Improving DC-Electrical Resistivity Imaging techniques for water infiltration detection and monitoring in earth hydraulic structures

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Summary

- **Context**
  - Research needs
  - The experimental dike

- **Infiltration study**
  - Infiltration in zone 2
  - TDR results

- **ERI development & results**
  - Optimization of electrode location
  - InGEOHT 3D
  - Imaging results
  - Time lapse results

- **Conclusion & Outlooks**
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Context

Context and research needs

- France contains more than 7000 km of dikes
- Managers need diagnostic toolbox to ensure the security of their structures
- Electrical Resistivity Imaging is considered as a relevant method owing to its sensitivity to clay content and water content
- Dike 3D behavior generates artifacts and limits the relevance of the imaging result

1. Improve ERI concerning the previous limitations
2. Test the capacity of this new developments to detect an infiltration
Context

The experimental dike (DikExpE.R.T)

- To test and improve ERI developments, an experimental dike was built at the Centre of Experimentation and Research of Rouen.

- The objective was to generate a continuous infiltration by a hydraulic system in the sandy part of the dike (in yellow).
24 moisture probes were installed into the dike to monitor the evolution of the infiltration.

+ 96 electrodes to test the ability to monitor the evolution of the infiltration.
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Infiltration study

- Infiltration in Zone 2 (central part of the dike)

7757 liters are injected in the dike during the 2 weeks.
Infiltration study

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ERI development and results

- InGEOHT 3D

Limitations of conventional inversion softwares:

- 2D time lapse inversion, or 3D but without topography,
- Difficulty to insert *a priori* information.

Consequences:

- Artifacts in the inversion result,
- Difficulty to interpret the result.
ERI development and results

- InGEOHT 3D

Importance of the *a priori* information

Only the sandy part is discretized for the inverse problem, because variations are expected to occur in this area.

The topography of the dike and each compaction layer are explicitly defined.
ERI development and results

- Imaging results

A set of electrical measurements was acquired before the beginning of the infiltration.

This figure presents the 3D electrical resistivity variations into the sandy part of the structure.

This model is selected as a reference model for the future monitoring.
1. InGEOHT 3D
2. Imaging results
3. Time lapse results

ERI development and results

7 sets of measurements are acquired at 7 different moments after the beginning of the infiltration.

-10  -8  % variation in ln(resistivity)  0  2  4  6  8  10
ERI development and results
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1. InGEOHT 3D
2. Imaging results
3. Time lapse results
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Electrical Resistivity is not a parameter directly related to soil erosion evolution

\[
\rho_{t1} = \rho_w a \Phi^{-m} S_{w_{t1}}^{-n}
\]

\[
\rho_{t2} = \rho_w a \Phi^{-m} S_{w_{t2}}^{-n}
\]

\(\rho_{t1}\): Resistivity at time 1; \(\rho_w\): Resistivity of the infiltration water; 
\(\Phi\): Porosity; \(S_w\): Water saturation; \(-n\) & \(-m\): Cementation exponent
Conclusion & Outlooks

\[ \rho_{t1} = \rho_w a \Phi^{-m} S_{w t1} \]

\[ \rho_{t2} = \rho_w a \Phi^{-m} S_{w t2} \]

Ratio between the result at time 1 and 2 gives the evolution of the water saturation.
A parametric study was performed recently on the sand

**Objective:**
- Create a law for this sand to interpret the resistivity evolution as a water content evolution

![Graph showing qualitative and quantitative correlations between resistivity and volumetric water content](image)
THANK YOU FOR YOUR ATTENTION
ERI development and results

- Optimization of electrodes location

On simule un nombre élevé d'électrodes (>96 ex : 122) correspondant à chacune des mailles

On calcule l'apport de chaque electrode pour la résolution finale

122 électrodes
ERI development and results

- Optimization of electrodes location

Classement des électrodes suivant l'apport de résolution:

Bleu = apport faible
Rouge = apport élevé

On sélectionne les 96 meilleures électrodes
1. Optimization of electrodes location
2. InGEOHT 3D
3. Imaging results

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