Lithologically Controlled Core-Log-Geocell Integration Using Probabilistic Multivariate Clustering Analysis and an Expert System

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Abstract. A workflow is presented which places far greater emphasis on formation lithology than is usual during the analysis and movement of core data to wireline log scale and then on to geomodel scale. Advanced classification techniques which utilise a consistent methodology at all scales are implemented within the new workflow. Such procedures permit more robust upscaling of petrophysical properties and thus ultimately more reliable hydrocarbon saturation estimates at geomodel scale, being consistently derived from the available core and log data. The lithological classification is also used to refine pore pressure and geomechanical understanding.

Lithological classifications are developed from core plug data and well logs using a Bayesian-based multivariate clustering analysis technique which provides a probabilistic classification at each scale. The probabilistic results at log scale are further analysed with an expert system that automatically assigns a lithology to each cluster and then predicts the probabilistic lithology at each wireline depth. The expert system can be modified for different regions and adjusted (and overruled) by an experienced analyst. The resulting multivariate models, with a consistent probabilistic lithological assignment, are used to QC and, if necessary, predict well log curves in missing intervals along the wellbore. In addition, upscaled core properties can be estimated along the wellbore using a multivariate model that combines core data with log data. Geomechanical properties such as pore pressure and minimum horizontal stress are calculated using lithology-dependent parameters for each rock type.

An example is presented for an onshore conventional gas field in which basic and saturation-dependent petrophysical properties are used to develop robust, related, lithological classifications at each of the core plug and wireline log scales. The developed wireline scale lithology then controls the development of a consistent lithology with associated properties at the geocellular model scale. The impact of different lithologies on hydrocarbon-in-place estimates and geomechanical properties can be clearly evaluated. It is concluded that such outcomes are considerably enhanced by the far better understanding and consistent inclusion of lithology at each scale.

The workflow brings more geological and petrophysical insight into the development of geocellular model properties than is usually employed. The paper outlines a readily understood workflow which fosters practical and insightful interaction between geologists, petrophysicists, and reservoir, geomechanical, and drilling engineers. It also motivates the use of available core data in a far more consistent and robust manner, thus adding value to its collection by improving project outcomes.