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## Electrical conductivity estimation from a new fractal model for porous media under reactive processes

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Near-surface geo-electrical methods monitoring the electrical conductivity have gained particular interest for environmental studies. Their sensitivity to key properties of storage and transport in porous media and their non-destructive nature make these methods a significant asset for studying the subsurface. Nevertheless, their quantitative interpretation depends on the efficiency of the used petrophysical relationship to link the physical properties, obtained from the electrical measurements, with the hydrological properties and state variables of interest. Therefore, the electrical conductivity of a porous medium is related to several geological parameters such as mineral matrix, porosity, permeability, and degree of water saturation. All of these parameters are controlled by the pore structure which plays a key role in the distribution of the conductive fluid. During reactive processes, the pore structure is significantly affected which translates into surface and volume variations. This evolution of the pore space leads to changes in the macroscopic hydraulic properties and, therefore, the electrical conductivity. In this study, we present an analytical fractal model to describe the electrical conductivity evolution during reactive processes. Under the assumption that the pore system is represented by a bundle of tortuous capillaries with constrictivity, we account for the reactive processes in the model by considering the geometrical variations in the pore structure (i.e., the increase and decrease of the pores aperture). The derivation of the electrical conductivity is based on upscaling procedures and a fractal law which describes the size distribution of pores. Considering the electrical charges dragged by the water in one capillary, we upscale the electrical property and obtain closed-mathematical expressions to calculate the electrical conductivity of the medium. This can be achieved thanks to the independence from scales of fractal media. For partially saturated conditions of the medium, the model's expressions can estimate the electrical conductivity as a function of hydraulic properties. The performance of the model has been tested with published data from different soil and rock textures, under reactive fluid flow or partial saturation conditions. The comparison shows that the model can satisfactorily reproduce the behavior of the data. The fractal distribution is consistent with micro-CT results and the dissolution rate is within the same order of magnitude of the value obtained from experimental results. From a geometrical approach and within a fractal framework, we included the effect of reactive processes in the estimates of the medium electrical conductivity which opens up new possibilities to characterize media from geoelectrical techniques.

