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Sea-level changes in Sri Lanka

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ABSTRACT

Coastal materials and landforms are valuable tools in the study of palaeo sea level, climatic and ecologic changes. In Sri Lanka, few researches have been conducted based on such indicators. Different types of deposits and landforms from the continental shelf and coastal lowlands reveal that their formation has followed the coastal transgressions and regressions as well as dry and wet climatic phases during the past 20,000 years.

Introduction

Eustatic changes in the last few million years are almost entirely the result of the abstraction of water from the hydrological cycle by the creation of Pleistocene ice-sheets and the subsequent return following their melting. Worldwide sea-level studies have concentrated mostly on the Late Pleistocene and Holocene Epochs. However, research on past climatic and sea-level changes in the Quaternary period of Sri Lanka, their effects on human beings is scarce.

Sea-level Indicators

Many coastal materials and landforms such as coastal barrier sands, beachrock, coral reefs and coral-limestone, submerged forests, sea-notches, marine molluscs and submerged features of the continental shelf are used as sea-level indicators in the study of world-wide sea-level changes during the Late Quaternary period. Such information is significant in the study of sea-level changes in Sri Lanka during the past 20,000 years.

Sea-level Indicators and Sea-level Changes in Sri Lanka

The Pleistocene aridity in the tropics was described by Kolla & Biscave (1977), Prell et al. (1980) and Williams (1985). It is suggested that desert-like conditions have occurred in some parts of the lowlands of Sri Lanka during the Last Glacial Maximum (LGM), and fluvial processes extended to several kilometres beyond the present shore. Extensive gem-bearing gravels in the coastal area between Ranna and Pallemalala in the Hambantota District have a considerable geological significance in the study of palaeo-stratigraphy and sea-level changes. Minerals of corundum family, mainly ruby, sapphire and cat's eye abound in these gem fields. They are associated with quartz and ironstone gravel that have deposited as fluvial material under dry climatic conditions during the last glaciation. Owing to dry climatic conditions, the low hills and ridges in the present coastal lowlands were thinly covered by wind blown sand (Cooray, 1984; Cooray and Katupotha, 1991; Dahanayake and Jayawardana 1979; Katupotha 1985). The Post-Glacial transgression (PGT) appears to have started around 17,000 yr B.P. from -100 m or -80m, and the termination of the last-Glacial stage has occurred around 10,800-10,300 yr B.P. Following the PGT, features such as low-lying ridges, well-marked troughs and terraces have formed across the former land area. At the same time, the sea-submerged former estuaries, stream channels, terraces, low hill, ridges and forests occur mainly between 100 m isobath and the present shoreline (Fig. 1).

The fossil notches may indicate both the position and approximate duration of a sea-level stand as well as the speed of the sea-level change (Pirazzoli, 1986). Along the southwestern and southern coasts of Sri Lanka, symmetrical notches have developed on rocky promontories and headlands due to a gradual emergence or submergence. Profiles with heights varying from 2 to 7 m were formed in this area during the period of high sea-level.

Submerged forests and the development of coastal peat deposits are also useful indicators in the study of sea-level variations. The submerged forests are defined as assemblages of tree remains in their growth position, regularly covered by the tide.

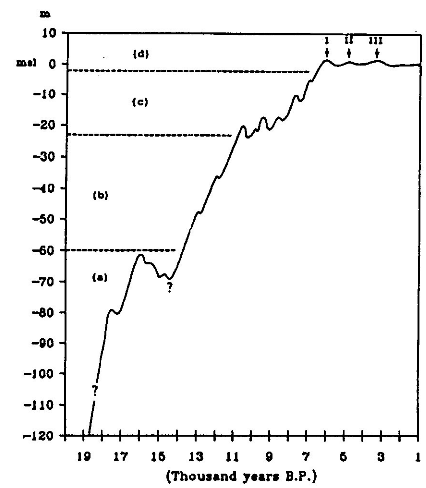

Fig. 1. Eustatic oscillations in Sri Lanka since last-Glacial Maximum. (a) Development of coralline algae, limestone and calcareous sandstone reefs on the continental shelf; (b) submergence of river valleys and development of marine terraces; (c) submergence of river valleys and coastal forest; formation of 25 m, 18 m, 10 m, and 2 m levels of beachrock in the nearshore zone; (d) three episodes of high sea-levels (about 1.5 m) higher than at present; development of coastal lagoons and lakes, estuarine deposits, inland buried coral deposits, emerged coral reef patches, inland shell deposits, present beachrock and coastal swamps; I, II and III = three episodes of high sea-level (Katupotha, 1993a).

Submerged forests are usually found as peat beds, containing the roots and trunks of trees (Whittow, 1984).

The preservation of trees in submerged forests in the continental shelf of Sri Lanka is an accurate reflection of past sea-levels.

The presence of marine shells, peat with tree trunks and sand at various levels below the present surface at the Muthurajawela peat swamp and Beira Lake indicates that marine transgressions over the land have taken place at least three times during the Holocene Epoch. One peat sample (about 30 cm below MSL) from a foundation pit at the Galadari Hotel Complex, near the Beira Lake in Colombo has been dated at 5,790 $\pm$ 80 yr B.P. (Katupotha, 1988b). This date indicates that the PGT has culminated during the First Phase of the Holocene transgression. Fine to medium grained sand in the upper layers of the peat deposits have been covered later by aeolian sand due to minor progradations.

Due to the encroachment of land by sea-water, present inland corals of the coastal lowlands in Sri Lanka thrived in former bays and lagoons as well as on small headlands and beachrock shoals (above the present MHW level) where the climatic and edaphic conditions were suitable. Interpretation of ^{14}C dates of emerged and buried coral samples (*in situ* position, Fig. 2), collected from the western and southern coasts, indicates that the mid and late-Holocene sea-level was at least 1.5 m above that of the present level which was caused by three episodes (Katupotha, 1992). Following these sea-level episodes, the present coastline, low hills and rises were submerged and headland-bay-beaches were created.

Present investigation of inland shell beds on the southern coastal zone indicates that they had piled up by three processes: (a) severe storm waves, (b) accumulation *in situ* after the lowering of sea-levels, and (c) discarding by early inhabitants and animals. These beds are found on former lagoon beaches, alluvial mounds (hummocks) and headlands of the southern coastal zone. They extend to 3 km or 4 km inland from the coast. The depositional sequence indicate that the marine shell species such as *Meretrix*, *Anadara* and *Cerethidae* have piled up separately or together even on headlands especially by severe storm waves, about 14 m above the present MSL. Coastal mound and embayment deposits vary between 4.5 m and 9.5 m from MSL. Deposition, mixing and embedding patterns together with human bones and other animal bones, stone artifacts and pieces of different kinds of pottery clearly indicate that they have piled up due to severe southern swells (Katupotha, 1993b). Several ^{14}C dates indicate that the shell valves had accumulated on floors of marine and brackish pools consequent to lowering of sea level around 4,700 B.P. or 3,600 B.P. (Katupotha, 1988a and 1988b). These deposits had been intermittently covered by wind-blown sand and alluvium.

Emerged beachrock reefs slightly above the supratidal zone and submerged beachrock reefs around the coast of Sri Lanka are also invaluable sea-level indicators (Fig. 3). The emerged beachrock reefs were formed during the Late Holocene (around 3,700 yr B.P.) and the submerged reefs were formed during the early stillstands of sea-levels since LGM (Cooray 1968; Cooray and Katupotha 1991; Katupotha 1988a, 1989).

Bryant (1987) referred to a close relationship between the increase of CO_2 concentration - warming, rising sea-level and retreat of coasts in both hemispheres since 100 yr B.P. (A.D. 1850). Disappearance of

Fig. 2. A segment of an emerged coral reef *(in situ*) at Akurala in the Galle District.

Fig. 3. A beachrock reef emerged above the supratidal zone at Chilaw on the western coastal zone.

bungalows along the coastline built in the 19th century, islets on the northwestern coast and increase of brackishwater towards inland along the streams indicate the secular and seasonal changes that have occurred along the present coastline of Sri Lanka.

Different types of sea-level indicators developed from outer shelf to coastal lowlands in Sri Lanka have a close relationship to the climatic and sea-level changes that followed the low stands of sea-level during the LGM. Recent oceanographic investigations reveal that the features such as low-lying ridges, well-marked troughs and terraces, former estuaries of the larger rivers, stream channels, low hills, ridges and forests mainly between 100 m isobath and the present shoreline have formed across a former land area. The rapid rise of sea-level during the PGT and in the Holocene period submerged all these features, and formed inland coral and shell deposits as well as beachrock above from the MHWS level along the present coastal lowlands owing to the high sea-level episodes.

Conclusion

Following the Post-Glacial Transgression which started around 17,000 yr B.P. and in the Holocene period, many coastal materials deposited and landforms developed between 100 m isobath and the present shoreline as well as long the present coastal lowlands. All these features indicate that coastal transgressions and regressions as well as dry and wet climatic phases have continued during their formation. However, detailed investigations about these features are required to investigate palaeo-ecology, climatology and palaeo-geography.

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