



Study of mass movements along Kundasang Road, Sabah

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Abstract: The study of mass movements has long been regarded as one of the most important aspects which should be implemented in road construction in Sabah. Mass movements is a general term for a variety of earth processes by which large masses of rock and/or earth material spontaneously move downward either slowly or quickly by gravitation. This paper will focus on the study of Kundasang Road, one of the most vulnerable to mass movements occurrence in West Coast Sabah. Mass movements in the study area landslide, creep, rock slide and rock fall. Several factors contribute to the occurrence of mass movements and these are categorized into geological, geomorphological, climatological and anthropological factors. Consideration of these hazards must be taken into account in development planning to counter their disruptive effects.

INTRODUCTION

The study of earth mass movement has long been regarded as one of the most interesting and important aspect of engineering geology which designers and planners from the private and public sectors address when implementing the initial stages of urban and rural development projects. This involves highways and infrastructure construction and land use planning among others. Failure to appreciate the problems relating to mass movements of earth material could lead to damage of man-made structures and even the loss of lives.

Mass movements is a general term for a variety of earth processes by which large masses of rock and/or earth material spontaneously move downward, either slowly or quickly by gravitation (Montgomery, 1986). Other synonymous term are mass wasting and gravity movement. Such earth processes become geologic hazards when their interaction with the material environment is capable of causing significant negative impact on a human's well being.

The focus of this study centers on the Kundasang Road which is continually threatened by these mass movements. Kundasang Road is the vital highway as well as the most accessible route linking Kundasang-Ranau to Kota Kinabalu City. Kundasang Road has repeatedly suffered structural

damages due to repeated occurrence of these mass movements during heavy rains.

GENERAL GEOLOGY SETTING

The geology of Northern Borneo (Sabah) is strongly related to the opening of the South China Sea in the northwest and the movement of the southwest Philippines Plate in the northeast (Holloway, 1981; Ru and Pigot, 1986). These movements have caused complex structures in Sabah (Holloway, 1981; Ru and Pigott, 1981). More precisely, Sabah is bordered to the east by the Sulu Sea, and is fringed northward by the Palawan Trench. The formation of the accretionary prism was related to the above movements and has caused compression to the Tertiary basins in Sabah. Similar plate motion that has affected most of Borneo Island has been discussed by Ben-Avraham (1978).

The Crocker basin *sensu lato* is considered to be part of the Tertiary basins in Sabah that have undergone accretionary process. This basin consists of complexly deformed Late Paleogene to early Miocene turbidite sequences, namely: the Crocker Formation, the Kulapis Formation, the Kudat Formation and the Labang Formation. These turbidite sequences are overlain by shallow marine quartzose sandstone of Middle Miocene to Late

Pliocene sequences, underlain by Pre-Tertiary ophiolites. All the above highly deformed terranes are imbricated by mélanges or chaotic formations, including the pre-Tertiary ophiolites.

LOCAL GEOLOGY

Rocks underlying the Kundasang area vary in type and age starting from Paleocene-Eocene rocks to very young alluvial still being deposited. Three formations are present in the map area: Trusmadi Formation, Crocker Formation and Quaternary sediment (Tongkul, 1987). Table 1 and Figure 1 show the stratigraphy of the rock units exposed in the study area.

FACTORS AFFECTING MASS MOVEMENTS IN KUNDASANG AREA

Several factors contribute to the occurrence of mass-movement in Kundasang area and these are categorized into geological, geomorphological, climatological, and anthropological.

Included in the geological factors are: the dense occurrence of geological faults providing zones of weakness; the presence of clayey material within the sliding areas. Geomorphological factors include steepness of slopes, relief, elevation, valley configuration and ridge form. Climatological factors include deep tropical weathering, lack of tropical forest and high rainfall. The anthropological factors

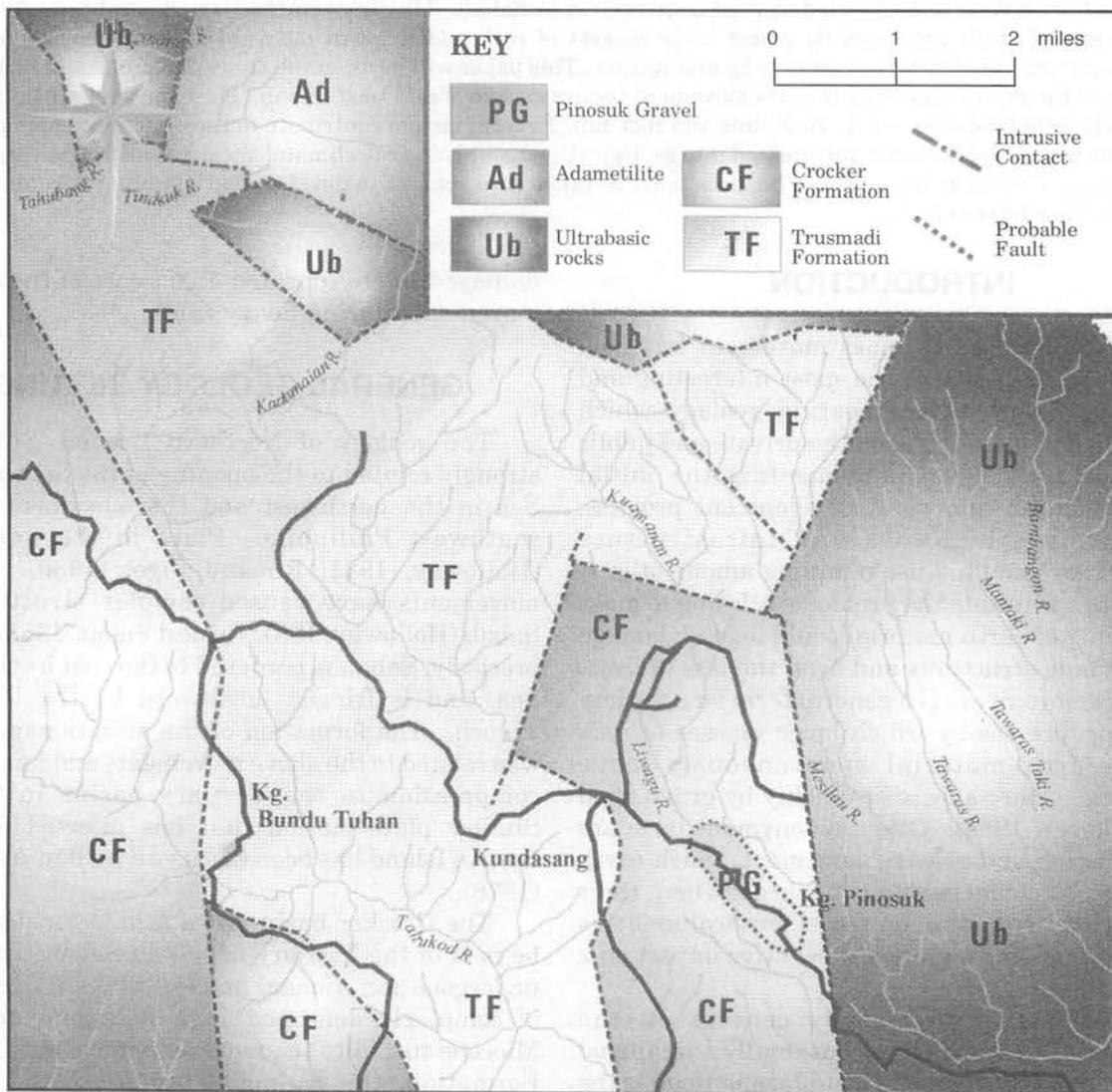


Figure 1. Local geology of the Kundasang area (modified from Jacobson, 1970).

Table 1. Stratigraphy of the study area.

Age	Rock Formation	Unit	General Character
Upper Pleistocene to Holocene	Quaternary Sediment (Pinosuk Gravel)		Poorly consolidated tilloid deposits — unconformably overlie ultrabasic granitic and tertiary sedimentary rocks.
Late Eocene to Lower Miocene	Crocker Formation	Shale	This unit is composed two types of shales, red and grey. It is a sequence of alternation of shale with siltstone or very fine sandstone.
		Shale-sandstone Interbedded	It is a sequence of interlayering of permeable sandstone with impermeable shale. The strength of this unit is quite variable. Groundwater in this unit tends to be under semi-confine to confine system.
		Sandstone	Light grey to cream coloured, medium to coarse grained and some time pebbly. It is highly folded, faulted, jointed, fractured occasionally cavernous, surfically oxidized and exhibit spheroidal weathering.
Eocene to Miocene	Trusmadi Formation	Trusmadi Slate and Trusmadi Phylites	Comprise dark coloured argillaceous rock either in thick bedded or interbedded with thin sandstone beds. Thick sandstone beds reported along with isolated exposures of volcanic rock is a common feature of this formation.

are those that result from man's activities such as steeping of natural slope due road building, instability of slope toes due to road cutting and removal of vegetation protection. Consideration of these hazards must be put in development planning to counter their disruptive effects.

MECHANISM OF FAILURE

Mass movements takes place when slope materials are no longer able to resist the force of gravity. This decrease in shear resistance resulting in mass movements is due either to internal or external causes. Internal causes involve some change in either the physical or the chemical properties of the rock or soil or its water content.

External causes which lead to an increase in shear stress on the slope usually involve a form of disturbance that may be either natural or induced by man.

The triggering mechanism in the Kundasang area most likely involved heavy rainfalls causing water saturation of slope material and loss of cohesion along rapture plane. Heavy rainfall, provided water that rendered rock and earth masses heavier and weakened cohesion along water lubricated bedding slide planes.

Examination of slide rock masses revealed that slips occurred along bedding planes and involves failure of shale layers. The inherently weak layers are characterized by moderate to high weathering, intense fracturing and low intact rock strength.

RECOMMENDATION

To correct to prevent the mass-movements in the study area, the following recommendations are proposed:

- Installation of piezometric and inclinometers to monitor seasonal build-up of pore water pressure and creep movement respectively.
- Surface drainage that include:
 - sealing off the cracks
 - a good vegetation cover
 - a good drainage pipe system and gutter system
 - shortcrete or other means of reducing erosive action of rain water run off
 - peripheral open ditches
- Subsurface drainage, i.e. horizontal drainage method.

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