Effects of Thermal and Electroosmotic Flux on Grounding Electrodes

I.F.R.Costa[1], M.C.Barbosa[1], A.O.Costa Neto[2]
1. COPPE/UFRJ, Rio de Janeiro, RJ, Brazil
2. UFVJM, Teófilo Otoni, MG, Brazil

INTRODUCTIONT: The present work proposes to establish the basis for a model that represents the risk of dryness of the soil along the area around of a vertical grounding electrode, considering the coupled study of the electroosmotic flow and the flow due to the thermal gradient, from the COMSOL *Multiphysics* program.

COMPUTATIONAL METHODS: For the model, a cylindrical geometry was adopted (Figure 1) for its reproduction, with a hollow element simulating the vertical electrode, through which the axis of symmetry passes.

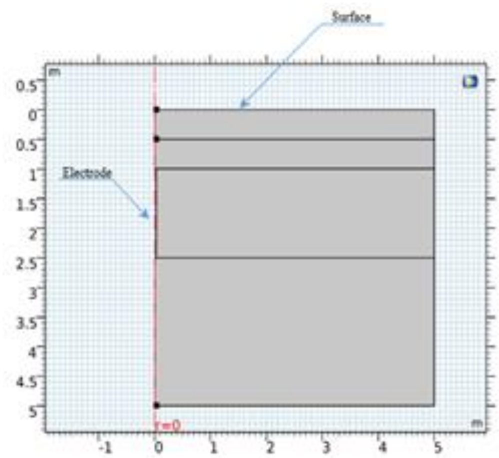

Figure 1. COMSOL geometry of the problem space

The first phenomenon considered is Joule heating.The laws that govern the process are demonstrated in equations 1 and 2.

$$Q_e = JE = (\sigma E)E = \sigma E^2 \quad (1)$$

$$E = -\nabla V \quad (2)$$

For heat transfer in the soil, Darcy's law is associated with solving the temperature field in every domain. The governing equations are given in 3, 4, 5 e 6.

$$(\rho C_p)_{eff}\frac{\partial T}{\partial t} + \rho C_P u\nabla T + \nabla q = Q_e \quad (3)$$

$$(\rho C_p)_{eff} = \theta_p \rho_p C_{p,\rho} + (1-\theta_p)\rho C_p \quad (4)$$

$$q = -k_{eff}\nabla T \quad (5)$$

$$k_{eff} = k_p^{\theta_p} k^{1-\theta_p} \quad (6)$$

It is noticed that the multiphysics coupling between the electric and the heat occurs in Equation 3, starting from Q_e (source of electromagnetic heat).

The electroosmotic velocity (Equation 7) is calculated from the Helmholtz-Smoluchowski ratio.

$$u_{eo} = \frac{\varepsilon_p \varepsilon_w \zeta}{\mu\tau}\nabla V \quad (7)$$

RESULTS: The results associated with the electrical potential considering σ = 0.01S/m (Figure 2), the temperature at 30 days of current injection (100A), in ºC (Figure 3), the conductive heat flow at the same time (Figure 4), and the electroosmotic velocity (Figure 5) are presented.

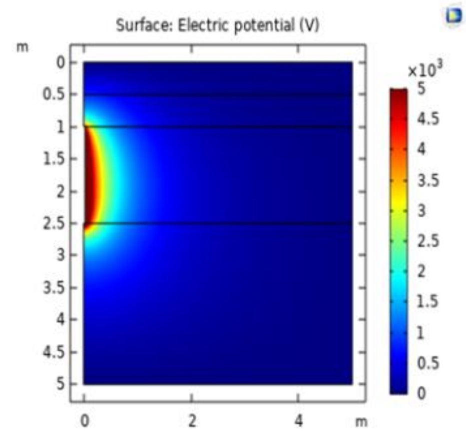

Figure 2. Distribution of electrical potential (Volts)

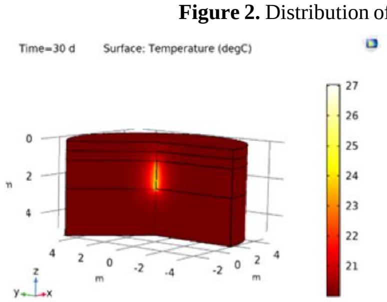

Figure 3. Temperature (ºC) distribution at 30 days

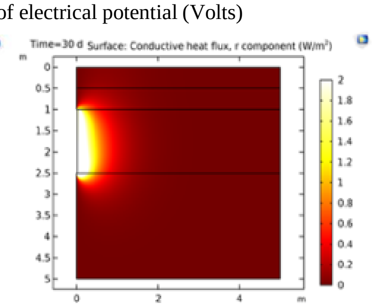

Figure 4. Heat flow (W/m²) due to driving at 30 days

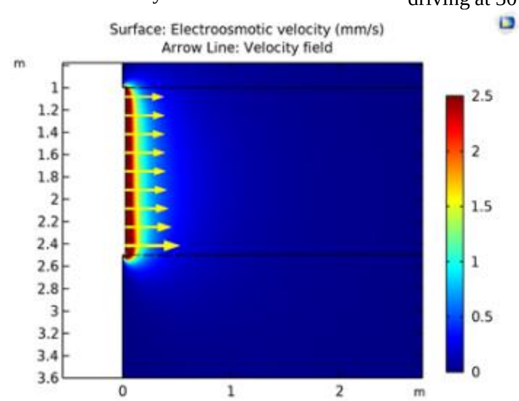

Figure 5. The electroosmotic velocity (mm/s) generated by the establishment of electrical potential

CONCLUSIONS: The coupled analysis of the electrical, thermal, and hydraulic phenomena involved proves the disturbance caused by the electric current in the vicinity of the grounding electrode. The most critical effects are restricted to the immediate vicinity of the electrode. It is still necessary to evolve with work for unsaturated soils, and the variation of soil properties with humidity, activities that are in progress.