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Quarternary Sediments at Sungei Besi, West Malaysia

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Abstract: Well stratified sediments consisting of gravel, sand, mud, clay and peat crop out in several opencast pits of the Sungei Besi Tin Mines near Kuala Lumpur. They lie unconformably over limestone and granite bedrock with their base below the present sea level. Pollen analyses and carbon-14 dating indicate that most of the sediments are Pleistocene in age. Abundant plant fragments, the lack of marine fossils, and the occurrence of gravelly lenses suggest a fluvial depositional environment. The dominance of angular grains of quartz, tourmaline and muscovite in these sediments indicate that they were derived from weathered granitic rocks nearby. The depositional history was probably related to the sea level changes during the Pleistocene.

INTRODUCTION

Quaternary sediments exposed in several mineholes (opencast pits) of the Sungei Besi Tin Mines were investigated from February to July 1965. These mineholes, six in number during the investigation, are located about 9 miles south of Kuala Lumpur, along the Kuala Lumpur–Serdang Road, and lie between latitudes 3°01′N and 3°03½′N and longitudes 101°42′E and 101°44′E (Fig. 1). Of the six mineholes examined, four showed good exposures of Quaternary sediments which are generally well stratified and lie unconformably over granite and limestone bedrock.

This paper is based on a thesis for the B.Sc. (Honours) degree from the University of Malaya, Kuala Lumpur (Ayob, 1965).

BEDROCK GEOLOGY

The bedrock is composed of limestone and granite. Procter (1955) recorded the presence of shale, breccia and grey schist as bedrock as well as the limestone and granite.

The granite is medium to coarse-grained muscovite granite, occasionally containing some tourmaline. It crops out in the eastern part of the area, and at most places it is strongly weathered. Dykes of fine-grained muscovite granite, aplite and tourmaline aplite also occur. These are about 30 cm wide and usually intrude along faults in the limestone.

The limestone is well bedded, recrystallised, generally medium to coarse-grained and is composed almost entirely of carbonates with few impurities. It is usually grey or rarely pinkish grey and sometimes contains thin black bands of carbonaceous particles. The beds vary in thickness from a few centimeters up to 50 cm, averaging about 20 cm, and they dip moderately, averaging about 35°, to the west (Fig. 1).

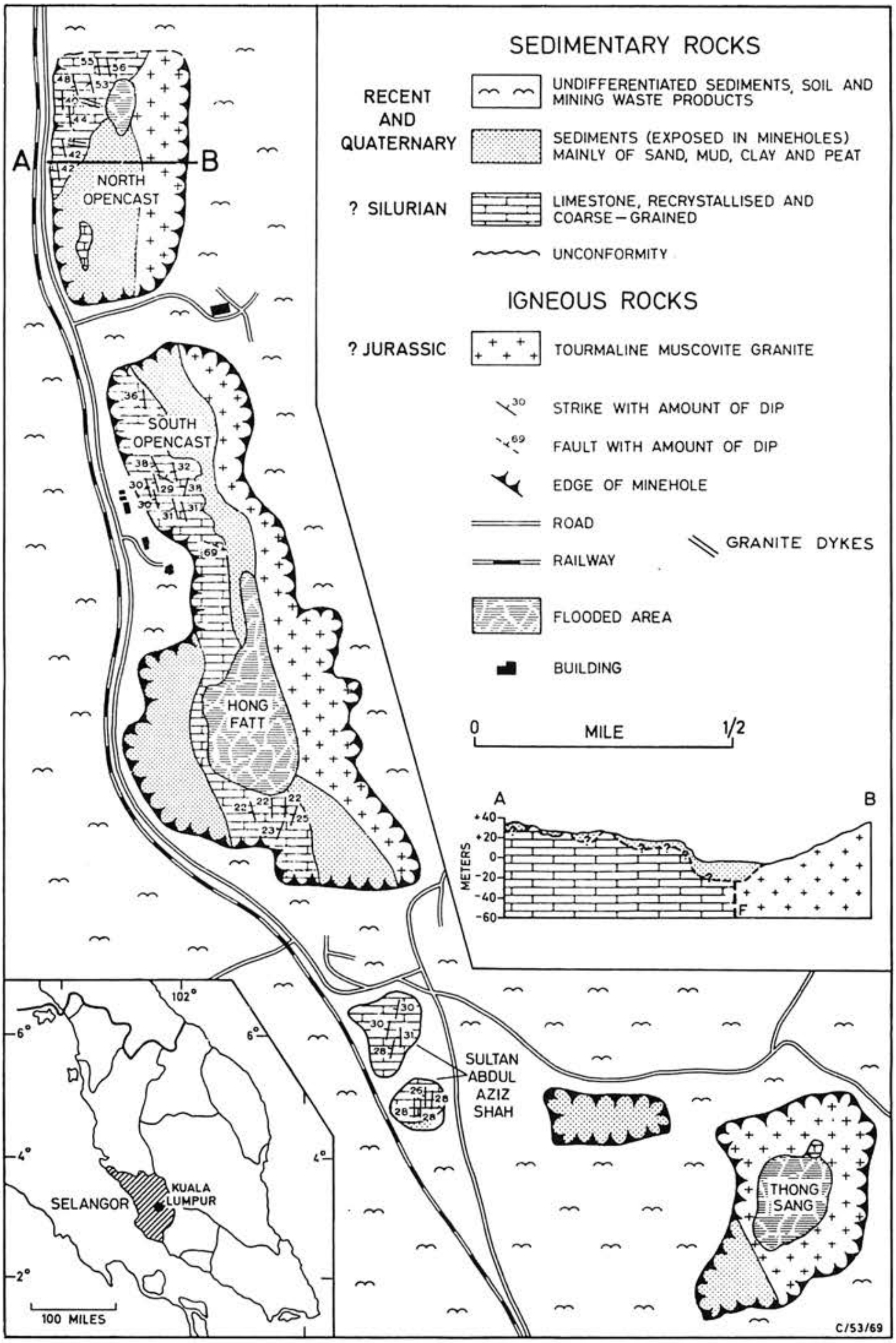

Fig. 1. Simplified geological map of Sungei Besi Tin Mines. Erratum: Unconformity in legend should be shown at base of Quateruary.

The limestone crops out either as a flat platform often breached by shallow potholes of about 30 to 60 cm diameter, or as jagged pinnacles with concordant tops (Fig. 2) which are about 38 meters above sea level. The limestone pinnacles often form the margins of large potholes with diameters between 3 and 10 meters and depths of 10 meters or more. These potholes have smooth walls which are vertical or steeply inclined. The limestone in this area is geologically and geomorphically similar to the Kuala Lumpur Limestone (described in Gobbett, 1964, p. 74–78) and probably is similar in age, *i.e.* Silurian.

The contact between the limestone and the granite was never seen but it is probably a fault, striking approximately north-south. The general bedrock surface in these mineholes was seen only in the Sultan Abdul Aziz Shah Mines I and II, where it is about 30 meters above the present sea level. In the other mineholes, it is not exposed even after the overlying sediments have been excavated down to about 5 meters below sea level. At many places only sediments were encountered in borings reaching depths of 20 to 30 meters below the present sea level.

THE QUATERNARY SEDIMENTS

Description

The Quaternary sediments are composed of well stratified, consolidated and unconsolidated, grey or brown muddy sand and sandy mud, dark brown or black muddy or sandy peat, white or brown clay, and gravel. The strata are generally horizontal. Some strata are gently inclined, with dips varying from 5° to 20° (Fig. 3). Strata in

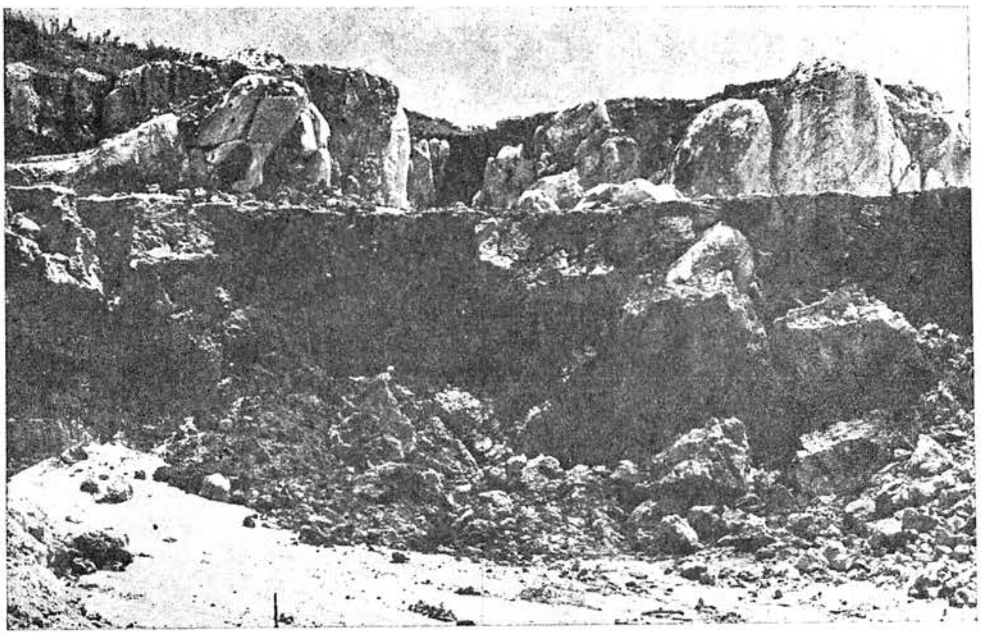

Fig. 2. Limestone pinnacles with concordant tops forming the rim of a large pothole seen in center background. Well stratified sandy peat in foreground, partly excavated. Vertical cut of peat is about 3 meters high. North Opencast, looking northwest.

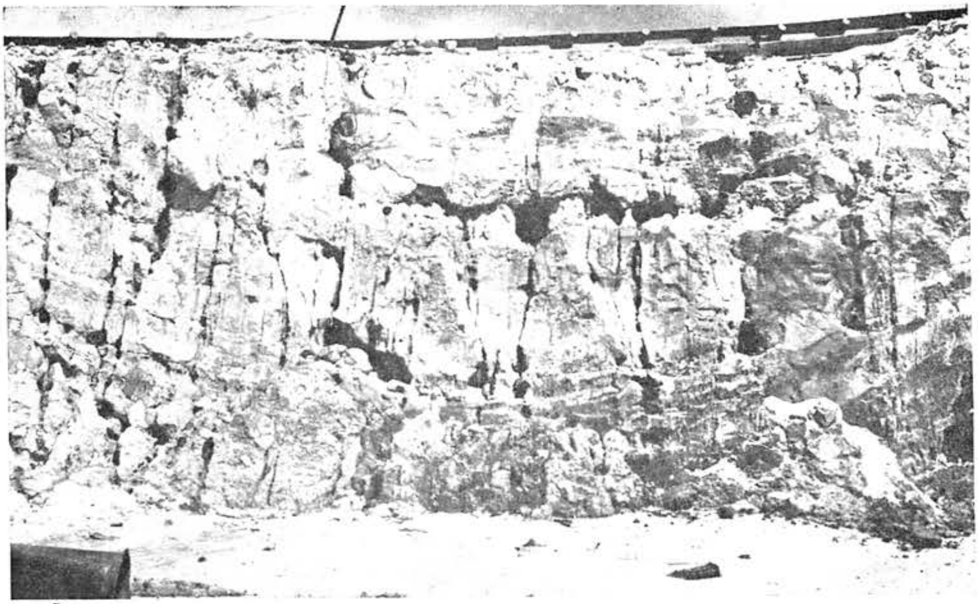

Fig. 3. Gently inclined sand and mud strata. Vertical cut is about 6 meters. North Opencast, looking west.

some of the large potholes lie concordantly on the pothole walls (Fig. 4). This is evidence that solution occured after deposition of sediments. The maximum thickness of sediments exposed above bedrock varies from as little as 5 meters, in the Sultan Abdul Aziz Shah Mine II, to more than 50 meters in the North Opencast. Sand forms the bulk of the sediments, with mud, peat and clay next in abundance and gravel occurring rarely. All these sediments are interstratified and no one sediment is restricted to any definite horizon. However, the lowest stratum in the limestone potholes is usually a tight clay and strata overlying this tight clay often contain considerable amounts of carbonised plant fragments.

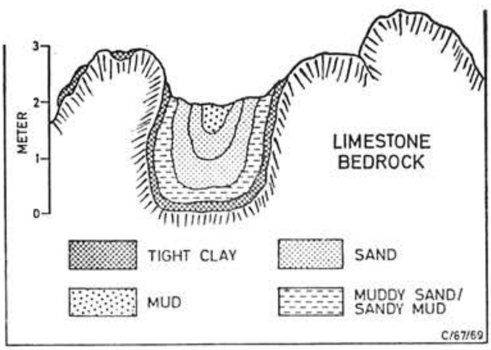

Fig. 4. Cross-section of a limestone pothole showing originally horizontal strata of sediments resting at steep angles concordant with pothole walls.

Sand

The sand deposits are grey or light brown to dark brown and are well stratified with strata generally between 15 cm and 2 meters thick. They are hard and fairly consolidated when containing more than 10% mud, or loosely packed when containing less than 10% mud. Generally the loosely packed sand deposits are common in the upper stratigraphic horizons and the consolidated sand strata in the lower stratigraphic horizons. Almost all of the sand deposits are muddy, with mud content varying from about 5% up to as much as 40%. Brown and dark brown sand strata usually contain up to 10% by weight of organic material, chiefly in the form of carbonised plant fragments.

These sand deposits are mainly fine to medium-grained, moderately to very poorly sorted (based on σ_ϕ, and using sorting classes of Folk and Ward, 1957) and unimodal, with modes between 1.5ϕ and 2.0ϕ (Fig. 5). The largest grains are usually between 2 and 5 mm but in some rare strata they are pebbles up to 5 cm large. In many sand strata, usually of thickness 15 to 30 cm, the largest grains are restricted to the lower part of the stratum and the smaller grains to the upper part.

The sand-sized and larger grains are composed of about 75% to 85% quartz, 5% to 10% muscovite and the rest of tourmaline, pyrite, cassiterite, zircon, chlorite and iron oxides. The quartz grains are angular to sub-angular and contain microlites, mineral inclusions and liquid and gaseous vacuoles. Tourmaline grains are generally sub-idiomorphic and include two varieties, a brown to dark brown variety which predominates, and a bluish white variety.

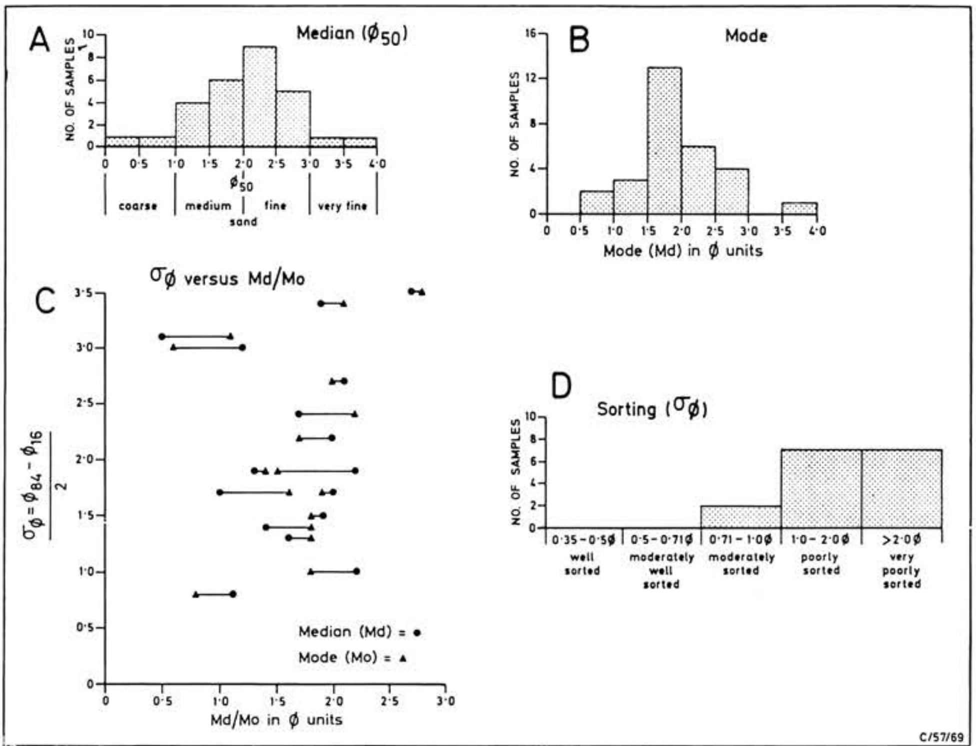

Fig. 5. Grain size data for sandy sediments at Sungei Besi. Parameters and sorting classes from Folk and Ward (1957).

Mud

The mud deposits are well stratified, generally grey when containing little or no carbonised plant fragments and greyish brown, or dark brown when containing a considerable amount of carbonised plant fragments, which may constitute up to 15%

by weight. These deposits are generally hard and consolidated, but some are loose and friable and these often contain more than 10% by weight of carbonised plant fragments. The deposits are commonly sandy, containing up to 30% sand.

The largest grains in these strata are usually coarse sand and rarely granules 3 to 4 mm large. Thick homogeneous mud deposits also occur. They are 3 to 5 meters thick and grey or bluish white, contain little or no caıbonised plant fragments, and have small pebbles as their largest grains. These mud deposits are very poorly sorted and bimodal. The sand grains are angular to sub-angular and are composed mainly of quartz and muscovite, with some cassiterite and pyrite.

Peat and organic remains

Organic remains occur as lignite deposits and muddy or sandy peat. The lignite is black and occurs as lenses or as unstratified accumulations, usually containing some sand.

Peat is generally brown to dark brown or black, fairly friable and usually well stratified with strata varying from about 15 cm to 1 meter thick. It consists largely of carbonised bark, leaves, twigs, stems and roots of large plants. These plant fragments are bound in a matrix of fine-grained sand and mud.

Plant remains in various stages of carbonisation occur commonly in the sand, mud and peat strata. These usually consist of brown to dark brown pieces of bark, stems and twigs. Stems with girths of about 30 cm are common and some with girths up to 1.5 meters also occur. Some of the stems were probably preserved in growing position since they are upright and penetrate stratification boundaries of strata containing them.

Clay

This sediment is well stratified with strata 15 to 30 cm thick. It is usually compact, soft and plastic. Most strata are whitish grey but some may be light brown or brown when containing fine carbonaceous particles. It is composed almost entirely of very fine grained clay minerals, probably mainly kaolinite, with very little or no silt and larger grains. It is common in the higher stratigraphic horizons.

Gravel

This sediment usually occurs as lenses in the sand and mud strata and rarely forms definite beds. It is generally loose, very poorly sorted and consists mainly of sub-rounded pebbles of quartz and granite and angular sand-sized quartz, tourmaline, pyrite and cassiterite grains all bound in a matrix of white clay. Much of this clay is probably a product of weathering *in situ* of other minerals. The largest clasts are about 8 to 10 cm in size and these are predominantly quartz.

Age determinations

The age of these sediments is indicated by the pollen content of peat and by carbon-14 dating of peat and wood.

Several samples of dark brown and black sandy peat were collected from the North Opencast and examined for pollen by the Staff of the Palaeontological Laboratory, Brunei Shell Company Limited, Brunei. It was found that the samples are rich in pollen and spores in excellent preservation and that most of the grains are still spherical. Dominating in all of these samples are pollen of Brownlowia-Pentaceae type, Blumeodendron type, Melastomaceous type and Myrtaceous type. Of special interest is a trisaccate grain of *Podocarpus imbricatus* type which is known in Borneo from Late Pliocene and younger only. (Details of pollen types are on file at the Department of Geology, University of Malaya, Kuala Lumpur).

Two samples of peat and one of wood were collected from sediments in the North Opencast and radiocarbon measurements were made by the National Physical Laboratory, Teddington, Middlesex, England. The results (Haile and Ayob, 1968), summarised in Table 1, indicate that most of the sediments in the Sungei Besi Tin Mines are pre-Holocene and most probably Pleistocene in age.

Table 1. Age of peat and wood samples in sediments of the Sungei Besi Tin Mines, Kuala Lumpur, based on carbon-14 measurements.

Reference Number	Material	Elevation above sea level (in meters)	Age in years before present (B.P.) *i.e.* before A.D. 1950
3966(NPL–143)	Wood	13	36,420+1,255 −1,085
3967(NPL–144)	Peat	12	>41,200
3968(NPL–145)	Peat	14	>41,500

(Details of pretreatment, reference standards and precision are on file at the National Physical Laboratory and the Department of Geology, University of Malaya, Kuala Lumpur).

Depositional environment

The presence of abundant plant fragments in these sediments, the occurrence of gravelly lenses and kaolinitic clay, and the absence of marine fossils suggest strongly that the depositional environment was non-marine and most probably fluviatile. A fluviatile environment is further indicated by the large variation in grain size between sediments: the gravels and sands may represent channel deposits, the mud and clay flood-plain deposits, and the peat and lignite backswamp deposits.

Source rocks

The dominance of angular quartz grains and the ubiquitous occurrence of muscovite and tourmaline indicate that granite and allied rocks were the main source rocks for these sediments. The angularity of quartz and tourmaline grains further indicates that these sediments were derived directly from weathering of granitic rocks not far from the area. It is probable that the granites of the Main Range were the source rocks for these sediments since they are known to contain muscovite and tourmaline and are located just east of this area.

DISCUSSION

The evidence indicates that there are at least two levels of bedrock surface underlying the sediments in this area, one at about 30 meters above the present sea level and the other below the present sea level. These bedrock surfaces were probably formed by fluviatile erosion down to stream base level at two different sea levels, one about 30 meters above the present level and the other more than 30 meters below the present level.

The sediments overlying the bedrock surfaces were most probably formed in one period of deposition, since the strata appear to be conformable throughout the entire sequence. This suggests that both the bedrock levels were formed prior to the deposition of the sediments and that the lower level was formed later than the upper level.

It is probable, therefore, that prior to the deposition of the sediments in this area, an erosion surface at about 30 meters above the present sea level was formed. At a later period, when the sea level was lowered below the present level, the rejuvenated streams carved away pre-existing rocks down to the new base level forming a lower bedrock surface. Non-eroded parts of the upper level formed hills on this new general bedrock surface. With the following rise in the sea level, the streams aggraded and began depositing sediments on the bedrock surface. These streams probably had their sources to the east in the Main Range and were laden with materials from weathering of granitic rocks.

The sediments in the Sungei Besi Tin Mines are stratigraphically and petrologically similar to the "Old Alluvium" (Walker, 1955), which consists of Quaternary sediments cropping out in tin mines in Perak, West Malaysia. It is probable that they are equivalent deposits formed during the same period of rise of the sea level in the Pleistocene.

After the deposition of sediments in this area, solution of limestone bedrock along bedding, joint and fault planes by ground water circulating through the permeable sand and gravel strata occurred. This led to the removal of the underlying limestone bedrock forming potholes into which the sediments subsided, resulting in sediment strata resting at steep angles concordant with the pothole walls.

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