Integrating Seismic Technology and Core-Log Analysis in Characterization of Reservoirs with Complex Lithologies

Chen, Jiajie (Jeff)[1], Don Caldwell[1] (1) Marathon Oil Company, Houston, TX

In a western African oil field with mixed siliciclastic-carbonate inputs, applying seismic amplitude volumes to resolve reservoir architectures was highly challenging. Here we took an alternative approach – using seismic acoustic impedance (AI) volume as the base for an integrated study involving regional geology, depositional environment, sequence stratigraphy, detailed seismic-core-log correlation, facies analysis, and reservoir modeling. The intervals concerned correspond to two 3rd order cycles, but the AI volumes were actually capable of revealing 4th order cycles by some high AI streaks. We described available cores, linked the seismic AI with log curves and core data, and further developed a depositional model based on which reservoir framework was established. Two new wells were drilled based on this model; both successfully predicted the positions of reservoir tops and payzone distribution. This study led to new understanding on reservoir architecture and flow unit distribution, depositional processes and their relationship with hydrocarbon accumulation. It also provided a reasonable volumetric estimation that was important to our field development plan. We conclude that for a complex geological setting with mixed carbonate and siliciclastic inputs, it is important to apply innovative seismic technology and integrate a large spectrum of datasets and methodologies in order to understand how the depositional systems and associated lithofacies responded to regional tectonic activities and global eustasy sea level variations, and how the reservoir zones distributed under the overall geological setting. All these results prepared us in a better position in business decision and field development.

Development Well and Execution Planning in a Complex Subsurface Environment – the Impact of Large and Small Scale Modelling on Well Deliverability

Philip, Giles[1], Steve Twartz[1], Jeromy E. DePledge[1] (1) Woodside Energy Ltd, Perth, Australia

The Thylacine Gas Field is in the Otway Basin (Offshore SE Australia). The interplay of intra-field faulting and the intrinsic layered geology mean that there is the potential for a high degree of compartmentalisation. A significant proportion of the reserves are thought to reside in the reservoirs of the Thylacine Sandstone Member, which are poor quality marine sands interbedded with thick successions of thinly bedded sand-shale and shale.

The Thylacine development required a low cost, high efficiency development concept to tap these difficult reservoirs. The horizontal wells required careful positioning and design to best exploit the resource due to a mix of the complex structure within the field as well as reservoir quality and distribution uncertainties. Installation of the Thylacine Alpha platform provided a base for drilling of these horizontal well. In an effort to better place the wells, and in some way predict the outcome of the wells, both deterministic (using Jason RockTrace) and probabilistic (using Shell proprietary software) AVO inversions were carried out. Simple acoustic impedance models showed improved resolution over the PSDM data, and provided considerable insight into reservoir architecture and geometry. In parallel, a review of the available core and log data from the exploration/appraisal wells supported construction of a geological model with a large degree of built-in predictability. The combination of predictive geological model, aimed at improving sub-seismic resolution, and seismic inversion to identify trends in seismic scale reservoir geometry proved invaluable in both the well planning and execution phases of the project.

This paper outlines first the planning phase of the wells and the outcome of the execution phase.

Diverging 3D Seismic Attributes Characterize Pores and Fluid Fill of Unayzah-A in Eastern Province, Saudi Arabia

Sodagar, Taher M.[1], Abdel Fattah M. Bakhiet[1] (1) Saudi Aramco, Dhahran, Saudi Arabia

Unayzah-A is a prolific hydrocarbon bearing reservoir in Eastern Saudi Arabia. Characterizing the variability of this aeolian reservoir and understanding the hydrocarbon fill are crucial in unlocking its gas potential. An integrated analysis and interpretation of 3D seismic and well data from the eastern province, was carried-out to not only provide a better understanding of the reservoir facies distribution, its paleo-depositional set-up and compartmentalization, but also to address the porous rock distribution and the associated fluid fill.

A multitude of seismic-based attributes such as DETECT and CURVATURE, interval absolute amplitude and acoustic impedance show details that are interpreted as an indication of the presence of porous units and the associated fluid fill that are governed by the structural modifications of the area of interest. DETECT and CURVATURE revealed the presence of four major north-south fault trends that controlled the topography during the Hercynian and resulted in Unayzah sequences filling the paleo-lows. A minor yet important perpendicular fault further segmenting the reservoir is also observed. Acoustic impedance at Unayzah-A level indicated porosity development in a southerly direction as evidenced by well-driven porosity maps in contrast to the northerly trend in fluid fill type as evidenced by interval absolute amplitude and well results. The diverging result from these two seismic attributes suggests the fluid type and porosity prediction can best be achieved by considering multi-attributes.

Deepwater Lithofacies Prediction from Seismically Derived Estimates of Porosity and Clay

Oppert, Shauna[1], Michael Farrell[2] (1) Exxonmobil Exploration Company, Houston, TX (2) Exxonmobil Upstream Research Company, Houston, TX

Reservoir properties are extracted from seismic data by constraining seismic inversion with rock physics relationships. We employ these relationships to simultaneously invert for porosity and clay in all fluid types. This can allow for improved characterization of both the reservoir and aquifer areas. From these seismically derived porosity and clay volumes, we predict the deepwater lithofacies using relationships that can be established from core data and well logs. The resultant seismic volumes aid in the optimization of drilling production wells and water injectors.

Traditional seismic inversion results are accurate only for a limited frequency band. Band-limited seismic inversion results can be useful as sand indicator volumes, however, the lack of low frequencies can cause errors when using these results in a more quantitative manner. We overcome this problem by incorporating low frequency data built from geologic information into the seismic inversion. The integration of environment of deposition maps, sub-regional seismic stratigraphic mapping, and average reservoir properties provide a basis for linking the seismic inversion results and the geologic model. This results in a more detailed and accurate prediction volumes for clay and porosity. Comparisons at wells show a good match to known lithofacies from core data to the seismically derived lithofacies.

Imaging Anisotropic Symmetry Using Prestack Converted-wave Seismic Data for Fracture Analysis

Gumble, Jason E.[1], James E. Gaiser[2], Robert H. Tatham[1] (1) University of Texas at Austin, Austin, TX (2) WesternGeco, Denver, CO

In an effort to extend practices developed for land 9C data to the marine environment, where we are limited to the use of converted waves for purposes of anisotropy analysis and characterization of rock properties, imaging of anisotropic symmetry for fracture analysis was made using prestack, converted wave seismic data. Models and real data were used in the investigation. Models included transverse isotropy with a horizontal axis of symmetry (HTI) commonly associated with vertical fractures, and tilted transverse isotropy (TTI) commonly associated with dipping fractures. The multi-layer models included varying degrees of anisotropy and dip. It was found that by using layer stripping techniques modified from those designed for poststack seismic data, that the anisotropic symmetry could be imaged using both amplitudes, and time differences resulting from shear-wave birefringence. When applied to two real data sets, one in the Gulf of Mexico and one in the Williston Basin in North America, the technique was able to image anisotropy in areas of high data coverage. In the Gulf of Mexico, depositional fabric was interpreted as the dominant factor in creating the anisotropy, and in the Williston Basin – open fracture direction and intensity were interpreted and compared to previous analysis using other techniques – including well log analysis, vertical seismic profiling and direct shear-wave surface seismic. We determine that the inclusion of azimuth and offset variations in the analysis is an important and necessary part of anisotropy analysis, which demands the use of prestack seismic data analysis and processing techniques. We also examine the effects of limited azimuthal coverage on such analysis and investigate possible corrections applicable in the data processing phase.