

P06

Top Seal Property Evolution and Geohistories

R.J. Knipe* (RDR Ltd), G. Lewis (Chevron USA Inc.), S. Muhuri (Chevron USA Inc.), M. Johnson (Chevron USA Inc.), M. Welch (RDR Ltd), G.M. Phillips (RDR Ltd), M. Hertle (Maersk Oil and Gas AS) & D. Condliffe (RDR Ltd)

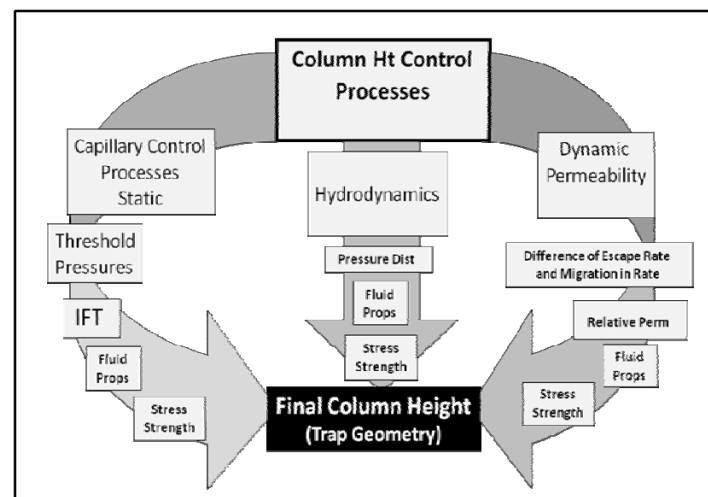
SUMMARY

The use of geohistory information to assess the best practice needed for the prediction of top seal properties in exploration is reviewed. An integrated approach combining petrophysical measurements, microstructural characterisation, down-hole tool data with basin modelling and tectonic setting is used to evaluate top seal property evolution. The results are used to highlight the importance of temperature - pressure histories for constraining top seal predictions. The study has incorporated top seal development from a range of basins. The identification and application of property-geohistory trends is used as a basis for a discussion on the prediction of sealing capacity and column heights.

Introduction

The prediction of trapped hydrocarbons requires an understanding of the petrophysical and mechanical properties of top seal lithologies. A review of the progress made in identifying the best practice to quantitatively evaluate and risk top seal for exploration via the incorporation of geohistory assessment is presented.

The work has involved the characterisation of a range of top seals from different basins and the integration of petrophysical, mineralogical and microstructural analyses with down hole tool data and burial history modelling. Quantitative analysis of seal rock has been combined with detailed geohistory data with the aim of more accurately defining the critical controls, constraining the uncertainties and evaluating the possible prediction levels. The work has focused on assessing the impact of temperature, burial and effective stress histories on the developing pore throat network parameters that control the flow and capillary sealing capacities. An additional objective has been the evaluation of the different processes that can control hydrocarbon column heights.

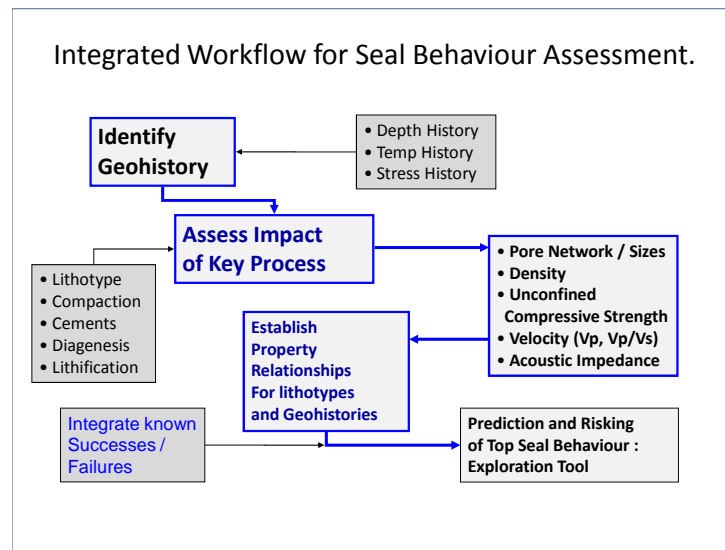


Review of seal control processes and parameters.

Study Areas

An evaluation of the variation in top seal properties from different basins with differing burial and / or tectonic histories. i.e. with different geohistories, is reported. The aim was to identify the key controls and to assess the predictability of top seal properties in each area. Prediction of the top seal properties depends upon understanding the relationships between the lithotype properties and the different geohistories experienced. Quantifying these relationships is fundamental for generating robust predictive 'tools' and depends on an evaluation of the pore-structure evolution and the strength development of the potential top seals during variable geohistories. The areas assessed include the Norwegian Sea (Voring Basin - Haltenbanken areas), the Gulf of Mexico and offshore Nigeria, where the combination of sample characterisation, down hole tool data and the regional tectonic setting of a number of wells were used. The project targeted shale samples from regionally extensive maximum flooding surfaces known to trap significant volumes of hydrocarbon. These samples were analyzed using conventional techniques (quantitative x-ray diffraction, scanning electron microscopy and capillary pressure analysis) to quantify their physical characteristics. The results were then combined with basin models to provide pressure and temperature histories for the seal rock.

The generalised work flow used in the assessment is shown below.



Critical Factors

The critical geological factors that can be assessed and impact on the seal property development include:

1. Burial Related Compaction, i.e. the maximum depth and effective stress history. This controls the porosities, densities, and the rock velocities.
2. Temperature History, i.e. the temperature-depth-time profiles. This controls the cementation / diagenetic history, impacts on the lithification state, and thus the sealing potential and strength (brittleness) of the seal.
3. Mineralogy, i.e. the clay and detrital mineral content and types (smectite, illite) together with cementing minerals, impact on the response to the above geohistory elements.
4. Tectonic history, i.e. the tectonic setting and associated stress system. For example the uplift magnitude, which includes both footwall uplift associated with fault block rotations, and inversion related exhumation.

Outcomes

The combination of potential parameters that can control seal properties, listed above, varies for the different geohistories and basins assessed. This variation provides the basis for the development of new databases and effective workflows for top seal property assessment. The trends emerging were calibrated using actual column height data from hydrocarbon accumulations and have been used to develop tools for predicting top seal properties.

The final result has been the generation of basin specific predictive seal property prediction tools for exploration that can form the basis for estimating sealing capacity and column heights; where a geohistory, clay content and burial depth can be used to define a likely range of hydrocarbon columns for a particular opportunity. In many cases without accurate definition and integration of regional pressure-temperature regimes the present day hydrocarbon columns could not be explained.