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PALEOZOIC GLACIAL SEDIMENTS OF SRI LANKA OBLITERATED BY NEOTECTONIC EVENTS? WEUDA DEPOSITS REVISITED

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ABSTRACT

A sequence of rhythmic varve like sediments within the valley of Weuda and isolated sand and gravel deposits in the northwestern plains of Sri Lanka, were reinvestigated. Inter-bedded peaty clay and sand intercalating with un-weathered feldspar, striated and faceted pentagonal quartzite pebbles, "U" shaped valley flanked with large boulders, isolated occurrences of poorly sorted white angular sands, ferruginized gravels and Permo-Triassic plant microfossils all favored a glacial origin for these sediments. However, Paleozoic glacial features appear to be either obliterated or erased due to post-glacial neotectonic movements, large scale pluvial processes, effects of denudation and intense tropical weathering. Study on provenance indicates that Paleozoic glacial deposits may have mixed with or covered by subsequent sediments.

Keywords: glacial sediments, neotectonic movements

INTRODUCTION

Fragments of information trickling through recent research findings are shedding some light to solve the dilemma of the origin for sediments deposited in the northwest Sri Lanka. Recent literature indicates possible glacial origin for some of the sediments (Dahanayake and Dassanayake, 1981; Dahanayake *et al*., 1989; Jayasena *et al*., 1983; Pitawala and Dahanayake, 1992). However, present topography and other features as used for the interpretations have cast some doubts on the origin of these unconsolidated sediments. The aim of this paper is to independently discuss the origin of rhythmic sequence of sand and peaty clay layers in Weuda area and sediments deposited in the Kurunegala District of the North Western province of Sri Lanka.

Geologic Framework

Geologically nine tenth of Sri Lanka is composed of Precambrian metamorphic rocks. They are subdivided into Highland Complex, Wanni Complex and Vijayan Complex (Cooray, 1991) (Figure 1).

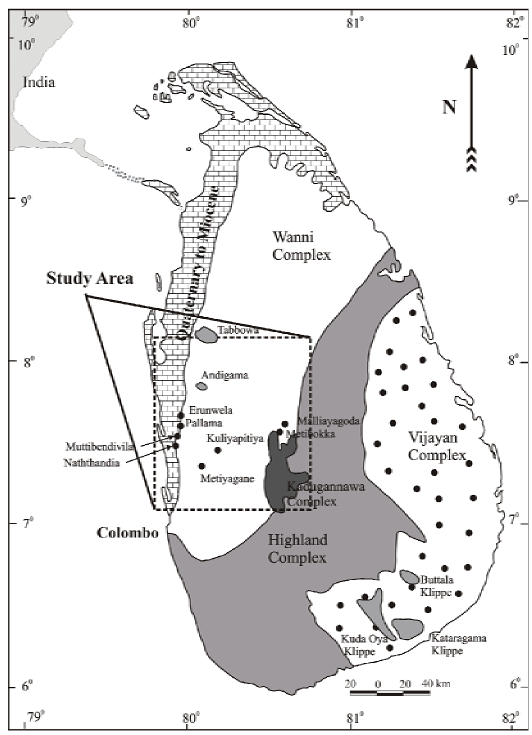

Figure 1: Geological Map of Sri Lanka (Modified after Cooray, 1984)

Highland Complex rocks extend in a broad band from southwest (Welipatanwila area) to the northeast (Trincomalee area). Meta-igneous rocks (charnockites, hornblende-biotite gneiss, migmatitic and quartzofeldspathic rocks) and metasedimentary rocks (quartzites, marble/dolomite and garnet-sillimanite-graphite schist) are present in the Highland Complex.

The Vijayan Complex lies east of the Highland Complex. It is composed of metamorphosed granitoids including charnockitic gneisses, migmatites, microcline - bearing quartzofeldspathic rocks, amphibolite and/or biotite gneiss.

Wanni Complex is located to the west of the Highland Complex and is composed of metamorphosed igneous and sedimentary rocks. Rock types present in this complex are more or less similar to those in the Vijayan Complex. In addition a small unit named "Kadugannawa Complex" is located in the central part of the country. This unit is composed of amphibolite or hornblende-biotite gneisses and migmatites. These rocks are exposed in doubly plunging synforms in the areas around Kandy (Vitanage, 1972).

The other remaining one tenth of the rocks in the island consist of Jurassic sandstones, shales and mudstones exposed in faulted basins at Tabbowa and Andigama, and Miocene limestones lying unconformably on the Precambrian basement of the North, Northwestern and Southeastern coastal belts (Cooray, 1984; Katupotha and Dias, 2001).

Quaternary sediments such as red earth in the Northwestern coastal belt overlying Miocene limestone, unconsolidated beach sand, alluvium, lagoonal and estuarine deposits, basal ferruginous gravels and terrace gravels are also present in a wide range of scattered locations. The origin of these deposits has been addressed by several workers (Cooray, 1963; Seneviratne *et al.,* 1964; Cooray, 1968; Cooray, 1984). Recently as buildings and other engineering structures were constructed within such deposits, new evidence favours large-scale erosional activities (Katupotha and Dias, 2001).

Modes of Occurrence

Surficial deposits disseminated within the area confined by longitudes 80° to 80°50'E and latitudes 7° to 8°N have been considered for the present study. Inter-bedded sand and peaty clay layers, which may have been reworked due to subsequent geological activities, are found at locations in the wide "U" shaped valley between the Weudakanda and Erapolakanda. Dahanayake and Dassanayake (1981), Jayasena *et al.,* (1983) and Pitawala and Dahanayake (1992), based on several studies, interpreted that these sediments as having formed due to either glacial or glacio-fluvial processes. These sediments with varying thickness lie on the crystalline basement of the Highland Complex.

A complete section reaching the bedrock in the central part of this valley has not yet been examined. However, deep drilling for groundwater exploration in the region has provided clues for the bedrock-soil interface sometime located at depths around 40 meters (Jayasena *et al.,* 1983). Observations made during field investigations of the study area, confirmed findings of Dahanayake and Dassanayake (1981). For example,

i. Pebbles in nonstratified unsorted sediments are mostly flattened and pentagonal in shape, quartzitic or quartzofeldspathic in composition. Polished and striated surfaces are rarely observed.
ii. Grains in the sand layers are angular, poorly sorted and are associated with unweathered feldspar.
iii. Rhythmic varve like layering with light and dark color sand and peaty clay layers were seen (Figure 2).
iv. Hard sand-bearing ferricrete crust was frequently observed at top and bottom of peaty clay layers.
v. Beds having convolution and hummocky cross bedding were seen in sand and sandy clay layers.

Representative stratigraphic sections were selected from Medamulla and Matibokka villages for further analysis (Figure 3). Rhythmic sedimentation of sand and peaty clay is the unique feature among these stratigraphic sections.

The peaty clay layers with an oily appearance are blackish gray in color and contain highly decomposed plant debris which gives sticky, highly plastic consistency. The layers contain minor proportions of angular quartz and feldspar in addition to clay minerals such as kaolinite, montmorillonite, volkonskoite and nontronite (Dahanayake *et al*., 1989). However, proportions of each clay mineral present vary from place to place and from top to bottom of the profile (Pitawala and Dahanayake, 1992).

Figure 2: Rhythmic varve like layering with light and dark color sand and peaty clay layers.

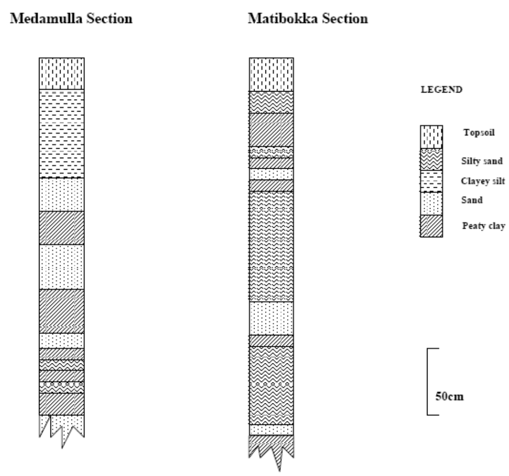

Figure 3: Stratigraphic sections of Medamulla and Matibokka areas.

Sand layers are dominated by coarse to fine angular quartz with small amounts of angular feldspar and minor proportions of hornblende and biotite flakes. Some layers from Malliyagoda section show dark colored bands of fine hornblende and biotite. Thickness of these layers varies from top to bottom. The sand layers in Matibokka region varies from 8cm to 1.5m while peaty clay layers ranges from few millimeters to a meter. At places, iron (Fe^{+3}) enrichments were evident by brick red colored sand present in the profile. These layers may represent transformation of the original deposits laid in the geological past under tropical climate. Well-preserved but highly decomposed assemblages of plant microfossils found in the peaty and sandy clay layers from Matibokka and Pussalla sections gave Permo-Triassic ages (?). However, significant discrepancies are associated with these ages (Dahanayake *et al*., 1989). The rhythmic varve-like feature could not be seen on the northeast and southwest sides of Weudakanda and Erapolakanda (Figure 4). This feature is gradually disappearing towards the Mawatagama area where one could observe two sedimentary facies separated by a very well-defined horizontal boundary. A striking feature of this latter section is the presence of well-defined nodular ironstones.

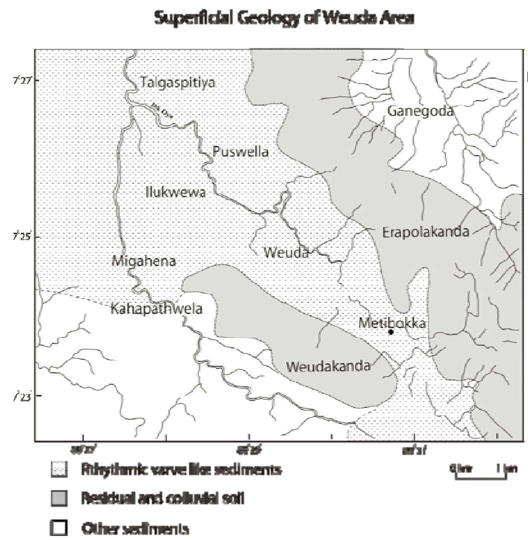

Figure 4: Superficial geology of Weuda area

A number of granitic gneiss flat pebbles with diameters ranging from approximately 0.3 – 2m rest on the dip slope of Weudakanda. These boulder-bearing deposits are characteristic features in the study area. They may have been transported along the dip slopes as landslide debris in the past; however subsequent *in-situ* spheroidal weathering has changed them to more or less spherical bodies at present. These deposits are not only common to Weudakanda and Erapolakanda slopes. Significant quantities of sub-rounded boulders with varying diameters are also scattered in other hill slopes adjacent to the study area.


(a)


(b)

Figure 5: (a) Section showing ferruginized and indurated gravel deposit in Metiyagane. (b) Photograph showing angular faceted quartz in the iron matrix

Weudakanda and Erapolakanda are covered with residual and colluvial (alluvium) soils (Figure 4). Some of these soils are reddish brown in color. Sub-aerial tropical weathering may have converted the original transported materials to iron-rich brown and reddish brown earth. Several intriguing isolated deposits were encountered along the descending areas starting from Weuda all the way towards the western coast in the northwest plain. They are white sand deposits in Naththandiya and suburban areas, ferruginized and indurated gravel bearing deposits exposed at Erunwela, Muttibendivila, Pallama, Metiyagane (Figure 5) and in the subsurface throughout the lower plains in the northwest (Cooray, 1963; Seneviratne *et al*., 1964; Cooray, 1968; Cooray, 1984); and poorly defined hummocky surfaces as at Kuliyapitiya and surrounding areas. This study has not been extended further to analyze these sediments; however we are questioning, as per these observations, whether the sediments were representing battered outwash plain deposits produced at several stages in the glacial history.

DISCUSSION AND CONCLUSIONS

Using detailed granulometric analysis followed by statistical treatment, Dahanayake and Dassanayake (1981) concluded that the sand and peaty clay layers in the Weuda area have a glaciofluvial origin. They plotted phi Skewness versus phi Median and Inclusive Graphic Standard Deviation against graphic Mean of the sediments and compared these with similar sediments found elsewhere to arrive at this conclusion. Pitawala and Dahanayake (1992) in addition carried out a separate study using the same set of statistical tests and obtained more or less similar results. Therefore, they concluded that the clay minerals in the Weuda sediments were characteristic of the clay minerals of glacial sediments in other parts of the world.

Palynological studies of plant microfossils preserved in the sediments indicate a Permo-Triassic age (Dahanayake *et al*., 1989). About 200 million years B.P, Sri Lanka was a fragment of East Gondwanaland together with India, Madagascar, Australia and East Antarctica (Dalziel, 1997 and Unrug, 1997). It should be noted here that the early Permian is the period during which the Gondwanaland experienced very cold climates that would have supported glaciations.

However, middle Permian is the period when Paleozoic climate changed from colder to a much warmer phase (Rees *et al*., 1999).The ages of the glacial period of Gondwanaland and those of plant microfossils found in Weuda sediments are more or less compatible; however, it is questionable whether the sediments could be preserved with the original structures after more than 200 million years. Even if the sediments were reworked, the preservation mechanism may need careful examination, or else, the unconsolidated sediments at present must have been preserved under very low denudation rates. Moreover, the glacial origin of the rhythmic varve like sand and peaty clay layers in Weuda can be questioned, as they do not show some characteristic features of typical varves, such as thin cyclothems with more or less similar thickness of sand and clay layers.

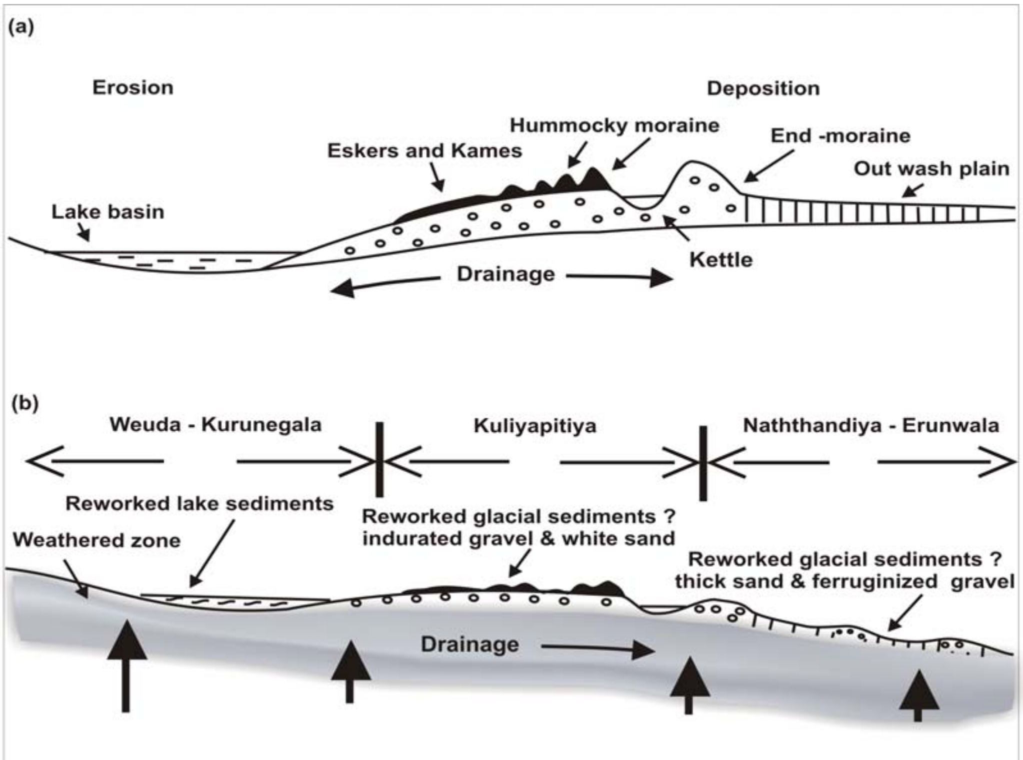

Figure 6: (a); Morphology sequence and type of sediments in an environment of ice retreat (modified after West, 1977) (b); Schematic diagram showing similar but reworked morphology sequence and type of sediments in northwest Sri Lanka. The neotectonic movements and denudation may be responsible for the present scattered deposits (?). The dark arrows and their relative lengths indicate differential upwarping. The distance for the section from Weuda to Erunwala is approximately 34 km

However, there are locations where the thickness of the glacial sediments (sand and clay layers) is not similar. The best example could be taken from the Glacial Lake Hitchcock in USA. The thickness of sand and clay layers of Glacial Lake Hitchcock varies from top to bottom of the profile (Ridge and Larson, 1990). However, it is difficult to imagine that the original shape and structures of glacial sediments at Weuda would be preserved for a period of more than 200 million years. Moreover, the morphology of the entire region and the mode of occurrence of the sediments indicate large-scale physical effects supporting a glacial origin for the sediments (Figure 6).

It should be noted that, regional neotectonic movements have changed the island's subdued morphology of the Paleozoic Era to three well-defined peneplains (Vitanage, 1970, 1972). This may have changed the original morphology and the depositional sequences. In line with the above thinking, widespread denudation during Quaternary period (Cooray, 1984) could have erased significant portions of evidence left behind by glacial processes within the island. Probably this particular sediment sequence may have been deposited in a "lake environment" and subsequently reworked at several stages before exposed as remnants at Weuda. Therefore, isolated occurrences of indurated ferruginized gravel deposits, white sand deposits and hummocky surfaces might also be representing a transformed, earlier glacial outwash deposit (Figure 5b).

On several isolated hill ranges, such as Nilgiri, Animale, Shivarai and other isolated plateaus in southern India, as well as on some mountains in Sri Lanka, temperate flora and fauna have been found. They do not exist in the low plains of southern India, but closely allied to the temperate flora and fauna of Himalayas, the Assam Range, the mountains of the Malay Peninsula and Java (Wadia, 1973). These observations support the idea that not only in Paleozoic Era but also in Pleistocene Epoch, temperate climates could support the existence of glaciation.

In this paper, the authors have discussed the facts that support the glacial origin of the rhythmic varve like sand and peaty clay layers in the Weuda area. Weuda is the only location where sediments of such nature have been proven to be of glacial origin. A sediment facies of pre-Jurassic period, the origin of which has not been established was reported from Tabbowa beds of northwestern province of Sri Lanka (Kehelpannala and Vitanage, 1983). Further, the unidentified sediment layer sandwiched between Miocene limestone and basement gneisses discovered by the magnetic surveys may have formed by glacial processes during the Permo-Triassic period (Tantirigoda and Geekiyanage, 1988). There can be other locations in Sri Lanka, where sediments deposited during Paleozoic glaciations may have been subsequently covered or mixed with Quaternary formations. However, we are aiming at extensive granulometric and palynological studies of samples collected at selected locations by deep drilling, as a further study in order to unravel the true identity of these sediments.

The authors plan to implement the above as a regional study incorporating intensive investigations in many parts of Sri Lanka and integrate the same with studies on surficial sediments in other fragments of the Gondwanaland. The authors believe it is important to carry out intensive research on surficial deposits as at Weuda to solve the baffling geological history of Sri Lanka.

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REFERENCES

Cooray, P.G., 1963. The Erunwela gravel and the probable significance of its ferricrete cap. Ceylon Geogr., 17:39-48.

Cooray, P.G., 1968. The geomorphology of part of the north-western coastal plain of Ceylon. Zeits. f. Geomorph. (Annals of geomorphology) NF Supp. 7:95-113.

Cooray, P.G., 1984. An Introduction to the Geology of Sri Lanka (2nd Edition), National Museum of Sri Lanka Publication, Colombo, 340 p.

Dahanayake, K., and Dassanayake, D.M.S.M., 1981. Glacial Sediments from Weuda Sri Lanka, Sedimentary Geology 30, 1-14.

Dahanayake, K., Jayasena, H.A.H., Singh, B.K., Triwari, R.S., and Tripathi, 1989. A Permo-Triassic (?) Plant Microfossil Assemblage from Sri Lanka, Review of Paleobotany and Palynology 58, 197- 203.

Dalziel, I.W.D., 1997. Neoproterozoic-Paleozoic geography and tectonics; review, hypothesis, Geological Society of America Bulletin 109(1), 16-42.

Jayasena, H.A.H., Singh, B.K., and Dahanayake, K., 1983. Glacial Sediments from Kurunegala District – Recent Advances of Knowledge (abs), Symposium of the Geology of Sri Lanka, Peradeniya. pp20.

Katupotha, K.N.J. and Dias, P., 2001. The Geological Evolution Correlated to the Startigraphy of the Kalpitiya Peninsula. Journal of Indian Association of Sedimentalogist. 20(1), 21-37.

Pitawala, A. and Dahanayake, K., 1992. Sedimentological and Mineralogical Studies of Some Clay-Sand, Successions of Weuda, Northwestern Sri Lanka, Proc. Sri Lanka Association of Advancement of Science, pp90.

Rees, P.M., M.T. Gibbs, A.M. Ziegler, J.E. Kutzbach, and P.J. Behling, 1999. Permian climates: Evaluating model predictions using global paleobotanical data. Geology, 27 (10), 891-894.

Ridge, J.C., and Larson, F.D., 1990. Reevaluation of Antevs' New England varve Chronology and New Radiocarbon Dates of Sediments from Glacial Lake Hitchcock: Geological Society of America, 102, 889-899.

Tantirigoda, D. A., Geekiyanage, P., 1988. An Interpretation of Gravity Anomalies over the Jaffna Peninsula in Northern Sri Lanka, Journal of Geological Society of Sri Lanka 1, 30-34.

Seneviratne, L.K., Kumarapeli, P.S., and Cooray, P.G., 1964. The quaternary deposits of northwest Ceylon (Abs) – Proc. 20th Sess. Ceylon Assn Adv. Sci., 1:22.

Unrug, R., 1997. Rodinia to Gondwana; the geodynamic map of Gondwana supercontinent assembly. Geological Society of America, Today 7(1), 1-6.

Vitanage P.W., 1972. Post Precambrian uplift and Regional Neotectonic Movements in Ceylon, Proc 24th IGC, Section 3, Montreal, 642-653.

Wadia, D.N., 1973. Geology of India (4th Edition), TATA Mc GRAW-Hill Publishing Company Ltd, New Delhi, 381-390.

West, R.G. 1977. Pleistocene Geology and Biology, Longman London and New York, 1-71.

Wilbert, K.V.H. and Vitanage, P.W., 1983. Post Gondwana Tectonics of Sri Lanka with Special Reference to Tabbowa Area and Central Highlands, Unpublished thesis, University of Peradeniya, Sri Lanka

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