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# The Role of Mineralogy (QEMSCAN) in the Facies Heterogeneity Characterization of Organic Rich Shale

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## SUMMARY

Due to the increased complexity of unconventional plays, existing workflows, developed for more conventional reservoirs, are not always applicable. A better understanding of the rock matrix is critical for the development of improved models for the exploration and exploitation of these resources.
As minerals control fundamental parameters such as grain density and directly or indirectly influence many of the wireline responses e.g. density, resistivity, spontaneous potential, gamma ray etc, accurate determination of the mineralogy is a vital input to petrophysical models. In addition, the composition and fabric of the reservoir rocks control geomechanical properties such as well bore stability and fracking potential. Therefore, accurate and reproducible quantification of the mineralogy and texture of the rock matrix is a particularly important factor in exploitation and development workflows for tight and / or unconventional resources.
QEMSCAN analyses on the COUY-1 well cores and cuttings (Toarcian Shale, Paris Basin, France) 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.

## Introduction

Due to the increased complexity of unconventional plays, existing geological and engineering workflows, developed for more conventional reservoirs, are not always applicable. A better understanding of the rock matrix is critical for the development of improved models for the exploration and exploitation of these resources.

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## Methodology and rationale

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. For instance, optical analysis is dependent on the grain size and the experience of the petrographer whilst X-ray diffraction (XRD) can be influenced by the presence of phases with variable or poor crystallinity and is sensitive to differences in sample preparation. This may be compounded in non-cored and / or lateral wells where cuttings are the only samples available for analysis. QEMSCAN is well-suited to the analysis of shale samples as it provides high resolution, reproducible data (e.g. Power and Burns, 2013), even from cuttings samples.

Nine core samples collected from the play interval of the Toarcian Black Shales of the Paris Basin (Couy-1 well; see Lorenz et al., 1987 and Lasseur et al., 2011) were cut into 20 mm cubes. Once initial nano-indentation analysis was complete, samples were prepared for QEMSCAN analysis. As shales are typically laminated, they are likely to be geomechanically anisotropic. Therefore, in order to provide some mineralogical control on the difference in brittleness between different laminae and sample orientations, each core cube was subsampled three times; one section was cut perpendicular to bedding, the second was cut parallel to bedding whilst the remnant sample was crushed to simulate idealised cuttings material (the third subsample). Each aliquot was then prepared using standard methodologies as a polished epoxy resin block.

After analysis, data were processed not only to determine the modal mineralogy but also to highlight textural detail in the samples. The reported mineral list therefore includes both mineral species and textural categories. For instance, the calcareous clays category (e.g. Figure 1) represents calcite and illitic clays intermixed at the submicron scale (essentially mineralogically impure micrite). Furthermore, to illustrate the degree of lithological variation due to lamination, each particle measured in the crushed samples was categorised on the basis of texture and mineralogy into one of eight lithotype groupings.

## Results and conclusions

At least two distinct stratigraphic units were defined, as illustrated in Figure 1. The uppermost four samples are similar and comprise laminated illitic siltstones with individual laminae of calcite cemented siltstone (calcareous siltstone), argillaceous siltstone (siltstone) and illitic silty mudstone. In contrast, the lowermost five samples are carbonate rich and comprise calcareous mudstones, dolomitic muddy limestone, calcareous illitic mudstone and dolomitic mudstone. In this lower interval, calcite and dolomite occur both as discrete grains / crystals and also finely intermixed with illitic clays (calcareous and dolomitic clays respectively).

Brittleness indices were calculated from the modal mineralogy using the formulae proposed by Jarvie et al., 2007 and Wang and Gale, 2009. However, as QEMSCAN analysis provides textural information in addition to modal mineralogical data, it is potentially possible to refine these brittleness calculations to include the nature / morphology of the mineral constituents i.e. brittle grains versus potentially ductile matrix. These brittleness indices will be compared with nano-indentation data in order to validate and refine the calculations, particularly with reference to the different textural forms of carbonate which are likely to have different mechanical properties.

As oil and gas exploration becomes increasingly focussed on unconventional resources, accurate and reproducible mineralogical and lithological data are essential components of any comprehensive workflow, not only to delineate the detailed stratigraphy, but also to refine petrophysical and geomechanical models.

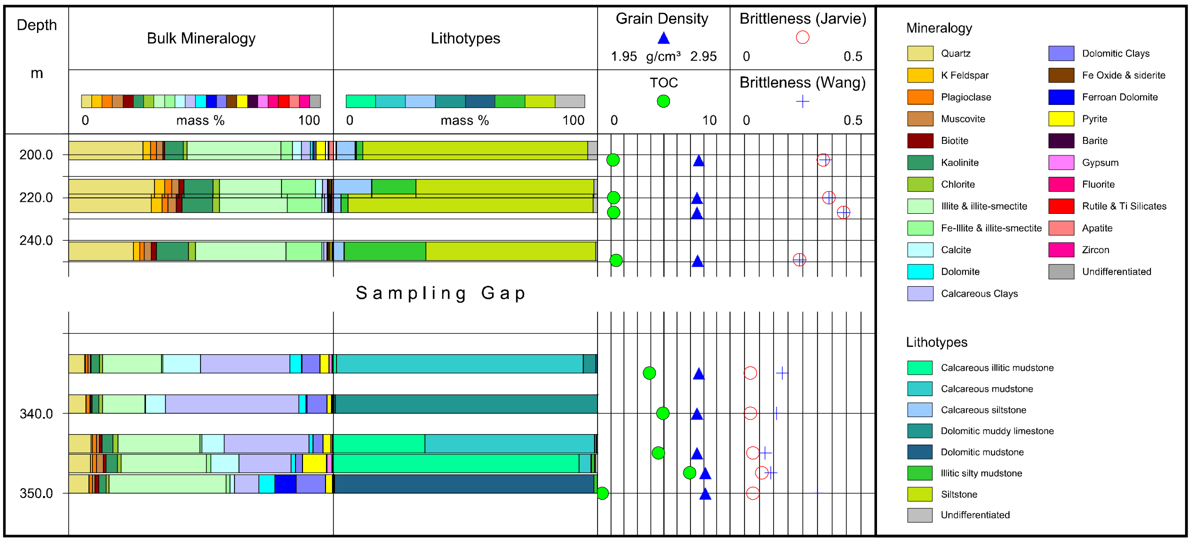


***Figure 1*** *Summary well plot for the simulated cuttings samples only showing the modal mineralogy, lithotype, grain density, total organic carbon, and brittleness indices of Jarvie et al., 2007 and Wang and Gale, 2009. Note that the depth scaling is variable for ease of presentation.*

## References


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