Characterization of Beach Sand Deposits with Heavy Minerals Using Geo-Physical Techniques

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Abstract: Mineralogical analysis through physical concentration and microscopic studies of beach sand is one of the most accurate methods in the determination of percentages of constituent heavy minerals of beach sand. However, in this study a magnetic survey method was tested as a field method to separate magnetic minerals from non-magnetic minerals in beach sand. The main objective of this study is to find out a relationship between magnetic survey data and heavy mineral composition data of beach sand. Beaches at Panadura and Beruwala were selected for the magnetic surveys, owing to their dominance of heavy mineral bearing beach sand. Samples were also taken adequately and systematically from each beach, and were analysed at the mineral laboratory. The iso-dynamic magnetic separator was used to separate the magnetic heavy minerals. ArcGIS software and geo-statistical and normal statistical analyses were used to build the relationship between magnetometer survey data and mineral composition data. However, According to the geographically weighted regression (GWR) analysis was not observed a significant relationship between magnetic survey data and mineral composition data.

Key Words: Magnetic Survey, ArcGIS software, Iso-dynamic magnetic separator, Magnetic heavy minerals, Beach sand

1. Introduction

Beach sand of Sri Lanka rich with valuable heavy minerals is very important for many industries. Heavy mineral placer deposits of differentscales, containing economicalconcentrations of ilmenite, rutile, garnet, zircon and monazite are abundant along thecoastal belt of Sri Lanka (Rathnayake and Senarathne, 2014). Other than Pulmude heavy mineral deposit, many other small beach placers occur around the island but are not given much attention.

Development of mineral survey on and off shore is important in order to assess the industrial and economical needs of heavy mineral (Jayawardena, 1984).

It would be beneficial, if we can estimate heavy mineral composition through a geophysical method. In Sri Lankan context no similar studies yet emerged to understand the possibility to characterize the heavy mineral beach sand according to their magnetic property using properly oriented magnetic survey. Two coastal regions were selected for the study PanaduraandBeruwala with the objectives to; identify a relation between magnetic surveys data of the beach profile and laboratory assessed heavy mineral composition, create a spatial database model according to the identified relationship, and identify the feasibility, reliability and efficiency of magnetic survey data to characterize the heavy mineral beach sand according to the model.

2. Study Area

Two coastal regions were selected, - Panadura and Beruwala. The width of the beach varies from place to place with a range of 20 to 100 m and traverse path for the survey were on a grid. Samples were collected from forty locations on the grid. Vertical depth of sampling approximately were one meter height

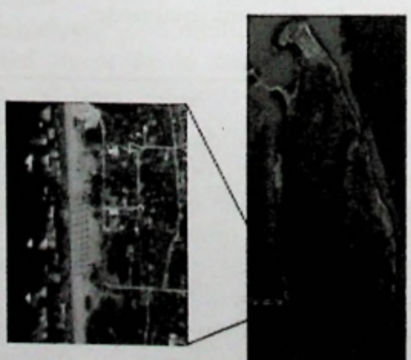

Figure 1: Study Area 01, Panadura beach

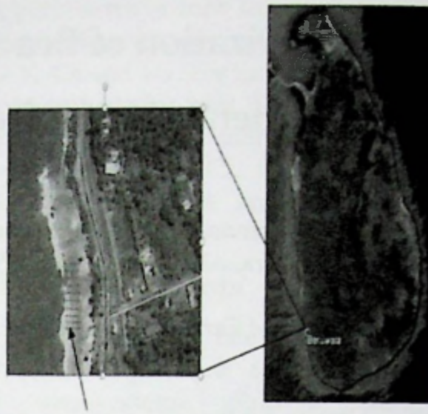

Figure 2: Study Area 02, Beruwala beach

3. Methodology

Selection of particular location to conduct the magnetic survey is vital and maximum consideration was given to minimize the disturbance which causes the external influence to the magnetometer such as power lines, steel fences etc. Before the start of the geophysical survey, blue nylon ropes were laid out on the grids. These ropes served as guide ropes during the actual data acquisition phases of the project.

The magnetic survey was conducted with a proton precession magnetometer which is used to measure the earth's magnetic field strength and can detect variations in this field caused by the presence of iron bearing objects. The proton precession magnetometer consists with display unit and sensor unit. Height of the bottom sensor above the ground is relative to the height of the surveyor. In the carrying mode at the side of the body, the bottom sensor is approximately 0.30 meters above the ground. The proton precession sensor had to be accurately balanced and aligned along the direction of the field component to be measured. The base point was established at the middle of the grid and the balancing and alignment procedures were oriented to magnetic north.

After finishing the magnetic survey for the one particular line samples were taken from the each grid lines at 10 m intervals at a depth of 1m. Sample collection was planned to collect representative samples for the whole mineral sand deposit using hand augur. Sample size was roughly 1 kg, because it needs a measurable sample to reduce the error of representative sampling.

Magnetic separation of the samples was done to separate minerals according to their magnetic susceptibility and how the individual grains respond to the electromagnetic field versus gravity. The main objective of this was to identify amount of magnetic mineral types in samples. Magnetic separation is possible only with grain size between 63 and 2000 microns, therefore a 300 g sample was sieved to separate the required grain size.

4. Results

Interpolated magnetic intensity and magnetic mineral composition values of Panadura location are showninfigure 3 and figure 6 respectively. Reclassified magnetic intensity and mineral composition values according to the equal interval reclassification method are represented in figure 4 and Figure 7 respectively. Selected grid code points on magnetic intensity and mineral composition values after converting raster data into points are shown in figure 5 and figure 8 respectively and those grid codes were subjected to the statistical analysis to study the relation between magnetic intensity data and magnetic mineral composition

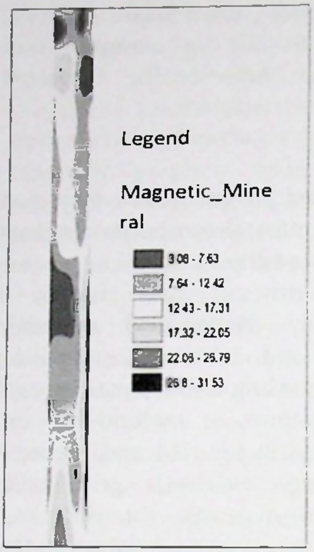

Figure 3: Magnetic mineral interpolated map

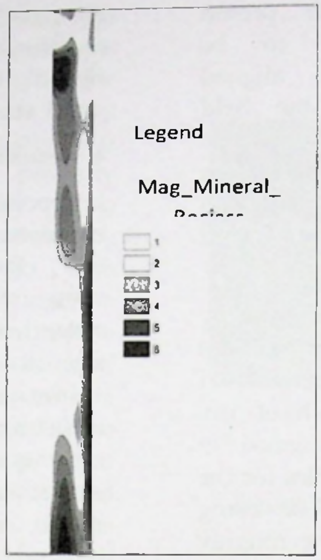

Figure 4: Magnetic mineral reclassified map

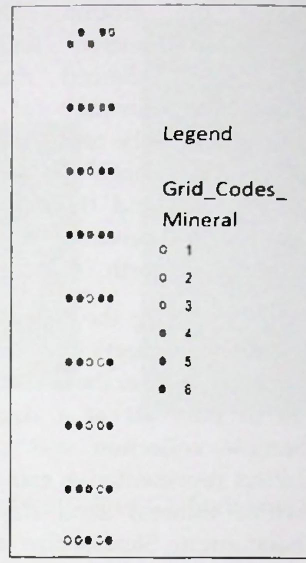

Figure 5:Selected points on magnetic mineral map

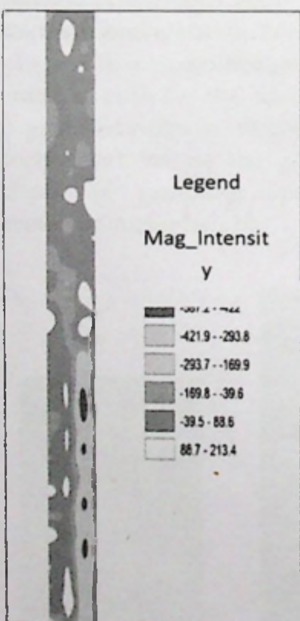

Figure 6: Magnetic mineral reclassified map

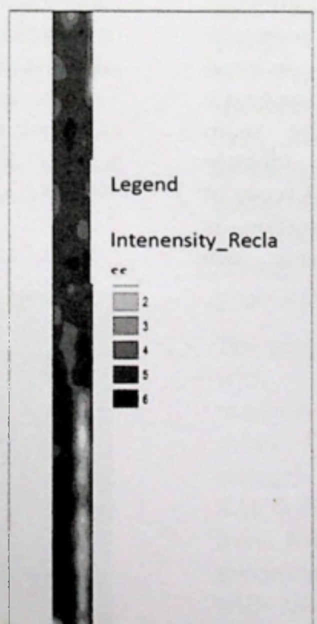

Figure 7: Meter reading reclassified map

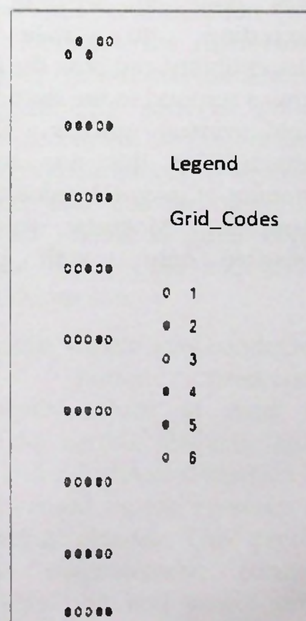

Figure 8: Selected points on intensity map

4. Discussion

Table 1: Geographically Weighted Regression Analysis Results Panadura

VARNAME	VARIABLE
Bandwidth	441.814
Sigma	1.442
AICc	182.990
R^2	0.013
R^2Adjusted	-0.008

The AICc (Akaike information criterion) value was quite high in the GWR (Geographically weighted regression analysis) analyses conducted for both Panadura and Beruwala beach profiles - a model cannot be fitted by magnetic results and mineral composition data.The parameters of GWR analysis of band width selection, it was observed that too large band width led to large buyers in the local estimate, for both Panadura and Beruwala survey sites.

4.1 Simple Regression Analysis Results

The regression equation is;

Meter Reading = 3.86 + 0.110 Mineral Composition

S = 1.44213 R-Sq = 1.3% R-Sq (adj) = 0.0%

The following parameters were considered in SLR in order to validate the fitted model statistically. Coefficient of determination (R2) of the fitted model was observed to confirm the variability of the observed data explained by the fitted model. According to the R2 observed by SLR analyses for both Panadura and Beruwala locations, R2 was observed to be a low value which was less than 80%. Hence it could be concluded that variability of the results were quite high. And, the P-value was not less than 0.05, and it meant that the model was not significant.

4.2 Hypothesis Testing

Null hypothesis and alternative hypothesis were set as follows and 2-sample t-test was carried out in order to test the validity of Null hypothesis and alternative hypothesis.

H_0(There is no significant difference between grid code means of magnetometer reading data and mineral composition data).

H_1 (There is a significant difference between grid code means of magnetometer reading data and mineral composition data.)

4.3 Two-Sample T-Test and CI: Meter Reading, Mineral Composition

Two-sample T for Meter Reading vs. Mineral Composition

Difference = mu (Meter Reading) - mu (Mineral Composition)

Estimate for difference: 0.800000

95% CI for difference: (0.222485, 1.377515)

T-Test of difference = 0 (vs not =): T-Value = 2.75 P-Value = 0.007 DF = 97

T-Value Estimate = 2.75

T-Table Value = 1.984 (95% CI and DF = 98)

T-Value Estimate > T-Table Value

According to the test results, null hypothesis had to be rejected. It meant that there was no significant relationship between grid codes of magnetometer reading data and mineral composition data.

4.4 Variogram Analysis

From the variogram analysis, a high nugget effect could be observed for both the beach survey sites in Panadura and Beruwala. It can be concluded that both magnetometer reading data and mineral composition data comprises sampling and analytical errors. High discontinuities and fewer correlations could be observed between magnetometer reading and mineral composition data.

5. Conclusion

There is no significant relationship between magnetometer reading data and mineral composition data, for both Panadura and Beruwala. Hence no model can be built to predict the heavy mineral concentration usingmagnetic survey data.

6. Recommendations

- Survey sites should be so carefully selected to avoid the influence of the iron bearing obstacles.
- It is problematic in observing a relationship between magnetic survey data and heavy mineral composition data. Hence a further endeavor in this study is not recommended.

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