Comparison of Heavy Mineral Composition along Mahaweli River with Placer Deposits at North East Coast of Sri Lanka

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Abstract
Pulmoddai and Verugal are two economically important heavy mineral beach placer deposits located on the northeast coast of Sri Lanka. Pulmoddai deposit is situated northward from the Mahaweli River mouth while the Verugal deposit is situated southward from the river mouth. At present, Pulmoddai is exploited for Ti and Zr raw material, whereas Verugal deposit is still in exploration stage. In the present study, we investigate and compare heavy mineral composition of selected locations along Mahaweli River and Pulmoddai and Verugal deposits to understand the river contribution of sediments towards these placer deposits. Sediment samples were collected from representative places along the Mahaweli River and both placer deposits. Sieve analysis was carried out to identify the textural significance. Panning was done to separate heavy minerals from the samples. Accuracy and reliability of panning process was tested using bromoform test. Grain counting method through a petrological microscope was used to analyze the mineral types in the panned heavy mineral fraction and to calculate their volumetric percentages. Data were analyzed using Gradistat™ 4.0 software. Results revealed that Ilmenite, Rutile, Zircon and the Garnet were the dominant heavy minerals in the northeast coast and the Mahaweli River sediments. Further, results revealed that heavy mineral assemblage of Mahaweli River sediments and Verugal deposit are more or less similar in heavy mineral composition in contrast to Pulmoddai deposit. These results support Mahaweli River sediments, mainly transport its sentiments towards the Verugal deposit.

Keywords: Heavy minerals, Mahaweli River, Placer deposits, Pulmoddai, Sri Lanka, Verugal

Introduction
Heavy mineral sands are placer deposits formed commonly in beach environments by concentration due to the specific gravity of the mineral grains (Baker, 1962). Heavy mineral sands have density over 2.6 g/cm^{-3} and are economically important and rich in titanium and zirconium. The current contribution of heavy mineral resources of Sri Lanka to the global economy is significant. The sources of these deposits may be the weathered and eroded hard rocks, transported through rivers into the ocean. Ocean waves and current results mechanical concentration of more resistant and high specific gravity minerals in the beaches (Amalan *et al.*, 2014 and Rantayake *et al.*, 2010). Eastern coast and Western coast of the island has been identified as the major potential areas of heavy minerals (Fernando, 1986). The Pulmoddai beach placer deposit is situated at 54 km North from the Trincomalee bay and extends a distance of 7.4 km with an average width of 150 m. Verugal deposit is around 50 km southward from the Trincomalee bay and spreads along an area more than 3kms (Fernando, 1986). Mahaweli River is the longest river (335 km) in Sri Lanka and one of the most economically and geologically important river systems which covers almost one-sixth of the island and mainly believed to be contributing towards all the north eastern coast heavy mineral deposits. The drainage basin encompasses an area of 10,448 km^2 covering large areas of highland complex metamorphic rocks. The river is flowing to the sea at the bay of Trincomalee through several distributaries in N-E of the country.

This study aims to identify contribution of Mahaweli River towards North-East Coast placer deposits. Criteria to determine sediment provenance are based on comparing the different textural and compositional properties of sediments from the system and nearby areas. Therefore, this study was focused on identifying textural and mineralogical variations along Mahaweli River, Verugal placer deposit and Pulmuddai placer deposit to identify river contributions towards the north east coast placer deposits.

Materials and Methods
Sampling locations (n=24) were initially selected by studying the aerial photographs and topographic maps. Sampling was carried out during the month of March 2014. The sample size was approximately 4 kg to 5 kg because samples were required for multiple analyses to

increase accuracy and precision of the results. Samples were collected along the Mahaweli River and from the Verugal and Pulmoddai deposits. Twelve stream sediment samples along the Mahaweli River from selected locations (Figure 1), nine sediment samples from the Verugal deposit and three sediment samples from the Pulmoddai deposit were collected for this study (Figure 1). Three replicate samples were taken from each location. Field observations on the sampling environment were noted down and all sampling points were located using GPS with an accuracy of ±5 m. The river samples were taken from the point bars of the Mahaweli River because most heavy minerals tend to deposit at the point bars.

Sample analysis included textural and mineralogical analysis of heavy minerals. Textural parameters of sediments were determined using dry sieving for bulk sediment samples. The sediment samples were oven dried at 105 ^{0}C for 24 hrs and sieve analysis was done using ASTM D 422 standard sieves (2 mm, 0.850 mm, 0.5 mm, 0.425 mm, 0.250 mm, 0.180 mm, 0.125 mm and 0.075 mm). 250 g of oven dried samples were panned carefully to remove lighter mineral particles with water and remaining heavy mineral particles were dried in an oven at 105 ^{0}C for 48 hours to use for the grain counting. Heavy mineral separation for selected number of samples using bromoform was conducted for the panned heavy mineral fraction to check the accuracy and reproducibility of the panning process. Grain counting was carried out to determine the relative abundance of heavy minerals in the sediment samples using reflective microscope. Mineral grains, spread on a glass slide, consisted with a grid of 1mm squares were used for the grain counting (Figure 2). At one time, approximately 200 mineral grains were counted and two further counting were made in the same sample. Therefore, 600 grains were counted from each sediment sample since the accuracy of heavy mineral analysis is largely a function of the number of grains counted on a microscopic slide. Volumetric percentages of each heavy mineral of each location were calculated based on these grain counting results.

Results and Discussion

The heavy minerals in all locations were consisted of ilmenite, rutile, zircon, garnet and monazite (Figure 2). The main concentrations of heavy minerals of Pulmoddai were confined to 180-125 and 125-75 µm fractions. Ilmenite was

Figure 2: Identified heavy minerals through a reflective microscope

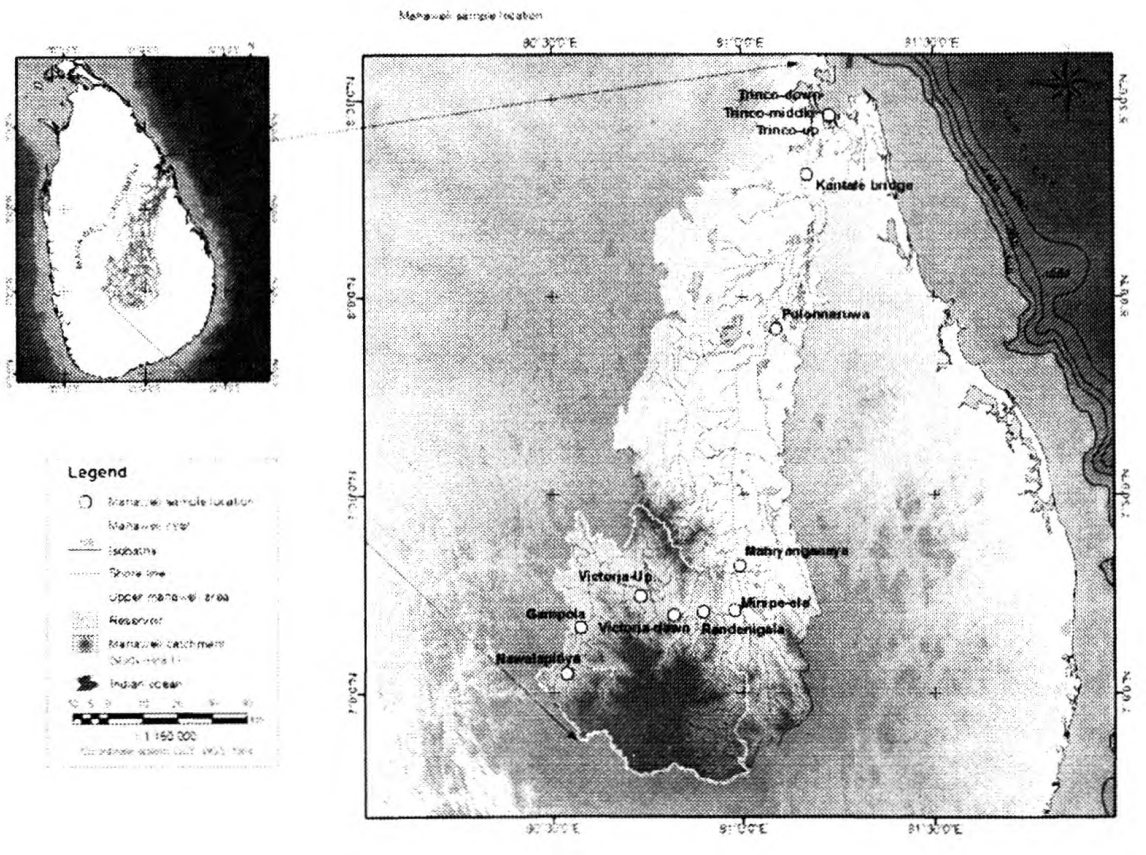

Figure 1: Sediment sampling locations along Mahaweli River

the main mineral component around 65%-70%. zircon and rutile were approximately 10-15% and garnet and monazite were the lowest around 2-5%. In Verugal deposit, heavy minerals were concentrated into the 250-180 and 180-125 μm fractions. Although ilmenite was the most abundant mineral (50%) in the deposit, its average value was lower than that of Pulmuddai deposit. zircon and garnet were around 10-20% and monazite and rutile were in very low amount compared to the Verugal deposit.

Mahaweli River has a high concentration of ilmenite, zircon and garnet and low concentration of rutile and monazite with a similar mineral composition to the sediments of Verugal deposit (Figure 3). Results show heavy mineral assemblage of Mahaweli River and Verugal deposit are more or less similar while heavy mineral assemblages of Pulmoddai deposit differ from the Mahaweli River.

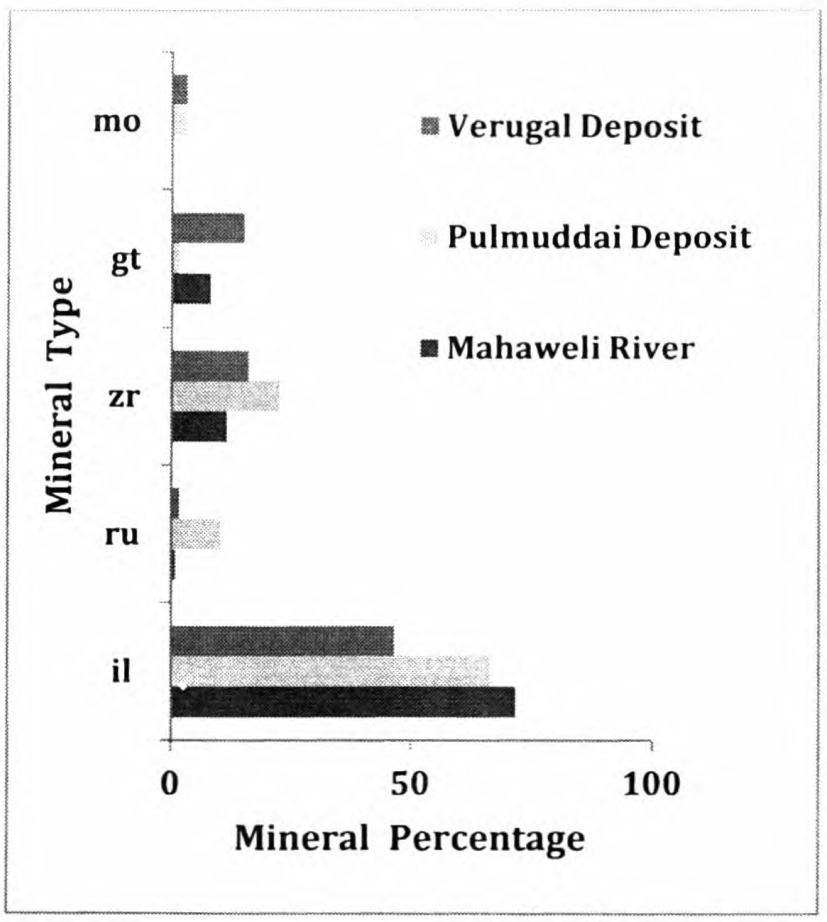

Figure 3: Average mineral percentage variation of Magaweli River, Verugal deposit and Pulmoddai deposit (il=ilmenite, ru=rutile, zr=zircon, gt=garnet, mo=monazite)

Comparison of average mineralogical data of the identified deposists with possible sources is important to understand the provenance of the deposit, because they have similar mineralogical assemblages (Kumar and Sreejith, 2010). Therefore, results indicated that Mahaweli River can be the major source area of the Verugal placer deposit. Although both deposits are located approximately similar distance, Verugal deposit may have more influence from the Mahaweli River. However, study of ocean currents related to sediment dynamics and isotopic analysis are necessary for precise source recognition.

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