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Couy-1 Well, Paris Basin, France - An Open Window on the Toarcian Series for Organic Rich Shale Characterization

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SUMMARY

The COUY-1 well (scientific well drilled in 1987, program "Géologie Profonde de la France") presents a complete log data set, continuous cores and a well known geological context. Consequently, it is an appropriate case study to test the new technologies and workflows for organic rich shale characterization. This well is an open window on the Lower Toarcian shale: "Schistes Cartons" in France, lateral equivalent of the famous "Posidonia Shale".
The integration of various analyses from COUY-1 logs, cores and cuttings (geochemistry, mineralogy, geomechanic, logs...) led us to update the characterisation of the Lower Toarcian organic rich shales, despite the age of the dataset (almost 30 years). These new analytic approaches (QEMSCAN, CT-Scan, Nano-indentation...), coupled to common analysis in an optimized workflow, allow to consider larger studies with heterogeneous databases, long as geoscientists have access to cuttings.
The main analysis recently performed from the COUY-1 dataset by SGS, with BRGM support, will be presented during the WS04 EAGE Workshop and compared with previous studies in Dutch North Sea and SW Algeria.

Introduction

In the course of organic rich shale characterization operational data and samples acquired at the well site play a major role. The mineralogical, textural, geochemical and geomechanical analyses of shale samples (cuttings, cores and sidewall cores) are essential for the shale characterization and the evaluation of their hydrocarbon potential.
The COUY-1 well (scientific well drilled in 1987, in the framework of the French National Program "Géologie Profonde de la France" [1]) presents a complete log data set, continuous cores and a well known geological context [1] [2]. Consequently, it is an appropriate case study to test the new technologies and workflows for organic rich shale characterization. This COUY-1 well is an open window on the famous Lower Toarcian Shale ("Schistes Cartons" in French, lateral equivalent of the "Posidonia Shale", see figure 1).
The main analysis recently performed from the COUY-1 dataset by SGS, with BRGM support, will be presented during the WS04 EAGE Workshop (Amsterdam, June 2014) [3] [4] [5] and compared with previous studies [6].

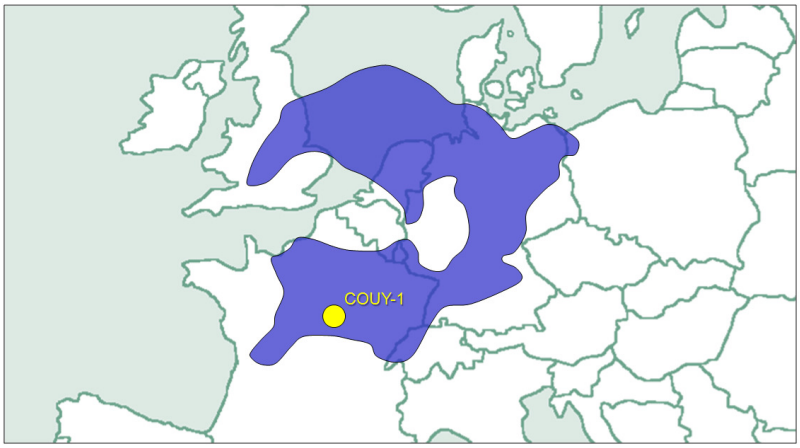

Figure 1 *COUY-1 scientific well location in the south part of the Paris Basin (France). In blue color, distribution of Lower Toarcian organic rich shale, from Frimmel 2004 simplified [7].*

Analytical workflow

Interpretation and integration of organic rich Lower Toarcian shale of COUY-1 are based on operational well data and analytical results from cuttings and core material. The WS04 workshop will focus on mineralogical analysis (QEMSCAN) [3], fracturing characterisation (CT-Scan), geomechanical analysis (Nano-indentation) [4] and log analysis [5].

- Mineralogy (QEMSCAN) - Despite recent advances in instrumentation and associated quantification techniques, mineral analysis methods are prone to a range of uncertainties, particularly in the analysis of fine sediments such as shales. QEMSCAN analyses on the COUY-1 cores and cuttings provide quantitative mineralogical data, textural data and mineral maps of each cutting/core sample, thereby allowing for the detailed characterisation and determination of the nature and distribution of the inorganic sample components. The particles are lithotyped in order to quantify the variations between the samples and brittleness indices were calculated from the modal mineralogy. Detailed results in [3].
- Fracturing (CT-Scan) – The natural discontinuity network in the shale formation (lamination, fractures, microfractures…) is one of the fundamental parameter constraining petrophysical and geomechanical properties. In old wells, in the absence of dipmeter or borehole image logs (BHI), only the rock samples allow to characterize the microfracturing: CT scanning x-rays are utilized to visualize the fracture type, density and distribution [8]. CT scanning is performed on the cuttings sample at a resolution of 2.5 µm. The data set consists of approximately 500 2D images from which a digital 3D image is created. These images are used to analyze the lamination and microfracture networks present in the cuttings, excluded the fracture orientations.

- Geomechanic (Nano-indentation) – In the absence of recent log, only the rock samples can be used to determine shale geomechanical properties. The major advantage of this method is that it applies both core samples and cuttings, very useful when cores are absent or disintegrated during storage or sample preparation. The method is based on a hard tip with known properties that is pressed into the surface of the rock sample. The ratio between the applied load and the displacement of the tip into the sample are used to calculate the hardness and Young's modulus of the sample. Detailed results in [4].
- Log analysis - An integrated workflow, based on the combination and calibration of different data sources, has been applied with the aim to obtain a reliable well-scale organic rich shale formation characterization. The COUY-1 well TOC content has been calculated from available logs using the Passey's formulas with an excellent matching with TOC values from core samples. Mineralogical data (QEMSCAN measurements from core/cuttings) have been used, along with the TOC content, routine core data and petrophysical deterministic analysis, to solve a probabilistic petrophysical model and characterize the mineralogy and the organic content of the shale formation. Once estimated the rock composition, the brittleness index can be estimated by assuming a multi-variable dependence between brittleness index and the shale mineral composition. The brittleness index calculated from the mineral composition is further calibrated with the geomechanical response based on nano-indentation measurements. Detailed results in [5].

Results/Conclusion

The integration of various analyses from COUY-1 logs, cores and cuttings (geochemistry, mineralogy, geomechanic, logs...) led us to update the characterisation of the Lower Toarcian organic rich shales, despite the age of the dataset (almost 30 years). These new analytic approaches (QEMSCAN, CT-Scan, Nano-indentation...), coupled to common analysis in an optimized workflow, allow to consider larger studies with heterogeneous databases, as long as geoscientists have access to cuttings.

References

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