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High-resolution reservoir quality prediction from cores by multifaceted analysis: a Carboniferous example from the Dutch offshore

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In Reservoir Quality (RQ) studies, only cores provide an intact sample of the sedimentary rock, which permits various parameters, such as mineralogical composition, texture, diagenetic alterations and porosity-permeability distribution to be measured. However, state-of-the-art routine core analysis (RCA) workflow for RQ prediction is still based on a mere collection of such measurements acquired with different analytical techniques and at different resolutions/scales. This protocol does not include operator-bias evaluation and usually fails at integrating the continuous sedimentological core description with spot measurements on plugs and thin sections. Moreover, RCA data rarely have verified uncertainty specifications, thus hampering statistically-rigorous extrapolation of spot measurements such as petrographic description, to the entire reservoir volume.

Because many sediment properties are interrelated, e.g. porosity is governed by grain size distribution, which in turn is related to mineralogical composition with a specific chemical expression, an integrated analysis of all these data is the best way to understand and predict their behaviour. Non-destructive, in-situ hyperspectral X-ray fluorescence core-scanning (XRF-CS) technology provides a spatially continuous, cm-scale “big-data” environment in which the relationship between the different variables can be statistically explored.

Based on this approach, we have integrated the sedimentological description of a fluvial Carboniferous core with the quantitative petrographic and chemical (i.e. inductively coupled plasma optical emission spectrometry) analysis and plug-derived poro-perm measurements, using the XRF-CS output. The calibration (Weltje & Tjallingii, 2008; Weltje et al., 2015; Bloemsma, 2015) and multivariate statistical analysis of these integrated data allowed us to identify the different diagenetic zones affecting reservoir quality, and to predict their occurrence across three different reservoir intervals. This is the first step of the so-called Integrated Core Analysis (ICA) workflow that we are developing, which intends to overcome some of the main abovementioned issues.

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