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SEDIMENTARY FACIES CHARACTERISTICS AND RESERVOIR PROPERTIES OF TERTIARY SANDSTONES IN SABAH AND SARAWAK, EAST MALAYSIA

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Sandstones are very important as reservoirs for oil and gas; more than 50% of the world's petroleum reserve is estimated to occur in sandstones. Depositional environments, and thus facies characteristics, determine the overall reservoir properties of sandstones. The purpose of studying the reservoir sedimentological characteristics and petrophysical properties of Tertiary reservoir quality sandstones from Sabah and Sarawak is to investigate and determine the relationships between sedimentological and facies characteristics, and reservoir properties of the different types of sandstones.

Sandstones from Sandakan Formation (Sandakan, Sabah), Miri Formation (Miri, Sarawak), Nyalau Formation (Bintulu, Sarawak) and West Crocker Formation (Kota Kinabalu, Sabah) were investigated and analysed in this study. The sedimentary sections represent a variety of rock types in terms of depositional facies and ages.

The Sandakan, Miri and Nyalau sandstones exhibit strong depositional facies control on their poro-perm properties. Many previous studies have shown that the reservoir quality (porosity and permeability) of sandstones are strongly influenced by their depositional facies (Scherer, 1987; Ramm, 1999; Sylvia et.al., 2000). The sandstone lenses (gutter casts) from Sandakan recorded the highest poro-perm (Φ :> 20%; k :> 10md), but with very limited lateral and vertical continuity. The HCS and SCS from Sandakan show moderate poro-perm (Φ: ~20%; k: 1-10md) and good lateral continuity. HCS and SCS sandstones from Miri recorded better poro-perm values than TCB sandstones because they are generally better sorted, fine average grain size and lack muddy laminations or drapes. Bioturbated sandstones from Miri are with low porosities due to the poor sorting caused by infiltration of silty or muddy particles. The high density values (d: ~2.3g/cm3) for Nyalau sandstones reflect a higher degree of compaction and cementation than Sandakan and Miri sandstones. The lower porosities of Nyalau sandstones (Φ: ~15%) reflects their burial history/ compaction.

The sandstones of West Crocker Formation show close relationships between diagenesis and poro-perm values, because these sandstones have undergone higher degree of compaction and cementation (geologically much older than Sandakan, Miri and Nyalau Formations). These sandstones recorded high densities (d:2.3-2.8g/cm3), high velocities (v: 4500-7500m/s) and low poro-perm values (Φ: <10%; k: <1md). Many studies have shown that diagenesis tends to accentuate the influence of depositional factors on the reservoir quality of sandstones (Wilson and Stanton, 1994; Nagtegaal, 1979; Weber, 1980). However, diagenesis may also influence reservoir properties in an irregular manner or even reverse depositional controls (Wescott, 1983; Stonecipher et. al., 1984).

HCS sandstones of Miri Formation show high reservoir qualities (Φ :> 20%; k :> 10md) with good lateral extent and uniform thickness (Table 1). The HCS and SCS sandstones of Sandakan show moderate reservoir qualities. They are fine grained, moderately sorted and with occasional mud lamination. The reduced sorting and the presence of mud laminations must have contributed to the slight reduction in reservoir quality. Low poro-perm values, high densities and high velocities Crocker sandstones are tight, non-reservoir quality sandstones because they have been cemented and compacted. Different phases of structural deformation and diagenetic modifications may further complicate the porosity and permeability evolution of these sandstones (Carpenter et al., 2006; Collins et al., 2006).

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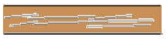
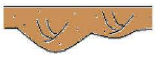
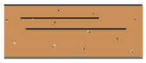
Table 1: Geometry, sandstone facies and reservoir quality of the different sandstones investigated in this study.

Geometry Sketch	Type of sandstone	Formation	Quality of Reservoir
	Gutter cast (Trough cross-bedding)	1.Sandakan	Non-reservoir quality
	Hummocky cross-stratified	1.Sandakan 2.Miri 3.Nyalau	Moderate quality High quality Low quality
	Swaley cross-stratified	1. Sandakan 2. Miri	Moderate quality Scatter?
	Bioturbated	1.Miri	Low-Moderate quality
	Trough cross-bedding	1.Nyalau 2.Miri	Low quality High-moderate quality
	Parallel to massive (Compacted, cemented)	1.Crocker	Non reservoir quality