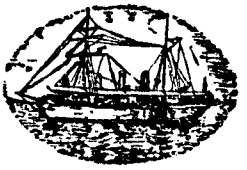

SYMPOSIUM ON CORALS AND CORAL REEFS

12 — 16 JANUARY 1969
MANDAPAM CAMP

SOUVENIR

CORALS AND CORAL REEFS

By

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THE appealing architectural design and the impressive colours of the living corals as well as of the dried skeletons of corals cannot fail to satisfy our aesthetic sense. They are a spectacular group of aquatic denizens and are regarded coveted curios and objects of decorative value. Corals have had tremendous impact on the social, cultural and economic aspects of human society even from time immemmorial. They are instrumental in the formation of extensive reefs throughout the tropics by the continued activity of several multi-billions of them for thousands of years. They are assisted in their ceaseless task by the calcareous algae and by many other marine animals. A coral reef is thus a natural object built up in the sea, and is a centre of attraction for the naturalist, the geologist and the common man alike A reef may extend a few meters to several hundred kilometers and is composed of enormous masses of limestone, with multitudes of living animals, the dominant being reef-corals. They often project above the surface of ocean waters forming the foundation of panoramic islands, or may remain submerged, being capable of sinking even man's mightiest ship.

DISTRIBUTION OF CORALS IN SPACE AND TIME

The large number of fossil corals unearthed from the plains, valleys and mountain tops speaks of their wide distribution in the geological past. The oldest coral fauna known is of the Middle Triassic from Germany, Southern Alps and Sicily. These forms flourished in the Palaeozoic Era. Present day corals dominate many marine communities. Corals thrive best in the warm tropical waters of the Indian, the Pacific and the Atlantic Oceans. The reefs are distributed as a belt around the globe between the Lat. 35° 10'N and 32° S covering an area of approximately 50,000,000 square miles. In the Indo-Pacifc region they are found in the Red Sea, Gulf of Aden, Persian Gulf, Gulf of Oman, eastern coast of Africa, the Madagascar, Seychelles, Mauritius, Chagos, Maldive and Laccadive Archipelagoes, in Ceylon and south-eastern coast of India, the Andaman and Nicobar Islands, the Australian region, China Sea, throughout the tropical Pacific as far east as the Bay of Panama. In the Atlantic Ocean they occur chiefly in the Caribbean waters. The bathymetric distribution of corals ranges from a

few centimeters to several thousand meters. But the reef-building activity is generally restricted to about 45 meters though reef-builders may grow to about 90 meters depth.

WHAT IS A CORAL ?

The 'coral' is a comprehensive term, including the *Millepora*, *Heliopora*, *Tubipora* and various gorgonids, the black or thorny corals and hundreds of stony corals. There are two main components in the structure of a coral—the living soft polyp and the non-living calcareous skeleton. The conspicuous skeleton attracts the prime attention, so that the minute polyps are often overlooked. Each polyp, in essence, is similar to a sea anemone. It is fixed at its bottom in a separate cavity of the skeleton. The body is almost cylindrical in shape, and can be contracted and expanded. Generally during day time (this is, however, not axiomatic) they retreat into the protective skeleton expanding out after sunset to feed on the minute planktonic animals by means of their tentacles. The body wall consists of an outer secretive, a middle connective and an inner digestive and reproductive layers. The central space is hollow, which forms the 'stomach' of the animal. At the top there is an opening surrounded by tentacles that serves as the mouth and anus. Corals are exclusively carnivorous and food catching is mostly done at night. The fleshy tentacles, armed with batteries of stinging cells ('nematocysts') can administer sufficient doses of poison to paralize the small animals that swim or drift around unaware of the impending danger. These defensive and offensive weapons also protect the polyps from largescale predators.

All the vital activities such as capture of food, digestion, reproduction and building up of skeleton are carried out by the polyps. They reproduce both sexually and asexually. Sexual reproduction results in a small ciliated larva that swims about in the sea for some time prior to its settling on a hard object to start with a small skeleton. It multiplies asexually, resulting in huge colonies in due course.

To mankind the coral skeletons are more significant than the polyps. They grow from a few millimeters to several meters in height and spread. They may be solitary, colonial, cylindrical, flabellate, cuneate, encrusting, pulvinate, massive, ramose or foliaceous. Many of them resemble bushes and trees in their growth form. Chemically the skeleton is mostly of calcium carbonate with a small percentage of silicon oxide, magnesium oxide, phosphoric acid, minerals and water.

COLOUR

Living corals create a spectacular scenery of 'under-water garden exhibiting a diversity of form and colour. The washed and dried skeleton of stony corals exhibited in museums are mostly white or dull yellow or brown. But in nature they are in greens, yellows, lavenders, purples, reds and blues.

The colour is either due to the presence of the symbiotic algae in the subsurface skeleton or due to the presence of pigments of lipochromids or melanoids in the skeletal tissue. The symbiotic zooxanthellae provide yellow and the boring algae green colours. Under ultraviolet rays corals are known to produce a more spectacular play of colours than under the natural light. On removal from water most of the colours fade out.

THE SKELETAL FORMATION

How and why does a coral polyp secrete a skeleton? How much do they grow annually? We know only very little by way of answers to these questions. The skeleton will be giving 'board' to the sensitive polyp and may also afford protection by allowing them to retreat into the calices. The mechanism of skeleton formation is understood to depend on a few chemical reactions. It is believed that calcium is directly taken from the sea water that enters the coelenteron. The calcium ions are brought to the calicoblastic outer epidermal layer by means of active transport through the middle body layer. These ions then combine with bicarbonates formed by the metabolic activities of the cells to form calcium bicarbonate, which on dissociation gives calcium carbonate and carbonic acid. Calcium carbonate gets precipitated and deposited in the skeleton while carbonic acid is quickly removed from the site as carbondioxide and water. The form and size of the skeleton to a large extent is controlled by species specific factors, i. e. genetically. But, the prevailing physical factors such as food, wave action, degree of sedimentation and depth and intensity of light have marked influence. To put it in other words a coral skeleton is the end product of both heredity and environment. Probably here we get excellent examples of the impact of environment on genotype in shaping the phenotypic characters of animals especially in colonial forms. How much skeleton is deposited annually ? A general statement, however, is not possible since it varies from species to species or even specimen, to specimen depending on the prevailing environment. Availability of more food and optimum light may trigger a higher rate of calcium deposition. Massive corals such as *Porites* may grow 1 to 2 cm in height and spread annually. Branching forms may have still higher growth rate, where they may show increase of 5 or 6 cm. Generally younger colonies grow faster than the older. They often exhibit an almost total cessation of growth after attaining a maximum size.

CORALS IN ECONOMY AND MEDICINE

The precious coral *Corallium* is a highly esteemed marine product of commerce and has been priced from antiquity. Even at the dawn of the Christian era there existed a trade of this coral between Mediterranean countries and India. This continued till the second world war, when Japan stepped in to meet our requirements. The ancient Indian society regarded this coral

as a substance endowed with mysterious and sacred properties. Pliny remarks that previous to the Indian demand it was used by the Gauls as ornaments on the weapons and helmets. Among the Romans branches of corals were hung round children's neck to preserve them from danger. Even to-day the Italians consider it as a protection from the evil eye and for young women a cure for sterility. In India and Tibet it is highly priced and is used to make necklaces and amulets. The skeleton of thorny corals is used in the Far East as a cure for rheumatism and in manufacture of cigar pipes. The red-coloured *Tubipora* form an ingredient in many indigenous prescriptions of South Indian physicians. The gorgonids are coveted curios. The blue-coloured *Heliopora* is of decorative value. The massive skeleton of stony corals is a source of lime and they also serve as sturdy blocks for building purposes and in the construction of roads. In the Ramnad district of Madras State large quantities of corals are brought ashore, on which the calcium carbide industry of this area depends for the raw material. Coral quarrying has become an alternative means of livelihood for many a fisherman in this area.

CORAL REEFS

A coral reef is a ridge of limestone, the top of which may be exposed at low tides. It is mostly built by corals, assisted by the calcareous algae and the dead parts of a variety of marine animals. The diversity of form and colour of corals, with multitudes of brilliantly coloured fishes moving about with elegance among other reef-dwellers and reef-building animals is a most fascinating sight. The mighty waves lashing the seaward side of a reef to become nothing but frothy masses bring about a deep contrast with the calm and quiet waters of the lagoon with hardly anything more than an occasional ripple.

TYPES OF REEFS AND THEIR DISTRIBUTION

Reefs are classified into fringing reefs, barrier reefs and atolls. A few coral formations that may not fit in with any of the above are called patch reefs. Generally speaking a reef has an outer wind-ward side that is exposed to the ocean waves and steeps down to several meters, a middle reef crust often with a boulder zone strewn with negro-heads, and an inner protected side with a reef flat.

Fringing reefs are about 500 to 800 metres in width, built on insular shores, a few metres away from the shore. Their lagoons are comparatively shallow. Reefs of this type occur in the Red Sea, eastern coast of Africa, Ceylon, south-eastern coast of India and Andamans and Nicobar Islands, Mergui Archipelago and the East Indies. The Galaxea Reef and the Manauli Reef and the Pulli reef, in the Gulf of Mannar, the Katchuvallimuni Reef, the Vellapertumuni Reef and the Kanthe Thurke Reef in the Palk Bay around Mandapam and the Little and Great Basses Reef of South Ceylon are all of fringing type.

The barrier reefs are situated far from the continent, their lagoons are 40 to 75 metres deep. The outer side slopes to greater depths. Their inner side may be clothed with fringing reefs. The structure may be broken up by deep channels, giving passage to ocean-going vessels. The classical example is the Great Barrier Reef of Australia, the largest coral formation in the world. This natural barrier extends about 1100 nautical miles, 20 - 70 miles away from the east coast of Australia. They may be several small islands between the barrier and the main land.

The name 'atoll' seems to have originated from the Maldivian word 'atollan' that denotes the ring-shaped reef of that area. Atolls are horse-shoe-shaped or circular reefs enclosing a lagoon. They are mostly found several miles away from the land. There is notable diversity in the size, shape and form of different atolls. An atoll might be elevated several metres, may be at sea level, with or without dry land or may even permanently be sunk below the surface. Atolls are found scattered throughout the tropics, albeit their concentration in the central Pacific. There are about 136 in Polynesia, 92 in Micronesia, 66 in Melenesia and 15 in Indonesia. There are 5 to the north-west of Australia and 68 in the rest of the Indian Ocean, including the Maldives, Laccadives, Chagos etc. There are about 25 atolls in the Caribbean and one in the Atlantic. Several atolls have been later elevated by natural causes and such elevated ones are not accounted above.

Sethu dam : The coral reef has found a place in the legend and mythology of India. Below the Pamban bridge, between Raman Point and Rameswaram Island, there extends a rocky barrier that has attracted the attention of the scientists as well as the religious-minded. Most of this structure can be seen while crossing the Pamban Pass in the train. It is composed of large square-cut sandstone masses similar in structure to the one used in the construction of the famous Sree Ramanathaswami Temple at Rameswaram. The western part of this structure is called the 'Great Dam'. The blocks measure one to two metres in length and breadth and are submerged at high tide. These are believed to be remnants of an ancient causeway to the island. Another version is that they are parts of a coral reef that had been subjected to many changes. From the very nature of the square-cut sandstone blocks, it appears that they are remnants of a man-made causeway rather than a natural reef. Who mede it? and at what period? These are the real problems. What precludes one from thinking that the erstwhile Dravidian rulers of this area and their industrious subjects who could afford to construct large temples of imposing architectural beauty, could also make a simple causeway to the island to worship their deity? It is possible that the Pamban channel got widened and deepened in due course probably during tidal waves caused by cyclonic storms, submerging the causeway. Investigations on the archaeology and geology of this area may throw more light on this.

The 'Adam's Bridge' extending between Dhanushkodi at the eastern end of Rameswaram Island and the Mannar Island in Ceylon is a ridge of sand that dries up to get exposed in parts at low tides. It is encumbered with islets, rocks and intricate channels. The depth ranges between one and one and a half metres. This is suggestive of a land connection from the Indian mainland to Ceylon in the past. It is believed, though not by all, that the 'Adam's Bridge ' is the remnant of the causeway built by Lord Rama with the help of an army of monkeys, during his invasion of Lanka. The story is told in the great epic of *Ramayana*, how the demon-king Ravana abducted Rama's wife Sita and carried her away to Lanka and how Rama crossed over to the island kingdom to regain her.

UNITY OUT OF DIVERSITY

Reefs are well known for their luxurient and diversified fauna and flora. The dominant animals on a reef are the reef-building corals of different sizes and shapes. The Atlantic reefs are poor in the reef-dwelling and reef-building animals compared to those of the Indo-Pacific. In the Indo-Pacific reefs, many alcyonarious hydroides, sponges, bryozoans, polychaetes, crustaceans, molluscs, echinoderms and fishes are found in constant association. Sponges are found as encrustations or as true borers on corals. A good many of them are in reds, yellows, greens and lavenders, adding colours to the reef. Bryozoans are mostly attached and encrusting. Both errant and tube-dwelling polychaetes are in plenty. Molluscs are numerous. The gastropods crawl around the coral colonies and many bivalves bore into the skeleton causing destruction to the framework of the reef. The most destructive among the boring bivalves is *Lithophaga*. Stomatopods, copepods and decapods are fairly common. The sea stars, sea cucumbers, sea urchins and brittle stars find excellent habitat among corals. Multi-coloured fishes are fairly common in the reef. But from this diversity the reef dewellers forge an appearance of unity and an atmosphere of co-existence by living together and letting others live in association.

THEORIES ON CORAL REEF FORMATION

The bottom of many reefs extends to several hundred meters deep in the sea bottom. But the present day reef corals can flourish only to a limited depth in carrying out their reef-building activity. How did the reef bottom happen to be at this greater depth ? This has been a subject of much controversy among the biologists as well as the geologists from the dawn of the 19th century. Many scientists, for the last century and a half, have come forward with ingenious hypotheses to explain the same. It was Charles Darwin - the father of the theory of Organic Evolution - who first suggested a satisfactory explanation in 1848. His contention, supported and later amplified by Dana in 1853, was that the barrier and atoll reefs were formed initally as fringing reefs comparatively at shallow waters. These fringing reefs first developed around the inshore regions of volcanic islands.

With the passage of time, the volcanoes sank with the reef. But the corals kept their upward growth in pace with the rate of subsidence of the inshore region of the valcano, finally causing the development of a barrier reef situated far away from the land. If such a volcanic island surrounded by fringing reefs, totally disappears under the sea, the central part of the island forms a lagoon, the reefs forming an atoll.

A second hypothesis suggests the possibility of the solution of limestone at the shore-ward side of a fringing reef by sea and rain waters, thus causing the formation of a wider and deeper lagoon. Fringing reefs could grow on the top of rising foundations caused by volcanic eruptions or by the accumulation of animal and plant remnants at the sea bottom. Corals in due course reached the surface by their upward and outward growth. Those on the top that reach surface die out and their solution gives rise an atoll. This hypothesis has to face the objection that the alkaline waters of the tropical seas are unable to dissolve any appreciable amount of calcium carbonate. Rain water might have played a significant role but the springs of several areas are alkaline due to the presence of bicarbonates. Further it has been pointed out that at present the lagoons in several areas are getting filled by sediment and not widening by erosion and solution as this theory demands.

A third hypothesis put forward in the early nineteen hundreds links the Pleistocoene glaciation to the coral reef formation. During the Pleistocoene glaciation large bodies of waters were drawn out from the tropical seas for the formation of polar ice caps causing a lowering of sea level. Most of the then existing reef-corals also died out due to the lowering of the temperature. With the amelioration of the climate and the melting of the ice caps the water level in the tropical oceans returned to the pre-glaciation level. The depth of platforms that were so cut could have been 55 to 99 meters below the present sea level. As the water temperature gradually rose, the reef corals that survived the period of glaciation began to reproduce actively and the planulae found congenial habitats on the wave-cut platforms. The reef kept up the pace as the sea level rose. This theory also is not accepted by all. It has been estimated that one-fifth of the Pleistocoene Era experienced the glacial condition. Of this, waves were cutting at levels intermediate between the present and the lowest glacial strand for 80% of the glacial period and only 20% of the glacial period (i. e. 4% of the entire Pleistocoene) experienced a low-enough wave cutting to form any major platforms as required by this theory. But in support of this theory it has been calculated that the Samoan reefs could have been formed after the glaciation.

A fourth hypothesis envisages anticedent platform at the ocean basin, probably formed by the erosion of volcanic cinder cones. Such platforms might have been further elevated by the deposition of the skeletal remains of the marine animals to make them ideal for the colonisation of the corals. The formation of the Maldives and the Laccadives in the Indian Oceans and

some of the reefs in the eastern Pacific including the Great Barrier Reef, have been explained by this hypothesis.

Recent investigations have proved the reliability of the Darwinian contention. Darwin's hypothesis alone required much vertical thickness of the reefs. Borings at the Faunafuti Atoll to a depth of 334 metres and at the Bikini Atoll in the eastern Pacific to depths of 1,246 and 1,383 meters respectively have revealed the calcareous reef basement, upholding Darwain's hopothesis. It appears that planation plus subsidence can account for most of the reefs ,though no single factor will explain the formation of all reefs.

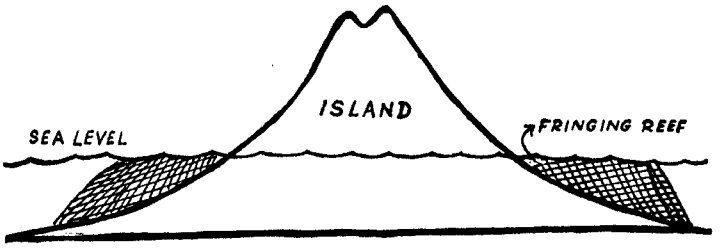
CORAL REEFS AND THE FORMATION OF CORAL ISLAND

Coral reefs have played a substantial role in moulding out many present day inhabited islands in the tropics. It is no exaggeration that "in no branch of biology we are so close to the earth science as in the study of coral reefs." Many exhilarating palm-fringed islands of *Micronesia Polyuasia, Melanesia* in the central and eastern Pacific and the Maldives and Laccadives in the central Indian ocean are formed out of coral reefs. A coral reef, when raised above the sea-leavel by natural means such as earthquake, volcanic erruption etc. is exposed to rain and sun causing the formation of sand. Waves may also deposit sand enabling sustenance ot vegetation. Many of the atolls are now being inhabited by people who ventured out from the mainland. The human habitation has changed the face of many atolls all over the world. Reefs were cut to make way for boats, lagoons were dredged and pits were sunk in the land to draw out fresh water. Natural vegetation has been removed and exotic plants and animals were introduced. Several interesting indigenous elements in the fauna were partly or fully destroyed leading to their extinction.

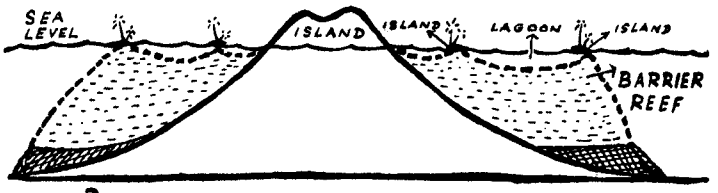
Figures 1 to 3. Formation of barrier reef (Fig. 2) and atoll (Fig. 3) from a fringing reef (Fig. 1) according to Darwin's hypothesis.

Figure 4. Secton illustrating the formation of platform by wave action in the marginal seas during glaciation (*After*, Browand, 1957).

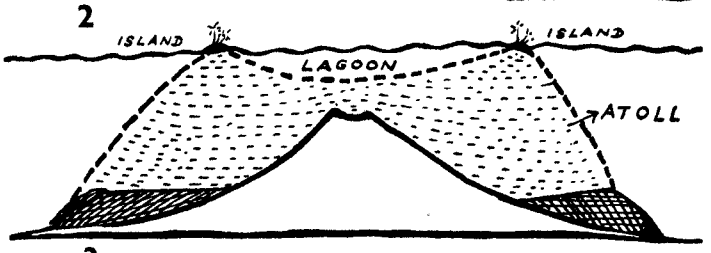
Figure 5. Formation of atoll from submerged banks. A. Basis of primitive rock cut down by currents. B. Upgrowth of shoals by means of deep sea corals assisted by other organisms. C. outward extenssion of reefs. D. Surface reefs formed by reef corals. E. L and formed by elevation. F. Lagoon (*After* Gardiner, 1904).


ISLAND
SEA LEVEL
FRINGING REEF

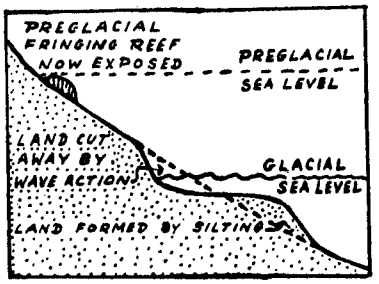
1


SEA LEVEL
ISLAND
ISLAND
LAGOON
ISLAND
BARRIER REEF

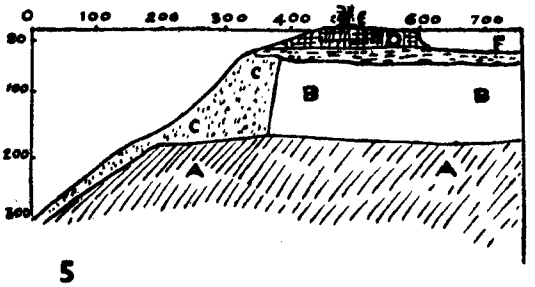
2


ISLAND
ISLAND
LAGOON
ATOLL

3


PREGLACIAL FRINGING REEF NOW EXPOSED
PREGLACIAL SEA LEVEL
LAND CUT AWAY BY WAVE ACTION
GLACIAL SEA LEVEL
LAND FORMED BY SILTING

4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