A Modified Leverett Approach and PLS-Regression for Integrated Formation Evaluation.

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Abstract.

Two different approaches for core-log integration are presented - one based on a modified Leverett technique and another on Partial-Least-Squares-regression. Data illustrating the techniques originate in a North Sea sandstone reservoir of Jurassic age. Special core analysis data covering three formations consist of air/water capillary pressure (0-15bar) versus saturation, porosities (12-29%), and permeabilities (1.5-2200mD) measured on 23 core plugs. These data constitute a wide-spanning training sample. Subsequent predictions of heights above free water level, saturations or permeabilities are based on conventional core and/or log data.

A traditional Leverett analysis indicates no unifying J-function when applied to the actual data set - systematic permeability trends are pronounced and the possible grouping of individual J-functions has little relation to reservoir units. In consequence, a modified J-function formalism is established. This makes use of scaled capillary pressure and effective water saturation in combination with another permeability dependence while the porosity is discarded. The resulting function is closely fitted to a power function of the effective water saturation. With the data in question this fit showed a correlation coefficient of 0.96 as compared to 0.82 for a similar Leverett procedure.

Compared to the above trial and error procedure, a PLS-regression unifies the training data more stringently while the data structure is efficiently analysed through loadings and scores plots. The PLS-regression establishes training models with correlation coefficients of about 0.97 when capillary pressure or effective water saturation are response variables. Pointing

out that permeability is the overall dominating predictor variable while porosity plays a minor role the PLS-analysis is in agreement with the first technique. Permeability prediction is more uncertain (r=0.82). Relatively little additional variance is accounted for by variables other than porosity. However, the other variables may influence permeability predictions positively.

Because the underlying mathematical problem is almost linearized by pertinent transformations both types of modelings are unaffected by non-linear effects. Therefore, the associated prediction evaluations and error analyses are reliable. It is also noteworthy that the two independent approaches agree mutually within computed limits of accuracy. Although the obtained numerical results may only have validity for the actual field, the analyses show that the two techniques have practical potentials for unifying wide-spanning capillary pressure measurements. Examples based on real data illustrate the applicability of the techniques.