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Numerical investigation of geo-electrical relationships in porous media

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The need to characterize the chemical and physical properties of both vadose and saturated zone has grown steadily over the past thirty years, as a consequence of the increasing anthropic pressure on the subsurface environment. Geo-electrical and electromagnetical tools have been recognized as very useful tools to characterize the subsurface with fast, field-scale, non-invasive surveys. These techniques have also benefited from fast and significant improvements in electronic technology.

In spite of all this, the conversion of the measured properties (e.g. electrical conductivity, dielectric constant) into the relevant information (e.g. water saturation) is still performed using empirical or semi-empirical constitutive equations. Typical examples are Archie's law for electrical resistivity and the Complex Refractive Index Method (or CRIM) for dielectric properties.

The main goal of this work is to create a conceptual and computational framework useful for the assessment of such relationships, and for the investigation of the role that several micro-geometrical factors (porosity, connectivity of the pore space, grain-size distribution) have in conditioning the electrical response of porous media. We have developed a novel pore-scale approach suitable to compute both the electrical conductivity and the dielectric constant of a variably saturated porous medium. We investigate the effects of both the volume electrical conductivity and the surface conductivity of the solid matrix. This is done particularly with reference to the assumption of the Waxman and Smits model for shaly sandstones. The effect of the exponent in the CRIM is the main objective of the simulations related to dielectric properties. A

sensitivity analysis is performed with respect to the role of the structural and geometrical parameters on a number of digital porous media.