Effect of Pore Space Geometry on Electrical Resistivity in Carbonates

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The electrical resistivity in fluid-filled sedimentary rocks is largely controlled by its pore space geometry, as the electric current is conducted predominantly through the pore fluid. Carbonate rocks are notorious for their complicated pore structure and display a wide range in electrical resistivity. Laboratory measurements of electrical resistivity in carbonates in combination with digital image analysis (DIA) of the pore structure help elucidate the complex relationship between the shape and size of pores and pore throats and the flow of the electric charge.

The laboratory setup allows to measure electrical resistivity of fully saturated core plugs under variable confining pressure up to 80 MPa. The pore structure in each sample is quantitatively assessed by DIA of thin sections. Two DIA parameters, dominant pore-size (DOMsize) and perimeter-over-area (PoA) best describe the pore structure of the investigated samples and demonstrate how electrical properties relate to the geological make up of the rock. The cementation factor (m) ranges from 1.75 to 3.5. Samples with a highly intricate pore network and, thus, a high PoA and small DOMsize have a low formation resistivity factor (the ratio of 100% brine saturated rock resistivity over fluid resistivity) and thus a low cementation factor for a given porosity. The resistivity in these rocks is decreased by the extensive network of connected pore throats. In contrast, samples with a similar amount of porosity but with with larger, simple pores that display a large DOMsize have a higher formation resistivity factor and value of m for a given porosity. It is assumed that the large pore void volume can be regarded as electrically dead volume which retards electric current. It is therefore concluded that the formation resistivity factor is dominantly controlled by the intricate network of connected pore throats whereas the pore size itself is less influential. This finding implies that in carbonates the formation resistivity factor and the cementation factor are pore geometrical factors only, and more importantly that the cementation factor is related to pore geometry rather than cementation. The results are of significance for prediction of carbonate pore structure and water saturation (Sw) from downhole logs.