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Sedimen Deposit of Floodplain Formation Resulting From Lateral Accretion Surfaces on Tropical Area: Study Case at Kampar River, Indonesia

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Abstract

Kampar rivers has a length of 413 km with average depth of 7.7 m and width of 143 m. Sixty percent of this rivers are meandering fluvial system which transport and deposit a mixture of suspended and bed-load (mixed load) along low energy. River channel that moving sideways by erosion is undergoing lateral migration and the top of the point bar becomes the edge of the floodplain and the fining-upward succession of the point bar will be capped by overbank deposits of Kampar River. Along the Kampar Rivers, there are more than 60% of floodplain sediments and almost all of the floodplain formed by bend migration on the suspended-load channels of Kampar watershed. This formation consist of succession of fine to medium sand and silt/mud, with root traces, that form as drapes on the prograding bank. These beds dip mostly channel wards and quickly wedge out as they grade up and onto the floodplain. The depositional model is presented showing how lateral accretion can make a significant contribution to the preservation of fine-grained within channel deposits in contemporary floodplains. The examples presented here demonstrate that analogues to ancient point-bar deposits containing alternating sandstone and shale sequences are common in the low-energy fluvial environments of Riau rivers especially Kampar rivers.

Keywords

Kampar Rivers, lateral accretion, floodplain, meandering, depositional model.

1. Introduction

Meanders develop by erosion of the bank closest to the thalweg, accompanied by deposition on the opposite side of the channel where the flow is sluggish and the bed-load can no longer be carried and river is considered to be meandering if there is accumulation of sediment on the inside of bends. Meandering rivers transport and deposit a mixture of suspended and bed-load (mixed load) a long low energy. The bed-load is carried by flow in the channel, with the coarsest material carried in the deepest parts of the channel. Finer bed-load is also carried in shallower parts of the flow and it is deposited along the inner bend of a meander loop where friction reduce the flow velocity (Nichols, 2009). Type of sediment is formed by meandering pattern are channel deposit, point bar, natural leeve, floodplain, oxbow lake, and crevasse splay.

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The relative contribution of a variety of accretion deposits to the formation of meandering river floodplains have been the subject of prolonged discussion in the geomorphological literature (Page, et al, 2003). A channel moving sideways by erosion on the outer bank and deposition on the inner bank is undergoing lateral migration and the deposit on the inner bank is point bars and it will show fining-up from coarser material at the base to finer at the top (Nichols, 2009). Migration of meanders produces a general fining-upward point bar deposits and, in turn silty and muddy floodplain deposits (Allen, 1970b; Boggs, Jr 2006). Multiple episodes of meander migration produce vertical stacking of fining-upward succession in meandering-river deposit (Boggs Jr, 2006).

Floodplains are dynamic feature that co-evolve with channel so at present no universal theory is available to predict floodplain width in natural rivers (as a function of drainage area, bank-full discharge, or sediment flux, etc) because floodplain morphology dynamically integrates across these and the other factors, over some unconfined time interval in the environment history of the watershed (Patrick Belmont, 2011). In this study we focus on floodplain deposit resulting from lateral accretion surface at river bend of Kampar Kanan River, Riau Province. Lateral accretion surfaces are most distinct when there has been an episode of low discharge allowing a layer of finer sediment to be deposited on the point bar surface (Allen 1965; Bridge 2003; Collinson et al, 2006; Nichols, 2009).

2. Overview of Kampar River

One of the meandering river system in the Riau Province, Indonesia is the Kampar River. Kampar River on the island of Sumatra in Indonesia originates in the mountainous Bukit Barisan of West Sumatra, and empties into the Malacca Strait on the island's eastern coast. The river is the confluence of two big tributaries are Kampar Kanan River and Kampar Kiri River. The tributaries meet in the Langgam subdistrict, Pelalawan Regency, before flowing into the Malacca Strait as the Kampar River. Koto Panjang, an artificial lake upstream of the river, is used to power a hydroelectric generating plant.

Study area is located in one of the Kampar Kanan river bends at Buluh China Village, Kampar District, Riau Province, Indonesia (Figure 1). The River has a lenght of 413 km and an average depth of 7.7 km and average width of 143 m. Fluvial meander system develop typical morphology that oxbow lake with tropical rain forest, sand bar and river with fishery product. It has been used as a local attraction. This study is one of the appreciation of Buluh Cina Village community that has been keeping the forest and natural conditions so this area can be used as one of the Geo-tourism in the Riau Province.

2.1. Geomorphic and Geological Setting

Buluh Cina Village is plain area with an elevation of 2 – 6 m above sea level. The landscape of study area is characterized mainly by active channels, abandoned channels , natural leeve, backswamps and floodplain. The study area is the floodplain of Kampar Kanan River, so this area will flood if higher rainfall. Distribution of geomorphic feature throughout the tudy area suggests that the landforms were developed mostly during Quaternary. Along The Kampar Kanan River is deposited Young Alluvium (Qh) during Holocene-aged. Young Alluvium (Qh) are consist of gravels, sands and clays.

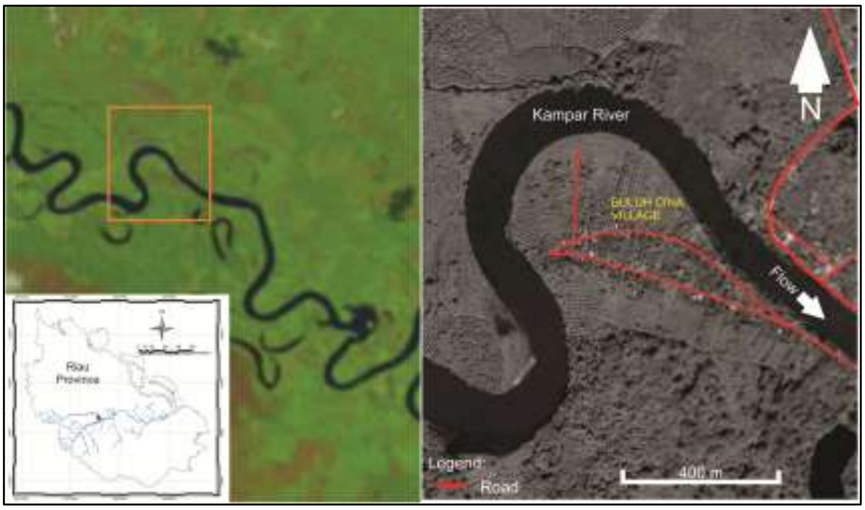

Figure 1. Location of Study Area.

The stratigraphy formation in the Buluh Cina Village are Older Alluvium (Qp) aged Pleistocene to Holocene. This sediments are consist of gravels, sands, clays, vegetation rafts and peat swamps (M.C.G. Clarke, W.Kartawa, A.Djunuddin, E. Suganda dan M.Bagdja, 1982).

Most of sand deposit along Kampar Kanan River has become mining site location, whether they have permission or illegally. This activity not only will affects the deposition process that happen naturally in the river, but also affects the river biota, tourism and water resources become damaged due to the mining. Morphological changes is forming in the Kampar Kanan River happen because of natural leeve (riverbank) erosion and sand mining, it make sliding riverbank and deepening of the riverbed.

2.2. Floods

Buluh Cina area located as floodplain area from Kampar Kanan River. This water are provided from large catchment area up to 5.321 km^2 came from Gadang Mountain and surroundings, with debit of water about 700 – 1000 m^3/s and relative slope 0,0008. In headwater part, there are hydroelectric power plant at Koto Panjang that built beside for electricity, and also to control volume of water. If there's any increasing volume due to heavy rain on the top side area and the dam of power plant cannot endure it, the condition will become a big flood that will be affected to this area. And this event has happened in January 2016, which the water of the river rising about 3 m from the condition at dry season, and flooding all the area.

3. Methodology

Data that used for this research consist of three data location of trench (TR-01, TR02, and TR-03), two drilling data (BC-01 and BC-02), and satellite image from landsat. The methodology for this study are consist of several steps and measurement, starting from scouting field surveys to check condition and to mark the drilling position, and then continued doing trenching at three position which located 2 m and 400 m away from the river. Some of them are already excavated and exposed, and revealed a 1 – 2 m thick sequence of sediment.

Drilling also conducted at two location up to 5 m depth using hand auger for coring, located 5 m from river and 400 m away from the river. This drillng data will provide a better visualization of the texture of sediment from bottom to top of the layer.

All of sediment that taken from trenching and drilling, will be analyze with sieve analysis by using mesh from 2.38 mm, 1.19 mm, 0.6 mm, 0.297 mm, 0.149 mm, and 0.074 mm to measure the weight each grain size and define the dominate grain size in every layer collected from field.

Interpretation of satellite image are using landsat image from april 1989 until april 2016. This image provide visual image to seek the geometrical changes of the river, and interpret the migration of the channel, and also correlate it with field survey data.

4. Lateral Accretion and Floodplain Deposit

4.1. Lateral Accretion Deposit on Kampar Kanan River at Buluh Cina Village

Based on the comparison of Satellite image data in 1989 and 2016, it shows a migration of the channel that occured in Kampar Kanan River that located near the Buluh Cina village (Figure 2). The basic dynamics of flow around meanders leads to erosion on the outside parts of bends and deposition on the point bars. Helical flow transport sediment, eroded from the cut bank, across the stream along the bottom and deposits it by lateral accretion on the point bar (Boggs, S.Jr. 2006. p.252). As the channel migrate the top of the point bar become the edge of the floodplain and the fining-upward succession of the point bar will be capped by overbank deposits.

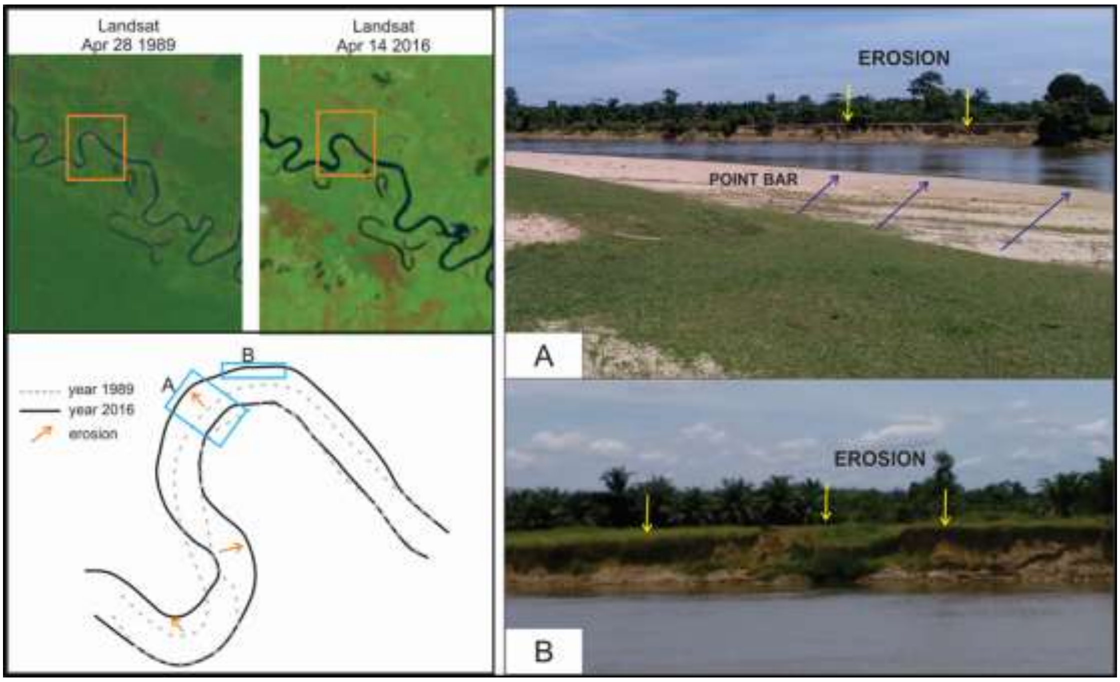

Figure 2. (A) Satellite image that showing geometrical changes the position of the river and image of point bar as result from river migration, and (B). Erosion at the nothern side of the river.

Field observations indicate that lateral accretion consists of a point bar, oblique accretion and overbank deposit. Sediment of point bar deposited medium sand with good sorting and upwards-fining couplets during flood events. Some flood channels become enlarged during floods, and may become the dominant channel (Wood, S.H et al, 2008). Oblique accretion sediment is defined here as the lateral accumulation of fine-grained floodplain deposit by progradation of a relatively steep convex bank in assosiation with channel migration (Page and Nanson, 1982). Oblique accretion are developed on the meandering low energy rivers of Kampar Kanan River. The presence of oblique-accretion deposits in Buluh Cina Floodplain was demonstrated by preliminary investigations at natural bank exposure, coring to a depth 5m, and trenches excavated at Kampar Kanan Rivers.

When the point bars occur, oblique accretion deposit occupy that part of the convex bank directly above at the point bar (Page, K.J 2003). At site oblique-accretion layers consist of sand, muddy fine sand strata dipping conformably with bank surface (Figure 3). Dip angles vary from near horizontal at the top and the bottom to less than 15^0 while at the bottom, there are point bar deposit with dip angle more than 15^0. (Figure 3).

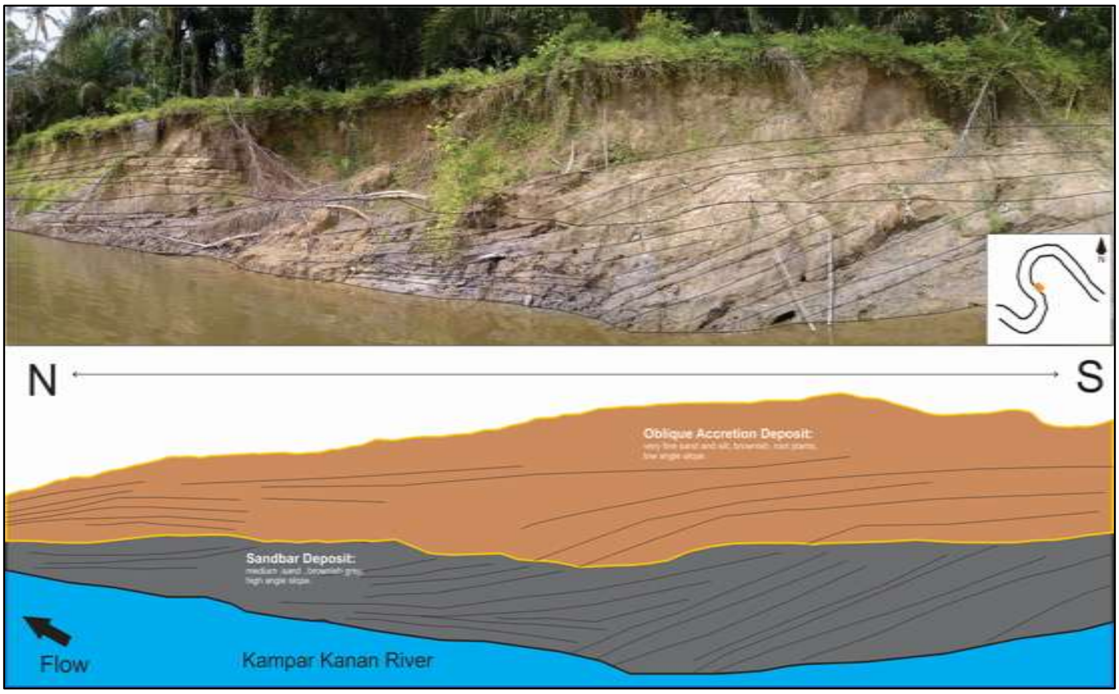

Figure 3. Deposit at western side of the river meander which shows sand bar deposit at bottom position with relative steep slope and deposit of oblique accretion at top with gentle slope than sand bar deposit.

On trench location (TR-01 and TR-03) shows very fine to fine sand sediments, root plant on the top and bioturbation on the top layer. It indicates as oblique accretion deposit. The decreasing rootplant and bioturbation and sediment with medium sand on the bottom layer and it indicates as point bar deposit (Figure 4).

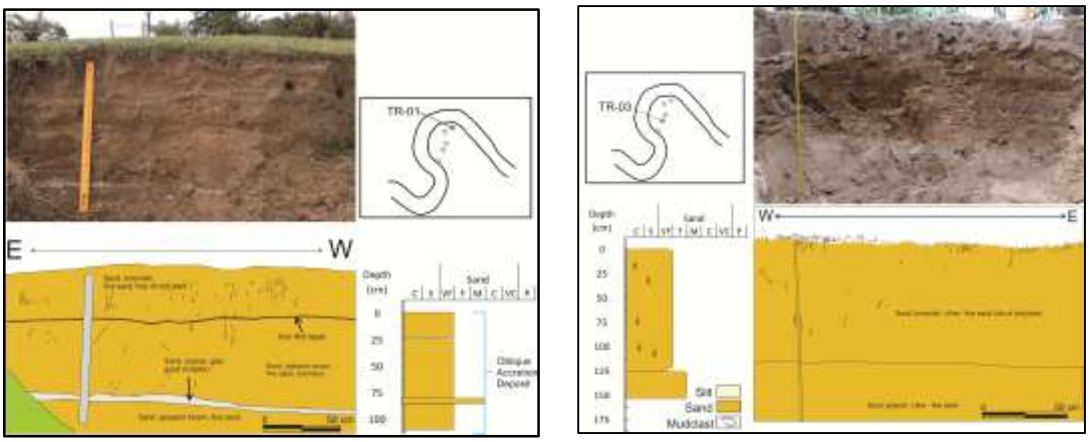

Figure 4. Deposit of lateral accretion which characterize with fine sand sediment at two different location (TR-01 and TR-03).

On TR-02 (Trench) location consist of very fine sediment at the bottom of the layer (125 – 75 cm) which indicates an oblique accretion deposit, and then silt – mud with 75 m thick that interpret as overbank deposit (figure 5). The boundary between silt and fine sand are gradual contact which affected from different grainsize and hardness, and also activity of organism and pedogenesis. Overbank sediment deposited on a floodplain was identified in the field using standard criteria (allen, 1965; Brown, 1987; Guccione, M. J, 1993). It was distinguished from channel deposits and colluvium by general lack of gravel, the lateral fining of texture with increasing distance from the channel and general lack of bedding , except proximal to channel (Guccione, M.J 1993).

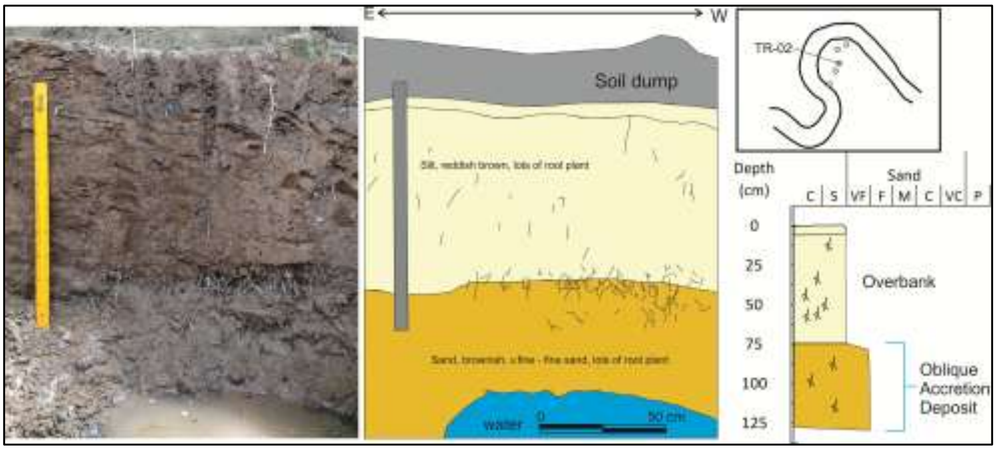

Figure 5. Succession at Trench (TR-02) that shows oblique accretion on bottom of the layer and overbank deposit at the top.

Based on sieve analysis from TR-01, TR02, and TR-03, considered from two different deposit shows that medium sand dominate at the bottom and very fine to fine sand sediment dominate at the upper part (figure 6).

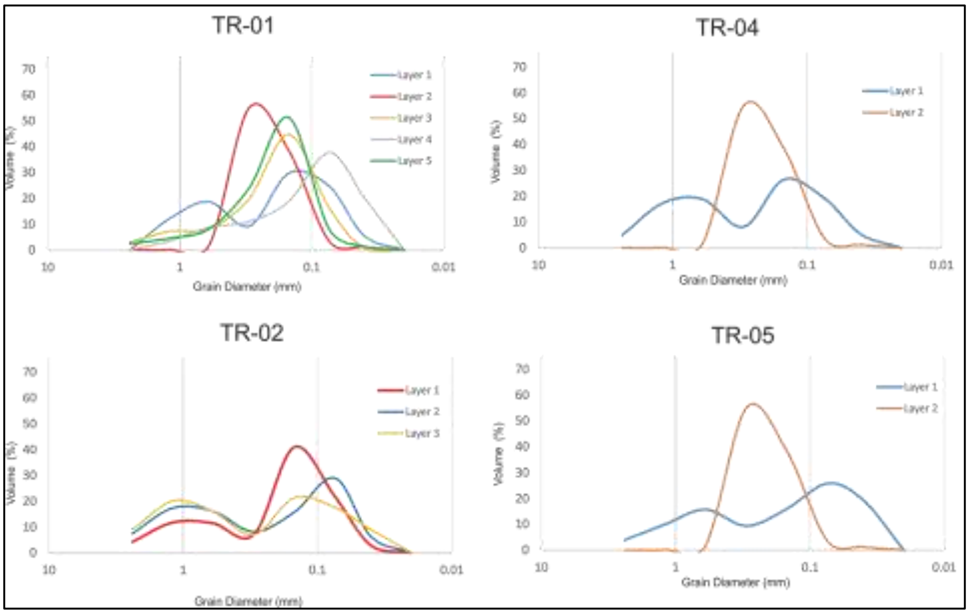

Figure 6. Sieve analysis that shows percentage of grain size distribution of each layer at four location (TR-01, TR-02, TR-04, and TR-05).

4.2. Lateral Accretion Deposit on Kampar Kanan River at Buluh Cina Village

Floodplain is a strip of land that borders a stream channel and that is normally inundated during seasonal floods. Sediment is transported over the flooding as bed load and suspended load during floods. The sediment comes from the main channel, the valley sides and the floodplain itself (Bridge, S. John in Posamentier, W. H. And Walker, G. R, 2006 p: 119). Based on drillling data using 5 m depth of core hand auger, it shows that floodplain formation originated from lateral accretion as sandbar, oblique accretion and overbank. Sandbar deposit located at the bottom and continued with oblique accretion deposit, and covered with overbank deposit at the top. The overbank deposits are not always shown in the floodplain formation, due to erosion process. Stratigraphy of this floodplain formation are showing repetitive deposit of sandbar and oblique accretion that there are two event happened in this area as shown on figure 7.

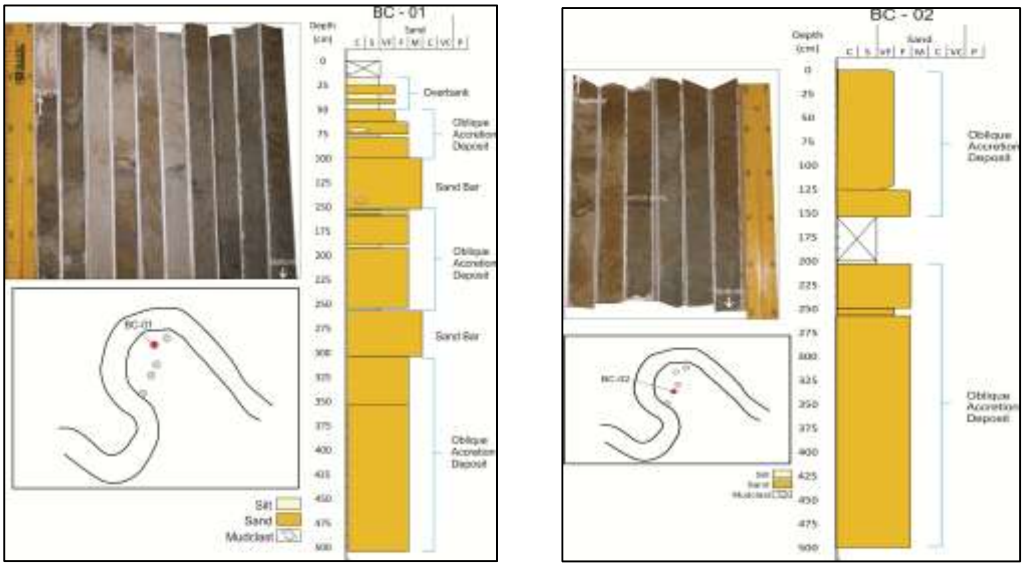

Figure 7. Analysis stratigraphy define from core data (BC-01 and BC-02) .

5. Discussion

Based on this research, it considered that lateral accretion gives a big contribution to the formation of floodplain. This formation form two type of deposit which are sandbar and oblique accretion that form at low energy in meandering river. Floods that happen periodically in this area also bring finer sediment such as silt and mud that characterize overbank deposit but not significally shown in this area. Therefore, in floodplain formation, lateral accretion gives bigger contribution than vertical accretion. Lateral accretion deposit characterize with fine to medium sand while overbank characterize with finer sediment (silt and clay).

The floodplain model that modified by Page et al, 2003 state that there are three models of stratigraphy produced by oblique accretion for different floodplain seetings: floodplain with point bar, floodplain with no point bar and floodplain with point bar and scrolls. Based on the model, this area are include in model of floodplain with point bar (Figure 8).

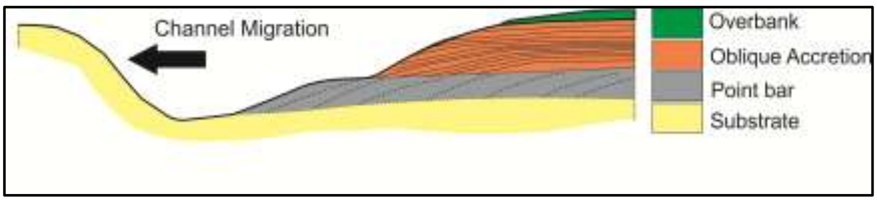

Figure 8. Model of stratigraphy in study area that related with Floodplain model with point bar (modified from Page, et al 2003)

6. Conclusion

- Floodplain Formation in study area are related with model floodplain with point bar which consist of succession of fine sand to medium sand with steep dip beds as sandbar and fine sand with gentle dip bed as oblique accretion deposit, and silt/mud, with root traces as an overbank deposit, all of this deposit form as drapes on the prograding bank. These beds dip mostly channel wards and quickly wedge out as they grade up and onto the floodplain.
- In this study, showing that lateral accretions are making significant contribution rather than vertical accretion to the preservation of fine-grained within channel deposits in contemporary floodplains.

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References

Allen, J.R.L (1965). A review Of The Origin and Characteristic Of Recent Alluvial Sediments. Sedimentology 5, 89 – 191.

Allen, P.A & Allen, J.R (2005) Basin Analysis: Principle and Applications (2nd edition). Blackwell Science, Oxford.

Belmont, P. (2011). Floodplain Width Adjustments in Response to Rapid Base Level Fall and Knickpoint Migration, Geomorphology 128 p. 92-102

Boggs, S. Jr. (2006). Principle of Sedimtology and Stratigrapy 4th ed, Pearson Prentice Hall, New Jersey, United States of America.

Bridge, J. S (2003) River and Floodplains: Forms, Processes, and Sedimentary Record. Blackwell Science, Oxford.

Brown, A.G. (1987). Holocene Floodplain Sedimentation and Channel Response Of The Lower River Severn, United Kingdom. Z. Geomorph. NF 31, 293-310.

Clarke, M.C.G et al (1982). Geological Map of The Pakanbaru Quadrangle, Sumatra. PPPG.

Collinson, J.D., Mountney, N & Thompson, D. (2006). Sedimentary Structure. Terra Publishing, London.

Guccione, M.J. (1993). Grain-Size Distribution of Overbank Sediment and its Use to Locate Channel Position. Spes. Publs Int. Ass. Sediment 17 p. 185 – 194.

Nichols, G. (2009). Sedimetology and Stratigraphy 2nd Ed, John Wiley & Sons Ltd, West Sussex, United Kingdom.

Nichols, G.j. & Fisher, J.A (2007). Processes, Facies and Architecture of Fluvial Distributary System Deposit. Sedimentary Geology, 195. 75-90.

Page, K.J et al. (2003). Floodplain Formation and Sedimen Stratigraphy Resulting From Oblique Accretion on The Murrumbidgee River, Australia. Journal Of Sedimentary Research Vol. 73 No.1. Tulsa, Oklahoma, USA.

Page, K.J., and Nanson, G.C. (1982) Concave-bank benches and assosiation and Floodplain Formation: Earth Surface Processes and Landforms, v.7, p.529-543.

Posamentier, H. W and Walker, R.G (2006). Facies Models Revisited, p. 119. Tulsa, Oklahoma. USA

Wood, Spencer H., Ziegler, Alan D., Bundarnsin, T. (2008). Floodplain Deposit, Channel Changes and Riverbank Stratigraphy of Mekong River Area at 14th Century City of Chiang Saen, Nothern Thailand, Geomorphology 101 p. 510 – 523.