

BY THE OLD HYDROGRAPHER

As it Was

Two famous scientists, Charles Darwin (1809-82) and John Murray (1841-1914) differed greatly as to how tropical atolls had assumed their unique structure: a shallow lagoon surrounded by a narrow strip of low land. In the early 1950s an opportunity arose to use marine seismic methods within two lagoons in the Ellice Islands in the Pacific. These investigations gave support to Darwin's idea that these structures had formed over a million years around a volcanic island sinking back into the earth's crust.

Charles Darwin, the young naturalist who circled the world during the years 1831-36 in HMS Beagle was later famous for his work on the "Origin of Species". During that part of the voyage when Commander Robert Fitzroy and his officers and men were engaged in surveys off the coasts of South America, Darwin made an excursion into the Andes. There he found shells that at some remote period of time must have lain beneath the sea. Later, in his Journal of Researches, he wrote: "Daily it so forced home on the mind of the geologist that nothing, not even the wind that blows, is so unstable as the level of the crust of the earth". If so much had obviously risen, so much else could have sunk, he thought.

So it was that later in the voyage, while pondering upon the structure of Cocos-Keeling atoll in the Indian Ocean and wondering how a shallow lagoon came to be encircled by a meagre strip of land, he finally came to the conclusion that atolls had begun as coral reefs fringing the coasts of high islands. These, having been raised up by volcanic action from the ocean floor, had for a million years been sinking slowly back into the earth's crust. As the highest peaks at last sank beneath the sea there remained a void at the centre of the reef where food for the coral polyps became scarce, so that a lagoon was formed with a floor of dead coral debris. Darwin published this thesis in his Structure and Distribution of Coral Reefs in 1842, six years after his return from the Beagle voyage.

During the Challenger Expedition of (1872-76) John Murray of Edinburgh was assistant to Wyville Thomson, the scientific leader. Challenger visited a number of Pacific atolls and high islands fringed with coral reefs. Murray, like Darwin, gave much thought to their construction.

On Challenger's return to England John Murray was employed until 1895 on compiling the Challenger Reports for publication in an office set up in Edinburgh for this purpose. Still giving much thought to the information on atolls dating from 1880, Murray presented a paper on the subject before the Royal Society of Edinburgh.

He argued that a coral reef occurred when the slow accumulation of marine sediment on a shoal of volcanic origin raised its level sufficiently close to the surface of the sea for coral to grow. When the coral reef reached the surface it would grow outwards where food was abundant, whilst the coral at the centre, starved of nutrient, would die and be dissolved in sea water so that the lagoon was formed.

Darwin disagreed violently with Murray's ideas and shortly before his death wrote of his wish "that some doubly rich millionaire would take it into his head to have borings made in some Pacific or Indian atoll, and bring home cores for slicing, at a depth of 500 or 600 feet".

Heeding these words, perhaps, the Royal Society in London formed a Coral Research Committee that began to collect funds to send an expedition to the atoll of Funafuti in the Ellice Islands (now the state of Tuvalu). The scientist W.J. Sollas was to lead the expedition, to include a drilling team and equipment transported to Funafuti in HMS Penguin in 1896.

The expedition was not capable of setting up a drilling platform within the lagoon but only on the perimeter stretch of land. However, drilling came to a halt at a depth of 105 feet as the material flowed like quicksand; two further expeditions were sent to Funafuti in 1898 and 1899 when drilling on land found only dead coral at depths to 1,114 feet. Some scientists claimed that the result proved Darwin's subsidence theory, whilst Murray's adherents averred that such borings on the perimeter involved only a marginal tallus of dead coral fragments and proved nothing.

I was fortunate in the early 1950s to be in command of another HMS Challenger. I took Dr Tom Gaskell and Dr John Swallow, from the Department of Geodesy and Geophysics at Cambridge University, to the Pacific where they were engaged in seismic operations to measure the thickness of the various ocean bed sediments overlying the basement rock.

Islands in the Ellice group were reported to lie badly out of their charted positions and this being long before the advent of GPS, I was sent to Funafuti and Nukufetan to fix their position by theodolite celestial observations. These visits proved an ideal opportunity for our scientists to use their seismic equipment within the lagoons to define the nature of the underlying structure.

The seismic technique was similar to that used at sea, but within the lagoon the ship lay at anchor, the sound signals being initiated by the firing of charges from the ship's boat at varying distances from the ship. Returning sonic signals from the atoll structure were picked up by hydrophones strung beneath four anchored sono-buoys and relayed by radio to the ship, their timing being recorded by the photographic device onboard.

The scientists found at a depth of 1,800 feet material with a sound velocity of 6,000 to 8,000 feet per/second, much as would be expected

in coral limestone. Below this lay elements with sound velocity of 12,000 feet per second, possibly very hard limestone or volcanic rock. The borders between these two layers fell rapidly away towards the perimeters of the atolls, giving the picture of a supposed volcanic hump within the heart of the atoll structure. Deeper again, an even harder material appeared, probably the true core of the original volcano.

As the experiments seemed to prove that there was 2,500 feet of coral limestone below Nukufetan it would seem that Funafuti was still an island about 500 feet high, surrounded by a coral reef, when Nukufetan disappeared beneath the waves.

We had spent three wonderful weeks on these two tropical isles, hosted by the delightful inhabitants. We had sailed with the islanders, played cricket with them and often, when the sky was overcast preventing star sights, danced the night away in their company.

Our observations, which appeared to support Darwin's theory of atoll construction, were made in 1951. In 1952 Darwin's "doubly rich millionaire" eventually arrived when United States surveyors, preparing for atom bomb tests on Eniwetok atoll, drilled from a platform in the middle of the lagoon to find the underlying basaltic foundation at a depth of 4,000 feet. Charles Darwin would have been pleased.

Further Reading

- Yonge, Maurice, "The Royal Society and the Study of Coral Reefs". Oceanography of the Past - Springer - Verlag - New York/Berlin (1980)
- Deacon, Margaret, "Scientists and the Sea 1650-1900" Academic Press, London/New York (1971) Chapter 16