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Laboratory electrical measurements on sediment samples and relation with textural parameters

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The increasing use of geophysical surveys for the hydrological subsurface characterization does not ensure by itself the correct interpretation of an image showing the spatial distribution of a physical quantity. Geo-electrical methods, such as Vertical Electrical Soundings and Electrical Resistivity Ground Imaging, for example, are affected by uncertainties arising from model equivalence, related to non-uniqueness or low sensitivity of the inverse problem. Moreover, the laboratory experiments we performed on samples of alluvial sediments, ranging from fine gravel to silt and clay, saturated with pore water of varying electrical conductivity, show that a low resistivity value can be attributed to granular porous media saturated by fluids with high salinity or to fine-grained soils, even in a freshwater hydrogeological environment .

This work aims at further investigating the electrical response of alluvial sediments at the REV (Representative Elementary Volume) scale, by systematically varying textural and fluid properties. The final purpose is to suggest a phenomenological model able to discriminate between the electrolytic conductivity component, connected to the free ions into the pore waters, and the “shale” component, due to unbalanced lattice charges on silty and clayey particles, and their physical-chemical interactions with adsorbed water molecules or other charged species. A georesistivimeter, commonly used for site surveys, was adapted for the laboratory tests with a specifically designed sample holder (a polycarbonate cylindrical cell, 12 cm height and 9 cm width, equipped with external copper plates as current electrodes and internal copper squared-grids as potential electrodes). The optimal acquisition conditions of DC measurements (time elapsed from the sample preparation, external applied electric field and temperature) were determined. Analysis were conducted on eight samples of Quaternary alluvial sediments of the Po plain (Northern Italy), texturally characterized by a coarse-to-fine grain ratio Γd (with threshold diameter d equal to 0.0625 mm) ranging from 0.29 to 61.5. This parameter has been useful to develop the above mentioned phenomenological model, which separates the contribution of the electrolytic, shale and pore solution/solid grains interaction components of electrical conduction. Such a model could be very effective if independent data on fluid conductivity, effective porosity and intrinsic conductivity of the fine sediment fraction are available. Since this last property is not easily measurable, the ongoing research is now focusing on analysis with alternate currents, to estimate both charge transport via classical ohmic conduction and polarization effects in the low frequency range (mHz-kHz), mostly due to charge accumulation against charged fine particles. The combination of electrical conductivity values and phase values is addressed to decrease model equivalence, even in the absence of external data.