Sedimentology and Clay Mineralogy of Blanket Deposit in Horton Plains

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1. Introduction

Occurrences and characteristics of Sri Lankan surficial deposits have been studied intensively (Cooray, 1984; Dahanayake et al., 1985). The Palaeoecological approach, extended to analyse surficial deposits, facilitates discovering of palaeo-climatic conditions. Perhaps it could be used to build up constructing models of reoccurrence of similar events (Premathilake and Risberg, 2003). Varve-like depositional sequences associated with disc shaped striated pentagonal pebbles have been recorded in Wauda sediments in Sri Lanka. These sediments are dated back to Permocarboniferous period and originated by glacial process as an exception to the quaternary surficial deposits (Dahanayake and Dassanayake, 1981).

Grain size distribution analysis followed by statistical treatment and grain morphometric analysis are useful tools to distinguish between different facies and energy regime dominated at the deposition (Drake, 1971; Tucker, 1981). Clay mineralogical studies provided invaluable insight into climatic conditions due to their environment specificity of weathering nature (Eherman et al., 2007; Chandrajith et al., 2009). Even though the fine sediment layers have been analysed extensively, gravel beneath the fine sediments has not been given sufficient attention. Present study investigates field relations, sedimentology and clay mineralogy and grain morphometric relations to unravel the origin of sedimentary sequences in the Horton plains, Sri Lanka.

2. Methodology

Stratigraphic sections were studied inside of HPNP and the surrounding area. Samples were collected from selected stratigraphic sections exposed along road cuts and at specific locations using 2” drill cores. Granulometric analysis was done by sieve/pipette methods and results were plotted as cumulative curves. Statistical parameters were calculated in phi units using cumulative curves. Sand grains separated from fine grain samples were observed under the microscope with a view to determine the radius of grains and the mineral content.

The long (L), intermediate (I) and short (S) axes of 375 selected pebbles were measured using vernier caliper. Sphericity \( \left( \varphi^3 \right) \) was determined using the Krumbein (1941) intercept sphericity equation \( \left( \varphi^3 = 15/S/L^2 \right) \) (Hoffmann, 1994). Roundness was determined by comparing each pebble to the Krumbein...
visual roundness chart. Shape was determined using the Zingg (1935) shape diagram and assigning each pebble to a shape category based on calculations.

Clay particles separated from HPNP samples were analyzed using XRD (X-Ray Diffraction) and TGA (thermo gravimetric analysis) at the University of Peradeniya, Sri Lanka.

3. Results and Discussion

Two categories of depositional sequences were observed in the Horton plain area (Figure 1). The two layer sequence is composed of Sandy silt/Silty sand top layer with a non-stratified Sandy pebbles at the bottom. The four layer sequence is composed of 1. Thick non-stratified sandy pebbles; 2. Sandy silt/silty sand; 3. Thin non-stratified sandy pebble; 4. Thick sandy silt/silty clay above the bedrock.

General thickness of sandy pebble layers varies from 8 up to 50cm in the valley bottom. The upper sandy pebble layer always displays lower thickness compared with the basal layer. Thickness of the dark sandy silt/clay layers are ranging 50 - 150cm in most cases. However the general thickness of the layer deviates at certain localities. Sandy pebbles lie either on the bed rock or on the yellowish saprolite layer above the bed rock depending on the erosive power generated by running water. Boundaries between these layers are sharp with a clear-cut boundary marking the blanket deposits. Similar observation was reported in the Liffey valley blanket peat deposit in Ireland (Thorp, 2003). Extent of deposit visually spreads up to the margin of the grassland and with thickness increasing towards the bottom of valley while it is tapering off towards the margin of the grasslands as observed along the road cuts. These sediments can be divided in to six categories as silty sand, sandy silt, sandy clay, clayey sand, silty clay and sandy pebble where particle size distribution is bimodal to multimodal that are particle distribution shows several peaks. High clay content at L8 and L9, which were collected from bogs outside of the HPNP, pointed out a major deference in origin of Horton Plains fine sediment layers from those observed at present bogs (Figure 2). These sediments are rich in silt, which indicate a characteristic feature of sub glacial tills (Haldrosen, 1981). Winter et al. (1973) Suggested particle size distribution for modern glaciated lands in Northeastern Minnesota, USA and that of HPNP sediments are closely comparable (Figure 2).
Standard deviation of HPNP sediments vary between 2.315 and 5.125 indicating poor sorting due to quick deposition (Tucker, 1991). Winter et al. (1973) recorded that majority of glacial samples are negatively skewed that also common to the HPNP sediments. Glacial sediments get more negatively skewed along glacier’s transportation path (Tucker, 1991). Most of HPNP samples are also negatively skewed showing a long transportation path for its sediments. Winter et al. (1973) recorded that the majority of fine grain till samples are negatively skewed. However, some desert dune sands also show a negatively skewed nature (Kukal, 1971). Moreover, Kukal (1971) mentioned that the negative skewness is also common to very fine glaciolacustrine sediments and Plots of phi diameter (Mdφ) versus phi skewness (αφ) for HPNP sediments agree with glacial sediment samples and most data points are concentrated in region for glaciolacustrine sediments. In addition HPNP sediment also favourably agree with glacial sediments when considering the plots of graphic mean versus inclusive graphic standard deviation and inclusive graphic skewness versus inclusive graphic standard deviation variations. Median grain size in HPNP is smaller than that of loesses. The percentage of silt fraction is also low compared to loess that generally lay within 60% to 80%. Standard deviations of loess ranging from 1 to 3, however sediments from HPNP frequently exceed 3 (Kukal, 1971). These parameters deviate from the origin from pure eolian process for HPNP sediments.

The radius ratio of quartz grains to that of heavy minerals is another significant indication of a sedimentary environment (Friedman, 2008). The radius ratios of sand portions in HPNP sediments have values for both alluvial and eolian origin. However, sand grains found in HPNP are angular to very angular in shape and striates sand grains with two to five individual marks are present indicating sand subjected to high pressures (Chakroun et al., 2009). Chakroun et al. 2009 suggested that sand grains are rounded for an eolian origin. High angular to sub angular sand grains are reported for englacial and supraglacial samples from modern glacial environments (Helan and...
Holmes, 1997). Sand grains found in HPNP are very angular to angular in shape. The plots of pebble shape versus pebble percentage and roundness value variations show a similar trend which was recorded by Hassler and Cowan (2001) for ice rafted sediments in west of Antarctic Peninsula (Figure 4). The sharp drop of the visual roundness values around 0.5 is significant in HPNP sediments. Drake (1971) also mentioned such characteristic drop of roundness values around 0.5.

![Figure 3](image-url)

**Figure 3** - Visual roundness versus pebble percentage for total pebble population

in New Hampshire, East Central America. An average pebble survives long enough to abrade to roundness 0.5 and then is crushed (Figure 3). It suggests that clasts undergo several cycles of crushing and abrasion per mile of transport (Drake, 1971). Dahanayake and Dassanayake (1981) recorded that striated and pentagonal pebbles as characteristic features of glaciated terrain. Pebbles with pentagonal outline are common in HPNP pebble population. Clay mineralogical analysis indicates presence of kaolin, illite, vermiculite and montmorillonite. Presence of smectite group minerals and high amounts of illite is characteristic for glacial sediments.

![Figure 4](image-url)

**Figure 4** - Plot of pebble shape versus pebble percentage for all three sites.

Kaolinite is normally derived from chemically weathering and requires humid and warm conditions (Ehermann et al., 2007). Premathilake and Risberg (2003) suggested arid phases may be indicated by the presence of kaolin in sand/sandy silt layers.

4. Conclusions
Sedimentological indications and morphological occurrences of the HPNP sediments support for glacial origin, however subsequent reworked by the alluvial and eolian processes were evident.

5. Acknowledgements
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6. References


