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A Study on Heavy Minerals Reserve and Separation Processes from Raw Beach Sands along the Coastal Belt of Bangladesh

Mohammad Islam Miah
Department of Petroleum and Mining Engineering
Chittagong University of Engineering and Technology, Chittagong-4349, Bangladesh
E-mail: islam_pme@yahoo.com, islam.pge20@gmail.com

Abstract

Bangladesh lies in the northeastern corner of the Indian subcontinent at the trend of the Bay of Bengal. A mineral is a naturally occurring homogeneous solid, inorganically formed with a definite chemical composition and ordered atomic arrangement. There are seventeen deposits areas (Cox's Bazar-Chittagong sea beaches, Nijhum Island & Kuakata) of *most prominent heavy mineral sands are discovered in the beaches along the coastal belt of Bangladesh till 1986. These minerals have been separated from beach sands using different gravity, magnetic and electrical separators in both laboratory and pilot plant. There are eight types of heavy minerals are found in these areas. Among them, major five economically extractable heavy minerals are Ilmenite, Rutile, Zircon, Garnet and Magnetite which have specific gravity: 3.5-5.18, hardness: 5-7.5, non-magnetic to strong magnetic, poor to good electrical conductivity and so on. In Bangladesh the total heavy minerals (major five) reserve is about 1.56 million tons which economic values large. These heavy minerals are more economical viable and can be used in different industries, nuclear power plants, meters and scientific apparatus, welding, rod coating and others. These minerals can be extracted and production by commercially to increase the national income.*

Keywords: *Bangladesh, Cox's Bazar, Heavy Minerals, Reserves and Economic Viable.*

1. Introduction

A non-renewable resource is a natural resource which cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate, once used there is no more remaining. Minerals are one kind of non-renewable resource which can be extracted by open cast mining method [1]. A mineral is a naturally occurring homogeneous solid, inorganically formed with a definite chemical composition and ordered atomic arrangement [2]. A sufficient mineral deposits formed by mechanical concentration of mineral particles from weathered debris. The mineral concentrated is usually a heavy mineral. There are two types of placer minerals are present as beach placer and alluvial placer. Beach placers are formed when the mechanical or chemical breakdown of rock (An aggregate of minerals) masses is followed by a redistribution of the material along a continental shelf. The movement of the sea gradually sorts the sediments, directing the finer materials into deep water and coarser materials towards the shore. The valuable minerals are gradually resistant to weathering and hence become concentrated. Long time upward warping of the coastal areas, Castaic's variations in sea level and the migration of wind-blown sands dune has converted some of these sediments to land information and consequently many beach placers occurs a considerable distance inland from the present coast line. However, some vital factors are bearing on the formation of economic deposits of heavy minerals. These are area of source rocks exposed to erosion, duration and severity of the erosion cycle, mineral content of the exposed rocks, climate, topography and location [4]. This paper shows delineate of physical properties of heavy minerals, total reserves and separation processes from raw beach sands along the coastal belt of Bangladesh.

2. History of Investigation

The mineral resources were first found in Cox's Bazar in 1960 and later Bangladesh Atomic Energy Commission started diverse researches. Investigation of heavy (radioactive) minerals like monazite by the erstwhile Geological Survey of Pakistan around the Cox's Bazar sea beach area started in 1961 and a number of precious heavy minerals were identified the same year. Geologists of the Pakistan Atomic Energy Commission carried out reconnaissance work in 1967 and found that the beach sand contains economically important heavy minerals. After systematic surveys during 1967 to 1969, it was recognized that a potential zone of heavy minerals exists along the entire coastal belt, mainly from Cox's Bazar to Badarmokam, and in some areas of Maheshkhali, Kutubdia and Matarbari islands. Later, in 1975, a pilot plant was installed at Kalatali, Cox's Bazar with the cooperation of the Australian Government to sample, separate and assesses the commercial viability of the heavy mineral content in the placer deposits. In this plant, a flow sheet adopted by the Australian Mineral Development Laboratory was used to separate heavy minerals. By 1985 the nearly 550 km-long

coastline of Bangladesh was surveyed either partially or completely to map the beach sand heavy minerals. It was found that the reserves were concentrated mainly along the sea beaches of Chittagong and Cox's Bazar districts. On the basis of surveys carried out so far along the coast of Bangladesh a number of heavy mineral placers are delineated. Systemic exploration works have been carried out from 1968 to present and evaluation works completed in 1986. These works finally resulted in the discovery of 17 deposits of minerals sands in the beaches along the coastal belt of Bangladesh. Fifteen deposits are in the Cox's Bazar-Chittagong sea beaches and nearby offshore island [7] (Figure 1). The minerals are scattered in an area of 7,986 hectares of land in Cox's Bazar district, located in the eastern end of the 500 km sea beach [8].

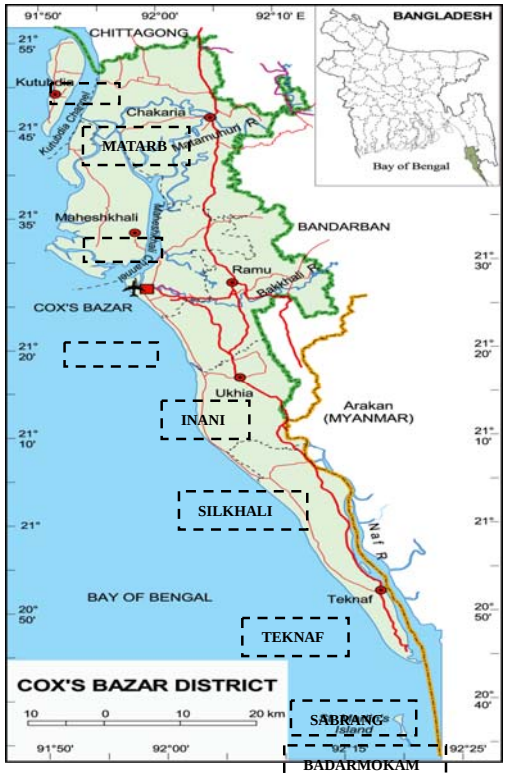

Fig. 1: Location map of heavy minerals deposits in Bangladesh (Source: Banglapedia, 2013)

3. Separation Process and Flow Charts

Heavy minerals are extracted from sea beach sands by open pit mining method using different types of equipments. Generally, mechanical and electrical equipments have been used in heavy minerals separation in Quality Control Laboratory. These are mainly tow major types as major equipments e.g. shaking table (Figure 2), Induced Roll Magnetic Separator, IRMS (Figure 3a & 3b), Electrostatic Plate Separator (ESPS) and High Tension Roll Separator (HTRS) and

Fig. 2: Shaking separator in wet process, Fig. 3a: IRMS Fig. 3b: Magnetic & None magnetic separation process.

minor equipments e.g. pressure filter, gas burner and permanent hand magnet. On the other hand, there are three types

separators are mainly used in laboratory and pilot plant. These are gravity separator (i.e. screw classifier, Wifley table, Vibro screen, air table, spiral, dewatering cone and hydro cyclone), magnetic separators (i.e. Low Intensity Magnetic Separator (LIMS), Wet High Intensity Magnetic Separator (WHIMS), IRMS and cross belt).

3.1 Working Flow Chart for Mineral Separation

In Bangladesh, generally two types of working flow chart have been developed from raw sand to desired heavy minerals at BSMEC. These are laboratory scale (small amount) mineral separation and large scale separation at pilot plant both dry and wet section. The raw sand has been collected from deposit of heavy mineral. Then heavy minerals have been separated successively by following as the below flow chart-1 [5&6].

In BSMEC pilot plant, raw sands collected from heavy mineral deposits are fed by Bobcat Loader into the Grizzly Feed Hopper (GFH) from where it reaches to the Trommel Screen Conveyer Belt. Water from bore pumps is mixed with the sand before the Trommel Screen to make slurry. Here the sands are screened out of oversize materials and thrash. It then enters into surge bin from where the slurry of sand and water is pumped through slurry pump and hoses to provide spiral concentration equipment for separation of heavy minerals components from light ones. In pilot plant separation process have been divided into sections, one is wet section and another is dry section. Both sections are shown in flow chart 2a and 2b [5,6&7].

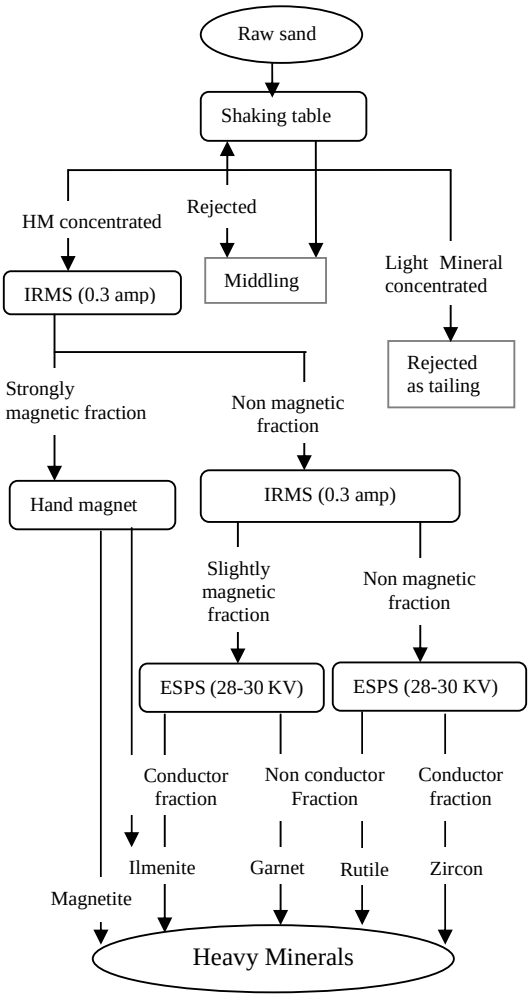

Fig. 4: Flow chart-1 for laboratory scale of heavy mineral separation

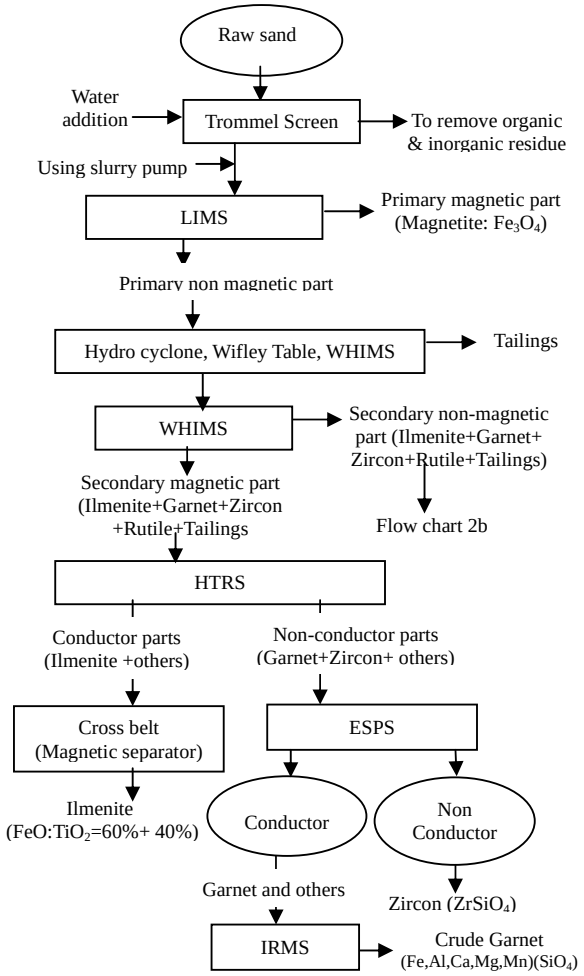

Fig. 5: Flow chart-2a for heavy minerals separation in pilot plant at BSMEC, Cox's Bazar.

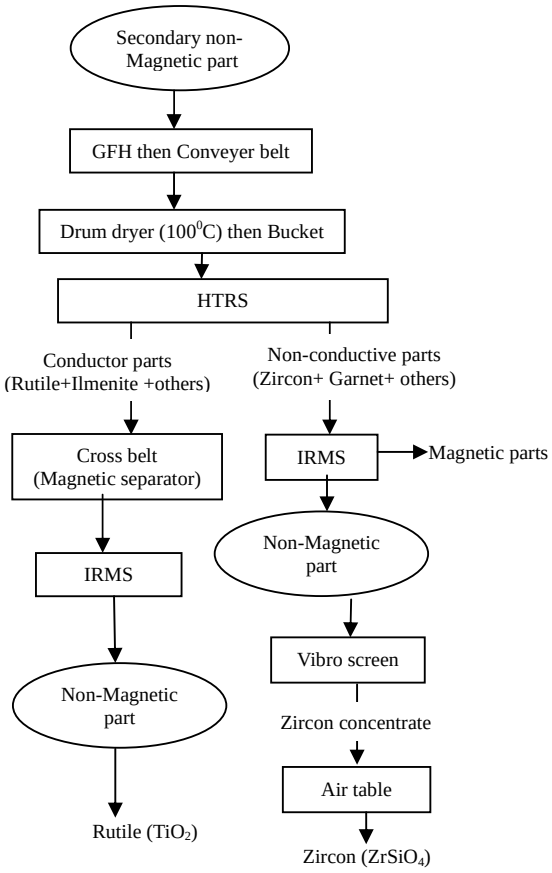

Fig. 6: Flow chart-2b for Rutile and Zircon minerals separation from secondary non magnetic part in pilot plant (dry section) at BSME, Cox's Bazar.

4. Physical Properties of Heavy Mineral of Studied Area

Those minerals which have specific gravity more than 2.88 are called heavy minerals. The physical properties of heavy minerals are specific gravity, hardness, crystal system, color, magnetic and electric property and radioactivity, etc. Specific gravity (Sp. gr.) is the ratio of the mass of unit volume of sand (soil) at a stated temperature to the mass of the equal volume of the air free distilled water at same temperature. Summarized physical properties [3, 5 & 6] of five heavy minerals (major) have been shown as tabulated form in Table 1. The major eight heavy minerals are present in the coastal belt of Bangladesh. Among minerals, Monazite and Zircon are well defined and slightly radioactive.

Table 1: Physical properties of Heavy Minerals

Properties	Magnetite	Ilmenite	Rutile	Zircon	Garnet
Sp. gr.	5.2	4.7	5	4.7	4.3
Hardness	6	5.5	6.5	7.5	7.5
Crystal system	Cubic	Hexagonal	Tetragonal	Tetragonal	Cubic
Color	Black	Black to grey	Pinkish red	Reddish brown	Less to pink
Magnetic property	Strong Magnetic	Moderate	Weak	Non	Non
Electrical property	Good conductor	Good	Non	Moderate	Non

5. Reserves and Discussions

All the seventeen deposits named as Badarmokam, Sabrang, Silkhali Teknaf, Inani, Cox's Bazar, Moheshkhali Foreshore Beach, Honak, Panirchara, Baraghoriapara, Fakirahata, Fakiraghona, Kutubgum, (Seven from Maheshkhali Island), Matarbari, Kutubdia and Nijhum islands, and Kuakata which consist of 20.496 million tons of raw sand which contains 4.355 million tons of heavy minerals (sp. gr. >2.88) [3&7]. Only eight types of economically important heavy minerals named as Zircon, Rutile, Ilmenite, Garnet, Magnetite, Leucoxene, Kyanite and Monazite occur in these deposits. The total stock of these eight types of heavy minerals in these seventeen deposits is 1.761 million tons where major five minerals (Zircon, Rutile, Ilmenite, Garnet & Magnetite) and other minor three (Monazite, Kayanite & Leucoxene) reserves are found as 1.557 and 0.204 million tons, respectively. On the other hand, light minerals reserve is 2.593 million tons which has specific gravity about less than 2.9. Total reserves of raw sands and heavy minerals have been listed [3&6] in Table 2. Graphically representation of minerals reserve versus heavy mineral bearing area has been shown in Figure 7 and 8.

Table 2: Total heavy mineral resource in Bangladesh

Name of Deposited Place	Reserve of Raw Sands (tons)	Total Minerals Reserve (tons)	Reserve of Eight Heavy Minerals (tons)
Cox's Bazar	5119000	920000	286764
Maheshkhali Island	4114230	784210	418328
Kuakata	2872486	831668	172657
Shilkhali	2756828	489714	279506
Teknaf	1939580	442291	272235
Badarmokam	1765000	411000	134959
Inani	729286	175476	89249
Kutubdia Island	404646	120000	44412
Nijum Island	379337	96348	22463
Sabrang	347558	68582	33907
Matabari Island	69030	15215	7020
Total	20,496,981	4,354,504	1,761,000

According to analysis, about 22% heavy minerals are present within total raw sand in 17 deposits places. Highest and lowest heavy mineral reserves are 4.489% and 0.074% in Cox's Bazar and Matabari area, respectively. Others heavy minerals deposit areas are stand of 4.06-0.33%. Ilmenite reserve is highest than the other heavy minerals. Remaining all heavy minerals is found in the aforementioned deposits area except garnet mineral in the Matarbari and Badarmokam. Correspondingly, a fractional distribution of total minerals and 8 identified heavy minerals reserve is shown in Figure 9 and 10. Among total minerals reserve, light minerals and commercial major five heavy minerals are 59 and 36 percent, respectively. On the other hand, Ilmenite is 23% and other minerals ranges from 5 to 2 percent or less. But Ilmenite, Garnet, Zircon, Magnetite & Rutile reserve are 58, 13, 9, 5 & 4 percent but other three heavy minerals is 11% within eight heavy minerals reserve. Economical feasibility of the heavy mineral deposits depended on the utilization of heavy minerals. These heavy minerals are more economical viable and already used in sectors.

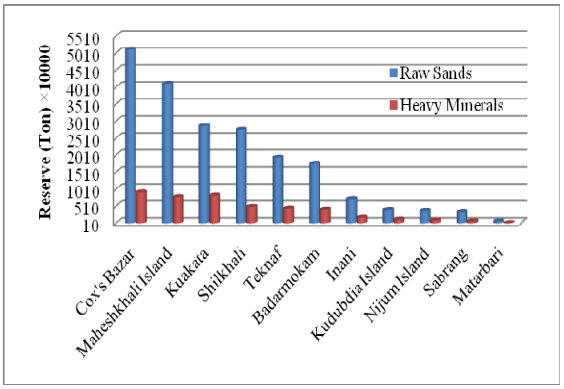

Fig. 7: Reserve vs. Heavy minerals deposited area

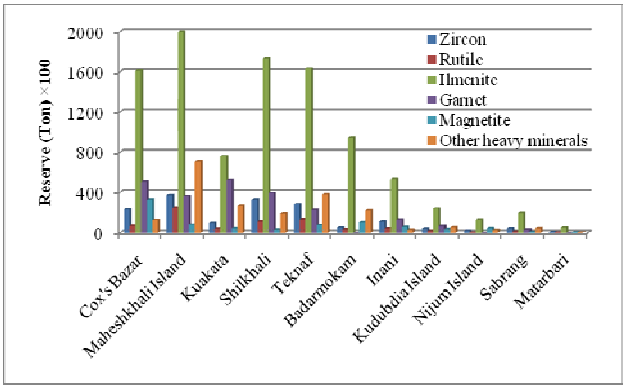

Fig. 8: Economical minerals reserve vs. deposited area

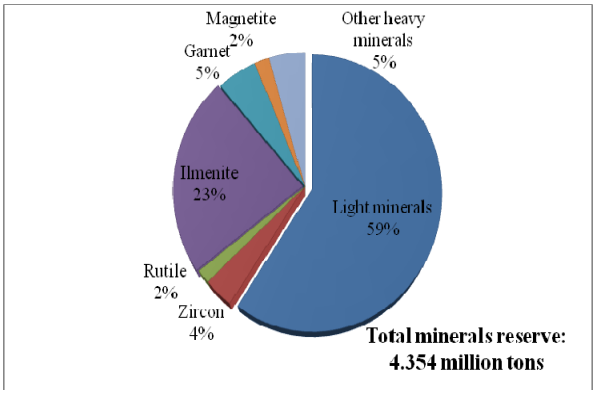

Fig. 9: Fractional distribution of total minerals reserve

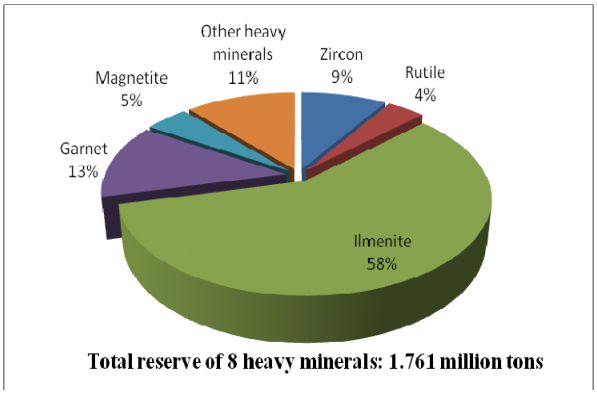

Fig. 10: Fractional distribution of eight heavy minerals

About 60% of all Zircon is used in foundry facing works, while 15% is consumed in the manufacture of zirconium metal, alloys and chemicals [6]. Rutile is used as raw material in the pigment industry, welding rod coating, leather dressing & finishing, and as a source of Ti metal. The industry consumes about 66% of the total Rutile production while 18% is used in welding rod coatings in this country. Ilmenite is a source of TiO_2 which is used chiefly as white pigment. It is extensively used in welding rod coatings and radiation shielding material. Titanium is used not only for building aircraft but also for brightening the color of paints and lifting coal from the mine [3]. One kilogram of titanium is now sold at 19,500 US dollars to 22,000 dollars in market. Mexico, India, North America and Australia are the main buyers of this mineral. It is possible to lift 1 million tons of Ilmenite from the coastal belt [8&9]. About 90% of the total Garnet production is used in the manufacture of emery cloth, paper, wheel and grinding stones. Magnetite used chiefly as a source of pig iron which is the primary material for the production of cast iron, wrought iron, malleable iron and the many varieties of ordinary and special steels. Monazite is a source of rare-earth metals and thorium. Leucoxene is being used as a substitute for Rutile with the increasing demand of TiO_2 material. Ilmenite, Leucoxene and Rutile are important because they contain some of the highest concentrations of titanium. Kyanite serves as a source of Aluminum. It is extensively used in the manufacture of refractory and foundry products. The utilization of heavy minerals is increasing day by causes for different uses in the world. The economic value has about 273.17 million USD based on world market price rate (USD/ton) of major five heavy mineral reserve as 1.56 million tons [3&7].

6. Conclusions

Heavy minerals have been found as beach sand heavy mineral placer deposits on the Cox's Bazar-Chittagong sea beaches, Nijhum Island & Kuakata along the coastal belt of Bangladesh. In these deposited areas, total heavy mineral reserve is 4.355 million tons. These heavy minerals are more economical viable and can be used in different industries, nuclear power plants, meters and scientific apparatus, welding rod coating, etc. These minerals can be extracted and large scale production by commercially to increase the national income. Yet the beach is allowed to lift the minerals, it will hurt the tourism and the biodiversity as well but it will open up a new vista of rapid economic development of this country. Proper exploitation of mineral resources will also generate employment opportunities in the field of research and other sectors. Government should take necessary steps to manage these resources and proper utilizations.

7. References

[1] Imam, B., "Energy Resources of Bangladesh", First Edition, UGC Publication No. 89, Bangladesh, pp. 280, 2005.
[2] B. A. Wills and T. J. Napier-Mum, "Wills' Mineral Processing Technology", Elsevier Science & Technology Books, pp. 421, 2006
[3] Badrul Imam, "Mineral Resources of Bangladesh (In Bangla)", Bangla Academi, Dhaka, pp. 159, 1996.
[4] M. Z. Kabir, "Exploration and Exploitation of Beach Placer Minerals" BSMEC, Cox's Bazar, (Report), pp. 1-10.
[5] S. M. Rana, Technique of laboratory scale heavy minela separation from raw sand and flow chart development (Report), BSMEC, Cox's Bazar. p. 1-18.
[6] M. M. Zaman, Economic heavy mineral and their exploration, identification techniques in laboratory and Pilot Plant at BSMEC, Cox's Bazar (Report), pp. 1-22.
[7] Jain, S. K., "Mineral Processing", CBS Publishers, Second Edition, pp. 518, 2011.
[8] http://www.dhakatwitter.com/2010/01/bangladesh-finds-8-potential-heavy-minerals-in-sea-beach-sand/#more-661 (Date of access 12/06/13)
[9] http://www.zimbio.com/Bangladesh/articles/HCfxx3ta0cn/Country+can+earn+forex+exporting+minerals (Date of access 12/06/13)