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# Sedimentological Character of Fan Delta: Modern Sediment Case Study in Muara Pingai Area, Singkarak Lake, West Sumatra Indonesia

Said Muzambiq[1] and Zaka L. Tarigan[2]

[1]Geology Department, Institut Teknologi Medan (ITM) Medan, Indonesia.
[2]Independent Geologist.

## ABSTRACT

*Muara Pingai is a village in Junjuang Siriah sub-district, Solok regency, West Sumatera. It is located on the edge of the western Singkarak Lake and on borders of Bukit Barisan. Morphology of Muara Pingai area is formed by sedimentological process from Bukit Barisan to Southern part of Singkarak Lake. Based on morphological fact and collected sedimentological data by outcrop observation, PVC cores and modern sediment analysis; this area has been formed by Fan Delta process which sediment has been transported by Pingai River as an inlet system to Singkarak Lake. Fan Delta of Muara Pingai is divided into three parts, classified by its position in Fan Delta system which is: Upper Fan, Middle Fan and Lower Fan. The complete facies of Fan Delta are shown by its sedimentary characters (grain size, sedimentary structure and content) and hydrodynamics. Further research in Muara Pingai may focus in Fan Delta Evolution with dating by carbon content and Fan Delta dimension that may be useful for sedimentary rate calculation and development of the Muara Pingai Fan Delta.*

**Keywords**: Singkarak Lake, Fan Delta, Modern Sedimentology, Hydrodynamics, Muara Pingai.

## INTRODUCTION

Lake Singkarak (Indonesian: Danau Singkarak) is a lake in West Sumatra, Indonesia. It is located between the cities of Padang Panjang and Solok. It has an area of 107.8 km², being approximately 21 km long and 7 km wide. The natural outlet for excess water is the Ombilin River which flows eastward to the Strait of Malacca. A hydroelectric project, however, has diverted most of the lake outflow to the Anai River which flows westward into the Indian Ocean near Padang.

Located in Southern part of Singkarak Lake, sub-district Muara Pingai is an area with unique landscape formed by sedimentological process that deposit sediment from Barisan Mountain by Pingai River, an inlet river of Singkarak lake. Figure 1 shows the image of Singkarak Lake and Muara Pingai area taken from Google satellite images.


Figure 1: Google satellite image of Singkarak Lake and Muara Pingai area

## DATA AND METHOLOGY

In this research, data collection is done by conducting actual outdoor field activities which is divided into 3 (three) types that is taking the core of sediment by PVC coring methods, outcrop analysis and modern sediment condition of Singkarak Lake. In addition, river basin observation activities, observation outcrops, and morphological observations were also performed to determine the geological conditions of the lake area and the surrounding of Singkarak.

Data collection is focused on Southern part of Lake Singkarak with total 7 points of observation around Muara Pingai area. Figure 2 shows some of the PVC core sampling location.


Figure 2: PVC core sampling process on various lands: (A) Point bar, (B) Lake beach, (C) Lake dash, and (D) River terrace

## RESULTS AND DISCUSSION

Based on the results from morphological observation, observation of outcrops and core description, it can be seen that in the area of Singkarak Lake there is a delta fan-like environment in the area of Muara Pingai. The area is plain at the end of the river valley that flows from Bukit Barisan and it is morphologically visible to have a positive feature that forms like shape of a fan (refer Figure 3). The delta fancy in its description can be divided into 3 (three) sections based on its position in an alluvial fan system namely upper fan, middle fan and lower fan.

Figure 3: Morphology of Muara Pingai Fan Delta (——)

### Upper Fan

It is the highest part of a fan delta formation. In this part, the deposition of the current force is still very large. In addition to the flow of water, the gravitational force and turbidite currents can sometimes occur when the water discharge is too large, flood or during landslides and then flows with large sediments such as crusts up to a lump that would later be deposited as fragments.

### Sedimentary Characters

The sedimentological characteristics of the upper fan can be explained based on observations on the outcrops found at the OBS-3 location (refer Figure 4). In the sedimentary outcrop at the top of the fan delta system in Muara Pingai area there are two recurrent facies which is facies of breccias and sandy sedimentary facies were found.

The first facies is facies of breccias that have the size of grains of sediment grains dominated by the skeletons to the lumps. It has an upwardly upward orientation and an imbrication pattern on the sediment that indicates the direction of its transport flow. The facies are formed due to avalanches with turbidite currents and are formed in areas associated with fault activity as the first part of the formation of a fan delta.

The second facies is facies of coarse sand found on the facies of the breccias. It has an upwardly upward orientation with an imbrication pattern shown by some of the ramps on the top that also shows the direction of its transport flow. The facies are formed by the remnant of the avalanche sediment material that forms the first facet with a smaller transport flow strength which is also indicated by the boundary plane corresponding to the lower facies and the erosion area with the facies above it.

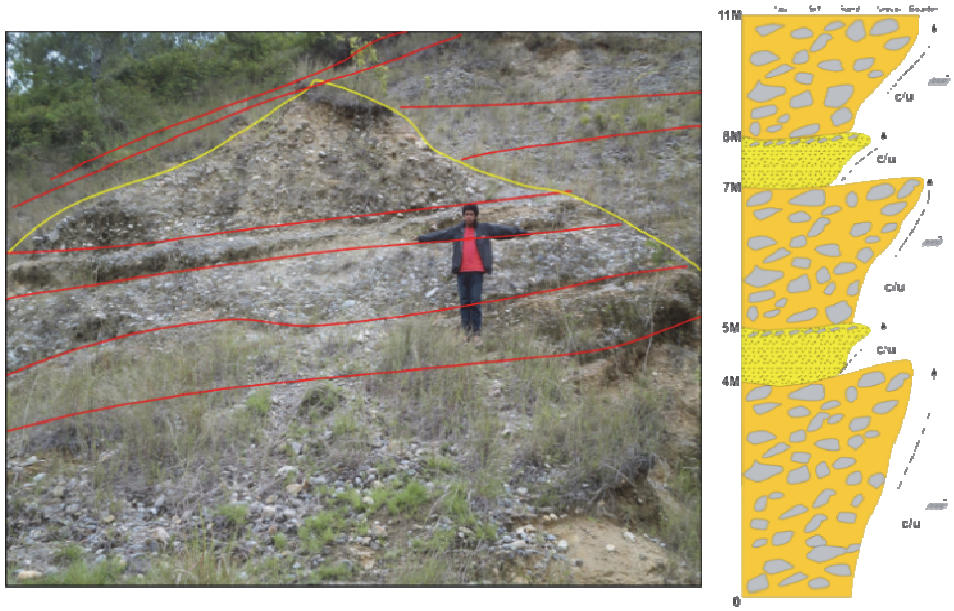


Figure 4: OBS-3 outcrop and stratigraphy sections

## Hydrodynamics

The hydrodynamic conditions occurring in the upper part of the fan are generally dominated by turbidite and gravity currents with slight traction current deposits as sediments continue to be transported to the lower part.
The coarsening upward viscous breccia facies exhibit sediment deposited by turbidite currents or due to avalanches that occur and do not undergo adequate transport processes to form rounded fragments so that they are dominated by angular fragments.

Sand-sized sediment facies are the result of sediment deposition which is transported by traction currents which are the remainder of turbidite currents or traction currents that flow at very active hydrodynamic conditions such as floods. It is also shown by the imbrication of fragments found at the top of the sand-sized sediment facies that have a coarsening upward orientation.

**Middle Fan**

It is the central part of a fan delta system, which generally has a flatter morphological shape. In this middle fan, sediments are rough from the rest of the sedimentation activity in the upper fan. This middle fan is contiguous with a layer of finer sediments such as sand until clay is deposited by water as a medium of transportation.

**Sedimentary Characters**

Sedimentological characters from the middle of the fan can be explained based on observations in the outcrop located in the middle of the fan delta system in the area of Muara Pingai where three facies that form the oriented coarsening upward was found.

The first facies are the gradations of silt-sized sediments to repeated coarse sand on the top layer. The gradual upward-grading sediment grain size change according to the strength of the current acting on the sediment transport and sedimentation of the facies from small strength traction to large traction current flow strengths in order to precipitate the rough-sand sediments. This facies precipitation process describes sedimentological conditions in the middle of the fan which is dominated by the river as the main media.

The second facies are the gradation of fine sand to coarse sand that also has the orientation of the coarse layer upwards. This facies indicates an increase in traction force flow strength due to the absence of fine-sized sediments but remains as a marker of deposited sediments under traction current conditions in the middle fan.

The last facies are sand conglomerates that have orientation of upward coarsening layer. This section shows the effect of turbidite currents that work on the upper fan which also reaches the middle fan. The rounded shape of the fragment explains the sediment has undergone a sedimentation process (refer Figure 5).

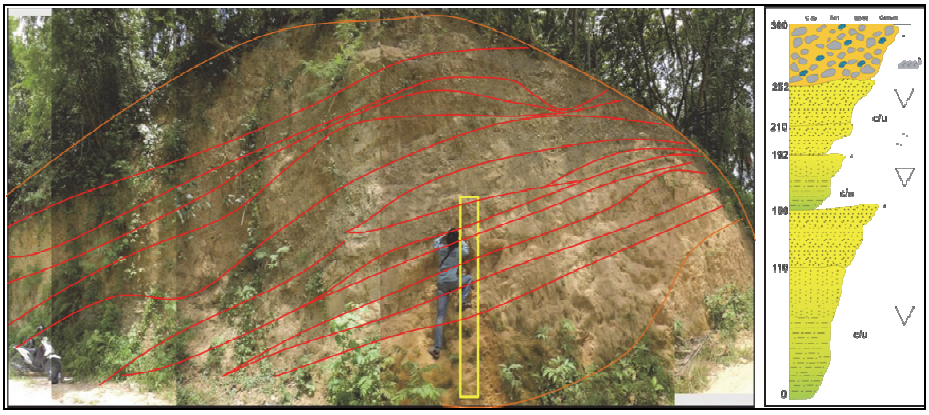

Figure 5: OBS-17 outcrop and stratigraphy section

## Hydrodymanics

Hydrodynamic conditions are generally dominated by traction currents flowing in rivers as the main sediment transport medium and as a source of sediment present in this delta fan system and less affected by turbidite currents which are usually the residuals of turbidite currents acting on the higher part (upper Fan).

Hydrodynamic patterns that work in the middle of the fan are generally the same as the braided river environment. This is because the rivers that flow are a braided type river that tends to flow not far from the upstream river and become inlet in to a lake.

## Lower Fan

This section is located at the end of the fan delta where the current strength is low and more dominated by the stream of the sediment. Generally, more finely sized sediments such as coarse sand to fine sand and clay are deposited in this section. On the Muara Pingai fan delta fan system, the lower part of this fan, the river with braided type flows into the lake.

## Sedimentary Characters

The sedimentological character of the lower fan section can be explained based on observations on the outcrops found at the location of SK-12A.

Based on the core descriptions on the location of SK-12A, a sediment layer pattern with graded bedding structure with coarsening upward pattern with some clay and silt clay inserts was obtained (refer Figure 6).

Variations of facies obtained in the SK-12A sediment core explain the complexity of the processes that occur in the lower fan. Starting from the influence of the traction flow from the river flowing into the kedanau with the type of braided river, the influence of the sediment deposition system on the lake shore to the existence of facies containing organic material such as mollusk shells and some wood pieces that can also be an indication of changes or developments that occur in the system. In this delta fan deposition lane.

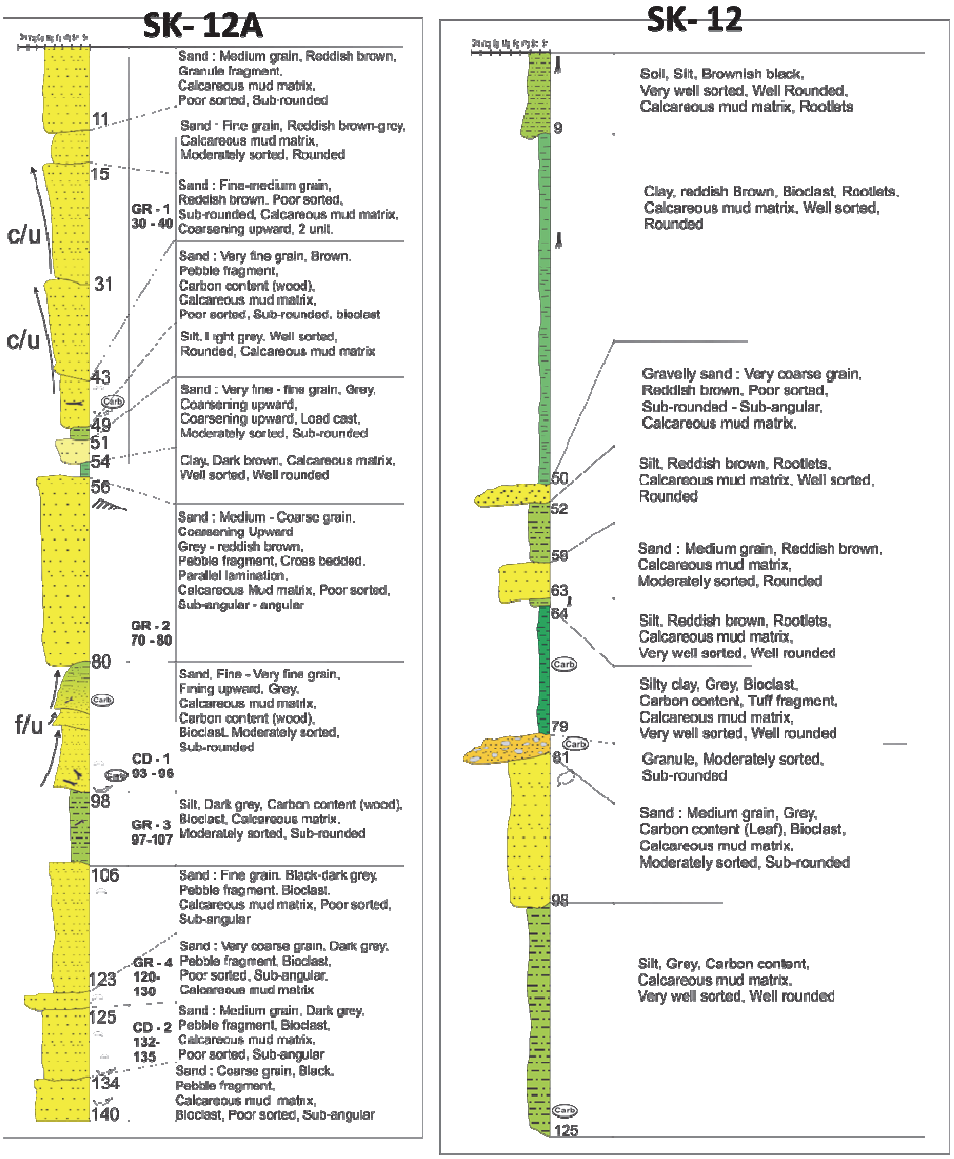


Figure 6: Stratigraphy column PVC core SK-12 and SK-12A in Muara Pingai area

## Hydrodymanics

Hydrodynamic conditions are generally dominated by traction currents flowing in rivers as the main sediment transport medium with the type of braided river stream that flows into the soil and brings the sediment into the lake system. Figure 7 shows the satellite image of Muara Pingai area and fan delta distribution.

In some parts, there is also a hydrodynamic condition that deposits fine-grained sediments such as the traces of the channel from the braided river which then undergoes a suspension condition and then the sedimentation process becomes inactive as (shown in Figure 6) in the stratigraphic column at the location of SK-12.

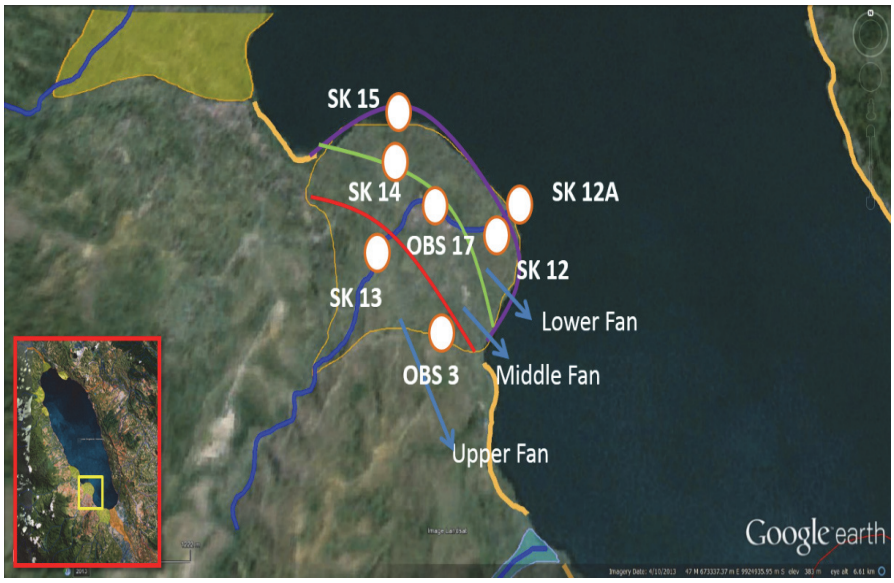


Figure 7: Satellite image of Muara Pingai area and fan delta distribution

## CONCLUSION

Based on modern sediment analysis, outcrop observation, and PVC cores sediment sample, Muara Pingai area is known formed by Fan Delta deposit controlled. Muara Pingai Fan Delta divided by 3 parts of delta system: Upper Fan, Middle Fan and Lower Fan. Further research may focus on recording the evolution of the delta fan in the Muara Pingai area by the method of calculating the age of sediment through carbon dating or other methods.

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