



# Planated Surfaces and Erratic Boulders of Sri Lanka

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## 1. Introduction

Sri Lanka is a tropical island positioned between 5° 50'N-9° 55'N and 79° 30'E-81° 55'E, southwest Bay of Bengal and southeast Arabian Sea in the Indian Ocean. Although, Sri Lanka became a separate landmass during the Triassic-Jurassic Period (203.6-199.6 Ma), its history goes back to the Achaean Eon of the Precambrian Super Eon.

Sri Lanka was positioned within 68°S - 65°S and 34°E-43°E during the Lower and Middle Jurassic Era (201.3-166.1 Ma). Climatic changes in the Permian, Triassic and Jurassic Periods caused glacio-fluvial processes in the country forming streams fed depositss. The Jurassic and later geologic periods of Sri Lanka have assumed importance as this investigation deals with the formation and evolution of its “Planated Surfaces” and “Erratic Boulders”.

## 2. Methodology

The prime object of presenting this paper is to suggest a process for the evolution of major “Planated Surfaces” and associated climate changes as a consequence of palaeo de-glaciation revealed by the occurrence of fairly conspicuous glacio-fluvial deposits, namely, “Erratics” within the country. In this paper, information regarding size and dimensions of erratic boulders was gathered from localities within Kurunegala, Trincomalee, Batticaloa and Ampara Districts.

## 3. Results and Discussion

In the Earth's history, there were five major glaciations, namely, Huronian, Cryogenian (or Sturtian-Varangian), Andean-Saharan, Karoo and

the Quaternary that occurred between 2,400 Ma and 0.0114 Ma. It is revealed that Gondwanaland emerged between the Huronian glaciation (2100-2400 Ma) in the Paleoproterozoic Era and the Andean-Saharan glaciation (420-450 Ma) in the Early Paleozoic Era (ICS, 2009). During this time, Sri Lanka was part of the Gondwanaland landmass comprising present day Africa, Madagascar, India and Antarctica. Within the Ordovician (488.3-445.6Ma) to Permian (299.0-253.8 Ma) Periods there were signs of the breaking up of Gondwanaland resulting in the severing of India and Sri Lanka together and subsequently Sri Lanka from India. By end of the Permian Period (260 Ma) Karoo Glaciation had ended and the present Mannar Basin developed within a deep canyon (about 4 km) on the Precambrian basement. During Late Triassic (235.0-208.5 Ma) global climate was warm and temperate conditions extended towards the poles.

During the Upper Jurassic (163.5-152 Ma). the global climate began to change due to the break-up of Pangaea. The interior of Pangaea became less dry, and seasonal snow and ice frosted the Polar Regions. By Lower and Middle Jurassic Era (201.3-166.1 Ma). Sri Lanka emerged as a separate landmass positioned within 52°S- 55°S and 17°E-22°E (Katupotha, 2013). Sri Lanka reached its present position at 5°52'N-9° 55'N, 79° 30'E-81° 55'E by Lower to Middle Pleistocene (1.806-0.781 Ma). Wayland 1919, Adams 1929, Coates 1934, Wadia 1943, Deraniyagala 1958 and Cooray 1984 explain that during the period from Lower to Upper Jurassic, Sri Lanka was subjected to at least four major *upliftments* through Jurassic, Miocene, Pliocene and Pleistocene times. Based on these upliftments above scholars presented the “Peneplain Concept”



to discuss the surface configuration of Sri Lanka. Accordingly, Adams (1929) came to the conclusion that the surface configuration of Sri Lanka comprises three distinct erosional surfaces arranged in tiers, one above the other. Inferring that they are due to successive cycles of erosion following secular uplifts of the Island, and he named them as “Three Peneplains of Ceylon” viz;

- 1) 3<sup>rd</sup> peneplain, about 6,000 feet (1,830m) above sea-level.
- 2) 2<sup>nd</sup> peneplain, about 1,600 feet (488m) above sea-level,
- 3) 1<sup>st</sup> peneplain, about 100 feet (30m) above sea-level.

Kularatnam (1953) pointed out that Coates (1934) who appears to have been sceptical of many of Adams' views, made no reference to this concept of three peneplains of Ceylon in his *Geology of Ceylon*. Wadia (1943) accepted the existence of the three peneplains without further enquiry, but put forward an alternative hypothesis of block-faulting to explain their origin. An examination of the relief maps of the Island on large scales, suggests a division not into three peneplains, but into the different morphological units on a regional scale which were supported by field investigations (Kularatnam, 1953). Kularatnam (1953) explains that “if we examine the Central Highlands of Ceylon by way of illustration, we find that it consist of a fairly compact unit, cover-big about 3,000-3,600 sq miles. It is a region of diversified landscape and genetically a veritable geological palimpsest. Sorting the variety of features into some kind of order, the Central Highlands may be designed into the groups of geomorphic units”.

As an ‘**Upliftment**’ in geological terms, is a consequence of tectonic activity, the present author is of the view that such major upliftments did not occur for the formation of “The face of Sri Lanka” through Jurassic, Miocene, Pliocene and Pleistocene times, and proposes a new “Planation Surface Concept” together with minor tectonic activity to reconstruct the morphogenesis of Sri Lanka’s topography based on glacial events during drifting of Sri Lanka from the southern hemisphere to the northern hemisphere. It is possible to identify “Four Major Planated Surfaces” developed in response to climatic and sea level fluctuations, which followed the

glaciations and de-glaciations. Such events broke up the existing glacio-fluvial sedimentary beds transforming the topography and structure of Sri Lanka. At present, the “First Planated Surface” is now submerged, which has been identified as a ‘submerged peneplain’ by Sommerville (1907) and Deraniyagala (1958).

By the Upper Jurassic Period Sri Lanka was detached from the southern supercontinent Gondwanaland, and the Indian Ocean began to open up. The landmasses of India and Sri Lanka separated from Australia and the Antarctica/Australia plate. As the climate warmed up the glacial meltwater deposited the coarser material near the terminal end of the glacier and the finer material further away. Such phenomena are salient features of paleoclimate of Sri Lanka. Between 145.5 Ma and 113.0 Ma, in Lower and Middle Cretaceous, Sri Lanka rotated anticlockwise from ENE-WSW to NE-SW while translocating northwards from 58°S - 60°S to 13°E-16°E. By Upper Cretaceous Sri Lanka moved further north and east to a position within 54°S-57°S, 30°E-35°E. Due to these changes, namely, anticlockwise rotation and northward movement Sri Lanka’s “Second Planated Surface” (present surface including the coastal plain) was formed by extensive retreating glaciers again.

Similarly, the “Third Planated Surface” and the “Fourth Rugged Central Highland” of Sri Lanka emerged due to thawing of massive glaciers, which covered Central Highland and Third Planation Surface since Palaeocene to Oligocene Periods. Within these periods, Sri Lanka moved from 31°S-34°S and 55°E-58°E to 9°S-13°S and 66°E-69°E passing the Tropic of Capricorn. With the emergence of Planated Surfaces and Central Highland of Sri Lanka, important depositional features of glacio-fluvial origin including outwash plain, valley terrains, erratic boulders, ice-rafted deposits (eskers and tills), kames and kame terraces were formed. The climate during the Miocene was similar to today's climate, but warmer. King (1962) postulated that the extreme planation in Sri Lanka, survived only on smooth ridges or crests. This would be the “Third Planated Surface” in the country. By the end of the Oligocene Period Sri Lanka reached 2°N-7°S



and 73°E– 76°E and passed the Equator by Mid Miocene (14 Ma) with the position around 0.3°N–4.30°N and 73°E–76°E.

As a result of the Pliocene-Quaternary climate changes the earlier glacial sedimentary deposits in Sri Lanka disappeared from greater part of Sri Lanka and at present such deposits can be identified as patches from several parts of the country. There are no Pleistocene glacial deposits have been reported, because by the Quaternary Period, Sri Lanka had already reached its present position. However, scattered erratic boulders and patches of old stream fed deposits from former glacial depositions such as, outwash plains, valley terrains, kames and kame terraces can be identified throughout on first, second and third planated surfaces, although most are worn to shadows.

Erratics are significant because, on being transported by glaciers, they are one of a series of indicators which mark the path of glacier movement. Their lithographic origin can be traced to the parent rock, allowing for confirmation of the ice flow route. Similarly they can be transported by ice-rafting. Ice rafted debris or ice-rafted deposits are deposited onto the bottom of the water body, for example, onto a river bed or an ocean floor. Erratic boulders at Tennamavadi are located at coordinates 8°58'N and 80°58'E in Sri Lanka's northeastern coastal zone very close to the present coast. The erratic boulders at Uraniya (Pottuvil) Lagoon (coordinates 6°53'N, 81°50'E) are about 2.0m - 4.0m above MSL (Photograph 1).

Erratic boulders at Nakolagane Temple site (coordinates 7°48'N and 80°18'E, Photograph 2) and erratic boulders at Viharagala Temple site (coordinates 7°46'N and 80°28'E, Photograph 3) in the Kurunegala District, are located above 120 to 200m MSL on the Second Planated Surface. The boulders of the Northwestern Province are derived from the rocks of Highland and Wannai Complexes.



Photograph 1 showing erratic boulders at Uraniya (Pottuvil) Lagoon 3.0 m above MSL, East Coast.

The lithology of these boulders being composed of a heterogeneous group of gneisses, migmatites and granites with scattered sedimentary bands confirm the source to be Highland Complex rocks (Cooray 1984). Colour and mineral composition indicate that the rocks are derived from the Highland Complex rocks. The erratics exhibit rounded, oval and elongated shapes ranging in from pebbles to large boulders hundreds to thousands of metric tons in weight. These appear to have been dropped on rock outcrops or on the ground by melting glaciers moving in a northeasterly direction.



Photograph 2 erratic boulders at Viharagala Temple site.



Photograph 3 erratic boulders at Nakolagane Temple site in Kurunegala District.

#### 4. Conclusions

Sri Lanka emerged as a separate landmass between 201.3-166.1 Ma (Lower and Middle Jurassic), when it was positioned within 52°S-055°S and 17°E-22°E. Sri Lanka reached its present position within 5° 52'N-9° 54'N and 79° 30'E-81° 55'E at some time between Lower and Middle Pleistocene. Many scholars proposed that Sri Lanka was subjected to at least four major upliftments during Jurassic, Miocene, Pliocene and Pleistocene times, this author is of the opinion that such major upliftments did not occur during the said geologic periods in Sri Lanka, and instead introduces the new “Four Major Planation Surface Concept” to interpret the morphogenesis of Sri Lanka leading to its present topography based on major glacial events during drifting of Sri Lanka from the southern to the northern hemisphere, and led to the break up of glacio-fluvial sedimentary beds altering the country's topography and structural configuration. The Pliocene-Quaternary climate changes appear to have obliterated earlier glacial sedimentary deposits from greater part of Sri Lanka. Despite no Pleistocene glacial deposits have been recorded, scattered erratic boulders can be identified, both, hinterland and near the coastal zones.

#### 5. Acknowledgments

My profound thanks go to Mr Nimal Ranasinghe, former Director, Geological Survey Department of Sri Lanka for his pertinent suggestions and editing of the manuscript. I am deeply grateful to Professor Gamini Adikari, Director General, Central Cultural Fund of Sri Lanka and International Water Management Institute (IWMI) for providing ready assistance for all field visits.

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