Evento finale - Progetto RESBA

WP3.4.1: Sviluppo di metodi e tecniche geofisici per la localizzazione, il rilevamento localizzato e la quantificazione delle perdite in una struttura di terrapieno.

WP3.4.1: Développement de méthodes et techniques géophysiques pour la localisation, la détection localisée et la quantification des fuites au sein d'une structure en remblai

REVIL André

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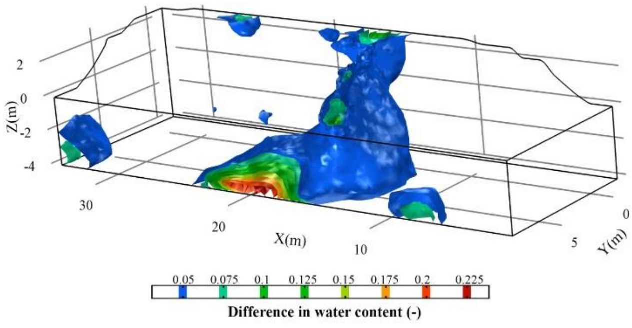
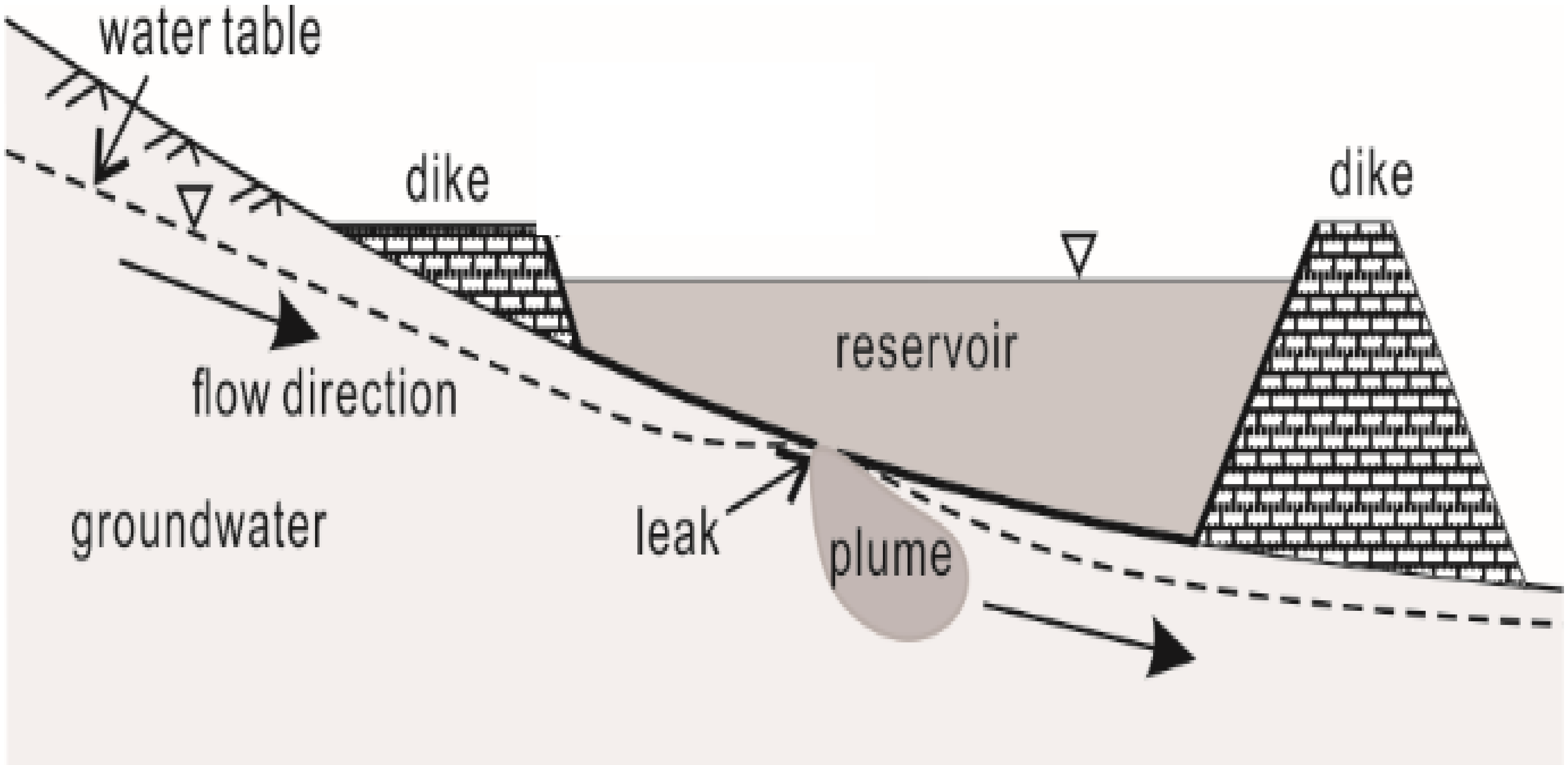


Webinar

3-4 Dicembre 2020

3-4 Décembre 2020

But du projet



Rileva e individua una perdita del serbatoio

Détecter et localiser la fuite en réservoir

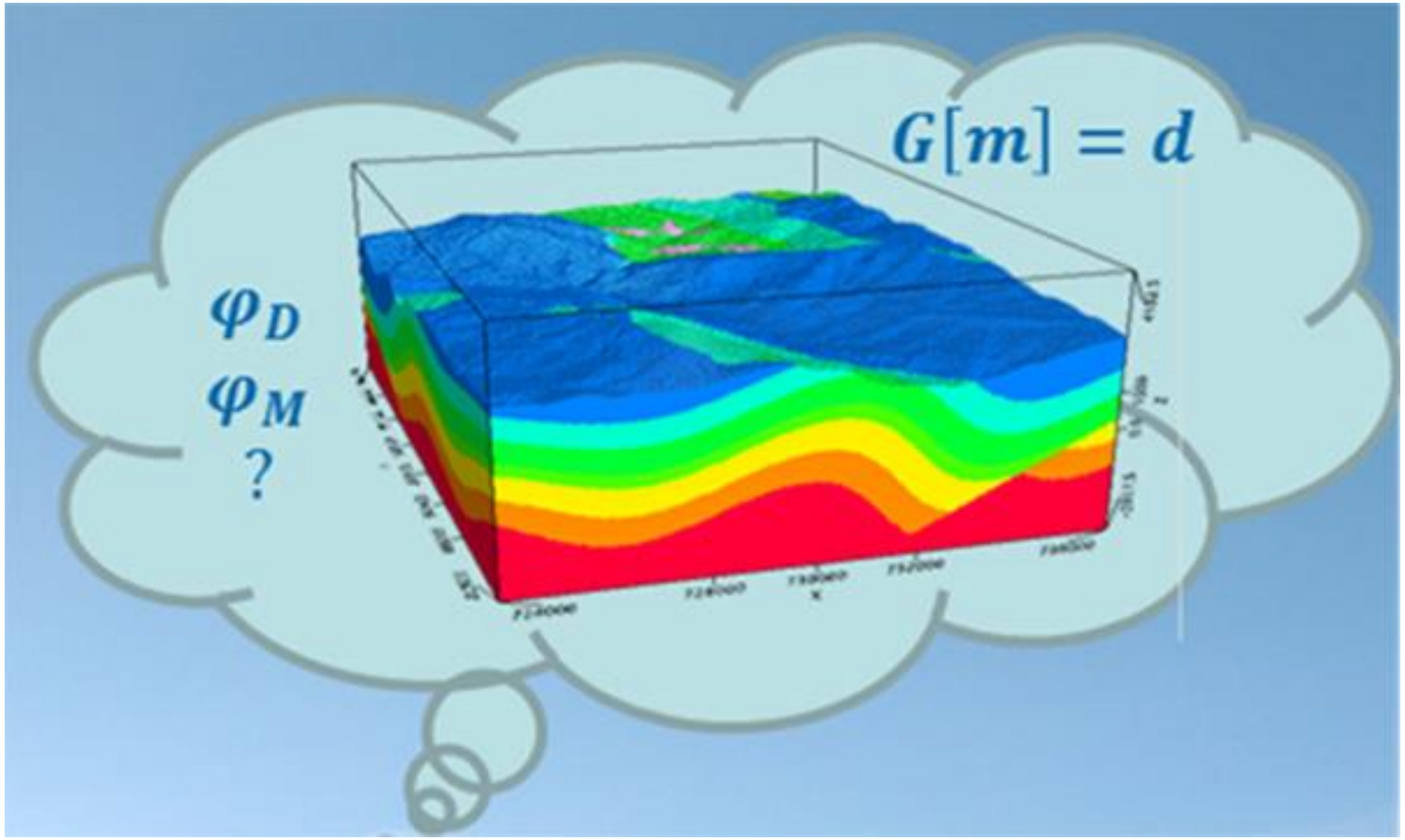
Moyen : imagerie géophysique

m Modèle

d_o Données observées

d_p Données prédites

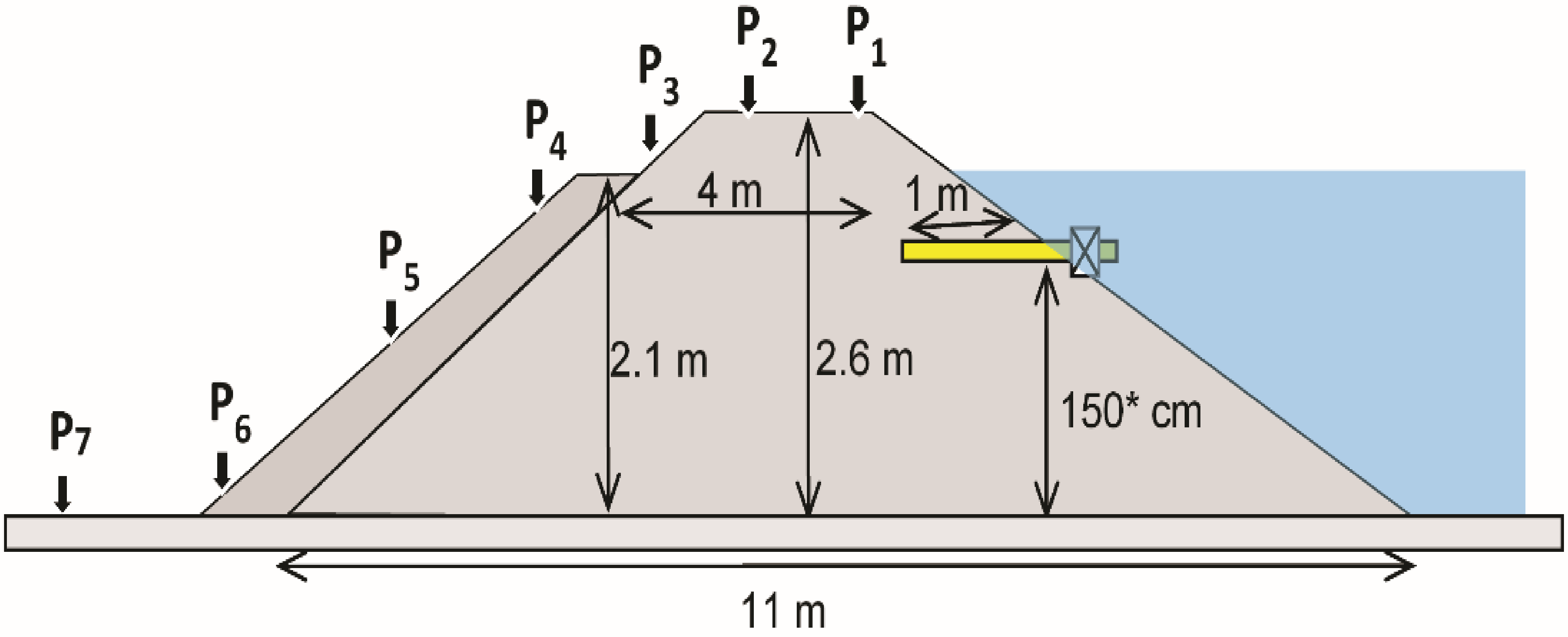
Imagerie médicale



Metodi non intrusivi per individuare le perdite

Méthodes non-intrusives de localiser les fuites

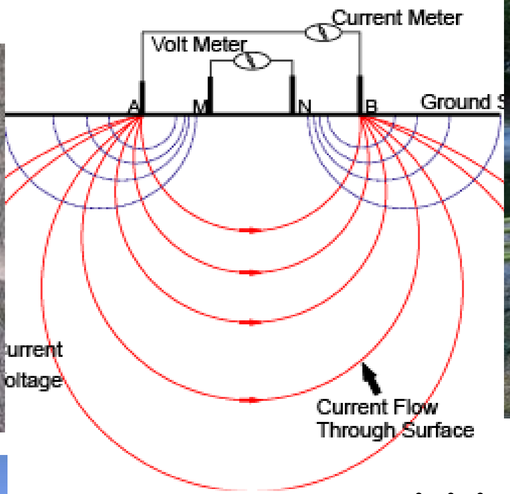
1. Polarisation provoquée appliquée au barrage

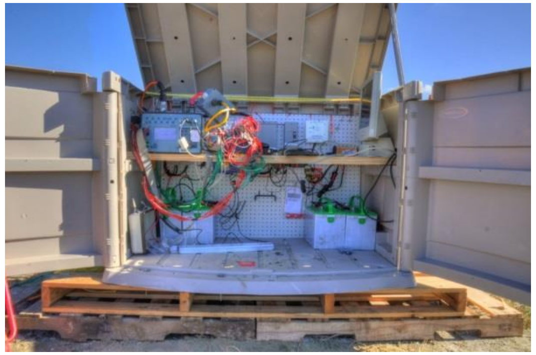


Sperimentazione presso **at IRSTEA Aix-en-Provence**

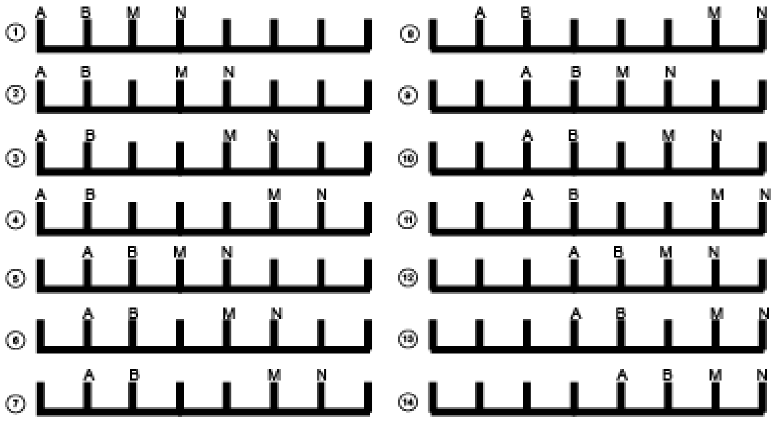
Experimentation at IRSTEA Aix-en-Provence

Principe

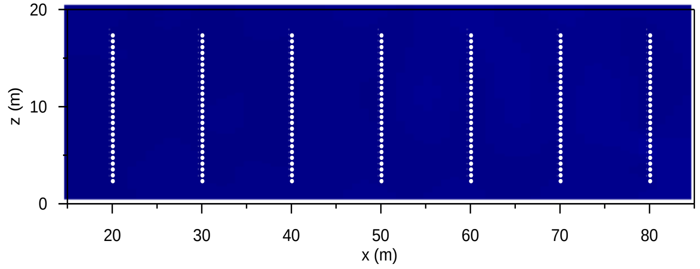


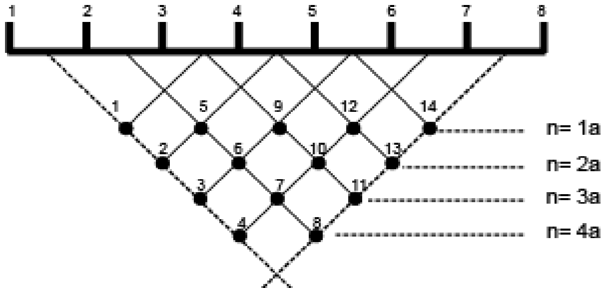


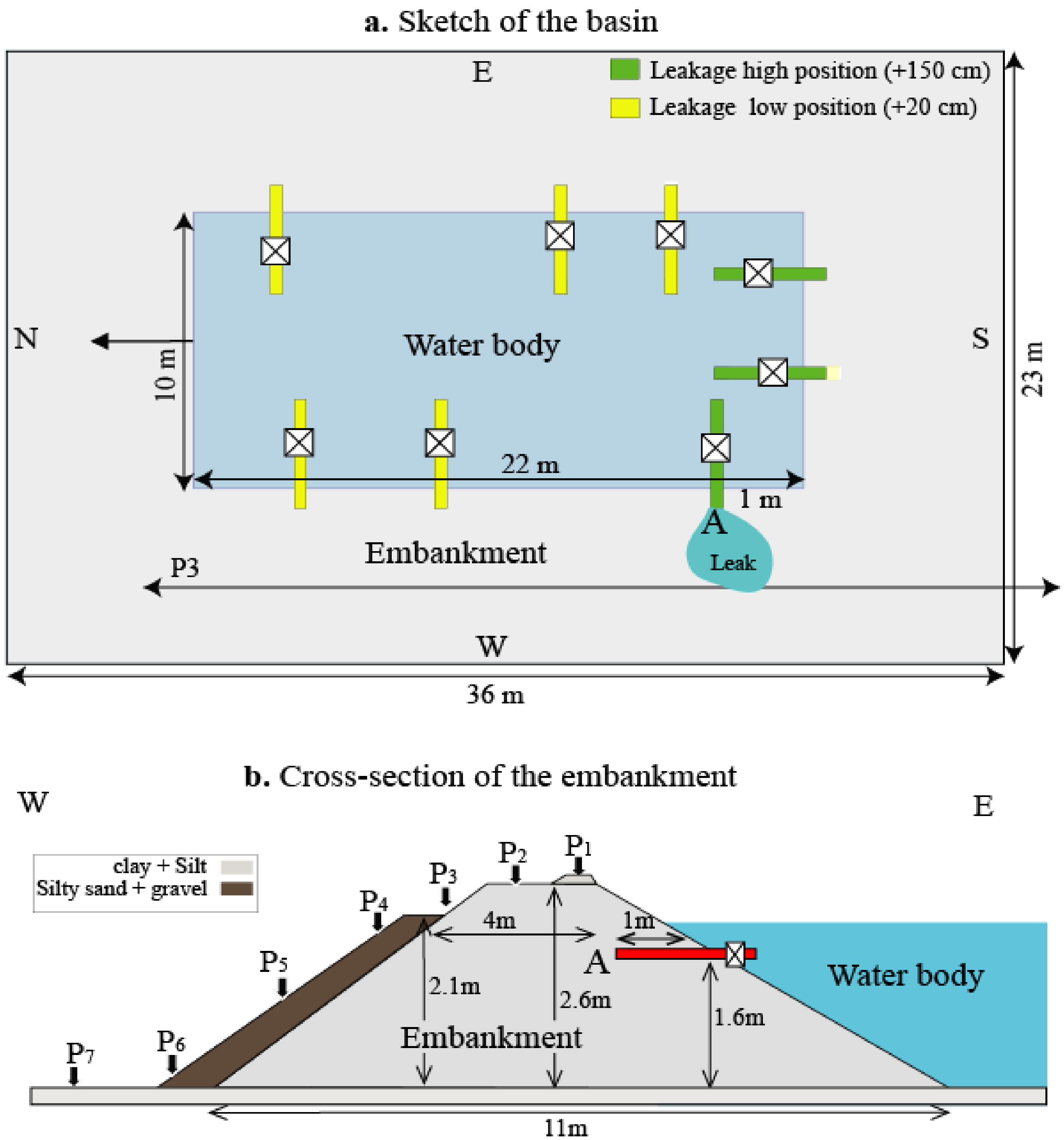
Acquisition multiélectrodes



Time-lapse

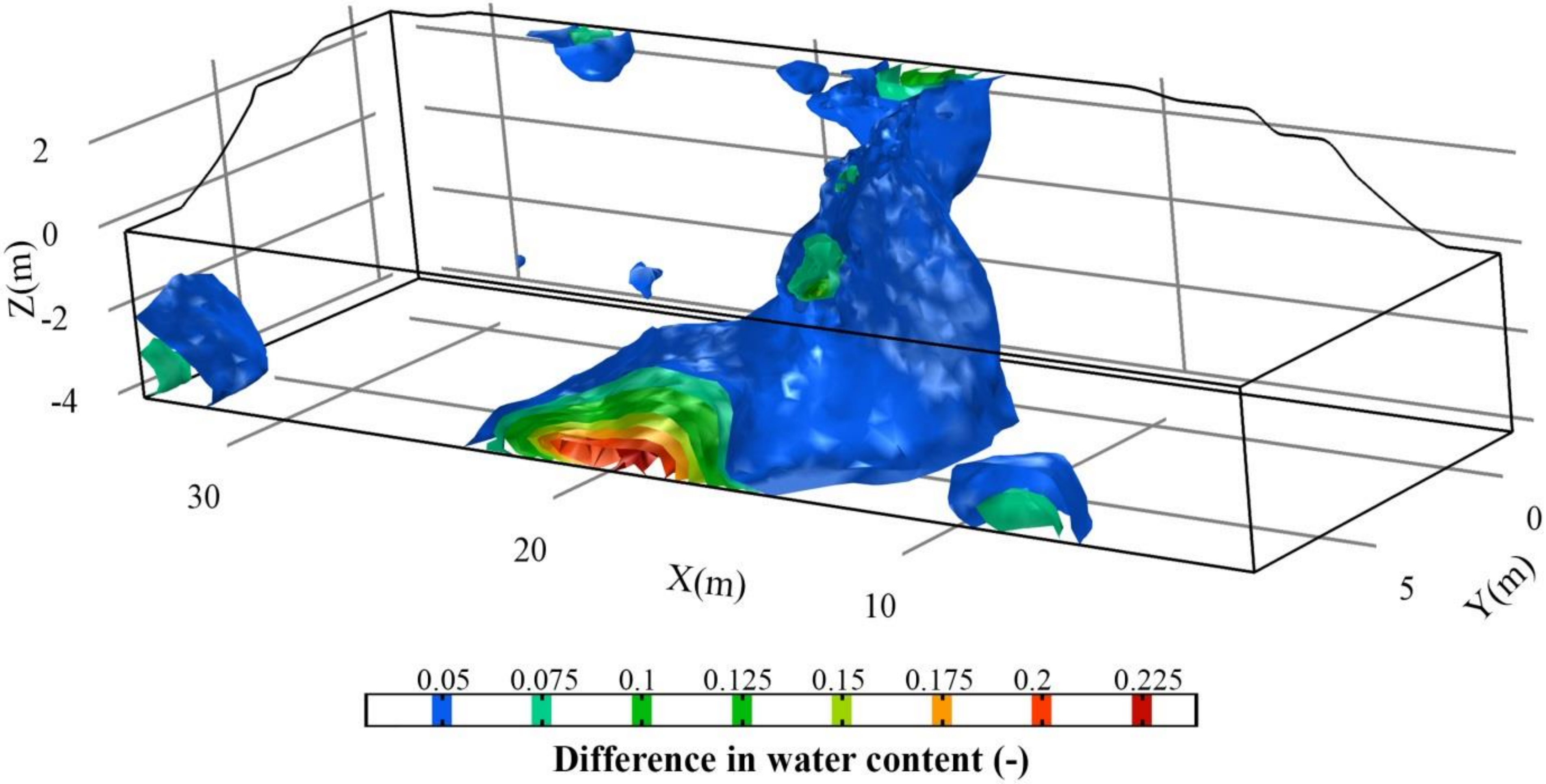






Création d'une fuite

Imagerie spatio-temporelle de la fuite



Rileva una perdita del serbatoio

Détecter la fuite en réservoir

Engineering Geology 254 (2019) 89–101

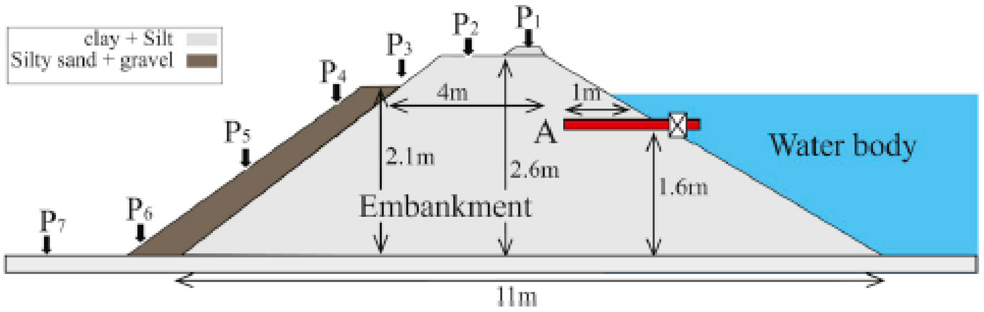
Contents lists available at ScienceDirect

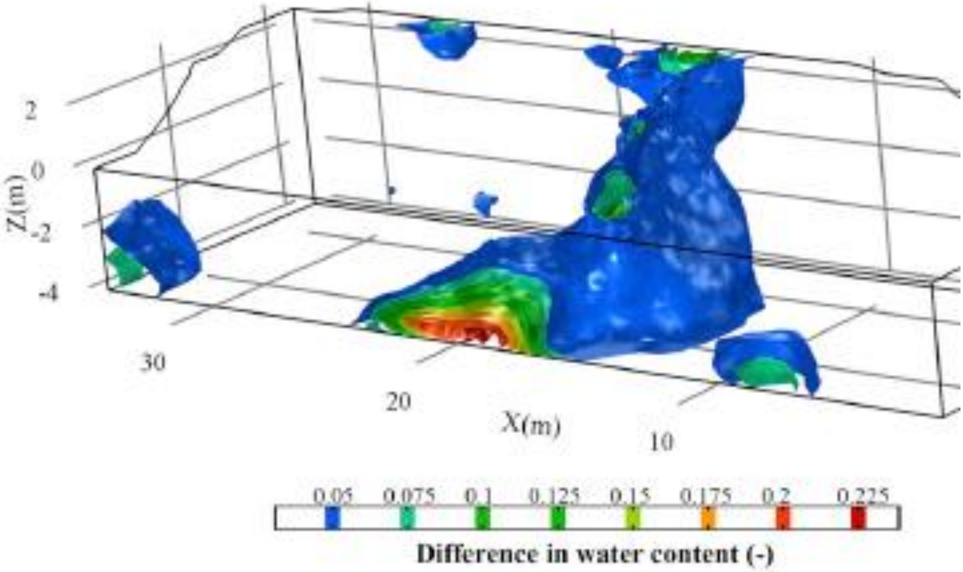
Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Induced polarization tomography applied to the detection and the monitoring of leaks in embankments

F. Abdulsamad[a], A. Revil[a,*], A. Soueid Ahmed[a], A. Coperey[a], M. Karaoulis[b], S. Nicaise[c], L. Peyras[c]

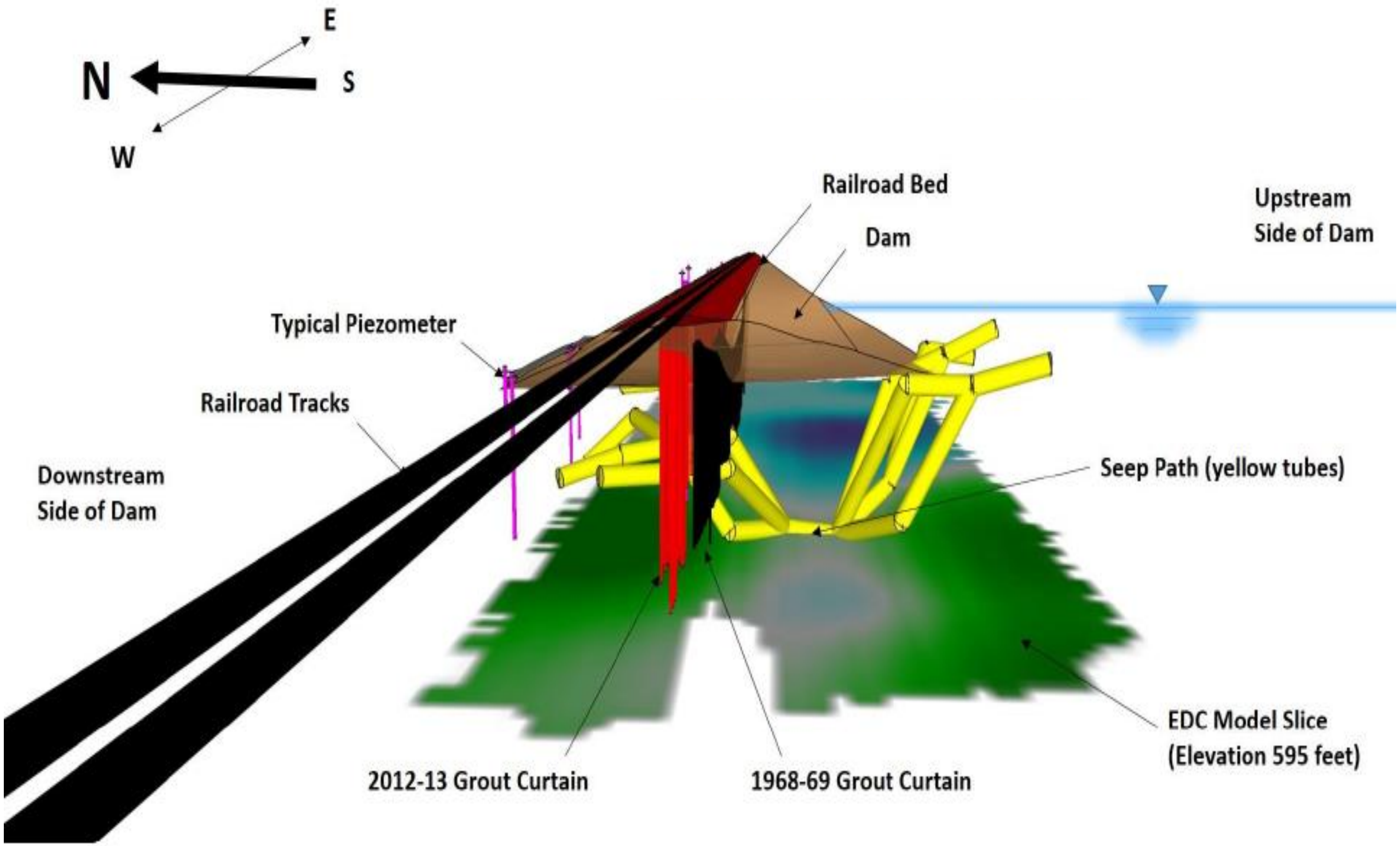




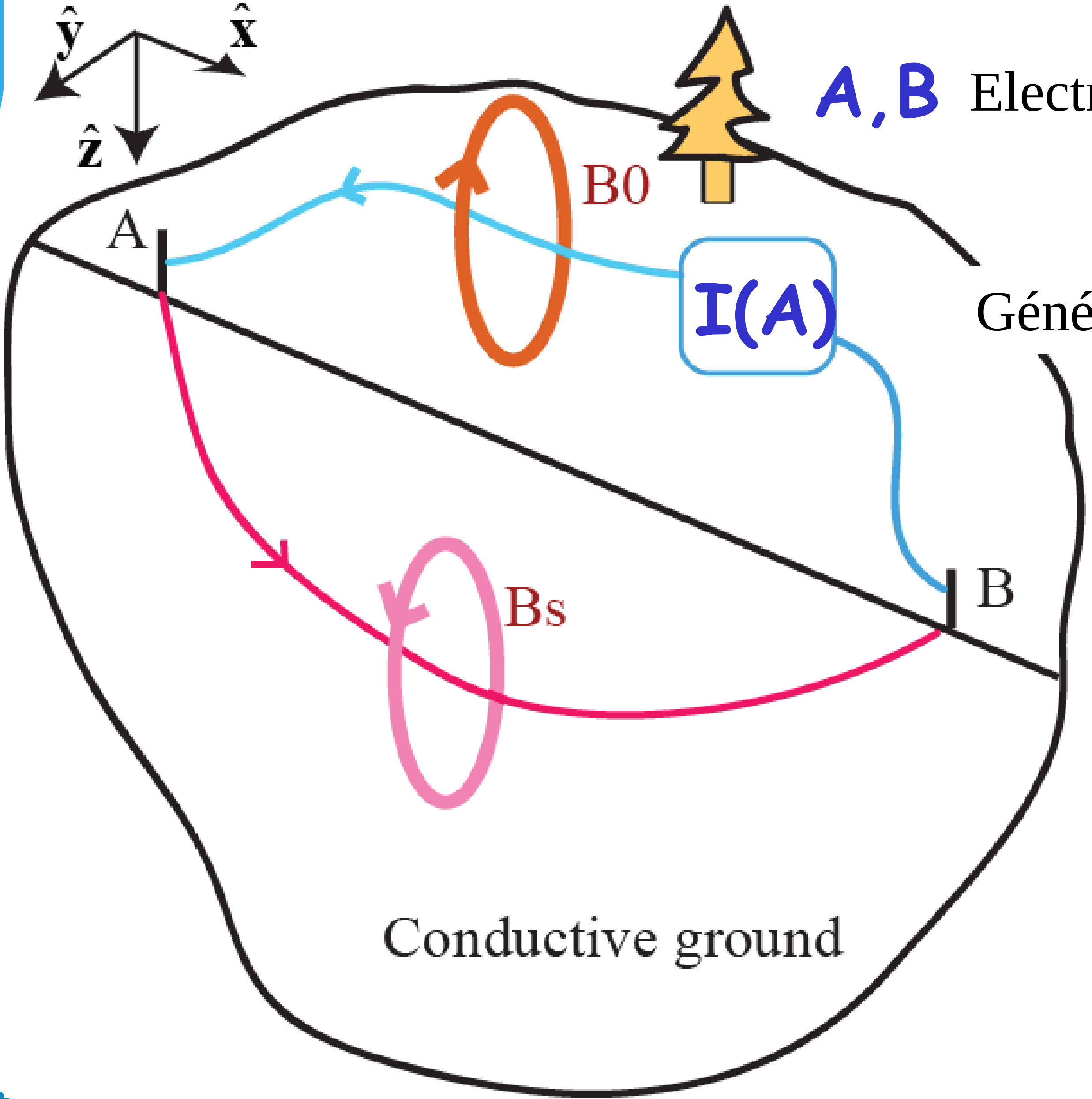
A B S T R A C T

During an induced polarization survey, both electrical conductivity and chargeability can be imaged. Recent petrophysical models have been developed to provide a consistent picture of these two parameters in terms of water and clay contents of soils. We test the ability of this method at a test site in which a controlled artificial leakage can be generated in an embankment surrounding an experimental basin. 3D tomography of the conductivity and normalized chargeability are performed during such a controlled leakage. Conductivity and induced polarization measurements were also performed on a core sample from the site. The sample was also characterized in terms of porosity and cation exchange capacity. Combining the 3D survey and these laboratory measurements, a 3D tomogram of the relative variation in water content (before leakage and during leakage) was estimated. It clearly exhibits the ground water flow path through the embankment from the outlet of the tube used to generate the leak to the bottom of the embankment. In addition, a self-potential survey was performed over the zone of leakage. This survey evidences also the projection of the ground water flow path over the ground surface. Both methods are found to provide a consistent picture. A 2.5D time lapse tomography of the electrical conductivity and normalized chargeability was also performed and evidences the position of the preferential flow paths below the profile. These results confirm the ability and efficiency of induced polarization to provide reliable information pertaining to the detection of leakages in dams and embankments.

2. Imagerie de magnétorésistivité de la fuite

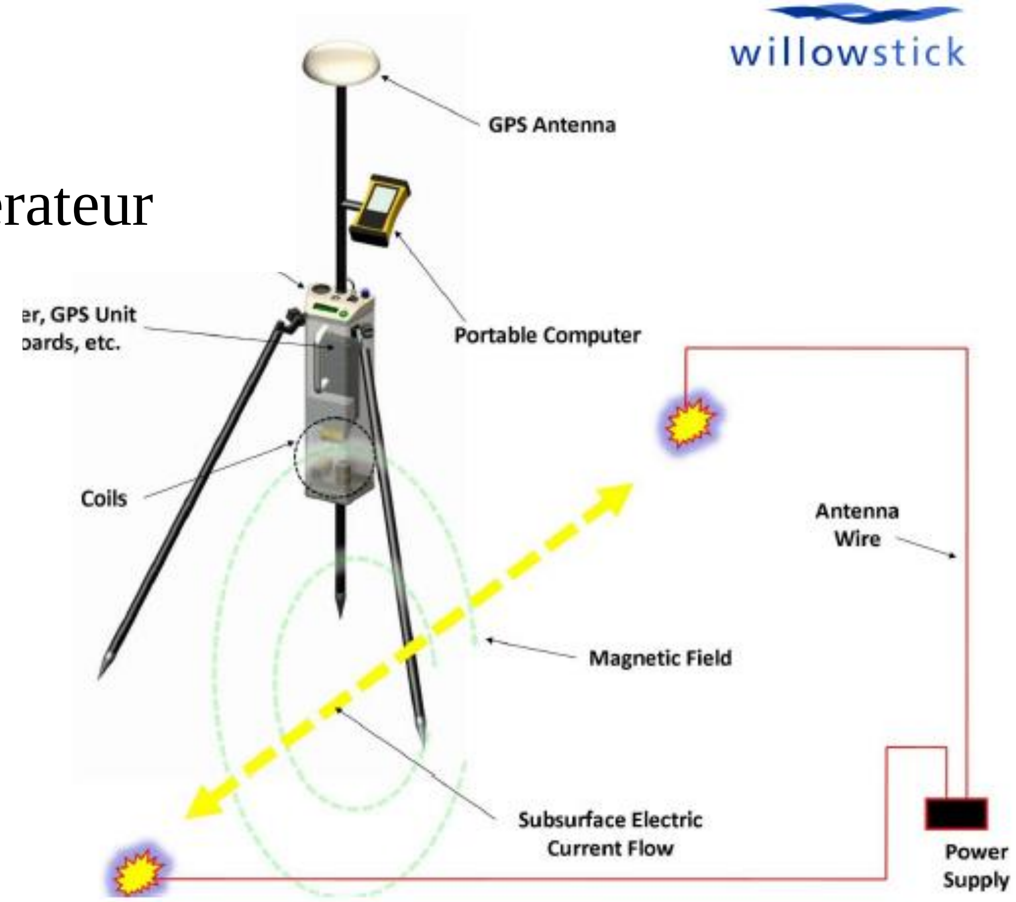


Yellow Tubes represent the centers
of preferential electric current flow



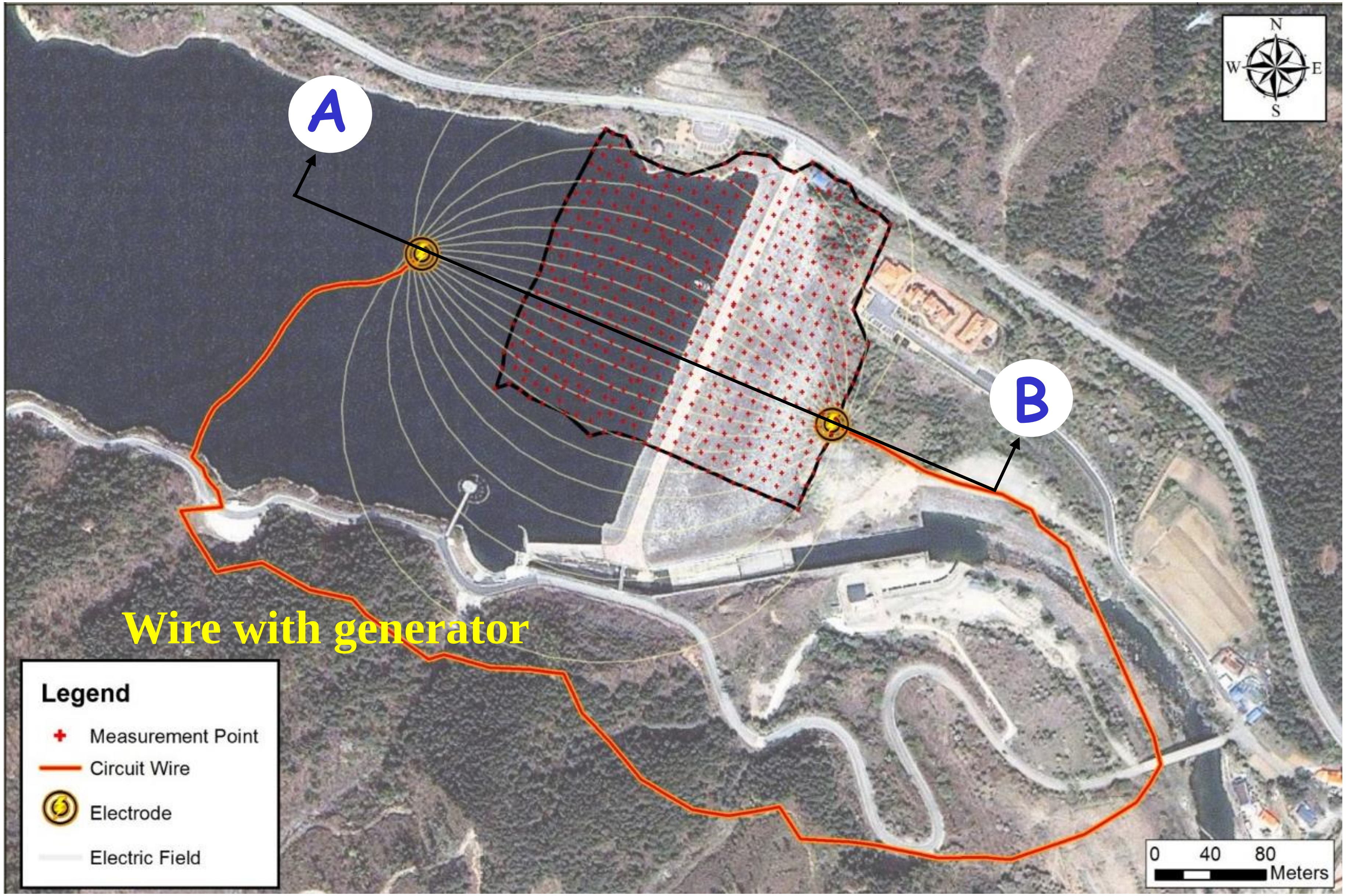
A,B Electrodes courant

Générateur



Rileva e individua una perdita del serbatoio

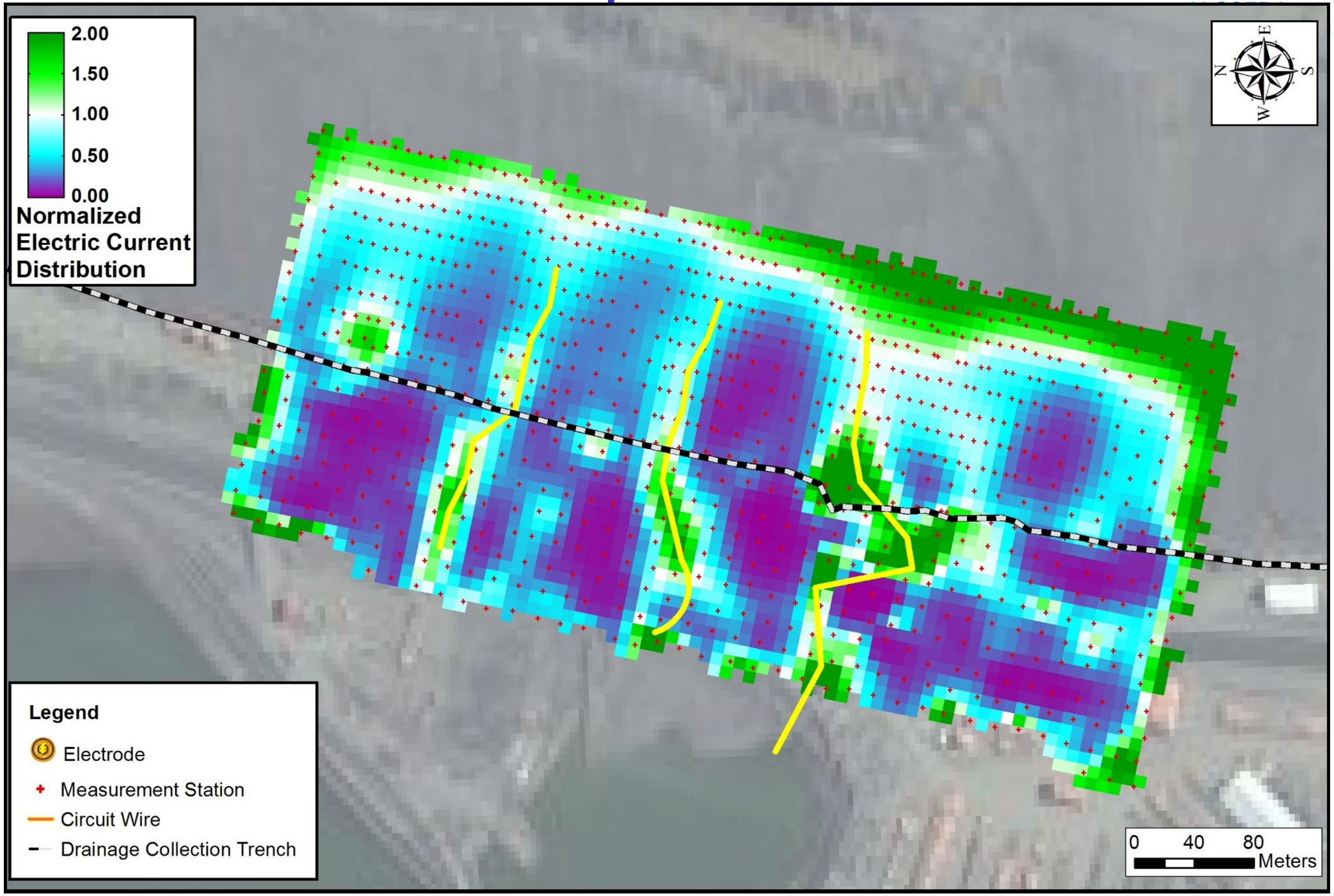
Détecter et localiser la fuite en réservoir



Rileva e individua una perdita del serbatoio

Détecter et localiser la fuite en réservoir

Localisation en 3D des fuites dans une digue



Détecter et localiser la fuite en réservoir par le champ magnétique

Rileva e localizza la perdita nel serbatoio tramite il campo magnetico

Geophysical Journal International

Geophys. J. Int. (2018) **215,** 222–239 doi: 10.1093/gji/ggy27
Advance Access publication 2018 July 06
GJI Geomagnetism, rock magnetism and palaeomagnetism

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Résilience des barrages
Resilienza sugli sbarramenti

Magnetometric resistivity: a new approach and its application to the detection of preferential flow paths in mine waste rock dumps

M. Jessop,[1] A. Jardani,[2] A. Revil[3] and V. Kofoed[1]

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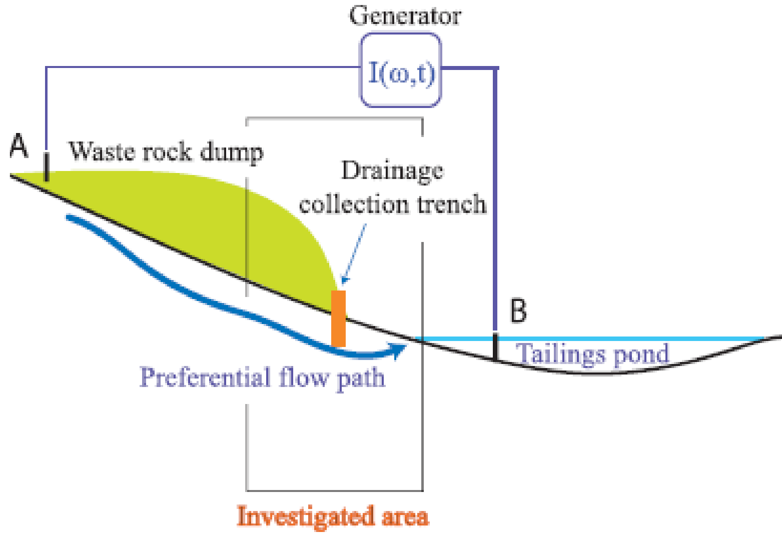
[2] *Université de Rouen, M2C, UMR 6143, CNRS, Morphodynamique Continentale et Côtière, Mont Saint Aignan, France*
[3] *Université Savoie Mont Blanc, CNRS, IRD, IFSTTAR, ISTerre, F-73000 Chambéry, France. E-mail: andre.revil@univ-smb.fr*

SUMMARY

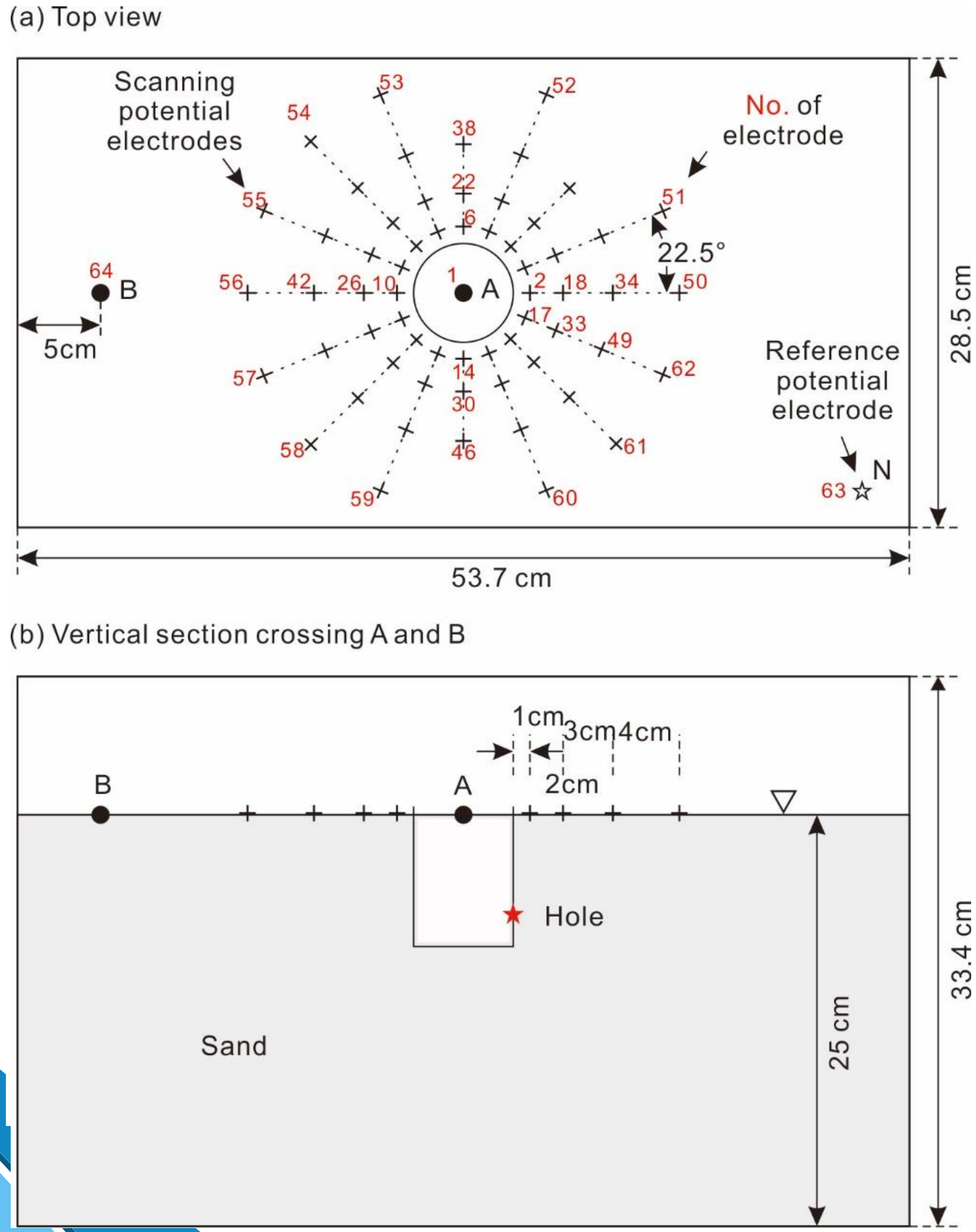
The injection of a low frequency electrical current in the ground between two electrodes A B generates a magnetic field that can be measured at the ground surface with sensitive mag sensors. The map of the magnetic field, measured at the frequency of the injected current, c used to determine the paths of the current through the ground. When the current is chann along preferential conductive paths, the MagnetoMetric Resistivity (MMR) method ca used to detect these paths. Conductive current paths can be associated with preferential paths of groundwater when the two electrodes A and B are in the direction of the flow and the flow path is highly electrically conductive with respect to the background. We first re the background equations for the magnetic field in MMR. Then, we provide the kernel c problem using Biot and Savart law to connect the components of the observed magnetic to the current density distribution. We also develop a simple approach to invert the mag field in terms of electrical current paths. To illustrate how the method works, we de five synthetic models to test the sensitivity of the method to the properties of the condu targets channelling the electrical current. The targets are characterized by different sh sizes, depths, and conductivity contrasts with the background. Then, we proceed with a study for which the MMR method is used to identify and map preferential groundwater paths by-passing a mine waste rock dump drainage collection trench into the tailings por this case, the conductivity of the flow paths is much stronger than the background conduc due to the high mineralization of the ground water along these paths. The method under the 3-D architecture of these flow paths.

Key words: Electrical properties; Hydrogeophysics; Electromagnetic theory; Mag anomalies: modelling and interpretation; Tomography.



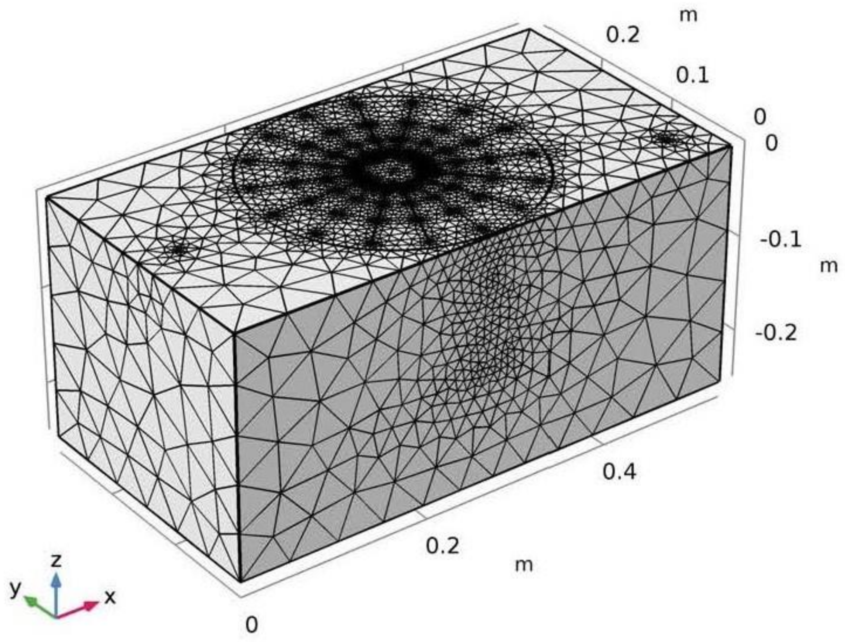
$$\mathbf{B}(\mathbf{r}) = \frac{\mu}{4\pi}\int \frac{\mathbf{J}_c(\mathbf{r}') \times (\mathbf{r}-\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|^3} d\tau' = \frac{\mu}{4\pi}\int \mathbf{J}_c(\mathbf{r}') \times \nabla' \left[\frac{1}{|\mathbf{r}-\mathbf{r}'|}\right] d\tau',$$

3. Méthode de mise-a-la-masse

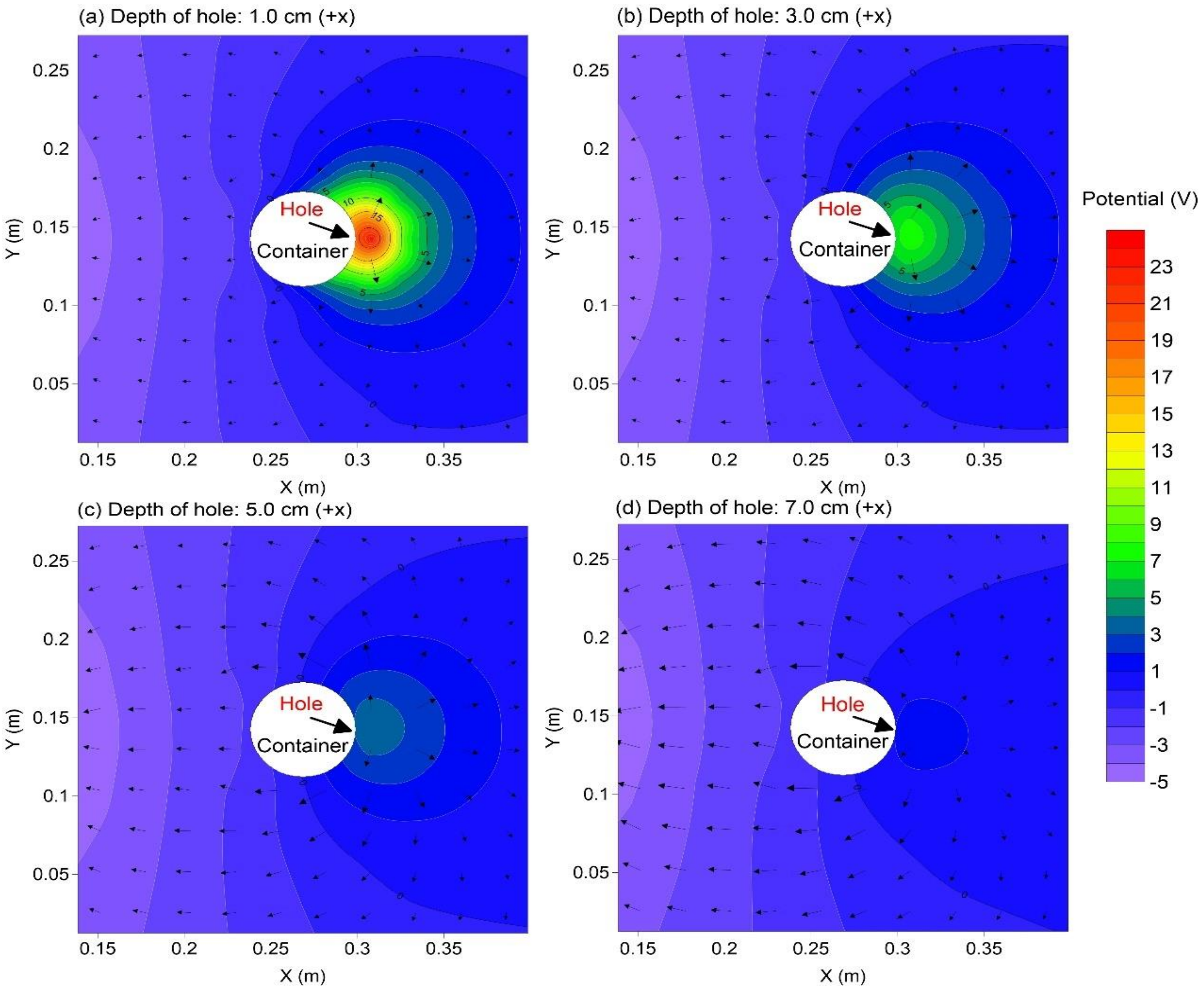


Expérience en laboratoire

Esperimento di laboratorio



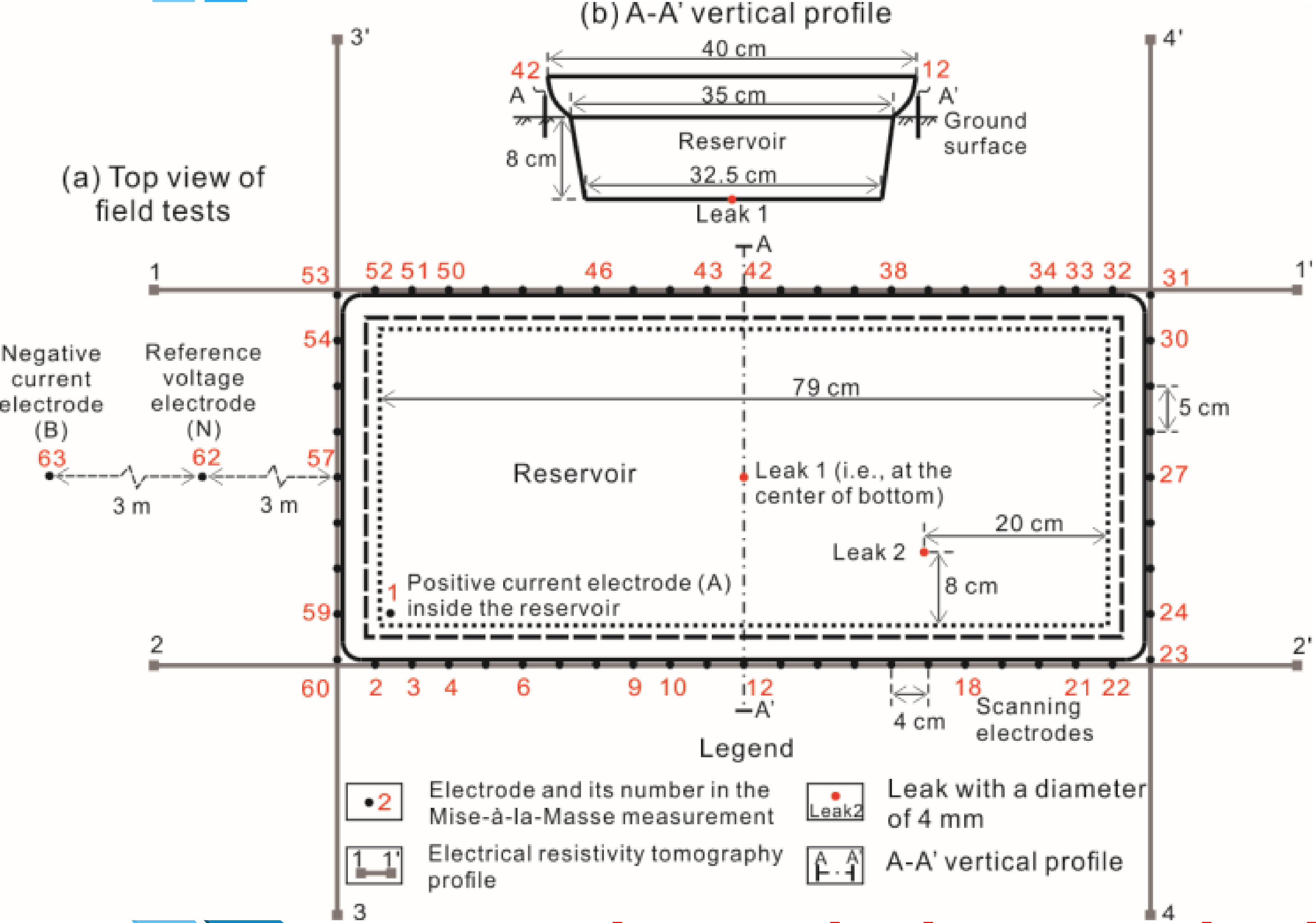
Modelisation par éléments finis

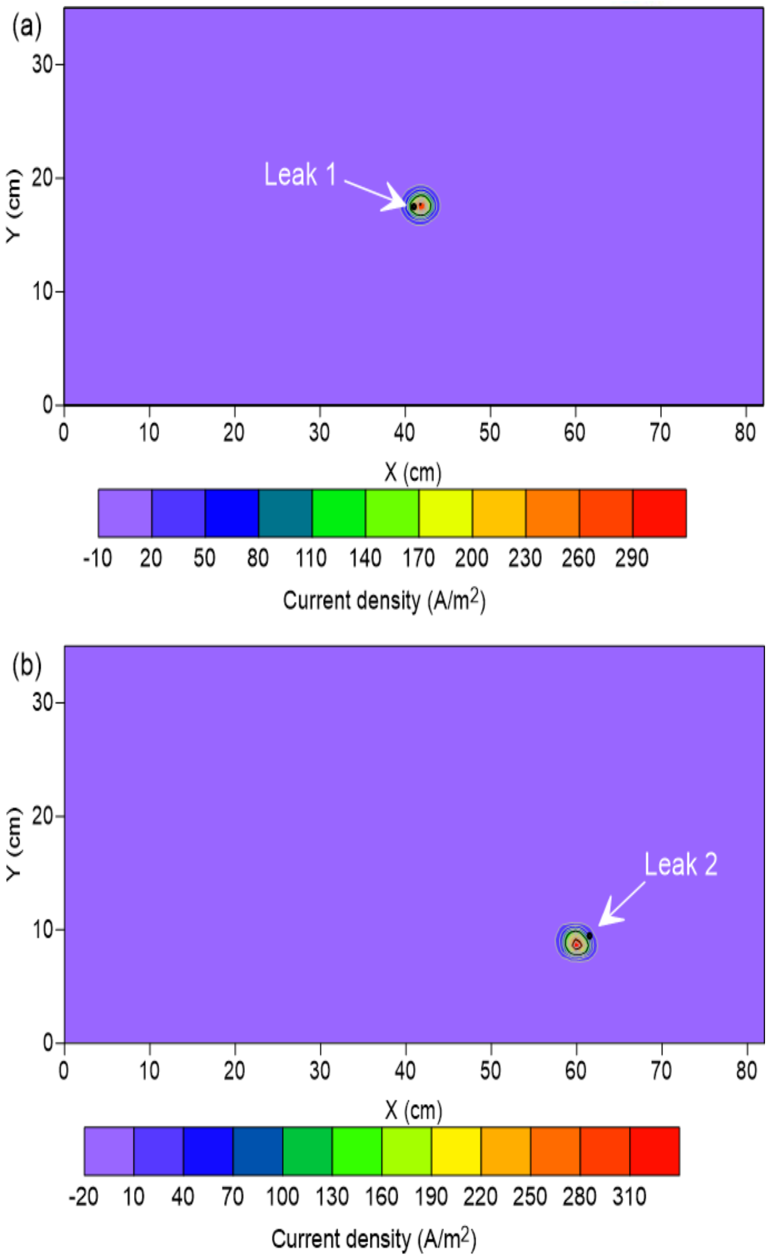


Misura al di fuori del giacimento della distribuzione del potenziale

Mesure à l'extérieur du reservoir de la distribution de potentiel

Travail sur un petit réservoir





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Engineering Geology 261 (2019) 105272

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RESBA

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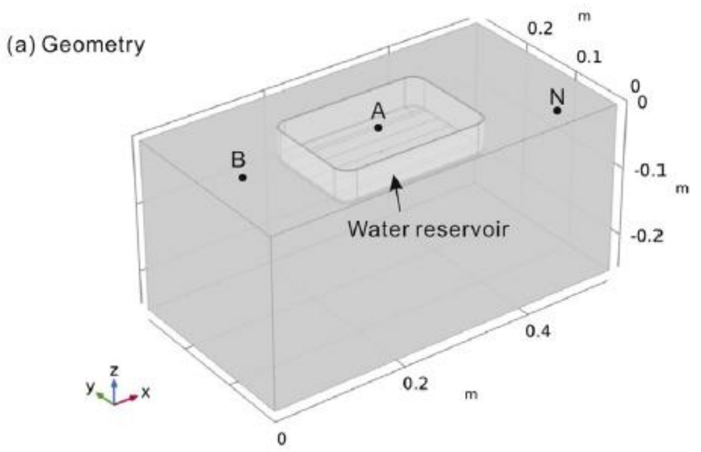
Resilienza sugli sbarramenti

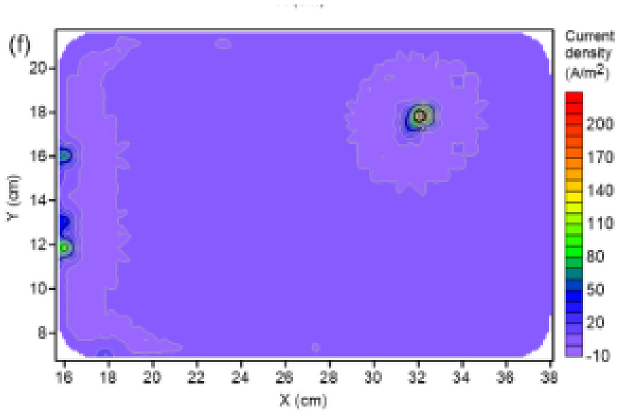
Application of the Mise-à-la-Masse method to detect the bottom leakage of water reservoirs

C. Ling[a,b], A. Revil[b,*], Y. Qi[b], F. Abdulsamad[b], P. Shi[c], S. Nicaise[d], L. Peyras[d]



A B S T R A C T

Leakages of reservoirs are responsible for the loss of water resources and the spread of contaminants. We develop a methodology to detect leaks located at the bottom side of a reservoir with the minimally invasive mise-à-la-masse method, which involves the potential electrodes located at the ground surface around the reservoir and the current source and sink placed in and out of the reservoir, respectively. This method allows localizing the secondary current distribution associated with leakage using the distribution of potential recorded on a set of electrodes during the mise-à-la-masse experiment. An initial model based on the distribution of root mean square values between the observation and the simulation data is first given to the inversion algorithm. The Tikhonov regularization, which includes a weighting matrix and a minimum support function, is used to strengthen the detection resolution of the leak. 29 sandbox experiments show that the proposed method and inversion algorithm can localize a single leak. For a leak with a crack shape, the inversion algorithm detects the location of the leak with a small bias. When the leak lasts, a conductive zone may occur below the leak due to the increase of water content or ionic strength of the pore water. The occurrence of such a conductive body could affect the localization of the leak because the conductivity distribution may not be well-resolved. The effect is analyzed using synthetic experiments. The results show that the bias between the real leak and inversion results increases with the position and size of the undetected conductive zone. Two small-scale field tests were conducted to test the performance of the mise-à-la-masse method. The two leaks are properly identified. This study provides an efficient approach to detect the bottom leakage of reservoirs.



Liste des articles - Elenco di articoli

Jessop M., A. Jardani, A. Revil, and V. Kofoed, Magnetometric resistivity: a new approach and its application to the detection of preferential flow paths in mine waste rock dumps, Geophysical Journal International, 215, 1, 222–239, 2018. https://doi-org.insu.bib.cnrs.fr/10.1093/gji/ggy275.

Vu M. T., A. Jardani, A. Revil, and M. Jessop, 2020. Magnetometric resistivity tomography using chaos polynomial expansion, Geophysical Journal International, 221(3), 1469-1483, https://doi.org /10.1093/gji/ggaa082.

Abdulsamad F., A. Revil, A. Soueid Ahmed, A. Coperey, M. Karaoulis, S. Nicaise, and L. Peyras, Induced polarization tomography applied to the detection and the monitoring of leaks in embankments dams and dikes, Engineering Geology, 254, 89–101, https://doi.org/10.1016/j.enggeo.2019.04.001.

Soueid Ahmed A., A. Revil, B. Steck, C. Vergniault, A. Jardani, and G. Vinceslas, 2019. Self-potential signals associated with localized leaks in dam embankments and dikes, Engineering Geology, 253, 229-239. https://doi.org /10.1016/j.enggeo.2019.03.019.

Ling C., A. Revil, F. Abdulsamad, Y. Qi, A. Soueid Ahmed, P. Shi, S. Nicaise, and L. Peyras, Leakage detection of water reservoirs using a Mise-à-la-Masse approach, Journal of Hydrology, Journal of Hydrology, 572, 51–65, https://doi.org/10.1016/j.jhydrol.2019.02.046.
Ling C., A. Revil, Y. Qi, F. Abdulsamad, P. Shi, S. Nicaise, and L. Peyras, 2019. Application of the Mise-à-la-Masse method to detect the bottom leakage of water reservoirs, Engineering Geology, 261, 105272. https://doi.org/10.1016/j.enggeo.2019.105272.