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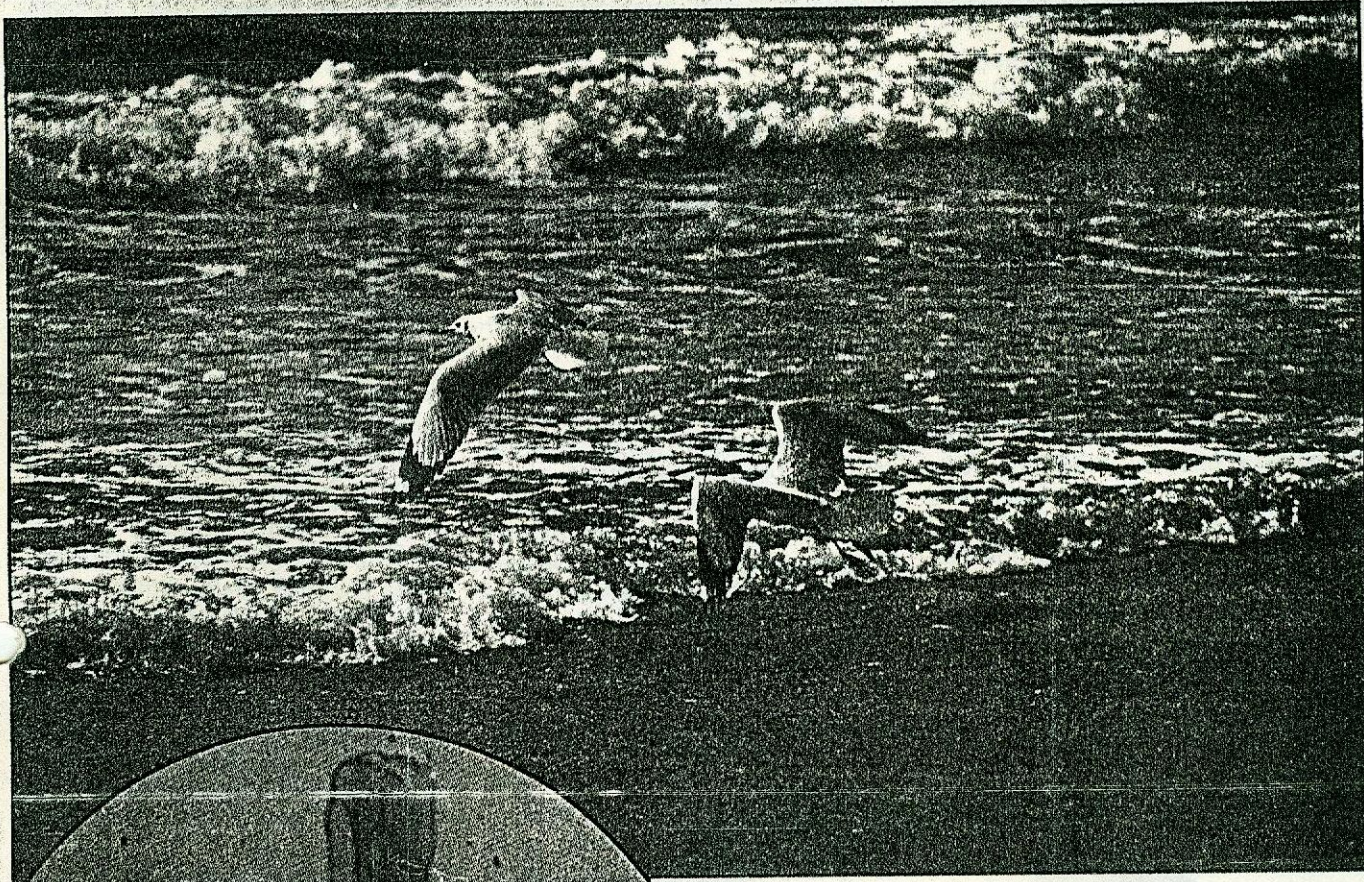
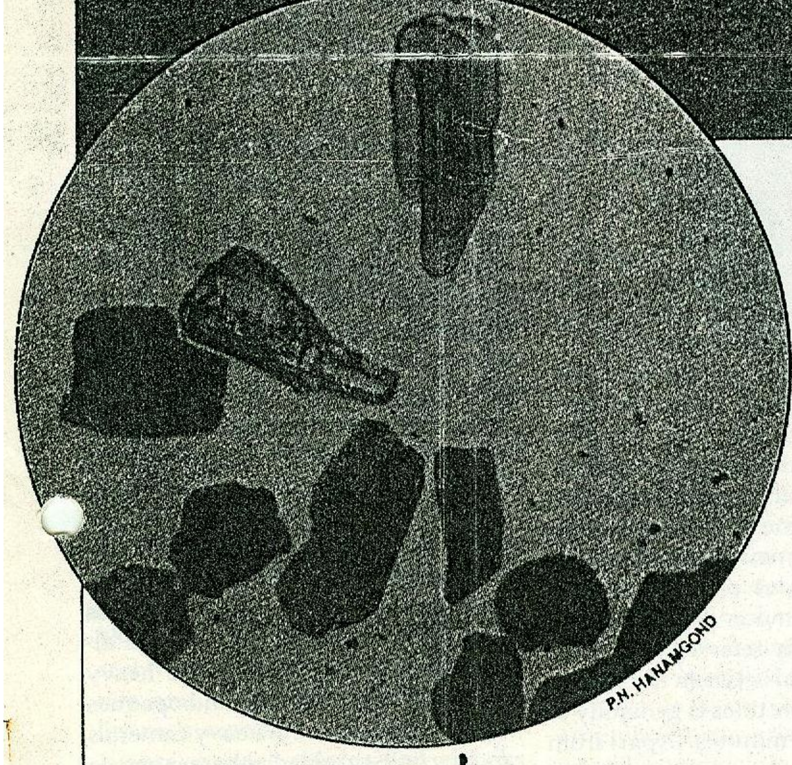
BIMAN BASU





P.N. HANAMGOND

INSIDE THE BEACH SANDS

From where does the sand on the beautiful beaches come?

PRAVEEN B. GAWALI says a sand grain can reveal it all

MAN'S fascination for the seas lies as much in its incredible expanse of ever-active water as in the glorious beaches lining their shores. A storll on the cool soft sands, especially during the magical hours of dawn or dusk, is always a joy. Kids love to play, run, trip jump about the sea beaches and revel in putting their incipient architectural skills to test by building sand-castles.

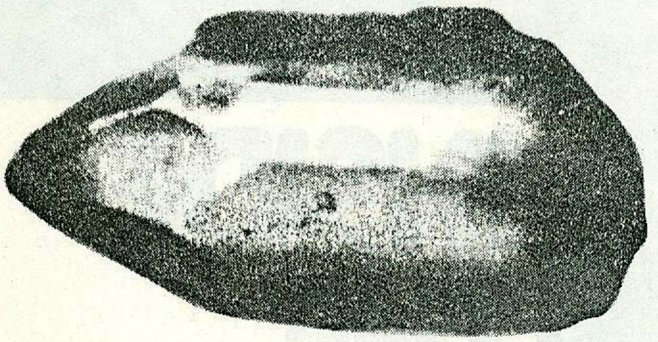
But where from does the sand come to accumulate on the beaches? What is the material the sand is made of? How does a beach form at all?

For most of us a beach is an accumulation of loose sand along the coasts. The beach sand is loose in the sense it is not as hard as rock. The widely accepted definition of a beach is that it is an accumulation of unconsolidated sediment extending shoreward from the mean lowtide line to some physiographic change such as sea, cliffs, dune, fields or a permanent vegetation. In other words, the beach starts not from the shore lines but even more inwards from the sea.

There are certain basic requirements for the formation of a beach. It can form at any part of the earth at the meeting ground of land and sea where there are sufficient sediments and space for accumulation of sand. Beaches in a way are born out of conflict between the land and the sea.

Although there are a number of coastal sedimentary environments, beach is by far the most widely distributed form. The nature of a beach, its shape, size and orientation depends upon a number of factors such as the prevailing waves, tides, currents, direction of the wave approach, the material composing the beach and the overall shape and composition of the coast.

Wave energy is a major factor controlling the development of and changes in the beach. The other factor having a major impact on the formation of beaches is the tides. Tides have a telling effect on beaches as they expose beaches alternately between the high and low tides. The generation of tides, however, depends upon the Moon's gravitational attraction and to some extent on the sun's attraction.



A Zircon grain (Photo: P.T. Hanamgond)

The high tide, also called spring tide, develops when the sun and moon are either on the same side of the earth as happens during new moon days or on the opposite sides of the earth like during the full moon days. The low tide is commonly referred to as neap tide. The interval between the successive high and low tides is generally of 12 hours and 26 minutes. Apart from waves and tides some water currents generated in the surf zone, just close-by to the beach, called long shore currents are also involved in the formation of beaches. These currents are generated following the breaking of waves and when a wave approaches at an angle to the shore. Such currents can transport sediments over large distances.

The material comprising a beach is nothing but loose debris produced by the weathering of rocks. The rocks come from many different sources. For one, the beach gets its material from the rocks lying in the hinterland or from the headland or from the bedrock. Most of the beaches are generally of this type. Many-a-times the erosion of the coast itself provides the sediments. Shoreward movement of sediments by a long-shore also contributes towards the accumulation of sands. In some beaches the biogenic or skeletal material of marine organisms is found to be overwhelming constituent. Beach materials could be local, or may have come from far of places. For example, some of the material of Harwada beach along the Uttara Kannada coast in Karnataka, must have probably come from the upper northern reaches of Karnataka and Maharashtra, some hudreds of kilometres away.

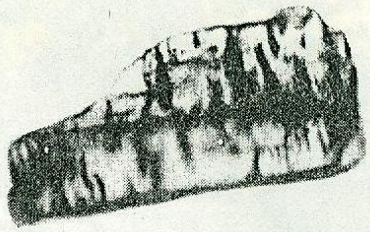
The loose sediments forming the beaches vary in size of particles, from clay-sized particles to large blocks of rocks. The predominant particle size of beach constituents is more than 200 mm in case of boulders and less than 0.002 mm in case of clayey beaches. In between these two lie the gravel, sand and silt sediments.

As the sands of beaches are fragments of rocks, their constituents are also minerals as in rocks. Sands could be of light or heavy minerals. The two ae differentiated on the basis of their specific gravity with the light minerals having a specific gravity of less than 2.8. The light minerals are always bigger in size than the heavy minerals. Garnet, zircon and opaques are the densest of the heavy minerals and the finest grained, whereas quartz and feldspars have the lowest density and largest size. What is surprising is that these two types of minerals occur side by side by what is called the hydraulic equivalence, though they possess markedly different densities.

Heavy minerals are also referred to as "black sands". These appear as streaks on most of the beaches due to concentration of heavy minerals. Streaks occur due to the action of bottom currents on the sediments during the time of deposition. They occur as water currents carry off the lighter materials leaving the heavier ones behind. The resulting banding, also called "colour banding", is fascinating. One of the curious feature of this banding is that its constituents are not uniform throught the band. Even the bands located within a few inches of each other contain varying proportions of different minerals pointing towards selective action of currents of different strengths. The manner in which the bands are deposited or sorted outmay be due to the gentle to-and-fro movement accompanied by the forward and backward movement of water currents. Apart from these, wind also contributes for the accumulation and ripples of bands in sands. But this happens only with moderate speed winds. Brisker winds simply whisk away the sand. A large scale mineral sorting leads to the formation of 'black sand' deposits. The deposits occur because of selective erosion of light minerals, the quartz and feldspars.

Only the stable minerals — those resistant to chemical and physical weatherinag, accumulate on the beaches. The rivers and streams dutifully draining the hinterland disintegrate rocks and carry the fragments off. The weathered rocks undergo a lot of further wear-and-tear till they reach their final destination, the sea. These suspended particles are dumped at the mouth of the river as the river flow is stopped in its tracks on entering the sea.

Quartz which is the most common mineral in sands is the most resistant mineral. Next come the feldspars. These are the last formed minerals according to the Bowen's reaction series and so are the last to decay. Bowen's reaction series lists the sequence or order of formation of rocks from a basaltic magma. There is an order in the making of different rock units of differing composition from the same parent magma. Those minerals formed at high temperature are not stable at low temperatures and hence prone to disintegration. Take the ice as an example. Ice can be ice only if a certain minimum temperature is maintained. Higher temperatures will melt the ice. Water turning to ice or vice versa is a response to changed temperature-pressure conditions. Similar is the case with different minerals. Quartz and feldspars are formed at lower temperatures and so are more resistant. Not surprisingly, these two constituents form the bulk of beach sands. Heavy minerals, too are resistant to weathering.



A fractured grain of sillimanite

Both the light and heavy minerals have academic and economic importance. But, the latter are geologically more important. Some decades back heavy minerals were studied primarily to match different rock layers. Two or more strata found at two or more far-flung localities are matched depending upon the kind of heavy minerals encountered. But this use has now been usurped by the more reliable fossils. Distinct demarcation between different rock layer boundaries solely on the basis of heavy minerals is difficult. So heavy minerals are now mainly studied to understand the source area as they identify the parent rocks more precisely by the great number of distinctive minerals. Thus, the presence of augite and hypersthene is related to the occurrence of volcanic rocks. On the other hand, amphiboles comprising ferromagnesian silicate minerals commonly found in igneous and metamorphic rocks point tolarge igneous bodies formed at great or intermediate depths in the Earth's crust. Presence of minerals like zircon, tourmaline, sphene means that the sediments are from high metamorphic terrain.

Sometimes the light mineral analysis also confirms the rock sources. For instance, presence of monocrystalline quartz an feldspar indicate acid plutonic source whereas undulatory and polycrystalline quartzpoint to metamorphic source. Plutonic rocks are those that form at great depths in the Earth's crust. Monocrystalline quartz is a single crystal of quartz. It is found in plutonic rocks because deep down in the crust, conditions are favourable for slow cooling. Here usually there isn't any let-up in the crystallization phase due to any sort of tectonic disturbance. But in polycrystalline varieties the grains are oriented randomly with respect to each other. This randomness is caused due to temperature and pressure changes as normally happens in metamorphically active regions. Such analysis shows that the now exposed southern Indian peninsula once had a very turbulent metamorphic history whose effects can be observed even today in the mineral grains of the peninsula's various rocks.

Assemblages of heavy minerals contained within sands have been used to analysethe transport paths of sediments of both modern and ancient sediments. Radioactive tracers are also used to track the movement of sediment in the shore region. Heavy mineral analysis has been valuable in the reconstruction of past history of earth and for determining the sequence of rock formation. For instance, we know that sandstone, shale, siltstone in a rock formation did indeed form in that specific sequence in time. Present day denudation and sedimentation proceses can also be well understood by the study of beach sands.

So, the next time you crunch the beach sands under your feet, give a moment's reflection to the immense utilities of these fragments in discreetly furthering our knowledge of the complex workings of mother Earth.

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