Geological approach for placer mineral exploration in Eastern coast of Sri Lanka - A case study

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Abstract

The present offshore placer mineral survey deals with exploration beyond the identified placer mineral deposit in Pulmoddai. The study area extends from Nilaveli to Kokilai, off Northeastern coast of Sri Lanka. Beach and offshore sediments occur as fine to medium sand and sandy silt, moderately to poorly sorted and negatively skewed modes.

Heavy mineral percentage makes up about 4.9% of the deposit and is mainly composed of ilmenite, zircon and rutile. There is a considerable concentration of heavy mineral, 43.9% and 10.6% at Arisimalai Point and the Yan Oya mouth area respectively. Heavy mineral potential is estimated at 735,000 m^3 based on the assumption of equal distribution throughout the area. Though few locations indicated considerable concentrations, heavy mineral concentration is not economically feasible for exploitation at available technology.

Keywords: Heavy minerals, Sediments, Deposits, Concentration

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Introduction

Placer deposits, black sand is an important economic deposit with high resistivity and specific gravity, formed by processes of mechanical concentration due to weathering, transportation and deposition in suitable locations. In Sri Lanka, a well-known occurrence of monazite deposit in Southwestern coast is reported by Wickremeratne (1986).

Sri Lanka is a coastal country where large number of exploitable placer mineral deposits lie along the beaches as well as in nearshore area. According to Cooray (1984) heavy mineral deposits occur along the Sri Lankan coastal stretch since prehistoric times. He also reports that the deposits at Pulmodai on East coast and Beruwala on West coast as the major deposits around Sri Lanka. Those at Trincomalee, Kaikawala, Induruwa, Kelani river, Negombo North and Kudremalai are minor deposits. Heavy mineral concentrations of garnet sands occur along the Southern coastlines at Ussangoda, Kirinda and Hambantota areas.

Pulmodai placer mineral deposit is a world famous deposit, lying along the coastal stretch from Nilaveli to mouth of the Kokilai Lagoon. It has been exploited economically since 1958 to extract ilmenite, rutile and zircon. The deposit extends along the beach for 7.2 km with an average width of 50 m and a maximum width of 250 m. It covers an area of 3.2 km^2 and has an even thickness of 6 m over Precambrian crystalline rock with no overburden. The deposit is very high grade, with a heavy mineral content of 80% and a composition of 70-72% ilmenite, 8-10% zircon, 8% rutile, 1% sillimanite and 0.3% monazite. In the Southwestern coast of Sri Lanka, monazite bearing heavy mineral sands occurs as 4 to 13% concentration, while monazite concentration varies from 0.3 to 2.8% of total heavies (Wickremeratne, 1986).

The current investigation was conducted from Nilaveli to Kokilai along the beach to offshore area (Fig. 1). However, the exploration survey was carried out to explore beyond the identified placer mineral deposit in Pulmodai. The total area covered was 35 km^2 during this investigation and surveyed towards to 30 m water depth. The field investigations for bottom sediment sampling were completed within a period of 15 days and another 15 days taken for laboratory analysis.

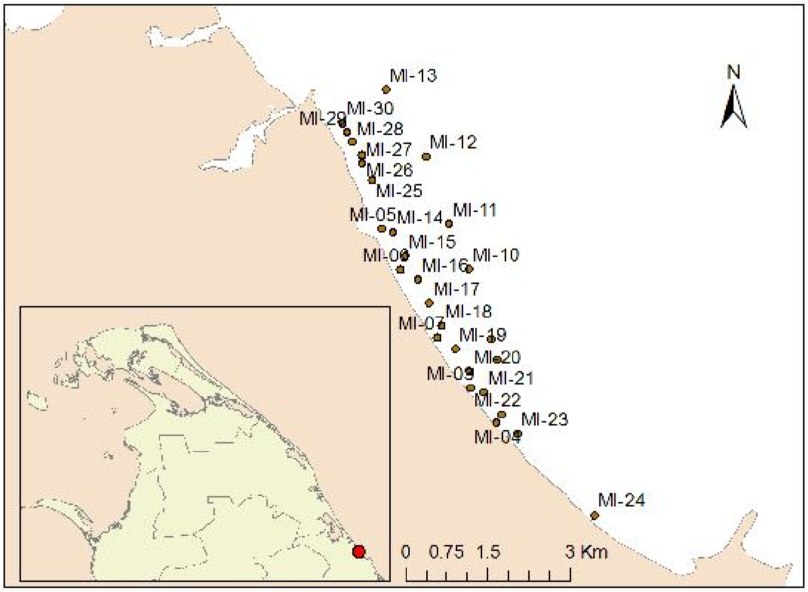

Fig. 1. Sample locations

Materials and Methods

Sediment samples were collected from Nilaveli to Kokilai. In total, sixty two samples were collected along the beach as well as the offshore area. The samples were collected using manually operated grab sampler. The locations of sediment samples were selected in a random manner based on field observations. The positions were fixed by hand held Global Positioning System (GPS) and sampling depths were measured using Bathy 1500 echo sounder with ±20 cm accuracy. Among the 62 samples, thirty samples, including beach and offshore samples were selected based on visual observations for sieving. Samples were washed and dried, and representative portions of samples were analyzed for grain size distribution. Three portions from each sample were analyzed following similar procedure and averaged to get more precise data. Grain size parameters were calculated using cumulative curves (Folk & Ward, 1957).

The grain size fractions of 0.125 and 0.250 mm were further analysed for heavy mineral. Samples with organic and inorganic carbonates were digested and removed by Hydrogen Peroxide (H_2O_2) and Hydrochloric acid (HCl). Later, heavy minerals were segregated using heavy liquid method (Bromoform of specific gravity 2.89). Further, individual minerals were identified by microscopic analysis and the percentage in the bulk sample was calculated. The distribution patterns of mean grain size, carbonate and heavy mineral concentrations are drawn.

Statistical parameters were calculated using following to formulas defined by Folk and Ward (1957).

$$Mean = \frac{(\phi_{16} + \phi_{50} + \phi_{84})}{3} \quad (a)$$

$$Sorting = \frac{(\phi_{16} + \phi_{84})}{4} + \frac{(\phi_{95} - \phi_{5})}{6.6} \quad (b)$$

$$Skewness = \frac{(\phi_{16} + \phi_{84} - 2\phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{(\phi_{5} + \phi_{95} - 2\phi_{50})}{2(\phi_{95} - \phi_{5})} \quad (c)$$

$$Kurtosis = \frac{(\phi_{95} - \phi_{5})}{2.44(\phi_{75} - \phi_{25})} \quad (d)$$

Results and Discussions

Table 1. Statistical parameters of the sediments in study area

Sample ID	Mean	Sorting	Skewness	Kurtosis
MI-1	3.30	0.42	-0.25	0.67
MI-2	2.86	0.65	-0.02	0.91
MI-3	3.28	0.46	-0.34	0.76
MI-4	3.08	0.58	-0.08	0.87
MI-5	2.96	0.63	-0.03	0.92
MI-6	3.29	0.44	-0.30	0.69
MI-7	3.17	0.56	-0.23	0.83
MI-8	3.34	0.47	-0.14	0.87
MI-9	3.29	0.52	-0.09	0.83
MI-10	0.80	1.13	0.17	1.33
MI-11	1.61	1.89	0.11	0.68
MI-12	3.38	0.69	-0.32	1.63
MI-13	0.20	-1.63	0.00	-4.32
MI-14	1.45	0.56	-0.28	0.98
MI-15	1.23	0.69	-0.02	0.91
MI16	1.33	0.59	-0.08	0.96
MI-17	1.13	0.90	0.19	1.78
MI18	1.42	0.59	-0.20	1.36
MI-19	1.62	0.64	-0.04	1.17
MI-20	1.34	0.65	-0.13	1.06
MI-21	1.75	0.90	-0.29	2.09
MI-22	1.72	0.65	-0.06	1.31
MI-23	0.93	1.71	-0.47	2.12
MI-24	1.84	0.69	-0.90	0.85
MI-25	1.76	0.77	-0.18	1.82
MI-26	2.07	0.19	0.92	-1.49
MI-27	1.44	1.23	0.18	0.65
MI-28	2.14	0.80	-0.14	0.97
MI-29	2.35	0.86	-0.20	1.15
MI-30	0.22	1.35	-0.32	0.55

The mean grain size of the bottom sediments varied between 0.22 and 3.29 Φ with an average of 2.0 Φ. Medium grain sand represents the majority of the survey area which equal to the 50% of the total samples (Fig. 2a). Percentages of fine and coarse grained sediments were 43 and 7% respectively.

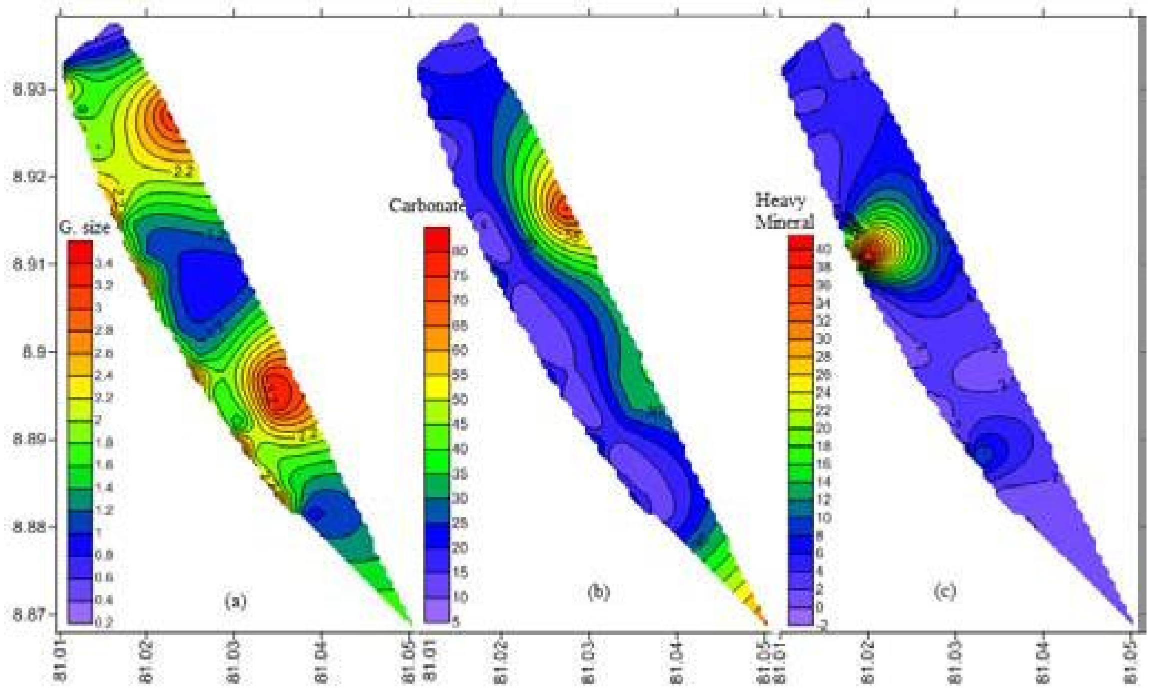

Fig. 2a. Grain size, **2b**. Carbonate and **2c.** Heavy mineral distribution

According to Folk and Ward (1957) nomenclature for sorting, 47% of the samples is moderately well, 17% poorly, 17% moderately, 16% well sorted and 3% very well sorted (Table. 1). Sorting of the sediments depends on the grain size. The moderately sorted sediments are of medium to fine sand. The poorly sorted sediments are medium to coarse sand while the moderately well and well sorted sediments are fine to very fine sand. The majority of sediments, i.e. 84% are negatively skewed (Table. 1), indicating perhaps the removal of the finer grains by the action of the high energy waves. The majority of samples contained considerable amounts of biogenic carbonates with an average value of 22.01% (Fig. 2b).

The distribution of heavy minerals in the samples varied between 0.01- 49.93% with 63% samples containing 3.5% only, which is less than the expected concentration level (Fig. 2c). The heavy minerals are mainly consists of ilmenite, zircon, and rutile. Ilmenite is the main contributor to the heavy minerals with the percentages from 58 to 62 in total heavy fraction. Rutile varied from 8 to 12%, while zircon varies from 4 to 6 % of total heavy mineral. The total area surveyed during this study is about 15 million square meters and total placer mineral volume was estimated assuming equal distribution of heavy mineral in one meter thick top most layers. The estimated volume of heavy mineral potential is 735,000 m^3.

Fig. 3. shows the comparison of heavy mineral and carbonate concentration in same samples. Carbonate concentration was greater than heavy mineral concentration except one sample. Also, it is interesting to notice that both concentrations are less than 30% in 90% of the total samples

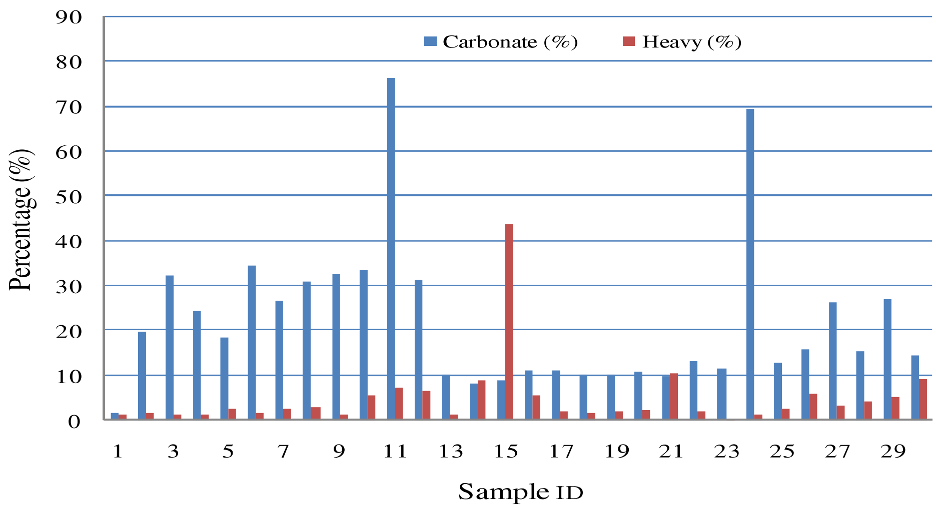

Fig. 3. Comparison of carbonates and heavy minerals concentration in sediments

Conclusions

Results indicated that the heavy mineral concentration varies from 0.01 to 49%. The percentage was below 3.5% in 63% of the total samples which is less than the expected level. Heavy mineral percentage made up an average value of 4.9% and is mainly composed of ilmenite, zircon and rutile. Arisimalaii Point and the Yan Oya mouth have indicated a considerable amount of heavy mineral concentration. The estimated heavy mineral potential is ~735,000 m^3 based on the assumption of equal distribution throughout the area. Though, few locations are enriched with considerable amount of heavy mineral concentrations, the deposit is not economically viable due to it’s discontinuous distribution.

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