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South Indian Beach Rock

K. REDDIAH, T. E. SIVAPRAKASAM, N. V. SUBBA RAO, P. T. CHERIAN, K. R. HALDER & T. ROY
Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta 12

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Occurrence of beach rock on the South Indian coasts at Sethukarai, Kilakarai, Tuticorin, Kanyakumari and Andaman and Nicobar Islands is reported. The beach rock occurs intertidally on these coasts, mostly near the coral shores. Though the coral shores of Andaman and Nicobar Islands contain predominantly calcareous beach sands, modern beach rock is rare.

THE earliest records on the beach rock of the Indian coasts are those[1-7], referring mainly to the Gulf of Mannar and the Laccadive and the Maldive Islands. Recently, beach rock is dated to determine Holocene eustatic movements[8]. Russell and McIntyre[9] provided an extensive review of the beach rock found elsewhere. Beach rock formation is originally considered as limiting to tropical shores, but Goudie[10] cites many references as Mediterranean beach rock.

The present paper deals with beach rock occurring mostly on the coasts of South India and briefly on the shores of Andaman and Nicobar Islands. The work is based on the field studies in connection with the coral reef studies of these regions during 1967-72.

Definition

The beach rock according to Emery *et al.*[11] is calcareous and is usually composed of loose sand and coarse debris lying on or adjacent to the beach. They consider that the presence of cross sectional breaks in the beach rock show the same texural laminations as the loose beach sand and that it is mostly intertidal. Russell and McIntyre[9] define it as beach material bounded by calcareous cement. It is controlled by critical ground water temperature and favours tropical coasts for its formation because of the presence of calcareous and warm water. They consider it as a marine feature as it is exposed by overwash from waves. Bissel and Chillinger[12] define it as friable to a well cemented beach sediment consisting of calcareous debris (detrital, fragmental, skeletal) cemented by calcium carbonate.

East Coast of South India

Sethukarai — The best developed beach rock can be observed on a number of mainland shores along the east coast of South India, bordering the Gulf of Mannar from Sethukarai to Valinukkum, a stretch of over 10 km in the Ramnad district, Tamilnadu. Its western coast line shows an extensive development of beach rock. When tide starts receding, a 2 m length of the beach rock is first exposed. The presence of *Balanus* sp. (2 to 5 mm) at the tips of beach rock indicate that it is exposed for sometime. With the gradual recession of the tide, the beach rock exposure become more marked. The swirling and surf action of the receding waves further expose the eroded edges (about 1 ft thick) of the rock while the top loose sand is removed (Fig. 1). The eroded edge of the beach rock is nearly 2 m away or 6 m beyond the high tide line in low spring tide. Thus the seaward edge of the exposed rock is almost equidistant to the low and high water marks. The rock is laminated with alternate white and dark bands mixed with shell fragments as found on the adjacent shore. A few feet behind the low water line, at the bathing place, the floor is covered with large quantities of broken shell. The exposed rock is soft, coarse grained and friable, and is furrowed by surf in swash (Fig. 2).

Shortly afterwards, erosion of the seaward edge undercuts and subsequently large blocks of rocks (6 to 12 in. thick) break up and sag down (Fig. 3). These eroded blocks which originally had a seaward dip are inclined landward. Many blocks get buried and some of the material removed by erosion is washed into the sea. The top layers of the originally soft beach rock is hardened later to need a hammer to break but the bottom layers are soft. Solution pits also appear though it is not clear whether these are formed by the seeping ground water or sea water.

Local reports indicate that this rock is formed often, mostly during summer and at the beginning of the monsoon season immediately after rains. Such extensive exposures of incipient beach rock are uncommon on the shores of the Indian mainland, but Gardiner[3] has observed this stage at some place in the Laccadives and Maldives. He has observed that usually this rock is very soft and can be easily dug out by a hammer or crowbar but it does not remain long in this condition. Oldham[2] mentions the occurrences of beach rocks in the lagoon beaches of most of Laccadive Islands. Only two layers are found at Sethukarai but Gardiner has shown 5 layers at Turadu and 7 layers at Duravadu South Mahlos, Maldives.

Kilakarai — About 3 km west of Sethukarai is the coast of Kilakarai. A 2 km long shore reef runs on either side of the harbour in a semicircle. Mention has been made of the presence of beach sandstones in this area between and beyond tide marks. Five rows of seaward dipping beds of beach rock extending over ½ km, striking E 75°N and dipping 10° to 20°S, are visible in low spring tides (Fig. 4). Beyond the high water line almost near the beach crest, there is an isolated beach rock striking at E 70°N and dipping 18°S. To the west of the harbour, the beach rock presents a patchy appearance. These are much older formations, having subjected to long continued abrasion, attained polished surfaces

Fig. 1 — Exposure of friable beach rock at Sethukarai in low water spring tides

Fig. 2 — Erosion of friable beach rock at Sethukarai (Swirling and surf action produces furrows on top and in lower layers)

Fig. 3 — Hardened beach rock at Sethukarai (Rock is undercut by erosion and large blocks break and fall apart)

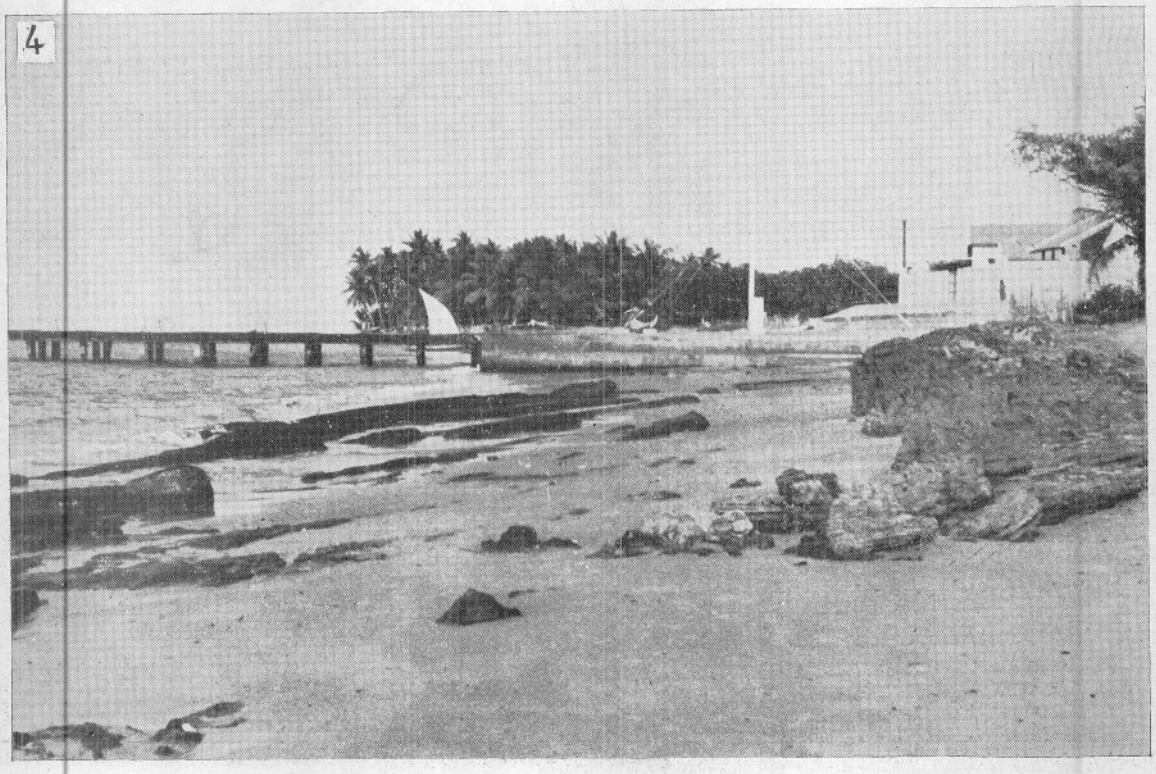

Fig. 4 — Layers of seaward dipping beach rock at Kilakarai harbour (Boulder at supratidal limit is a relict beach rock)

Fig. 5 — Eroded beach rock exposure at Hare Island close to an emergent reef (photo by S. V.)

Fig. 6 — Beach rock exposures at Kanyakumari (Beaches are covered with ilmenite and monazite sand)

and in many cases covered with encrusting algal and shell growth. The isolated boulder above the high tide line contains solution cavities caused by rain water. This boulder represents the relic formed during Holocene before the eustatic movement occurred raising it to the present level.

Tuticorin — Sewell[5] reports the occurrence of beach sandstone at Tuticorin. The topography of the area is altered later owing to the development of the harbour. About 5 km away opposite the present harbour, there is a coral island called Hare. This island is now connected to the mainland by a motorable road and the isthmus has north and south break waters. The island at the north break water as well as on the seaward side is fringed with coral and shingle. At places corals are found in position of growth. The island rim has emerged about $\frac{1}{2}$ m above the high tide line by the Holocence eustatic movements. Blocks of modern beach rock are found intertidally and are being washed away (Fig. 5). Animal borers, particularly, the sipunculid, *Themiste signifer*, are found deep inside the blocks. No incipient beach rock is found on these beaches.

Kanyakumari — The most extensive beach rock exposures are found on the north-eastern coast of Kanyakumari. There are huge sand dunes about 100 ft high, the intertidal zone of which is entirely covered with beach rock, several metres thick (Fig. 6). Its extension up to 10 km near a village called Kovalam is observed. The sands are dark coloured, and of ilmenite and monazite. There are occasional patches of incipient beach rock which includes the black sands. At Kovalam, the beach rock is found at a little distance away from the beach. It is quarried during the rainy season and is used as a building material.

Other South Indian shores — Reddiah[6] has reported beach sandstone on Appa Island, in the Gulf of Mannar. Examination on the west coast of India from Kanyakumari to Mangalore showed no beachrock. Outcrops of granite and low level laterite mostly occur. At Varakala, there are sandstone outcrops but no recent or present day beach rocks are found.

Andaman and Nicobar Islands — Six islands in the Andaman and Nicobar group, viz. South Andaman, Cinque, Car Nicobar, Camorta, Nancowry and Havelock Islands, have been visited and very few beach rock exposures are observed. Almost all the islands have coral shores fringed by subtidal reef platforms. The beach sands contain large quantities of lime. The most thoroughly surveyed island, Car Nicobar, shows patches of exposure of the present-day beach rock only at one place called Mus. The island is, however, fringed with sandstones and conglomerates raised 2 m above the high tide level. These generally have seaward dips. These may be Holocene beach rock formations, elevated by eustatic movement in recent times. Similar patchy exposures of modern beach rock are also found on Camorta Island.

Discussion

Beach rock is known to occur throughout the tropics and also in the mediterranean shores, but the manner in which it is formed and the causes of its formation have been disputed. Sewell[5] has reviewed the work of various authors. The factors responsible for its formation are mainly rain water, bacterial action and sea water. More recently, Russell[13] and Russell and McIntyre[9] have explained the importance of ground water in the formation of beach rock. Emery *et al.*[11] and Emery[14] have considered the ground water as unlikely to take part in the formation of beach rock. Stoddart and Cann[15] have raised objections to Russell's theory and stated that the initial bonding material has been found to be aragonite which is the primary cement derived from sea water. The chemical origin of cement is also disputed since calcite[13], aragonite[16,17] or a mixture of both[11] are found to act. It is further considered[18] that aragonite changes to calcite by meteoric water. Another objection raised by them is the absence of water table on some small islands. In the present study it has been observed that some islands in the Gulf of Mannar are fringed by subtidal reef-flats where cementation and lithification occur far away from the beach without the influence of ground water. This indicates that such formations may have some other source also such as rain water during sub-aerial exposure of the reef-flats especially in low spring tides.

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