Turbidity Currents and Cable Breaks in the Western New Britain Trench

ABSTRACT

The western New Britain Trench is receiving abundant sediment from the west. Evidence for earthquake-triggered turbidity currents has been detected in the New Britain Trench through breaks in a submarine telephone cable in 1966 and 1968. The average velocity of the turbidity currents is 50 and 30 km/hr, respectively, assuming that the most likely single source of the turbidity currents is the Markham River delta at Lae, New Guinea. Bottom photographs and sediment samples support these conclusions. Deep-sea channels are present.

INTRODUCTION

Evidence of turbidity currents has been found in the western New Britain Trench, which is part of a complex island arc in the Solomon Sea of the western Pacific Ocean (Fig. 1). Two cable failures (Table 1) in a submarine telecommunications cable (SEACOM of Cable and Wireless Ltd.) in the trench give direct evidence of sediment movement. Both cable failures occurred where the cable crossed deep-sea channels, and both followed large earthquakes by several hours. The cable failure of 23 December 1966 was a tension break, with some length of the cable so deeply or extensively buried that it could not be recovered. In contrast, the cable fault of 17 September 1968 consisted mainly of tangling and mauling. This suggests that the damage was caused by earthquake-triggered turbidity currents, the 1966 turbidity current probably being much larger than the 1968 one. The average velocities of the turbidity currents can be calculated and are presented.

Figure 1. Bathymetry of the western Solomon Sea (500 fathom contours, depths corrected for sound velocity). Earthquake epicenters, cable breaks, Recorder stations, and Figure 2 locations are shown.
This study will trace the birth and existence of turbidity currents in this region, past and present, through the associated environmental evidence. Although turbidity currents may originate from many different causes and may be of several different forms, we will deal specifically with the inferred relatively high density type caused by slope failure.

The New Britain Trench lies along the northern margin of a deep basin bounded by New Guinea on the west, New Britain on the north, and the Solomon Islands on the east. The very active regional tectonics is associated with frequent large earthquakes and volcanic eruptions, although no known volcanic exists in the area of the trench itself. The very high submarine and subaerial relief shows abundant evidence of geologically rapid elevation changes. Such subaerial high relief is in areas of high tropical rainfall leads to very rapid erosion, with the concomitant introduction of large amounts of sediment into the sea. In New Guinea, at the western end of the trench, several rivers (the largest being the Markham) bring down abundant sediment to the Huon Gulf (western Solomon Sea), most of which temporarily accumulates at the mouth of the river, while the rest is transported to sea as suspended material. Evidence will be presented to show that the river deltas are the probable sources of the inferred turbidity currents.

This study is based on two surveys, a reconnaissance survey in July, 1961, by White and Krause with the C.S. Recorder (E. J. M. Reilly, Acting Commander) of Cable and Wireless Ltd., and a buoy-controlled, detailed survey in October, 1968, by Cable and Wireless’ C.S. Retriever (G. Garrett, Commander) equipped with a precision depth recorder. Depths have been corrected for sound velocity.

**BATHYMETRY**

A cross section across New Britain Island and the New Britain Trench shows typical features of an island arc, from the volcanoes on the island to the rise seaward of the trench, despite the peculiarity that westward the trench can be followed onto land at Loe, New Guinea (Fig. 1). The marine features are (Figs. 1–3): (1) a rise of the sea floor south of the trench; (2) the trench itself; (3) a swell or ridge on the trench’s landward side; and (4) the stepped, steep slope of the land. To the west, the New Britain Trench divides into two branches which become rapidly shallower westward (Fig. 1). The main branch passes into the Huon Gulf and becomes a deep submarine valley leading directly to the subaerial Markham River valley at Loe. The other branch leads northwesterly to Vitoa Strait and the line of volcanism (Krause, 1965) via a flat-bottomed, sillied basin, floored with very fluid gray silt below a depth of 2900 fathoms (3500 m). The basin is separated from the main trench floor by a low ridge which rises and broadens majestically westward to become the impressive Huon Peninsula of eastern New Guinea. Most of the sediment derived from the northeastern end of the Huon Peninsula and from the volcanic districts at the western end of New Britain probablycollects in the flat-bottomed basin, both through pelagic sedimentation and through slides and turbidity currents.

The Retriever profiles show that the detailed characters of the bottom of the New Britain Trench can be attributed mainly to turbidity current deposition and transportation but modified by tectonism (Figs. 2–4). The main fill of the trench has been from the direction of Loe. In the west, under the Huon Gulf, the trench valley is steep and narrow. At the point where this emerges into the flat main trench below 3500 fathoms (4000 m) depth, the bottom is irregular, probably a small deep-sea fan (profile AB, Fig. 4). Eastward, the gradient rapidly flattens to 1:200 in the vicinity of the cable where at least two deep-sea channels are present. The 1966 cable break is associated with a very large channel on the southern margin of the trench. The 1968 cable failure seems to be associated with another channel in the center of the trench.
Some 25 nautical miles (45 km) to the east of the cable, the gradient decreases and no channel is obvious (profile KL, Fig. 4). A topographic dam evidently has blocked the sediment transport here. Beyond this, the trench is much more irregular, narrow and deeper.

**Inferred Average Turbidity Current Velocities**

Given both the time of the earthquake and of the cable fault occurrence, the average velocity of the turbidity current can be calculated by assuming a point of origin. If the 1966 New Britain Trench turbidity current originated within 20 nautical miles (37 km) of the earthquake epicenter, its velocity would have been 8 to 20 knots (15-37 km/hr) for the 5.6 hrs time separation of events (Figs. 5, 6). Assuming the Markham delta source, 28 knots (52 km/h) is obtained. This is a limiting value as the Markham delta is the most distant possible source. For the 1968 event, assuming the delta source, the average velocity is 15 knots (28 km/hr) (10.22 hrs). The 1968 turbidity current is by inference much smaller and less dense than the 1966 one, and thus would be expected to travel more slowly. For comparison, the turbidity currents which damaged cables off the Grand Banks, Oceanesville and Messina, all traveled at velocities in excess of 10 knots (12 km/hr), with a maximum at Oceanesville of 40 knots (75 km/hr), and a similar velocity off the Grand Banks (Heezen, 1963).

**Source of the Turbidity Currents**

**Background**

Many turbidity currents and submarine slides are thought to have formed from masses of unconsolidated sediment that have failed (in the sense of soil mechanics) and moved downslope, the turbidity current forming as the sediment mass incorporates water and then becomes a heavy, turbulent fluid moving along the bottom (Chamberlain, 1964; Shepard, 1965). Such failure occurs generally as the sediment accumulation approaches a condition of instability. The actual failure is often triggered by earthquakes or large storms (Chamberlain, 1964). The situation in the Huon Gulf fits this description.

**Earthquakes as a Triggering Mechanism**

The Solomon Sea region is an area of extremely high seismoc activity, having 5 to 10 percent of the world's earthquakes (Brooks, 1965). Not only is the area affected by the local earthquakes but also by earthquakes with epicenters as far away as the Solomon Islands. Earthquakes there are often associated with very large, low frequency ground motions at long distances (Richter, 1958), which can be expected to affect water-saturated ground.
Because the exact effect of the earthquakes on the river delta is difficult to estimate, let us assume that a delta is affected by any earthquake of magnitude equal to or greater than M = 6 (large to very large earthquake) within a radius of 180 nautical miles (330 km). Such earthquakes within this radius occur twice each year (Denham, 1969). In addition, about one very large earthquake (M = 7 +) per 3 yrs affects the larger New Guinea-Solomon region (Denham, 1969). Thus, enough earthquakes exist to trigger any accumulating sediment mass whenever it approaches instability. Therefore, the question of slump frequency hinges on the available unstable sediment, rather than the frequency of earthquakes.

**Sediment Availability**

For the purpose of evaluating the sediment availability, the Markham River is here compared to the larger Magdalena River of Colombia (Table 2) because of its well-studied turbidity currents (Heeen, 1956; Menard, 1964). The submarine cable there was broken 17 times in 26 yrs, in depths ranging from 500 to 1500 ft (1000 to 3000 m). The drainage basin of the Magdalena River is much larger and has a high relief, but the annual rainfall is less (Anonymous, 1950, 1959).

Both rivers are extremely turbid with fast currents and carry abundant suspended sediment and debris many miles to sea. Both have unstable deltas. Docks and shores have disappeared at the Markham River, and breakwaters have disappeared at the Magdalena River, in association with slides or turbidity currents, or both.

No gauging of actual riverflow and no estimate of sediment load is available for either river, but the flow of the Magdalena River is obviously much greater with a more than proportionately greater suspended load. The Magdalena slides probably will be much larger than for the Markham River because of a greater rate of deposition and of fewer triggering earthquakes (Barazangi and Dornan, 1969). Also, the submarine slides are steeper at the Markham River, leading to instability for smaller massels (Krause, 1971). Thus, submarine slide frequency off the two rivers will tend to be more similar than the river flow.

**Evidence of Sediment Instability and Slumping**

Foreshore instability at the mouth of the Markham River is seen in past events, such as the disappearance of part of the beach and a landing jetty at Voco Bay (in front of Lek), and erosion and slumping between Voco Bay and the end of the Lek airstrip. The beach at the end of the Lek was slowly advancing in July, 1961. Beneath the few inches of sand and gravel then being deposited on the beach is a very soft, wet clay similar to that in the extensive swamp which backs the beach. Any beach deposited rapidly on such a weak, well-lubricated foundation is liable to slump seaward, whether from the weight of sand deposited, the effects of high storms, or the scouring action of the local, variable, strong currents.

Furthermore, rapid depositional changes occur along the shore due to the highly variable currents, which are in turn influenced by the constantly shifting sand bars at the Markham River mouth. Such changes at Lek in July, 1961, consisted of the rapid deposition of very fine, muddy silt at the beach, the position changes of the nearby small Butibum River mouth and the rapid growth of the Voco Point sand-spit.

**Huon Gulf, Sediment Accumulation and Transport**

The rapid deposition of suspended sediment in Huon Gulf is revealed by animal tracks at Recorder station REC-10 on a prominent bench 150 ft (270 m) above and south of the canyon axis (6’51’S, 147’09’W, 670 ft - 1225 m depth). The channel is 3.2 km east-southeast of the Markham delta. Bottom photographs showed a diverse but relatively sparse fauna of gastropods, crinoids, sea-feathers, deep-sea crabs and burrowing organisms, and debris of palm fronds, bits of wood, and the like. The tracks of the snails and crabs are all fresh, with a few examples of newer tracks crossing older ones. For instance, an example (where, for example, a snail is visible) are partly marked by deposition of fine silt with the appearance of having been sprinkled with fine powder. The bottom consists of very fluid, poorly sorted, fine sediment, mainly clayey silt.

In contrast, the present existence of strong currents in the deep axis of the main canyon is demonstrated by a bottom photograph which, through the muddy water, show large current ripple marks, cobbles of dark rock swept clear of sediment, except on their "lee" side, and other marks of strong currents (Recorder station REC-9, 7’03’8’’S, 147’35’4’’E, 1556 ft = 4864 m, 41 nautical mi = 76 km east-southeast of Lek). No evidence of bottom life is present except for a few possible worm casts.

**COMPARISON WITH THE PAST BY THE TRENCH SEDIMENTS**

The trench floor consists of two types, the major one of thin alternating layers of very fine sand and green silt, the other of coarse sand and pebbles with mud, as shown by two gravity cores and six grab samples taken by the C.S. *Retro*.

In gravity core NG-B (7’00’5’’S, 149’03’E), 3612 ft = 6606 m depth, 133 cm long, taken on the flat floor channel plain, thin (0.1 to 3.2 cm) layers of very fine sand alternate with thicker (0.2 to 7.1 cm) green silt layers. In addition, the sand layers occur in two populations, several (2 to 10) very thin (0.1 to 0.5 cm) layers being followed by a single thicker (0.5 to 3.2 cm) layer showing disturbance, burrows or grading. Average thicknesses with standard deviations are: very thin sand layers, 0.2 ± 0.1 cm; thicker sand layers, 1.0 ± 0.3 cm; green silt layers, 1.0 cm with 85 percent of the layers between 0.7 and 3.5 cm; and sand-silt units, 1.0 to 3.5 cm (made of the four thickest units). The mode of the sand-silt units is 1.0 cm. The other core and grab samples show conformational results. Rates of deposition calculated from the core data are too sensitive to the necessary assumptions to do more than confirm to an order of magnitude the wide break record of one turbidite event.

The gravel probably marks existing channels. Gravel (maximum length 5 cm) with coarse sand occurs in grab sample NG-S-B (7’07’S, 149’27’E, 3530 ft = 6493 m depth). The gravel size suggests that the turbidity current in the inferred channel flowed at 5 to 8 knots (10 to 15 km/hr) at 1 m above the bottom (Sundberg, 1956). A 9-m rock is also shown resting at the bottom of Recorder station REC-7 (7’09’5’’S, 149’08’E, 3490 ft = 6638 m depth). The soft bottom here is shown to have much bottom life, mainly Holothurians. Old, indistinct Holothurian tracks and facetal pedicles are crossed by successive sets of newer tracks, indicating that deposition of the cored fluid and has been discontinuous or is slow relative to the Huon Gulf.

Investigations elsewhere on such submarine channels as found in the trench (Menard, 1964; Piper, 1970) show that powerful turbidity
REFERENCES CITED


The LIZA Amphibole

The primary mineral of dunite, the diopside amphibole (clinoenstatite + jadeite). This mineral is the most common in dunite, olivine + orthopyroxene. The diopside amphibole is a greenish to brownish green amphibole, ranging in color from light green to dark gray. The amphibole in dunite contains mica, quartz, plagioclase, and pyroxene. Dunite, olivine + orthopyroxene, is a rock that contains mica, quartz, plagioclase, and orthopyroxene. Dunite, olivine + orthopyroxene, is a rock that contains mica, quartz, plagioclase, and orthopyroxene.