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Geometry and wireline signatures of tidal sandstone reservoirs: outcrop analogues from Brunei Darussalam

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Traditionally, the petroleum reservoirs in Brunei Darussalam have been interpreted as wave-dominated delta deposits but recent studies show that a significant number of the producing reservoirs are tidal sandstones. The reservoir properties and geometries of these two reservoirs types are significantly different, therefore it is important to be able to distinguish them. To date, the characteristics of the tidal reservoirs have not been described in detail. Consequently, the objective of the study is to determine in outcrop the reservoir properties and geometry of tidal sandstones and to recognise equivalents in subsurface.

The outcrop facies include tidal channel sands, tidal sand flats, tidal mud flats, embayment mudstones and coaly shales. Tidal channel sands are dominated by fine clean sandstones. Individual channels are typically 3 to 4 m wide and range from 0.5 m to 1.0 m in thickness. Sedimentary structures consist of high angle cross beds, mud clasts at the base of channels, asymmetrical wave ripples and bioturbated bedding surfaces.

Tidal channel units are laterally continuous for at least the 230 m lateral extent of the outcrop with only minor variation in thickness. There is a consistent nett to gross of 90% and channel sand units are ~3 m but can be stacked to much greater thicknesses (up to 19 m in the outcrop). Reservoir quality can be reduced somewhat by lateral variability in sandstone thickness and the presence of mud-filled channels.

Tidal channels have minor vertical permeability barriers caused by mud laminae capping most channel sets. However, successive sands remain connected and lateral continuity is preserved because the mud caps are discontinuous. Porosities are typically higher in the tidal channel sands (~20%).

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Tidal sand flats consist of thin fine sands interbedded with muds. The sands typically contain organic matter as laminae with occasional coal clasts. Sedimentary structures consist of lenticular bedding, wavy bedding, flaser bedding and reactivation surfaces.

Tidal sand flats have lateral continuity in the order of tens of metres and a highly variable nett to gross (ranging from 90% to 60% in sections 90 m apart) due to rapid lateral changes in the thickness of muds. Tidal sand flats are typically less than 1 m thick, which limits the volume of the potential reservoir. Porosities are relatively low to medium (~12%—~15%), because intergranular porosities are clogged by clay pellets. Major vertical permeability barriers occurred due to laterally extensive muds within the unit. Horizontal permeability is controlled by the lateral continuity of individual sandstone packages.

A portable gamma ray spectrometer was used to create a synthetic outcrop gamma log. The tidal channel sands show a tabular signature with sharp contacts . Subsurface successions that have been interpreted as tidal sandstones have a similar gamma signature, suggesting that it is possible to identify tidal successions with wireline data. Higher resolution tools such as FMI and OBDT logs may be required to confirm a tidal genesis.