Half-day visit to Solok-Sawahlunto area, Ombilin Basin: A short observation on non-marine depositional sequences

RM Iman Argakoesoemah and Didit Ariady Firmansyah

Introduction

This is a brief note of our visit to Solok, Sawahlunto area, Ombilin Basin on November 8, 2008 for the purpose of broadening our knowledge on non-marine depositional sequence and its relationship to the development of hydrocarbon petroleum system in the region. Exposure of the outcrops is excellent in the form of accessibility and vertical extent of the stacked sequences.

Unfortunately, as the time was limited, there was no opportunity to conduct sufficient detailed description of the outcrops. However, several notes of broad observation of the outcrops were made. Part of them is discussed in this paper.

A total of eight (8) locations (=STA) were visited during this half-day reconnaissance trip. The traverse began from Solok using a car towards the northeast to locations 1 to 8 following the existing main road to Sawahlunto (Figure 1). The outcrops are easily accessed and visible from the main road. Some of the outcrops are located immediately on the edge of the road.

General Overview

The Ombilin Basin has been interpreted as a small intermontane basin which began to form in the Late Eocene by north-south tensional displacements, followed by dextral strike-slip faulting of the Sumatra Fault System in the Oligocene, resulted in a pull-apart development of the horst and graben structures in northwest-southeast trending (Situmorang et al, 1991; Howells, 1997). Basin uplift in the Mid-Miocene or later reduced its extent to the present size, where the intermontane basin is outlined. To the west, the basin is presently bounded by a series of Quaternary to Holocene volcanoes, while to the east by the pre-Tertiary non-volcanic sediments.

The basin began with deposition of the sand-rich, conglomeratic sequence of alluvial fans of the basin margins of the Brani Formation followed by the Sangkarewang, Sawahlunto, Sawahtambang, and Ombilin Formations (Koesoemadinata and Matasak, 1981; Koning, 1985; and Noeradi et al, 2005), Figure 2. Fresh water lacustrine setting could be present in the depocentre of the basin. This transgression stage is stratigraphically represented by a mega-sequence ranging from non-marine coarse clastic rift



Figure 1. *Index map of station (STA) of the observations during visit to Solok-Sawahlunto*

deposits to shales of deep open marine with the maximum flooding occurred in the Mid-Miocene.

The Sawahlunto Formation consists of non-marine argillaceous deposits with numerous coals and some quartz sandstones. The Ombilin Underground Coalmines situated in Sawahlunto city has produced coals since 1891 from this formation. The estimated reserves are of about 200 million metric tons. There are three main coal seams with the most potential up to 18 m thick and average 9.3 m thick of black and lustrous bituminous coal rank (Silkina and Toquero, 2008). It should be noted that large extent of the coals could also have potential for coalbed methane (CBM) deposits.

The formation is probably conformable overlain by the Sawahtambang Formation. The age-diagnostic fossils are not present, but erosion surface could mark the boundary between both formations as shown by a shift of Ro value plot in Sinamar-1 well (Koning, 1985). The Sawahtambang has been described as thick coarse quartz-rich sandstones with some overbank coaly claystone suggesting that the formation was deposited in the fluvial, braided river setting.

The geothermal gradient in Sinamar-1 (1984) is only 1.62 degF/100' (29.6 degC/km) which is cooler than the average gradient of 3.3 degF/100' (60.3 degC/km) in the Central Sumatra Basin. Several oil shows were reported in the sandstones of the Sawahtambang Formation. One open-hole DST recorded minor flow of oil (36 deg API gravity) in the upper formation and a gas flow exceeding 13 MMCFD (60 deg API gravity) in the middle part of the formation (Koning, 1985). The source rocks might be the mature shales (Ro=0.6%) of the Sangkarewang Formation (Avg TOC= 2.6%) while the Sawahlunto coals are still immature with Ro=0.53% (Fletcher and Yarmanto, 1993). The hydrocarbon accumulation is considered non-commercial (Koning and Karsani, 2000). The later well, South Sinamar-1 (1994) drilling result is dry.

Brief Outcrop Overview

Several large outcrop exposures are present along the coalmines in the Sawahlunto area.

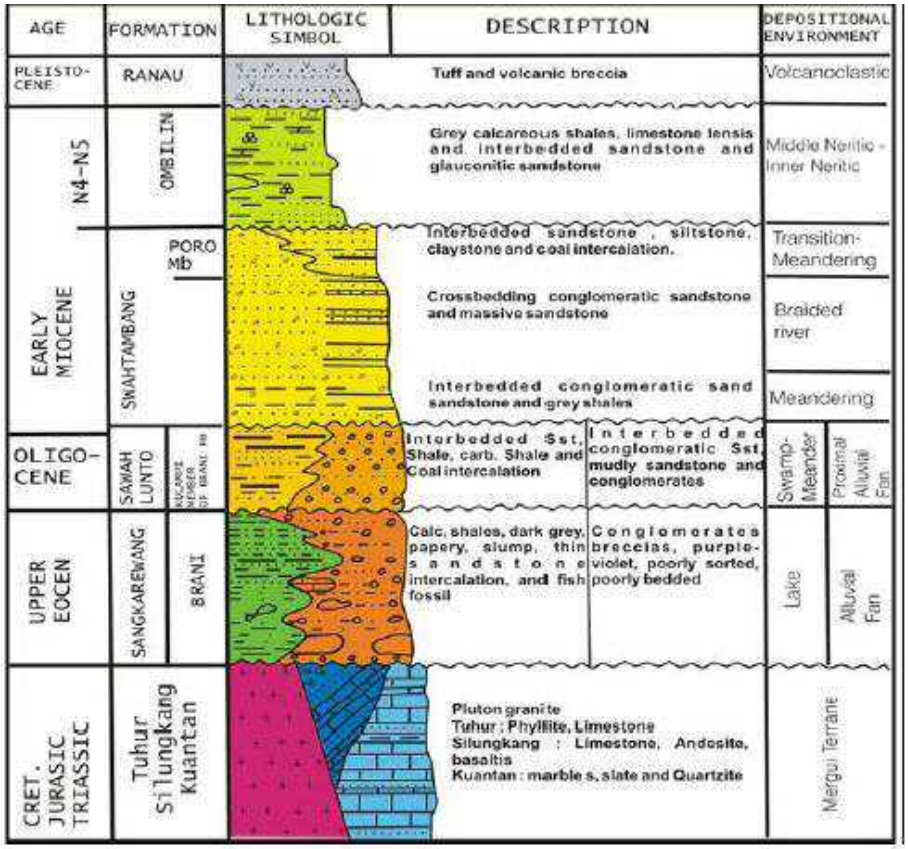


***Figure 2**. General lithostratigraphic column of Ombilin Basin (Noeradi et al, 2005)*

Description for a broad mega-sequence overview can be conducted from a distance as the outcrops extend several hundreds of meters laterally. Some of them could have few hundreds of meters of repeated vertical sequences. A closer look will give much better impression on sedimentary sequences and lithological description and composition.

Below are a brief description and preliminary interpretation of the outcrops based on quick observation and reading materials.

Coaly claystone and coal of the floodplain deposits have vertically separated each sand-rich sequence as the river channels moved laterally and vertically with time. These relatively thin floodplain deposits may help correlate the sand-rich sequence locally. Some of them could have been significantly extended laterally and can be used for local correlation marker. Thickness of the individual sand-rich sequence could be tens of meters. Individual coal layer may not be useful for regional correlation as the main swampy, floodplain area may not be very extensive in the Sawahlunto Formation at this location STA 7, Allied Indo Coal.

Based on the rift basin model, Noeradi et al (2005) interpreted that the Brani coarse clastics of fanglomerate and other related sediments representing rift basin margin facies that was deposited during the early syn-rift phase while the Sawahlunto Formation was deposited during deposition of the late syn-rift. The Sawahtambang and Ombilin Formations are considered to be the post-rift phase based on seismically continuous, widespread reflector package over the whole basin.

Further geophysical interpretation should be taken to ensure that the lithological contrast between the thick sandstone package of the Sawahtambang Formation and the thick, open-marine shale package of the Ombilin Formation shall not lead to improper interpretation. The impedance or velocity contrast between both formations shall be continuous laterally along the presence of both formations in the basin unless the lithological contrast diminishes near the basin margin.

Conclusion and Recomendation

Below are some brief conclusions and recommendations:

(1) Quality of the outcrops is extremely excellent. They are continuous and some of them extend to several hundreds of meters both in vertical and lateral views. Any detailed geological observations could be made continuously.

(2) Any outcrops in the Solok-Sawahlunto region specifically in the area where coalmines are present and active should have to be properly documented. Regular field visit and detailed geological study should be performed to ensure that the geological information is continuously recorded otherwise the outcrops will disappear shortly due to coalmine activity.

(3) Sufficient safety preparation should be conducted if continuous measured section is planned since the field condition in some outcrops need special attention for the purpose of safety precaution.

(4) The outcrops are useful for the study of non-marine Tertiary sequence stratigraphy though the deposition and tectonic in the region are active. Non-marine biostratigraphy should be conducted to establish the vertical stratigraphic relationship and lateral regional correlation across the basin.

(5) In addition to the coalmine purposes further exploration for hydrocarbon occurrence in the basin should remain to be interesting not only for conventional hydrocarbon but also for unconventional exploration specifically coalbed methane.

References

Fletcher, G. and Yarmanto, 1993, Ombilin basin field guide book. Indonesian Petroleum Association, Post Convention Field Trip, 59 pp.

Howells, C., 1997, Tertiary response to oblique subduction and indentation in Sumatra, Indonesia: new ideas for hydrocarbon exploration. Geological Society of London, Special Publications, v.126, p. 365-374.

Koesoemadinata, R.P. and Th. Matasak, 1981, Stratigraphy and sedimentation – Ombilin basin, Central Sumatra (West Sumatra Province). Indonesian Petroleum Association, Proceedings of the 10th Annual Convention, p. 217-249.

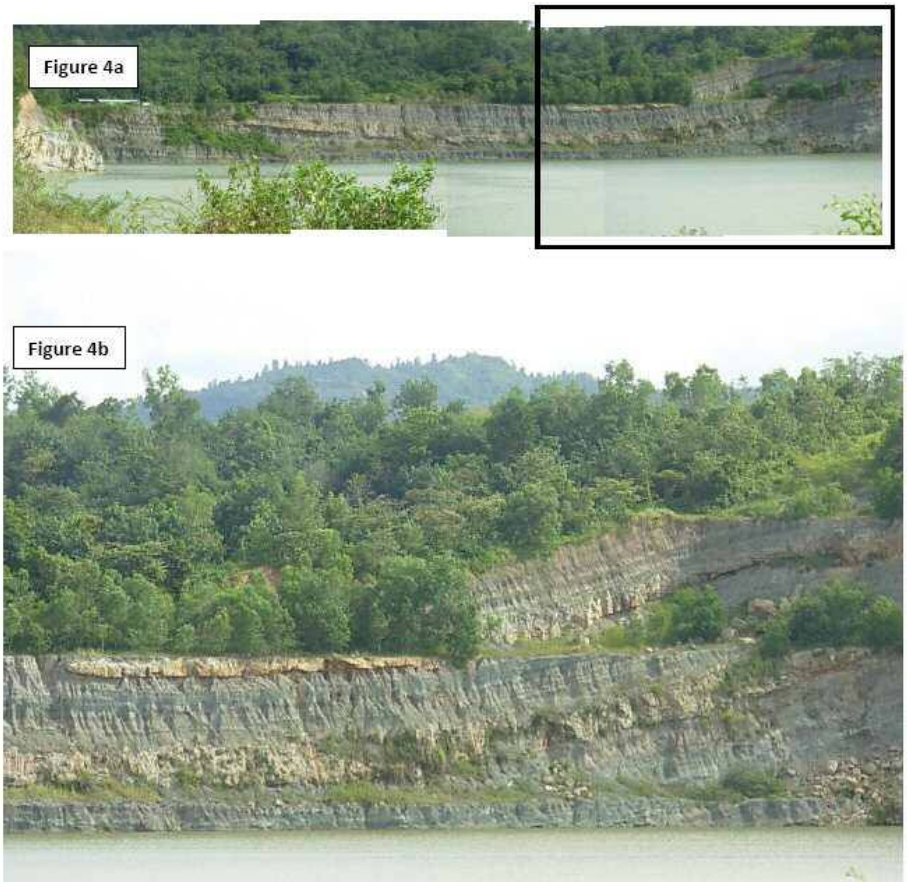
Koning, T., 1985, Petroleum geology of the Ombilin intermontane basin, West Sumatra. Indonesian Petroleum Association, Proceedings of the 14th Annual Convention, p. 117-137.

Koning, T. and Aulia Karsani, 2000, Abstract: Exploration in the Ombilin intermontane basin, West Sumatra. AAPG International Conference and Exhibition, Bali, Indonesia. AAPG Search and Discovery Article #90913.

Noeradi, D., Djuhaeni, and Batara Simanjuntak, 2005, Rift play in Ombilin basin outcrop, West Sumatra. Indonesian Petroleum Association, Proceedings of the 30th Annual Convention, p. 39-51.



Figure 3. *Repeated stacked sand-rich sequences with several lenses of large fluvial channels. Thickness and width of some channels should be measurable. The thick, coarser grain of sediments (dirty white) encased by light grey argillaceous flood-plain deposits could be interpreted as part of the main channel fill, but the thin and discontinuous one of much smaller channel fills could be interpreted as the crevasse splays. However, detailed observation should be made, as the alluvial fan sequence is present and could be inter-fingering laterally with the fluvial deposits, see Figure 2. The information is important for interpretation of the variation of fluvial system (and alluvial fan) depositional outline and development including non-marine sequence stratigraphy interpretation of the region.*



Figures 4a (above) and 4b (below). *This picture shows several erosion surfaces indicated by irregular sharp-based contact between fluvial channel (dirty white) and flood plain (light grey) deposits of the Sawahlunto Formation at STA 2 location, Korean coalmine. The width of some channels is possible to be measured in the outcrops. It should be noted that the channels at this location may not be the main river channels as their sizes are relatively smaller than those observed in the basin. The thin, discontinuous, silty sand-sheets within the swamp are possible deposit of the crevasse splays. Note: This outcrop extends laterally for several hundred meters.*

Silkina, I. and Napoleon Toquero, 2008, It's About Time. Time Technology Pty Ltd, Scientific and Technical Division, PTBA Ombilin Coal Project, 14 pp.

Situmorang, B., Barlian Yulihanto, Agus Guntur, Romina Himawan, and T. Gamal Jacob, 2005, Structural development of the Ombilin basin, West Sumatra. Indonesian Petroleum Association, Proceedings of the 20th Annual Convention, p. 1-15.

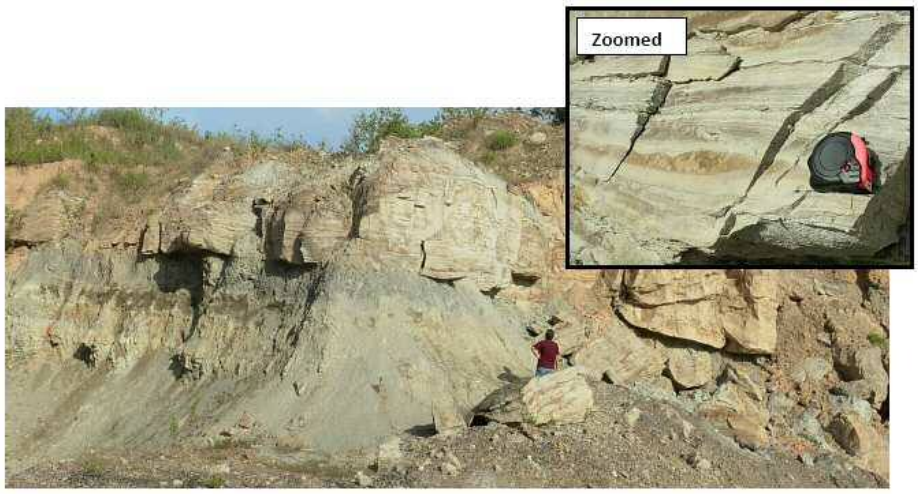
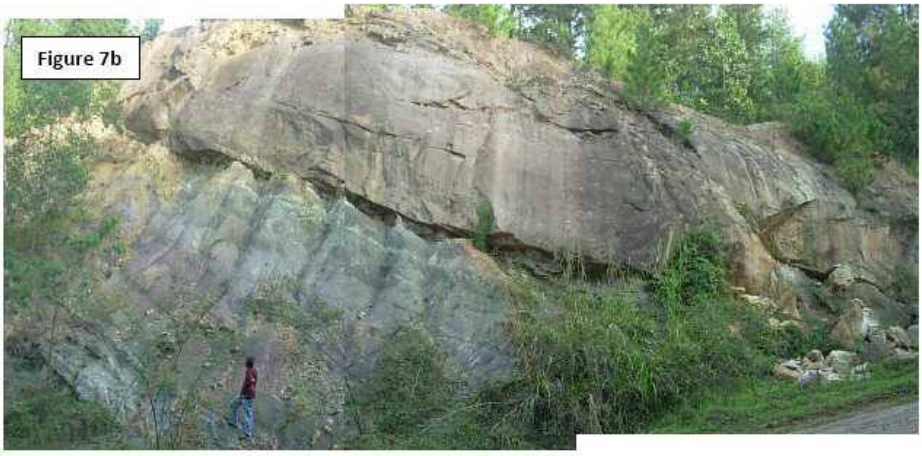


Figure 5. *Detailed view of erosional surface shown by irregular sharp-based contact between fluvial channel and the underlying flood plain sediments. The outcrop is very fresh showing excellent view of micro-sedimentary structure. Ripple lamination and others in carbonaceous siltstones with finer grain of sandstones are present, see the inserted photograph. Note: It is Sawahlunto Formation at STA 3 location, Korean coalmine.*



Figure 6. *Detailed view of erosion surface of thick sand-rich channels eroded fine-grained sandstones of the underlying earlier channel. These thick, stacked sandstone deposits are interpreted to have been deposited as multi-storey river system channel of the Sawahlunto Formation at STA 4 location as opposed to the interpretation of possible proximal alluvial fan sediments. Detailed sedimentary structure of the sandstones and biostratigraphy analysis of the intercalated shale between the channels are crucial just to confirm the possibility of fresh water lake deposits present in the depocentre of the basin at this location. That possibility could enrich alternative interpretation of other non-marine depositions present in the basin. The basin geome-*





Figures 7a (above) and 7b (below). Possible inter-fingering contact between the overlying alluvial fan deposits and underlying meandering swampy sediments of the Sawahlunto Formation. It should be noted here that the possibility to have freshwater lacustrine delta during Sawahlunto deposition should not be ignored. Therefore, further detailed stratigraphical and sedimentological observations are obviously required for this outcrop at this location and others in the surrounding areas. Note: The

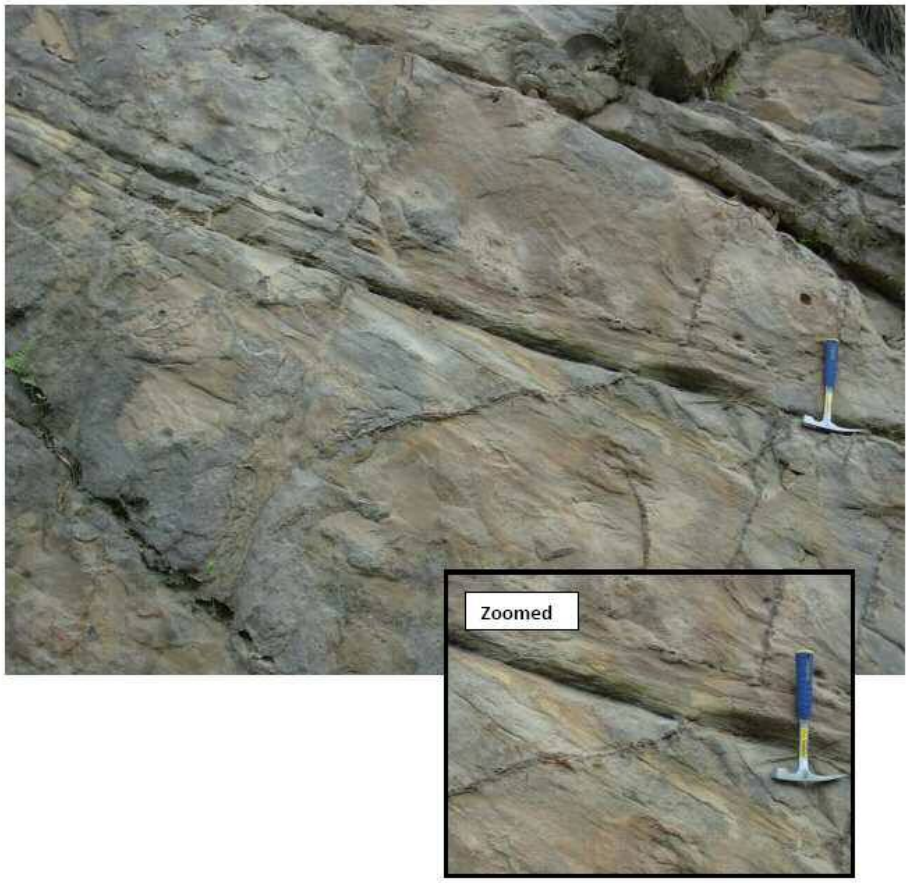


Figure 8. *Close-up of the sedimentary structures of stacked channels developed in the Sawahlunto Formation located at STA 5. Parallel lamination and others with top and bottom sets of cross-bedding structures can be recognized along the outcrop. Paleocurrent could be measured accordingly. Any possible broad direction of the major fluvial shift is interesting to be exercised.*



Figure 9. *Large scale of outcrop showing the presence of thick and large channel sandstones that seems to be encased by thick floodplain deposits (light grey) of the Sawahlunto Formation at STA 6, Allied Indo Coal mining. Since the lateral extent of the channel sandstone package is significantly thick, wide and gentle it could be interpreted that the equilibrium profile (=base level) of the fluvial system at the time in this location rose above the alluvial profile resulted in the river aggraded the floodplain. This is an indication of positive fluvial accommodation took place during deposition of the Sawahlunto.*



Figure 10. Development of thin, scattered crevasse splays within the large and thick overbank swampy deposits (light grey) of the Sawahlunto Formation at location STA 7, Allied Indo Coal mining. The tectonic contribution to the fluvial accommodation in the basin centre at the time seems to be significant resulted in thick fluvial system accumulation as indicated by anomalously thick floodplain deposits. This is a typical of the presence of local tectonic sag where the accelerated subsidence took place in the pull-apart tectonic setting, ie. the Sawahlunto deposition.



Figure 11. *Outcrop of the Sawahtambang Formation in location STA 8 (Sawahtambang gorge) showing multi-story, stacked thick sandstones of the braided river deposits where some appear to have been amalgamated. The formation is well-cropped out in the basin margin. Towards the basin depocentre, part of the formation has been eroded following the Mid-Miocene to Pliocene basin uplift.*

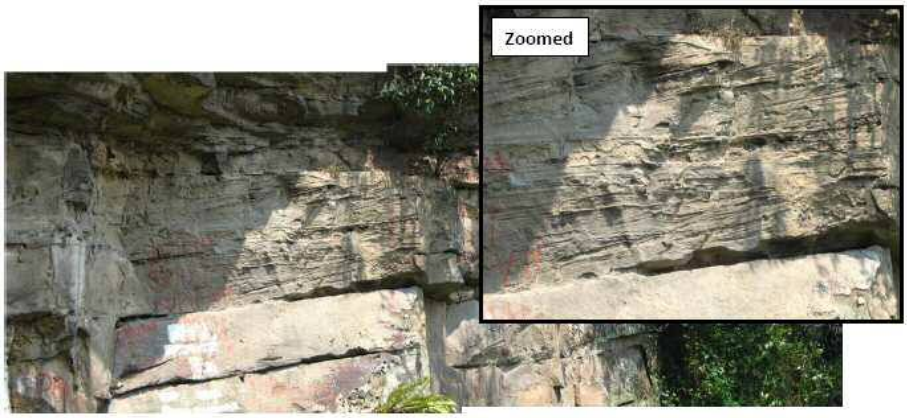


Figure 12. *Part of the close-up of the outcrop in Figure 11 above showing detailed sedimentary structures. Cross-bedded sandstones with composition of mostly quartz are common in the Sawahlunto Formation.*



Figure 13. *Outcrop of the Sawahtambang Formation at the same location (STA 8) as shown in Figures 11 and 12 above, but it is located across the main road. Good layered, multi-story quartz-rich sandstones with irregular shape of the base of the channels can be observed from a distance.*