Monitoring the Excavation Damaged Zone by 3D reconstruction of Electrical Resistivity

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A damaged zone is formed during the excavation of underground galleries, altering the rock properties. A 3D electrical resistivity tomography of the Excavation Damaged Zone (EDZ) is developed in Opalinus Clay. This anisotropic formation possesses a very low permeability and a self-sealing behavior suitable for nuclear waste storage [4]. The Mont Terri Underground Rock Laboratory (URR) in Switzerland, is constructed in such a geological formation.

(A) MONITORING THE EDZ

A non-invasive monitoring method is developed to follow the evolution of the EDZ with time. For this purpose a reconstruction of the media resistivity at different periods of the gallery 04 excavation is implemented.

The electrical measurements have been carried out from three rings of 32 electrodes surrounding the gallery by four years. The electrodes have been set up in July 2004. At this period several niches excavated and the rings were located at a distance of 1.15 and 4m from the front-end face [3].

The inverse problem aims at reconstructing the resistivity distribution of the media in order to explain the measurements. In order to ill the possibility of the problem, the geometry of the reconstructed elements is defined differently from the FEM of the forward problem [2]. Data sets are acquired on 3 parallel rings, so the mapping of the inverse problem is performed in three aspects, corresponding to the areas located around the electrode rings.

(B) RECONSTRUCTION OF THE MEDIA RESISTIVITY

The reconstruction of the media resistivity is computed with the EIDORS software [1]. The media surrounding the gallery is represented with a Finite Element Model (FEM) using the NETGEN software. The tunnel shape is constructed from the position of the electrodes rings. The shape is then extended to form a cylinder having a length of about 60m to avoid boundary effects. A finer mesh is designed near the electrodes and the presence of the niches may taken into account depending on the period of acquisition of the analyzed data set. Mixed boundary conditions are assumed between the tunnel and the rock media. Neumann boundary conditions are applied to the electrodes where a current is injected, elsewhere Dirichlet boundary conditions hold.

The shape of the contrasts vary with time, while the background resistivity remains stable. In July 2004 an important area with a high resistivity is present solely around ring 3. This pattern appear after the front-end disappearance around rings 1 and 2, that was closer to the front-end face.

Results of the inversion show that the resistivity is homogeneous in the 2 first meters around the gallery. The shape of the contrasts vary with time, while the background resistivity remains stable. In July 2004 an important area with a high resistivity is present solely around ring 3. This pattern appear after the front-end disappearance around rings 1 and 2, that was closer to the front-end face.

Conclusions

The choice of the inverse problem mapping allows finding some contrasts in the media without the use of any subjective constraint such as smoothing matrix. The quality of the resulting images is tested with an inversion showing the stability of the inversion and the reduce area of the perturbed region. The resulting values of resistivity vary between 3 and 3 D.m in agreement with the measured values of the background resistivity [3]. This study points out the fact that electrical resistivity measurement is sensitive to the EDZ and that they allow following its evolution. The 3D reconstruction developed here shows the presence of EDZ following the excavation of the Mont Terri gallery 04. The EDZ extension has a maximal depth of about 1.3m right after the excavation of the gallery. This EDZ is not present all around the gallery and some saturated conduits areas remain after this excavation. The reconstructions performed here underlines the influence of the EDZ formation revealed by the high resistivity contrasts.

(C) RESULTS AND INTERPRETATIONS

The results of the inversion are presented on the maps below. The 3D reconstruction developed here shows the presence of EDZ following the excavation of the Mont Terri gallery 04. The EDZ extension has a maximal depth of about 1.3m right after the excavation of the gallery. This EDZ is not present all around the gallery and some saturated conduits areas remain after this excavation. The reconstructions performed here underlines the influence of the EDZ formation revealed by the high resistivity contrasts.

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REFERENCE