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Geocellular Modelling and Connectivity Analysis of a Tide-Influenced Channel Belt System: Example from the Mitchell River Delta, Gulf of Carpentaria, Australia

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Abstract

The interaction of tidal and fluvial processes in marginal marine settings, particularly tidally influenced channel systems, can produce profound lateral and vertical facies heterogeneity, in forms such as Lateral Accretion Packages (LAPs) and Inclined Heterolithic Stratification (IHS). LAPs form at the convex banks of sinuous channels, and can be composed of either homogeneous or heterogeneous deposits. Within tidal reaches, they are often comprised of IHS deposits. IHS deposits are inclined alternating shale and sand layers that form by laterally accreting fluvial-estuarine point bars. Understanding the 3D distribution of tidally influenced channel architectures in modern channel systems has important implications for the effective modelling of subsurface channel reservoir distribution, connectivity and fluid flow. In this research, 3D geocellular modelling of a selected modern point bar from the Mitchell River system, Gulf of Carpentaria (GoC), Queensland, Australia, is used to predict heterogeneity and connectivity associated with a tidally influenced channel reservoir system.

The modelling workflow consisted of four main stages: (a) data integration, (b) mapping, (c) geocellular modelling and (d) connectivity assessment. Analysis of high-resolution satellite imagery merged with Shuttle Radar Topography Mission Digital Elevation Models data for an area of 14.57 km × 2.34 km allowed direct mapping and measurement of dimensions and orientation of the stratigraphic architecture of the selected point bar geometry. Core and auger well log data and a stratigraphic cross section oriented perpendicular to the channel axis were used in order to constrain the stratigraphic architecture and the facies distribution. Five facies were identified in the studied point bar strata, including Lag Sand Deposits with rippled sandstone 2.5 m thick, which is common in upstream locations on the point bar, and heterogeneous sand and mud facies. Inclined heterolithic mud deposits (IHS) are confined to the upper 3 m of the point bar.

As the focus of this project is the impact of IHS on reservoir connectivity, a new approach was proposed to resolve the heterogeneity associated with tidally influenced channel systems, by developing three geological models based on the presence and continuity of IHS deposits (the products of fluvial and tidal interaction processes). Connectivity analysis of the three realisations showed marked contrast between models using point bar geobodies. The tide-dominated, fluvial-influenced channel system represents the worst reservoir connectivity in the subsurface, as the volume contains considerable bodies of mainly mud facies. Although there are significant

objects in this point bar model, the majority of these bodies are very small and supposedly form 75% mudstone of the total volume. In scenario two (Ft channel system; fluvial dominated, tidally influenced channel system), the model suggests fluid flow will preferentially concentrate in the lower part of the point bar, where clean sand sediments form a continuous body. The geo-volume in realization three (F channel system; fluvial dominated channel system) reflects the connectivity of the channel comprised of just the point bar object, which can represent best reservoir continuity and limited compartmentalization. Thus, reservoir quality increases as the fluvial process in the channel system becomes more dominant.

We recommend that further field work, such as a new stratigraphic cross sections, should be obtained parallel to the channel axis in order to capture 3D heterogeneity within tidally influenced channel systems, and that the Fullbore Formation Microimager tool should be used to obtain the corrected inclination of IHS deposits.

Keywords: Tidal, Fluvial, Lateral Accretion Packages, Inclined Heterolithic Stratification, Lag Sand Deposits, Rippled Sandstone, Heterogeneous Sand, Heterogeneous Mud, Net/Gross, Fullbore Formation Microimager

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