Depositional controls on petrophysical properties and reservoir characteristics of Middle Miocene Miri Formation sandstones, Sarawak

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Abstract: Rock exposures around the town of Miri, Sarawak, belonging to the Miri Formation (Middle Miocene strata), represent the uplifted part of the subsurface sedimentary strata of the Miri oilfield. Data derived from outcrop studies concerning facies and sand body characteristics, and petrophysical properties are crucial for subsurface reservoir characterization and modeling of hydrocarbon reservoirs deposited in similar settings. The aim of this paper is to integrate lithofacies and petrophysical properties of Miri sandstones, in order to characterize and quantify the Miri reservoirs.

The Miri Formation consists of a wide range of siliciclastic, tide-generated and storm-and wave- generated facies. Twelve lithofacies have been identified and grouped into two major facies associations: (i) the estuarine, tide-

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dominated, and (ii) the shoreface-offshore transition, storm-and wave-dominated facies associations. The estuarine lithofacies are characterized by distinct and diagnostic tidal signatures; tidal dune cross-bedding with mud draped cosets and foresets including mud couplets, bidirectional (herringbone) cross-bedding, rhythmic stratifications, flaser bedding, wave bedding and lenticular bedding. Shoreface-offshore transition, storm-and-wave facies association is represented by sandstone bodies with evidences of storm and wave generated sedimentary structures; swaley cross-stratified sandstones, amalgamated hummocky cross-stratified sandstones, bioturbated sandstones and mudstone inter-bedding with parallel stratified to hummocky cross-stratified sandstone.

Petrophysical properties were determined for six sandstone lithofacies: (i) Lithofacies A (multiple stacked trough cross-bedded sandstone, tidal channels and bars, estuary mouth), (ii) Lithofacies B (parallel-bedded sandstone of estuary upper flow sand flat), (iii) Lithofacies F (homogeneous coarse sandstone, outer estuarine tempestites), (iv) Lithofacies G (swaley cross-stratified, upper-to-middle shoreface sandstone), (v) Lithofacies I (fine-grained bioturbated sandstone of the lower shoreface) and (vi) Lithofacies L (fine-grained, hummocky cross stratified sandstone, offshore transition).

These lithofacies are characterized by a wide range of permeability values, which vary by several orders of magnitude (0.35 to 287 md), while porosity vary by only a few percent. Lithofacies A and F recorded the best reservoir properties; porosities are 23.3-29.7% and permeabilities are 9.64-287 md. Lithofacies G shows a wide range of porosity and permeability values that range from high to low reservoir properties; porosities are 23.5-27.5% and permeabilities are 3.4-45 md. Lower shoreface and offshore transition (lithofacies I and L respectively) display the lowest reservoir properties; porosities are 13.5-24.5 % and permeabilities are 0.35-3.4 md. In general, high reservoir quality of Miri sandstones is associated with coarser grain size, low clay contain and better sorted grains. Extensive clay drapes, bioturbation, and increasing proportion of very fine grains content result in significant decrease in permeability in both tide-generated and wave-generated lithofacies.