

## Charles Darwin and Coral Reefs

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CHRISTMAS DAY of the year eighteen hundred and thirty-one found the young Charles Darwin making his final preparations for the long voyage which laid the foundations of his scientific career. He was then in his twenty-third year, and had just taken his degree at Cambridge. His keen interest in sport and in the pursuit of outdoor studies in natural history robbed him of any academic distinction, and his place as tenth on the list of the pass graduates gave no clue to those rare qualities of mind which afterwards gained him a secure place among the immortals.

Darwin's interest in natural history was manifested in his boyhood days, and was fostered by the two years which he devoted to the study of medicine at Edinburgh.

A further opportunity for scientific studies was given to him after graduation by his friendship with Henslow and Sedgwick. It was the botanist Henslow who secured for him the position of naturalist on the *Beagle*, and it was Sedgwick who fostered that love for geology which led him to give it such a prominent place during his voyage on the *Beagle*.

The observations and collections made by Darwin during this five years' cruise—for such it proved to be—provided the basis of many years of fruitful labour and thought in his after life. Indeed it was his one great opportunity, as he never subsequently left the shores of England.

The aspect of his work with which this lecture is concerned is his study of coral reefs. This is the most notable of his contributions to geology. His conclusions, which brought a unity of thought into the problem of their origin, have withstood, with some minor modifications, not only the buffetings of criticism in his own day, but those of our times. It is therefore very surprising to find that the actual time afforded for the visitation and field study of coral reefs amounted to about one month only out of the five years' voyage.

Coral reefs are not well developed in the Atlantic Ocean except in, and about, the West Indies, and this region was not visited by the *Beagle*. Neither are they to be seen in any notable measure along the western coast of South America. It was therefore not until the homeward voyage of the *Beagle* from South America across the South Pacific and Indian Oceans that Darwin was brought face to face with the coral isles.

After leaving the Galapagos Islands the *Beagle* passed through the Low Archipelago, and it was here that Darwin had his first glimpse of the typical coral reefs of the Pacific.

He described his first impressions as follows: "A long and brilliantly white beach is capped by a margin of green vegetation; and the strip, looking either way, rapidly narrows away in the distance, and sinks beneath the horizon. From the masthead a

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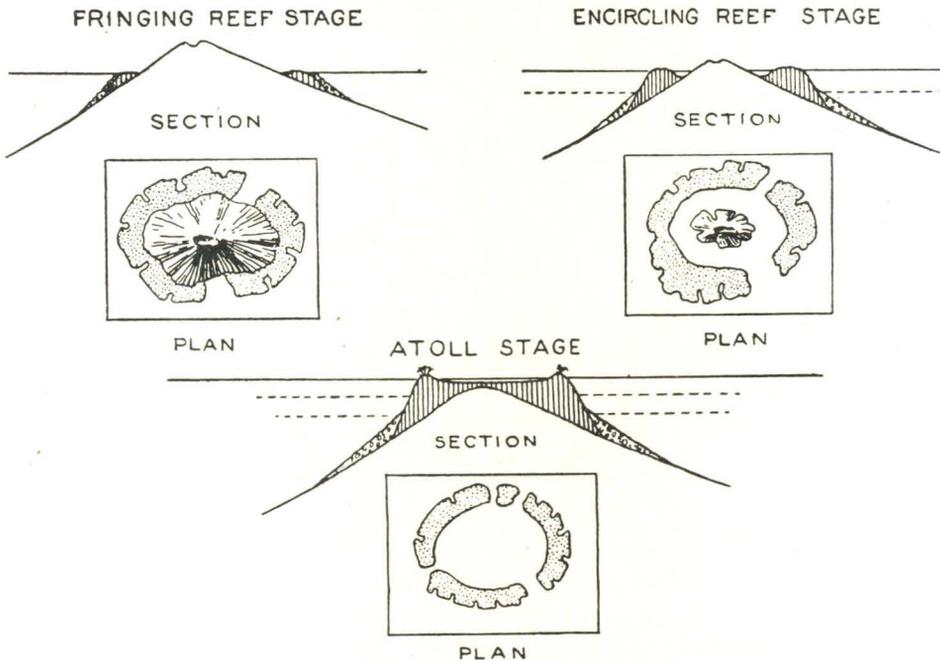
<sup>1</sup> A lecture delivered at the University, being one of four to commemorate the visit of Darwin to Australia in 1836.

wide expanse of smooth water can be seen within the ring. These low coral islands bear no proportion to the vast ocean out of which they abruptly rise; and it seems wonderful that such weak invaders are not overwhelmed by the all-powerful and never-tiring waves of that great sea, miscalled the Pacific."

One can imagine the feelings which stirred the heart of the young naturalist as he sailed by the great chains of coral islands which form this archipelago. Many of these coral-girt lagoons had been the haunts and refuges of the buccaneers whose exploits had given the islands a colour of romance.

It was not, however, until the *Beagle* reached Tahiti that Darwin came to close grips with coral reef problems. The stay of eleven days was all too short, and as the examination and collections of the more striking elements of the fauna and flora claimed much of the young naturalist's time, little could be given to the study of the coral reefs.

Darwin's next opportunity came when, after having left Australia, the *Beagle* called at the Cocos (Keeling) Islands. It was here that the coral reef problem appears



first to have dominated Darwin's thought, and we find that after the short stay of eleven days at these islands his journal is full of his observations and impressions. The only other occasion which was afforded him for coral reef investigation occurred during the ten days' visit to the Mauritius group.

It is astounding that with this brief acquaintance with coral reefs Darwin should have been able to offer a clear explanation of their origin. This, however, was not forthcoming for several years after his return to England, and was the result of much study of the work of other investigators as well as his own.

Darwin showed that the essential facts of observation are as follows :

- (1) In their distribution coral reefs are practically limited to the tropical zone between latitudes 28° N. and 28° S.
- (2) Reef-building corals do not flourish at depths deeper than 30 fathoms.
- (3) The reefs are built up almost to the level of low tide, the seaward edge being slightly higher than the main reef.
- (4) The outer edge of the reefs are very steep, angles of slope up to about 45° being quite characteristic.
- (5) The reefs as a rule are discontinuous, with many gaps where the reef does not reach sea-level.
- (6) Reef-building corals require clear salt water with a temperature of not less than 68° F.
- (7) The growth of coral is most active on the seaward side, the inner edge consisting chiefly of dead coral.

As the result of his studies Darwin recognised three distinct kinds of reefs, which he named fringing reefs, barrier reefs and atolls.

The *fringing reefs* lie close to the shore, and are built upon the shallow floor of the sea, which is the seaward extension of the beach. This shallow platform continues for some distance beyond the reef on its seaward side. Between the reef and the beach there is a narrow zone of water which is usually much less than twenty fathoms in depth. There are many gaps in the reefs, chiefly opposite the mouths of rivers.

The *barrier reef* is a larger type which stands farther from the shore than the fringing reef. As a rule the seaward edge of the reef descends abruptly into deep water. The zone of water between the barrier reef and the land may be many miles in breadth, and may reach depths of from twenty to fifty fathoms. As in the fringing reef, the chief breaks in the reef lie opposite the mouths of rivers.

The *atoll* is quite distinctive in character. It consists of a narrow more or less horseshoe-shaped island standing only about fifteen feet above sea-level. The island consists entirely of reef material which has been formed by fragments broken off its outer edge and tossed up on to the reef platform by the waves. Further upbuilding is effected in this way, and thus a beach is formed. The drift of sand dunes from the beach further increases the elevation and breadth of the island. The narrow strip of land built up is protected from the attack of the waves by the outward growth of the coral reef, which builds a bulwark against the sea.

These horseshoe-shaped islands have their openings chiefly on the sheltered side, with the toe of the horseshoe facing the stormy side of the atoll.

The low-lying islands vary greatly in size, the largest reef being up to about fifty miles in diameter. The central lagoon is shallow, in strong contrast with the deep water surrounding the atoll.

Before Darwin's investigations it was considered that these atolls were built up from the crater edges of submarine volcanoes. Darwin, however, saw clearly that this implied an enormous number of such volcanoes, with their peaks rising to within

a range of thirty fathoms below sea-level. Not only did he regard such a coincidence as being beyond the bounds of belief, but saw a further difficulty. For over an area of hundreds of thousands of square miles of the western Pacific Ocean, where atolls are numerous, there is no vestige of any volcanic island.

It was on this problem that the genius of Darwin shed the light of a simple and adequate explanation; one that not only offered a sound theory for the origin of atolls, but also for the building of fringing and barrier reefs.

Darwin pictured first of all a great archipelago of islands girt about by fringing reefs, and so situated that it lay in a part of the ocean where the sea floor was gradually subsiding. As the islands sank the corals built upward and outward. Thus the fringing reef became gradually transformed into a barrier reef, and with the complete submergence of the island the barrier reef became an atoll. In this way islands originally differing in elevation would as the result of continued subsidence be finally represented by atolls.

Although this theory of Charles Darwin has been found inadequate to explain every occurrence of coral reefs, it undoubtedly offers an explanation of the origin of coral reefs in general. A convincing proof of the Darwin Theory was demonstrated by the investigation of the late Professor David at the coral atoll of Funafuti. Here, after great difficulties had been overcome, a bore was sunk to a depth of 1,114 feet. For the whole depth nothing but coral rock was encountered. Moreover, this coral rock was shown to be in its original position of growth, and hence even if the corals had lived at a depth of thirty fathoms—an extreme limit—a subsidence of about 930 feet must have taken place.

Although Darwin's claim to fame rests chiefly on his biological work, this contribution to geology has won for him a high place in records of geological science.

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