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Regional Low Gravity Anomalies Influencing High Concentrations of Heavy Minerals on Placer Deposits

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Abstract**—**Regions of low gravity and gravity anomalies both influence heavy mineral concentrations on placer deposits. Economically imported heavy minerals are likely to have higher levels of deposition in low gravity regions of placer deposits. This can be found in coastal regions of Southern Asia, particularly in Sri Lanka and Peninsula India and areas located in the lowest gravity region of the world. The area about 70 kilometers of the east coast of Sri Lanka is covered by a high percentage of ilmenite deposits, and the southwest coast of the island consists of Monazite placer deposit. These deposits are one of the largest placer deposits in the world. In India, the heavy mineral industry has a good market. On the other hand, based on the coastal placer deposits recorded, the high gravity region located around Papua New Guinea, has no such heavy mineral deposits. In low gravity regions, with the help of other depositional environmental factors, the grains have more time and space to float in the sea, this helps bring high concentrations of heavy mineral deposits to the coast. The effect of low and high gravity can be demonstrated by using heavy mineral separation devices. The ***Wilfley*** heavy mineral separating table is one of these; it is extensively used in industries and in laboratories for heavy mineral separation. The horizontally oscillating Wilfley table helps to separate heavy and light mineral grains in to deferent fractions, with the use of water. In this experiment, the low and high angle of the Wilfley table are representing low and high gravity respectively. A sample mixture of grain size <0.85 mm of heavy and light mineral grains has been used for this experiment. The high and low angle of the table was 6^0 and 2^0 respectively for this experiment. The separated fractions from the table are again separated into heavy and light minerals, with the use of heavy liquid, which consists of a specific gravity of 2.85. The fractions of separated heavy and light minerals have been used for drawing the two-dimensional graphs. The graphs show that the low gravity stage has a high percentage of heavy minerals collected in the upper area of the table than in the high gravity stage. The results of the experiment can be used for the comparison of regional low gravity and high gravity levels of heavy minerals. If there are any heavy mineral deposits in the high gravity regions, these deposits will take place far away from the coast, within the continental shelf.

Keywords—Anomaly, gravity, influence, mineral.

I. Introduction

EARTH'S surface is not uniform in its gravitational fields from region to region for various reasons, such as underlying geology and rock densities. The variations in the density of the plates of Earth's crust have been published and displayed as gravity anomaly maps [1]. The gravity field anomalies can be used for predicting placer deposition of heavy minerals. Significant gravity anomalies (both high and low) are remarkably evident in satellite imagery [1]. The low gravity field anomalies affect the heavy mineral sedimentation of placer deposits. These gravity anomalies can be used for demarcating the heavy mineral concentrations on placer deposits. Sand grains can float in sea water in low gravity regions for a longer retention time, due to the high buoyancy effect compared with high gravity regions. When the retention time is longer, the sea water can bring a greater concentration of sediments to the placer. This process impacts heavy mineral concentration on the placer of low gravity regions. The known deposits can remarkably be correlated with the low gravity zones of the earth's surface. Nevertheless, in low gravity regions a mixture of course, medium and fine sands and in high gravity regions fine-grained sands can be deposited on the placer. This natural process can be demonstrated in laboratory conditions with the use of heavy mineral separation devices. Scientifically the correlation is valid, but further tests need to be conducted using various samples from different locations in the world. Generally, the heavy minerals originate from weathered land mass and transported to sea by its tributaries [9].

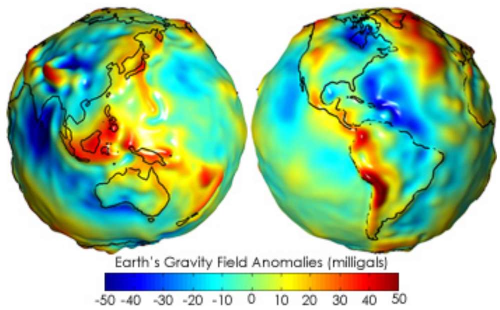

Fig. 1 Global gravity anomaly and geoid [1]

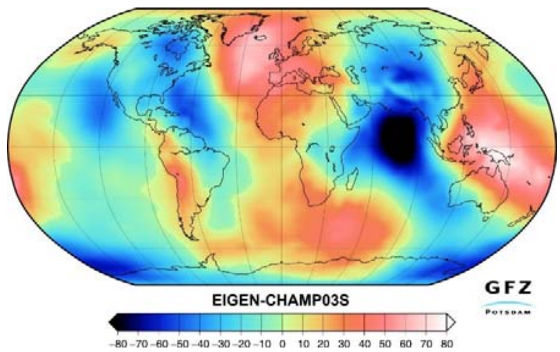

Fig. 2 Earth gravity anomaly map [1]

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Fig. 3 Lowest and highest gravity zones on Earth [1]

II. Purpose and Scope

How gravity anomalies can affect the heavy mineral deposition on placer deposits in different regions of the world. Gravity anomaly maps can be used for demarcating heavy mineral deposits in the world.

III. Method of Experiment

The shaking action of the table, which oscillates backwards and forwards at right angles to the slope of the table, is used to sort heavy minerals [3]. Riffles on the table surface provide retention times and holding back material that is closest to the table surface. The combination effect of the oscillation and riffles causes the heaviest to ride the surface of the table and thus move to the upper section of heavy mineral concentration. This procedure can be demonstrated within a laboratory, with heavy mineral separation equipment such as the Wilfley Table. This process used <0.85 mm sand containing heavy minerals. The effect of sorting grains can change using several small incline angles of the Wilfley table. The experiment used a slope of two and six degrees on the Wilfley table. When shaking the table, the heavy mineral sand mixture slurry is fed to the top of the right-hand side of the table. Finally, the split fractions collect at the bottom of eight containers, which are named as cut one to eight fractions. The higher angle of inclination used was six degrees and the lower was two degrees.

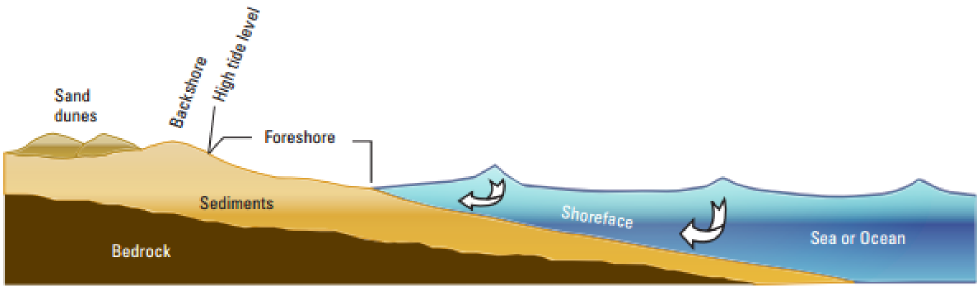

Fig. 4 Shoreline depositional environment (Bradley S, USGS) - not to scale [2]

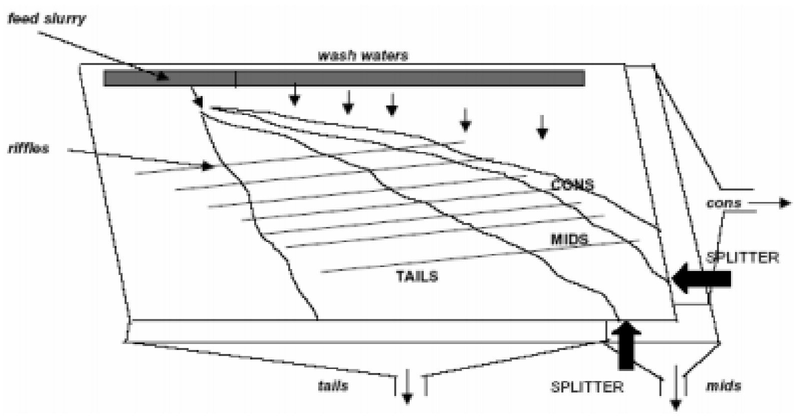

Fig. 5 Shaking table (Abols and Grady) [3]

The eight cut fractions were dried and weighed. Each of the fractions were separated into heavy (<density 2.85) and light minerals. The data are used for the line graph below. Details below in Table I are the data reported from the experiment.

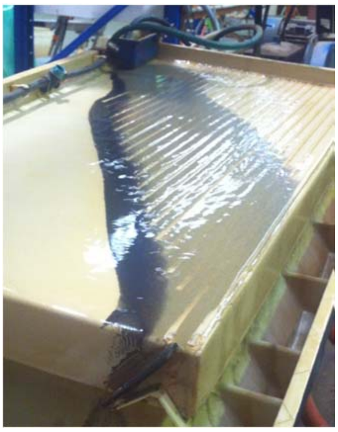

Fig. 6 Wilfley Table, low gravity stage (2^{O}) of processing

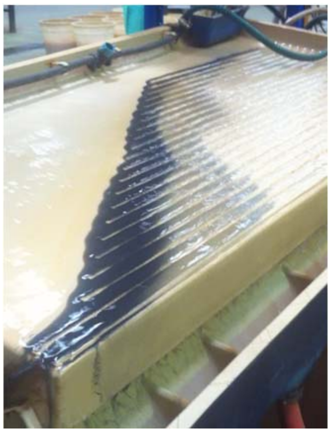

Fig. 7 Wilfley Table, High gravity (6^{0}) stage of processing

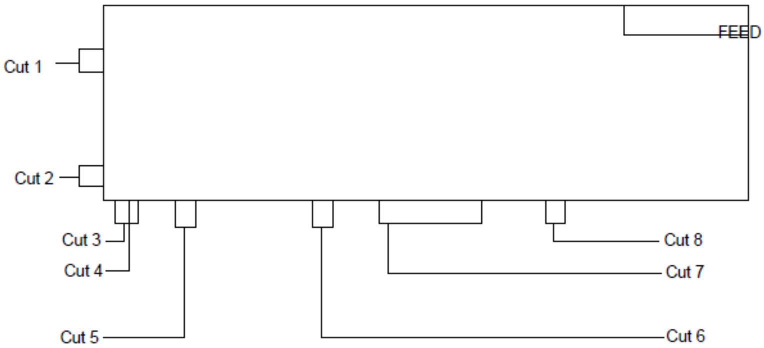

Fig. 8 Wilfley Table plane view and separated sample fraction collection (cut 1- 8)

TABLE I
USED WILFLEY TABLE FOR GRAVITY SEPARATION AND THE EXPERIMENT DATA

Table Angle		Cut 1 (g)	Cut 2 (g)	Cut 3 (gm)	Cut 4 (g)	Cut 5 (g)	Cut 6 (g)	Cut 7 (g)	Cut 8 (g)
Low Gravity (2^{0})	Total Sample Weight 1931.4g	0	410.4	224.7	348.0	348.8	593.7	1.2	5.7
	Heavy minerals Weight	0	160.2	2.13	2.4	2.8	1,2	0.006	0.05
High Gravity (6^{0})	Total Sample Weight 1931.4	0	146.0	146.2	166.4	442.2	792.6	198.6	25.5
	Heavy minerals Weights	0	98.9	39.3	11.33	2.2	8.4	4	0.25

Fig. 9 Low gravity (2^{0}) mineral separation chart

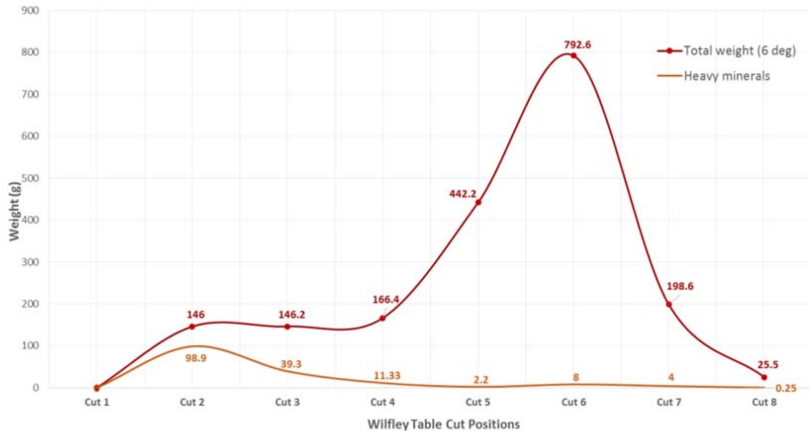

Fig. 10 High gravity (6^0) mineral separation chart

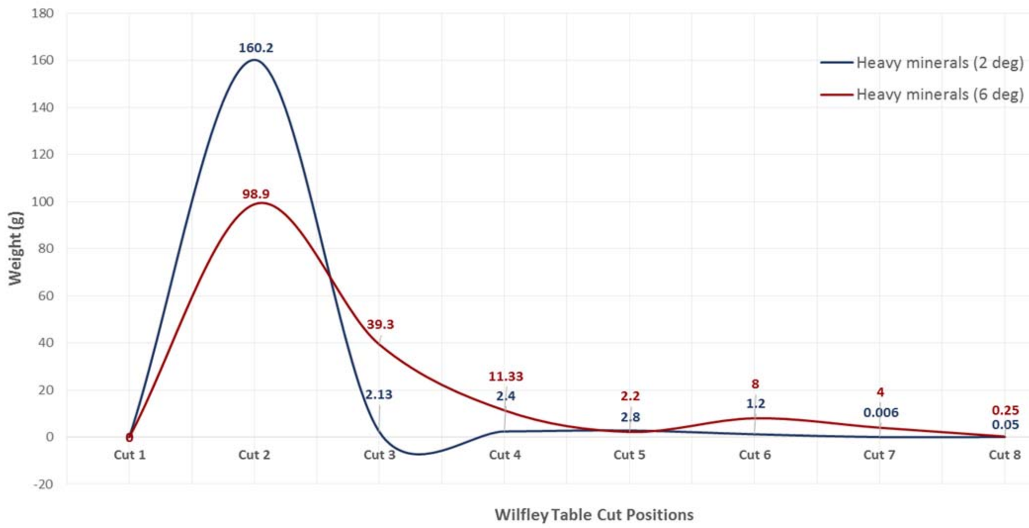

Fig. 11 Comparison of high & low gravity heavy mineral separation

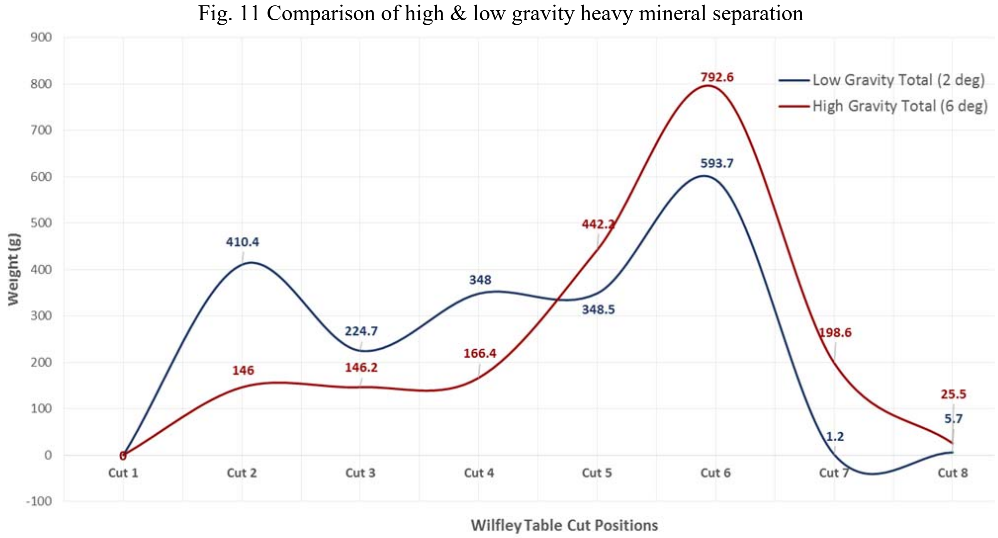

Fig. 12 Comparison of high & low gravity heavy total sample weight

These graphs clearly indicate how low gravity plays a major role in heavy mineral sedimentation on placer deposits and hence justifies the occurrence of heavy mineral deposits in low gravity anomaly regions.

IV. Comparison of Experiment Results with Known Published Information

The experiment utilised the Wilfley Table as a gravity separation device. The use of different angles of the table indicates heavy mineral separation and how far gravity influences heavy mineral deposition in different environments. There were two different types of experimental angles used. Fig. 9 in the 2^0 stage (low gravity stage) has a greater sample weight of heavy minerals (cut 2). Natural environments with low gravity shoreline, exhibit a high concentration of heavy mineral deposition with lighter minerals.

Fig. 10, 6^0 (high gravity stage) demonstrates that heavy minerals are spread further across the other cut zones beyond cut 2. Fig. 11 demonstrates that, at low gravity (2^0), heavy minerals are preferentially collected at cut 2, and at higher gravity (6^0), heavy minerals are spread further through cuts 3 and 4.

Fig. 12 shows total sample separation without further separation of heavy minerals at both high and low gravity, indicating that, at the low gravity stage, more heavy minerals are collected.

The island of Sri Lanka has rich heavy mineral deposits, which correlate to zones of low gravity and placer deposits in shoreline areas. Heavy mineral sand concentration is found along a 72 km stretch of the North-Eastern Pulmoddai beach of Sri Lanka [2]. The black mineral sands of Pulmoddai beach have heavy-mineral concentrations of 50% to 60% and were considered to be one of the richest mineral sand deposits in the world [6], [7] the other deposit is one of the world's most thorium rich sediments and is located in the South-Western coast of Sri Lanka [4]. Nevertheless, ilmenite and thorium bearing mineral sand is found regularly along the coastal stretch covering Aluthgama, Baruwala, Induruwa in SW sector and Kudiramalai in NW sector of Sri Lanka [5]. On the other hand, high gravity regions of Indonesia and Malaysian have no such high percentage of heavy mineral occurrences recorded. For this region, the main concept of the paper must be studied in detail.

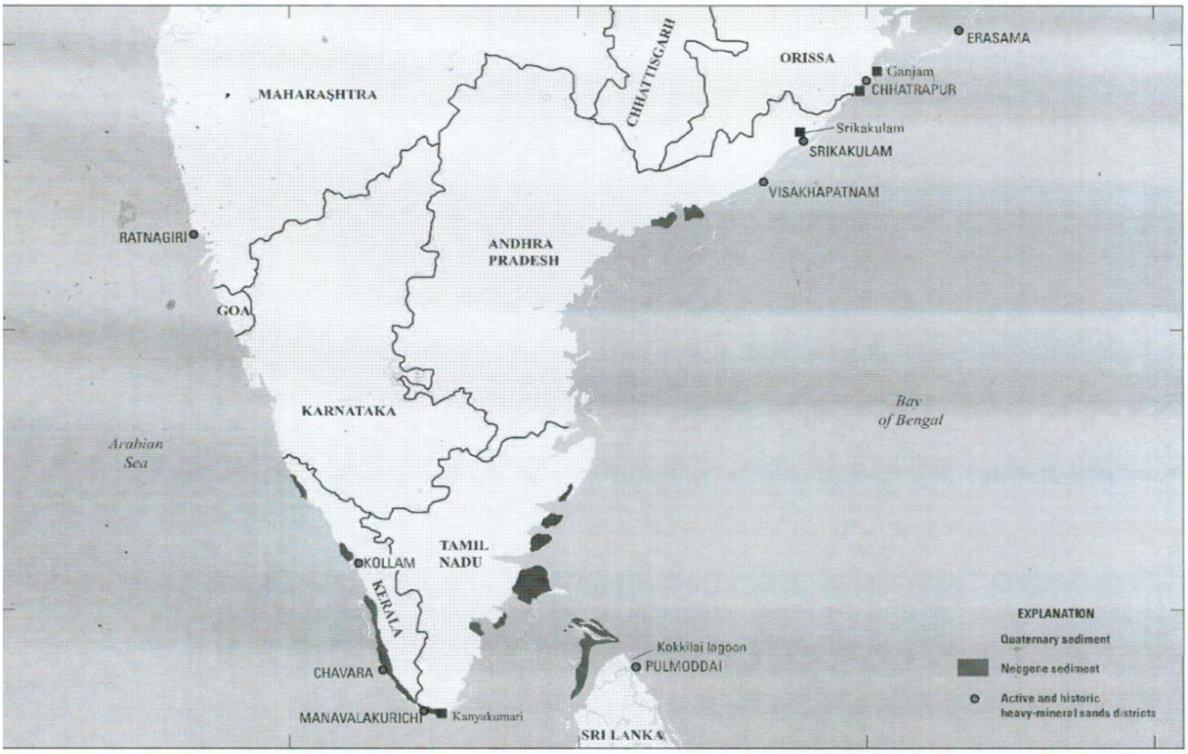

Fig. 13 A part of heavy mineral concentration in Sri Lanka and India [2]

V. Conclusion

Geologically Earth's gravity is one of the significant energy factors influencing sedimentary processes. However, there are other factors such as the current of waves, tidal condition of sea water levels, wind, monsoon conditions and angle of continental shelf, which can influence heavy mineral deposition in coastal environments. However, gravity is not uniform across various locations due to varying densities of underlying rocks. Further heavy mineral studies in coastal regions can be undertaken with the use of gravity anomalies. The gravity anomaly maps can be used to locate heavy mineral deposits within coastal environments in the world.

Fig. 14 Beach mineral sands in Sri Lanka. According to Geological Survey Department's 1980 publication 'Mineral Resources of Sri Lanka,' ilmenite, rutile, zircon and monazite are present and the deposits are sufficiently concentrated for economic exploitation in Pulmoddai north of Trincomalee and Kaikawala near Induruwa [8]

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