publications (the references run to 315) and present them in a readable form. This work will be of great interest to researchers as well as professionals working in the field of marine geology. The write-up is available for consultation in the library of the Geological Society of India.

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CONTROLS ON FORMATION OF BEACH SAND DEPOSITS ALONG ANDHRA PRADESH COAST: A STUDY ON HEAVY MINERAL DISTRIBUTION PATTERN, SIZE CHARACTERISTICS, SOME BENEFICIATION PROBLEMS AND COASTAL ZONE MANAGEMENT PLAN*

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EXTENDED ABSTRACT

The coast of Andhra Pradesh extending over 900 km length exposes varied compositional suite of heavy minerals. Formation of the sizeable economically viable heavy mineral deposits along the coast are principally controlled by the presence of a suite of suitable rocks in the hinterland, existing drainage, climate, coastal processes and geomorphic features favourable for sediment deposition. Although the provenance is a key factor for contributing substantial amount of heavy minerals, the climate plays a vital role in releasing the heavy minerals from the source rocks. Many beach placer deposits of the world occur between the latitudes 30° S and 30° N. The ideal case is the alternate tropical to subtropical climate, which favours effective weathering processes. The transporting agents like rivers, streams, and wind carry the resistant minerals, quartz and heavy minerals to suitable depositional environment.

In case of coastal processes, the sorting of heavies takes place by wave action on foreshore. The bulk of sediment is carried away by long shore currents resulting in the formation of sandbars extending over several kilometers along the coast. Rock promontories, bay features, creeks etc. are more favourable sites for sediment deposition. The sea level oscillations and other coastal features like shape of coastline beach-slope control the sediment deposition and may give rise to better concentration of heavies. The marine transgression with low sediment-input allows rich concentration of heavies on beaches, where as dunes are affected. On the contrary, marine transgression with high-sediment causes the dispersal of heavy minerals in sand dunes, where as beaches are preserved. Marine regression with low or high sediment result in erosion of beaches and dunes are preserved. Thus, the mechanism of sediment

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deposition and heavy mineral concentration along beaches is controlled by various factors.

The coast of India extending over 6000 km exhibits variation in composition of heavy minerals from west to eastern seaboards. On the West Coast, pocket beaches of Maharashtra contain only ilmenite and magnetite. Malabar Coast shows low concentration of heavies containing mainly pyriboles, ilmenite, zircon, monazite and garnets. Further in the south, Kerala coast exhibits one of the richest grades of ore containing abundant ilmenite, zircon, monazite and rutile. On the East Coast along the Tamil Nadu coast, garnet sand deposits are being mined economically.

Wide variation in heavy mineral assemblages is distinctly observed along the 900 km long Andhra Pradesh coast. In the southern part, major rivers like Godavari and Krishna traverse through vast country rocks consisting of Deccan basalts, crystallines and Gondwana sediments. The coast of Nellore shows concentration of heavies at <2% and heavies increase gradually northward up to 20-40%, consisting of ilmenite (49%), magnetite (25%) and pyriboles (20%) with negligible garnets, zircon, monazite etc. Similar pattern continues up to Godavari River confluence. In the north, youthful rivers like Tandava, Gosthani, Champavathi, Nagavali, Vamsadhara and Mahendratanaya are controlled by lineaments and traverse across the Eastern Ghats consisting mainly of khondalite, leptynite and charnockite. Beaches of north Andhra coast contain uniform grade of 20% heavies, of which, ilmenite, garnet and sillimanite are abundant minerals with rutile, zircon, monazite as other minor minerals. The coast of Visakhapatnam shows 47% ilmenite, 21% garnet and 20% sillimanite. The abundance of garnet and sillimanite increases marginally in the northern continuity. The coast of Kalingapatnam shows 40% ilmenite, 24% garnet and 31% sillimanite. The other associated economic minerals like rutile, zircon, monazite contribute about 1-2% of the bulk composition with negligible pyriboles and magnetites. In some cases, the red beds adjoining the beaches forming badlands, contain heavy minerals up to 4%. Ilmenite is the principal mineral in red beds constituting 70% of the total heavies with negligible garnet (<1%).

In recent years, many flourishing mineral based industries including foreign enterprises like Trans World and Western Australia are showing keen interest in exploiting heavy minerals from beach and sand dune deposits of India. However, some teething problems are expected in recovering ilmenites from southern coast, as they are closely associated with pyriboles and magnetites. The size-mode of total heavies including pyriboles and magnetite is confined 150μ size. The removal of pyriboles from ore is a problem. The beaches of northern part of the Andhra Pradesh contain heavy minerals primarily ilmenite, garnet and sillimanite with other accessory minerals as rutile, zircon and monazite (0.04 - 1.0%, 0.02 - 0.08% and 0.02 - 0.04% by weight respectively). The size-mode of raw sand and total heavies are 212μ and 150-106μ respectively. Garnets show two size-modes 212μ and 150μ, and nearly 30% of garnet goes to 212-micron size fraction. Taking this factor into consideration, part of the garnet crop can be recovered at this pre-concentration stage. The interference of fine garnets during ilmenite recovery and upgradation of ilmenite chemical grade from 50% to above 70% TiO_2 are the present day problems in existing flow sheet operations.

Attempts were made to examine the recovery of heavies in pre-concentration methods by adopting simple gravity separation techniques followed by magnetic separation for recovery of garnets from ilmenites. Four type areas are taken for this study and it has been observed that coastal areas close to red beds (bad lands) contain 85% ilmenite and less garnet. Studies were conducted on another type area, which contains 7 to 9% garnets in total heavy minerals. Recovery of garnets at various magnetic fields shows recovery of garnet at 10,000 Gaus magnetic field and is effective with up to 70% recovery. By adopting the same flowsheet, recovery of sillimanite up to 86% is possible. Number of sizeable beach sand deposits are located along the northern coastal Andhra Pradesh. By setting up mobile preconcentration plants at various points, upgradation of heavies up to 98% can be achieved locally and the final product may be transported to mineral separation Plant at OSCOM, Chatrapur, located on the northern continuity of these sand deposits at about 150 km distance.

The coastal zone is a sensitive zone and is the source for a variety of living and non-living resources including heavy minerals. Coastal nations should integrate management policy, decision-making processes and maintain environments under their national jurisdiction. Government Policies and Acts should be enforced effectively to create awareness in public at different levels for proper utilization of coastal resources. At several places along the coast, dunes are levelled and large areas are encroached upon for townships, settlements and aquaculture resulting in a loss of mineral wealth. After all, minerals are a wasting asset and are non-renewable. Elsewhere in other countries, a single mineral-based industry has given employment opportunity to nearly 20,000 persons. Hence, the vast coastal stretch of Andhra Pradesh containing various resources may be judiciously exploited with minimal harm to the environment.