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Research article

Heavy Mineral Potentiality and alteration studies for Ilmenite in Astaranga Beach sands, Dist-Puri, Odisha, India

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Abstract

Fifteen beach samples were collected from a depth of 1mt at different locations of the Astaranga beach, Puri with at an interval of 300 mts. The sand samples were studied for heavy mineral concentration at different location points and were subjected to scanning electron microscope studies for the mineral Ilmenite. The percentage of total heavy mineral in Astaranga beach varies from 16.42% to 24.47%. The important minerals are Ilmenite, Rutile, Zircon, Sillimanite, Garnet, Monazite, Pyroxene and others. For all samples a set of sieves bearing ASTM nos. 30,40,60,80,100,120,140,170 and 200 were used to separate different size fractions. The sieve apparatures varies from 0.59mm to 0.74mm. It was observed that maximum concentration of heavies was confined to +200 ASTM sieve or 0.74mm. The total average heavy mineral concentration and light mineral concentration was found to be 20.07% and 79.49% respectively. The concentration percentage of different heavy minerals varied from higher to lower in the order , Ilmenite, Zircon, Sillimanite, Garnet, Rutile, Pyroxene, Monazite and others. The Ilmenite mineral in this area is found to have altered to secondary phases like Pseudorutile, Leucoxene and Rutile along the fractures, cavities and grain boundaries. The alteration condition was observed as streaks, irregular patches, bands, and rim like structures around the Ilmenite grains. Detailed study of alteration in Ilmenite was carried out by Energy Dispersive Spectrometer (EDS) attached to Scanning Electron Microscope. The potentialities of heavies found at different locations of the Astaranga beach suggest a good source for the exploration.

Keywords: Alteration. Heavy minerals, Ilmenite , Total heavies, Total lights, Weight percentage

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1. Introduction

The State Odisha is endowed with a long stretch of coast line for a length of 480 km and the total extension of India's coast line is about 6500 km. Most part of the coast line of India and Odisha is blessed with various types of placer deposits known as heavy minerals. Heavy mineral deposits are mostly found in the states like Kerala, Tamil Nadu, Odisha and Andhra Pradesh. The placer deposits of Chavara in Kerala, Manavalakurichi in Tamil Nadu and Chhatrapur in Odisha are under active exploration by IREL (Indian Rare Earth Ltd.) of Govt. of India and Chhatrapur deposit under the aegis of IREL is named as OSCOM (Odisha Sand Complex).

Beach placer deposits are considered as a major source of economic mineral deposit formed by sedimentary processes. Their easy availability and low cost mining gives good profit to the country. Odisha is a huge reserve of about 116 million tones and Chhatrapur deposit itself has a reserve of 62.06 million tones (Padhi and Mishra, 2006)[1]. Besides Chhatrapur deposit, the other localities are Ramayapatna, Markandi, Mayurpada, Niladripur, Paluru, Malud, Astaranga and Ersama are good locations for heavy mineral exploitation. Astaranga and Ersama are located to the north and south side of the Devi river confluence with the Bay of Bengal (Fig.1).The Eastern Ghats Mobile Belt consisting of Charnockite, Khondalite, Migmatite, Granite, Gneiss etc acts as the provenance for the coastal placer deposits of the southern coast of Odisha (Bhattacharya and Sengupta,(1994)[2]; Dwivedy (1995[3] Mohanty et.al., (2004) [4]and P.Behera, (2003)[5]. Geochemical characteristics of ilmenite sands of Chhatrapur beach placer deposits of Odisha, India was studied by PIXE and ERXRF methods by A.K.Mohanty et al.(2003)[6]. They found TiO_2 within a range of 52.2 to 56.85 wt% .D.S Rao and D.Sengupta (2014)[7] studied the Ilmenite in the beach placer s of Chhatrapur beach, Odisha for texture, micromorphology and elemental composition.by XRD and Electronmicrope. They found that the ilmenites have been weathered by chemical and mechanical processes. The Tio_2 content was calculated as 50.25 to 55.41%. N.Surekha Rao and S.Mishra (2009) studied the sources of ilmenite, monazite, magnetite etc by Isodynamic Separator and XRD and concluded that the sources could be the rocks of Eastern Ghat Mobile Belt[8].

The purpose of the paper is to evaluate heavy mineral concentration found at different locations of the Astaranga beach and dunes where samples were collected from a depth of 1 mt. The paper also aims to study the individual heavy mineral distribution in different size fraction and the chemical characteristics of Ilmenite and its alteration products. This study will definitely focus on the potentiality aspect as well as the suitable beneficiation process for the heavies.

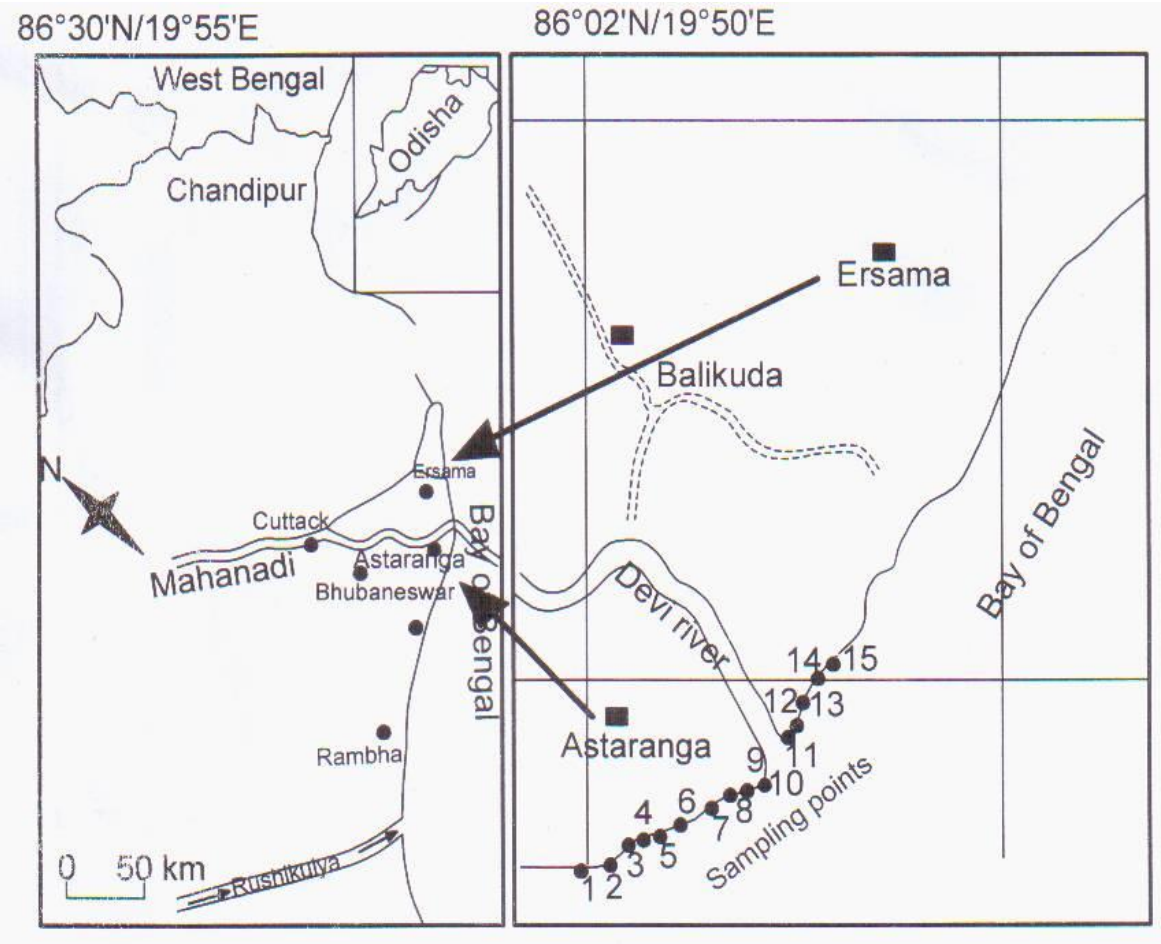

Fig.1: Location map of Astaranga beach, Puri district, Odisha showing sampling points

2. Materials and Methods

Fifteen beach sand samples were collected from the Astaranga beach by using a hand operated sand auger. The distance between two locations was 300 mt and the samples were collected from a depth of 1 mt. The samples were brought to the laboratory, dried and thoroughly mixed. Each sample was reduced to 100 gms by coning and quartering processes. The samples were treated with dilute HCL to remove shell materials followed by repeated washing with water to remove the ultra fine clays. The samples were then sieved with ASTM sieve numbering 30,40,60,80,100,120,140,170,200. After the sieving each fraction of the sample was put in a heavy liquid Bromoform (sp.gr-2.89) and the total heavy mineral concentration was calculated. The heavy mineral fractions were taken to prepare the slides for the study under the microscope. Minimum 300 grains were calculated and then number percentage was determined. The number percent of each of the heavy minerals was multiplied with their respective specific gravity values and the wt% of the individual member was calculated.

Results obtained were recorded in a tabular form. The location map of the sample points is shown in Fig.1 and the values of the average no% and average wt% is shown in Table 1.

Table 1: Calculation of wt% of heavy minerals of Astaranga Beach (average values for all)

Sl. No.	Name of the Mineral	No%	Sp. Gravity	No% x Sp. Gravity	Wt%
1	Ilmenite	47.16	4.67	220.23	51.05
2	Rutile	6.44	4.1	26.4	6.12
3	Zircon	16.25	4.68	76.05	17.63
4	Sillimanite	13.37	3.24	43.31	10.04
5	Garnet	10.45	4.0	41.8	9.69
6	Monazite	0.83	5.1	4.23	0.98
7	Pyroxene	3.7	3.6	13.32	3.08
8	Others	1.71	3.5	5.98	1.38

Results and discussion

1.1 Total heavy minerals (THM) in bulk samples and heavy minerals (HM) in size fractions

The total heavy mineral percentage has been calculated for different samples collected at different locations. The percentage of light fractions and heavy fractions have been shown by bar diagram (Fig 2).

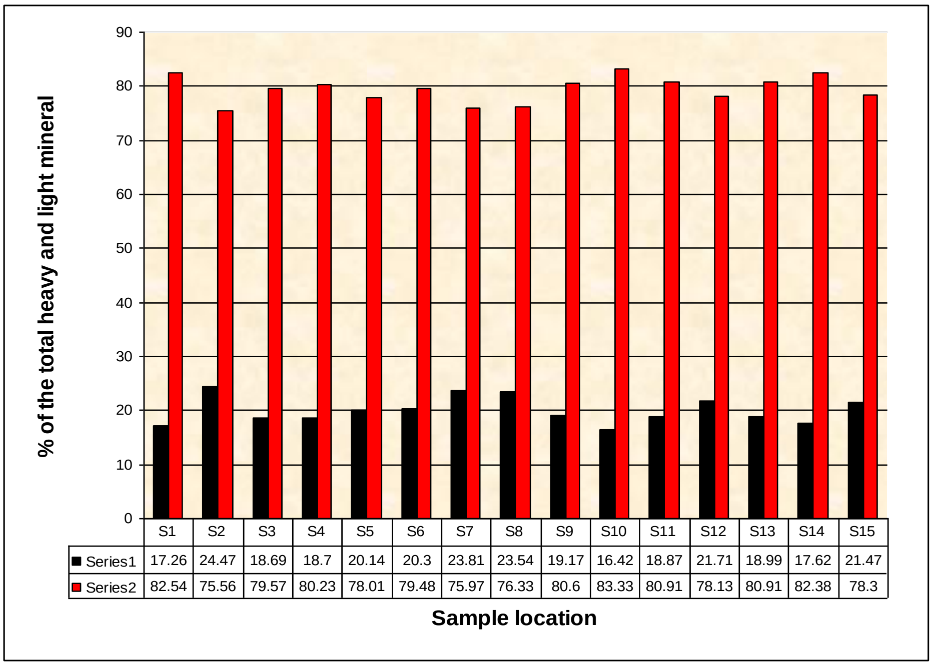

Fig. 2: The total heavy mineral (THM) concentration and light fraction for the individual

At Location-1 the heavy mineral % is 17.26 and Light Mineral is 82.54% similarly in Location-2 the heavy mineral % is 24.47 and light mineral is 75.56%, in location-3 the heavy mineral % is 18.69 and light mineral is 79.77%, in location-4 the heavy mineral % is 18.7 and light mineral is 80.23%, in location-5 the heavy mineral % is 20.14 and lighter mineral is 78.01%: The heavy mineral and lighter mineral percentage of 15 locations are represented in Fig.2. Out of the 15 locations the heavy mineral % is highest in location No.-2 and lowest in location No-10.

The results of wt% has been shown in Table-1. The wt% of Ilmenite is highest i.e. 51.05 then it is followed by Ziron (17.63%) Sillimanite (10.04%), Garnet (9.69%), Rutile (6.12%), Pyroxene (3.08%), Others (1.38%), Monazite (0.98%).

Black-- Heavy

Light-- Red

3.2 Individual concentration of heavies in different size fractions and in total samples

Fifteen samples were taken for determination of different heavy mineral species. The dominant heavy minerals indentified are Ilmenite, Zircon, Sillimanite, Garnet, Rutile, Pyroxenes and Monazites. Amongst the heavy minerals Ilmenite, Zircon, Sillimanite, Garnet Rutile constitute the major percentages. The number percentage and weight percentage of Ilmenite is highest in Astaranga beach and the no% and wt% of Monazite is lowest in that beach. In all the samples Ilmenite percentage in the THM are high to very high in 120 to 200 ASTM sieve. The data suggest that Ilmenite is finer grained compared to Garnet and

Sillimanite. Garnet and Sillimanite are predominantly concentrated in coarse sizes. Zircon and Monazite are concentrated below 120 ASTM sieve.

3.3 Mineralogy

Garnets are mainly represented by almandine and pyrope. Garnet is mostly sub rounded and sub angular, buff to brown colour with conchoidal fracture. Inclusions are noted within Garnet. Sillimanite is tabular, rectangular and square like and sometimes stained by iron hydrooxides. Monazite grains are rounded to elliptical, where as Zircon grains are generally elongated with edges. Some of the Zircon grains are rounded to sub rounded indicating long distance transport. Inclusions of Ilmenite, Quartz and Monazite are observed in Zircon grains, Rutile grains are tabular. Ilmenite grains are tabular, sub rounded and show complex internal structure. They vary from pure Ilmenite (without any inclusions and alteration parts) to impure varieties containing exsolution lamellae of Hematite and complex alteration products. The Ilmenite grains are sparsely altered. Microscopic studies under reflected light reveal exsolution bands, lamellae, blebs, spots of Hematite in Ilmenite grains. The linear cavities indicate leaching of Hematite lamellae from Ilmenite. Hematite also contains exsolution laths and streaks of Ilmenite. Ilmenite grains in some cases have altered to pseudoilmenite, pseudorutile, leucoxene/rutile along fracture, margins, cavities and structural weak planes.

3.4 Mineral chemistry of Ilmenite and its alteration products

Ilmenites alteration product leucoxene is highly enriched in titanium (TiO_2=81.01-96.84%) and depleted in iron (FeO(t) = 1.12-16.81%) contents. Silica (SiO_2) and Alumina (Al_2O_3) contents in leucoxene phase vary between

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0.00-8.13 % and 0.00-9.26%. In Pseudorutile phase the FeO (t) and TiO_2 percents are significantly higher and lower than leucoxene phase and vary between 31.13 to 41.04 and 57.96 to 64.13 respectively. Several authors have studied the alteration characteristics of placer Ilmenite grains from India and abroad (Frost et al, 1983[9]; Chernet, 1999[10]; The chemistry of alteration is controlled by processes such as (a) simultaneous leaching and oxidation of ferrous iron from Ilmenite to form Pseudoilmenite and Pseudorutile and (b) subsequent leaching of iron during the transformation of pseudorutile to leucoxene. The latter process is also associated with hydrolysation. Frost et.al (1983)[9] noted that Alumina and Silica were introduced to the altered phases of Ilmenite from the existing environment during alteration process. The reactions for transformation of Ilmenite to Pseudorutile and Leucoxene phases are as follows (Frost et.al 1983)[9]

$$6FeTiO_3(\text{Ilmenite})+1.5O_2+3H_2o \qquad 2Fe_2Ti_3O_9(\text{Pseudorutile})+2Fe(OH)_3$$

$$Fe_2Ti_3O_9\,(\text{Pseudorutile}) + 3H_2O \qquad 3TiO_2\,(\text{Leucoxene or rutile}) + 2Fe(OH)_3$$

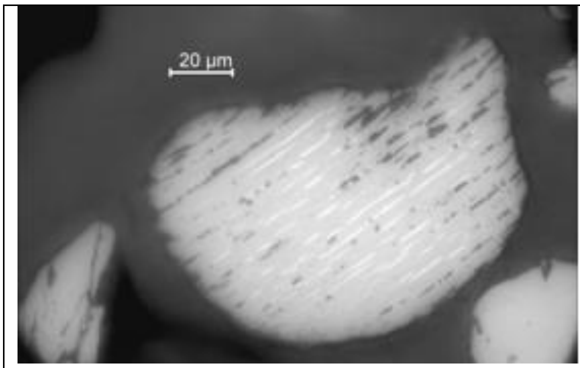

Fig. 3: Fine exsolution lamellae of iron ore hematite in ilmenite grain at Astaranga, Puri

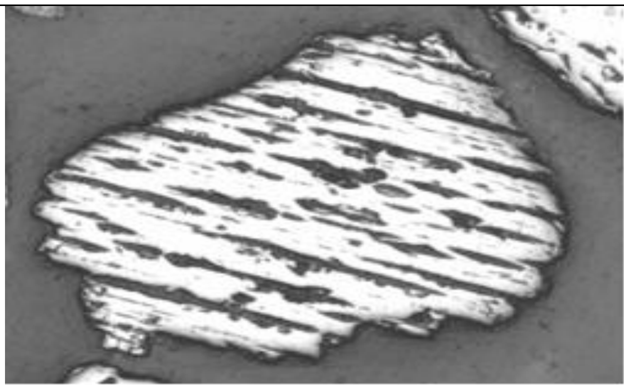

Fig. 4: Parallel arrangements of linear pits within ilmenite grain. Astaranga

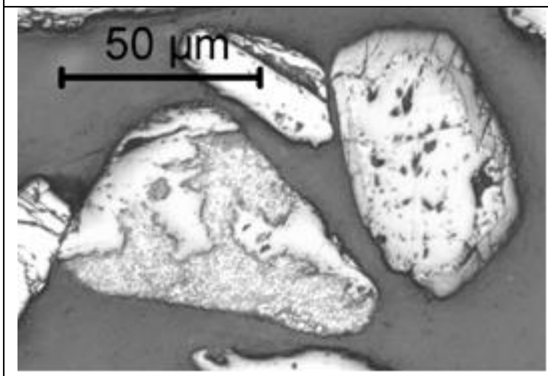

Fig. 5: Leucoxene as irregular patch and as partial rim around ilmenite grains, Astarang Puri

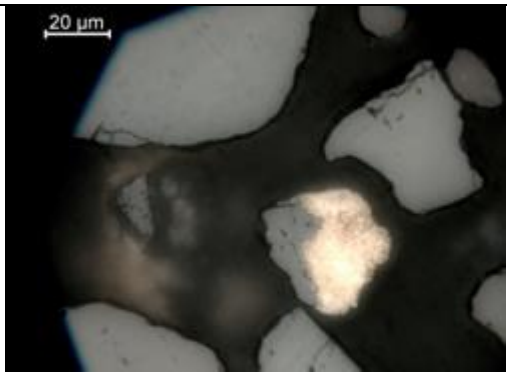

Fig.6: Leucoxene showing strong internal reflection. under crossed nicols. Astarang, Puri

In the Fig 3, Ilmenite shows exsolution effects of iron ore hematite, in Fig 4 paraallel linear pits are found on the body of Ilmenite, in Fig 5, leucoxeneis found as irregular patches and as partial rim like structures around ilmenite grains and in Fig 6, leucoxene shows strong internal refection under cross nicols and appeared bright.

4. Conclusion

1. The heavy minerals of Astaranga beach are predominantly composed of Ilmenite, Garnet, Sillimanite, Rutile, Zircon, Pyroxene and Monazite.

2.The total heavy mineral percentage varies from 16.42% to 24.47%. The average heavy mineral concentration is 20.07%.

3. The heavy minerals are mostly concentrated between 120 to 200 ASTM sieves i.e. in the size fraction of 0.59mm to o,74mm..

4. Ilmenite is finer grained compared to Garnet and Sillimanite, Rutile and predominantly occur below 120 ASTM sieve. Ilmenite constitutes 51.05% (wt%) of total heavy minerals of Astaranga beach. Ilmenite is partly altered to Pseudorutile and Leucoxene which occur as fine to coarse irregular patches, blebs, streaks, laths, veins and rims.

5. Maximum concentration of heavies are found in + 200 ASTM sieve.

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