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The Key to High Resolution Reservoir Characterization

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SUMMARY

The core provides essential information on grain-size distributions, porosity and permeability variations as well as rock fabric and texture information, which are essential for facies and depositional environment interpretations. Extrapolation and reconciliation of these core lithofacies with open hole derived electrofacies is often problematic, due to the differences in resolutions between the two data types. Core facies are typically “lumped together” into units that can be segregated based upon their log responses. This up-scaling — often based upon log response cutoffs — can lead to differing rock “types” being lumped together because critical textural information related to sedimentary structures is omitted. As a consequence, stratigraphic correlations become based upon recognition of “log shapes,” rather than true reservoir properties, e.g., grain-size trends, bedding attitudes and facies contacts. Integration of core analysis and core descriptions with open hole logs and borehole image-based texture analysis prior to the stratigraphic interpretation can significantly enhance reservoir characterization and stratigraphic correlation. Key core derived information, e.g., grain-size trends, textures or spatial information, can be more readily extrapolated to high resolution borehole images, which in turn provide the essential intermediate link between the physical core and open hole log responses.

Introduction

The core provides essential information on grain-size distributions, porosity and permeability variations as well as rock fabric and texture information, which are essential for facies and depositional environment interpretations. Extrapolation and reconciliation of these core lithofacies with open hole derived electrofacies is often problematic, due to the differences in resolutions between the two data types. Core facies are typically “lumped together” into units that can be segregated based upon their log responses. This up-scaling — often based upon log response cutoffs — can lead to differing rock “types” being lumped together because critical textural information related to sedimentary structures is omitted. As a consequence, stratigraphic correlations become based upon recognition of “log shapes,” rather than true reservoir properties, e.g., grain-size trends, bedding attitudes and facies contacts. Manual interpretation of facies using open hole logs, borehole image (BHI) logs and core is a method, which works well in clastic successions. The main advantage of this integrated methodology is that core grain-size distributions and core textural features can be extrapolated with confidence into uncored intervals.

Methodology

Manual facies interpretation is an established technique, but the methodology is largely concealed and only occasionally elucidated to through reference to internal company reports or one off papers, e.g., in Samantray et al. (2010). Figures 1a to 1c shows a widely used manual image interpretation scheme from MacPherson et al. (2005) that summarize on a single page, the open hole logs with image log textures. An experienced geologist creates a field specific image facies scheme from a geological image interpretation of borehole image features with a petrophysical interpretation of open hole logs. Characteristic log cutoff values for certain rock types, e.g., argillaceous sandstones, are determined depending on formation log responses, log data availability and data quality in the field.

Figure 1 Image facies scheme (a), image facies (b), image facies association scheme (c) for clastic rocks after MacPherson et al. (2005) in Samantray et al. (2010).

These image log rock facies types are calibrated against core data in the initial phases of a project and combined with geological fabrics interpreted from the image log and core, Figure 1b. This integration of geological textures identified from the borehole images, core and the open hole logs creates a geological facies, e.g., cross-bedded sandstone.

Results

This type of interpretation relies heavily on the experience of the BHI interpreter to correctly identify the key image features, texture and orientation data. The identified image-based facies are then used to identify depositional environments and sediment dispersal directions within the geological reservoir models. Facies can also be combined into associations based upon depositional or reservoir property, Figure 1c. This can help to distinguish between good and poor reservoir “rock types” for instance, where log responses do not clearly differentiate, for instance a cross-bedded clean sandstone (Sx) may have a different reservoir behavior than the equivalent laminated clean sandstone (Sl).

Figure 2 Manual image facies interpretation with core integration and cyclicity analysis.

Conclusions

An integration of the core interpretation, standard petrophysical log analysis, and image-based petrophysical log texture analysis (Figure 2) prior to stratigraphic interpretation can significantly enhance reservoir characterization. Maintenance of key core derived elements through the use of a core calibrated image petrophysics approach is critical to improving the understanding of the spatial distribution of reservoir genetic units.

References

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