A STUDY OF THE MECHANISM OF DEPOSITION OF HEAVY MINERALS ON THE BEACH BY WAVE ACTION.

SINGHAMUNI ARACHCHILAGE NANDADEVA.

A THESIS SUBMITTED IN FULFILMENT
OF THE REQUIREMENT FOR THE DEGREE OF

MASTER OF PHILOSOPHY.

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING TECHNOLOGY
OPEN UNIVERSITY OF SRI LANKA

APRIL 2000.

ABSTRACT

A large deposit of valuable minerals comprising mainly ilmenite, rutile, zircon, monazite, garnet and sillimanite in the form of very fine beach sand is found at Pulmoddai in the north east coast of Sri Lanka. These minerals are generally found in igneous rocks that are found inland. They are broken down into sand form due to mechanical and chemical action and transportation by rivers and creeks finding its way finally into the sea.

This process can take millions of years for a sizeable quantity of minerals to reach the sea. Then, after reaching the sea how can the entire quantity get deposited on a single selected location back on the beach? Why can't those minerals go further into the deep sea and get lost in the sea? The purpose of this research project was therefore, to study the mechanism by which these sands are pushed back to the beach where the right type of conditions prevail.

For the purpose of the research a wave tank was designed and fabricated out of steel plates. Waves were satisfactorily generated using a wave plate pivoted at the bottom and driven by a variable speed electric motor. After preliminary experiments uniform currents were generated across the tank by pumping water through a honeycomb type gate fitted onto one side of the tank. Transparent perspex sheets were fitted to the two longitudinal sides to observe the water waves, formation of sand ripples, actual motion of sand particles and the movement of ripples.

Tests were carried out to study the formation of different types of waves by varying the frequency and amplitude of the wave generating plate. Same tests were repeated with a sand bed using a sample of actual beach sand from Pulmoddai beach. Different stages during the formation of ripples under pure water waves and also under a combination of water waves and ripples were studied. Also how the sand ripples formed under pure waves began to move as soon as the currents were introduced was observed. It was found that combined wave and current action is jointly responsible for the mass transportation of sand to the artificial beach of the wave tank.

The ripples thus formed under the combined effect of waves and currents move in the direction of waves still maintaining the shape of ripples with or without the original shape. This forward motion is accompanied by a vortex formation sequence. Vortices are of different shapes and forms. However, these forms are repeated in sequence and as a result the ripples are shifting forward.

Generally, the sea waves travel from sea towards the land. These waves can be classified into four main types namely collapsing, spilling, surging and plunging. Depending on the strength of these waves, water waves travelling on the surface of the water make an influence on the sea bed. The effect on the sea bed also varies with the depth of the water from the water surface. If the sea conditions are such that the waves are symmetrical and sinusoidal, the sand grains on the sea bed move "to and fro" without a resultant displacement. These waves also cause the sand grains on the sea bed into suspension loosening the topmost layer of the sand bed. However, if the waves are not symmetrical, but are asymmetric then there is a resultant movement of the sand particles even though the motion is still in the form of "to and fro".

One way of causing the symmetrical ripples to become asymmetric is by water currents. If the water currents act continuously on the waves then the sand particles while following a path of "to and fro" motion moves forward with a resultant positive displacement from the original location. In fact it is the waves which are mainly responsible for making the initial motion of the sand grains by bringing them to a state of suspension.

In the sea one way of generating currents is by waves approaching the beach at an oblique angle. Similarly in an area of a straight long beach where the land is projected into the sea or a formation of a series of rock outcrop may convert waves which are approaching the beach at right angles, into currents when the waves hit the rock outcrop or projected land at an angle. Sudden variation of water depth also can convert waves into currents. The result is the presence of waves and currents in the same area that becomes ideal for transporting sand.

Creation of artificial structures to convert waves into currents in areas where land is getting eroded may completely change the natural situation thereby causing sand to travel onto the beach thus replenishing the beach and avoiding sea erosion. On the other hand disturbing the naturally formed headlands can cause the non-eroding areas to severely erode. In fact, it may be possible to bring any minerals that are present in the sea onto the beach by building barriers such as breakwaters in calculated angles, whereby simply converting a portion of water waves into strong currents in the right direction.

At Pulmoddai, if the sea in the deposit area is used to make a harbour by building a break-water to facilitate the ships to undertake loading of minerals at Pulmoddai itself, there could be a possibility of disappearing the deposit into the deep sea.

Therefore, it would be interesting to undertake further research on the effect of the land projected into the sea on the sand transportation from sea and redeposition on the beach and also the rate of sand ripple movement under the combined effect of waves and currents.