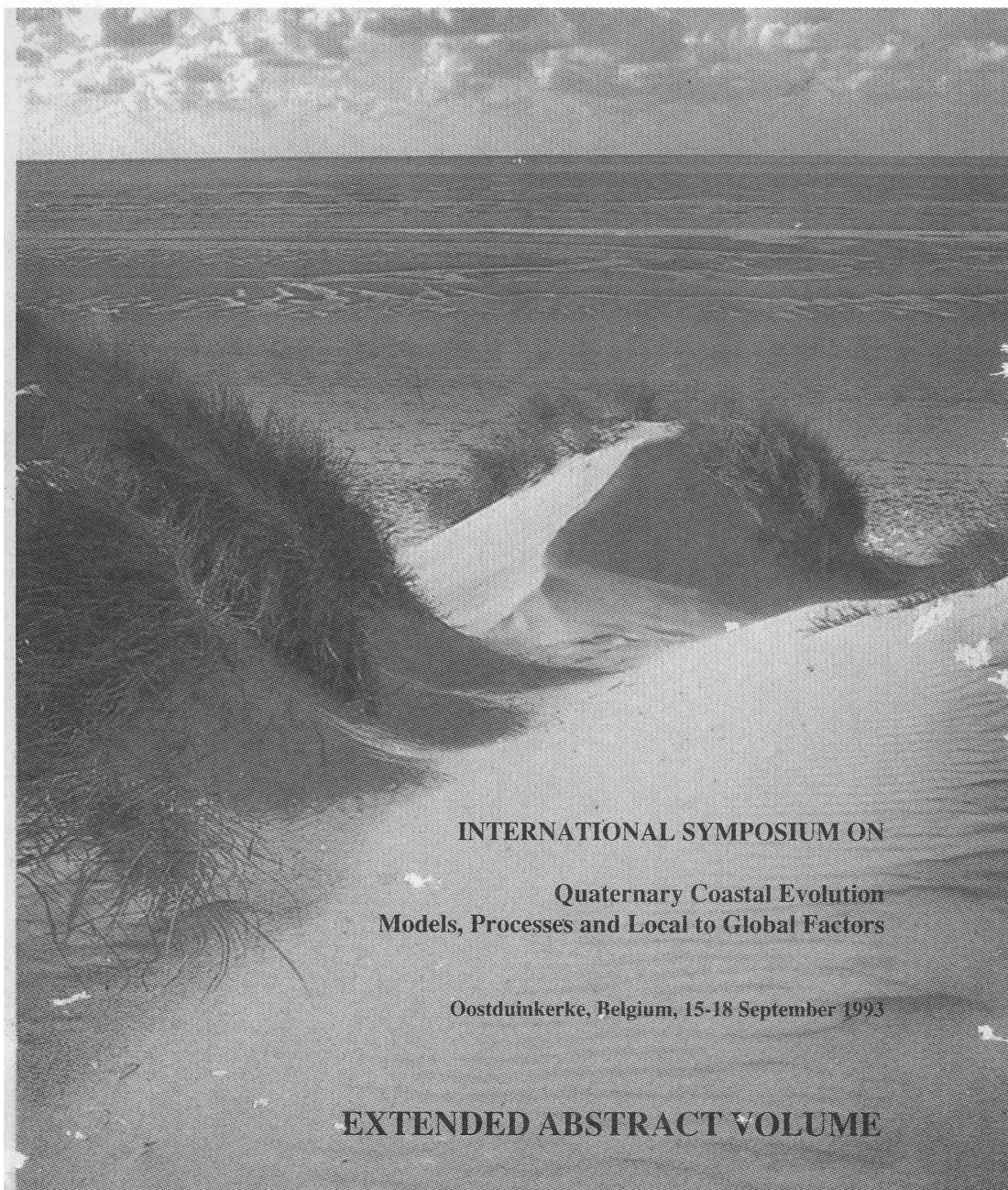


INTERNATIONAL GEOLOGICAL CORRELATION PROGRAMME



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EXTENDED ABSTRACT VOLUME

LOCAL SEA-LEVEL INDICATORS FOR INVESTIGATION OF COASTAL EVOLUTION IN SRI LANKA DURING THE PAST 20,000 YEARS

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Many materials such as coastal barrier sands, beachrock, ooids, corals and reefs, coralline algae, submerged forests, marine notches, marine mollusks, pelagic foraminifera etc. have been used in the study of worldwide sea-level changes during the Quaternary period. The Quaternary period comprises two epochs, "Pleistocene" and "Holocene". It began approximately ca. 2 million years ago and continue up to the present (Fairbridge, 1968). Subdivisions of the Pleistocene and Holocene epochs, and their correlation to Glacial and Interglacial stages and climatic changes have been identified by many scholars (Emilliani 1955 and 1978; Fairbridge 1961; Giresse 1987; Kolla and Biscave 1977; Pickett et al. 1985; Prell et al. 1980; Williams 1982). Based on local sea-level indicators, this paper attempt to reveal coastal evolution in Sri Lanka during the past 20,000 years.

During the last glacial maximum (LGM), ca. 18,000 yr B.P. ago, the southwestern monsoon wind prevailed weaker than today over much of tropical Africa, Australia and south Asia with less rain in summer and stronger monsoon winds in winter (Kolla and Biscave (1977; Giresse 1987; Prell et al. 1980; Williams 1982). During this period the sea-level was about 80-120 m below the present sea-level, and different palaeo-cultures had been extended towards the seaside from the present coastline in these areas.

The post-Glacial transgression (PGT) appears to have started around 17,000 years B.P. and the termination of the last-Glacial stage was around 10,800-10,300 yr B.P. This PGT brought about a massive and rapid Global rise of sea-level. Fairbridge (1961), Giresse (1982), Mörner (1982), Pirazzoli (1986) and Walcott (1973) have quantitatively proved that in many locations in tropical and sub-tropical coasts the sea-level rose to its present level some 5,000 - 6,000 years ago and has since fluctuated within 3 metres of its present level, including one or more conspicuous stands at 2 - 3 m above from present level some 2,000 - 3,000 yr B.P. General form of the sea-level/time curve is asymptotic, showing a rise of approximately 1 m/100 years at first then showing to 2 or 3 cm per 100 years at 7,000 - 5,000 yr B.P.

Sea-level indicators around Sri Lankan coast point to the development of landforms between present submerged continental shelf and the coastal lowland (Fig. 1). These compare well with world-wide events which occurred in many locations since LGM. To account of sea-level changes in western Europe (Roep 1986), southern and eastern Asia and Australia, recent coastal sediments and fossil barrier deposits are widely used. Wayland (1919), Deraniyagala (1958) and Spath (1985) emphasize that desert like conditions occurred during the LGM in much of the low country in Sri Lanka. This desert-like conditions is very similar to the Pleistocene aridity in tropical Africa, Australia and South Asia which was described by Kolla and Biscave (1977) and Williams (1985). According to the dry climatic condition that prevailed and on the basis of weathering conditions, colour and constituent of the sand and height of the ridges indicate that the low hills and ridges in the western coastal lowlands were coated mainly by wind blown sand during this period (Cooray 1984; Cooray and Katupotha 1992;

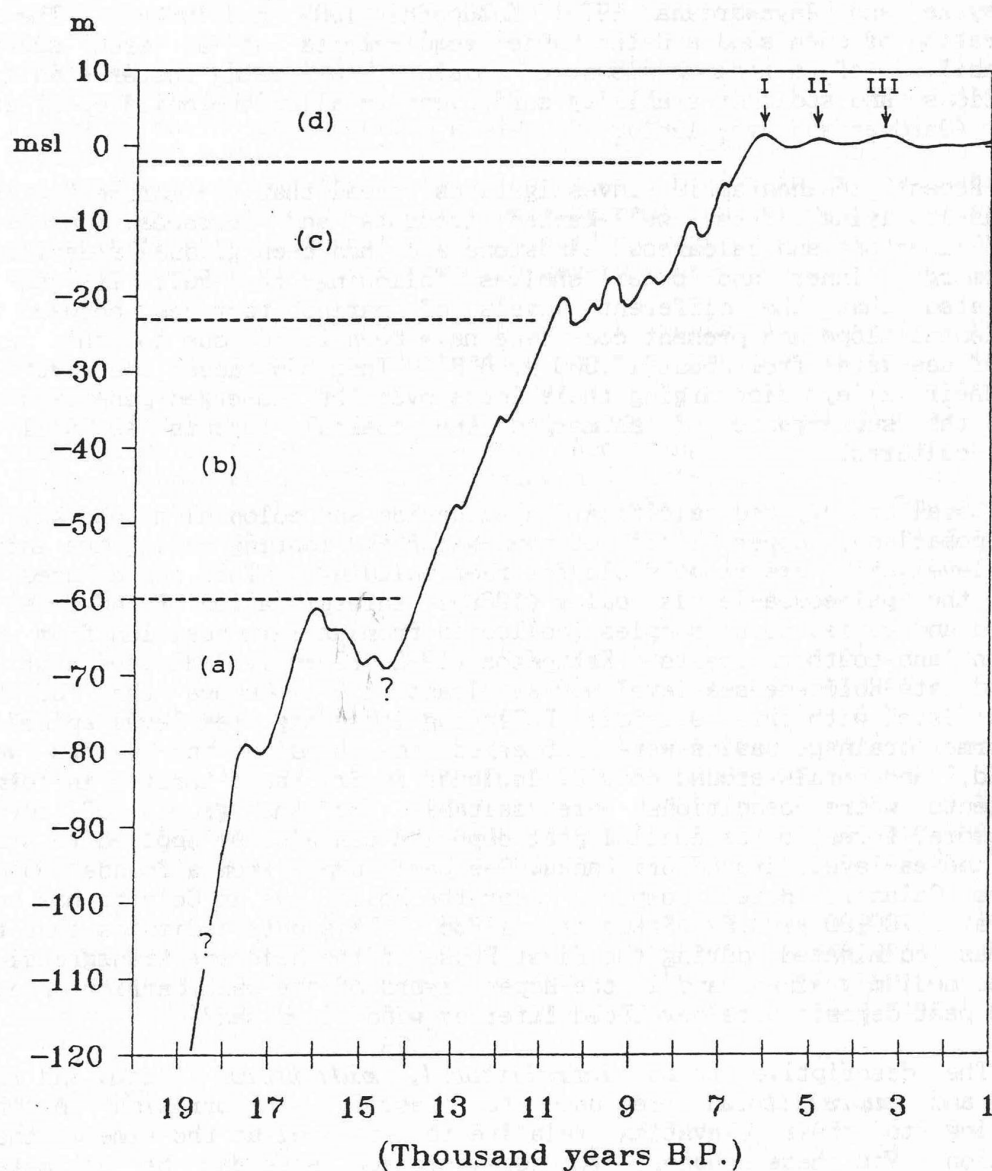


Figure 1. Eustatic oscillations in Sri Lanka since last-Glacial Maximum

(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 reef in the nearshore zone. (d) three episodes of high sea-levels (about 1.5 m) higher than at present; development of coastal lagoon and lakes; estuarine deposits; inland buried coral deposits; emerged coral patches; inland shell deposits; present beachrock and coastal swamps. I, II and III = three episodes of high sea-level (Deraniyagala 1958, Katupotha 1991 and 1992, Wickramaratne et al. 1988).

Dahanayake and Jayawardana 1979; Katupotha 1985 and 1988a). The red colouration of such sand are the basic requirements of an iron source, availability of a minimum amount of moisture, oxidizing inter-stadial conditions, and sediment stability sufficient to allow the build up of iron oxides (Gardner and Pye, 1981).

Recent oceanographic investigations reveal that the marine features such as low-lying ridges, well-marked troughs and terraces; coralline algae, limestone and calcareous sandstone etc. had been gradually developed on submerged inner and outer shelves following the PGT. It can be speculated that the different levels of marine terraces between the continental slope and present coastline have been formed due to the rapid rise of sea-level from about 17,000 yr B.P. This has caused the rivers to fill their valleys discharging their loads over the submerged peneplain and also the submergence of submerged the coastal forests as well as palaeo-cultures.

Coral ecology and calcification, zonation and colonial morphology (*in situ* position), upper limit of open-water and moating during the inter-tidal level etc. are responsible for reef building. This can be used to study the palaeosea-levels Hopley (1986). Interpretation of ^{14}C dates of emerged and buried coral samples (collected from *in situ* position from the western and southern coasts, Katupotha (1992) recently indicates that the mid and late-Holocene sea-level was at least 1.5 m above that of the present level with three episodes. Following these high sea-level episodes, the former drainage basins were submerged and headland-bay-beaches were created, and corals around coastal lowlands in Sri Lanka thrived in former embayments where conditions were suitable for the growth of coral. Furthermore, formation of coastal peat deposits can also be applied to study of palaeosea-levels around Sri Lanka. One peat sample 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 back barrier ridges on the peat deposit were developed later by wind blown sand.

The descriptive terms *infralittoral*, *midlittoral* (tidal and surf zone) and *supralittoral* are used to classify sea-corrosion notches according to their elevation relative to sea-level at the time of their formation. Via these sources, the local erosion rates can be estimated, while 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, symmetrical notches have been developed on rocky promontories and headlands due a gradual emergence or submergence. Profiles with heights varying 2-3 and 6-7 m were formed in this area during period of high sea-level. However, detail investigations on the sea notches is required for coming to any conclusion.

Present investigation of raised shell beds on the southern coast indicate that they have been piled up by severe storm waves at former coastal embayments, alluvial mounds (hummocks) and headlands along the southern coastal zone. These beds extend 3 or 4 kilometers inland from the coastline. The deposition sequence clearly indicate that the marine shell *Meretrix*, *Anadara* and *Cerethidae* spp. have piled up separately or together on coastal mounds and embayments and even on headlands by severe storm waves. Coastal mound and embayment deposits vary between 4.5 m and 9.5 m

and headland deposits are about 14 m above from the present msl. Deposition, mixing and embedding patterns together with human bones, elk and reptile bones, stone artifacts and pieces of pottery clearly represent that they have been piled up by severe southern swells. Several ^{14}C dates of these shell beds indicate that the shell valves had accumulated on the floors of marine and brackish pools consequent to the lowering of sea level around 4,700 B.P. or 3,600 B.P. (Katupotha, 1988b and 1988c). Furthermore, during these periods the coral colonies were buried in muddy water pools which were washed down into the embayments by terrestrial waters. The deposits had been intermittently covered by vast quantities of coral sand and various type of debris moved by severe monsoon waves.

Emerged and submerged beachrock reefs in Brazil, Venezuela, Caribbean, Thailand and Australian coasts provide useful evidence on palaeosea-level as well as tide level. The possible correlations of Sri Lankan beachrock with those countries reveal the post-glacial sea-level rise with alternate stillstands. Accordingly, these beachrock located slightly above mean high-water spring and inter-tidal zone on the west coast of Sri Lanka was formed during the Late Holocene (around 3,700 yr B.P.) and the submerged reefs on the terraces were formed during the early stillstands of sea-levels since LGM (Cooray 1968; Cooray and Katupotha 1992; Katupotha 1988b and 1988c, 1989; Wickramaratna et al 1988).

Many scientists explain that there has been a close relationship between increasing of CO_2 concentration - warming, rising sea-level and retreat of coasts in both hemispheres since 100 yr B.P. (A.D. 1850). Fairbridge's (1961) studies also indicate the rising of sea-level and glacial retreat since 100 yr B.P. Disappearance of bungalows along the coastline built in the 19th century, islets on the northwestern coast and increasing of brackishwater towards the inland along the streams indicate the secular and seasonal changes occurring along the present coastline of Sri Lanka.

Thus, the different types of sea-level indicators developed from outer shelf to coastal lowlands in Sri Lanka have a close relationship with the climatic and sea-level changes which followed the low stands of sea-level during the LGM and the rapid rise of sea-level during the PGT as well as in the Holocene epoch.

REFERENCES

- Cooray, P.G. 1968. A note on the occurrence of beachrock along the west coast of Ceylon. *J. of Sedimen. Petrology* 38, 650-654.
- Cooray P.G., 1984. An Introduction to the Geology of Sri Lanka. 2nd Revised Edition, Ceylon National Museum Publication, Colombo.
- Cooray, P.G. and Katupotha, J., 1992. Geological evolution of the coastal zone of Sri Lanka. *Proceedings. In Causes of Coastal Evolution in Sri Lanka, CCD/GTZ (1991), Colombo, Sri Lanka.*
- Dahanayake, K. and Jayawardana, S.K., 1979. Study of red and brown earth deposits on northwest Sri Lanka. *J. Geolog. Society of India* 20, 433-440.
- Deraniyagala, P.E.P., 1958. The Pleistocene of Ceylon. Ceylon National Museum Publication, Colombo.
- Emilliani, C., 1955. Pleistocene temperatures. *J. of Geology* 63, 538-575.
- Emilliani, C., 1978. The cause of the ice ages. *Earth and Planet. Sci. Let.* 37, 349-352.
- Fairbridge, R.W. 1961. Eustatic changes in sea-level. *Physics and Chemistry of the Earth* 4. 99-185.