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Wave and Tide Influence in Neogene Paralic Hydrocarbon Potential Reservoirs in Sabah

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Evaluating mixed-energy clastic paralic system requires detailed facies analysis, whichdetermined tide and wave regimes efficacy. This approach is applied to paralic successions in Neogene Sabah basin, utilizing well preserved outcrop data, guarded paleoenvironmental modeling. Series of field excursions revealed that the tidally-wave generated deposits formed significantly thick successions in the central region of Sabah interpreted as paralic depositional system. The overall sedimentary units consist of upward-coarsening successions interpreted as prograding storm wave-, tidal-influenced deposits, indicating greater variability of coastal processes. Shoreline paleoenvironmental modelling suggests that a large-scale stratigraphic change from relatively tide-dominated to wave influenced facies successions reflects the development of wide embayments with early suppressed energy, the Tanjong Formation and the lower part of the Sandakan formation. These unitsare graded into mainly thick sequence of swaley-hummocky sandstones that erosionally overlain by subordinate tidallywave-dominated successions of planar cross beds. The overlying subset rock units are exposed in Sandakan Peninsula and Meliau basin display a change towards greater storm-wave energy and the development of storm-flood parasequences. Stratigraphic units of paralic systemin Sabah that possibly host potential hydrocarbon reservoirs are shaped by a wide range of depositional processes that reflect the distribution of sediment, the characteristics of the receptacle basin and the dynamics of depositional systems. This formed thick Neogene paralic sequence; with abundant evidences of fair-weather condition signatures in the thick flaser sandstone interbeds indicate significant tidal influence to depict probable hydrocarbon reservoir potential.

Keywords: dominated sequence, Paralic environment, Reservoir potential, Neogene basin

I. INTRODUCTION

Various established Neogene shallow marine lithologic units in Sabah by previous workers are proven in this study as paralic depositional systems. Paralic depositional system has not been described in detail from any ancient sedimentary record in Sabah. Modeling of paleo-marine sedimentary processes has been applied in order to better decipher the relative autogenic controls on stratigraphic architecture in these variable, mixed-energy clastic paralic potential reservoir. Such reservoirs contribute significantly to global conventional hydrocarbon production. Facies models for paralic system consider wave-, tidal-dominated, shallow marine systems essentially imply microenvironment conditions associated with

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shoreline and beach, and consider solely the effects of storm and fair-weather tidal energy, and sediment caliber on the resulting facies successions. An integral part of such system is the distinction between a supratidal and a subtidal interval in paralic environment. Paralic depositional system are largely associated with fair-weather tidal and wave processes and the development of tidal-forced currents, leading to the dominance of heterolithic layers associated with large scale cross beds and bioturbation. Bioturbation in such mixed-energy depositional system is sporadically distributed and generally of lower intensity. Beach setting of lower to upper shorefaces is dominated mainly by some combination of fair-weather bioturbation and storm-generated event beds, with fair-weather waves largely confined to the role of sediment sorting and winnowing of clay and silt. The morphology and sediment dynamics of beaches and shorefaces can be greatly affected by increases in tidal range, illustrated by a growing body of literature on modern paralic systems (Sanudin *et al.,* 2014). The most important impact of a large tidal range on beach dynamics is the shift of position of wave agitation throughout a tidal cycle, which affects both the duration and the nature of wave processes influencing a given part of the beach-shoreface profile, with tide-generated currents being subordinate (Sanudin *et al.,* 2015). Observations from modern tidal-dominated systems in Sabah clearly suggest that the impact of tides is significant and that recognisable suites of facies for such deposits should exist. We present a case study of a thick paralic depositional sequence, that extensively crops out in central Sabah as the Tanjong and Sandakan formations (Figure 1 and Figure 2) and the best exposures are in Sandakan Town, Meliau basin and Imbak Canyon with low values of free-air gravity anomaly (Nordin *et al.,* 2016). Excellent outcrop exposures allow detailed facies observations, facilitate the evaluation of the relative importance of tidal processes sedimentary system, and widely open to the recognition of similar deposits elsewhere in Sabah and other parts of Borneo (Sanudin *et al*., 2010).

II. METHODOLOGY

This study uses outcrop analysis to explore the sedimentary structure and processes, stratigraphy and the depositional environment of the study area. Basic sedimentology data such as highlighting rock composition, physical properties, facies analysis, sedimentation units and including current structures recorded in vertical log analysis. The stratigraphic procedures in this observation were carried out according to International Stratigraphic Guide. Measured sections have been analysed for sedimentary facies characterization from number of selected outcrops at the study area. Surficial weathering of the outcrop hinders detailed examination of the thinly interbedded sandstone and mudstone components of the outcrop. This facies characteristic however, is well expressed in most of the out crops. Examination of stratigraphic interval allows detailed facies observations in sandstone and mudstone dominated portions of the succession, as well as observations of stratigraphic features on different spatial scales (Junaidi *et al.* 2015; Muhd Nur Ismail & Sanudin, 2017). Sedimentary logs from measured sections are presented in the facies analysis requirement (Figure 2). Selected sandstone samples were analysed for mineral and physical properties by using polarized research microscope and SEM available at the department.

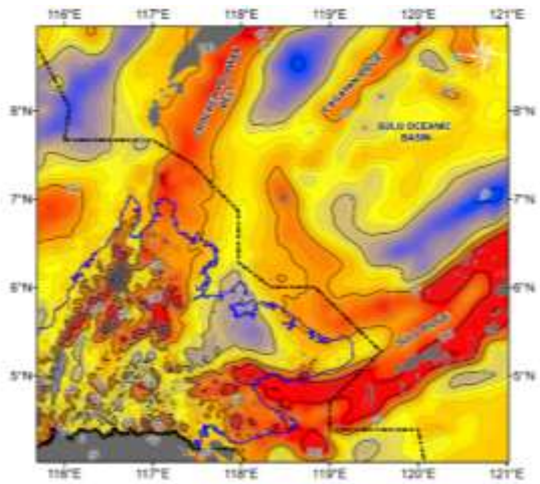

Figure 1. Free-air gravity anomaly map in Sabah combining airborne gravity (Sabah area) and DTU10 satellite altimetry (outside Sabah territory), outlined by blue colour, (contour interval = 10 mGal) (Nordin *et al.*, 2016)

Figure 2. Geological map of Sabah showing paralic sediment in yellow colour (Yin, 1985)

III. SEDIMENTARY FACIES

Facies observations from the outcrops indicate that the interval generally coarsens upward from a largely homogenized mudstone with thin, laminated sandstone layers in the basal portion, through heterolithic, mudstone- and siltstone-dominated lower portions to sandstone-dominated upper portion. The entire coarsening-upward sequence is succeeded by burrowed and unburrowed sandy and silty mudstones passing into regionally mappable sequence. The base of the mudstone-dominated lower interval is not exposed in the measured sections. Sandstone-dominated heterolithic interval of rippled sandstone and mudstone layers is overlain abruptly by non-bioturbated sandstones that pass into bioturbated mudstones. The entire coarsening-upward succession contains abundant carbonaceous debris, which locally forms distinct carbonaceous laminae. The coarsening upward succession in the study area has been assigned to five facies, which are heterolitic facies, swaley cross beds, hummocky cross beds, planar cross-bedded facies and thick mudstone facies (Figure 3 and 4). There is no evidence of the occurrence of channelised layer throughout the observation. Individual facies is described as follows.

A. Heterolithic Facies (He)

Heterolithic facies consists of interbedded layer of sandstone and mudstone formed from low energy tidal current rippled fine sand layer and mud deposit during fair weather periods.

The heterolithic layers are flaser with more than 50% sand, lenticular more than 50% mud and almost equivalent amount as wavy. Horizontal planar parallel-laminated amalgamated bedsets several tens of centimeters in thickness are more abundant upward interbedded thin fine sandstone showing the gradational changes to the upper facies. The outcrop with thickness up to 20m show thick heterolithic bed gradually change from domination of flaser bedding to lenticular bedding, interbedded with medium to fine grain sandstone (Figure 3). In flaser and wavy bedding have intense bioturbation and the common trace fossil can be found is *Ophiomorpha*.

Weakly traced heterolithic layers are dominated by bioturbated sandy mudstone, with lesser bands of fissile, and parallel laminated to oscillation ripple laminated very fine- to fine-grained sandstone layers, lenticular beds. This facies is dominated by mudstone layers ranging in meters-scale thicknesses, occupying the lower unit of the sequence. In some intervals, laminated mudstones directly overlie scoured surfaces truncating underlying thin sand laminae.

Flaser bedding may developed when the rippled sand layer is formed by higher energy during high tidal currents in which the depositional and preservation of sand are more likely to form rather than for the mud. Meanwhile the mud is deposited during slack tide periods in which the lenticular more favourable to form when the current and wave action is suppressed and allowing minimum sand to be deposited. These three types of heterolithic sedimentary structures are common in the Tanjong Formation and lower sequence of the Sandakan Formation, interpreted as tidal flat deposits. The accumulation of this heterolithic layer probably deposited in low energy aqueous environment by the settling of grains from low energy fair-weather conditions.

B. Hummocky Cross-Stratified Facies (HcS)

Bedding sets of this HcS overlying the heterolithic successions is a sandstone-dominated interval. The erosional boundary between the two in some parts of the measured section is sharp and, in places, undulatory owing to small-scale scour with interfingering in other parts. This relationship gave grading in some parts and truncates in other parts. The sandstone scour in outcrop occurs on meter scale in width and decimeter scale in depth. Overlying the scoured surface is sandstone-dominated interval consisting of meter-scale, erosionally amalgamated, moderately to well-sorted, fine-grained sandstone. The cross-stratified interval is almost entirely lacking mudstone laminae and beds, with sandy components containing thin layer carbonaceous siltstone (Figure 4a). Bedsets infilling scours of the hummocks tend to be more sand rich toward their bases, and more flaser like with organic rich towards way-up. Sandstones are medium to fine grained, and are commonly sharp based, with gradational to locally planar cross laminated at tops. Sandy low-angle undulating small-scale hummocky cross-stratification and long-wavelength oscillation ripples bounded by mud layers are common.

The HcS is thick-bedded and sand dominated facies, from one meter thick sand bodies that persist over several hundred of meter in outcrop. The lithological sequence of this facies is composed of medium to coarse-grained grains sandstone. The dominant sedimentary structure is the hummocky cross-stratification. The gentle undulating layer has wave lengths of less than a meter to few metersand heights from swale to adjacent hummocky of almost equivalent dimension. The upper set of hummocky cross stratification beds show small scale symmetric ripples and, at places, the hummocky sandstone underlies the swaley cross-stratified sequence. Sandstones are dominated by truncation-bounded, low-angle, undulatory parallel to cross laminated beds occupying scours resembling those of the undulating structure, and are interpreted as hummocky complex cross-stratification formed at lower shoreface environment.

C. Swaley (ScS)

These facies preserve a record of higher energy and probably high frequency episodic storm deposition, which is reflected by the presence of ScS. This suggests deposition dominated by combined oscillatory and bidirectional flow conditions on the shelf during storms. Facies models often show ScS to overlay intervals dominated by HcS. Preferential formation of swales rather than hummocks has been attributed to the higher aggradation rates due to high deposition– to–transport ratios that typically occur in shallower water during storms (Figure 4a and 4b). The upward increase of carbonaceous laminae and beds within swale bedsets suggests waning current velocities and increased depositional rates for material with lower energy settling velocities. Organic-rich intervals showing rhythmic bedding likely represent immediately waning energy sedimentation that was not completely eroded by subsequent storm-related scour. Rare heterolithic intervals suggests occasional conditions of fair-weather energy tidal deposits and preservation, although their general scarcity implies that such conditions were unusual. The swaley cross-stratified sandstones pass upward into a low-angle to horizontal planar stratified sandstone. The dominant sediment quality of the succession is typically upper fine- to medium-grained clean sand.

These facies are meters in thickness of clean sand exposed at the upper section of outcrops and may or may not associate with planar cross beds at tops. The most common primary sedimentary structures within the swaley cross bed sands are parallel to low-angle cross-lamination, thin mudstone bedding and swaley cross-stratification. The size of the swaley structure increases with increasing bed thickness. In the study area the swaley cross-stratification generally overlies the hummocky cross stratification, suggesting a genetic link between them. In a prograding shoreline sequences, the swaley cross bedded facies is directly overlain by foreshore deposits, which suggests that these facies is part of a storm-dominated structure upper shoreface formed above wave base.

D. Planar Cross-Stratified Facies (PcS)

This facies is characterised by the present of planar cross-stratified bedded sandstone with thin layer of mudstone interbeds. The thickness of the facies range from few meters to tens of meters. The field observations suggest that the planar stratified interval is genetically related to the underlying strata, and is part of an overall progradational, coarsening-upward and shallowing upward parts of the paralic succession (Figure 4b). Sandstones are dominated by truncation-bounded, low-angle, parallel laminated beds occupying scours resembling truncated swales, and are interpreted as swaley cross-stratification at lower section. The swaley cross-stratified interval is almost entirely lacking mudstone laminae and beds. Bedsets infilling planar tend to be more heterolithicand organic rich toward their bases, and more sandy towards their tops.

The horizontal planar stratified interval needs to be reconciled with the widespread evidence for storm domination and tidal influence in the underlying swaley cross-stratified sandstones and heterolithic intervals.This overlying planar bedsets dominated by high energy sandstone interval consisting of erosionally amalgamated, well-sorted, winnowed coarse-grained sandstone of foreshore environment.

E. Thick Mudstone (Tm)

Comprises of mudstone-dominated layer that grade downwards into dominated carbonaceous heterolithic layers. The mudstone portion of the facies association is moderately exposed in outcrop, improving markedly as siltstone and calystone ratios with sandy bed thicknesses decrease. Mudstones are characterized by bed-scale variations from silty claystone, to dense, massive, fissile and largely unburrowed claystones (Figure 3). Weakly burrowed claystones are gray in color, locally silt-poor and apparently structureless, normally graded, and/or containing thin parallel interlaminae of silt and sand. In some intervals, graded and laminated mudstones at base directly overlie planar bedsets of scoured lenticular truncating underlying sandstone planar laminae.

Mudstones are well exposed in the study area, especially along a river course, developed in units of varying thicknesses, traceable in out-crops for tens of meters. The accumulation of carbonaceous-mudstone probably deposited in low energy aqueous environment by the settling of grains from suspension in a logoon environment. The flat-bedded sedimentary structure or most commonly no structure of this facies also reflect lagoonal environment.

IV. FACIES ASSOCIATION AND ENVIRONMENTAL DEPOSITION

After examining several measured sections of the rock units of the Tanjong and Sandakan formations in the study area, the facies associations were assigned. The facies analysis information suggested that the characteristics of the facies are part of the paralic system of shallow marine environment, specifically ranging from foreshore associated with lagoon to tidal and shoreface depositional environment with the influence of wave and storm events (Figure 5). Both HcS and ScS facies are part of the parasequence located at the shoreface of a shoreline environment at the study area. The sequence is dominated by HcS facies at the lower set, gradually coarsening upward with facies combination between HcS and ScS and the middle course and finally dominated by ScS at the upper set. The total thickness of every set varies according to rock unit and location. The ScS facies characteristic is either graded or abrupt with the PcS facies. Regular interfingering between PcS facies and the Tm facies can be observed in several sections in both rock units. These wave dominated parasequence is underlain by very thick tidal influence shoreline deposit of He facies. These facies associations are assigned to be part of the lagoonal shoreline deposits of a wide spread paralic system of Neogene basin (Figure 5).

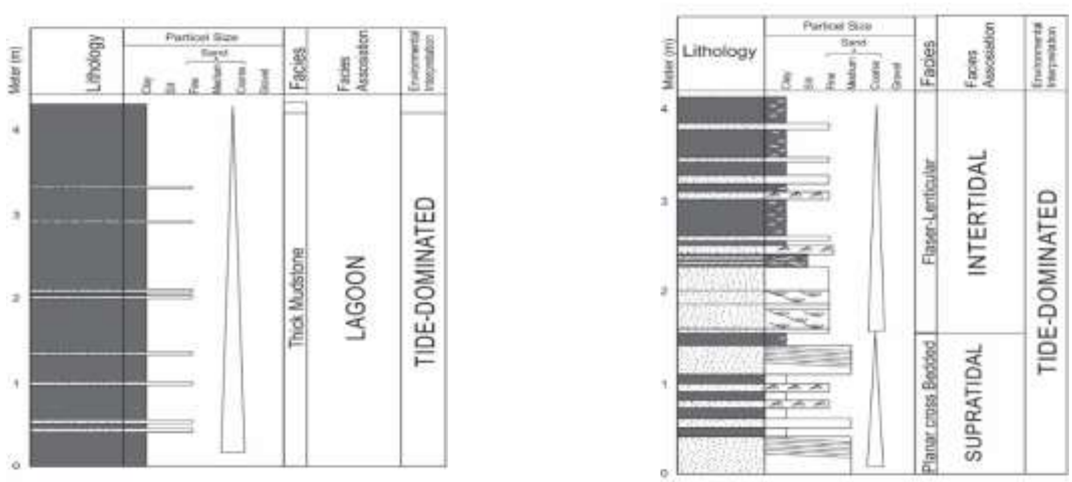

Figure 3. Self-explained measured sections (at Imbak Canyon) showing sequences of facies associations of the Tanjong Formation

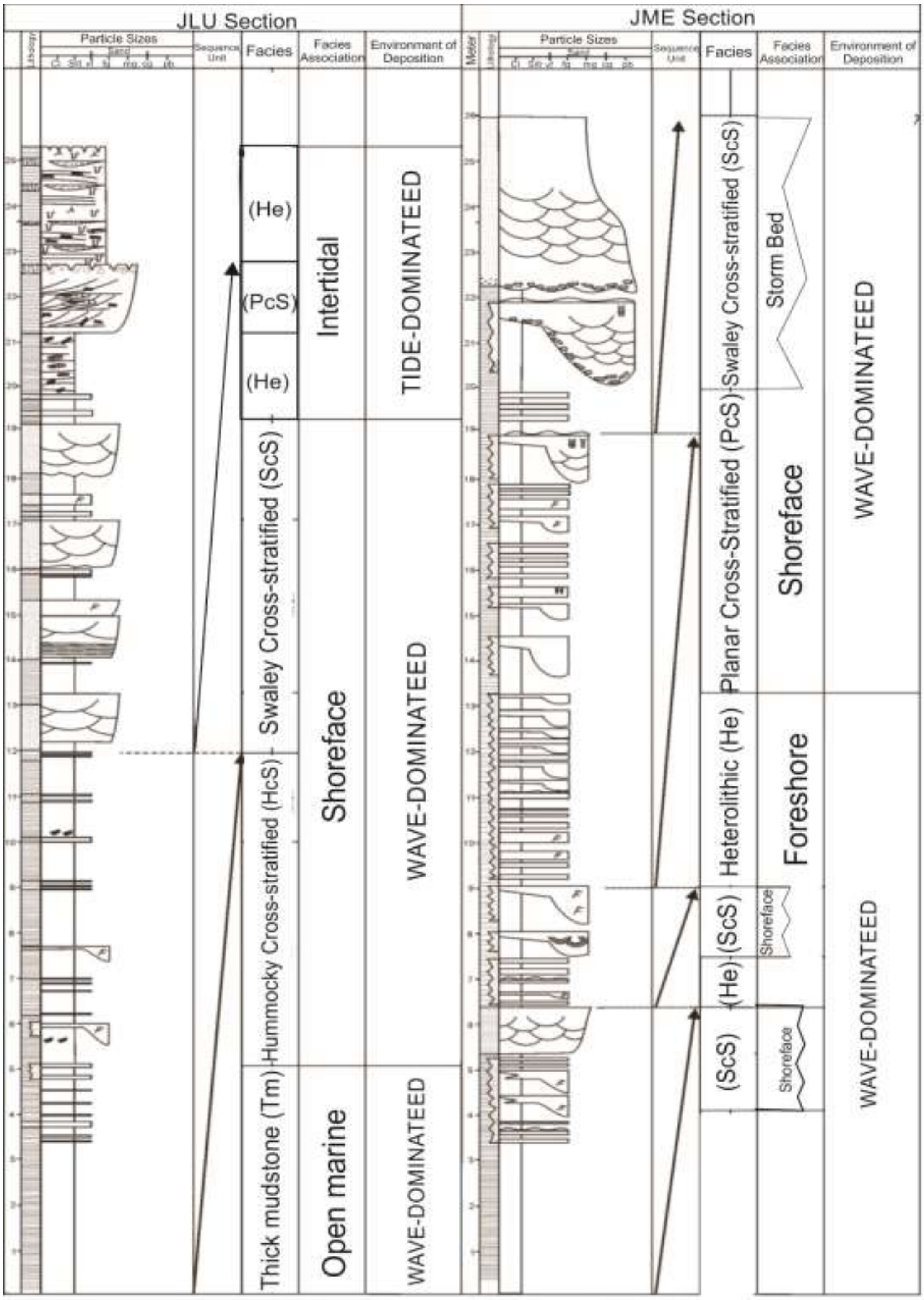

Figure 4(a). Measured sections (at Sandakan Town - JLU: North Bypass Road and JME: Mellrose Rd) showing the facies analysis of the Sandakan Formation

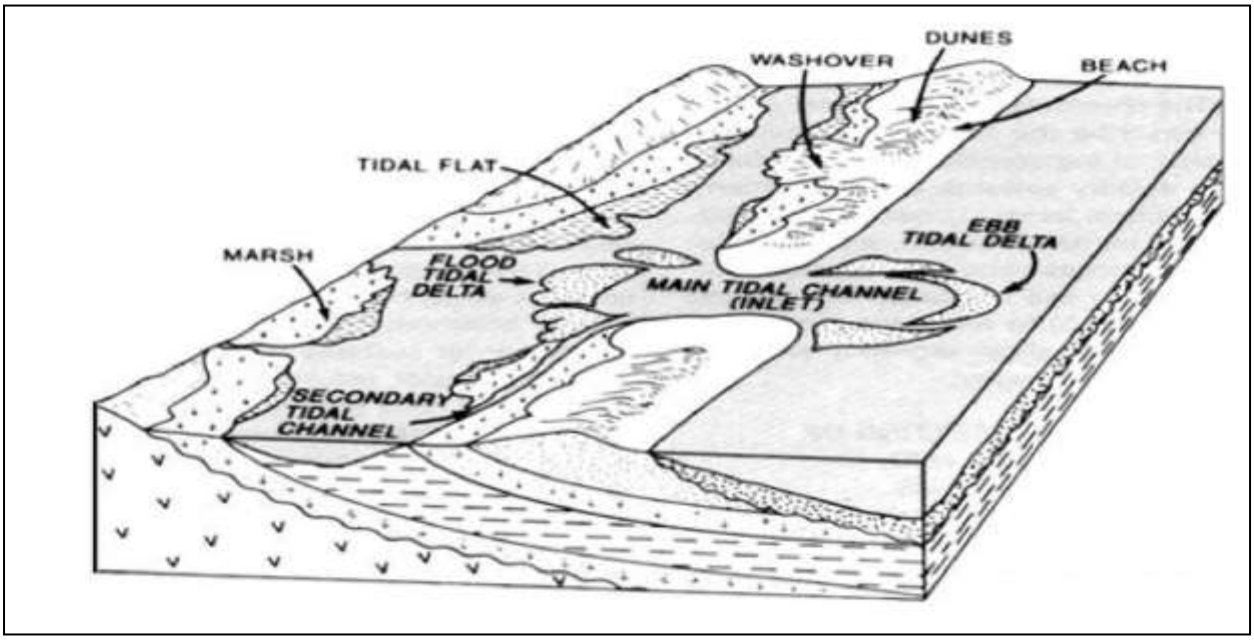

Figure 5. Depositional model in a paralic system can be considered as equivalent to that of the study area (modified from Reinson, 1992)

V. PETROGRAPHY

Petrographic sections of good sorting sandstones were selected from swaley-hummocky cross bedded sandstone and were analysed. Sandstones are texturally and mineralogically mature quartz arenites with good sorting allowing good porosity and permeability. The major component of the selected thin section contains almost equal shapes and sizesof quartz minerals with tangential and long grain contacts. These grain contacts observed in the selected sandstone and are interpreted as secondary growths in between grains during the accumulation of long history authigenesis (Figure 6 and 7). Sippel (1968) has suggested that this characteristic is an intergrowth contacts that may caused intergrainular pressure solution following authigenesis. Quartz overgrowth is clearly demonstrated in between grains showing the result of pressure solution. This resulted in the decrease effective porosity and reduced the capillary passages. However, major dissolution of authigenic cements and labile grains increase the secondary porosity. Estimated pore volume is between 18% to 22% porosity. Detrital types of mineral identified from this section are as follows:

Quartz: Quartz constitutes the most percentage of grains in the samples identified, forming more than 70% of the total grains. They are typically sub-angular to subrounded monocrystalline grains. These grains are abundant and have uniform to slightly extinction optical property. These grains conform in character to the common quartz grains of other Neogene rock units in Sabah, and are debatably considered to be recycled orogenic belt origin. Polycrystalline quartz grains, with highly strained extinctions, comprised to 5 – 8% (visual estimation), possibly derived from older recycled metamorphic sources, have been recognized. Those are the equant micro-interlocking quartz crystals. Other quartz characteristics are composite grains, fused of two or more strained sub-crystals with poorly defined crystal boundaries.

Feldspar: feldspar grains occur in quantities rarely exceeding 10% of the detrital suite, and are present in every examined samples. The dominant feldspar type is plagioclase with multiple typical lamellar twins of albite. Feldspar is seen to be altered to sericite and/or clay minerals. Primary depositional controls affectively account for significant difference in the distribution of feldspar origin. Alteration of feldspar occurs along cleavage orientation, resulting the formation of ineffective secondary porosity. Lithic Fragments: this detritus constitutes of mainly sedimentary origin from a recylcled provenance, which rarely forms less than 5% of the components. Mudstone clasts form the major component of lithic fragments.

Micas: mica detrital form a minor component with variable percentage in the samples. This component is not more than 1%. Muscovite and biotite are the most common detrital, with rare chlorite detritus.

Opaque and heavy minerals: this grain present in a variable perncentage with maximum of 2%. Generally only stable opaque minerals were observed, dominated by enhedral to subhedral shape, include; zircon, spinel, and hematite.

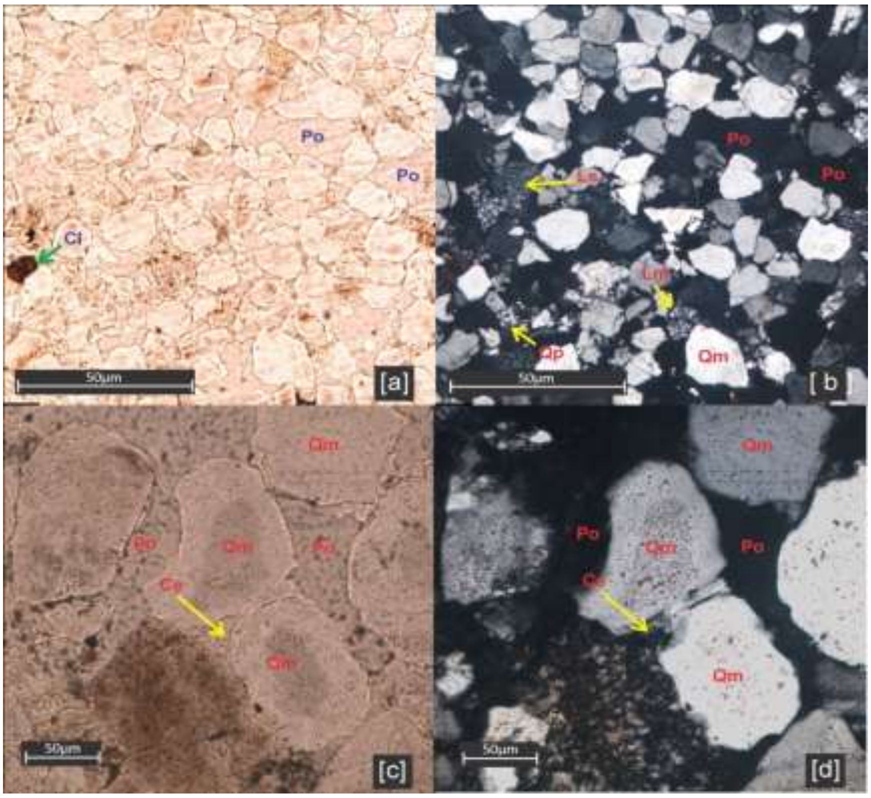

Figure 6. Tanjong sandstone microgrpah: Qm – monocrystalline quartz, Qp – polycrystalline quartz, Lm and Ls – lithic grians, Ce – cement, Cl – clay and Po – pore space

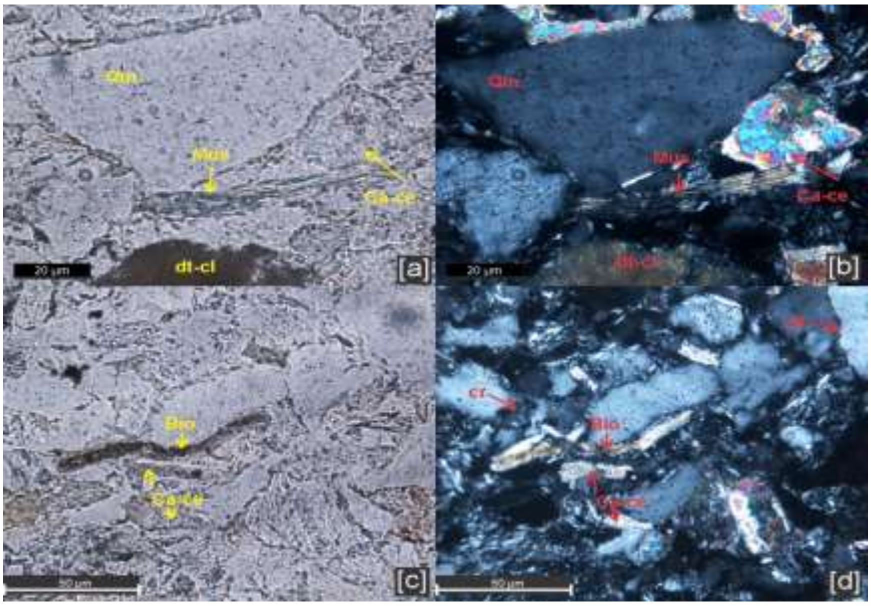

Figure 7. Petrographic section from a selected sandstone from Sandakan Formatiom: Qm – quartz, Bio – biotite, Mus – muscovite, Ca-ce – calcite cement, gr – quartz overgrowth and dt-cl – calcite detritus.

VI. DIAGENETIC EVIDENCE

A. Cement and Authigenic Clay Minerals

Data sets of SEM from swaley-hummocky sandstone facies indicate the following reservoir quality prediction of paralic depositional system in Neogene sedimentary basin in Sabah (Figure 8): (a) grain coatings on quartz grains (e.g., clay mineral, chlorite, polycrystalline quartz) as an inhibitor of quartz cementation, (b) depth as vertical effective stress due to overburden pressure reduced pore volume, (c) diagenetic secondary porosity related to dissolution of labile framework grains and matrix improve pore quality. Early diagenesis involved precipitation of authigenic clay mineral to reduce primary porosity. This is the beginning of the early porosity occlusion. Porosity general decreases with depth as the result of cementation and compaction. Different degree occlusions occur in different facies according to percentage of clay matrix. Cleansandstone in swaley-hummocky facies may retained the porosity quality compared to that of other facies.

B. Quartz Cement

Quartz overgrowth cement is believed to have developed contemporaneously and is considered synchronous within the continuous sandstone diagenesis during preceding lithification. Quartz overgrowth cement usually developed along the contact between quartz grains and is typically syntaxial to anhedral form that exhibit both compromise and free growth boundaries. This detritus usually requires space in between grains to be precipitated. Heavy clay matrix may responsible for the clay coatings to the quartz grain to the inhibition of quartz cements.

C. Authigenic Chlorite

Chlorite content in the samples observed is not as much as other types of cements. Pore-lining chlorites are usually developed in intergranular networks. It also occurs as rims surrounding the perimeter of detrital grains. Chlorite consists of microcrystalline plates, aligned in a grain-perpendicular form, occasionally enclosed by quartz overgrowths. Chlorite pore lining fringes are commonly developed upon detrital mixed layer clay substrate. Pore bridging chlorite crystals were also observed in some samples. Chlorite forms very occasionally as replacement of sausoritised feldspar and decayed lithic grains.

D. Authigenic Kaolinite

Authigenic kaolinite is estimated to be distributed in primary voids, limiting connectivity and presenting zones of isolated microporosity. Intergranular pores are locally filled with clusters of vermicular kaolinite, consisting of euhedral, fresh stacks with evidence of illitisation. Blocky habits are also noticed in some samples. In occasional cases, kaolinite phase (partially illitised) locally replaced detrital micaceous mineral.

E. Authigenic Illite

Authigenic illite cement is developed in most of the samples analysed (Figure 8). Illite is one of the pore occluding cement. The formation of illite cement in the Sandakan and Tanjong sandstone could be as the result of the reaction between a labile mineral and kaolinite in the presence of connate water in pore spaces at deeper burial. This illitisation process, however, is less responsible for the loss of porosity that affected the sandstone during diagenetic process. Fibrous illite was recorded forming thin lining along pore walls and thin coating around detrital grains.The above result of the sandstone diagenetic study indicated that the sandstones of the Sandakan and Tanjong are characterized by three main stages of authigenic-mineral formation: (i) an early diagenetic-clay coating around detrital grains, (ii) formation of kaolinite at intermediate burial depths, and (iii) growth of pore bridging illite at the final stage of deeper burial.

VII. RESERVOIR CHARACTERISTICS

In the Neogene paralic sandstone facies, important characteristics such as porosity, permeability, and diagenetic properties were determined by a combination of depositional and burial effects. It is critical to know the distribution of these properties within a basin in order to achieve the maximum efficiency in reservoir management for hydrocarbon potential. For reservoir potential in the study area, a quantitative work in characterizing and evaluating the reservoir is needed to understand the reservoir characteristics. Knowledge of the sandstone sandstone properties is essential in the exploration for, and the production of subsurface hydrocarbon potential. Besides that, it is also essential to understand the reservoir and its capacity. Petrophysical properties are influenced by porosity, permeability, velocity and density; these properties are partly controlled by facies characteristics which in turn are related to depositional processes.

Sandstone porosity in the study area varies from 18% to 22%. In case of visual thin section study, porosity is highest in the well sorted clean sand of the swaley-hummocky facies. Secondary pores are the abundant pore types and are affected by dissolution of labile minerals and authigenic cements. Secondary intergranular pores are primarily associated with the dissolution of calcite cement and other authigenic clay cement. Microporosity is associated with the presence of authigenic clay minerals, especially kaolinite. Porosity reduction is expected to be sandstone diagenesis and depth controlled. Intergranular macroporosity is inversely correlated with cement and authigenic clay percentage. It implies that intergranular macroporosity reduces with increasing cement. With increasing depth the detrital grain contacts are turned from tangential to long contact and thus reduced porosity. At greater depths, the volumetric amounts of quartz and clay cement increases and partially occlude intergranular pore spaces.

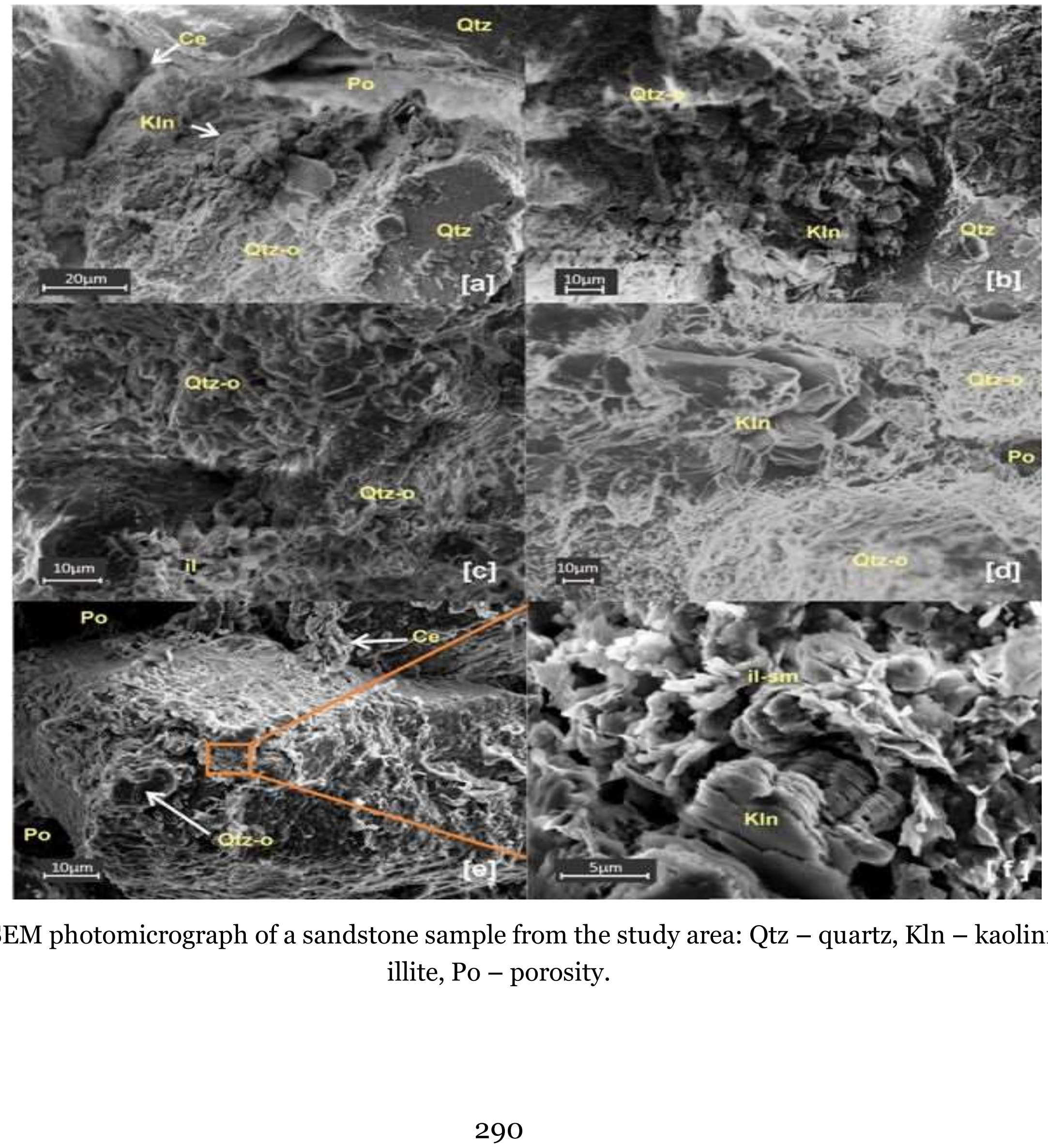

Figure 8. SEM photomicrograph of a sandstone sample from the study area: Qtz – quartz, Kln – kaolinite,il – illite, Po – porosity.

VIII. DISCUSSION AND CONCLUSION

Facies observations from the outcrops revealed the interval generally coarsens upward from a largely homogenized mudstone with thin, laminated sandstone layers in the basal portion, through heterolithic, mudstone- and siltstone-dominated lower portions to a sandstone-dominated upper portion. The entire coarsening-upward succession is capped by burrowed and unburrowed sandy and silty mudstones passing into a regionally mappable sequence. The base of the mudstone-dominated lower interval is not exposed in outcrops. Sandstone-dominated heterolithic interval of rippled sandstone and mudstone layers is overlain abruptly by non-bioturbated sandstones that pass into bioturbated mudstones. The entire coarsening-upward succession contains abundant carbonaceous debris, which locally forms distinct carbonaceous laminae, and rare beds. The measured upward succession of paralic system at the study area can be differentiated into five facies, namely; Heterolitic facies, swaley cross beds, hummocky cross beds, Planar Cross-bedded facies and thick mudstone facies (Figure 3 and 4). Data sets from shoreface facies association dominated with thick swaley-hummocky sandstone cross stratifications indicate the possible reservoir quality of paralic depositional system in the Neogene sedimentary basin in Sabah.

The Tanjong and Sandakan formations, Upper Miocene age, as a potential reservoir is largely dependent on the facies and original sandstone composition, which was influenced by deposition in a paralic setting, local sourcing and depositional activity. Sandstones representing swaley-hummocky cross bedded for petrographic analysis are texturally and mineralogically mature quartz arenites with good sorting gave good porosity and permeability, which is in agreeable to that of other Neogene potential reservoirs in Sabah (Sanudin *et al.*, 2015). Grain framework as detritus of the sandstones is dominated by quartz, minor feldspar and lithic fragments. Cement component recognized in this study include quartz, kaolinite, calcite, and illite. Reservoir quality is mostly controlled by the pore occluding authigenic cements. Porosity, permeability and cement characteristics exhibit good agreement to each other. Thus, the thick swaley-hummocky sandstones of the shoreface facies association interbedded with sandy heterolithic layers (flaser) of the Tanjong and Sandakan formations are generally the selected good reservoir potential.

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