

# The reconstruction of 3D geo-lithological model of Pekan, Pahang: A possible onshore extension of Penyu Basin

ASHLEY AISYAH YOONG, ABDUL GHANI MD RAFAK, KHAIRUL ARIFIN MOHD NOH\*  
& RADZIAMIR MAZLAN

Department of Geosciences, Universiti Teknologi PETRONAS, 31750 Tronoh, Perak, Malaysia

\*Corresponding author email address: khairula.nmoh@utp.edu.my

**Abstract:** Well studies have confirmed the presence of Quaternary sediments in both onshore and offshore areas near the township of Pekan in Pahang, while the Tertiary sediments are only found offshore. This could be well-explained through the palaeo-environmental evolution of the Tertiary sediments in Penyu Basin, where it started from continental (older sediments) to marine (younger sediments) environments, suggesting that transgression had occurred causing the Pahang River delta to be located where it is today. In fact, the presence of ancient river channels found in the Penyu Basin supports the transgression claim. Thus, to prove the possible extension of the basin, this paper aims to delineate the geometry of the basement at Pekan area, as well as to study the distribution of different basement rocks in the area by reconstructing the geo-lithological model of Pekan. Thirty (30) well data from previous work, conducted by the Jabatan Penyiasatan Kajibumi Malaysia in 1992 and 1993 were used to reconstruct the geo-lithological model. Utilizing the *Lithoblending* algorithm to reconstruct the model has allowed us to have a greater control on the model by using nearby well data to extend the lithology laterally, rather than extrapolating vertically below the boreholes, which can lead to inaccuracy in correlation. The outcome of the geo-lithological modelling revealed that the basin originates 5km from the present shoreline, deepens and widens towards the east, i.e. offshore area. In addition, two different types of basement rocks were identified in the area, namely weathered granite and metasediment. The contact between these two basement rocks, are found to be underlying the present-day Pahang River. The deepening and widening of the basement as well as the contact point between the basement rocks is interpreted as corresponding to the opening of the Penyu Basin.

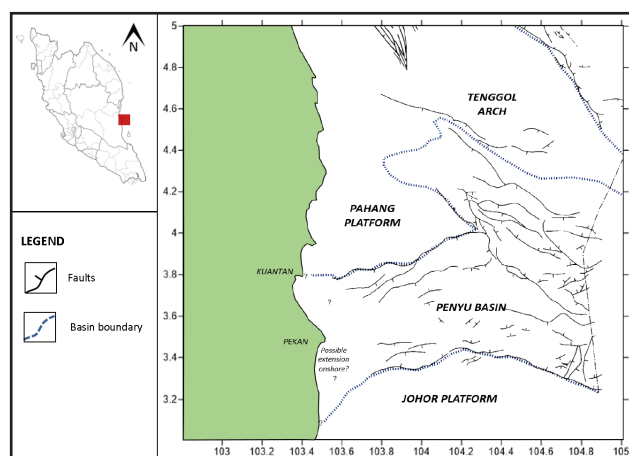
**Keywords:** geo-lithological model, modelling, subsurface of Pekan, Penyu Basin

## INTRODUCTION

Penyu Basin is an elongated Tertiary basin with an extent of 160 kilometers by 100 kilometres, making it the smallest basin among the three basins of the Malay Dome (Tan, 2009). It has been explored for the past 40 years with previous studies mainly focused on the development of the basin as well as its potential fields. The work done were generally used to assist in uncovering the geometry of the Penyu Basin which had contributed to a better understanding of the basin evolution history.

However, it can still be argued that the geometry of the basin is not well-defined, despite the known location of the basin. This was due to a statement made in 1989, where Hutchison had suggested that the Penyu Basin extends onshore (Figure 1), underlying the alluvial plain of Pahang River (Madon, 1996). This claim was later supported by Tjia where he stated that the western part of the Penyu Basin depression extends under the Pahang River delta (Tate *et al.*, 2008).

There might be a possible linkage between Penyu Basin and the Pahang River delta, considering the morphology of both areas. In fact, ancient river channels and oblique prograding delta were among the sedimentary features found within the chaotic facies of Early to Middle Miocene sedimentary succession in Penyu Basin (Liew *et al.*, 2002). This observation could serve as the key to unfold the relation between the Penyu Basin and the Pahang River delta. However, presently there are insufficient reliable data and



**Figure 1:** The possible location of the Penyu Basin onshore extension (modified from Tate *et al.*, 2008).

geological investigations at Pekan to directly link these two areas due to their structurally and geological complexities.

In 1992 and 1993, Saffeen Baharuddin conducted a regional groundwater study in the Pekan vicinity, where thirty (30) wells were drilled and terminated as soon as the drilling hit the basement. Since the terrain of Pekan is rather flat, the investigations conducted could certainly be utilized to support the onshore claims made by both Hutchison and Tjia.

This paper aims to discuss on the geometry of the Pekan basement, as well as to study the distribution of different

basement rocks in the area, which may assist in proving the Penyu Basin onshore extension theory. A geo-lithological model approach has been undertaken in this study.

### GEOLOGICAL SETTING OF PENYU BASIN

The collision of India into Eurasia plate in the early Tertiary has formed several extensional basins in the offshore east of Peninsular Malaysia which includes Penyu Basin. The Rhu oil discovery in 1995 has proven that the Penyu Basin has its own working petroleum system (Madon & Anuar, 1999).

The formation of Penyu Basin is well known to be a part of the tectonic development of the Southeast Asian region, as it is one of the major extension basins in Sundaland. According to Tjia (1998), during Late Cretaceous, onshore Peninsular Malaysia experienced diastrophism which includes strike-slip motion along major faults, alkali basalt flow and a unique radiometric age of granitic complexes.

Approximately 45 Ma, when the famous Indian-Eurasia plate collision took place, crustal slabs of Southeast Asia were thrust out along the NW wrench fault, (as cited by Tjia, 1995) in Figure 2. The NW wrench fault can be related to the major NW-trending strike-slip fault in Peninsular Malaysia as well as the 100km NW-SE Rumbia fault which divided the Penyu Basin into two (Madon & Anuar, 1999).

There are four major fault bounded sub-basins in the Penyu Basin, namely Kuantan, Pekan, Rumbia and Merchong Graben (Madon, 1995). In addition, Madon also mentioned that the Kuantan and Pekan grabens, are offshore extensions of the late Mesozoic basement of Peninsular. This

claim could be further analyzed by studying the structure and distribution of the Pekan basement.

### GEOLOGY OF PEKAN

The geology of Pekan is generally covered by unconsolidated Quaternary alluvium overlying the Permian metasedimentary and volcanic bedrocks (Nossin, 1965). The Quaternary alluvium, made up of clay, silt, sand, and gravel, can easily be related to the Pahang River delta development.

It is estimated that the delta only became part of the landmass about 1800 years ago due to its large size of 30 km by 60 km (Nossin, 1964; 1965). The delta depocenter appears to be deeper and wider to the East, forming a pathway that supplies sediments to the neighboring basin, namely the Penyu Basin. Thus, this observation can explain the deposition and geometry of the Quaternary alluvium sediments in the subsurface of the study area.

Based on Umar Hamzah *et al.* (1999) previous work, Che Aziz (2002) has classified the Quaternary alluvium in Pekan into two sedimentary sequences, according to their respective age: (1) Holocene and Recent sediments and, (2) Pleistocene and older sediments. Though both sedimentary sequences are Quaternary alluvium, Che Aziz also mentioned that, unlike Sequence A (Holocene and Recent Sediments), Sequence B (Pleistocene and older sediments) does not appear to be related to the present-day Pahang River delta complex depositional system (Che Aziz, 2002).

#### Sequence A: Holocene and Recent sediments

According to Che Aziz (2001), this sedimentary sequence formed the Pahang River delta complex today, with a range of thickness between 10 to 35 meters. Che Aziz (2002) also mentioned that the eastern end of the delta complex marks the thickest part of the sequence. Two sub-sequence have been identified to characterize the subsurface better.

##### 1. Holocene sediments

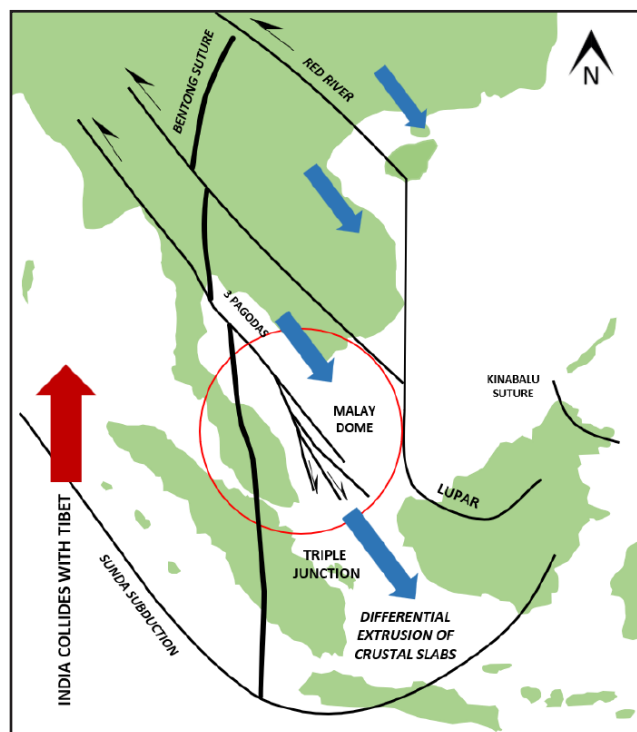
These sediments consist of fossiliferous dark grey saline lagoonal clay, and blocky to upward fining well-sorted medium to fine, beach ridge and strand-plain sands.

##### 2. Recent sediments

Upward fining granule to coarse sand, to silty point bar deposit, carbonaceous laminations with occasionally fine cross-laminated silt and very fine sand of channel levee deposits, and crudely laminated mud of flood plain deposits are referred as the Recent sediments.

#### Sequence B: Pleistocene and older sediments

As for this lower sedimentary sequence, it is predominantly blocky to crudely upward fining gravel, to coarse and medium angular sand intercalated by light grey to white non-marine (continental) clay (Che Aziz, 2002). Despite having a thick sequence, this sequence is basically made up of only two litho-facies types, which are as sand facies and clay facies.



**Figure 2:** Middle Miocene tectonic setting (modified from Tjia, 1998).

## METHODOLOGY

### Data Set

For this study, only the lithology information of the wells is made available. There are thirty (30) onshore well data (Figure 3) that will be used in the construction of the lithological model, which are from hydrology and groundwater work conducted by Safeen Baharuddin (1992; 1993).

### Workflow

The reconstruction workflow (Figure 4) begins with the QC process, where well data are checked accordingly. At the end of the process, the well data are digitized and plotted according to their respective locations.

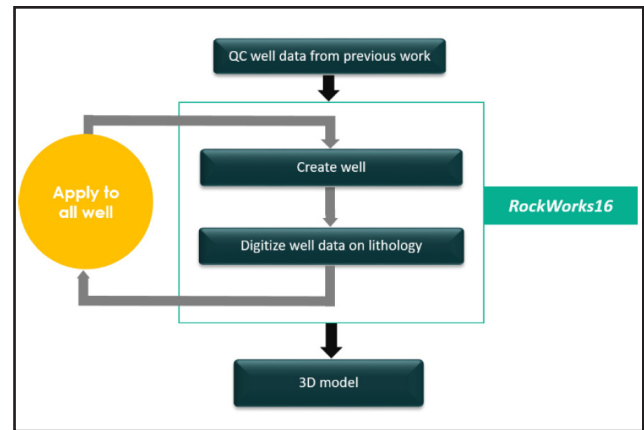


Figure 4: Geo-Lithological model workflow.

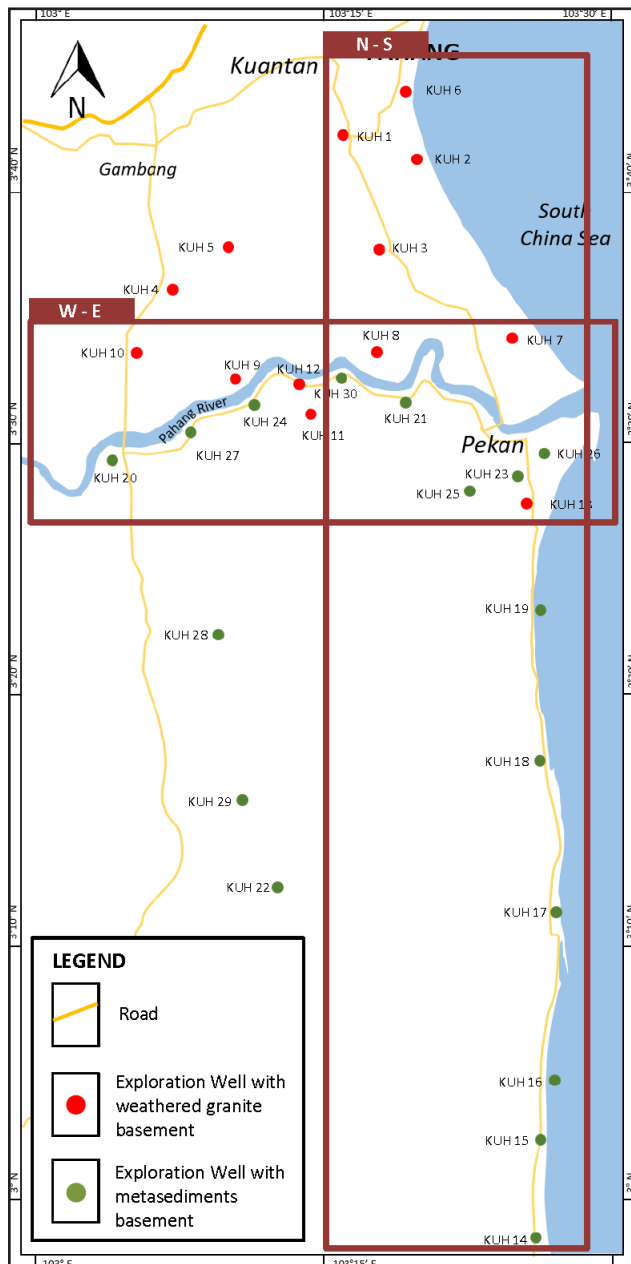


Figure 3: Well location and its type of basement rock (modified from Ismail *et al.*, 2002).

A 3D log utilizing all thirty (30) well data was also created as shown in Figure 4. These logs are then used to create two 3D geo-lithological models with different orientation (N-S and W-E) involving different selection of wells (Figure 3). The models were created by applying the *Lithoblending* algorithm. This algorithm gives a better representation of the subsurface, as it uses nearby well data to extend the lithology horizontally, rather than extrapolating vertically below the borehole which may be inaccurate.

## RESULTS AND DISCUSSION

From the data collected by Safeen Baharuddin (1992; 1993), the sediments observed are generally sand, clay, silt, and soil veneer, while there are two different types of basement rock present in the study area.

### W-E geo-lithological model

The W-E orientation model is shown representing the subsurface lithology of the Holocene and older sediments deposited over the basement, as well as the geometry of the basement that underlies the Pahang River. Based on the W-E geo-lithological model constructed, it can be observed that the basement of the area deepened towards the shoreline to the East (Figure 5), and most likely to have a continuation offshore. In fact, the depth contour of Penyu Basin basement does correspond to this finding, as the west part of the basin's basement was elevated.

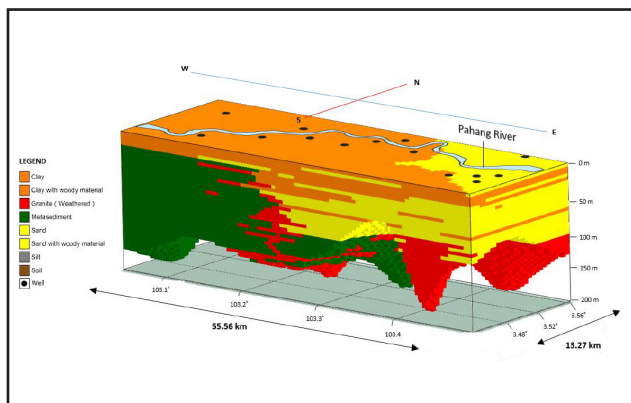
### N-S geo-lithological model

As the W-E orientation model discriminates the geometry of the basement of Pekan area, the N-S orientation model on the other hand, unfolded more on the distribution of different basement rock types in the area.

From Figure 6, it is observed that most of the northern region wells, commonly have the weathered granite basement while the southern region are generally wells with metasediment basement. Despite having different type of basement rocks, the exact boundary between these two basement rocks remains unknown. It is believed that the separation between these two basement types can be a point where it leads to the opening of Penyu Basin.

**Table 1:** Depth and type of basement rocks (Safeen Baharudding, 1992; 1993).

Well	Depth of basement	Type of basement	Well	Depth of basement	Type of basement
KUH 1	47.21	Weathered granite	KUH 16	80.25	Metasediment
KUH 2	84.12		KUH 17	77.00	
KUH 3	86.67		KUH 18	115.00	
KUH 4	18.00		KUH 19	103.82	
KUH 5	24.94		KUH 20	17.00	
KUH 6	36.57		KUH 21	103.53	
KUH 7	103.13		KUH 22	3.00	
KUH 8	87.78		KUH 23	-	
KUH 9	32.00		KUH 24	40.00	
KUH 10	16.00		KUH 25	-	
KUH 11	53.13		KUH 26	-	
KUH 12	-		KUH 27	-	
KUH 13	75.29	Metasediment	KUH 28	2.40	
KUH 14	48.00		KUH 29	2.00	
KUH 15	78.50		KUH 30	-	



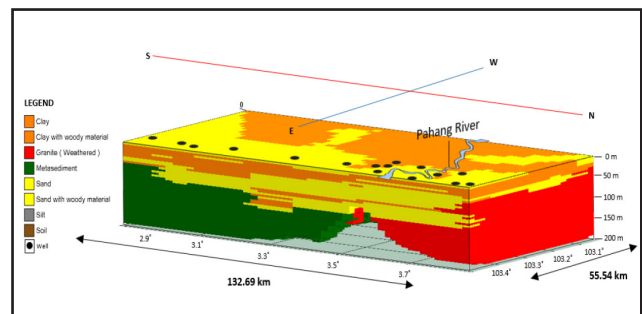
**Figure 5:** Geo-lithological model with W-E orientation view.

## CONCLUSION

The Geo-lithological model constructed have certainly provided a small insight on the basement structure and the distribution of different basement rock types in the study area of Pekan, Pahang from the geological prospective. However, further detail geophysical investigations should be done in order to locate the exact boundary between the two types of basement rocks, as well as to gather more reliable onshore data to correlate with the offshore data to assist in proving the theory of the Penyu Basin onshore extension.

## ACKNOWLEDGEMENT

The authors thank the Universiti Teknologi PETRONAS for financial support via the Yayasan Universiti Teknologi PETRONAS research grant. We also appreciate the logistical and technical support provided by the Department of Geosciences, Universiti Teknologi PETRONAS throughout the duration of the project. We would like to thank the Jabatan Penyiasatan Kajibumi Malaysia or now formally



**Figure 6:** Geo-lithological model with N-S orientation view.

known as Jabatan Mineral dan Geosains Malaysia (JMG) for providing us the hydrology data in Pekan, Pahang.

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*Manuscript received 9 November 2017*

*Revised manuscript received 27 February 2018*

*Manuscript accepted 5 March 2018*