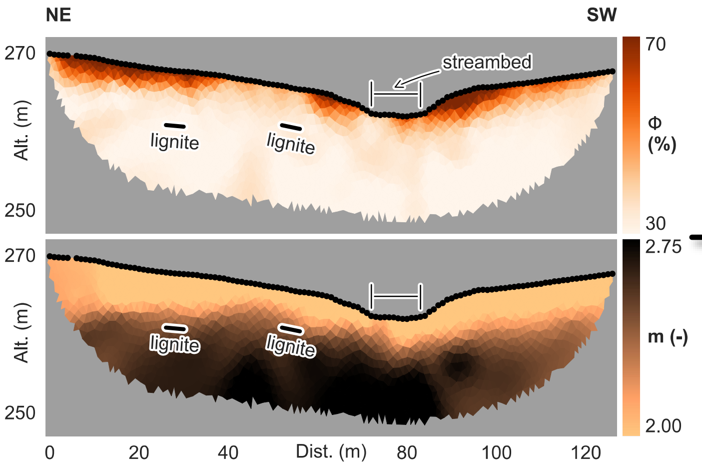




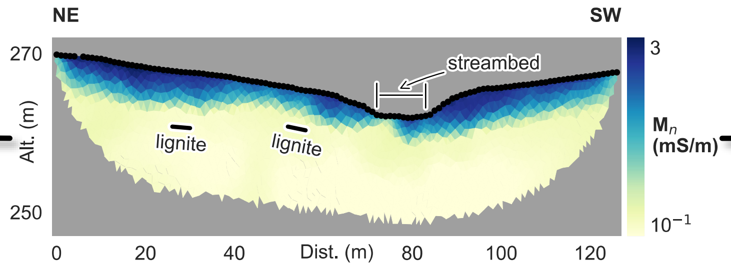


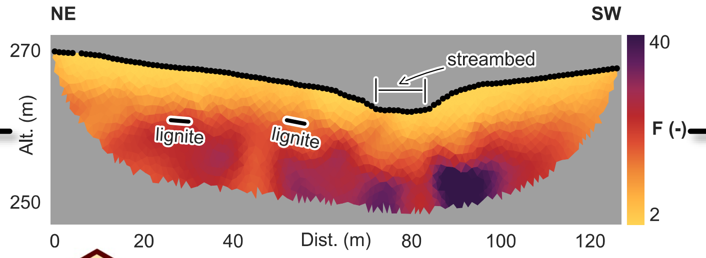
Assess hydraulic conductivity





Obtain M_n and formation factor $F = \Phi^{-m}$ from joint inversion results …





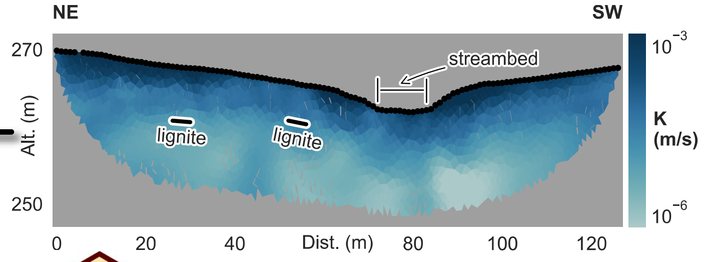
… to compute the intrinsic permeability $k = \frac{4.03\times10^{-9}}{F^{3.68} M_n^{1.19}}$ after Weller et al. (2015)

and transform k to the hydraulic conductivity $K = k\,\frac{g\rho}{\mu}$

Gravitational acceleration $g = 9.81\,\frac{m}{s^2}$

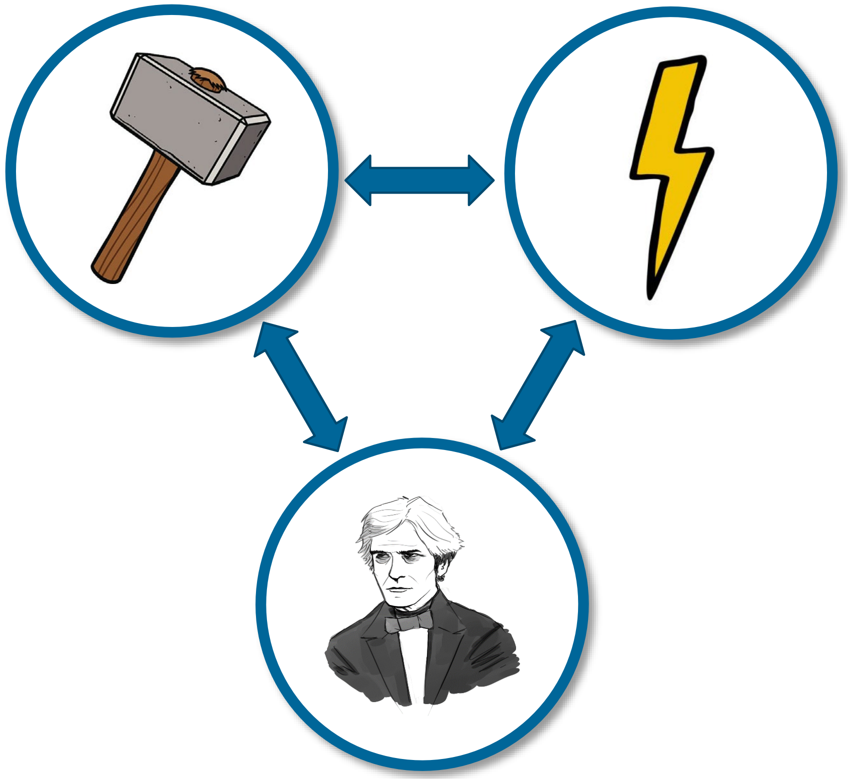
Density of water $\rho = 1000\,kg/m^3$, and the

Dynamic viscosity of water $\mu = 1.0016 \times 10^{-3}\,Pa$



On-going work

- Refine the petrophysical model
- Include further geophysical methods



- Collect further datasets in the HOAL
- Apply the joint inversion to data collected in different environments

HOAL lignite: Laboratory measurements