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Bouldery Mudflow Deposit at Ranau, Sabah, East Malaysia.

LEONG TIN KONG

University of Malaya

Abstract: A Quaternary diamicton covering an area of at least 4 sq km occurs around and northwest of Ranau, Sabah. The deposit consists of large round boulders of adamellite and cobbles and fragments of sedimentary rock in a muddy matrix. The largest boulder in the deposit measures approximately $20 \times 10 \times 10$ meters and is estimated to weigh not less than 4,700,000 kg.

Absence of sorting, lack of lateral gradation in size of clasts, the great size of the boulders, and field relationships indicate that this is a mudflow deposit. The mudflow probably originated in the Pinosuk Plateau where rock debris of a similar composition is present. The deposit in Ranau represents the most easterly extension of the mudflow.

INTRODUCTION

The Ranau area was first mapped as part of a reconnaissance survey of the Jesselton–Kinabalu area by Collenette (1958). The area was mapped in detail by the author in March–May 1968 for a B.Sc. (Hons.) thesis submitted to the University of Malaya. This paper is based on part of the thesis.

LOCATION AND EXTENT

In and around Ranau, Sabah, (fig. 1) a diamicton overlies Tertiary sedimentary rocks and alluvium on the Ranau Plain. In the Ranau area the diamicton covers at least 4 sq km (fig. 2). It covers the area around and to the west and northwest of Ranau and probably extends to the Pinosuk Plateau. The deposit in Ranau is the most easterly extension of the diamicton.

The diamicton lies on the Ranau Plain and beyond the northwestern margin of the Plain, covering most of the hill-slope between the Ranau–Tambunan road and the Ranau–Tamparuli road. Most of Ranau town, including the government quarters, Public Works and Water Works Departments, the Rest House and shops, is located on the deposit.

Large adamellite boulders are conspicuous in the field and, based on their presence, it has been possible to map from a distance the approximate extent of the diamicton. In this manner isolated patches have been mapped across the deep valley of the Liwagu River west of Ranau. Unfortunately the diamicton cannot be distinguished on aerial photographs.

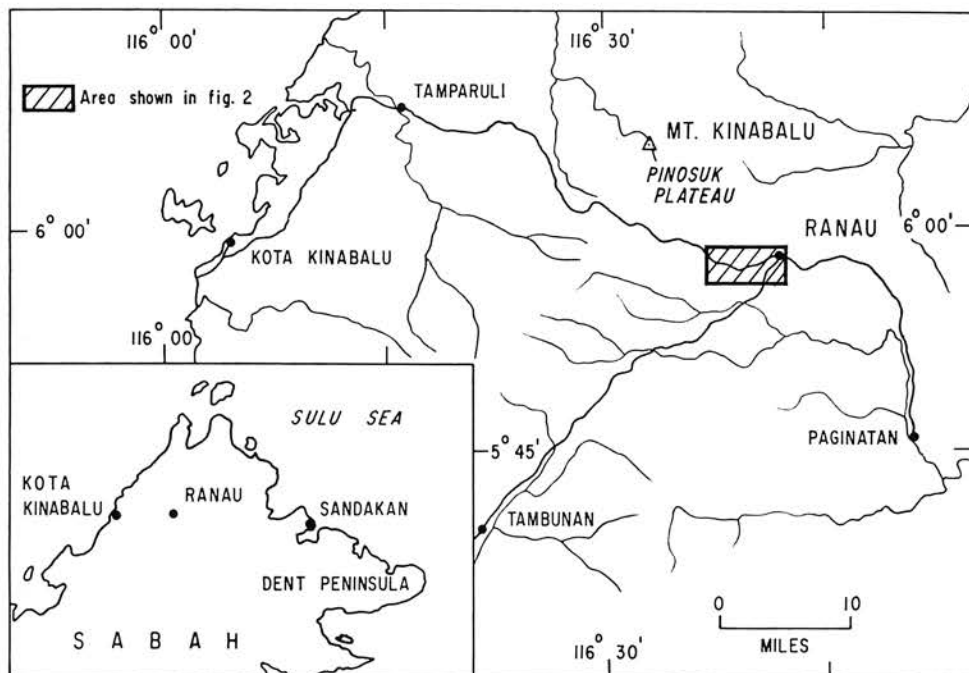


Fig. 1. Sabah, showing location of Ranau area.

COMPOSITION

The term 'diamicton' is used here for the deposit because it has no genetic implications. It is any nonsorted or poorly sorted terrigenous sediment that consists of sand and/or larger particles in a muddy matrix (Flint, Sanders and Rodgers, 1960a, 1960b).

The diamicton in the Ranau area is characterised by the presence of large rounded boulders of adamellite and cobbles and angular fragments of sedimentary rock in a muddy matrix. The large boulders are exclusively coarse-grained, porphyritic adamellites. These adamellites contain orthoclase phenocrysts up to 6 cm in length and subhedral crystals of hornblende up to 1.5 cm in length. The orthoclase crystals show up on the rock surfaces as white crystals set in a finer-grained darker background.

The largest boulder in the area is found near the Ranau hospital. This boulder is ellipsoidal in shape and measures approximately 20 meters long with a width and height of 10 meters. However, the average size of adamellite boulders is around 3 to 5 meters, boulders of this size being common around the Water-Works, the Public Works Department workshops along the Ranau-Tamparuli road, and on the plain south and southeast of the town. The adamellite boulders are rarely smaller than 40 cm across. All these boulders are ellipsoidal (fig. 3, 4).

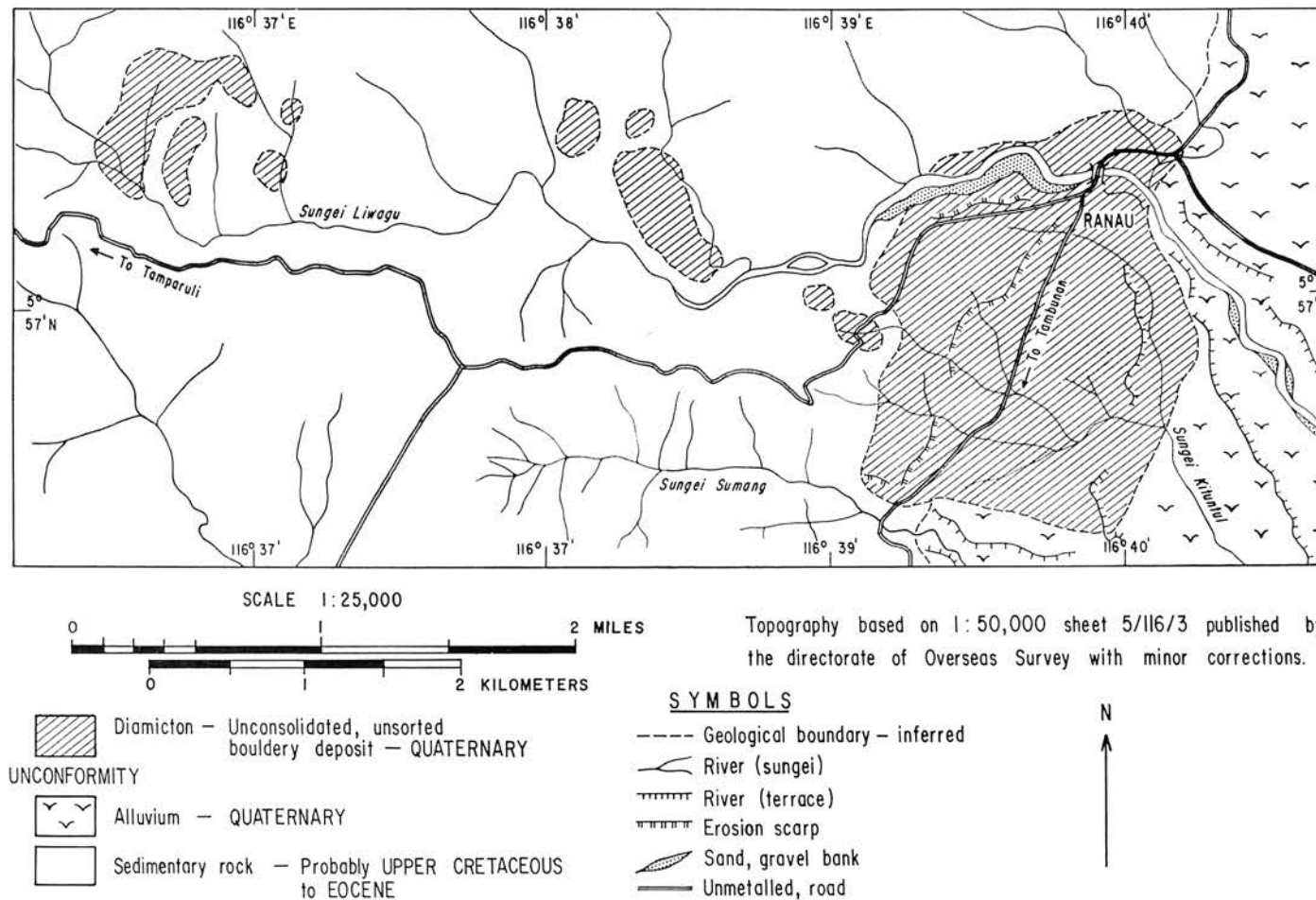


Fig. 2. Geologic map of the Ranau area showing distribution of the diamicton.

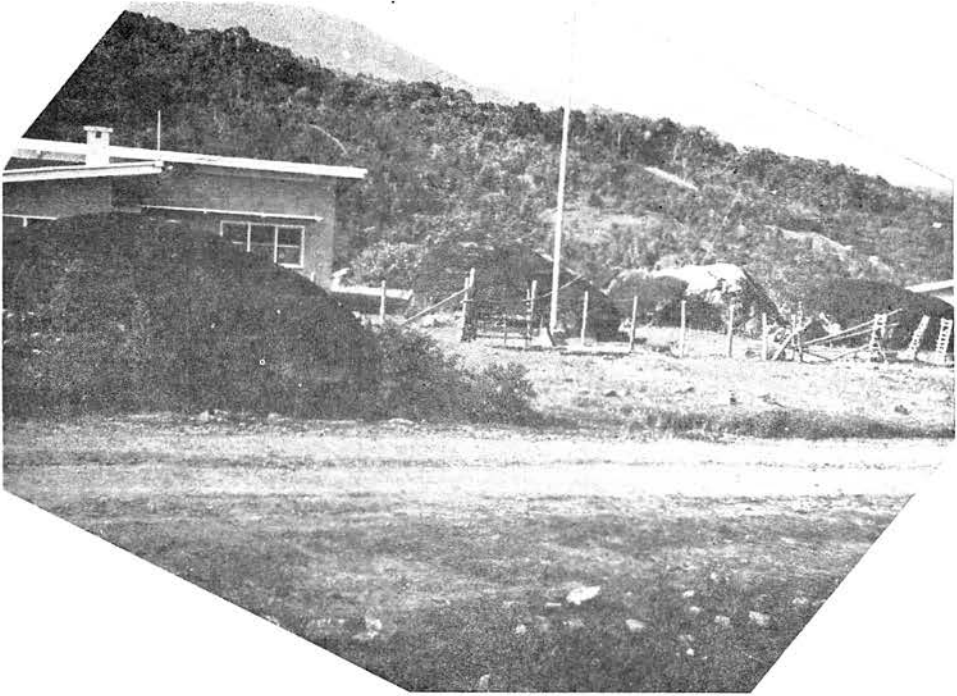


Fig. 3. Large adamellite boulders located near the Water Works, Ranau. These boulders mark the occurrence of the diamicton.

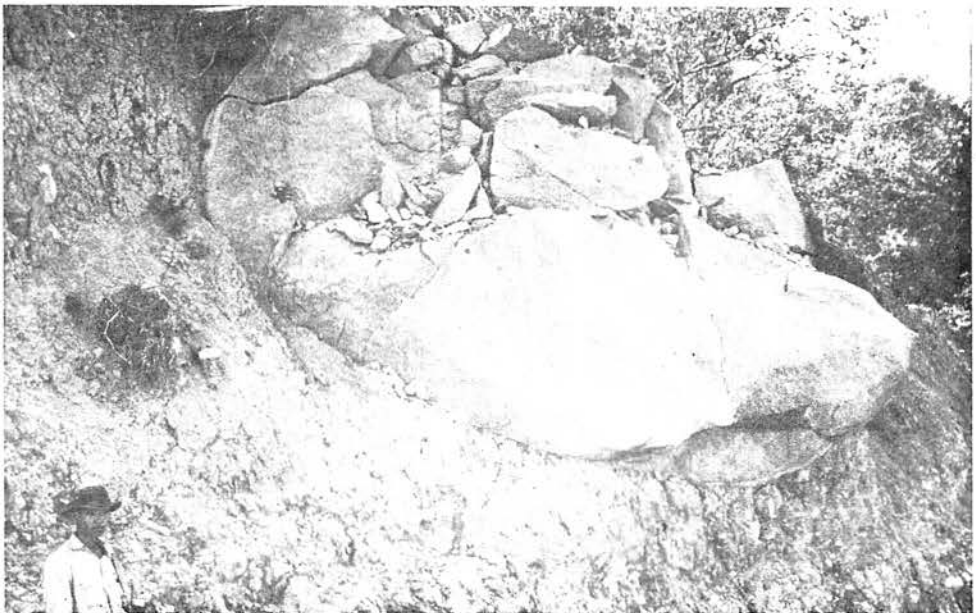


Fig. 4. Adamellite boulder and smaller clasts embedded in matrix, forming the diamicton. Exposure is a road-cut along the Ranau-Tamparuli road.

Although the adamellite boulders make up the most conspicuous component of the deposit, they do not represent the major component volumetrically. They appear conspicuous and dominant because the matrix in which they were embedded has been extensively eroded leaving the boulders lying on the surface, generally uncovered by vegetation.

Much of the deposit is made up of angular to sub-angular pebbles and cobbles of fine to very fine sandstones or quartzites. Most of these fragments are less than 20 cm across (fig. 5). A few pieces of adamellite of this size were found but these are finer grained than the huge boulders.

The matrix of the diamicton is yellowish orange to reddish orange clay and silt, locally sandy.

A rough visual estimate of the average percentage composition and size of clasts is given in Table 1. This estimate is derived from two exposures of the deposit, one along the Ranau-Tamparuli road, the other at the site of the government quarters. The sample plots do not include any huge adamellite boulders, which are estimated to make up about 10 to 15 percent by volume of the deposit originally.

Weathering and erosion of the diamicton have given rise in some areas to a thin layer of clean white sand lying on top of the underlying deposit. This sand layer, which is usually not more than 5 cm thick, covers a stretch of about 250 meters along the Ranau-Tambunan road. The formation of this white sand can be seen in weathered exposures of the diamicton, where the sandstone clasts are extensively weathered to produce bodies of friable whitish sand which still maintains the original shape of the clasts.



Fig. 5. Diamicton along Ranau-Tambunan road showing smaller clasts and extremely poor sorting.

Table 1. Rough Estimate of Composition, Size and Roundness of Larger Clasts* in the Diamicton.

Locality	Percentage of clasts*	Percentage of matrix	Average Diameter of clasts (cm)	Percentage in number of near-average-diameter clasts	Percentage (in number of clasts) based on Roundness				Percentage (in number of clasts) based on Lithology	
					R	S-R	S-A	A	Sed. or Met.	Adamellite
Ranau-Tamparuli Road	55	45	5	50	0.5	6.5	22	71	90	10
Near Government quarters Ranau	63	37	3	70	0	28	62	10	85	15

*Granules, pebbles and cobbles up to 20 cm.

R = Rounded
S-R = Sub-rounded
S-A = Sub-angular

A = Angular
Sed. = Sedimentary
Met. = Metamorphic

MODE OF DEPOSITION

Collenette considered the adamellite boulders and allied clastic sediments to be an alluvial piedmont fan deposited by the Liwagu, Sumang and Kaingalan rivers. However, it is difficult to conceive that the Liwagu River, even at maximum flood, could have transported boulders of this size. If the deposit is fluvial, one would expect some sorting and separation of the sizes of clasts upon deposition. Moreover, the smallest boulders would have been transported furthest, that is, nearest to the margin of the deposit. No such gradation was found.

It might be postulated that the diamicton could be the result of gravity creep. However, in the course of the present survey, no adamellite plugs were discovered that could have been the source of the adamellite boulders. Moreover, parts of the diamicton are resting on the ridges and slopes of small hills; thus they could not have resulted from gravity creep.

Although glacial features have been found on Mount Kinabalu, they are restricted to the summit of the mountain (elevation 4,100 meters) (Koopmans and Stauffer, 1967). The diamicton is now resting at an elevation of approximately 600 meters and therefore could not have been deposited by glaciers.

The huge boulders, absence of sorting and grading in size of clasts, and field relationships indicate that the diamicton is a mudflow deposit.

According to Pettijohn (1957), "sorting is nil and the largest available blocks are moved and deposited concurrently with the finest particles" when materials move "as a semi-solid plastic body, mudflows and glacial ice belong to this cate-

gory". This description corresponds well with the features of the diamicton as observed in the field. In an exposure along the Ranau-Tamparuli road the diamicton occurs within a channel in the underlying sedimentary rock (fig. 6). The walls and base of the channel are highly irregular, indicating probable scouring and rapid infilling of the channel by the diamicton and the absence of fluvial erosion. The present extent of the diamicton in the area surveyed suggests that it was deposited in a narrow belt such would be expected of a mudflow moving down a valley.

The most likely source of the deposit appears to be the Pinosuk Plateau, as was suggested by Collenette (1958). The Plateau is made up of rock debris which appears similar in composition to that of the mudflow deposit (Collenette 1958). The same sort of rounded adamellite boulders are present there, and if the deposit was in fact derived from there, this would explain the roundness of the boulders in the diamicton, as it is not likely that the boulders could have been rounded during transportation. The Pinosuk Plateau lies only about 10 km northwest of Ranau, at an elevation of approximately 600 meters above Ranau Plain giving a gradient of approximately 60 meters per kilometer. This distance is well within the range of established mud-

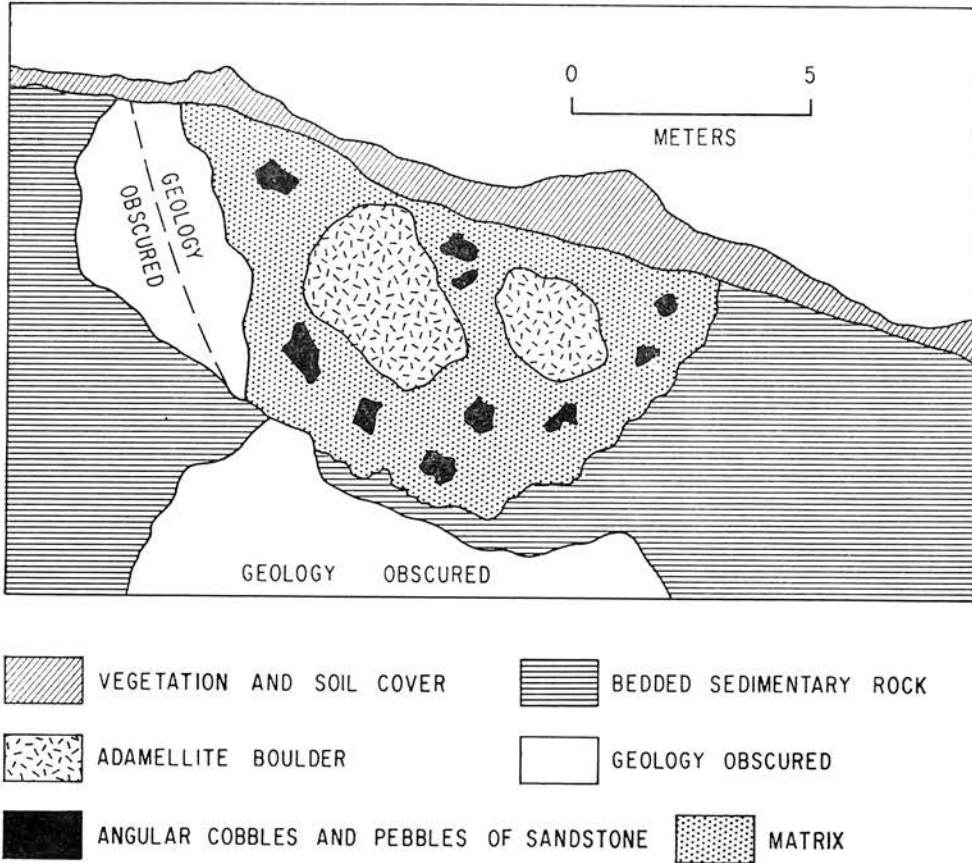


Fig. 6. Exposure along Ranau-Tamparuli road showing infill of channel by diamicton.

flows; one mudflow near Wrightwood, California, travelled some 24 km over a gradient of only 15 meters per kilometer before coming to rest (Sharp and Nobles 1953). The linear pattern of the deposit at Ranau indicates an east-southeastward flow, which is consistent with the location of the Pinosuk Plateau. The mudflow could have been due to saturation of the original material by high rainfall causing it to move under gravity.

ROCK STRATIGRAPHIC POSITION

The deposit overlies part of the Tertiary sedimentary rocks. South-east of the Rest House along Liwagu River, the diamicton rapidly decreases in thickness. The top of the diamicton there is at least 10 meters higher than the alluvial deposit that is seen about 50 meters downstream. Therefore, although no section has been observed where both diamicton and alluvium are present, it can be inferred that the diamicton overlies part of the alluvium. An erosion scarp has been cut into the diamicton, west of the Ranau-Tambunan road, by the Liwagu River. Thus the diamicton forms part of the Ranau Plain and is presumably Quaternary.

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