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An Empirical Model for Estimating the Rock Lithology and the Cation Exchange Capacity from Dielectric Permittivity Data

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Abstract

Linear regression analysis has been used in this study to develop a predictive model for the CEC using a data base of dielectric and petrographic parameters for both carbonate and sandstone rocks. Among several predictors of CEC, regression analysis indicates that only five variables are statistically significant for estimating the CEC. These are the static relative dielectric permittivity (ζ_s), the fractal dimension (d'_{MC}), the rock specific surface area (SA), the rock lithology, and the porosity (ϕ). The linear regression model has been tested independently with a random sample that has not been used in the correlation development, yielding an average error of 25% for the tested samples with a standard deviation on the error of approximately 18%. This model appears to be robust in predicting the CEC value, and offers a novel approach for estimating the rock cation exchange capacity using petrographic properties and dielectric parameters.

The CEC increases with increasing $(\phi \cdot SA)$ values, and increases with increasing ζ_s values. As anticipated, for a constant porosity value, the CEC increases with increasing specific surface area. For sedimentary rocks, the cation exchange capacity is a surface phenomenon value that depends on the cation substitution sites, and on the localization on the negative charges on the substitution sites residing on the surface of the particles. This dependence, physically ties the CEC to the specific surface area. This dependence was not obvious when correlating the CEC to the specific area alone, but was clear when the CEC was correlated to the product $(\phi \cdot SA)$. In general, greater values of the fractal dimension implicate a greater degree of fractionation of the rock material, and are, therefore, associated with finer textures. Whereas smaller values of the fractal dimension implicate coarser textures. A greater degree of fractionation implicates a larger reactive surface which may lead to a higher CEC value when the rock texture is clay-dominated. However, for the relatively, clean sandstone and carbonate rock samples used, an increase in the fractal dimension causes a decrease in the CEC value.