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Forward modeling by means of resistor network – new tool for fracture detection in crystalline rocks

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The resistivity model of crystalline rock with sparse fracture network can be considered as highly inhomogeneous medium. It is built with relatively non-conductive country rock and very thin and highly conductive fractures. The fractures enable electric current flow in otherwise non-conductive medium. These fractures can be of irregular shape and they can be mutually interconnected. The measured apparent resistivity in such medium strongly depends on the accurate position of the individual electrodes in relation to the conductive fractures. This is especially important e.g. in the case of very detailed resistivity measurement performed directly the on rock surface.

Commonly used 2D models of resistivity distribution are based on blocks of rectangular shape with finite dimensions. The individual blocks are characterized by their resistivity values. The fractures are however very thin and they cannot be directly modeled using the finite size blocks because the fracture cross-section area is negligible compared to the block size area.

We developed resistor-network model. In this case the medium is replaced by discrete 2D orthogonal resistors lattice. Instead of resistivity [Ohmm] which represents continuous material property we are using discrete model built up by individual resistors which are characterized by their resistance values [Ohm].

Resistor network model is used for evaluating apparent resistivity pseudosections in ERT method. We demonstrate the possibilities of this model for Wenner - alpha and Wenner - Schlumberger electrode arrays. Some basic model calculations demonstrate agreement between Finite-element calculation (Res2DMod by Loke) and proposed Resistor network approach. Special model calculations demonstrate the new possibility for modelling of anisotropic resistivity medium. The effects of fractures and fracture zones of different kind are presented.

The results are promising e.g. in underground storage monitoring projects for the interpretation of ERT measurements performed in underground tunnels in crystalline rocks with isolated fractures.