GEOLOGICAL FORMATION & PALEOENVIROMENT OF THE RAKWANA-PANNILA MOUNTAIN - SRI LANKA

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Abstract

The Rakwana mountain range, which is located in the margin of the northern side of Sinharaja,UNESCO world heritage site, is an area having rich bio–diversity,included unique geological formations such as limestone caves etc. Numerous fossils of Elephants(*Elephas* spp.), Gaur(*Bos gaurus*), Sambar Deer (*Rusa unicolor*), Rhinoceros (*Rhinoceros kangawena*), Red dogs(*Cuon sinhaleyus*), Hippopotamus (*Hexaprotodon sinhaleyus*) & Tiger (*Panthera tigris*) dated to 17,000-13,000 ybp belongs to the Pleistocene Epoch, could be identified during the recent excavations of the alluvial deposits in Sabaragamu basin. Isolated living Elephants, Sambar Deer & Eel (*Anguilliformes* ssp.) are unique to this area. The detailed study of the limestone cavern at Pannila mountain revealed that it is of 750 meters in length. The height of the cave entrance is 300 cm (3.5 feets) of which 60 cm filled with water, where special cave characteristics are visible. Stalagmite and stalactites of 5 m height formed after re-crystallization of pre-existing limestones could also be observed at the core of the cave. The studied limestone cave popularly known as *'Pannila Hunugala'* is a part of the basement marble bed in the Highland Complex of Sri Lanka belongs to the Precambrian age. It is postulated that the same marble bed is extended to the marble beds located at the Samanalawewa, Waulpane and Rakwana. The action of chemical weathering occurred in the recent times makes it secondary features like stalagmite and stalactite. It is interesting to study that the existence of animal fossils within and around the cave is an indication of the period of cave formation, which probably contemporaneously to the Pleistocene Epoch. It was reported in the literature that during the Pleistocene Epoch, the entire island experienced heavy rain fall resultant the growing of thick rain forests, of which Sinharaja is one of the best existing example (Deraniyagala 1958). These heavy showers created large lakes and marshes in the Sabaragamuwa basin providing habitats for a number of marsh-loving mammals and other animal species mentioned above that were once lived in Sri Lanka and have got extinct as a result of the Earth's Precession change in the following period.

Key Words: Sinharaja Forest, Crystalline Limestone, Paleontology, Pleistocene Geology, Sri Lanka

Introduction

Presently Sri Lanka is an island existing in the Indian Ocean. It was a part of Gondwanaland during middle Jurassic epoch and began breaking up from the Indian continent during the late Jurassic as a separate single land mass. During the early Miocene era Sri Lanka was further shifted south-east direction forming the Calvary basin where huge amount of lime mud had been deposited. During the Quaternary period geostatic changes has made a land bridge between Indian subcontinent and Sri Lanka allowing plants and animal passing in both sides. Disconnection of land bridge again has made an important impact on evolution by isolation. Hence some extinct animals and plants can be found in different places of the country as fossil evidences. The geological records in sediments and rocks give further strong details on paleoclimate proving the paleo existing of those animals and plants. . Therefore by studying Palaeo-Biodiversity it can be discussed the ancient life and its diversity that is hidden in geological formations and role of geological processes in preservation of them, human evolution, Extinct animals, Climax of the biological diversity of pre historic man's tools, pre historic man's hunting and gathering systems, belief, customs and interaction with the environment can be studied.

The island of Sri Lanka consists of crystalline and foliated metamorphic rocks of pre Cambrian age, 1000my to 2500my old. These rocks account to more than 90% of the surface and are divided into two distinct groups named Highland series and the Vijayan series. The highland series consists of a succession of meta-sedimentary rocks, quartzite, marble, white granulite and granulitic gneiss, charnockite and gneiss, garnet-sillimanite-graphite-gneiss, garnet-biotite gneiss and biotite gneiss. The argillaceous rocks of the Highland series found in the south western area of Sri Lanka consists of more feldspathic and garntiferous rocks and wollastonite rock.The younger Vijayan series which further sub divided into Eastern Vijayan and western Vijayan consists mainly of migmatitic microcline-hornblende-biotite gneiss and calcareous gneiss. Marble and quartzite are rare in eastern Vijayan rocks and they also occupy the eastern and south eastern low lands and uplands. The western Vijayan rocks are characterized by the occurrence of pink-feldspar–hornblende granites, migmatites and gneiss and also occur in northwestern and northern lowlands and uplands. north- western portion is formed of Mosozoic (Jurrasic – Thabbowa beds; Andigama- Pallama beds), Tertiary (Miocene – Jaffna limestone; Minihagalkanda beds) Quaternary (Pleistocene – Rathnapura beds) sedimentary formations which are fossiliferous. (Cooray 1984). Calcium carbonate is an easily soluble mineral form stalagmites and stalactites. Those are mostly found on Marble bed rock. These caves are found at Nitre cave in Rangala area, Ravana's cave in Ella, Mathurata (near Padiyapelella), Wellawaya, Hakgala, Isthripura (near Welimada) Padanwela (Near Wilson's bungalow), Patanagedara (near Laggala), Kudawa (near Gilimale), Norton bridge area, Wawulpane and Pannila (6^0 28′52.10″NN,80^0 32′23.04″EE | Ele 1005m)

Methology & Materials

To identify fossils from, that found in Sri Lanka was examine according to ***comparative anatomy ,Relativedating***(Places historical events in their correct order but does not yield numerical estimates of how many years ago the events happened which is base on six fundamental geological principles as Principle of superposition , original horizontality , lateral continuity ,Cross cutting relationships, inclusions & fossil/faunal succession) & ***Biostratigraphy(***fossil content of the bed is used to interpret the historical sequence which is base on the *Principle of the Irreversibility of Evolution*)has done. As primary sources early research and publications that have done was used and to identify fossils time period, the geological time scale system chronologic measurement relating stratigraphy was used.As materials for this research we used digital caliper (150mm|6"),Scale bars, Gramin 30 GPS with BaseCamp GIS.

Speleothem dimensions were used for measure the volume of Stalagmite & Stalagtites

Speleothem dimensions were measured using a caliper. The diameters were measured at the base (the point of attachmentof the speleothem to the roof or floor), at the place where the most conspicuous width changes took place, and near the tip of the speleothem. The height of each speleothem was also measured with a 10m measuring tape. Stalactites showing evidence of breakage were noted as such. A very fragile, translucent framework of calcite with euhedral crystal terminations was assumed to represent undisturbed stalactites, while an unusually thick layer of calcite with no crystal terminations suggested that the stalactite had been broken at some point in time. A few small curtains were present, and because they had roughly boxlike shapes, the length, width, and height were measured. Any other slightly anomalous formations were noted and appropriate measurements were taken. The volume of calcite contained within the stalagmites and stalactites was calculated using equation 01 & 02, derived from the volume formula for a truncated cone. This equation was determined to best quantify the volume of a speleothem using a reasonable number of measurements

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$$\text{Volume} = [1/3\, \pi\, (h1)(R^2\text{base} + R1^2 + R_{base}R1)] + [1/3\, \pi (h2 - h1)(R1^2 + R2^2 + R1R2] + [1/3\, \pi\, (h_{total} - h2)R2^2] \quad \textbf{(01)}$$

Where: $h1$ = height from base to first radius measurement (mm)

h2 = height from base to second radius measurement (mm)

R_{base} = radius at the base of speleothem (mm)

$Volume = \pi r^2 h$ (h =Average Height / 10)

$$R1^2, R2^2, R3^2, R4^2, R5^2, R6^2 \ldots\ldots\ldots\ldots\ldots Rn^2 \quad \textbf{(02)}$$

Discription : $R1^2, R2^2, R3^2 .. Rn^2$ (Average radius of Stalagmite & Stalagtites)

Measurements of Stalagmite (GM) & Stalactites (GT)

Chart 01:Coding No :01-Area 03(Drop rate :15 per mini | Temp cave in $22.1C^{0}$,Temp cave out $28C^{0}$)

GT1 (cm)	C1 220	R1 34.998	C2 187	R2 29.749	C3 176	R3 27.999	C4 160	R4 25.453	C5 150	R5 23.863	C6 134	R6 21.317	C7 120	R7 19.090	C8 115	R8 18.295	C9 105	R9 16.704	C10 97	R10 15.431
GM1 (cm)	195	31.021	190	30.226	180	28.635	171	27.203	165	26.249	160	25.453	150	23.863	140	22.272	120	19.090	110	17.499
GT1H1 (cm)	180		170		180		185		160		165		185		180		190		170	176.5
GM1H2 (cm)	100		105		110		95		90		100		97		93		99		104	99.3

Calculation of volume

GT1 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
	34.998	29.749	27.999	25.453	23.863	21.317	19.090	18.295	16.704	15.431
GT1 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
	67947.822	49094.612	43488.470	35939.087	31589.240	25208.167	20216.266	18567.521	15478.542	13209.222
GM1 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
	31.021	30.226	28.635	27.203	26.249	25.453	23.863	22.272	19.090	17.499
GM1 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
	30033.450	28513.793	25591.044	23095.493	21503.995	20219.555	17772.303	15481.465	11373.797	9556.967

Chart 02:Coding No :02-Area 03(Drop rate :7ml per mini | Temp cave in $22C^{0}$,Temp cave out $28C^{0}$)

GT2 (cm)	C1 175	R1 27.840	C2 180	R2 28.635	C3 175	R3 27.840	C4 170	R4 27.044	C5 156	R5 24.817	C6 141	R6 22.431	C7 128	R7 20.363	C8 100	R8 15.908	C9 80	R9 12.727	C10 70	R10 11.136
GM2																				
GT2H1 (cm)	212		200		190		185		180		205		193		187		190		198	194.0
GM2H2																				

Calculation of volume

GT2 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
	27.840	28.635	27.840	27.044	24.817	22.431	20.363	15.908	12.727	11.136
GT2 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
	47259.005	49996.602	47259.005	44595.185	37553.003	30679.154	25283.060	15430.403	9876.389	7561.441
GM2 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
GM2 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10

Chart 03:Coding No :03-Area 03(Drop rate :30ml per mini | Temp cave in 22C^0,Temp cave out 28C^0)

	C1	R1	C2	R2	C3	R3	C4	R4	C5	R5	C6	R6	C7	R7	C8	R8	C9	R9	C10	R10
GT3 (cm)	278	44.225	263	41.839	230	36.589	210	33.408	195	31.021	175	27.840	154	24.499	110	17.499	95	15.113	84	13.363
GM3 (cm)	165	26.249	170	27.044	183	29.112	196	31.180	175	27.840	161	25.612	150	23.863	143	22.749	117	18.613	95	15.113
GT3H1 (cm)	227		220		203		196		184		190		200		210		217		180	
GM3H2 (cm)	150		145		136		138		130		128		123		119		115		110	129.4

Calculation of volume

GT3 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
	44.225	41.839	36.589	33.408	31.021	27.840	24.499	17.499	15.113	13.363
GT3 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
	119256.427	106735.454	81629.510	68052.967	58675.622	47259.005	36596.776	18671.215	13926.676	10888.149
GM3 Radius (cm)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
	26.249	27.044	29.112	31.180	27.840	25.612	26.863	22.749	18.613	15.113
GM3 volume (cm^3)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
	28022.326	29745.448	34468.528	39539.473	31522.243	26678.760	29348.620	21047.634	14090.014	9289.237

Result

According to the second formula, average of stalagmite formation dated, coding 01 as 13576.92ybp, coding 02 as 14923.07ybp and coding 03 as 9923.07ybp. Approximately *Stalagmite & Stalagtites* formation in pannila hunagala have been started within late Pleistocene & Holocene. According to our measurements the variation of tolerance in formation of *Stalagmite & Stalactites* belongs to 32000 ybp- 7500ypb.

'Pannila Hunugala' is a part of the basement marble bed in the Highland Complex of Sri Lanka which is belongs to the Precambrian age. It is postulated that the same marble bed is extended to the marble beds located at the Samanalawewa, Waulpane and Rakwana. The action of chemical weathering occurred in the recent times makes it secondary features like stalagmite and stalactite.

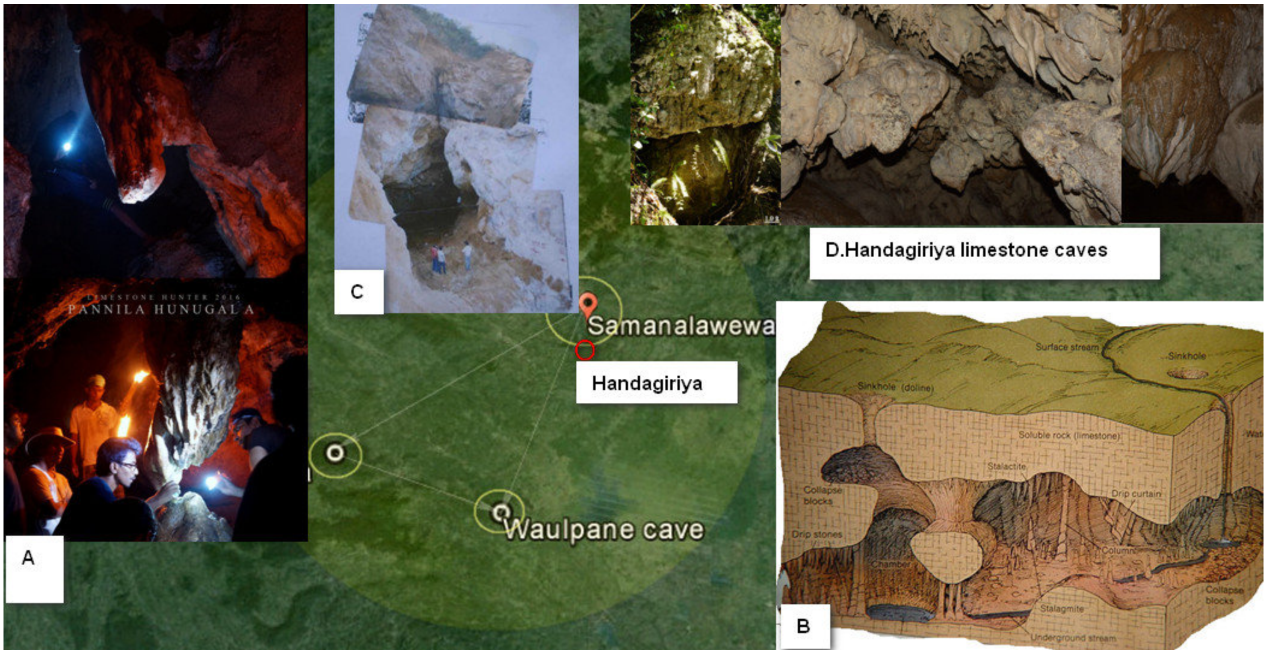

Fig 01:Distribution of limestone (+ marble) formation in Highland Complex in Sri Lanka

A.Pannila Hunugala(Sinharaja heritage site) , C. Cavity of right bank at river level in Samanalawewa. , D . Handagiriya(Balangoda), B. Model for action of chemical weathering formations of limestone cave.

CONCLUSION

Sri Lanka consists of fossils bearing deposits formed in different time periods of the past. Though we have number of fossils, still there is no law or an act has been made to protect and preserve these fossils. Studying of those fossils is important in identifying the paleoclimate and its recurrences and as well as preserving the deposits for future endeavor. It seems that Palaeo – Biodiversity heritage in Sri Lanka is gradually destroyed by human activities. Caves are among the most fascinating structures in the earth's crust. The processes which removed material from caves in principle are rather simple, but they were manifest geologically in response to many environmental factors. Deposition in caves was also complex. Although there is many in caves to explore and further study, it appears that they can be interpreted within the basic framework of earth history presented in Scripture. The cave itself has very important ecological characters. Using these baseline data, further studies should be done regarding the existing animals and there ecology within the cave.

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