RATES AND CAUSES OF COASTAL EROSION ON THE ZANZIBAR ISLAND.

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ABSTRACT.

Studies on coastal erosion on the Zanzibar Island were made through field measurements, aerial photoanalysis and interviews with the old section of the village communities around the eroded areas. Alarming rates of coastal erosion over the past four decades were deduced. Whereas estimates of erosion rates obtained from interviews in the north where the problem is much more serious gave figures of more then 150m in a period of 5 to 6 years, aerial photoanalysis indicate higher average annual rates of more than 40m between 1947 and 1977. Recent field measurements at Maruhubi, north of Zanzibar township gave annual coastal erosion rate of 3m.

The high rates of coastal erosion were found to be caused by the high wave activity during some periods of the monsoons amplified by a high tidal range. Destruction of the protective mangrove forests adding to the problem. The unconsolidated rock formations and tectonic activity on the western coast were found to be the causes of comparatively intensive erosion than on the east coast.

INTRODUCTION.

The Tanzanian coastal zone is currently undergoing erosion and the Islands of Zanzibar are no exception. Beach (coastal) erosion on the Zanzibar (Unguja) Island has recently begun to raise concern of the residents of the coastal villages as well as the Zanzibar government. This concern was raised after a marked loss of agriculturally useful land in some areas like Nungwi and Mkokotoni, north of the Zanzibar town. Beach erosion on the Island was documented as early as late twenties (Stockley, 1928). During the early 70's and through 80's, the problem has reached alarming proportions. Rossi and St. Ange (1986) assessed the problem and gave recommendations drawn out of their brief visit to the affected areas and interviews with the people. Apart from the above mentioned work, no comprehensive study of the extent, causes and management approach to the problem have been carried out in the past. Hence, this work quantifies the magnitude of the problem of coastal erosion in Zanzibar and highlights some of the probable causes.

Study area description.

The studied area extends from Maruhubi north of the Zanzibar town to the northern tip of the Island (Fig. 1). The oldest rocks encountered on the Island, which are marly sands with subordinate limestone in nature, are of the lower Miocene (Stockley, 1928; Kent et al., 1971). These rocks dip eastward with attitudes of 2° to 5° and are overlained at Chuwini, Bububu and Mtoni by the Pliocene

rocks. The Pliocene rocks are composed of limestones and soft sandstones. Large part of the Island is studded by the Quaternary raised reef limestones, which rest unconformably on the Pliocene rocks (Kent et al., 1971; Fig. 2). Hard beach sandstones (beach rocks) occur on the west coast of the Island and have a dip angles of 5 to 6°, and dip seaward. These beach sandstones are conglomeratic in nature with pebbles of limestone, sandstone, quartz and feldspar cemented with calcite (Kent et al., 1971). Alluvial deposits which occur in low lying areas are covered by mangrove vegetation. The beaches on the Zanzibar Island can be classified to be mainly cliffed with pocket beaches. Pocket beaches are mainly of calcareous sand but at places a mixture of calcareous and quartz sand with streaks of heavy minerals can be found.

Offshore and immediate to the beach the coast is characterized by a wide and active coral platform characteristic of the fringing reef of the East African coast, with a shoreline parallel to the raised coral islands and sand banks.

Methodology.

Record of visual observations of wave activity and beach erosion at Maruhubi during 1984/85 was compared with interviews held with the elderly people and measurement on aerial photographs between 1947 and 1977. Monitoring of sea encroachment on land in one year was made from November 1984 to December 1985 by establishing a frame of references of coconut trees, one along the shoreline at Nov. 1984 (having signs of being uprooted) and another

one three meters away from the shore.

The aerial photographs of 1947 and 1977 for Nungwi area, north of the Zanzibar town, were selected for study. Using a stereoscope a common feature on the photograph was used to measure the distance between the feature and coastline. The difference in the two distances as recorded on the two photographs was taken to represent land lost in 30 years time. A number of old people/fishermen at Nungwi were approached for interview as a group on what they knew about the coastline in their times. They were requested to describe the coastline during their childhood and in recent years. Majority of the interviewee were certainly above 40 years. They were also requested to tell if they remember any major storm activity.

Results.

Areas of severe coastal (beach) erosion are Ras Nungwi, Mkokotoni and Maruhubi. Beach erosion is intense at Nungwi and decrease in intensity southward to Maruhubi. Aerial photoanalysis indicate erosion of 1.2 km of land in 30 years (1947-1977) in the north-south direction at Ras Nungwi. Similar result was deduced from maps (Admiralty, 1956; Map of Zanzibar, 1985). While in 1956 the light house at Ras Nungwi was approximately 1.5km from the coastline, it was only about 250m from the coastline in 1985 (Admiralty, 1956; Map of Zanzibar, 1985). Westward of Ras Nungwi erosion attained 1.3 km giving an average land recession of more than 40m annually. Annual land recession by erosion measured at 3m at Maruhubi in 1985. Villagers interviewed at both Nungwi and

Mkoketoni villages speak of severe coastal erosion in recent years with that of Nungwi put at 150m in 5 or 6 years.

DISCUSSION.

Although coastal erosion is a worldwide problem (Bird, 1983) resulting from a number of causes, more often it is a combination of few causes only. Some of probable regional and local causes which may be responsible for the beach erosion on the Island include tectonic activity, sea level rise, land subsidence, high wave energy and man's activities.

The tectonic processes causing regional or local vertical movement of the coastline relative to the sea have been known to cause changes in sea level (Bruun, 1962). Where such movements lead to a rise in sea level, coastal erosion takes place. The tectonic history of East Africa is known to have been episodic in character and probably still active to date (Kent et al., 1971). On the western coast of Zanzibar, there are normal block faults (Fig. 3) which dip steeply eastward (Kaaya, 1982). These faults would certainly cause subsidence of the coastline, thus, contributing to the rising sea level. Francis and Dubi (in preparation) have deduced from tide gauge records a yearly 0.4cm rise in sea level at the Zanzibar harbour. Because offshore areas north of the Zanzibar harbour are intensely faulted (Fig. 3), rates of sea level rising might be higher in these areas than at the harbour.

The most important factor which bring about beach erosion is hydraulic forces playing on the coastline which is normally

amplified by other factors. For instance, the increased wind strength at the peak periods of the western Indian Ocean monsoons in East Africa (Newell, 1957; Harvey, 1977) generates strong waves which contribute to the episodic erosion of the coastlines. The wave height at Nungwi is more than two meters and period of about 10 seconds (Dubi, A. M., personal communication) during the SE monsoons. The waves approaches the coastline obliquely, thus, causing formation of longshore currents. The effect of wave action is amplified by large tidal range. The mean spring tide of Zanzibar, which is about 4m (Admiralty, 1956), brings about significant variation of water level, thus interacting with high waves to erode the coastline. During spring tide large piece of land can be eroded.

The underwater topography (Fig. 4) largely attributed to coral reefs modify the direction of spread of the wave generated currents and tidal currents such that zones are created of intense wave action and erosion depending on whether or not the geologic setting is favorable. Different rates of erosion in different areas can be attributed to the nature of rock formation. Hard rocks such as raised coral reefs are resistant to wave attack (mechanical erosion), whereas loose beach sands and alluvial deposits are easily eroded. This is the major criteria determining a local aerial distribution of erosion intensities in the area. Most areas which have experienced erosion are those covered by alluvial deposits, beach sandstone and soft sandstones. Because of the nature of the Zanzibar coastline, cliffs which are resistant to

wave attack form headlands whereas those covered by unconsolidated sediments form bays.

Man's activities that contribute to beach erosion are many but those which have been considered to be relevant to the Zanzibar problem include felling of the mangrove vegetation and coral reef destruction. The mangrove forests normally make a good protection amour against wave attack on the beach (Savage, 1972). In Zanzibar, mangrove constitute most of the coastal forests. Cutting down of these trees for fire wood and poles for construction purposes has greatly reduced the size of the forests in recent years. Destruction of mangrove forests at both Nungwi and Mkokotoni has paved way for the encroaching sea.

Destruction of coral reef deposits through dynamite fishing, anchoring and tramping by shell collectors, increases water depth and thus, reducing their effective ability as wave breakers. Hence, causing high waves to break close to the shore. However, there is disagreement among experts on the role played by coral reef destruction in beach erosion (Beach Erosion Monitoring Committee, 1988). It is contended that extensive seaward deposits of coral reefs are destroyed during dynamite fishing, but landward part of the structure remains intact, thus, continues to play its role as wave breaker (Beach Monitoring Committee, 1988). Furthermore, it is urged that the role of coral reef as wave breakers diminishes during spring tides as the waves bypass these structures without breaking (Beach Monitoring Committee, 1988).

CONCLUSION.

1. It is undoubted that coastal erosion is a serious problem on the Zanzibar Island, representing erosion rates which are so far the highest to be reported in Tanzania.

2. Local and/or global sea level rise amplified by faulting are the most likely causes of high rates of erosion on the Island.

3. The increased rates of erosion have been partly caused by high wave energy and high tidal range.

4. Destruction of mangrove forests on the Island have resulted in the increased rate of land recession especially along the soft rocks and other unconsolidated formations.

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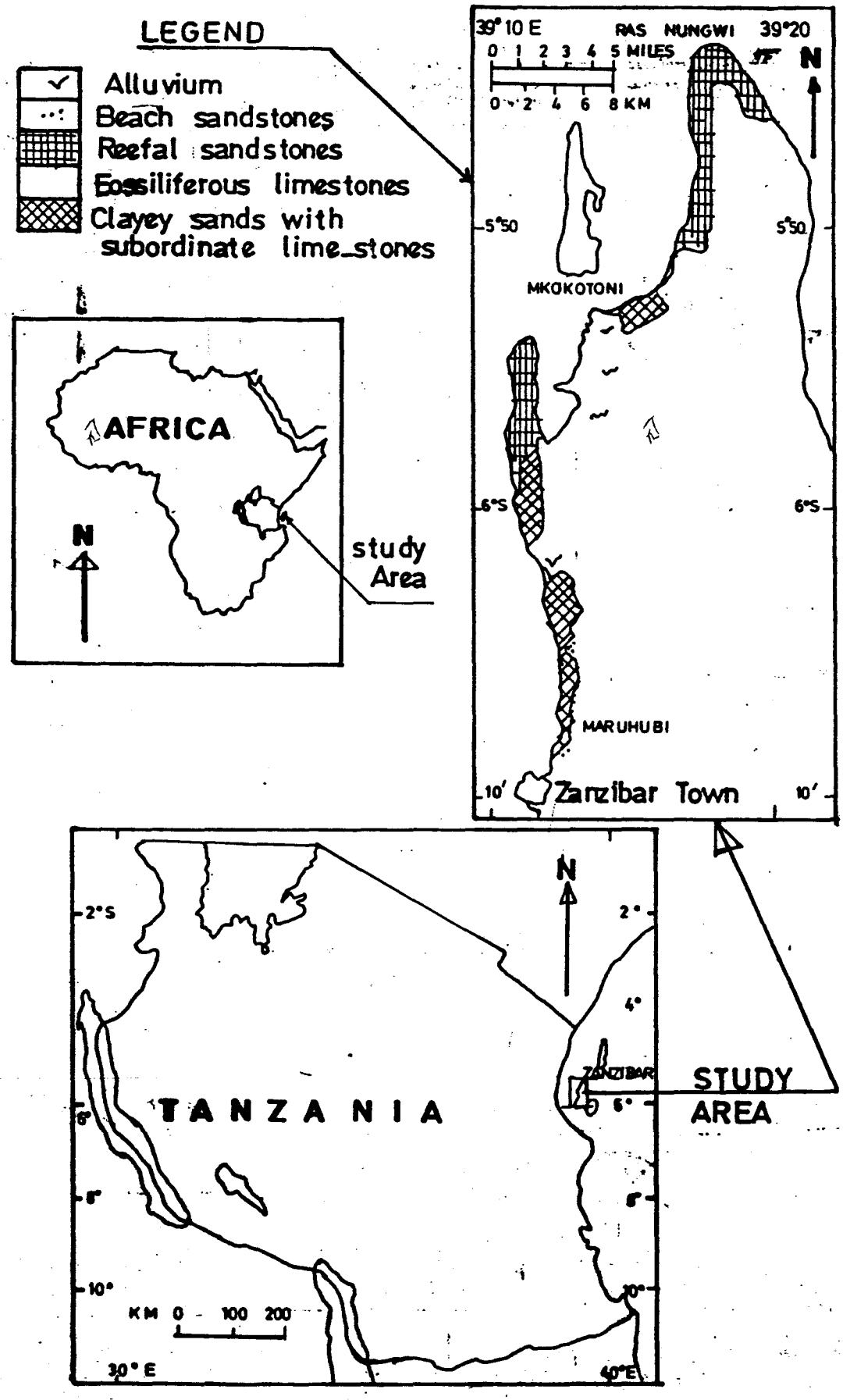
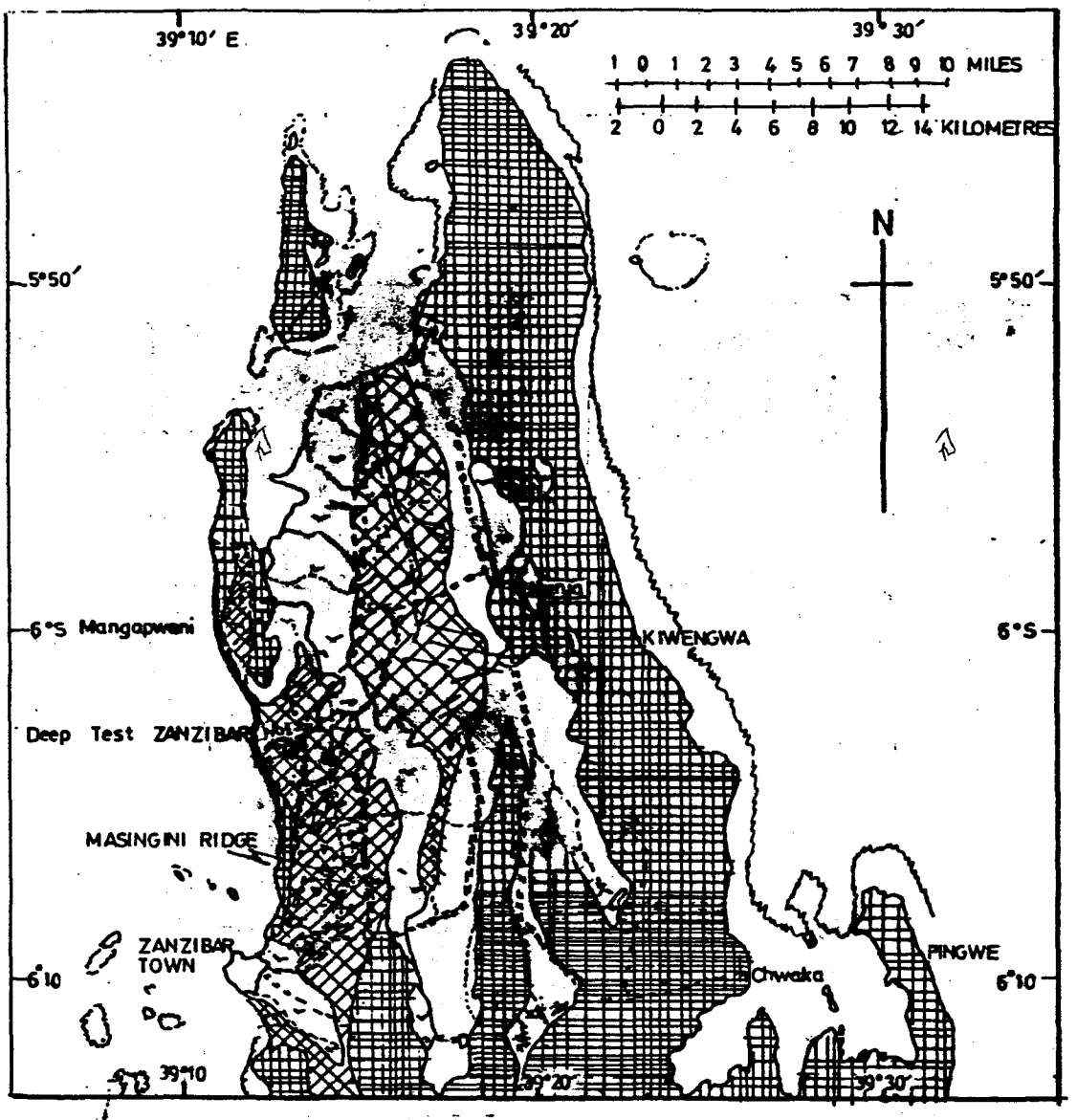


Fig 1 Location of the study area



LEGEND

- Alluvium
- Beach sandstones
- Reetal limestones
- limestones and soft sandstones
- Fossiliferous limestones
- morly sand lithology
- Clayey sands with subordinate limestone
- Raised reef features
- Fault
- Conjectural Fault
- 6° Dip of 6° in direction of arrow
- Stratigraphical boundary
- " " (approxl)
- PHOTOGEOLOGY: Dip & strike 1°—5°
- —·····— Fault
- — ‡ — Anticlinal axis

Fig 2 Surface geology of Zanzibar (Unguja) Island

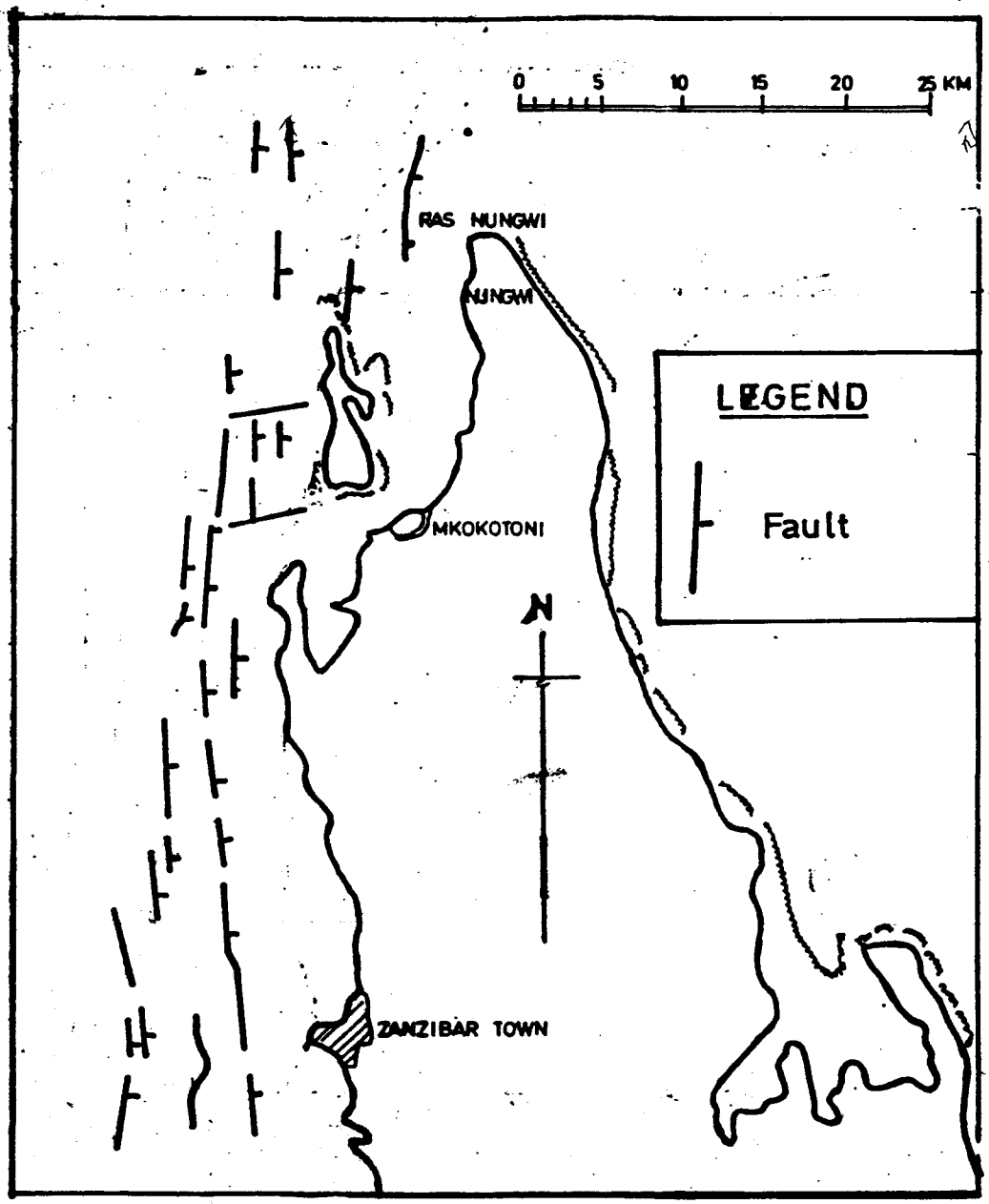


Fig. 3 Fault system off the West coast of Unguja Island, north of Zanzibar Town.

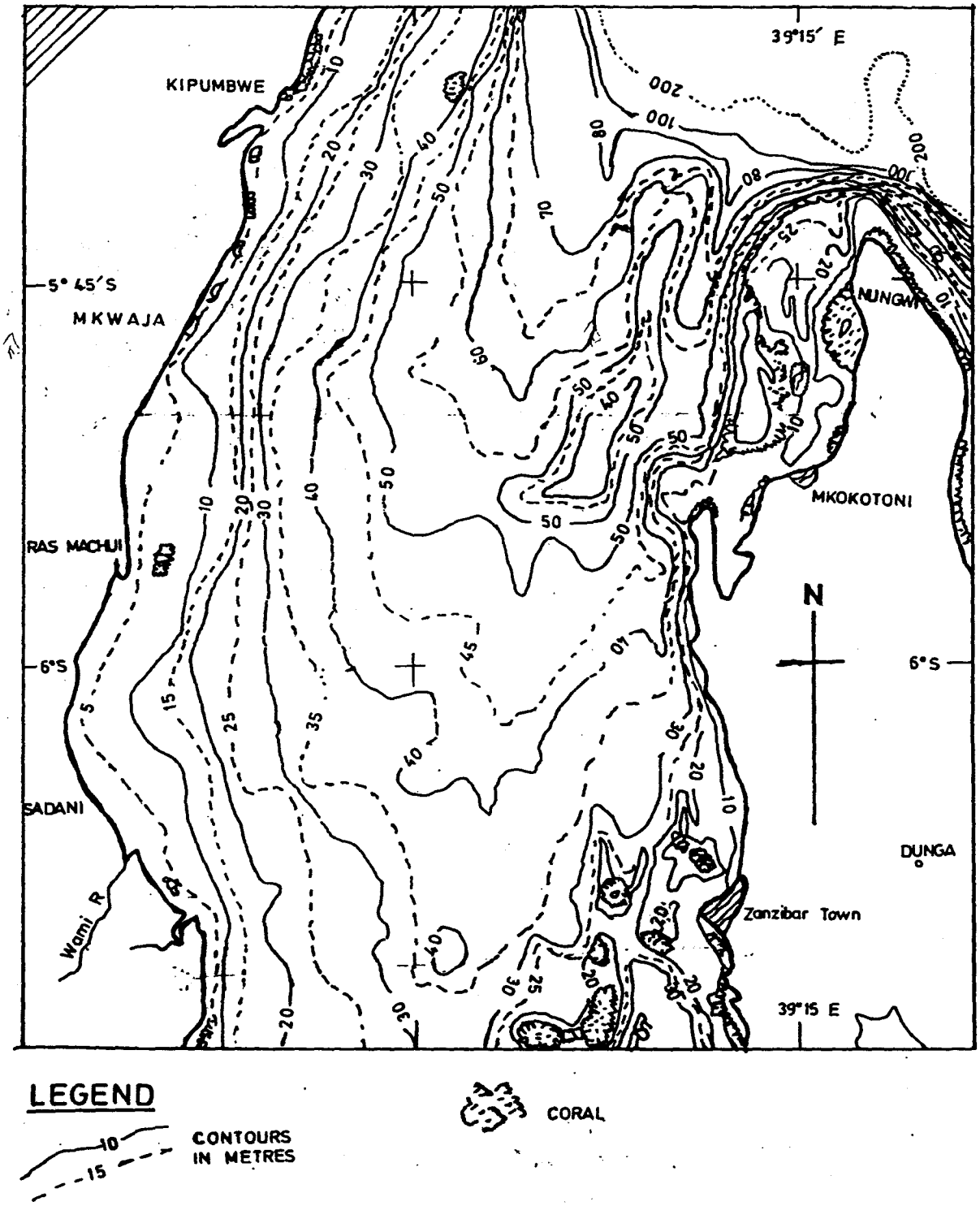


Fig. 4 Zanzibar channel bathymetry, North of Zanzibar Town.