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GEOMORPHOLOGY AND GEOLOGY OF LAKE LINUMUNSUT, TONGOD, SABAH

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Abstract: Lake Linumunsut in central Sabah is a drowned river valley caused by landslide debris damming one of Namatoi River tributaries. The lake sits on mudstone layers of Kapilit Formation deposited about 12-15 million years ago. The morphology of the lake has changed slightly over the last 30 years due to siltation. The lake is filled with mud and very fine-grained sands up to 3 meters thick eroded from the mudstone and thin sandstone in the catchments area. The lake will not be completely filled up with sediments in the near future as the unsettled mud is easily flushed out from the lake during heavy rain. However the morphology of the lake will change drastically once stream down cutting along Linumunsut River reach the bottom of the lake.

Keywords: Lake Linumunsut, drowned valley, landslide, siltation and stream erosion

INTRODUCTION

Lake Linumunsut, located at the foot of the northern rim of the Maliau Basin is a rare geomorphological phenomenon in Sabah, Malaysian Borneo (Fig. 1). The occurrence of a huge landslide is thought to have caused the initial formation of the lake (Lamb, 1988) but how the lake evolved, remains unclear. In an attempt to understand the evolution of the lake a study on its geomorphology and geology was carried out during a scientific expedition from 15-22 October 2001 organized by Yayasan Sabah.

Aerial photographs and topographic maps were used to study the landscape of the lake and its surrounding areas. Fieldwork around the lake and along three rivers (Gaharu River, Beruang River and Namatoi River) provided information on rock types (surface and bedrock), orientation of strata and geological processes. The approximate depth of sediment in the lake was measured using a 5-metre pole, made from a small tree trunk. Mud samples were taken from the lake to determine grain sizes whereas mudstone samples were taken from bedrock outcrops to determine its age.

GEOMORPHOLOGY

Drainage System

The area surrounding Lake Linumunsut displays a system of subparallel stream trending approximately North-South and East-West (parallel and trellis pattern). The lake is fed by two main rivers, the Gaharu River located in the south and the Mata Pelanduk River in the northeast and three smaller parallel rivers fed from the north. The size of the lake is about 0.15 km^2 while the catchment area is about 4 km^2. Another river located northwest, named Linumunsut River drains the lake into the Namatoi River, the major river here (Fig. 2).

Topography

Lake Linumunsut lies about 400 metres above sea level and is located in an asymmetric valley (see Fig. 2). The valley is steeper on the northern side whereas on the southern side, a gentle slope abruptly becomes steep near the rim of the Maliau Basin. The boundary of the lake follows the shape of the drowned river valleys. The morphology and size of the lake has changed significantly during the period between 1970-1995 as seen on aerial photographs (Fig. 3). The size of the lake has increased to compensate for the increased in amount of sediments in the drowned river valleys. The volume of sediments that have entered the lake appears to have doubled during this period. The formation of marsh along the advancing deltaic deposits from the Gaharu River has also partially blocked the mouth of the Mata Pelanduk River (Photo. 1).

Stream Erosion

Headward erosion along the rivers has created v-shaped valleys and several small waterfalls. Along the Namatoi River, deep gorges up to 30 metres wide and 20 metres deep have carved through the recent aluvium comprising boulders and gravel and into the bedrock mudstones. A huge landslide scarp occurs upstream of the Namatoi River towards the rim of the Maliau Basin. Along Linumunsut River, the valley reaches up to 10 metres deep, cutting through recent alluvium. Along the Gaharu and Beruang Rivers, erosion has cut into the bedrock.

GEOLOGY

Rock Units

The Linumunsut and surrounding area represents the base of a thick sedimentary sequence forming the Maliau Basin (Tongkul & Chang, 2003). The Linumunsut area comprised of three sedimentary rock units, the Tanjong Formation, Kapilit Formation and recent fluvial deposits.

Figure 1: Location map of Lake Linumunsut, central Sabah.

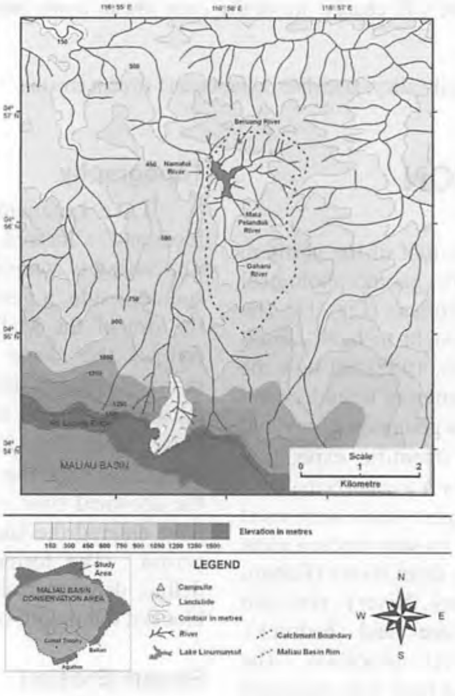

Figure 2: Topographic map of Lake Linumunsut and surrounding areas.

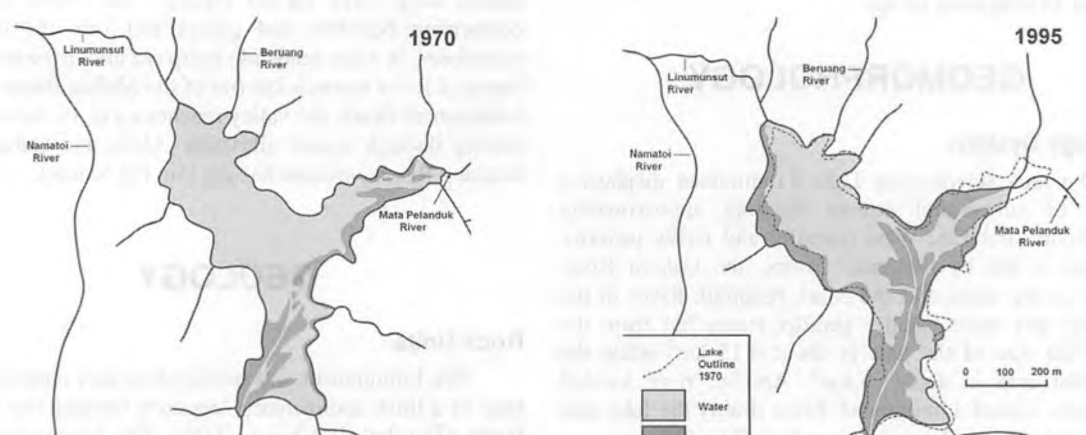

Figure 3: Outline of Lake Linumunsut as drawn from aerial photographs in 1970 and 1995.

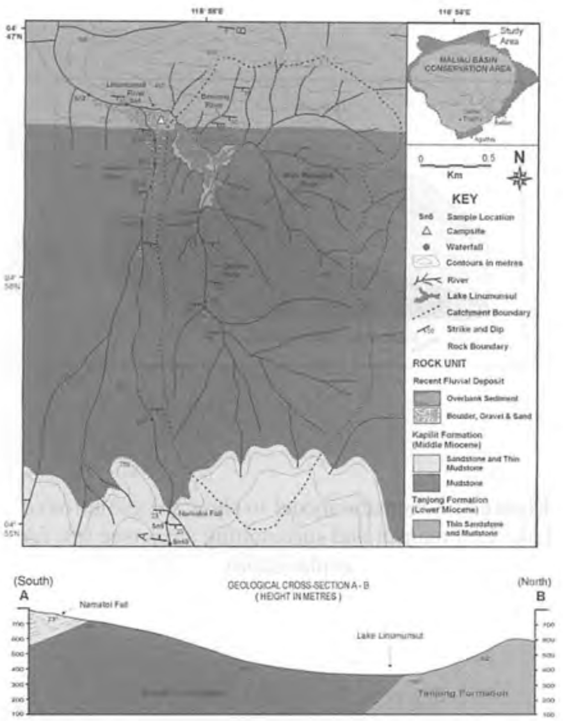

Figure 4: Geological map of Lake Linumunsut and surrounding areas.

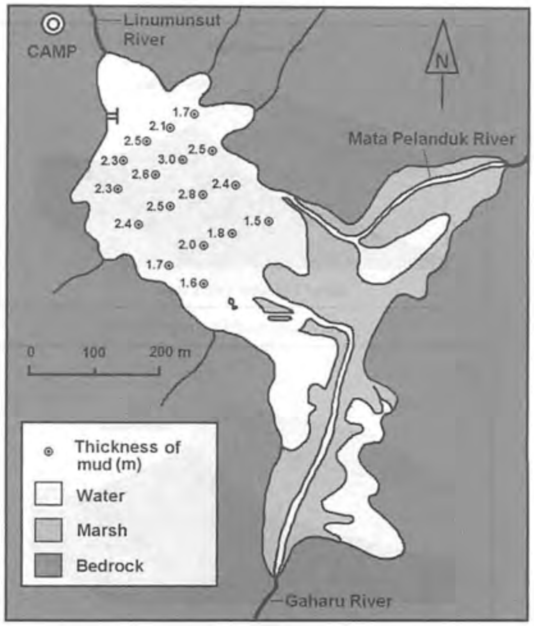

Figure 5: Approximate depth of sediment at the bottom of the lake.

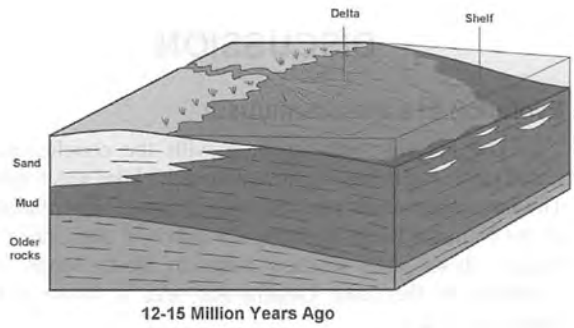

Figure 6: Schematic model to show the ancient depositional environment of Lake Linumunsut and surrounding areas.

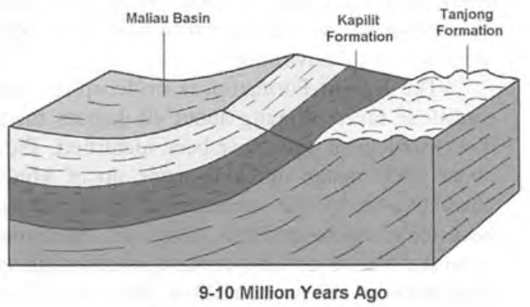

Figure 7: Schematic model to show folding and uplift of sedimentary rocks at Lake Linumunsut and surrounding areas.

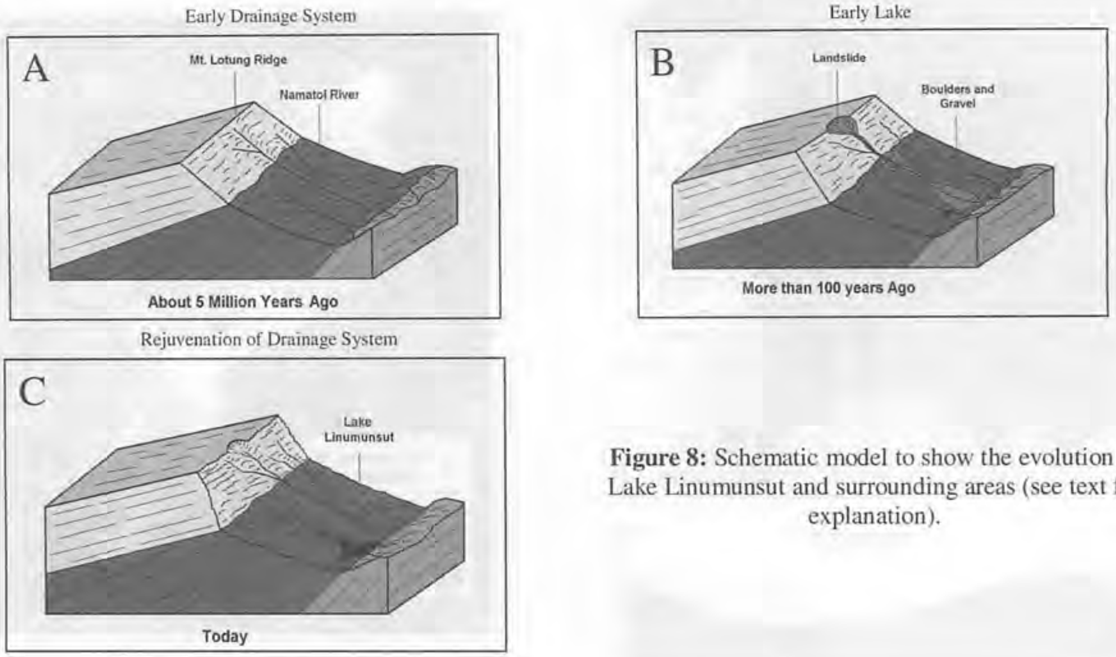

Figure 8: Schematic model to show the evolution of Lake Linumunsut and surrounding areas (see text for explanation).

The distribution of the sedimentary units is shown in Fig. 4.

The Tanjong Formation made up of thin-medium bedded sandstones and mudstones are exposed along the Beruang and Namatoi Rivers. The sandstones and mudstones dip steeply at about 50 degrees towards south. The sediments are interpreted to have been deposited in a shallow coastal environment.

The Kapilit Formation is made up of mudstone and sandstone layers dipping about 40 degrees towards south. Two lithological units have been identified. The lower part, about 2000 meters thick is made up of Mudstone Unit characterised by the presence of thick mudstones with occasional sandstone beds (Photo 2). Mudstone samples from the Mudstone Unit contain microfossils which show ages between 12 to 15 million years old (Table 1). The Mudstone Unit is interpreted to have been deposited in a slope to shallow shelf marine setting. The upper part is made up of Sandstone Unit which is characterised by the presence of cross-bedded sandstone and mudstone of various thicknesses. Blocks from the sandstone show gastropod and bivalve fossils (Photo. 3). The Sandstone Unit is interpreted to have been deposited in a shallow coastal environment.

The area around the lake is covered with recent fluvial deposits, composed of sandstone boulders and gravel together with sands. Such deposits can be seen clearly along the Namatoi River (Photo. 4) and Beruang River. The lake itself is filled with mud, silts and very fine sands reaching up to 3 metres thick (Fig. 5).

Geological Structures

The Lake Linumunsut area shows an East-West structural trend. The strike of bedding falls between 90-100 degrees east and dips some 40-50 degrees towards South. The fractures are orientated perpendicular to the bedding strike. Faults are quite rare, only one small normal fault trending East-West having been seen in the Namatoi River. The orientation of beddings suggests that the area has been subjected to N-S tectonic compression.

DISCUSSION

Evolution of Lake Linumunsut

The present study concurs with the conclusion of Lamb (1988) who has suggested how the lake was formed. The lake is the result of damming of one of the tributaries of the Namatoi River by landslide debris at the foot of the Maliau Basin cliffs washed down by flash floods. The evolution of the Lake Linumunsut area is illustrated in Figures 6, 7 & 8.

About 15 million years ago, Lake Linumunsut and its surrounding area were an ancient coastal-shelf area, where a huge volume of mud and sands were deposited (Fig. 6). About 9 million years ago the sediments were subjected to regional tectonic compression and uplift. This compression resulted in the gentle folding of the sediment (Fig. 7) in an East-West orientation and development of fractures perpendicular to it.

About 5 million years ago continued tectonic compression in this region might have uplifted the area to its present height above sea level (Fig. 8a). The East-West orientation of the mudstone and sandstone layers and North-South orientation of fractures controlled the evolution of an early drainage system. The presence of more competent sandstone layers and softer mudstone layers controlled the evolution of the river valley.

The steep cliffs of the Maliau Basin show that a few thousand metres of sediments have been eroded during the past. Landslides along the edge of the cliff must have been

Photo 1: Aerial view of Lake Linumunsut showing drowned river valley and development of marsh across the lake.

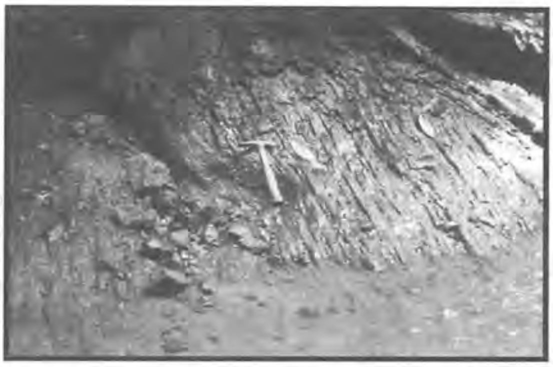

Photo 2: Mudstone layers with thin sandstone interbeds of Kapilit Formation along the Gaharu River.

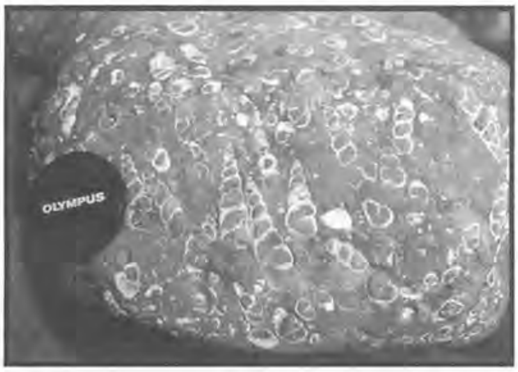

Photo 3: Gastropod fossils in sandstone boulder of Kapilit Formation along the Namatoi River.

Photo 4: Recent fluvial deposits consisting of boulders and gravel along the Namatoi River.

Table 1. Summary of Results from Biostratigraphical Analysis by Sarawak Shell Bhd.

Sample Number	Nannoplankton Zone	Palynological Zone	Planktonic Foraminifera Zone	Environment of Deposition Based on Benthonic Foraminifera
L1	NN4-NN5	P400/500	-	Inner-middle shelf
L2	(NN4?)-NN5	P400/500	-	Inner-middle shelf
Sn1	Barren	P400	Barren	Inner-middle shelf
Sn2	Barren	P400	Barren	Shallow shelf
Sn3	Barren	P400	Barren	Slope
Sn4	Barren	P400	Barren	Base of slope
Sn5	Barren	P400	Barren	Basinal
Sn6	NN6- (NN7?)	P400	-	Outer shelf-slope
Sn7	NN4-NN5	P400	SN5-SN13	Base of slope
Sn9	-	P500/610	Barren	Shallow coastal
Sn10	-	P500/610	Barren	Near river mouth

Note: P400 (Late Lower Miocene: 16-17 Ma), P400/500 (Early Middle Miocene: 14-15 Ma), P500/61 (Late Middle Miocene: 11-13 Ma), SN5-SN13 (Middle Lower Miocene to Late Middle Miocene: 12-22 Ma), NN4 (Late Lower Miocene: 16-17 Ma), NN5 (Early Middle Miocene: 14-15 Ma), NN6 (Middle Middle Miocene: 12-13 ma), NN7 (Late Middle Miocene: 11-12 Ma).

quite common and resulted in temporary damming of rivers at the foot of the cliff. In time, the debris is eroded or washed down and the streams revert to their original form. It is envisaged that one such landslide triggered the development of Lake Linumunsut (Fig. 8b & 8c). However it is still uncertain when the lake started to form. It is possible that the lake must have existed more than 100 years ago based on the amounts of sediments that have entered the lake and the huge size of trees that have overgrown the debris that blocked the Linumunsut River valley.

Siltation of Lake Linumunsut

In 1976, during an earlier scientific expedition to Lake Linumunsut, Lamb (1988) suggested that due to erosion and siltation the lake would be completely filled with silt in 10-20 years time. The present study shows that while there has been an increase in the amount of sediments in the lake, it is unlikely that the lake will be completely filled with silt in the near future as erosion of the surrounding areas mostly brings mud, which, during heavy rain, is easily flushed out from the lake. However, based on the morphological changes of the lake during the past 30 years, it is likely that the lake may become marshland in 40-50 years time.

Disappearance of Lake Linumunsut

Headward erosion and downcutting will continue in all the rivers. This will create deeper gorges and longer streams. Along the Linumunsut River this erosional process will have a significant impact on the lake. As the river valley gets deeper and wider more water would be drained out from the lake. The process will continue until the whole lake is drained and the drowned river valley returns to its original morphology. It is uncertain how long this will take and further hydrological study is required.

Acknowledgements

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