ISERME 2024 Proceedings
2nd September 2024 – Sapporo, Japan
https://doi.org/10.31705/ISERME.2024.20

Characterization of Heavy Minerals in Nilaveli and Batticaloa Beach Stretches

Benjamin[1] R, Anojithan[1] M, Lokugamhewa [1] SW, *Ratnayake[1] NP, Abeysinghe[1] AMKB, Premasiri[1] HMR, Dushyantha[2] NP, Batapola[1] NM and Dilshara[1] RMP
[1]*Department of Earth Resources Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka*
[2]*Department of Applied Earth Sciences, Faculty of Applied Sciences, Uva Wellassa University, Sri Lanka*
*Corresponding author – Email: nalin@uom.lk

Abstract

The northeastern coast of Sri Lanka is notable for its significant heavy mineral deposits, especially the Pulmoddai deposit (containing 70-85 wt% heavy minerals) and the Verugal deposit (containing 45-50 wt% heavy minerals). However, regions like Batticaloa and Nilaveli remain underexplored and show potential. This study conducted a comparative analysis of these two beaches stretches to characterize their heavy mineral content in beach sand. Twenty-four composite samples were collected along the Batticaloa (n=17) and Nilaveli (n=7) stretches. Bromoform separation was used to determine their heavy mineral contents, followed by petrographic microscopic grain counting to ascertain the volumetric percentage of each heavy mineral type. The results revealed a higher mineral content in the Batticaloa beach stretch (1.20-14.50 wt%) compared to Nilaveli (0.36-6.42 wt%), despite Nilaveli's proximity to the Mahaweli River. The Batticaloa beach stretch showed average contents of 53.14% ilmenite, 2.06% rutile, 6.44% garnet, 31.94% zircon, and 4% monazite, indicating a significant potential for economically valuable monazite. The high heavy mineral content identified in the Batticaloa beach stretch suggests that further detailed explorations are warranted to assess the economic viability of the deposit.

Keywords: Beach Sand; Bromoform separation; Heavy minerals; Ilmenite

1 Introduction

Heavy minerals, including ilmenite, rutile, garnet, zircon, and monazite, are valuable due to their industrial applications and economic importance. Titanium minerals like illmenite are generally used for the production of pigments and welding electrodes and zircon minerals are used for the production of ceramic, refractory materials, and aerospace components [1]. Their distribution and concentration can be influenced by various geological and environmental factors [2], [3]. The enrichment of heavy minerals in beach sands depends on weathering of source rock, mechanical erosion, transport, hydrodynamic, sorting, and accumulation at suitable sites [4].

The northeastern coast of Sri Lanka is renowned for its heavy mineral-rich deposits such as Pulmoddai and Verugal, which contain significant percentages of heavy minerals [5]. The Pulmoddai deposit contains approximately 70-85 wt% heavy minerals, while 45-50 wt% of heavy minerals present in the Verugal deposit [6]. Despite these well-known deposits, other areas such as the beaches of Nilaveli and Batticaloa remain unexplored, thus further investigations are required to unravel their heavy mineral potential. Therefore, this study focuses on the characterization of heavy minerals along these beach stretches.

This study will contribute to the understanding of heavy minerals distribution in the northeastern coastal regions of Sri Lanka, which will underscore the economic potential of these untapped resources. Further exploration and detailed analysis could pave the way for sustainable exploitation of these minerals, benefiting the local economy and contributing to the national growth.

2 Methodology

2.1 Study Area

The study areas of the research are Nilaveli and Batticaloa-Padirippu beach stretches, which extend over lengths of 10 km and 23 km, respectively. The Mahaweli River is the main source of sediments for these two beaches. The Nilaveli deposit is located approximately 37 km northward from the mouth of the Mahaweli River whereas the Batticaloa-Padirippu deposit is located about 141 km southward from the river mouth (Figure 1). The northeast monsoon generally contributes the enrichments of these heavy minerals in the beach sand [2], [5].

Figure 1 Location map of Batticaloa and Nilaveli beaches.

2.2 Sample Collection

The study area was divided into exploration blocks, and in those blocks, suitable points on the beach face were selected to collect the samples as shown in Figure 2. At each location, 3 kg of composite samples were collected representatively using a hand auger. Near each selected sampling point, three pits were dug at the beach face to a depth of 0.5 m, which is the accepted mining depth in beach-faces of Sri Lanka. A composite sample was then prepared from the sand samples obtained from these three pits.

2.3 Sample Analysis

To identify and quantify the heavy minerals, it is essential to separate them from the beach sand. Due to their high density, heavy minerals can be efficiently separated using bromoform method, [6]. The separation process involved oven-drying 1 kg of samples at 105ºC for 4-5 hours, sieving through a 1 mm sieve, and then, treating 250 g of the sieved sample with 0.3% NaOH. After stirring and neutralizing with distilled water, the sample was oven-dried again, sieved through a 45 µm sieve, and 125 g of retained sand was separated using 200 ml of analytical grade bromoform in a separation funnel. The process was repeated twice to optimize separation, and the separated heavy minerals were then dried and weighed. The heavy mineral percentage in each sample was calculated.

The separated heavy minerals were analysed using a petrological microscope under reflected and transmitted light to identify and count each heavy mineral component (ilmenite, rutile, garnet, monazite, zircon, and quartz). Samples were prepared by drying the separated heavy mineral particles at 105 ºC for 48 hours, then spreading them in a single layer on a microscopic slide with a sugar solution to ensure a thin layer. The prepared slides were mounted on a microscope stage, and the distinct optical properties of the minerals were used to identify the minerals and count each mineral type which were repeated at three different locations for averaging.

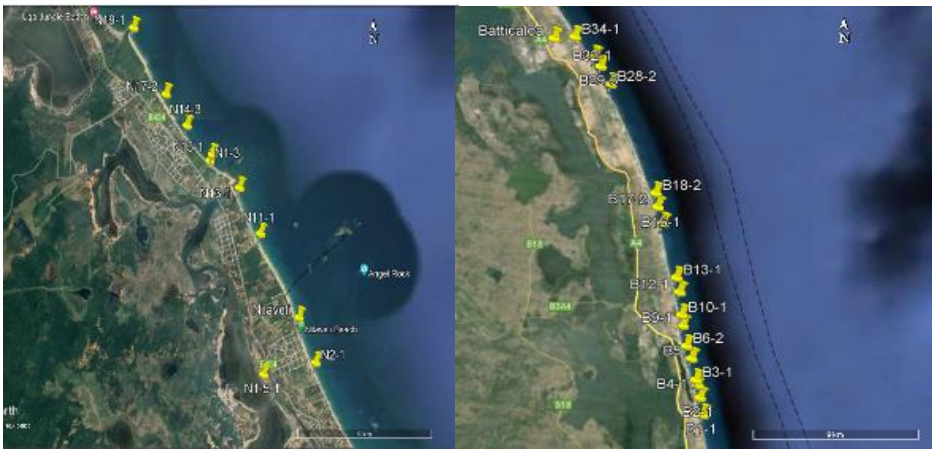

Figure 2 Sampling locations in Nilaveli and Batticaloa beaches

3 Results and Discussion

The total heavy mineral (THM) percentages of sand samples at Nilaveli and Batticaloa beach stretches were compared (Figure 3). Accordingly, the Batticaloa beach stretch has a higher THM content (1.20-14.50 wt%) compared to the Nilaveli one (0.36-6.42%), showing a high potential for exploiting heavy minerals in the Batticaloa beach. Moreover, most of the sand samples in Batticaloa beach exceeded the economic grade of heavy minerals (5%). Therefore, this study further characterized different heavy mineral composition in the Batticaloa beach (Figures 3-8).

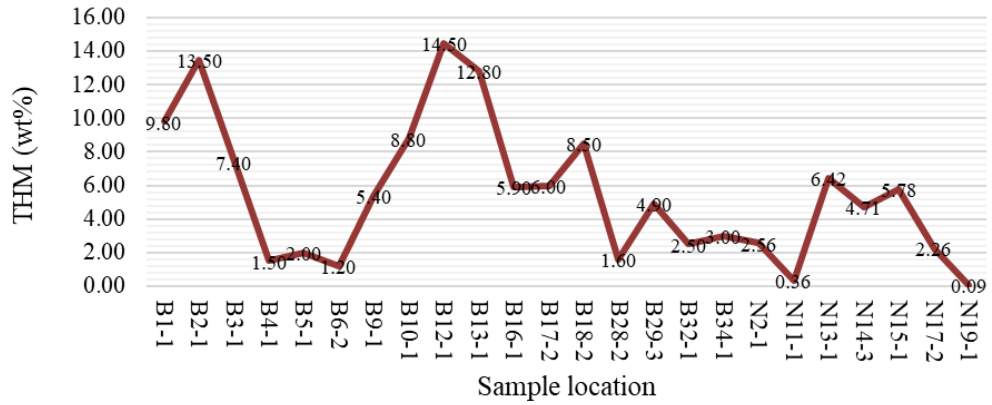

Figure 3 A comparison of total heavy mineral content between Batticaloa and Nilaveli beach stretches.

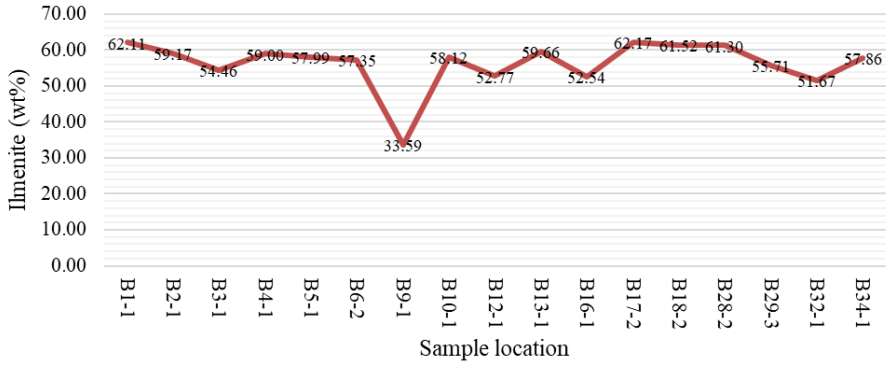

Figure 4 Ilmenite content out of THM content at each sampling location of the Batticaloa beach stretch.

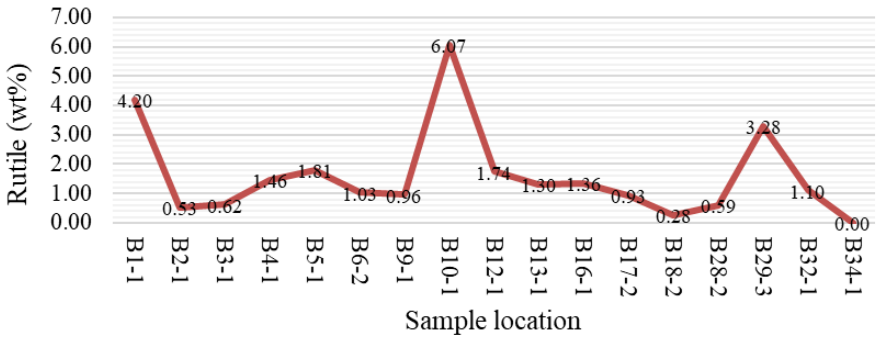

Figure 5 Rutile content out of THM content at each sampling location of the Batticaloa beach stretch.

Figure 6 Monazite content out of THM content at each sampling location of the Batticaloa beach stretch.

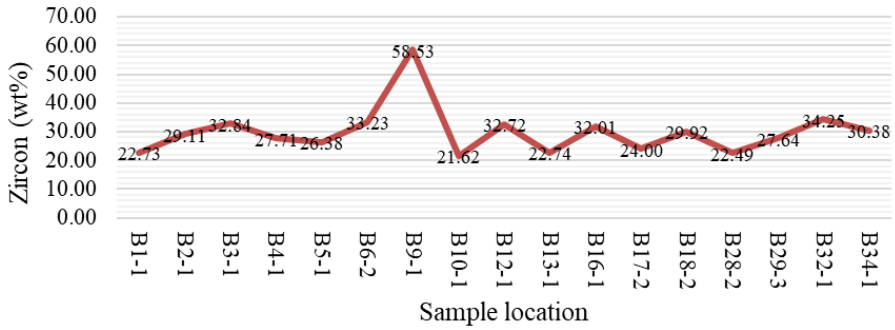

Figure 7 Zircon content out of THM content at each sampling location of the Batticaloa beach stretch.

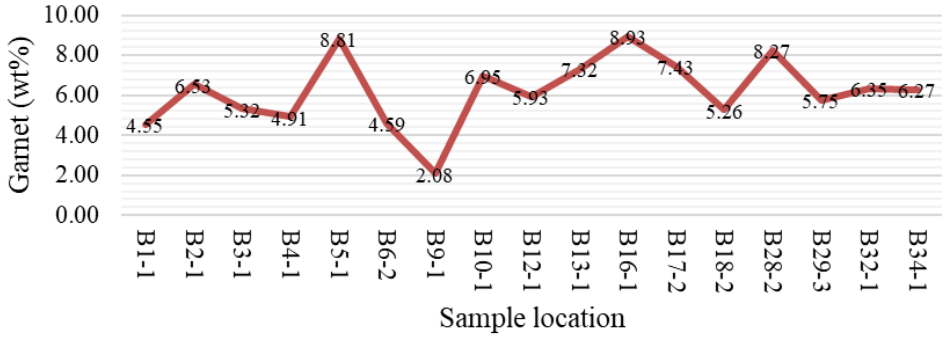

Figure 8 Garnet content out of THM content at each sampling location of the Batticaloa beach stretch.

In Sri Lanka, a deposit with heavy mineral content greater than 5% can be considered a potential deposit [5]. The ilmenite content in the study area remains relatively constant, as shown in Figure 5 except in B9-1 location. Conversely, zircon concentration in the same location showed a high percentage whereas the other locations remained unchanged. However, rutile, monazite, and garnet concentrations in beach sands showed notable changes with the sampling locations.

The present study showed high potential for monazite in Batticaloa deposit ranging from 1.36-6.05%. Since monazite is currently explored to extract rare earth element (REE) globally, with a high market price (6500 USD/MT according to unpublished data from LMSL), these findings add significant value to this area (Figure 6) [9], [10].

4 Conclusion

This study reveals that Batticaloa beach stretches, with an average heavy mineral content of 6.43%, have higher potential compared to Nilaveli beach (4.17%). Most sand samples in Batticaloa showed high heavy mineral potential, particularly for ilmenite and zircon. Despite B9-1, the ilmenite and zircon concertation in each sand samples stayed steady whereas rutile, monazite, and garnet showed significant fluctuations. Furthermore, the high monazite concentration in these samples increase the economic value of the deposit, showing new pathways for the economic growth in Sri Lanka. These findings require further exploration and investment to harness the substantial heavy mineral resources in the northeastern coastal stretch of Sri Lanka, which can contribute to the nation's economic growth.

Acknowledgement

The authors wish to acknowledge the technical support and guidance provided by Ms. W.A.S.M Wickramaarachi, and Ms. A.R. Amarasinghe of the Department of Earth Resources Engineering, University of Moratuwa. Furthermore, authors are grateful for all the academic and non-academic staff in the Department of Earth Resources Engineering for their immense support during the project.

References

[1] A. Papadopoulos, I. T. Tzifas, and H. Tsikos, "The potential for REE and associated critical metals in coastal sand (placer) deposits of Greece: A review," *Minerals*, vol. 9, no. 8, p. 469, 2019.

[2] U. Perera, A. S. Ratnayake, W. Weerasingha, H. C. S. Subasinghe, and T. D. U. Wijewardhana, "Grain size distribution of modern beach sediments in Sri Lanka," *Anthr. Coasts*, vol. 6, no. 1, p. 10, 2023.

[3] C. S. Subasinghe *et al.*, "Global distribution, genesis, exploitation, applications, production, and demand of industrial heavy minerals," *Arab. J. Geosci.*, vol. 15, no. 20, pp. 1–28, 2022.

[4] G. M. Mudd and S. M. Jowitt, "Rare earth elements from heavy mineral sands: assessing the potential of a forgotten resource," *Appl. Earth Sci.*, vol. 125, no. 3, pp. 107–113, 2016.

[5] H. C. S. Subasinghe, A. S. Ratnayake, and K. A. G. Sameera, "State-of-the-art and perspectives in the heavy mineral industry of Sri Lanka," *Miner. Econ.*, vol. 34, no. 3, pp. 427–439, 2021.

[6] R. M. L. Udarika, E. P. N. Udayakumara, K. Amalan, N. P. Ratnayake, and H. M. R. Premasiri, "Comparison of heavy mineral composition along Mahaweli River with placer deposits at North East Coast of Sri Lanka," in *International symposium on agriculture and environment*, 2016.

[7] G. Shalini, V. S. Hegde, M. Soumya, and M. M. Korkoppa, "Provenance and Implications of Heavy Minerals in the Beach Sands of India's Central West Coast," *J. Coast. Res.*, vol. 36, no. 2, pp. 353–361, 2020.

[8] S. Ghosal, S. Agrahari, D. Banerjee, and D. Sengupta, "Assessment of Natural Enrichment of Heavy Minerals along Coastal Placers of India: Role of Lake and River Mouth Embayment and Its Implications," *Spat. Model. Assess. Environ. Contam. Risk Assess. Remediat.*, pp. 69–81, 2021.

[9] N. Dushyantha *et al.*, "The story of rare earth elements (REEs): occurrences, global distribution, genesis, geology, mineralogy and global production," *Ore Geol. Rev.*, p. 103521, 2020.

[10] N. M. Batapola *et al.*, "A comparison of global rare earth element (REE) resources and their mineralogy with REE prospects in Sri Lanka," *J. Asian Earth Sci.*, vol. 200, p. 104475, 2020.