Delineation of the Surface Pattern of Heavy Mineral Deposit of Tulatoli Paleo Dune Within Teknaf Beach Strip of Cox's Bazar District with Radiometric Survey

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Abstract

Radiometric survey with portable gamma detector as carried out in the dunes of old beach formation extending along Lamburi –Tulatoli-Moheshkhalipara area in Teknaf Upazila of Cox's Bazar district has conveniently enabled detecting in field environment the surface distribution pattern of radioactive materials occurring in the heavy mineral composites within heavy mineral deposits of area. Investigations with auger sand samples as collected from the high gamma anomalous spots reveal that concentrations of heavy minerals are significantly higher in the spots showing high gamma counts. Thus, the anomalous spots of higher gamma counts**,** encountered on the surface of the heavy mineral lenses**,** are viewed to show trends of higher concentration of heavy minerals in the concerned spots. Accordingly, the technique of radiometric survey is conceived as a very cheap but superbly dependable approach for identifying the extent**,** size and continuity of the heavy mineral lenses. Radiometric survey prior to launching exploratory drilling activities on heavy mineral lenses can be a dependable and meaningful preceding effort for planning and pointing exploratory drill- locations well within the radiometrically located places of interest. By far more, the concerned survey could aptly be milked in framing a guideline for cost effective exploratory drilling program by keeping the efforts limited well within area of interest and by avoiding erratic execution of drills in an area which might enhance exploration expenses for unproductive exploratory drills.

Keywords: Proportionate factor, path finder, dependable technique, cost effective drilling.

1. Introduction

Application of radiometric survey in delineating heavy mineral sand deposits in placer formations, especially in beach sand has been found to be significantly effective both in respect of technical efficiency and from economic point of view. Radiometric survey is probably the cheapest field method for identification of the naturally occurring radioactive substances. Occurrence of detectable level of Thorium (^{232}Th) bearing Monazite is widely common in the heavy mineral deposits occurring in beach formations of Bangladesh and thus any minimum level of detectable presence of natural gamma releasing radioactive material in heavy mineral suites makes the use of a portable gamma detector superbly convenient as the cheapest appliance for delineating the surface trend/pattern of the mineral deposit in field environment.

1.1. Brief Geology of the South-eastern Beach Belt, The Bay of Bengal

The beach formation along the south-eastern margin of the Bay of Bengal, extending continuously for one hundred and twenty Kilometers from Badarmokam, the southernmost tip of the Land mass of Bangladesh in Teknaf Peninsula up to Bankkhali river along the northern side of Cox's Bazar urban area, marvelously identifies itself to be the longest natural sea beach in the world. One of the typical characteristics of this extra-ordinary long beach of Cox's Bazar is that almost the entire beach formation is constituted with reasonably thick well sorted sandy materials. The beach is visualized to form within the broad part of shallow marine 'Plain of Denudation' of the Bay of Bengal extending along the Arakan coast [1**]**. The most part of the beach along its elongation is regionally bounded by successive anticlines such as Cox's Bazar Anticline, Inani Anticline and Hnila Anticline that spread parallel to the coastline. Neogene sediments dominate in these Structures. However, Bhuban is the oldest exposed rock-unit as found in the Hnila Anticline. In other two Structures, Bokabil is the oldest exposed formation. The western flanks of these anticlines have regionally been effected by faults leading to missing of the faulted parts in the Bay. There exists another anticline in Moheshkhali Island. The exposed axial zone is constituted with Bokabil [2**]**. The anticline has also been effected by local faulting. The faulted parts of the Anticlines might have caused well spread accumulation of huge sediments in the eastern margin of the Bay to form a dominatingly extended gentle slope of the Shelf resulting the formation of the regionally extended excellent beach of Cox's Bazar .

The beach formation of Cox's Bazar is a recent geological feature and has been formed on a wide and regionally extending gentle slope of the Shelf. The depositional aspects of the sediments that form the beach are widely controlled by moderate ocean current dynamics. The black heavy mineral deposits occurring as placer in the beach area, are mostly lenticular in shape. The deposits do exist both in the back dunes and in the fore dunes [3**]** . There also exist evidences of repetition in the cycles of deposition of these minerals. However, the vertical extent of repeats has not been ascertained formally.

Along the eastern margin of the Bay within Chittagong district there also exist a few more discontinuous beach formations like Parki, Potenga and Fouzdarhat etc. However, similar heavy mineral deposits of geological and economic interest are not reported to occur further north of Cox's Bazar district. Again, the reported deposits of Nijhum Dwip and in Kuakata occurring along the northern margin of the Bay have been found to maintain some

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differences with those of Cox's Bazar belt mostly in respect of mineral contents and in a few physical factors of the minerals. The views thus open up avenues for a concept of separate source areas dominantly playing roles up on these two belts. Again, a number of heavy minerals occurring in the deposits of Cox's Bazar beach belt are almost absent in the sediments of the adjacently stretching hills. The situation thus favors the idea that the contribution of these local hills in the formation of beach mineral deposits are very limited and localized. A study on sediment movement in the estuarine zone of the Karnafuli River, as carried out by BAEC with radioisotope tracer ^{46}Sc (Scandium-46) in 1989, evidently proved the mobility of sand/sediment occurring from south to north [4]. Accordingly, besides the Himalayan ranges the Arakan hills may be viewed to be the dominating source area for formation of placer mineral deposits in Cox's Bazar beach [5].

1.2 The Study Area

The study area, extending in between Lamburi-Tulatoli-Moheshkhalipara region within Teknaf Upazila of Cox's Bazar district, happens to be a typical a paleo beach formation at close proximity from Teknaf urban area. The zone is nearly one kilometer east of the present beach of Teknaf. Teknaf peninsula, covering the south eastern part of the landmass of Bangladesh, is the extreme south part of the strand formed as coastal deposit and is restricted to a narrow zone along the western edge of the tectonically active fold belt. The strand virtually extends upto Cox's Bazar in the north to form the longest continuous beach in the world. Regionally, the beach formation overlies Late Tertiary Formation. Prominent lenses of placer heavy minerals deposited in the recent/active beach strip of Badarmokam, Shah Pareer Dwip, Sabrang, Teknaf and Silkhali regions of the Peninsula, have greatly enhanced the economic importance of the beach. The lens bodies are generally constituted with medium to fine grained well-sorted sub rounded sand particles. Presence of concretions shell fragments are also common. The formation occasionally includes small mud-flat deposit**s** **[**6]. The exposure of the loose sandy formation appears to terminate within the recent silty to clayey soil formation of the Naf valley. Repetitions of placer heavy mineral lenses in vertical column in the present day beach berms are prominent in Badarmokam, Shah Pareer dwip and Silkhali regions. In the Peninsula a good number of heavy mineral rich back dunes do occurs along the northern extension of a few tens of kilometers from Teknaf town. However, in the southwestern region of Teknaf urban area such heavy mineral rich back dunes are well limited within Lamburi-Tulatoli-Moheshkhalipara region.

2. Materials and Methods

2.1 Previous Studies with Beach Radiactive Minerals of the Area

Presence of Thorium bearing Monazite was already reported from the pioneering survey of Geological Survey of Pakistan (GSP) with Cox's Bazar beach sand heavy minerals in early Sixties [7]. In later stage of the decade the then Pakistan Atomic Energy Commission (PAEC) undertook the venture as an option for exploration of nuclear raw materials along with other bulk non nuclear heavy minerals along the beach belts of Cox's Bazar. The then investigations already revealed economic presence of Ilmenite, Magnetite, Zircon, Rutile, Leucoxene, Garnet, Kyanite and Monazite in heavy mineral deposits of the beach belt [8].

However, after the emergence of Bangladesh, the newly born country was more interested to give extra ordinary priority to the exploration of overall beach sand minerals that resulted discovery of seventeen deposits with total reserve of 1.76 million tons of economically important heavy minerals [9]. The reports/publications on BAEC studies reveal that like many other parts of paleo dunes in the belt this area is also featured with occurrence of important heavy minerals including Monazite. Similarly, the paleao dunes occuring in the older beach formations of Sabrang, Teknaf and Silkhali zones in Teknaf peninsular belt have been found to contain concerning quantity of radioactive materials (Thorium bearing Monazite). Moreover, presence of such radioactive materials is also quite common in the heavy mineral bodies occurring in the berm belts of the present day beach formations. However, the investigation with radioactive Monazite was kept limited to mere routine microscopic studies.

2.2 Recent radiometric surveys in the beach formations of Bangladesh

Ground radiometric survey with a portable gamma detector was conducted in recent past in the Jhaubon – Laboni-Kolatali beach of Cox's Bazar. The pertinent laboratory investigations of sand samples from the spots of gamma anomalies of the concerned area have revealed that the ratio between the percentage of Monazite in heavy mineral suites as determined optically and the corresponding XBG (times background) gamma counts (cps) of the spot maintains a proportionate factor of 0.11 [10] Again, it has been observed from another subsequent study as accomplished with ground radiometric survey in Badarmokam – Shah Pareer Dwip beach of Teknaf Upazila and relevant laboratory investigations of sand samples from the spots of gamma anomalies that the in situ distribution pattern of Monazite and that of Zircon do maintain closely identical appearances. Accordingly, it has been inferred that presence of radioactive Monazite in beach sand heavy mineral suites could be an effective path finder for Zircon in beach placer formation. Thus, in identical field environment of placer formation the radiometric survey could be an effective field technique for speculation on the presence of Zircon in the area.

2.3 Present Field and Laboratory Investigations

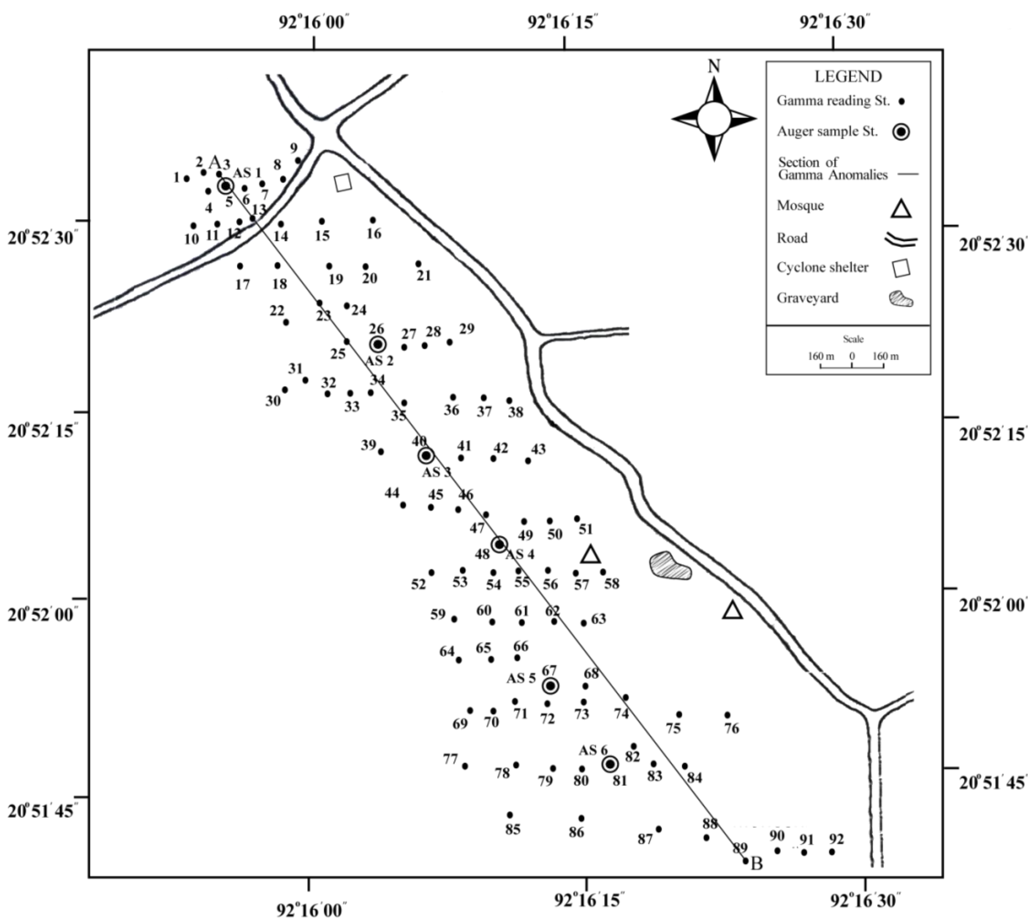
The present study primarily concerns with radiometric survey with a gross gamma detector for establishing the surface distribution pattern of radioactive materials as occurring within the heavy mineral lens of the paleo dune of Tulatoli. The prime motive of the concerned radiometric survey is aimed at viewing whether the gamma contour map can purposefully be used for planning and execution of a cost –effective exploratory drilling program for the area.

The specific venture of systematic radiometric survey as launched in Lamburi-Tulatoli-Moheshkhalipara area, includes in situ gamma readings in 92 spots within an area of 2 km x 600 m. The GPS co-ordinates of every individual spot has been recorded while taking gamma reading (in cps) in the concerned spots and accordingly the high gamma anomalies in field have been located. The survey has been furnished such that the studied area is covered with traverses across the main traverse of around 2 km in NNW-SSW direction parallel to Tulatoli-Moheshkhalipara road. The gamma value in the dune further south of Moheshkhalipara as found to drop down to background level have not been incorporated in the present study. Hand auger sampling of +1 m vertical column depth individually from six gamma anomalous spots have been collected for laboratory studies on heavy minerals concentration levels. Map 1 representing the location of study, contains both the stations of gamma reading taken in field and the spots of hand auger drilling from gamma anomalies. Table 1, records the in situ gamma counts in the corresponding stations specified with GPS co-ordinates. Map 2 displays the gamma contours in the studied area and delineates the surface distribution pattern of the radioactive materials in the area. Fig. 1 shows a graphical view of gamma anomalies in a section.

3. Results and Discussions

3.1 Field and Laboratory Findings

In view of speculating the Heavy Mineral (HM) concentrations in the high gamma anomalous spots six representative vertical column samples have been collected with hand auger from selective spots of high counts (gamma anomalous spots shown in Map 1). Heavy mineral contents in every individual auger sample have been determined successively for every 0.25 m interval such that the entire column of the sample is covered. Table 2 contains the level of HM concentration (in per cent) in vertical column of every individual auger drilled hole. Fig. 2 contains the bar diagram of HM distribution in vertical column of every of the six auger drill holes.



Map 1. Stations of Gamma reading and auger samples in Lamburi-Tulatoli-Moheshkhalipara paleo beach

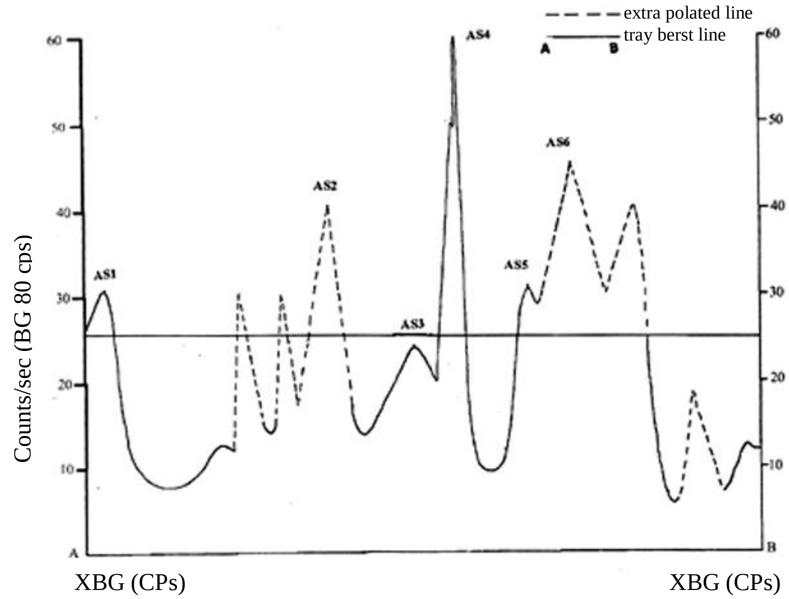


Fig 1. Graphical view of gamma anomalies in the area

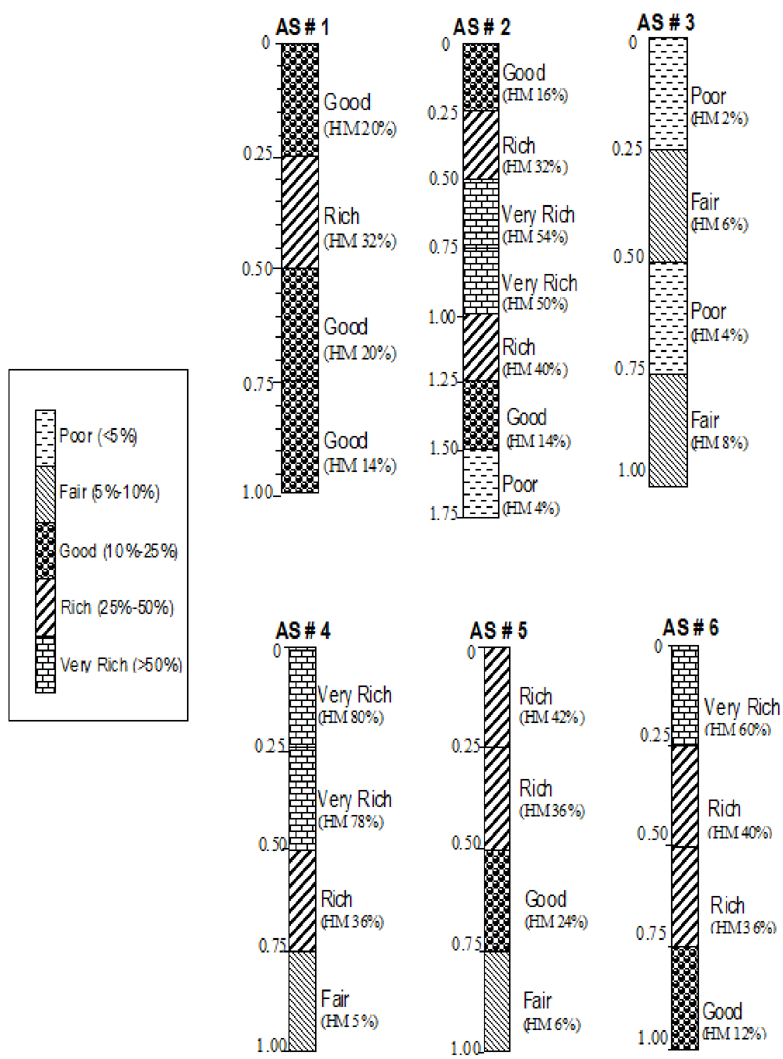


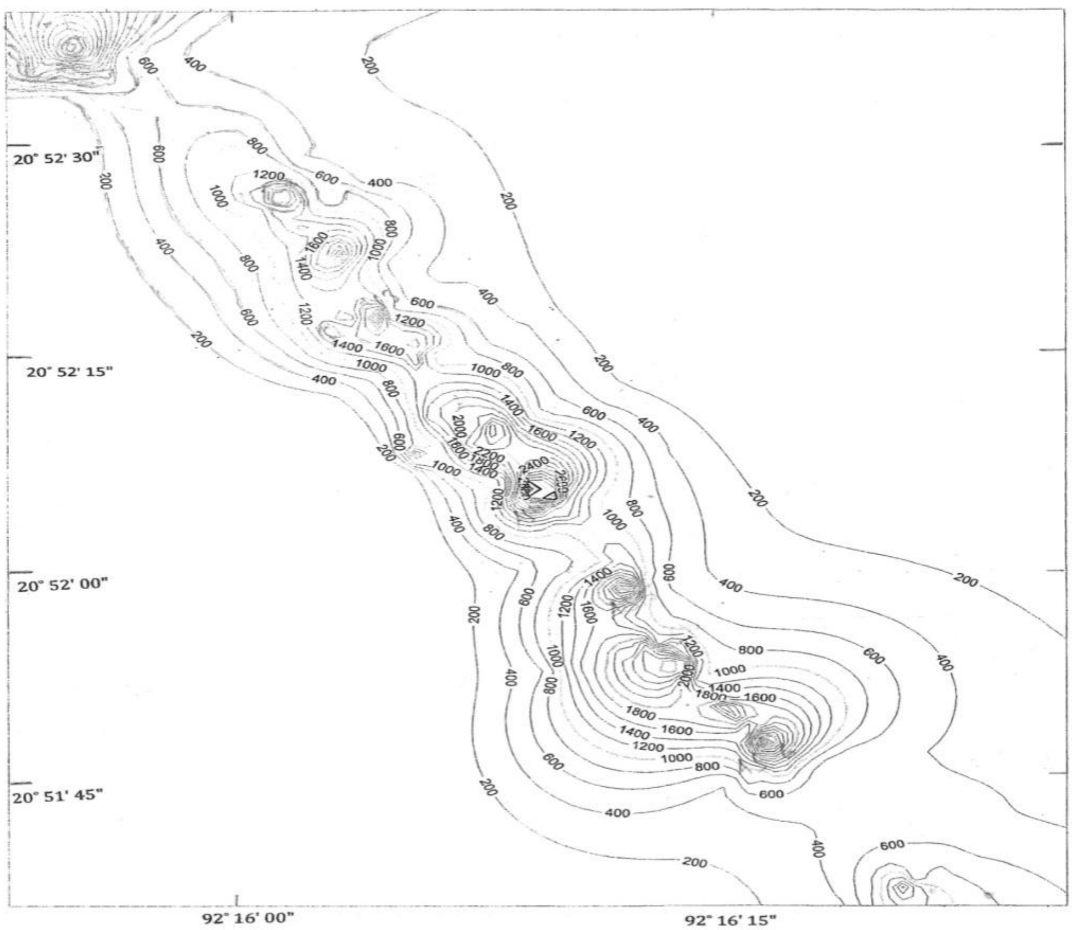
Fig. 2. Bar diagram of HM contents in the auger sand samples

Table 1. cps values of gamma anomalous spots in between lamburi –Tulatoli-Moheshkhalipara

Station no.	Co-ordinates		Gamma reading (cps)	Station no.	Co-ordinates		Gamma reading (cps)
	Longitude (E)	Latitude (N)			Longitude (E)	Latitude (N)	
1	92˚15' 53"	20˚52' 34"	1420	2	92˚15' 54"	20˚52' 34.2"	1980
3	92˚15' 55"	20˚52' 34"	2200	4	92˚15' 55.4"	20˚52' 33"	2350
5	92˚15' 56"	20˚52' 33"	3000	6	92˚15' 56.5"	20˚52' 33"	1850
7	92˚15' 57"	20˚52' 33"	1270	8	92˚15' 57.8"	20˚52' 34"	610
9	92˚15' 59"	20˚52' 35"	400	10	92˚15' 54"	20˚52' 30"	200
11	92˚15' 55"	20˚52' 30"	830	12	92˚15' 56"	20˚52' 30"	1050
13	92˚15' 57"	20˚52' 30"	920	14	92˚15' 58"	20˚52' 30"	570
15	92˚16' 00"	20˚52' 30"	390	16	92˚16' 02"	20˚52' 30"	280
17	92˚15' 56"	20˚52' 27"	290	18	92˚15' 57"	20˚52' 27"	610
19	92˚16' 01"	20˚52' 27"	800	20	92˚16' 03"	20˚52' 27"	380
21	92˚16' 06"	20˚52' 27"	350	22	92˚15' 58.2"	20˚52' 22"	600
23	92˚16' 00"	20˚52' 29"	1020	24	92˚16' 02"	20˚52' 29"	1900
25	92˚16' 02"	20˚52' 21"	1450	26	92˚16' 03.5"	20˚52' 20"	2200
27	92˚16' 05"	20˚52' 20"	990	28	92˚16' 06"	20˚52' 20"	470
29	92˚16' 07"	20˚52' 20"	380	30	92˚15' 58.5"	20˚52' 17"	200
31	92˚15' 59.2"	20˚52' 17.5"	410	32	92˚16' 01"	20˚52' 17"	650
33	92˚16' 02"	20˚52' 17"	1050	34	92˚16' 02.9"	20˚52' 17"	1120
35	92˚16' 05"	20˚52' 16"	1220	36	92˚16' 05.5"	20˚52' 17"	750
37	92˚16' 06.5"	20 ˚52 ' 17"	400	38	92˚16' 08"	"20˚52' 17"	240
39	92˚16' 03.7"	20˚52' 17"	520	40	92˚16' 06.1"	20˚52' 17"	970
41	92˚16' 08.3"	20˚52' 17"	1350	42	92˚16' 03.7"	20˚52' 17"	1000
43	92˚16' 10.5"	20˚52' 17"	370	44	92˚16' 05.5"	20˚52' 17"	240
45	92˚16' 07"	20˚52' 17"	800	46	92˚16' 08"	20˚52' 07"	1100
47	92˚16' 09"	20˚52' 07"	1460	48	92˚16' 10"	20˚52' 03"	4840
49	92˚16' 12"	20˚52' 07"	1800	50	92˚16' 13.5"	20˚52' 07"	950
51	92˚16' 15"	20˚52' 07"	410	52	92˚16' 08"	20˚52' 02"	200
53	92˚16' 09.5"	20˚52' 02"	910	54	92˚16' 11"	20˚52' 02"	1120
55	92˚16' 12"	20˚52' 02"	1280	56	92˚16' 10"	20˚52' 02"	1000
57	92˚16' 13.3"	20˚52' 02"	600	58	92˚16' 17.4"	20˚52' 02"	420
59	92˚16' 10"	20˚51' 58.5"	670	60	92˚16' 10"	20˚51' 58.5"	1150
61	92˚16' 10"	20˚51' 58.5"	1900	62	92˚16' 10"	20˚51' 58.5"	2400
63	92˚16' 10"	20˚51' 58.5"	1790	64	92˚16' 10"	20˚51' 55"	900
65	92˚16' 10"	20˚51' 55"	1460	66	92˚16' 10"	20˚51' 55"	1900
67	92˚16' 10"	20˚51' 53"	2700	68	92˚16' 10"	20˚51' 53"	1250
69	92˚16' 08.4"	20˚51' 50.9"	360	70	92˚16' 10"	20˚51' 50.9"	770

Station no.	Co-ordinates		Gamma reading (cps)	Stati on no.	Co-ordinates		Gamma reading (cps)
	Longitude (E)	Latitude (N)			Longitude (E)	Latitude (N)	
71	92˚16' 11.4"	20˚51' 51"	1220	72	92˚16' 13.5"	20˚51' 51"	2410
73	92˚16' 15"	20˚51' 53"	1870	74	92˚16' 17"	20˚51' 53"	1100
75	92˚16' 23"	20˚51' 51"	780	76	92˚16' 26"	20˚51' 51"	380
77	92˚16' 08"	20˚51' 47"	300	78	92˚16' 11"	20˚51' 47"	600
79	92˚16' 13"	20˚51' 47"	880	80	92˚16' 15"	20˚51' 47"	1360
81	92˚16' 16.4"	20˚51' 47"	1600	82	92˚16' 18.4"	20˚51' 50.2"	3200
83	92˚16' 18.9"	20˚51' 47"	600	84	92˚16' 20"	20˚51' 47"	400
85	92˚16' 10.5"	20˚51' 57.5"	280	86	92˚16' 15"	20˚51' 57.5"	390
87	92˚16' 18.5"	20˚51' 57.1"	400	88	92˚16' 22"	20˚51' 54"	1010
89	92˚16' 23.1"	20˚51' 53"	1680	90	92˚16' 24"	20˚51' 54"	860
91	92˚16' 26"	20˚51' 54"	400	92	92˚16' 10"	20˚51' 50.9"	350

Background (BG) gamma value= 80cps



Map 2. Gamma contour map showing the surface pattern of heavy mineral deposit in Lamburi-Tulatoli-Moheshkhalipara paleo beach

Table 2. Hand auger samples collected in vertical column.

Auger sample no.	Co-ordinates (long/ lat.)	Corresponding radiometric station no.	surface spot Gamma value (cps)	Sample Thickness (m)	Sample Depth (m)	HM Content (%)	Remarks (**)
AS 1	92^0 15' 56 "E 20^0 52' 33"N	5	3000	1.0 m	0.00 -0.25	20	good
					0.25-0.50	32	rich
					0.50- 1.00	16	good
AS 2	92˚16' 03.5"E 20˚52' 20"N	26	2200	1.75 m	0.00-0.25	16	good
					0.25- 0.50	32	rich
					0.50- 1.00	52	very rich
					1.00-1.25	36	rich
					1.25-1.50	14	good
					1.50-1.75	4	poor
AS 3	92˚16' 08"E 20˚52' 07"N	40	1100	1.0 m	0.00-0.25	2	poor
					0.25-0.50	6	fair
					0.50-0.75	4	poor
					0.75-1.00	8	fair
AS4	92^0 16' 10 "E 20^0 52' 03"N	48	4840	1.0 m	0.00 -0.50	78	very rich
					0.50-0.75	36	rich
					0.75- 1.00	6	fair
AS 5	92^0 16' 10 "E 20^0 51' 53"N	67	2700	1.0 m	0.00 -0.50	38	rich
					0.50-0.75	24	good
					0.75- 1.00	6	fair
AS 6	92^0 16' 16.4 "E 20^0 51' 47"N	81	3200	1.0 .	0.00 -0.25	60	Very rich
					0.25-0.75	38	Rich good
					0.75- 1.00	12	fair

(** 0.00% - 4.00% → poor, 5.00% - 10.00% → fair, 11.00% - 30.00% → good, 31.00% - 40.00% → rich, + 41.00% → very rich)

3.2 Inferences

a) The gamma contour map (Map 2) explicitly delineates the surface orientation of the radioactive material, both in extension and in width, as distributed in the heavy mineral deposit of the concerned paleo channel.

b) The in situ radiometric anomalies are found to maintain a number of concentric depositional patterns serially oriented along the extension of the HM deposit of the area.

c) Concentration of heavy minerals as determined from the hand auger drilling (Fig. 2) shows a generalized view that the higher the gamma reading the more is the level of concentration of heavy minerals for a spot.

d) The auger samples from the gamma anomalous spots specify that those spots are significantly rich in heavy mineral contents.

e) Repetition of depositional cycles are well indicated in auger samplings.

The findings are thus interpreted as the composite surface patterns of the heavy mineral lenses occurring in the studied area. The effectiveness of very radiometric survey in delineating the exposed pattern and extension of the heavy mineral deposit in the area is evidently observed. It is also viewed that in presence of detectable level of radioactive material in heavy mineral deposits of placer sand, application of radiometric survey is a very dependable nuclear technique for initial identification of the surface pattern of the deposit. Furthermore, many of the economically lucrative heavy minerals like Zircon, Garnet, Monazite etc., being light colored, despite their dominating presence the very initial detection of any such sand body in field with naked eye is greatly subject to confusion. However, the anomalous presence of natural gamma releasing materials in the sand body is easily identifiable with radiometric technique. Accordingly, application of radiometric survey at the pioneering stage of exploration is viewed to be a very good option in the ventures of exploration.

4. Conclusion

Radiometric survey found to be the cheapest but superbly dependable technique for identifying the extent and the continuity of the heavy mineral lenses and the gaps too in between two successive ones. All these elements are very much helpful for planning required number of drillings well within the deposit body and executing drillings in the radiometrically located places of interest. Eventually, the findings would enable outlining at the initial stage the area to be necessarily brought under the exploratory drilling program. The strive is thus viewed to frame a guideline for cost effective exploratory drilling program by keeping the efforts limited well within area of interest and by avoiding erratic execution of drills in an area that might enhance exploration expenses for unproductive exploratory drills.

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