Journal of Himalayan Earth Sciences 43 (2010) 7-7

New dimensions to play fairway evaluation within a sequence stratigraphic framework: Eocene carbonate play, southwestern part of the Lower Indus Basin, Pakistan

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Sequence stratigraphic methodology provides a powerful tool for subdividing the stratigraphic succession into genetically related sedimentary packages using key sequence stratigraphic surfaces. Spatial and temporal relationship of the depositional systems corresponding to each genetic package is a key to defining the petroleum play elements and documenting their extent and geological uncertainties. The methodology involves the preparation of geoseismic sections and wireline log/outcrop correlation panels at regional scale. Wheeler diagrams (Stratigraphic Charts) are then prepared and can be converted to Chronostratigraphic charts after a biometric or chronologic calibration. Subsequently, a Petroleum System is formulated based on a potential or proven source rock within the sedimentary succession of interest. Reservoir-Seal pairs are then identified to define plays and reconstruct/draw the play schematics. Lithofacies and respective depositional systems are delineated for both the reservoir and seal through an integrated use of outcrops, cores and logs to make Gross Depositional Environment Maps. These maps are the foundation of reservoir and seal distribution maps and the Common Risk Segments maps. Overlaying the reservoir, seal and source maps provide the play fairway map showing the areas of low, medium and high chances of success.

Case study of the Paleocene-Eocene Dunghan-Laki play fairway is presented from the southwestern part of the Lower Indus Basin and nearby shallow offshore region. Sequence stratigraphically, the play comprises Dunghan equivalent falling stage systems tract shelf-margin carbonate buildups overlain by the transgressive systems tract shale (top seal) of the Laki Formation. Further up in the stratigraphic section, a lack of thick shale between the thick and massive Middle Eocene Kirthar Limestone and the underlying Highstand shelf-margin carbonate buildups of Ypresian age (equivalent to the upper Laki Formation and SML of the Fold Belt) makes the Laki carbonates a high risk play. Based on limited stratigraphic information from a couple of boreholes that penetrated the relatively viable part of the play fairway, e.g., Karachi South 1A, a lack of 'thick and regionally pervasive' top seal (shale or marls) turns out to be the key geological risk at play level. Accordingly, the key de-risking challenge lies ahead in the form of predicting the extent and thickness of this seal element. It is possible to address this uncertainty through precise well-to-seismic tie, geological characterization of the correlative seismic reflection geometries and carrying out a seismic stratigraphic interpretation to extrapolate the sequence stratigraphic correlations away from boreholes into the tracts of Thanetian-Ypresian carbonate buildups both onshore and offshore. In this way, part-plays (geographic sectors) can be high-graded to prioritize and focus 3D seismic surveys and subsequently carry out high-resolution seismic stratigraphy to precisely demarcate different geomorphic elements and their thicknesses. Sectors of thick shale deposition and lateral carbonate-to-shale transition can be, thus, defined to map structural and stratigraphic traps that fall within the high-graded part-play.