[PS]Syn-Rift Lacustrine Axial Delta Reservoir Quality and its Distribution: New Insight from Sumpur Delta in Singkarak Lake, West Sumatra, Indonesia*

Reybi Waren[1], Endo Finaldhi[1], Enry H. Sihombing[1], Iqbal Fardiansyah[1], Faizil Fitris[1], Habash Semimbar[1], Satia Graha[1], Abdullah F. Talib[1], and Willy R. Paksi[1]

Search and Discovery Article #51263 (2016)**
Posted June 13, 2016

*Adapted from poster presentation given at AAPG Asia Pacific Region, Geosciences Technology Workshop, Characterization of Asian Hydrocarbon Reservoirs, Bangkok, Thailand, March 31 - April 1, 2016

[1]Indonesian Association of Geologist (IAGI) – Riau Chapter, Indonesia (iagi.riau@gmail.com)

Abstract

Paleogene syn-rift lacustrine deposits in western Indonesia basins have been recognized as one of the potential reservoirs. Central Sumatra Basin for instance, lacustrine reservoirs have been explored and produced sporadically even though the understanding of its reservoirs both geometry and quality are still inadequate. Similarly, this lack of understanding occurs in Ombilin Basin that has promising exploration target in syn-rift deposit. It is believed that the syn-rift lacustrine reservoirs in both basins will play as important role in further opportunities.

Lake Singkarak, which is situated in West Sumatra, is known as a pull-apart basin in Indonesia that is filled by syn-rift deposits. This basin setting will provide significant information and facts in understanding lacustrine syn-rift reservoirs that will be improved in subsurface analysis in Central Sumatra, Ombilin, and/or other petroleum basins. In addition, Lake Singkarak deposit has been considered holding possible hydrocarbon potential for exploration target. Numerous regional study of Lake Singkarak has been conducted since 1961. The most recent study provided sedimentology facies model, which are alluvial fan, braided river, meandering river, fan delta, shoreline, lacustrine delta, shallow lacustrine, and shelf-slope lacustrine facies. These facies have constructed a fundamental regional understanding of Lake Singkarak syn-rift system. However, detailed analysis on reservoir geometry and quality are unexplored. In order to obtain deep understanding how each reservoir facies distribute in such lacustrine delta or more commonly known as axial fluvial delta environment, detail analysis on modern system in this particular environment have been performed.

Axial fluvial delta will be represented by Sumpur Delta, which is located in the northern part of Lake Singkarak. Sumpur Axial Fluvial Delta (SAFD) is created in the fault-tip area and parallel to the fault. The fault activities led distinctively of accommodation space or basin geometry and sediment filling in Sumpur Axial Fluvial Delta system.

References Cited

Bachtiar, A., P.A. Suandhi, P.T. Setyobudi, F. Fitris, O. Malda, and Z. Lesmana, 2015, Sedimentology Facies Model From Modern Tropical Rift Basin of Lake Singkarak, Research Study for Central Sumatra and Ombilin Basins, Sumatera, Indonesia: International Conference and Exhibition AAPG, September, 2015, Melbourne.

Emelia, F., 2009, Alternatif Pemanfaatan Danau Bagi Pengembangan Wisata Melalui Konsep Keberlanjutan Sumberdaya Perairan dan Perikan di Danau Singkarak, Sumatera Barat: Departemen Manajemen Sumberdaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.

Kastowo, L.G.H., and T.C. Amin, 1996, Geological Map of the Padang Quadrangle Sumatera: Geological Survey of Indonesia, Ministry of Mines, Bandung.

Sieh, K., and D. Natawidjaja, 2000, Neotectonic of the Sumatran Fault, Indonesia: Journal of Geophysical Research, v. 105/B12, 28, p. 295-326.

Silitonga, P.H., and Kastowo, 1995, Geological Map of the Solok Quadrangle Sumatera: Geological Survey of Indonesia, Ministry of Mines, Bandung.

Syn-Rift Lacustrine Axial Delta Reservoir Quality and Its Distribution :

New Insight from Sumpur Delta in Singkarak Lake, West Sumatra, Indonesia

Reybi Waren, Endo Finaldhi, Enry Horas Sihombing, Iqbal Fardiansyah, Faizil Fitris, Habash Semimbar, Satia Graha, Abdullah F. Talib, Willy R. Paksi

Indonesian Association of Geologists
Ikatan Ahli Geologi Indonesia (IAGI)
Riau Chapter

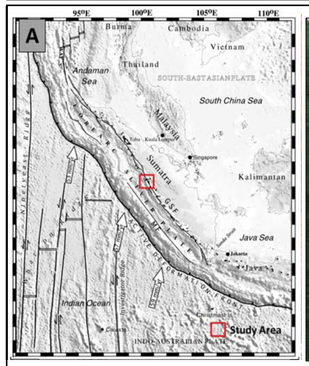
ABSTRACT

Paleogene syn-rift lacustrine rocks in Sumatra basins have been proven as a viable and prolific petroleum system play. Due to active tectonics and confined environment, reservoir distribution and geometry of the Paleogene rock is highly complex. Further complexity results where the lacustrine delta orientation is axial. Finding suitable modern analogues is essential to understand reservoir architecture in the subsurface. A modern system field study of the Sumpur lacustrine delta in Singkarak Lake has been performed by acquiring and analyzing river bed sampling, river-mouth coring, offshore lacustrine sediments grab sampling, and aerial geo-drone photos. This study illustrates how grain texture, recent faunal analysis, depositional facies, and its sequences describe the complexity of potential reservoir geometry and quality distribution, both laterally and vertically.

Seven depositional facies have been recognized: fluvial channel (FC), upper distributary channel (UDC), lower distributary channel (LDC), subaqueous distributary channel (SDC), mouth bar (MB), shoreline (SH), and abandoned delta (ABD). According to sand quality and facies geometry perspectives, lower distributary channel facies association (LDC, SDC, and MB) are associated with the most favorable reservoir potential. Lower distributary channels, one of the most promising reservoir, are characterized by granule- to pebble-sized clasts at the basal scouring surface, with cross-stratified very coarse to coarse sand in an overall fining upward facies succession. This facies gradually transitions distally to subaqueous distributary channels, which are dominantly composed of medium to fine grained sand, as the most potential reservoir. In addition, channel width narrows from 28m to 12m as water depth and distance from source increases. Mouth bars, which are characterized by fine to medium grained, very well sorted fabric, sub-rounded to sub-angular grain shaped, and high sphericity, are also categorized as potential reservoirs, although their distribution is somewhat localized. The remaining facies are not favorable as potential reservoirs due to their low quality and localized distribution.

An improved understanding of the heterogeneities within the Sumpur delta depositional system contributes new insights into the Singkarak lacustrine system. We propose a new model of the Singkarak axial lacustrine delta as a result of this study. This model provides facies architecture, the probability of delta evolution, and an improved reservoir analogue, all of which are valuable as reservoir prediction tools to reduce subsurface uncertainty for exploration and development activities in analogues petroleum-rich-system.

INTRODUCTION



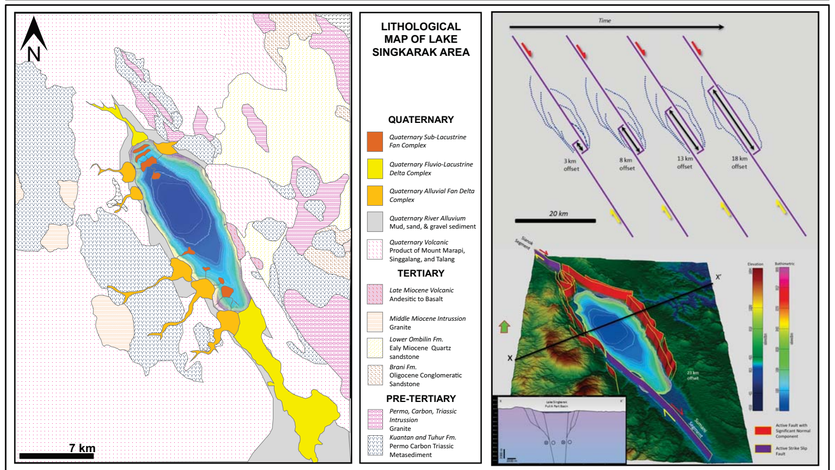
Neotectonic Sumatra Island (Sieh & Natawidjaja, 2000)

Satelite Image of Lake Singkarak (Google Earth)

Drone image of Sumpur Axial Fluvial Delta in the river-mouth area.

Lake Singkarak is located in the Sumatra Island, Indonesia. It is known as product of neotectonic forming pull apart basin. Sumpur Axial Fluvial Delta (red square) is developed in the Northern part of the lake as one of the major inlets. This fluvial dominated delta holds geometry about 675 m of length and 515 m of width with mean stream gradient about 0.7 degree.

REGIONAL GEOLOGY



Regional geology map of Lake Singkarak area (modified from Silitonga and Kastowo, 1995; Kastowo, et. al., 1996) overlaid by quaternary depositional facies Lake Singkarak (modified from Bachtiar, et. al., 2015), fault interpretations (modified from Sieh and Natawidjadja, 2000), and bathymetric data (modified from Puslit-limnologi, 2001 op. cit. Emelia, 2009) showing structural controlled of lobates and sediment sources to SAFD.

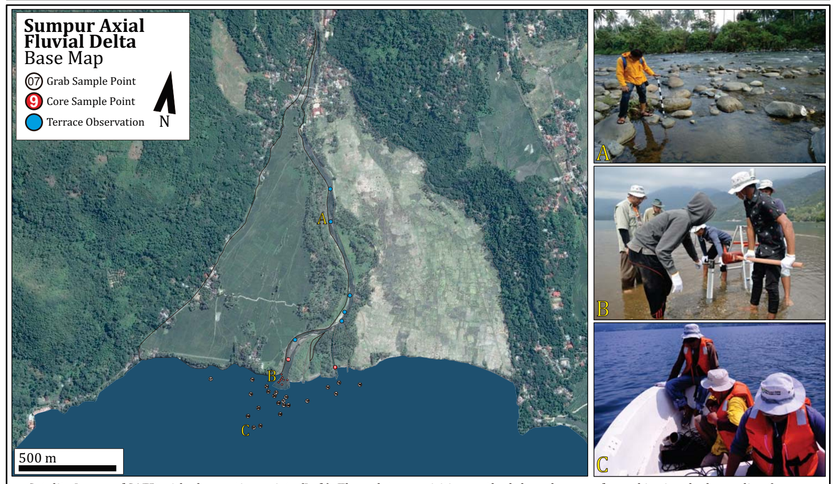
Provenance of Sumpur Axial Fluvial Delta

Lingkarak is surrounded by four main lithological ages consist of Pre-Tertiary metasediments and intrusive volcanics, Tertiary extrusive, Quaternary extrusive volcanics, and recent alluvial deposit. The sediments filling the Sumpur Axial Fluvial Delta has provenances from metamorphic rocks of Kuantan Formation, Triassic-Cretaceous granite intrusion, and Quaternary extrusive volcanics of Ranau Formation. These sources of sediments are located in the north-western part of the lake.

Tectonic Control on Sumpur Axial Fluvial Delta

Transtensional movement of Sianok and Sumani segments of the Sumatran strike –slip fault system has generated the Lake Singkarak (Bellier and Sebrier, 1994 op. cit. Sieh and Natawidjaja, 2000). Faults in Sianok Segment have created the accommodation space or basin geometry and sediment-filling in SAFD.

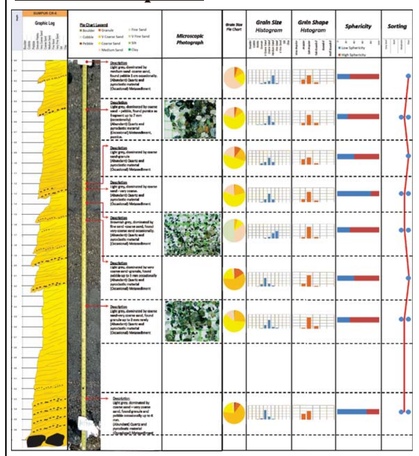
DATA & METHODOLOGY



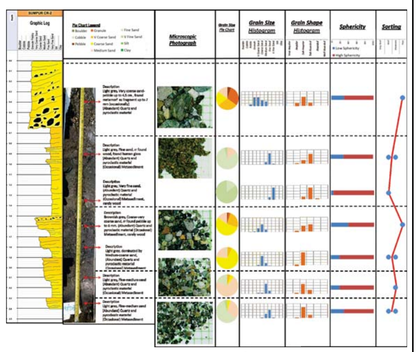
Satelite Image of SAFD with observation points (Left). Three data acquisition methods have been performed in river bed sampling (upper-right), river-mouth coring (middle right), and offshore grab sampling (lower right).

To characterize reservoir potential in such complex environment settings, the following methods are used: (1) Delta morphology interpretation from satellite image which is combined with aerial photos by using drone. (2) Sediment texture analysis and depositional facies interpretation of recent sediments from river bed sampling, river mouth coring, surface trenching, and offshore grab samplings to describe various facies characters. In order to support the facies character, available faunal analyses have been performed. (3) Facies geometry mapping by integrating bathymetry data from offshore sampling points and facies data points to illustrate the distribution of potential reservoirs.

Core Description



Core Description of CR06



Core Description of CR02

Nine cores have been retrieved in Lower Distributary Channel (LDC) facies. Most of the cores are illustrated super imposed fining upward succession which indicate channel axis environment (CR06). While, coarsening upward facies succession is found in the lower part of CR02 indicating channel margin facies. It is believed, this facies will possibly act as low quality reservoir and/or baffle within LDC facies.

SUMMARY, DISCUSSION, AND FORWARD PLAN

Summary

- Sumpur Axial Fluvial Delta is a fluvial dominated delta with elongate to irregular lobate geometry that is prograded axially parallel to NNW-SSE faults.
- Sumpur Axial Fluvial Delta is divided into seven depositional facies: a) Fluvial channel; b) Upper distributary channel; c) Lower distributary channel; d) Subaqueous distributary channel; e) Mouth bar; f) Shoreline; g) Abandoned delta.
- There are three favorable potential reservoirs in Sunpur Axial Fluvial Delta: 1) Lower distributary channel facies association (lower distributary channel, subaqueous distributary channel, and mouth bar facies); 2) Shoreline associated with abandoned distributary/delta facies; 3) Sand bar in upper distributary channel facies.
- The Sumpur Axial Fluvial Delta model can be utilized as a viable analogue for reservoir prediction tool in subsurface condition in Paleogene syn-rift lacustrine rocks of Sumatra basins.

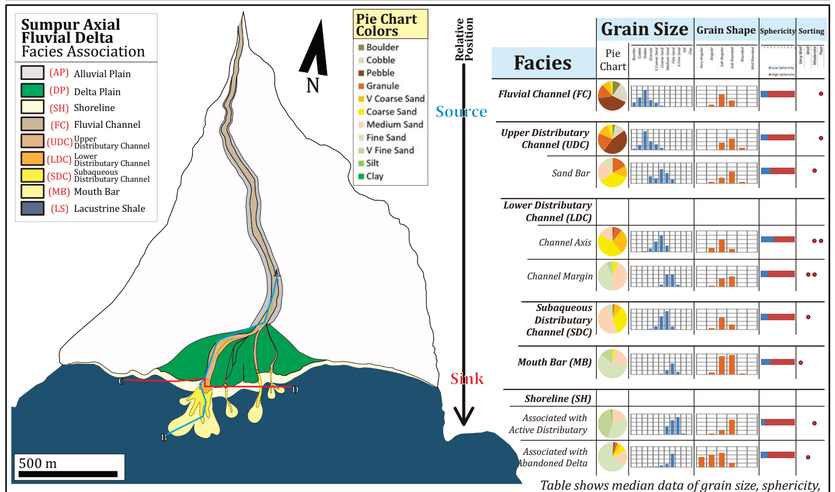
Discussion

We recognize that the size of potential reservoirs in SAFD are not economically attractive. To illustrate that, the largest potential reservoir area is about 64 square meters or 15 acre. However, understanding the cycle of deposition and its reservoir architecture will lead us to know how big the potential reservoir size properly. The regressive phase of Lake Singkarak had led the progradation of SAFD. Consequently, superimposed of progradational stacking pattern creates an opportunity of exploration and development targeting potential reservoir within various depositional cycles. Although it will increase the opportunity in SAFD system, the challenging risk will be centered on how to predict the connectivity between the depositional cycles.

Forward Plan

The Sumpur Axial Fluvial Delta is expected as a feeder to sub-lacustrine fan environment. Therefore, we would like to enhance our knowledge by observing sub lacustrine environment in the near future to understand reservoir geometry in this particular area.

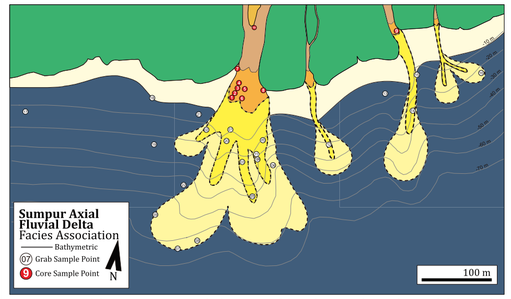
PROPOSED MODEL



Map shows regional facies association distribution in Sumpur Axial Fluvial Delta.

Table shows median data of grain size, sphericity, sorting and grain shape of area of interest.

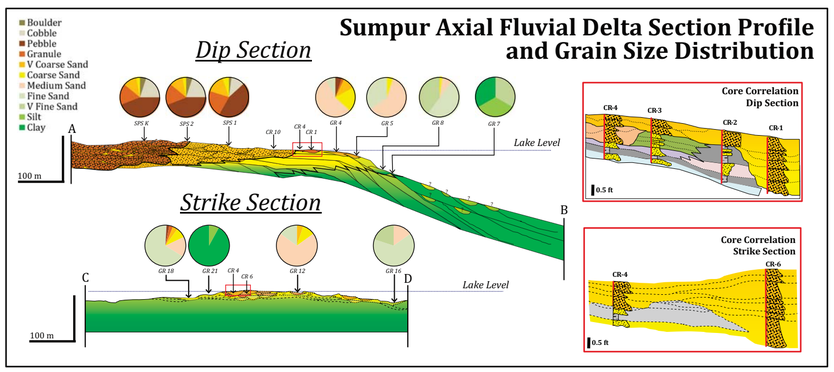
There are four main depositional facies association that can be observed in SAFD. First is, Fluvial Plain facies association consists of Fluvial Channel facies (FC). Secondly, Delta Plain facies association contains Upper Distributary Channel facies (UDC) and Lower Distributary Channel facies (LDC). Thirdly, Delta Front facies association consists of Subaqueous Distributary Channel facies (SDC) and Mouth Bar facies (MB). Last facies association is Shallow Lacustrine, consisting Shoreline facies (SH) and Abandoned Delta facies (ABD).



Depositional facies map in specific location of distributary channel, mouth bar, and shoreline facies.

In SAFD, the most favorable potential reservoir is lower distributary channel facies association (LDC, SDC, and MB). These three facies, coarse to fine grained with moderate to well sorted fabric, are indicated promising ranges of permeability and porosity. Additionally, these facies have high degree of connectivity which may generate a large reservoir tank.

However, the existence of silt grained in the channel margin area will contaminate the reservoir quality. The less favorable potential reservoir is shoreline facies which is associated with abandoned distributary/delta but its geometry is limited along the shoreline. The least favorable potential reservoir is point bar in UDC. Even though it appears to be a promising reservoir, its geometry is somewhat localized.



LITERATURE CITIED

- Bachtiar, A., Suandhi, P. A., Setyobudi, P. T., Fitris, F., Malda, O., and Lesmana, Z., 2015, Sedimentology Facies Model From Modern Tropical Rift Basin of Lake Singkarak, Research Study for Central Sumatra and Ombilin Basins, Sumatera, Indonesia. International Conference and Exhibition AAPG, September, 2015, Melbourne.
- Emelia, F., 2009. Alternatif Pemanfaatan Danau Bagi Pengembangan Wisata Melalui Konsep Keberlanjutan Sumberdaya Perairan dan Perikan di Danau Singkarak, Sumatera Barat. Departemen Manajemen Sumberdaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.
- Kastowo, Leo, G. H., and Amin, T. C., 1996. Geological Map of the Padang Quadrangle Sumatera. Geological Survey of Indonesia, Ministry of Mines, Bandung.
- Sieh, K., and Natawidjaja, D., 2000, Neotectonic of the Sumatran Fault, Indonesia. Journal of Geophysical Research, vol. 105, no. B12, 28: 295-326.
- Silitonga, P. H., and Kastowo, 1995. Geological Map of the Solok Quadrangle Sumatera. Geological Survey of Indonesia, Ministry of Mines, Bandung.

ACKNOWLEDGEMENT

Authors would like to express big gratitude especially to IAGI Riau Chapter in supporting the work, research and publication funding. This work could not be completed without outstanding supports from: **Gantok Subiyantoro** and **Irdas Muswar** as the leaders of IAGI Riau Chapter. **Dedek Priscilla**, **Putri Amalia** and **Agung Budiman** as their support for all the field work logistic preparation, and **Rivdhal Saputra** as his support for field work activity in Singkarak Lake.

Lastly, our big appreciations are pointed to **local people in Singkarak Area** (Sumpur, Malalo, and Sumani).