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GEOTOURISM AND GEOHERITAGE POTENTIALS: VISTAS AND UNIQUE OPPORTUNITIES OF SRI LANKA

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ABSTRACT : Geotourism is 'tourism that focuses on geology and landscape as the basis for providing visitor engagement, learning, and enjoyment'. Geotourism and geo-heritage are relatively new form of tourism with considerable Sri Lanka and global growth potentials. Interest in geotourism is developing at a very rapid rate around the world. It is of great importance to support and enhance the global movement about geotourism generally and specifically into geo land mark included geo-heritage sites. The country like Sri Lanka represents an area rich with numerous geological and geomorphological formations which are excellent representatives of this area's geodiversity since Archean eon to present. However, the geotourism potential of these geo sites still remains fully unrevealed and neglected. For many millennia, the prehistoric community has been concerned about the unrestricted appreciation of sites of geological or geomorphic interest. The features of geologic or geomorphic interests, based on folds, faults and topographic relief provide spectacular vistas and unique opportunities to learn about earth's geologic processes and history. This should be our geological heritage, which represents the collective memory of the Mother Nature. Geotourism is essentially 'geological tourism'. The geological element focuses on geology and landscape and includes both 'form', such as landforms, rock outcrops, rock types, sediments, soils and crystals, and 'process', such as volcanism, erosion, glaciation etc. The tourism element of geotourism includes tourists visiting, learning from, appreciating and engaging in geo sites. Thus, the nature of the abiotic geological heritage involves a sustainable, viable and responsible tourism development that enhances the wellbeing of the local communities.

KEY WORDS: Geotourism, Geoheritage, Geosites, Employment, Economy, Sri Lanka

INTRODUCTION

Geotourism is defined as "tourism that sustains or enhances the geographical character of a place - its environment, culture, aesthetics, heritage, and the well-being of its residents, according to criteria's of National Geographic in 2003. Hence, geotourism is simply interpreting as an act or process of learning (or knowledge gaining) pursuit from geological heritage sites or geosites, while recreation, relaxing and enjoying the geological or Geoheritage. Geoheritage is some diversity of geological formations inherited naturally or due to human activity. Some geoheritage sites, or "geosites", are related to human activity such as mining, and can also be viewed in terms of cultural heritage. This is providing a holistic tourism experience, and offer opportunities for visitors and multitudes to gain knowledge about the values of the geologic attractions widespread geosites in Sri Lanka. Due to the development of the subject "Geotourism", geosites emerge as themes. A geosite is a location that has a particular geological or geomorphological significance. More precisely, geosites are defined as geological or geomorphological objects that have acquired a scientific, cultural/ historical, aesthetic and/or social/economic value due to human perception or exploitation.

The geotourism relatively a new concept, and abiotic nature based a new approach of is attracting increasing interest around the world.

As a contemporary concept, geotourism draws on both geology and tourism. According to Kubalíková (2013) "Geotourism could be people going to a place to look at and learn about one or more aspects of geology and geomorphology". Thus the "Tourism" that sustains or enhances the geographical characters of a place, its environment, heritage, aesthetic, culture, and the well-being of its residents" and "geo" means geographical and/or geological (Figure 1). These relations between geology and tourism science may be evidenced in many aspects. Natural landscapes including peaks, valleys, caves, stones, rivers, lakes, waterfalls and springs

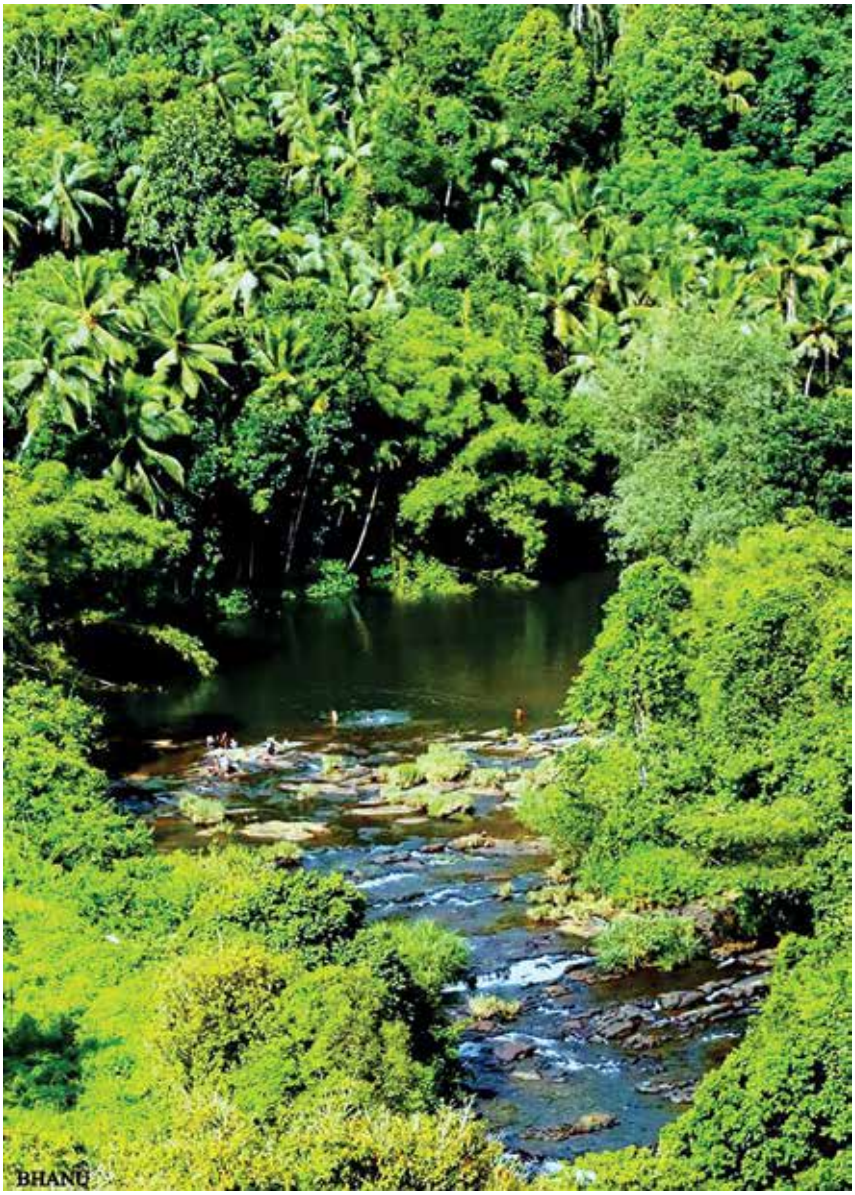


FIGURE 01: Gomalu Oya, one of branch of the Kalani River at Thalapitiya (Sabaragamuwa Province) shows the relationship between geology, landforms and ecology. Image ©Aravinda Ravibhanu 2014.

are all generated by geological processes and controlled by varying geological factors. Hence, naturally-created in-situ features or places such as beaches, coral reefs and reef patches, islets, waterfalls, escarpment, mountain peaks, geologic deposits such as coastal dunes, red sand beds, shell beds, mineral deposits, lagoons and lakes, river estuaries, caves, erratic boulders etc. can be captivated as geologic features for tourism activities and to develop as geoparks. Proposed geopark is an area containing one or more sites of particular geological importance, intended to conserve the geological heritage and promote public awareness of it, typically through tourism. Likewise, geologic features, which were made using geologic material mainly by rocks, sand, clay and other minerals belonging to the culture of a particular society, such as traditions, languages, or buildings, which come from the past and are still important and can be identified as geoheritages. Heritage has two aspects, culture and natural. Natural heritage too has many facets, but in this case, we focus on Geoheritage, which means landscape and geological settings, we have inherited in this country, Sri Lanka. We proposed to cluster these unique situations to create Geological parks.

Purpose and Significance of the Monograph

The aim of this monograph is to explore the potential of geological heritage (geoheritage) in the Sri Lanka which is an important milestone towards geotourism development. To determine its strengths, weaknesses, opportunities, and threats as well as interactions between them when it comes to tourism development. For this purpose, Government Departments/ Institutions, such as Department of Wildlife and Conservation, Forest Department, Geological Survey and Mines Bureau, Department of Tourism Developments, Universities, Local Governments, Schools etc. should be engaged positively to enhance this idea. Using these nature-based heritages of particular geological importance, intended to conserve the geological heritage and promote public awareness of it, typically through tourism.

Therefore, proceed initial discussions with above institutions & departments via Eco Astronomy Inc community. Questionnaire of discussions has developed for selected area which representing the geotourism land marks in Sri Lanka. The monograph, conclude that there is a serious need of developing a comprehensive marketing plan of the specific places as well as considering multidisciplinary approach in view of the scientific and tourist value of the present geoheritage. Consequently, this provides an important step towards geotourism development in the Sri Lanka for the benefit of many different communities living in around the island. You can explore the role of geotourism with this monograph, which is neglected field in Sri Lanka, but it is very significant as conservation and education tools as well as for the economic development of the country. In addition, it is based on the best practice of geoethics consists of research and reflection on the values, which support appropriate behaviors and practices, wherever human activities interact culturally, economically and sociologically.

Concept of Geotourism and Geodiversity

Concept of geotourim is abiotic based tourism and coalesce with geology and tourism disciplines may be evidenced in many aspects. The many earth science communities are liable to lose its influence on creation and interpretation of geosites and related topics because of this concept has been broadened to include everything. Like, Natural landscapes including peaks, valleys, caves, stones, rivers, lakes, waterfalls and springs are all generated by geological processes and controlled by varying geological factors. Complicated geological factors lead to diversified shapes of natural landscapes. Erosion and deposition of sediment (grains of sand, silt and clay) by streams, glaciers, wind, groundwater, springs and waves are surface processes that create many familiar landforms. Erosion produces geologic features such as valleys, canyons, river channels, bays, caves and cliffs. In particular, structural features generated by tectonic activities, and their natures, characteristics, scales and attitudes all directly control the formation

and development of natural landscapes. From the macro-perspective, they can control the pattern of geomorphic units, shapes, trends and elevations of mountains, layout of water systems, and formation of rivers, lakes and groundwater; from the micro-perspective, they control the development of peaks, valleys, caves and springs. Finally, it's all representing Geodiversity, a copy-cat adaptation of biodiversity, but while biodiversity might be a measure of the health of an ecosystem, the value of geological and geomorphic sites does not depend on diversity. Many geological and geomorphic features are restricted to a single rock or feature, which enhances their value. Geodiversity might be useful as a way of recording diverse features within a given area, but it should not be treated as a value-judgement on the significance of individual sites.

Geodiversity

Figure 2 depicts the close relationship the tourism with different disciplines. In This Figure, "A" is represent the Geology, Geography and geographical landform destinations. Letter "B" Geotourim + geologic industries and mining. Letter "C" combines as Cultural tourism, which is the subset of tourism concerned with a traveler's engagement with a country or region's culture, specifically the lifestyle of the people in those in specific geological and geographical areas, the history of those people, their art, architecture, religion(s), and other elements that helped shape their way of life, and letter "D" represents the Paleoanthropology-Speleology sites or destinations. Also "E" is related to Nature-based tourism: a broad term that covers all tourism experiences centered on wild or natural environments.

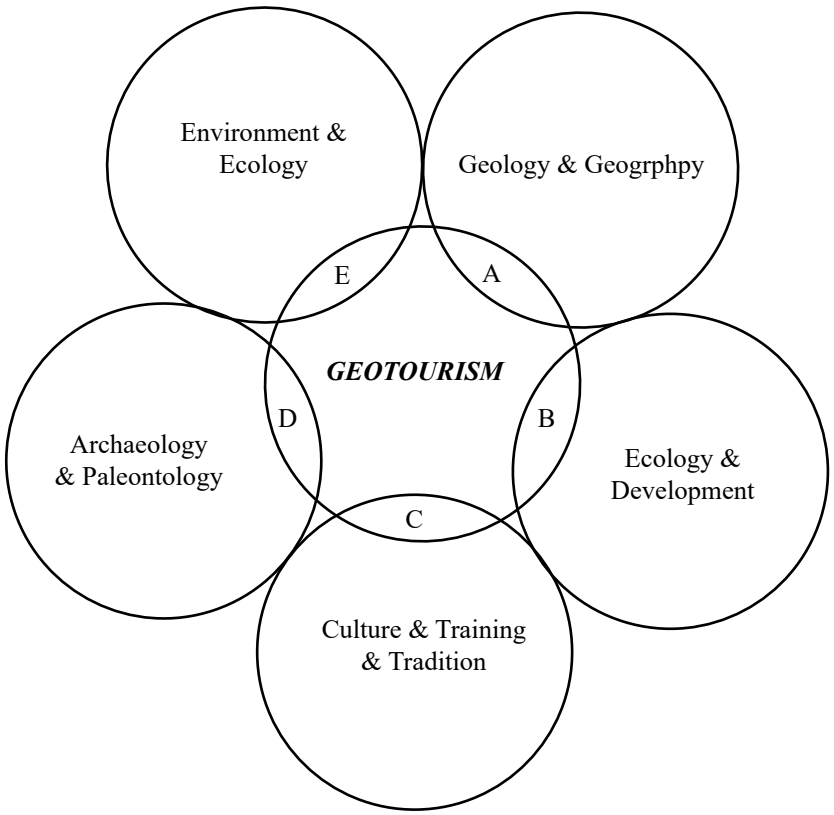


FIGURE 02: The facts that incorporate with Geotourism via Multidisciplinary Approach in Sri Lanka.

Hence geodiversity is encompasses all of our Earth's geologic forms and processes, soils, sediments, rocks, minerals, and even fossils. Thus, geodiversity is the abiotic equivalent of biodiversity and describes the variety of geological, geomorphological, pedological and hydrological features and processes. This means that geodiversity can be considered the stage upon which biodiversity acts. Thus the Geodiversity refers to the variety of the geological and physical elements of nature as mentioned above. Together with biodiversity, geodiversity constitutes the natural diversity of the planet Earth.

Geology of Sri Lanka (in brief)

More than 90% of Sri Lanka's surface lies on Precambrian strata. Some of it dating back 2 billion years. The granulite facies rocks of the Highland Series (gneisses, sillimanite-graphite gneisses, quartzite, marbles, and some charnockites) make up most of the island. The amphibolite facies gneisses, granites, and granitic gneisses of the Vijayan Series occur in the eastern and southeastern lowlands. Jurassic sediments are present in very small areas near the western coast. Miocene limestone underlie the northwestern part of the country and extend south in a relatively narrow belt along the west coast. The metamorphic rock surface was created by the transformation of ancient sediments under intense heat and pressure, during mountain-building processes.

The theory of plate tectonics suggests that these rocks and related rocks forming most of south India were part of a single southern landmass called Gondwanaland. Beginning about 200 million years ago, forces within the Earth's mantle began to separate the lands of the Southern Hemisphere, and a crustal plate supporting both India and Sri Lanka moved toward the northeast (Katupotha 2019). About 45 million years ago, the Indian plate collided with the Asian landmass, raising the Himalayas in northern India and continuing to advance slowly, up to the present time. Sri Lanka does not experience earthquakes or major volcanic events because, it rides on the center of the plate. Most of those in-situ geologic features have a close relationship with geologic time periods, particularly Precambrian age (Highland Complex, Vijayan and Wanni Complexes, Kadugannawa Complex; Kataragama, Kuda Oya and Baddulla Klippe [cliff or crag]; Miocene to Pleistocene and Recent times (Cooray 1984, Cooray and Katupotha 1991, Kehelpannala 2003).

In Sri Lanka, **(1). Highland Complex (HC):** an association of interlayered, predominantly granulite-facies, granitoid (charnockitic to enderbitic) gneisses and clastic to calcareous shallow water metasediments with ages, based on magmatic and detrital zircons, ranging between, 670 and, 1900 (millions years ago) and intruded by, 550 (millions years ago) late- to post-tectonic granitoids. The gneisses were ubiquitously intruded by mafic dykes that are now structurally concordant with their host rocks. **(2). Wanni Complex (WC):** an upper amphibolite- to granulite-facies assemblage of 770–1100 Ma granitic, monzonitic, charnockitic and enderbitic gneisses, migmatites, minor clastic metasediments, including garnet–cordierite gneisses, as well as late to post-tectonic granites. Most of the sediments in this unit occur close to the boundary with the HC (Kehelpannala, 1997). **(3). Vijayan Complex (VC):** an upper amphibolite-facies suite of, 1020–1030 Ma granitoid gneisses, including augen-gneisses, with minor amphibolite layers (derived from mafic dykes) and sedimentary xenoliths such as metaquartzite and calc-silicate rock. The Vijayan complex of migmatites, granitic gneisses and granitoid rocks on the east and west of the centrally situated Highland Series belt (Cooray 1984, Kroner et al 2003). **(4). Kadugannawa Complex (KC):** an upper amphibolite to granulite facies calc-alkaline suite of ,890–1006 Ma hornblende and biotite–hornblende orthogneisses of gabbroic, dioritic, and trondhjemitic composition with interlayered granodioritic to granitic gneisses, charnockites, enderbites, and minor shallow-water metasediments (Figures 3 and 4).

The two small basins of Mesozoic (Jurassic) deposits are faulted into the Precambrian basement in the northwestern part of the island. One is the Tabbowa basin, which is exposed at

the surface, the other the Andigama-Pallegama basin to the south of it, covered by later deposits. The rest of the island, chiefly in the extreme north and northwest is underlain by sedimentary Miocene limestone belts of unconsolidated post-Miocene deposits, mainly sands and clays, occupy the coastal areas, especially of the northwest and the east (Cooray 1984, Cooray and Katupotha 1991).

Mannar Basin is deposited my material flow from southeast India, which has been collecting sediments from the highlands of India and west and north west Sri Lankan land mass since the breakup of Gondwanaland.

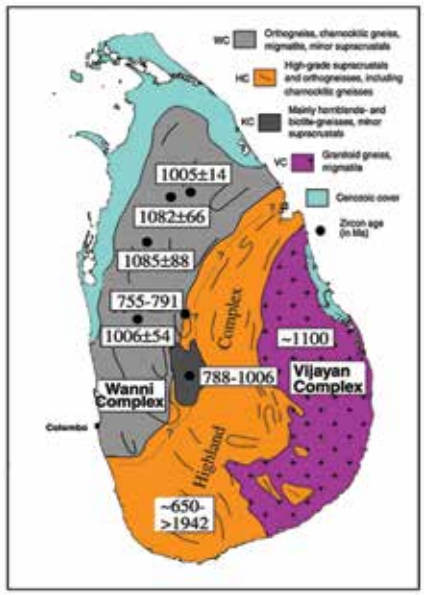


FIGURE 03: (Left): Lithotectonic boundaries of Sri Lanka (Coory 1984; Kroner et al 1991; Kehelpannala 2003; 2017), and **FIGURE 04:** (Right): Depicts the Main Geological Zones, includes specific dating.

The island contains relatively limited strata of sedimentation surrounding its ancient uplands. Aside from recent deposits along river valleys, only two small fragments of Jurassic (140 to 190 million years ago) sediment occur in Puttalam District, while a more extensive belt of Miocene (5 to 20 million years ago) limestone is found along the northwest coast, overlain in many areas by Pleistocene (2.6 my to 11,700 years ago) deposits. Island of Sri Lanka and the Indian sub continents separate from Mannar Basin. Stratigraphic section of the Barracuda and Pearl-1 wells show the existence of around 2,902 m thick Upper Cretaceous to Recent sediments (Premarathne *et al*. 2013, Amila and Sampei 2015)). The top layers of

Mountain and Mountain Ranges

Geographically a mountain has its own peak, means the highest point and formed naturally by rocky material manly igneous, metamorphic, sedimentary or mixed. Usually many peaks have their own names, which differ from the name of the mountain and place to place. As well, a mountain can have many peaks, but a peak can be a part of one mountain merely. Hill is a naturally raised area of land, not as high or as a mountain. The essential framework of the Central Hill over 1,500m (meters) appears in the form of an overturned "T" or anchor, with the Central Ridge forming the shank on which are some of the highest mountain peaks in Sri Lanka (Figure 5).

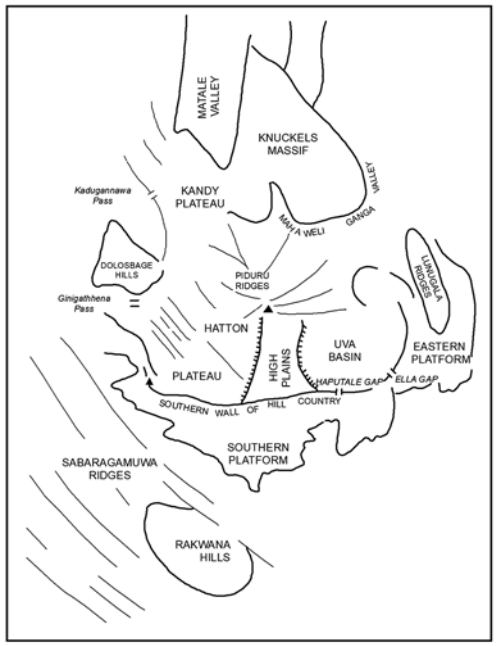


FIGURE 05: Physiographic regions of the Central Hill Country (E.K Cook 1931).

No	Mountain	District	Province	Summit (m)	Co-ordinates
1	Pidurutalagala	Nuwara Eliya	Central	2,524	07°59′45″N 80°46′26″E
2	Kirigalpotta	Nuwara Eliya	Central	2,395	06°47′07″N 80°46′00″E
3	Thotapola Kanda	Nuwara Eliya	Central	2,357	06°49′59″N 80°49′11″E
4	Kudahagala (Agrabopat Hills)	Nuwara Eliya	Central	2,320	06°48′47″N 80°46′59″E
5	Sri Pada	Ratnapura	Sabaragamuwa	2,243	06°48′02″N 80°28′57″E
6	Kikilimana	Nuwara Eliya	Central	2,240	06°59′06″N 80°44′22″E
7	Great Western	Nuwara Eliya	Central	2,216	06°58′00″N 80°41′38″E
8	Hakgala	Nuwara Eliya	Central	2,170	06°55′01″N 80°48′49E
9	Conical Hill	Nuwara Eliya	Central	2,100	06°54′45″N 80°46′24″E
10	Mahakudugala	Nuwara Eliya	Central	2,100	07°02′35″N 80°50′40″E
11	One Tree Hill	Nuwara Eliya	Central	2,100	06°57′28″N 80°45′45″E
12	Waterfall Point	Nuwara Eliya	Central	2,074	
13	Namunukula	Badulla	Uva	2,036	06°55′59″N 81°07′01″E
14	Gommolli Kanda	Badulla/ Ratnapura	Uva/ Sabaragamuwa	2,034	06°46′00″N 80°48′33″E
15	Knuckles	Kandy	Central	1,863	07°24′01″N 80°48′36″E

Source: National Atlas of Sri Lanka, 2007, Survey Department of Sri Lanka.

The property comprises the Peak Wilderness Protected Area, the Horton Plains National Park and the Knuckles Conservation Forest. There are nearly 14 Mountains Ranges/Peaks or Hills in the Central Hill Country (out of 14 Mountains Ranges/Peaks, eleven are in Central Province, one in Uva/Sabaragamuwa in Sri Lanka (Table 1). To the northwest of the shank is the Matale hills, with Knuckles range (1,863 meters, in Table 1) forming the high points, on either side of this central mountainous anchor-shank is two plateaus, the Hatton Plateau to the west and the Uva basin (or Welimada Plateau) to the east each averaging 1,200m in height. From east to west arm of the "Anchor" is termed the southern mountain wall, because here it presents a sheer drop of over 1,200 metres to the southern platform lying at its base. Forming a detached portion from the massif to the southwest lies the Rakwana hills and the Bulutota massif averaging 900 metres, the intervening tract being occupied by the upper tributaries of the Kalu and Walawe rivers.

Sri Pada Mountain (Samanala) is located in the southern reaches of the Central Highlands in the Ratnapura District (Sabaragamuwa Province) and Nuwara Eliya District of the Central Province (Table 1). It is the fifth-tallest mountain peak of Sri Lanka (2,243m), and has about 40 km northeast of the city of Ratnapura and 32 km southwest of the city of Hatton.

The surrounding region is largely forested hills, with no mountain of comparable size nearby. The region along the mountain is a wildlife reserve, housing many species varying from elephants, leopards, and including many endemic species. At higher elevations there is a series of isolated cloud forests, harbouring a variety of flora and fauna (Figures 6 - 10). Although the range constitutes approximately 0.03% of the island's total area, it is home to a significantly higher proportion of the country's biodiversity. Sri Pada Peak is important as a watershed. The districts to the southern and the eastern of Sri Pada mountain/Peak yield precious gemstone such as emeralds, rubies

FIGURE 06: Nanuoya Mountain area from close to the Nanuoya Railway Station. Image ©Aravinda Ravibhanu 2015

FIGURE 07 (Left) **:** Kirigalpotta Mountain, dead end. Image ©Aravinda Ravibhanu 2013. **FIGURE 08** (Right) **:** Kunudiya Rock from Geththampana - Erathna trail to Sri Pada Peak. Image ©Aravinda Ravibhanu 2014.

FIGURE 09: Morning view of the Sri Pada Mountain from Colombo (Ragama). Image ©Aravinda Ravibhanu 2018

FIGURE 10: View of the Sri Pada Mountain from Maussawa. Image ©Aravinda Ravibhanu 2018

and sapphires, for which the island has been famous, and which earned for its ancient name of Ratnadvipa.

The Knuckles Mountain Range lies in central Sri Lanka, in the Districts of Matale and Kandy and the isolated Knuckles range harbours several relict, endemic flora and fauna that are distinct from central massif (Figure 9). More than 34 percent of Sri Lanka's endemic trees, shrubs, and herbs are only found in these forests. The range takes its name from a series of recumbent folds and peaks in the west of the massif which resemble the knuckles of clenched fist when viewed from certain locations in the Kandy District. The Sinhalese residents have traditionally referred to the area as Dumbara Kanduvetiya meaning Mist-laden Mountain Range.

The higher mountain area is often robed in thick layers of cloud and the range is of great scientific interest. It is a climatic microcosm of the rest of Sri Lanka as the conditions of all the climatic zones in the country are exhibited in the massif. At higher elevations there is a series of isolated cloud forests, harbouring a variety of flora and fauna (Figure 11). More than 34 percent of Sri Lanka's endemic trees, shrubs, and herbs are only found in these forests. Knuckles Conservation Forest was included in UNESCO natural world heritage list in 2010 as part of Central Highlands of Sri Lanka (Figure 12 and 14).

FIGURE 11: Cloud forest morphology in Sri Pada Mountains. Image ©Aravinda Ravibhanu 2014.

FIGURE 12: Seven Sisters Mountain Range in Knuckles area (view of the western side of Sri Pada) Image ©Aravinda Ravibhanu 2015

FIGURE 13 (Left) **:** Knuckles Mountain Range from Pitawalapathna. Image ©Aravinda Ravibhanu 2015. **FIGURE 14** (Right) **:** Sea Fourth Mountain village via ITN Tower Yatiyanthota Trail. Image © Aravinda Ravibhanu 2014

Sea Fourth Mountain village close to ITN Tower at Yatiyantota is very fantastic calm and cool place. It is significant as tourism site (Figure 14). Gommolli Kanda is regarded as the 14th highest mountain in Sri Lanka situated at 2,034 m above MSL. The mountain got its name from the native language of Sri Lanka, Sinhala as the peak of the mountain has a shape of hump of a bull. Another popular mountain peak named Balathoduwa is also situated close to Gommolli Kanda.

Gommplli Kanda and Balathoduwa peaks are visible from World's End of Horton Plains National Park on a clear day without heavy mist. Sri Lanka's highest waterfall - Bambarakanda Falls also situated close to Gommolli Kanda (Figures 15 and 16). There are salient mountain ranges in Central Highland in Sri Lanka is important as geotourism heritage sites, e.g. Norton Bridge Mountain Range, South East Mountain range from Horton plains, world's end trail at Horton plains national park etc. (Figures 17 – 19)

Standing five hundred meters tall over the rivers, tanks, bunds and elephant infested jungles Govinda hela was once the unreachable fortress of King Buwanakabahu of 6 century AC, the rulers of Eastern Digamadulla when the tyrant Invading King Kalinga Maga was ruling the ancient Rajarata, the kingdom of Anuradhapura and Polonnaruwa. The mountain re-discovered by Colonial British was named Westminster Abbey (Figure 19). Govinda Hela, a protected forest reserve, has probably the largest number of ebony trees in a single location. At every nook, corner and turn amidst hundreds of rocks stand sentinel, both aging and young ebony trees, with mature specimens dark black in colour. Rocks of all sizes – small, large and giant, some forming deep caverns – dominate the forest. Trees with vines snaking around their trunks and thick scrub complete the image of the wilderness.

FIGURE 15: (Left) Highly weathered rocky face of the Bambaragala water fall. **FIGURE 16:** (Right) Bambaragala fall depicts the water deficit in dry season. Image © Jinadasa Katupotha

FIGURE 17 (LEFT) : Part of a Norton Bridge Mountain Range close to upper Laxapana. Image ©Aravinda Ravibhanu 2015. **FIGURE 18 (RIGHT) :** A South East Mountain range from Horton plains at world's end trail. Image ©Aravinda Ravibhanu 2015


FIGURE 19: (Left) Govinda hela was once the unreachable fortress of King Buwanakabahu of six century AD. Image © Jinadasa Katupotha. **FIGURE 20:** (Right): Samanala Wewa Reservoir view form world's end trail at Horton plains national park. Image ©Aravinda Ravibhanu 2014

The forest reserve is the home to numerous species of birds as well as large families of wild boars, who tend to surprise the unwary travelers. The two km trek upwards is not for the weary and faint-hearted and the likelihood of getting lost without a proper guide is high in the jungles surrounding Govinda Hela (Figures 19). After crossing two bridges and traveling nearly half km the trek tends to become perilous with many steep rocks and high slopes. The trek had been more difficult nearly one decade back when the climbers had to negotiate uneven rocks and a rope ladder to reach to the top. Gladly the conditions have changed for better with newly constructed cemented steps at some parts and aluminum ladders installed over the rock faces. After the daredevil climb, the view from the top and cool breeze compensate the attempts, the weariness, and the aching limbs. The ruins scattered on the top are the remains of a palace and a monastery but the main attraction is the 'Hulan Kapolla', a space between two rocks through which a gushing wind blows, with the loud but unmistakable "ho, ho" sound of a strong blast.

Inselburgs

Inselbergs are isolated rocky outcrops consisting generally of Precambrian granite or gneiss. The words "island mountains, bornhardts, monasnocks" etc use for the bald domical hills standing in isolation as inselbergs or forming components of massifs. The geomorphology and the geology of inselbergs can be identified as erosional remnants. Inselbergs of Sri Lanka have stood out against the levelling process of nature largely because they are made of resistant granitic rocks containing large proportions of quartz, one of the most indestructible of rock-forming minerals (Cooray, 1984). In Sri Lanka, bare rock mounds or turtle back shaped inselburges are scattered in the II - Second Planated Surface (Katupotha 2013). The relief of this Planated Surface constitutes by Flat terrain to Undulating terrain, Rolling and Hilly Terrains. Sigiriya, Yapahuwa, Etugala, Pidurangala and Lakegala (near Meemure) in Sri Lanka are spectacular and typical examples of inselbergs.

The geographical setting of the area around the Dambulla Archaeological Site comprises of a part of the ll - Planated Surface (Katupotha, 2013) of Sri Lanka. For the purpose of this article the mid-portions of the drainage basins of the Dambulu-Oya and the Mirisgoni-Oya are considered here as the environs of Dambulla. The area comprises an undulating nature extending at an elevation of about 150m above the MSL. The land has been moderately dissected by a number of non-perenial streams draining the ridges and valleys lying northwards from Matale Hills of the Central Massif and covered with numerous cap-rocks indicating the long period of sub-areal denudation (Chandrasena, 1983). They have withstood sub-areal erosions over a long period of time and have helped the ancients in carving out rock cisterns, ponds and lakes. The availability of Crystalline Limestones in nearby ridges extending from Naula through Sigiriya to Habarana, has helped the early monasteries

in procuring suitable rock types for fashioning images and moonstones etc. Quartzite veins have in many cases provided favorable sites for the location of dams of numerous reservoirs.

The geographical features of the area have helped the ancient settlers to develop an extensive agricultural land-scape and to support a large number of population, in the area in and around the Archaeological Site of Dambulla (Figure 21). The rock-knobs of Dambulla descend abruptly to the valleys of Dambulu-oya confining human settlements to the narrow pediments of rock-wastes located above the valley floors. Depending on the small tank irrigation system, most of the human settlements would have been scattered as hamlets throughout the area while Dambulla

FIGURE 21: The largest and best preserved cave temple complex in the country, the Golden Temple of Dambulla, a UNESCO World Heritage Site.

as the center of religious activities and other central functions would have had a relatively larger concentration of population.

Sigiriya or Sinha giri is an ancient rock fortress located in Inamalu Korale in the northern Matale District in the Central Province. Sigiriya rock outcrop site was declared a UNESCO World Heritage Site since 1982. From the third century BCE, Buddhist monks occupied Sigiriya, but it is said that it was only after King Kasyapa seizing the throne in 1527 yr. BP, the palace and gardens were built and the rock fortified. Although, the Sigiriya rocky mass is situated rising about 364m above MSL, on the Second Planated Surface, the surrounding area stretches in an undulating terrain with heights between 100m and 150m (Katupotha and Kodituwakku 2015). Rock-shelters created by erratic boulders, granite tors and corestones are also located in the same Planated Surface. Sigiriya Rock is the number one tourist attraction in Sri Lanka and the main reason most tourists travel to Sigiriya. But it was another adventure that captivated me during our stay in Sigiriya (Figures 22 – 26).

While Sigiriya Rock is rich in history and has some pretty dramatic features such as the lion's paw and the mirror wall, Pidurangala Rock has a much more natural feel, despite also boat rock shelter type temple, and is the best viewing spot of Sigiriya Rock as it is only slightly lower. Pidurangala is a popular spot for sunrise and

FIGURE 22: Top of the Sigiriya rock shows the present situation. Image ©Tharinda Elvitigala

FIGURE 23: Top of the Sigiriya rock shows the present situation. Image ©Tharinda Elvitigala

you can enjoy 360-degree views of not only the valleys but also Sigiriya Rock. Many travelers wake up for the sunrise at Pidurangala and then head to sunset on top of Sigiriya Rock.

Pidurangala is a massive inselburg formation located a few kilometers north of Sigiriya. It has an interesting history closely related to that of the Sigiriya Rock Fortress. Being less grand and far more difficult to climb it is often overlooked by tourists. Whilst Pidurangala appears larger than Sigiriya; its upper surface is steeply sloped and was not suitable for large-scale building activity. The rocky outcrops that surround the central rock gives one indication of what the

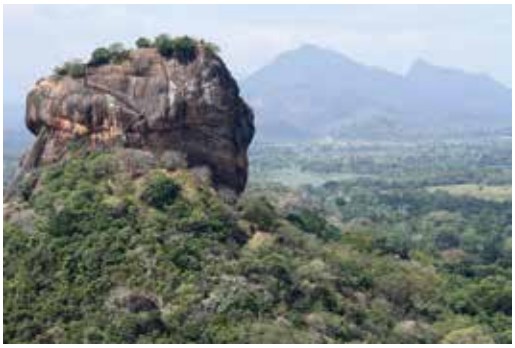


FIGURE 24: (Left) and **25** (Right) : Jungle swathes the eastern face of the Sigiriya rock, topped with the citadel built by King Kashyapa I - in the late fifth century A.D. in central Sri Lanka. Image © Jinadasa Katupotha 2014.

FIGURE 26: Way to Sigiriya rock. Image © Tharinda Elvitigala.

area around Sigiriya may have looked like prior to its clearing and preparation as a royal citadel. The Pidurangala area has been occupied on and off for over two thousand five hundred years by monks who lived in the caves around the site (Figure 27). It really came into prominence when King Kasyapa (477- 495 AD), who built Sigiriya, moved monks living around Sigiriya Rock to a newly refurbished and enlarged temple and monastery here at Pidurangala (Figure 27). It is significant as an Ancient Forest Monastery (Katupotha 2014).

Yapahuwa was one of the ephemeral capitals of medieval Sri Lanka. The citadel of Yapahuwa lying midway between Kurunagala and Anuradhapura was built around a huge granite rock rising abruptly, almost a hundred meters above the surrounding lowlands. The rock fortress complex of Yapahuwa is situated in the North Western Province, Sri Lanka. It is approximately between southeast of Mahawa, midway Kurunegala and Anuradhapura, which is very important site for geotourism (Figures

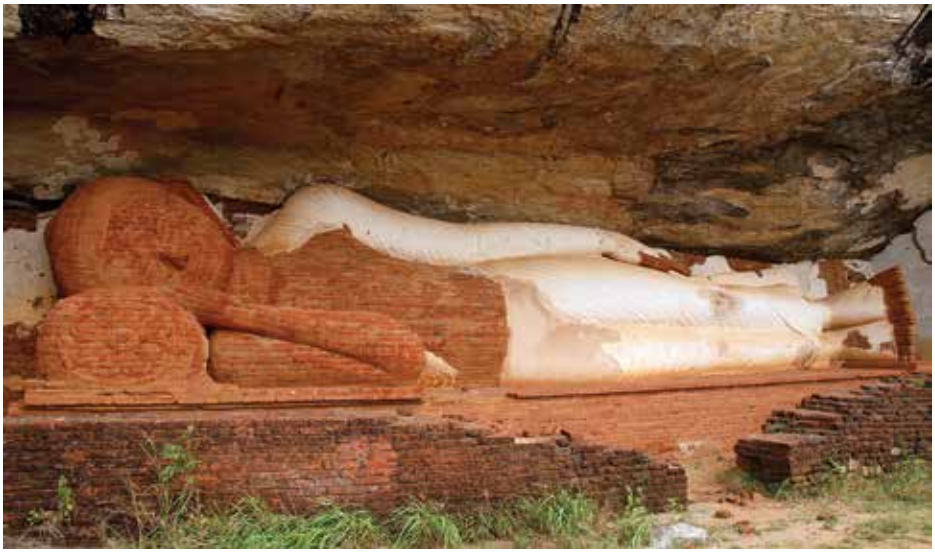


FIGURE 27: Load Budda's repose statue at Pindurangala cave. Image © Tharinda Elvigala.

FIGURE 28 (Left): Entrance to the Yapahuwa rock is a magnificence rocky carvings. **FIGURE 29** (Right)**:** Very tight folding pattern can be seen on huge rock Yapahuwa. Image © Tarinda Elvitigala.

FIGURE 30 (LEFT) : A Trail Journey to Yapahuwa Kingdom. **FIGURE 31:** (Right): Highly metamorphosed (fold) rocky patches can be seen in the main rock. Image ©Lasath Poldoowa and Tarinda Elvitigala.

28 – 32). The original name of this Buddhist Heritage is Yapahuwa, but now this is called as Yapahuwa which is a kind of distortion of its genuine etymological sense.

Lakegala is situated near the Border between Kandy and Matale Districts. There are several access points to Lakegala rock, but the safest access road is from Meemure Village (Figure 33 and 34). "The Rock of Lanka" is the meaning of "Lakegala", and the rock is about 1218m high, and it is in the Knuckles mountain range "Dumbara Valley (Mitiyawatha)"

Ritigala Mountain:

The ruins of Ritigala monastery are located on the eastern side of the mountain at the foot of the gorge which separates the main peak from the northern ridge. The ruins cover an area of 24 hectares (Figures 35 - 36). The ancient man-made reservoir is a feat of engineering with a bund of polygonal plan completing a circumference of 366 meters. The construction of the reservoir is credited to King Pandukabhaya (437 -367 BC). The reservoir, possibly served a ritual bathing purpose.

FIGURE 32 (Left) and **FIGURE 33** (Right) **:** Lakegala, view from Meemuree village. Image © Jinadasa Katupotha 2017

FIGURES 34 : Ancient library building, and (Left) **FIGURE 35** (Right) **:** The ascending footpaths, however, through rugged terrain clear into glades of sacred spaces for those souls in search of enlightenment. Image © Jinadasa Katupotha 2017.

The edge of the reservoir is followed in a clockwise direction to arrive at the other bank, and cross the bed of the stream feeding the reservoir. The steep steps here onwards lead up to a beautifully constructed pavement, a stone path 1.5 meters wide that meander upwards through the forest, linking the major buildings of the monastery. The stone cut path is laid with interlocking four-sided slabs of hewn stone (Figure 36). Three large circular platforms at intervals along the pavement allow for rest. Raised platforms formed by retaining walls of massive stones are found in pairs, linked together by a stone bridge. The main axis of the combined platforms is set exactly east west. The structures were then most possibly roofed and divided into rooms. These are believed to be used for solitary practices such as meditation, as well as congregational functions such as teaching and ceremony. Over a stone bridge lie interlocking ashlars and the ruins of a monastery hospital, where the medicinal herbs-leaves and roots-grinding stones and huge stone cut Ayurvedic oil baths can still be seen. The pavement continues straight ahead to reach one of the round-abouts. About 20 metres before reaching the round-about, a path heads off to the right, leading through enormous tree roots to a lookout, reached by a stone high above a burbling stream. Further up is another lookout. Then is found an artificial waterfall contrived by placing a stone slab between two rocks.

With the exception of a few broken granite Buddha statues in a number of caves, Ritigala has none of the traditional icons of Buddhist temples: no bo tree, no stupas. The first Lanka Vihare (temple) was founded near Ritigala at the foot of the mountain in the second century BC. The Aritta Vihare was founded a century afterwards. Royals proved generous patrons. In the ninth century AD, King Sena made endowment of the monastery, a larger complex higher up the slope for a group of Buddhist ascetics called the Pansukulikas (rag robes) monks who devoted themselves to extreme austerity in search of supreme enlightenment. Carving (rock pieces) to be found at Ritigala is in the form of decorated urinals that consist of urine cup, drain hole and foot supports. It is believed that these decorated stones were meant to depict the architectural and ritualistic excesses of the traditional monastic chapters to which the Pamsukuilikaa (monks devoted to extreme austerity) were opposed. It is also argued that the act of urination on decorated urinal stones was for them a symbolic act of dissociation. However, Ritigala complex is available as geotourism and geoarchaeological site mainly used by granitic gneissic rocks of Wanni complex and easily be promote as tourism destination site.

Danigala Inselberg complex

Danigala circular inselberg (Lat: 7°40'50"N and Lon: 81°12'48"E) is a unique geological rock situated in near Kandegama in the Polonnaruwa district. The sky view of the rock (Figure 36A) shows a unique semi-circular structure, which was affected by geological weathering conditions since past million years period. A part of the northwest slop direction of Danigala inselberg is known to have interesting petroglyphs found in Chithra Lena. The type of symbols (bind rune coding) and petroglyphs found are relatively discovered (Figure 36B) in Sri Lanka during an archaeoastronomical and geological preliminary survey by South Asian Astrobiology and Earth Sciences Research unit of Eco Astronomy Sri Lanka with the corporation of Central Cultural Fund (CCF-Polonnaruwa-Alahana Parivena Project). These petroglyphs are mute science prints of an ancient cultural vestiges of a by-gone society, now perceived and assessed as art (Blum 2002; Kumara 2013). The predominant forms found are likely compared with other sites in Sri Lanka, but still quite not similar due to the process of the engraved recorded. However, few of bind ruins coding in Danigala petroglyphs are quite similar to archaeoastronomical ruins symbols of Shamans as well the engraving technique dominantly found to be close to the petroglyphs of Edakkal Caves, Wayanad, Karnataka in India. archaeoastronomical beliefs associated with the petroglyphs discovered in the Danigala Chiththra lena rock-shelter (Sumanaranthna A.R.,2020)

FIGURES 36A (Left) **:** Aerial view of Danigala Circular Rock. **FIGURES 36B** (Right) **:** Danigala Chithra Lena - Linear chamber entrance and left wall representing sections of the *Petroglyphs* includes anthropomorphic figures. Images © Aravinda Ravibhanu Sumanarathna and Aruna Bandara.

Waterfalls

Morphologically, a cascade of water falling from a height, formed when a river or stream flows over a precipice or steep incline. Likewise, a waterfall is a place where water flows over a vertical drop or a series of steep drops in the course of a stream or river in tropical areas. On the other hand, waterfalls also occur where meltwater drops over the edge of a tabular iceberg or ice shelf. There are over 100 of waterfalls in Central Mountainous area and associated peaks offer fantastic scenic features

in Sri Lanka, e.g. Most Beautiful Waterfalls in Sri Lanka are Bambarakanda, Diyaluma, Bopath Ella, Devon, Ravana, Bakers, Hunnas Luxapana, Aberdeen, Dunhinda (Badulla), Diyaluma (Koslanda), Elgin (Hatton Plateau) and Perawella or Bomburuella, Mohini Ella-Behind the scenes of Sama viharaya (see some Figure from 37 - 49). Beside above hundreds of medium and small-scale waterfalls advantage to say the proud of the country. These are found to occur, especially to the west, south and east and are perennial owing to the heavy rainfall on the central mountain mass, though fluctuations in their falling volume occur as a result of variation in the seasonal rainfall. Similarly, seasonal waterfalls occur in the Dry Zone and Intermediate of Hilly lands of Sri Lanka. Thus, the waterfalls are found in areas with bands of hard and soft rock (otherwise known as resistant and less resistant rocks). The hard rock takes longer to erode than the soft rock (differential erosion) so the river erodes the land at different rates.

FIGURE 37 (Left)**:** Long range view of Luxapana water fall at Kiriwandenita Image ©Jinadasa Katupotha.. **FIGURE 38** (Right)**:** Luxapana water fall view from middle of the Lakshapana waterfall trekking. Image © Aravinda Ravibhanu 2015. **FIGURE 39:** (Left, down) Devon Waterfall Devon Falls, known as the 'Veil of the Valley', is a waterfall in Sri Lanka, situated 6 km (3.7 mi) west of Talawakele, Image © Jinadasa Katupotha.

FIGURE 40 (LEFT) : Diyaluma fall. It is situated 6km away from Koslanda on Colombo-Badulla highway. Image ©Jinadasa Katupotha. **FIGURE 41 (RIGHT) :** Dry session, close to Warnagala dam. Warnagala Waterfall is situated in the Kuruwita – Erathna track which leads to the Sri Pada. Image © Aravinda Ravibhanu 2015.

FIGURE 42 (Left) **:** Seetha Gangula via Erathna Trail: **FIGURE 43** (Right): Warnagala waterfall is situated in the Kuruwita – Erathna track which leads to the Sri Pada Mountain Range. It is 40 meters in height and has got its name with the colour. Image ©Aravinda Ravibhanu 2015.

FIGURE 44: Maapalana Ella, near Palabaddalala, Rathnapura. According to legends, the fall gets its name from a local nobelsman (maapaa) who used to bath at this fall. Image ©Aravinda Ravibhanu 2014.

FIGURE 45 and 46: Olu Ella. Image © Jinadasa Katupotha 2017 Olu Ella is the 6th tallest waterfall in the country and the tallest in the Kegalle District. This is also the highest waterfall in connected to the Kelani River. Image ©Arvinda Ravibhanu 2016

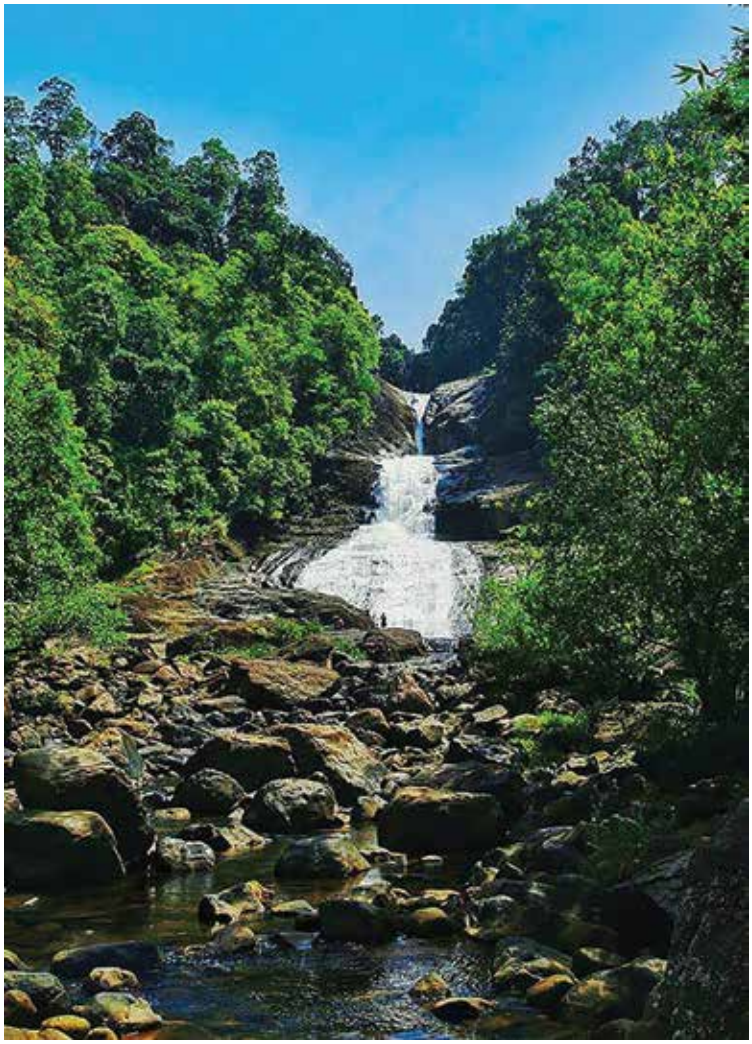
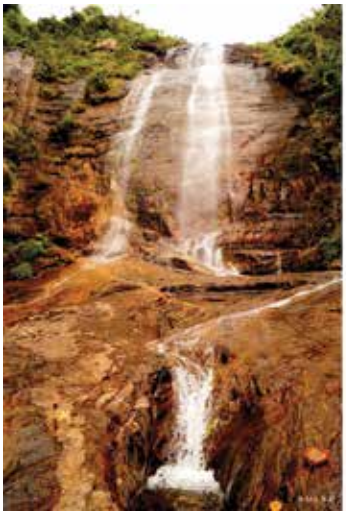


FIGURE 47: Bopath Ella is the most visited waterfall in Ratnapura District. But not many foreign tourists. Image © Arvinda Ravibhanu 2014.



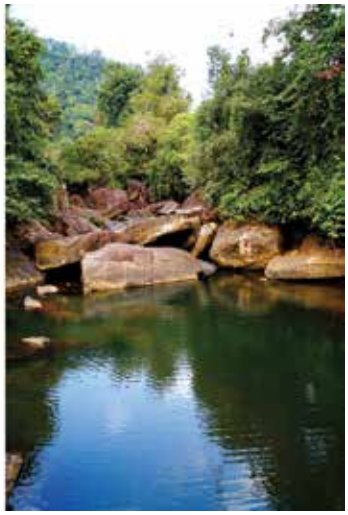


FIGURE 48 (Left)**:** The Kota Ganga Ella is a cluster of cascading waterfalls on Knuckles Mountain Range. Image ©Aravinda Ravibhanu 2018, **FIGURE 49** (Right)**:** Gomalu Oya is a Branch of Seethawaka River, and mini fall is located at Ambalampitaya. Image ©Aravinda Ravibhanu 2015.

Pihimbi Ela fall is a seasonal tributary of the Kiri Oya, which is connected to the Minneriya Tank and located on the Second Planated Surface in the Dry Zone (Figure 50 and 51). The mean annual rainfall of the area varies between 1,250 and 1,500 mm and monthly rainfall from October to December varies 300 - 600 mm and other months are evidently dry. Likewise, monthly temperature of November to January shows the 25o C – 27.5o C and other months are > 27.5o C. Tropical Dry Mixed Evergreen forest is the foremost type and forms climate, topography as well as the regional geology and soil.

There are two main rock veins occur over the study (a) Dolomitic marble and calc-granulite or gneiss in the Highland Complex, and (b) Garnet sillimanite biotite gneiss ± graphite pelitic schist or gneiss. Morphologically, top of the waterfall is at 167m and lower part is 163m above from MSL, and is located over the dolomitic marble limestone formation, which is being eroded. When a river crosses a band of hard rock differential erosion occurs. The hard rocks erode less than the softer rocks. Due to this reason, the waterfall is formed at the site of a Knick point. Water and its load gain velocity by falling at a waterfall thus increasing erosion at the bottom of the fall. Once a depression forms, currents cause pebbles to swirl around within it, increasing the erosion forming a plunge pool.

FIGURE 50 & 51: Pihimbi Ela, after the heavy rain ©Jinasada Katupotha 2014.

This fascinating waterfall of the Pihimbi Ela occurs only during the northeast monsoon season from November to January. When light rains occur during May and June the resultant stream would only flow over the formations unable to form a waterfall. During other months, the study area is completely dried out. This nature has geologic and, geomorphic and environmental significant. Likewise, the site also holds has Geoarchaological and Geotourism values, by virtue of its location within the Sigiriya and Minneriya Protected Areas of the Highland Complex of Sri Lanka.

Geocavings (Speleology)

There are several ways of classifying caves due to formation and evolution. Accordingly, solutional caves are generally formed in limestone or other similar rock such as gypsum or dolomite. They form when acidic water dissolves the rock, seeping through the bedding planes. Lava caves are also called primary caves because they form at the same time as the surrounding rock. Sometimes lava flow creates a hollow tube, which results in the cave, but not in Sri Lanka. Sea caves are formed by the sea, due to the constant activity of waves. They can be both over and under water.

Geocavings are very fascinating features in rocky caves especially in limestone caves. The study of caves is called speleology, and the exploration of caves is called spelunking. Caves are famous of their dripstone features called speleothems, the most well-known of which are stalactites and stalagmites. Scientists and cavers who explore with serious purpose continue to call themselves speleologists. Caves are formed by the dissolution of limestone. Rainwater picks up carbon dioxide from the air and as it percolates through the soil, which turns into a weak acid. This slowly dissolves out the limestone along the joints, bedding planes and fractures, some of which become enlarged enough to form caves. Caves can be dangerous places; hypothermia, falling, flooding, falling rocks and physical exhaustion are the main risks. Rescuing people from underground is difficult and time-consuming, and requires special skills, training, and equipment.

Caves have also an exceptional scientific value due to the fact that they represent one of the best archives for all the Quaternary and allow for extremely accurate paleo environmental and paleo climatic reconstructions. It is possible to maintain the aesthetic and scientific values of a cave when transforming it into a show cave; but to reach this goal it is important to follow strict rules before and during for the geotourism. Cave tourism is becoming increasingly important to tourism development and as such tourists are motivated to visit cave for its inherent natural landscape features. This captivating activity is relatively new to Sri Lanka and is rather an unusual experienced not to be missed. Sri Lanka

FIGURE 52 (Left)**:** Batadombalena pre historic cave, view from outside. **FIGURE 53** (Right)**:** Batadombalena pre historic cave, view from inside. Image ©Aravinda Ravibhanu 2013.

is dotted with many caves from the Ritigala Mountains in the north to the central hills and the southern hillocks of the South. The most famous being Batadombalena (Figures 52 – 59) at Kuruvita (Sumanarathna 2016, Sumanarathna *et al* 2016), attributed to the "Balangoda Man" Prehistoric man skeletal remains were uncovered inside this cave at Belilena and Pahiyanlena.

Sabaragamuwa geological basin associated with northern side of Sinharaja area revealed that the existence of caves in the vicinity of Pannila mountain. The cave formation is seen within the rocks of crystalline limestons (marble), which is popularly known as 'Pannila Hunugala' is of 550m in length and 350 cm height at its entrance of which 60 cm filled with water, where special cave characteristics are visible (Figures 54 – 57). Stalagmite and stalactites of 2.5 m height at the core of the cave was believed to be formed after re-crystallization of pre-existing crystalline limestones the basement rock-in the Highland Complex of Sri Lanka belongs to the Precambrian age (Sumanarathna *et al* 2016).

FIGURE 54: Wavulpane cave located in Bulutota Rakwana range is one of the archeological site located in Sri Lanka. The cave is about 278 metres above MSL.

The Rakwana mountain range, which is located in the margins of the northern side of Sinharaja, a UNESCO world heritage site, is an area having rich bio–diversity. The recent excavations of the alluvial deposits in

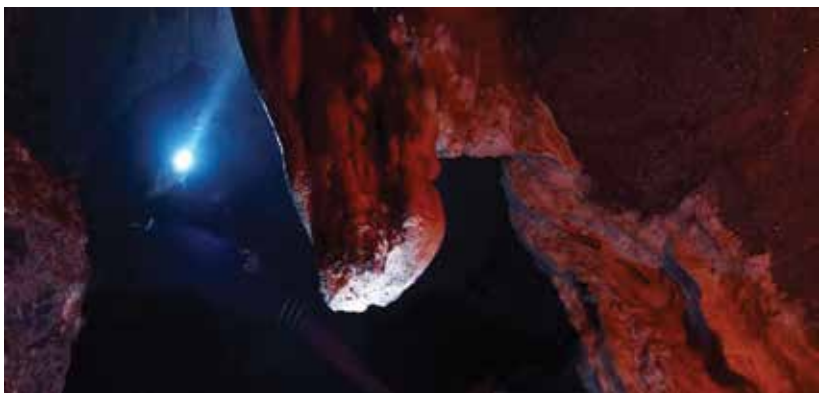


FIGURE 55: Coolant conditions makes magical light in side of Rakwana pannila marble cave. Image ©Aravinda Ravibhanu 2016.

FIGURE 56 (Left)**:** Real Speleothems. Stalactites & Stalagmites of Rakwana Pannila Marble Cave.
FIGURE 57 (Right)**:** Flowstone. Image ©Aravinda Ravibhanu 2016.

Pahiyangala caves lies in Yatagampitiya, which is a remote village about 5 km away from Bulathsinhala (40Km along Piliyandala-Horana road), in the Kalutara District. Excavation has proved that these caves were inhabited by prehistoric cave men some 40,000 years ago (Osahn *et al* 2019 & 2020). This cave is known to be the most ancient pre-historic human settlement in Asia. Pahiyangala caves lies in Yatagampitiya, which is a remote village about 5 km away from Bulathsinhala (40Km along Piliyandala-Horana road), in the Kalutara District. Excavation has proved that these caves were inhabited by prehistoric cave men some 40,000 years ago (Osahn *et al* 2019 & 2020). This cave is known to be the most ancient pre-historic human settlement in Asia (Figure 58).

Belilena is a one of famous and hugh caves in Sri Lanka (Figure 65). It is located 8km far from the Kitulgala town. It holds evidence of a lost generation of Sri Lanka 12,000 years old; this cave is belonged to the Balangoda Man, described as Homo sapiens balangodensis by Paul E. P. Deraniyagala who found here ten skeletons of these people, who lived 2000 feet above the sea level. The fossils are believed to be more than 32,000 years old. Archaeological excavations are done here by Deraniyagala (1958) and finding settlements of the area date back to a very early period, as shown by recent cave excavations as well as those carried out at other sites. The earliest settlement dates back to around 32,000 years ago. Skeletal remains, microsites, bone implements, charts and food remnants have been found in local caves. Evidence of prehistoric animals has established that hippopotamus, rhinoceros, lion and three species of elephant lived in the area.

Ma-Lena a marble cave, which is located at western foothill of the peak wilderness mountain range is an underground cave complex. The cave is situated in Guruluwana, Siripagama of Rathnapura District and close proximity to Kalu Ganga (Figures 60 and 61). Physio graphically the cave belongs to wet zone of the country. Though it has several entrances to the cave, northern and southern entrances were identified as the main and largest. North entrance opens to a higher elevated chamber complex while the other opens to a complex of chamber situated at lower elevation. Both chamber complexes are connected by vertical tunnels and small chambers at various places. The cave complex was hydrologically active. Geologically, the cave is made up of impure marble of Highland Complex. The grain size of the marble varied

FIGURE 58: Fa-hien caves lies in Yatagampitiya, which is a remote village about 5 km away from Bulathsinhala, in the Kalutara District. Excavation has proved that these caves were inhabited by prehistoric cave men some 37,000 years ago. This cave is known to be the most ancient pre-historic human settlement in Asia. Image ©Pathmakumara Jayasingha

from place to place. The formation of cave chambers is directly correlated with a fluvial weathering process. The chamber walls and ceilings were seen nicely polished by the flowing water. Speleothems were characterized brimpools, cave curtains, stalagmites, stalactites, cave pearls, siliceous deposits, cave pillars, helictites and flowstones. The cave was home for chiropteran bats which were definitely in thousands of numbers.

FIGURE 59: Kitulgala Belilena holds evidence of a lost generation of Sri Lanka 12,000 years old; this cave is belonged to the Balangoda Man. Image ©Padmakumara Jayasinghe

FIGURE 60 (Left) and **61** (Right) **:** Ma-Lena which is located at western foothill of the peak wilderness mountain range is an underground cave complex. Image © Pathmakumara Jayasinghe.

Alawala Pothgul Viharaya is an important archaeological cave site which is situated in Attanagalla DS division of Gampaha district (Figure 62 – 63). Archeologists believe that, Alawala is a pre historic cave considering the facts which was found by the excavations. Few caves can be seen in the Pothgulkanda temple premises. Most important excavated pre historic cave is located middle of the mountain. Pothgulkanda is a matching site for the cultural tourism and archaeological tourism. Temple needs a proper plan for developing cave tourism here.

Mineral Resource as Geoheritage

Rock is a solid mass consisting of one or more minerals and mineral is a solid substance of natural, inorganic material with a defined crystal structure and chemical composition. Locations of enormous number of mineral deposits of Sri Lanka presently being exploited and mining as basic industries. Despite their high environmental and landscape impact, abandoned mining sites may represent a potential source of income considering their possibility of being re-used as geoheritage and geotouristic resources after rehabilitation.

FIGURE 62 (Left)**:** Alawala rock shelter. **FIGURE 63** (Right)**:** Excavations trench at Alawala pre historic site. Image ©Pathmakumara Jayasingha.

Mining tourism is one of the niche forms of tourism, in recent years has become an opportunity for the regional development. In the article, it has been presented comparatively other forms of tourism, and in particular attention on mineral was drawn to the various aspects of deposits of existing deposits in different areas in the country, for e.g. graphite mining at Kahatagaha/Bogala, saltpans at Puttalam, Hambantota, Elephant pass and Rigam; gem mining and lapidary at Ratnapura and other sites; Phosphate at Eppawala; Collection of ilmenite at (Pulmudai – East coast). The present study examines the way tourists perceive visiting mines and other geological object.

In fact, mining sites can rightfully be defined as geosites because, other than cultural monuments of mining heritage, they (i) can provide access to geological rarities and spectacular scenery; (ii) allow a more comprehensive vision of geological features by unveiling the exposition of rocks, minerals, geological structures, and stratigraphic units; and (iii) have several natural, ecological, and landscape potentials (Marescotti et al 2018). Mineral resources and their economic values briefly described by Jayatileke (2015), and all these mineral mining sites have geotourism value.

Gemstones: Gems are valuable because of scarcity, high hardness, chemical resistance and its beauty. Sri Lanka is famous for high quality blue sapphires and star sapphires. Various varieties of gemstones such as corundum (blue sapphire, ruby, yellow sapphire, pink sapphire, white sapphire, star sapphire, etc.,), spinel, garnet, grossularite, tourmaline (complex boro – silicate), zircon, chrysoberyl (cat's eye), beryl (aquamarine) and quartz are available in Sri Lankan gem beds. Other than the above-mentioned gem varieties, rare gem varieties like cordierite, andalusite, apatite, kornerupine, sinhalite, taaffeite and ekanite are also occasionally found in Sri Lankan gem beds. The extensive mining locations are found in Kuruwita (Figures 64 & 65), Ratnapura, Monaragala, Matale, Matara and Hambantota Districts.

Graphite: Sri Lankan graphite is very famous in the world for its purity (97 – 99 %) and found in Highland, Kadugannawa, Vijayan and Wanni Complexes. Chemically graphite is Carbon (C), and it is very soft. Graphite is a good electricity conducting material, and is used in electrical industry as carbon brushes in motors, electrodes, high temperature electrical elements under reduction condition, etc. It should be noted that the hardest material in the world is diamond and its chemical composition is also

FIGURE 64 (Left) **& 65** (Right)**:** A deep gem pit and operation system by local people at Bubuladeniya village. Image © Jinadasa Katupotha.


FIGURE 66 (Left) **& 67** (Right)**:** Graphite mines at Bogala. Photos: Copyright. © GSMB)

Carbon (C), but its crystal structure is cubic system. Diamond has not been reported from Sri Lankan soil/rocks. Graphite is commercially mined at Bogala, Rangala (both in Kegalle District) and Kahatagaha (Dodangaslanda in Kurunegala District). Bogala mine (Figures 66 & 67) is over 400 meters deep and Kahatagaha mine is about 650 meters deep.

The processed graphite products including graphite nano particles and nano tubes, are very expensive. The latest product developed using graphite is graphene, which has a wide application in electronic industry. Presently, raw graphite is exported at around US $ 1 per kg where as the price of graphene is over US $ 6,000 per kg. If it is possible to improve such industry that is very useful for mining geotourism.

Ilmenite Mineral Sand Deposits: The major minerals in this deposit are ilmenite and rutile. Other associated minerals are zircon, monazite, garnet, sillimanite and few other heavy minerals. This is the only commercially exploited mineral sands deposit in Sri Lanka, although several other mineral sand deposits are available as beach mineral sand deposits. Some of them are along the beach north of Mullativu, Trincomalee (Nayaru & Nilaveli), Induruwa (Galle district) and along the Talai-Mannar beach (Figures 68 & 69). A well-known mineral sand deposit in Sri Lanka is at Pulmoddai, north of Trincomalee and Mannar Island.

The important chemical element in ilmenite and rutile is Titanium. Titanium minerals are used to extract the Titanium metal and also to produce the titanium pigment. Titanium


FIGURE 68 & 69: Well-developed ilmenite mineral sand deposit at most point of Talai-Mannar, Palk Bay side. © Jinadasa Katupotha.

metal is strong, light weight, and can stand high temperatures. Therefore, it is used in the air craft industry and also in space travel. Titanium pigment, rutile, is extensively used in the paint industry to impart whiteness, opacity and brightness. It is also used in paper, rubber, plastic and other industries. In addition to the above-mentioned garnet sand' rich beach sand deposits are available in the Southern coastal area (Dondara and Hambantota). All these coastal deposits can define as geological sites.

Apatite deposit: Chemical composition of apatite $Ca_5(PO_4)_3(OH, F, Cl)$ is Calcium Phosphate with Fluorine, Chlorine, and hydroxide. Apatite is also called as rock phosphate. Rock phosphate is commercially used as a fertilizer to provide Phosphorous (P) to plants, and P is needed for the physiological processes of plants. The rock phosphate deposit in Sri Lanka is at Eppawala in the Anuradhapura District (Figures 70 & 71). This deposit covers on area over 7.5 km² and the estimated quantity is over 50 million tons. The P_2O_5 content of this apatite deposit is around 35%, but its solubility is low to use as a phosphate supplement for short term crops like paddy. Powdered rock phosphate is used as a fertilizer for long term crops like Tea, Coconut, and Rubber etc. The solubility could be improved by mixing with sulfuric acid to convert phosphate in to supper phosphate. This reaction improves the solubility by about 20%. The solubility could be further improved by the action of phosphoric acid, and converting it to triple supper phosphate. The treatment of rock phosphate with these acids is not an environmentally friendly process. The Eppawala apatite deposit is presently being mined and ground to powders by Government owned Lanka Phosphate Ltd.

Dolomite, Calcite and Magnesite deposits: These are known as crystalline limestone and also as marble. Dolomite is a combination of calcium carbonate and magnesium carbonate and its magnesium content may go up to 22 percent. Calcite and magnesite are nearly pure calcium carbonate and magnesium carbonate respectively. The term dolomitic limestone is also used when MgO content is 10 to 18 percent. Generally, crystalline limestone is white in colour, but other colors like ash, green, yellow etc., are also found as small pockets.

Crystalline limestone deposits are scattered throughout the Highland – South Western, Vijayan and Wanni complexes. Some of the well-known localities for limestone deposits are Habarana, Matale, Digan in Kandy (Figures 72 & 73), Ratnapura, Balangoda, Badulla, Bibile, Welimada, Ambilipitiya, Hambantota, Kataragama, etc. The dolomitic limestone is the most abundant type of material, while calcite is occasionally found as pockets within dolomite and dolomitic limestone. Well known

FIGURE 70 & 71: Rock phosphate deposit and phosphate manure production at Eppawala.
© Jinadasa Katupotha.


FIGURE 72 & 73: A patch of limestone (Dolomite) deposit (quarry) and a limekiln at Digana (Kandy) area. © Jinadasa Katupotha.

occurrence of calcite deposits are in Balangoda and these are mined for calcite other calcite pockets found in other areas are too small.

Dolomite is presently being mined and powdered for use as a fertilizer to provide Magnesium for plants. For this purpose, MgO content should be higher than 18%. This powdered material is also used to stabilize the soil and to adjust the pH value of soil. Dolomitic limestone is mined to produce quick lime and slaked lime for the building industry.

This burnt lime is marketed as quick lime or as hydrated lime powder after adding water or as slaked lime, as a paste. This dolomite lime became important as a substitute for coral lime, since coral mining has been banned to protect coastal erosion. Other than the above-mentioned major uses, dolomitic limestone is also used as a minor raw material in ceramic and glass industry. Powders are also used in the rubber and paint industries as a filler material, and also to produce wall finishing materials. Sri Lankan crystalline limestone cannot be cut into marble slabs due to its coarse crystallinity nature. Calcite is softer than the other two varieties (calcite is 3 and other two are around 4 in the Moh's scale), and hence it could be ground easily. Therefore, calcite powder is used as a filler in industries. Calcite is also used in other industries as a minor raw material, filler, soft abrasive materials, etc.

Limestone Deposits:

The entire Jaffna peninsula and northern coastal area from Puttalam (several kilometers into the country) is covered with Miocene age hard compacted sedimentary limestone. Calcium carbonate content varies widely from low values to over 95 percent. Sand is present as large particles of impurities. Most of the area of the deposit is covered with a thick over burden. The only limestone quarry in operation is at Aruwakkalu (Figures 74 & 75) about 20 km away from Puttalam. It is an open cast mine for the cement factory at Puttalam. The CaCO3 content of the limestone should be more than 75% for use in cement manufacturing.

Vein Quartz Deposits:

Chemical composition of quartz is SiO_2 and the name vein quartz is used for the quartz deposits in the form of a vein, which had originated due to igneous activities. Vein quartz deposits of high purity (over 98 percent Silica) are found in many parts of the country; mainly in Galaha (Figure 76 & 77), Rattota, Balangoda, Pelmadulla, Embilipitiya, Ratnapura, etc. High purity quartz are important to produce fused quartz and Silicon, which are used in computer chips and other electronic devices.

Feldspar Deposits:

Feldspar is an alumino silicate of potassium, sodium and calcium, and occurs due to igneous activities as veins or dykes (as pegmatites). Feldspar deposits are found in many parts of Sri Lanka. Some of them are in Kaltota (Figures 79 & 80), Namaloya, Koslanda, Balangoda etc.


FIGURE 74 (Left) **:** A Miocene limestone bed at Aruwakkaru. Overburden soils are designated as Red Beds in eonian origin. **FIGURE 75** (Right) **:** Fossilized Miocene limestone block. Image© Jinadasa Katupotha


FIGURE 76 (Left) **77** (Right) **:** Damshila Quartz mining site and at Galaha (Kandy District) Image. © Sandun Dalpatadu.


FIGURE 78 (Left) **79** (Right) **:** Damshila Quartz mining site and at Galaha (Kandy District). Image © Sandun Dalpatadu.

In Owella (Rattota) deposit feldspar occurs (Figures 88 - 89) with other pegmatite minerals such as quartz, biotite (mica) and fluorite (calcium floride), as thick bands with clear boundaries. This deposit occurs up to more than 600 meters below the surface. Feldspar is one of the major raw material in ceramic and glass industries.


FIGURE 80 (Left) **:** Feldspar mines at Kaltota (Balangoda) area. Image© Jinadasa Katupotha
FIGURES 81 (Right) : Feldspar deposit at Rattota mines (Matale area). Image © Jinadasa Katupotha

Mica: Mica is a group of minerals of the hydrated alumino silicate of iron (Fe), magnesium (Mg), potassium (K), sodium (Na) etc. Mica could be easily identified by its unique flaky structure. The most common types of mica in Sri Lanka are phlogopite (Mg rich mica) and biotite (Fe rich mica). Muscovite (K rich mica) also occur in certain areas (Kabitigollawa). Some of the mica deposits are found in Matale (Figures 80 - 83), Talatu Oya, Badulla, Maskeliya, Haldumulla, Kabitigollawa, Balangoda etc. One of the underground mines is at Wariyapola, Matale for Phlogopite and muscovite was mined in Kabitigollawa.

Mica mining in Sri Lanka has been reported even prior to 1900. During the Second World War period the demand for mica increased. Presently the important commercial variety is muscovite, which is white or colorless. Phlogopite is also in demand if it is in large sheets. Mica is graded into sheets, scrap, flake and powders. Mixing and processing of mica has to be done with extra care, to avoid contact with eyes and also in inhaling. The flakiness nature of mica tends to adhere to eyes, lungs, etc, and is also difficult to remove. Mica can withstand high temperatures, high di–electric strength, and is an electrical insulator. Because of these properties sheet mica is used in electrical and electronic industries.


FIGURE 82 : Mica mines at flakes and a mine at Matale. Image © Sandun Dalpatadu.


FIGURE 83 (Left) **& 84** (Right) **:** Mined mica processing processes is undertaking. Image © Sandun Dalpatadu.

Silica Sand: Silica sand can be grouped in to three types, river sand, sea sand and industrial sand. River sand is a material derived from weathered rock and transported by running water. River sand, if not excavated, will be carried to sea and accumulated in shallow sea and beach. River sand is mainly used in building construction, especially for concrete, since it does not contain chloride and sulphate, which adversely affect (corrosion) reinforced steel in concrete. Due to the rapid growth of the construction industry, river sand was extracted extensively creating a shortage of river sand. Because of this reason it has become a necessity to use sea sand for construction. Now sea sand is pumped to form domes and allowed to wash away chloride and sulphate by rain water, till sand become good enough to use in building construction. Washed sea sand is characterized by the presence of high shell content.

White colour high purity (over 98 % SiO_2) Silica sand deposits are found in Marawila, Nattandiya and Madampe (in Chilaw District) and also in Ampara and Jaffna peninsula. Silica sand is extracted from Nattandiya and Madampe areas for use as a major raw material in glass and ceramic industries.

Iron ore: There are few iron ore deposits discovered in Sri Lanka, but they are small deposits compared to the known world iron ore deposits. Iron ore deposits of Sri Lanka were divided into three broad categories such as primary iron ore deposit (Magnetite deposits),


FIGURE 85 (Up) **& 86** (Down) **:** Silica sand deposits, located within the intermediate zone at Nattandiya Image © Jinadasa Katupotha.

FIGURE 87 (Left) **& 88** (Right) **:** Uva-Wellassa Iron deposit at Kukurampola-Buttala. This deposit lies in an area of 64 Square Kilometers. Image © Jinadasa Katupotha

Secondary iron ore deposit (Hydrated iron oxide ore deposits), and Seruwila copper-magnetite type ores. The only Magnesite deposit so far identified is in Randeniya (Wellawaya), which is also surrounded with dolomite. The quantity of Magnesite is estimated to be about 4,000 tons. An interesting iron ore is located at Palawatte, Buttala in Uva province, Monaragala district. It is a primary magnetite deposit (Figure 87 & 88).

The hydrated type of small iron ore deposits are scattered in Sabaragamuwa Province (Ratnapura, Rakwana, Balangoda, Kalawana etc.) and in the Southern Province (Ambalangoda, Akuressa, Deniyaya etc.). These deposits are in the form of small hillocks and as scattered boulders of about 2 – 4-meter width, but not extended in depth. The most important of these deposits are located at Dela, Naragolla, Opatha and Poranuwa in Ratnapura District and Wilpita in Galle District. Three magnetite deposits have been identified in Sri Lanka. They are at Wilagedara, Panirendawa and Seruwila. The Wilagedara deposit is too small to be mined. The deposit at Panirendawa has been estimated to contain around 5.6 million tons of magnetite, but they are four separate blocks, and these occur underground about 25 – 170 meters below the surface. Therefore, excavation of this deposit is costly and not economical. The Seruwila deposit extends below to about 70 meters from the surface. The iron content is high, but considerable amount of copper (in the form of Chalcopyrite) is also associated in this magnetite ore. Therefore, the direct smelling process cannot be used to extract iron from this ore.

Clay: Clay is not a primary mineral and it is a product of weathering of primary minerals. Chemically it is hydrated aluminosilicate. Clays, characterized by fine grain become plastic when mixed with water. Clay deposits are basically grouped into two types.

i. Primary or residual or in–situ clay deposits (Figures 89 & 90). This type of deposits are formed due to weathering of primary rock minerals or due to action of hydrothermal solution on primary minerals mainly feldspar and mica. These deposits are characterized by large grain (particle) size compared to secondary clay deposits and also by the presence of other mineral particles like quartz, feldspar, mica, ilmenite etc.

ii. Secondary or sedimentary clay deposits: When rocks are weathered some of the rock forming minerals (e.g. Feldspar, mica) gets converted to clays. These clays are carried away

by air, water and glaciers (mass of ice) and get deposited in river banks, river mouths (delta) lakes, sea etc. to form sedimentary clay deposits, and these processes of transportation and sedimentation continue for a very long period. Clay of this type is characterized by fine grain (particle) size and contaminated with organic matter. The main clay minerals present in clays are Kaolinite, Montmorillonite and micaceous clay minerals. Properties of these clay minerals differ from each other; hence characteristics of clay are governed by the percentage of these clay minerals in the deposit.

Kaolinite is comparatively less plastic and of high refractoriness (stand for high temperatures of about 1600o C). Montmorillonite is highly plastic and of less refractoriness. Hydrous mica clays give intermediate plasticity and refractoriness. Clay is the main raw material in the ceramic industry. Two varieties of clays, that is Kaolin and Ball clay, are mixed to obtain the required properties. Kaolin is the name given to pure white clays composed mainly of kaolinite. It is the final product in the weathering of feldspars in granites, pegmatites and feldspar rich gneisses (Cooary, 1984). Kaolin (also known as China clay) consist of mainly Kaolinite and deposits are formed by weathering of feldspar. Well known Kaolin deposits in Sri Lanka are located at Metiyagoda and Boralasgamuwa. Boralasgamuwa deposit has already been extracted and exhausted, but there are few more deposits nearby but cannot be mined because the area is urbanized.

A new Kaoline deposit has been found in Millaniya (Bandaragama) and extraction has already started. Kaoline is mainly used in the ceramic industry and also used in paint, rubber, paper and some other industries. Ball clay deposits are a kind of sedimentary clay deposit characterized by very fine particles, high plasticity and is usually gray in colour but turns to white or cream colour on firing. Ball clay is added to the ceramic body mixture to improve the plasticity. There are ball clay deposits in flood plains of rivers in Kalutara area. A well know ball clay mine is at Dediyawala (Kalutara) which has been mining for the last forty years.

Alluvial clay deposits are formed by sedimentation of clays in river banks and lakes. These are characterized by the presence of high organic matter and impurities. Some of the alluvial deposits in the dry zone of Sri Lanka are characterized by comparatively higher amounts of montmorillonite. Alluvial clay deposits are wide spread in the country and are being mined in a small scale for brick, tile and pottery industries.

Rock (stone) deposits: Rocks (stones) cut to slabs or into different shapes and sizes (dimension stone) are used in building industry with or without polishing. The commercial name for this is granite, and it is used as a floor tile or wall tile (Figures 91 & 92). Rocks are

FIGURE 89 (Left) **& 90** (Right) **:** Kaolin mining at Mitiyagoda. Image© Jinadasa Katupotha

FIGURE 91 (Left) **& 92** (Right) **:** Granite rocky quarry at Ingiriya. Like these mining sites blasts for separates large blocks and product different sizes of metals. Image© Jinadasa Katupotha

also used to produce monuments and also as paving blocks. Other than the above-mentioned purposes, rocks are crushed in to pieces to be used as coarse aggregate for concrete and road construction. These types of quarries are wide spread throughout the country.

The city of Anuradhapura, today the provincial capital of the North Central Province served the ancient Sinhala kings as a capital between the 3rd century BCE and the 10th century CE.1 Thus, it is one of the oldest continuously inhabited cities in the world. The earliest written sources began to appear in the 5th century BCE, 2 and Anuradhapura has remarkable architectural remains make it one of the most important archaeological sites in the cultural landscape of Sri Lanka. Similar rock products places can be seen in various places in Sri Lanka. Rocky boulders detach for production of different monuments at Darshana Gal Ketayam is famous n Keragala, Gampaha Distreict in Sri Lanka (Figures 101 - 104).

Other than the above mentioned mineral deposits, there are few rare minerals deposits in small quantities, e.g. wollastonite and serpentine deposits which are not sufficient to excavate economically. Wallastonite could be used as a fluxing material in the ceramic industry, and as a filler material in paint, rubber and paper industries. This is in fibrous form in veins of 2 to 7 - centimeter width, in the calc gneisses in Ambalangoda and Galle areas. Two

FIGURE 93 (Up) **& 94** (Down) **:** Rocky boulders detach for production of different monuments and carving of rocks at Darshana Gal Ketayam in Keragala. Images © Jinadasa Katupotha

serpentine deposits occur at Udawalawe and Rupha (Walapane). The Udawalawe deposit is dark green in colour and occur at several meters below ground. Rupha deposit is associated with marble, and is also called green marble, and is exposed to the surface.

Special other sites

Rose Quart Range (Namal Uyana)

Rose Quartz Mountain Range at Jathika Namal Uyana is located at Galkiriyagama (Madatugama - Pubbogama - Andiyagala Road), Sri Lanka. The Jathika Namal Uyana in Sri Lanka is the biggest Na tree (ironwood) forest and pink quartz hilly land (Figure 95 & 96). The forest is home to a large bed of fossilized plants and is a nature reserve for animals. The Na tree is endemic to Sri Lanka and the replanted woodland is over 250 acres in range. This mineral deposit is located in the Wanni complex has a history of over 550 million years. This exclusive natural place has been taking forward to the consideration of the world around 30 years before from today, by a great Buddhist hermit, Venerable Wanawasi Rahula Thero.

The rose quartz mountain consists of is larger than 972 hectares and was declared open as a National Forest Reserve on the 8th of May 2005. The rose quartz mountain is well known for its healing properties, archaeological reserve with ruins of ancient monastery and palace and diverse wildlife.

Kudremalai Point

In northwestern, northern and northeastern Sri Lanka are composed of Miocene age limestone, which is identified as massive coral beds. However, this massive Miocene belt is generally about 20 km wide and overplayed by the red soil layer which commonly addresses as Red Earth formation. This belt is bound on the seashore and on the land, border is near to the 30m contour. The composition of the Red Earth layer is extremely uniform and containing quartz, clay and iron oxide with a small amount of ilmenite, magnetite, spinel, zircon, garnet and monazite (De Alwis and Pluth, 1976).

Four layers were identified as (1) surface soil layer, (2) ferruginous Red Earth layer, (3) weathered limestone and (4) limestone basement on the surface of the Kudiramalei point (Figure 3a). Each layers consists a gap like a step cutting. Surface soil layer consist with coarse sand, silt and mud matrix and also, very few quartz pebbles were found on its body and the bottom of the layer (Figures 97 & 98). This layer is 3 m in height (Wilpattu National Park, Field Report 2018).

Ussangoda

About the occurrences of serpentinites are known to occur in the Precambrian rocks of Sri Lanka. These are found at Ussangoda (Figures 99 & 100), Ginigalpelessa and Indikolapelessa (both in the south central) and at Yodagannawa (in the north central). Integrated geophysical, geological, geochemical and drilling surveys

FIGURE 95 (Left) **& 96** (Right) **:** Namal Uyana Rose quartz range at Galkiriyagama. Image © Jinadasa Katupotha.


FIGURE 97 (Left) **& 98** (Right) **:** Highly weathered Miocene beds (Left) and windblown red sand layer overlain on the Miocene rock at the Kudiramalei Point. Image © Jinadasa Katupotha.

have been carried out on the first two mentioned. According to a geochemical analysis of the soil overlying the Ussangoda deposits, the average Ni and Cr content are of ~1000ppm and ~7700ppm, respectively. Core drilling revealed that the serpentinite is ~100m thick and dips steeply (~700) towards west. Higher Cr and Ni values in the soil suggests supergene enrichment. The soil is ~40cm thick and consists of hematite rich clayey sand associated with pebble layers. The top 10cm of the soil profile is very fine grained and cover an area of ~3 km². Field relations and drilling show that the serpentinite is concordant to the host garnatiferous biotite gneiss with some development of flaky graphite at the contact (Ranasinghe, 1987).

Akurala emerged coral reef patches

Emerged coral reef patches occur at or above Mean High Water Spring (MHWS) level and are located on the small headland mostly cemented to beach rock in the vicinity of Akurala, Hikkaduwa, Dadalla, Koggala, Aranwala, Denuwala and Pallikkudawa (Figures 101 & 102) . Upright branching and massive coral of these buried and emerged corals indicate that they have thrived on palaeo-bays or lagoons, when the sea level was higher than at present level. C14 dated of samples from emerged reef patches have been clustered around 6200-5800 and 2600-2300 yr BP (Katupotha 1988 a and b).


FIGURE 99 (Left) **& 100** (Right) **:** Foliated / deformed rock strata and eroded coast at Ussangoda Image © Jinadasa Katupotha


FIGURE 101 (Left) **& 102** (Right) **:** Emerged coral reef patches at Akurala (Hikkaduwa) and Polhena (Matara). Image © Jinadasa Katupotha

Shell Deposits

Large inland shell deposits are found in the area between Tangalle and Kirinda (southern coast). These can also be used as sea level indicators and past human occupations (Figure 103 & 104). Shell deposits particularly along the rims of emerged coastal embayments and lagoon floors ave14C ages between 4,650±60 BE and 3,570±60 B.P. (Katupotha, 1988b; Katupotha and Wijayananda, 1989). The depositional pattern and compositions of these deposits indicate that they probably accumulated by three processes, namely:

(a) The bulk of the valves piled up by wave action on the rimes of coastal embayment, following the coastal progradation since Late Holocene, around 4,000 BE.

(b) The shells gathered on lagoon floors in marine or brackish pools, and they were deposited in situ during the same; and

(c) Shells on the coastal hills and dunes were left by early inhabitants during their daily activities.

Geographically, the Gulf of Mannar was one of the most abundant sources of natural pearls in the world for more than two millennia. Pearls were the most valuable aquatic resource in Sri Lanka and were exploited since ancient times, more than 3500 years' time. Under the right conditions, millions upon millions of pearl-producing bi-valve molluscs Pinctada genus of saltwater oysters mainly Margaritifera vulgaris) populated the low-lying shoals and rock and coral formations of the Gulf of Mannar (Ostroff 2016). Owing to that, Sri Lanka is a wondrous island, because it's endowed plethora of resources such as an abundant biodiversity, gemstone, rich culture, great history, varied landscapes and many more. The pearl beds of South India and Sri Lanka constituted one of the two major sources of pearls in the world, rivalled in size only by that of Hainan. The pearls fished from the Gulf of Mannar were also considered among the best in the world and fetched a high price in Europe. The area to the north of Kal Aru coast, the pearl shell deposit can be found along the northwestern coast.


FIGURE 103 (Left) **& 104** (Right) **:** Mined and cleaned shells at Kalametiya area (Left). Discarded pearl shells after removing of pearls from mollusks at KalAru coastal area, Northwestern Coast (Right). Image © Jinadasa Katupotha


FIGURE 105 (Left) **& 106** (Right) **:** Highly eroded beach rock at Chilaw coastal belt. Emerged beachrok reef at Mullativu coast. Image © Jinadasa Katupotha

The exploitation of pearl fisheries continued during the Dutch and the British colonial rule (Katupotha 2019). Discarded pearl shell deposits can be seen from Kudremale point to Northwards (Figure 104). The British earned considerable revenue from pearls of Ceylon, e.g. from March 1828 to May 1837 alone Sterling Pounds 227,131 were credited as revenue into the Ceylon Treasury on account of the pearl fisheries. The pearling industry is all extinct today.

Beachrock

Beachrock is a distinctive formation which forms a series of parallel reef at many locations along the coast around Sri Lanka. The best exposed reef occur along the western and southern coasts, and have, so far, been noted that Chilaw, Negombo, Pamunugama, Colombo, Kaikawala, Aturuwala, Beruwala, Galle, Ahangama, Matara, Hambantota and Mullativu coast (Figures 105 – 106). They are similar to those found along the coasts of Brazil (Katupotha 1989), Uruguay and Hawaiian Islands (Cooray, 1968). Each submerged reef on the western continental shelf represents a former strandline. The beach rock at Pitipana-Negombo above from the supratidal level has been dated at 2,470±70 and 3,460±160 yr BP (Katupotha 1988 a).

Erratic Boulders: As a glacial deposit, an erratic is a piece of rock that differs from the size and type of rock native to the area in which it rests. Erratic can range in size from pebbles to large boulders such as big rocks (hundreds to thousands of metric tons in weight). Geologists identify erratics by studying the compositions and orientation of surrounding rocks in comparison to the composition and orientation of the erratic itself (Figures 107-108). Due to the Pliocene-Quaternary climate changes, the earlier glacial sedimentary deposits in Sri Lanka have disappeared from greater part of Sri Lanka. However, there are no Pleistocene glacial deposits in Sri Lanka, but scattered erratic boulders and patches of ice-rafted deposits can be identified as glacial deposits older than Pleistocene Glaciation. Likewise, outwash plain type landforms can be identified from the "Second and Third Planated Surfaces", while valley terrains can be identified from the upper part of the "Third Planated Surface" and from the "Rugged Central Highland" area (Katupotha 2013).

Dambatenna popular tea factory was built in 1890 by Sir Thomas Lipton, one of the most famous figures in tea history. The geotourism tour through the works is an education on the processes involved in the fermentation, rolling, drying, cutting, sieving and grading of tea located in Dambatenna geomorphological site. It's probably the most comprehensive tea-factory

FIGURE 107 (Left) **:** Erratic boulders Potuvil Lagoon area. Image © Jinadasa Katupotha (Katupotha 2013). **FIGURE 108** (Right) **:** Erratic boulders at Nakolagane.

and its surrounding tour, and afterwards you can sip a cuppa. Dambatenne is 9km northeast of Haputale. Buses from Haputale pass the factory every 30 minutes. Sir Thomas Lipton was used to enjoy the view from this place when he was at Dambetenna estate (Figures 109-110).

Due to the Postglacial Transgrssion, Mannar and Palk basins and the 1st Planated Surface were submerged (Katuptha 2013). Accordingly, Sri Lanka and India appear as separate land masses. Because of sea level rise many massifs type low mountains and ridges, peaks, hill and rock outcrops were submerged. Some of them

FIGURE 109 (Left) **:** Land use pattern followed the landscape in the Dambatenna area. **FIGURE 110** (Right)**:** Sir Thomas Lipton was used to enjoy the view from this place when he was at Dambetenna estate Image © Jinadasa Katupotha

Islands

There are six major kinds of islands: (a) continental (b) tidal, (c) barrier, (d) oceanic, (e) coral (f), and artificial. Island of Sri Lanka categorized as continental by the Island Directory Tables of the United Nations Environment Programme (1998). As a continental island, Sri Lanka Maritime claims: the territorial sea 12 nm (nautical mile), contiguous zone 24 nm, exclusive economic zone 200 nm, and continental shelf as 200 nm or to the edge of the continental margin.

are emerging as island and islets, which are occurring above present levels (Katupotha 2018). As mentioned above, surrounding Sri Lanka, it is possible to see submerged Rocky Mountains and ridges, peaks, hill and rock outcrops and reefs. As a Precambrian rocky block, Sri Lankan land mass of the above submerged features and emerged features also were belonged to same rock types, e.g. Pigeon Island on the northeast coast, Little Basses reef (Kudarawana Kotte) and Greas Basses reef (Maharawana Kotte) in

the offshore areas to the south east, many rocky islands and islets of Koddiyar Bay (Trincomalee District), Seenigama Dewalaya (southwest coast) and Babayrian Rocky islands, west coast and on submerged 1st planated surface. Besides, hundreds of rocky outcrops can see as emerging features during the low tide level (Katupotha 2018). Presently most of those features appeared as erosional remnants and nearby sea surface covered by living corals and/or coral reefs of beach rock or sand rock reefs. Some barrier islands form when ocean currents pile up sand on sandbars parallel to coastlines or in front of the lagoon mouths and mainlands, e.g. the Battalangunduwa island chain formed such a way. Eventually the sandbars rise above the water as islands. Coral islands are low islands formed in warm waters by tiny sea animals called corals. Organic and inorganic material, like rock and sand, helps create coral islands. The islands of the Bahamas, in the Atlantic Ocean and Caribbean Sea, are good examples of such coral islands. When consider the northern islands, west of the Jaffna Peninsula, e.g. Neduntivu (Delft), Pungudutivu, Iranativu, Kayts can identify as low islands, formed following the PTG (Katupotha 1988a 1988b and Weerabaddana *et al* 2016). Another kind of coral island is the atoll. An atoll is a coral reef that begins by growing in a ring around the sides of an oceanic island. As the volcano slowly sinks into the sea, the reef continues to grow. Atolls are found chiefly in the Pacific and Indian Oceans. Although, in Sri Lankan coastal waters no such slowly sinks volcanos based coral islands, like Bahamas, Maldives, Lakadiv, somewhat similar types can identify in the areas of West of Jaffna Peninsula and Rawana's Bridge (Adams's Bridge).

Concerning to Sri Lanka some islands, e.g. Pigen Island in the eastern coast (Figure 111), Nilwella Island in southern coast and Babaryan Island in southwest coast can identify as bedrock and coral related islands.

Many islands of Sri Lanka, especially from Palk Bay, Gulf of Mannar, Dutch Bay and Puttalam lagoon are made up of sand, coral and tidal flats. These islands can develop using *Poly Motu* Concept (Bourdeix 2011). The *Poly motu* concept (*poly*=many, *motu*=island) is to use the geographical isolation of dedicated sites for conservation and reproduction of individual varieties of plants, trees and even animals. Multifunctional land management strengthens the links between people, landscape and biodiversity. It gives a special cachet to the sites, generates incomes and promotes ecotourism activities.

Blowhole at Kudawella

The set of mechanisms that operate along a coastline, bringing about various combination of erosion and deposition. A cliffed coastline is affected by slope processes and by wave activity. Both agents are given rise to distinctive landforms, including the geo, the beveled cliff, and the blow hole (a chamber with a relatively narrow exit at the top of the cliff, from which

FIGURE 111 : Shallow and well protected bathing place at Pigeon Island. Image © Jinadasa Katupotha


FIGURE 112 (Left) & **113** (Right) **:** Sea water spraying upwards rocky hole called blow hole at Kudawella head land is a unique feature. © Nadun Nandana.

water and spray are forced when waves are driven against the coast) (Allaby and Allaby, 1991). A typical example including these features can be observed at Nakulugamuwa (Figure 112 & 113).

Blowhole is also the name of a rare geologic feature in which air is blown through a small hole at the surface due to pressure differences between a closed underground system and the surface. It is estimated that the closed underground passages have a volume of at least seven million cubic metre. Wind speeds can approach 48 km per hour. Another well-known example of the blowhole is the natural entrance to the Wind Cave. La Bufadora is a large blowhole located in the Punta Banda Peninsula of Baja California, Mexico. It consists of a littoral cave with an opening that has a recurrence eruption interval of 13 -17 seconds, ejecting water up to 35m SL.

Hot spring

Hot water springs at Mahapelassa off Embilipitiya, Kanniyai off Trincomalee (Figure 114 & 115) and Mahaoya are well known to people. These thermal springs have their outflow temperature ranging between 34°C and 56°C and lie close to the boundary between Highland-Vijayan lithologic Complexes (Premasiri *et al* 2006) consisting mainly of crystalline metamorphic rocks (Cooray, 1984). The hottest springs lie at Kapuralla (56°Q, followed by Mahaoya (55°Q; Mahapelassa (44-46°C) and Marangala-Wahawa close to Padiyatalawa (42-45°C); Nelumwewa which was known earlier as Madawewa is now under a lake, and records 45°C in mud samples (Fonseka 1994).


FIGURE 114 (Up) & **115** (Down) **:** Well preserved hot springs at Knniyai in Tricomalee use for local tourists. Image © Jinadasa Katupotha

Pothole

A pothole is a circular or cylindrical hole in the riverbed which is produced by the force of water and abrasion. A pothole is formed when a circular current of water carrying small pebbles and sediment begins to wear away a rock surface. In Earth science, a pothole is a smooth, bowl-shaped, or cylindrical hollow, generally deeper than wide, found carved into the rocky bed of a watercourse. Other names used for riverine potholes are pot, (stream) kettle, giant's kettle, evorsion, hollow, rock mill, churn hole, eddy mill, and kolk. Although somewhat related to a pothole in origin, a plunge pool (or plunge basin or waterfall lake) is the deep depression in a stream bed at the base of a waterfall.

attributes like slope, bedrock character, rocky exposed on the riverbed, etc.

In Sri Lanka, pothole morphology can be found as riverine potholes and stream bed potholes rocky river beds as well as in coastal rocky surfaces of the southern coast (Figures 116 and 117). It is possible to infer that such giant holes to be associated with the meltwater of a glacier. During the snowball earth, the landmass of Sri Lanka also coved by thick glaciers. By Oligocene Period (33.9 - 28.1 ma), the Central Highland of Sri Lanka was covered by ice caps (Katupotha 2013). Due to the climate change, the glaciers on Second and Third planated surfaces were melted and potholes formed by the flowing

FIGURES 116 (Left) and **117** (Right) : The pothole located along the southern coast close to Hotel Jetwing Yala. Image © Chamara, 2015.

Geologists associate potholes with large volumes of very turbulent water. Most often they are thought to be associated with the meltwater of a glacier. The sediment being moved by the glacier, along with the structure of the underlying bedrock, together created the potential for potholes. Such potholes can be found in many European countries including Finland. In such area, the land surfaces emerged, and due to the retreating of ice sheets and flowing of meltwater formed the riverine potholes. Regarding the hydrological parameters like discharge, suspended load, stream power, velocity has been considered and some normal

of meltwater streams and southern wave action with 2m - 3m wide and about 4m deep. The river bed potholes are dominantly seen in Highland Complex around waterfall morphology. It is possible to recognize many potholes in different sizes in the upper catchments of Bothpath Ella, Diyaluma, Dunhinda, Laxapana waterfalls. Similarly, branches of Mahaveli river at the Horton Plain National Park also represent many potholes without a high rapid slope. Branches of the Kelani river at the Kithulga and Seethawaka Ganga (Irahandapana area) are the best place to study the complex of potholes.

Ibbankatuwa Ancient burial ground

Ibbankatuwa Ancient burial ground lies five kilometers before the Dambulla town on the Kurunegala-Dambulla Road. The Ibbankatuwa tomb site was first identified in 1970 by the Archaeological Department. The site is reached by traveling about 500m in to this road. The area where the tombs have been found is about 15×15 meters. About 10 tombs have been unearthed and each tomb is separated by four stone slabs and covered by another slab on the top. According to the way of interment two distinct burial customs, urn (bodies were placed in urns and interred) and cist (ashes of deceased were interred) have been identified. This Early Iron Age burial ground has been dated to 750 BC to 400 BC. Excavations have revealed that each tomb containing personal belonging such as clay pots, beads, necklaces, etc, similar to the practices in ancient Egypt pyramids. The gemstones found in some necklaces are only found in India indicating links to India during this time. Currently, the tomb site has been designated an archaeological protected site in Sri Lanka.

Cremated remains along with grave goods and tools used by deceased, have been found at the site in large terra-cotta urns and cists as well as in the area between the cists (Figures 118 & 119). The finds include variety of clay pots, iron, copper and gold artifacts, beads, necklaces, etc. The gemstones found in some necklaces are not naturally found in Sri Lanka which indicates that they may have been imported. The site was developed in to a tourist attraction in 2017 and was formally open to the public

Rajagala

Rajagalathenna (Rajagala) a famous archaeological site is rugged and heavily forested mountain situated 316m above MSL, in a sparsely populated part of the Eastern Province, Sri Lanka which has an important archaeological value. This site is only second to the Mihintale monastery in Anuradhapura and it spreads over 650 ha, and it consists more than 600 prehistoric ruins, monuments and artifacts, and nearly 100 of them are ancient Stupas Figures 120 – 121). Access to the mountain from Ampara Town is about 24 kilometers north of Ampara - Maha Oya Road (A27), via Uhana and the village of Bakkiella.

The Bogoda Wooden Bridge

The Bogoda Wooden Bridge was built in the 16th century during the Dambadeniya era. This is said to be the oldest surviving wooden bridge in Sri Lanka. The bridge is situated at 7 kilometers (4.3 mi) west of Badulla. All parts of this bridge were constructed from wood, including the use of wooden nails as fixing material. The roof tiles show the influence of kingdom of Kandy. The bridge was built across the Gallanda Oya, which linked Badulla and Kandy on an ancient route.

The Bogoda Bridge is over 400 years old and made entirely from wooden planks, which are said to have come from one tree. It is an exclusive construction as it has a 2.4 meters tall tiled roof structure for its entire span of nearly 15 meters length with a 1.5 meters breadth. Wooden fences of the bridge are decorated in various ancient designs and have been erected on either sides (Figures 122 & 123).

FIGURE 118 (Left) **& 119** (Right) **:** An ancient burial site located near Ibbankatuwa Wewa in Galewela DS, Sri Lanka. Source: Department of Archaeology. Image © Jinadasa Katupotha

FIGURE 120 (Left) **:** Ruins of the Daana Shalawa at Rajagala .Image©Pathmasiri Kannagara.
FIGURE 121 (Right) **:** Old meditation house at Rajagala. Image ©Pathmasiri Kannagara.

FIGURE 122 (Left) **& 123** (Right) **:** The Bogoda Bridge is over 400 years old and made entirely from wooden planks. Image © Jinadasa Katupotha

The structure of the bridge is standing on a huge tree trunk 11 metres in height. Jackfruit (*Artocarpus heterophyllus*) logs and Kumbuk (*Terminalia arjuna*) logs were mainly used as the constructive material of the bridge. Furthermore, Kaluwara (*Diospyros ebenum*) timber and Milla timber were used for the wooden decorations.

Rivers and Marine Entrances

The hydrographic pattern is a function essentially follow the relief and geologic structure in When carefully investigation of geological structure, associated fault and fold systems and their orientation, microrelief, elevation, etc. emphasized that there is no actual radial drainage pattern exists in Sri Lanka (Silva and Katupotha 2018; Katupotha 2019). Many river estuaries in Sri Lanka are beautiful tourist sites/destinations (Figures 124 & 125). Non-barrier Delta Estuaries with Seasonal Rivers in northwestern coastal stretch can be used as geotourism and ecotourism purposes.

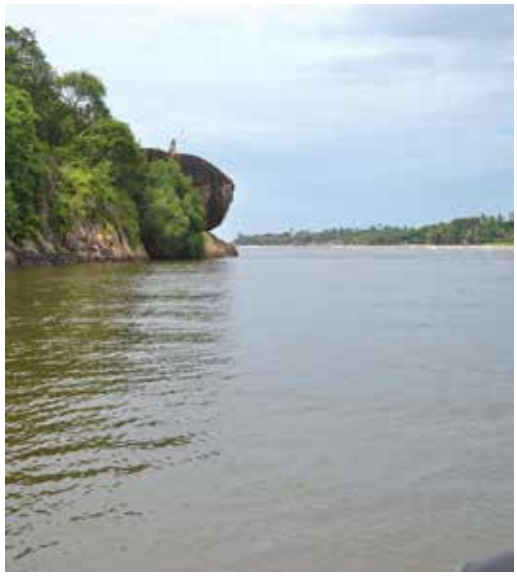


FIGURE 124 : Bentota Ganga (river) mouth is an extremely beautiful place as a tourist destination site. Image © Jinadasa Katupotha

FIGURE 125 : Bentota Ganga (river) mouth is an extremely beautiful place as a tourist destination site. Image © Jinadasa Katupotha

CONCLUSION

Tourism geology is a branch of tourism earth-science. It studies the distributions, types, and characteristics, causes of formation and changes of varied scenic spots by geological theories, methods, technologies and results. The relations between geology and tourism science may be evidenced in many aspects. Natural landscapes including peaks, valleys, caves, stones, rivers, lakes, waterfalls and springs are all generated by geological processes and controlled by varied geological factors. Complicated geological factors lead to diversified shapes of natural landscapes. In particular, structural features generated by tectonic activities, and their natures, characteristics, scales and attitudes all directly control the formation and development of natural landscapes.

Anze Chen *et al* (1991) explain that the relationship between tourism and geographical environment has been under study overseas for more forty years. The research on the occurrence and change rules of tourism involves a range of earth scientific issues, such as geographic factors leading to tourism, and the earth scientific backgrounds, especially the climate, beach, sunshine, view, landform and landscape, scenic water and scenic forest, which stimulate tourist flows. Besides, the geographical distribution and movement of tourist flows are often controlled by some special rules. Such rules govern the tourist movements from cold areas to warm areas, from humid and rainy areas to sunny areas, from developed areas to countryside, from the urban to the country or from the country to the urban.

Naturally-created these in-situ features or places peaks, valleys, caves, stones, rivers, lakes, waterfalls and springs are all generated by geological processes and controlled by varying land based and coastal geological factors in Sri Lanka can be absorbed as geoheritages and geosites for tourism development. For this purpose, Department of Wildlife and Conservation, Forest Department, Geological Survey and Mines Bureau, Department of Tourism Developments, Universities, Local Governments, Schools etc. should be engaged positively to enhance geotourism concept. Using these nature-based heritages of particular geological importance, intended to conserve the geological heritage and promote public awareness of it, typically through tourism to increase the income of the public and enrich the humanity and nature. Further it is necessary to compile a detail research to fulfil the gap of geotourism field emphasizing mentioned sites and searching new sites.

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REFERENCES

Allen, Mamoon. (2015). Geotourism: an opportunity to enhance geoethics and boost geoheritage appreciation. http://sp.lyellcollection.org/ at Carleton University Library on July 13, 2015, Geological Society, London, Special Publications, 419, 25–29.

Arumugam (1969). Water resources of Ceylon its utilization and development. A water resources Board Publication.

Blum, Ralph, (2002). *The New Book Of Runes*. Copyright: 1990 / 1991 Scanned: September-18-2002.

Bourdeix R., V. Johnson, L. Baudouin *et al.*, (2011). Polymotu: A new concept of island-based germplasm bank based on an old Polynesian practice. Departmental Bulletin Paper, Ogasawara research (37): 33-51.

Central Cultural Fund. (2013). List of Proposed Caves for Cave Tourism in Sri Lanka. Geology Unit, Research Laboratory.

Chen Anze, Lu Yunting and Young C.Y. Ng, (1991). The Principles of Geotourism. (electronic) Springer Geography ISBN 978-3-662-46696-4

Cooray, P.G. (1984). An Introduction to the Geology of Sri Lanka (2nd Edition), National Museum of Sri Lanka Publication, Colombo, pp 135-170.

Cooray, P.G. (1994). The Precambrian of Sri Lanka: a historical review. Precambrian Research, 1994, 66: 3-18.

Cooray P.G and Jinadasa Katupotha. (1991). Geological evolution of the coastal zone of Sri Lanka Conference: Causes of Coastal Erosion in Sri Lanka. at Colombo, Conference Volume. February 1991, DOI: 10.13140/RG.2.1.1278.2566.

De Alwis K. A. And Pluth D. J. The Red Latosols of Sri Lanka: I. Macromorphological, Physical and Chemical Properties, Genesis, and Classification.

Deraniyagala P.E.P. (1958), The Pleistocene of Ceylon. Ceylon National Museums Publication, Government Press, Ceylon.

Department of Agrarian Development (2007). Main watersheds, sub watersheds, village tanks cascades and anicut clusters of Sri Lanka.

Dowling Ross and Newsome, (2018). Geotourism: definition, characteristics and international perspectives. In. Handbook of Geotourism. Edited by Ross Dowling and David Newsome

Gray Murray. (2004). Geodiversity, valuing and conserving abiotic nature. John Wiley & Sons Ltd, the Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England

Ginting, Nurlisa and Febriandy. (2018). Implementation of geotourism concept in developing natural tourist attraction at Parbaba Village, Toba's caldera. IOP Conf. Series: Earth and Environmental Science 126 (2018), 1-9, doi:10.1088/1755-1315/126/1/012160.

Jayatileke Sarath. (2015). Geology and Mineral Resources of Sri Lanka. Senior Deputy Director Industrial Technology Institute 363, Bauddhaloka Mawatha Colombo 07.

Jayasingha, P., & Welianga, W. (2010). A Classification for Sri Lankan Caves. Annual Archaeological Congress-2010 organized by the Department of Archaeology, Sri Lanka on 07-09 July 2010.

Katupotha, J. (1988a). Hiroshima University Radiocarbon Dates 1: West and South Coasts of Sri Lanka. 30(1): 125-128.

Katupotha, J. (1988b). Hiroshima University Radiocarbon Dates 1: West and South Coasts of Sri Lanka. 30 (3): 341-346.

Katupotha, J. (1989). Katupotha J. (1989). Coastal landforms during the Holocene Epoch in Sri Lanka: are they comparable to those in Brazil and Venezuela, Ext. Abs. International Symposium on Global changes in South America during the Quaternary, Sao Paulo (Brazil), May 8-12, 1989, pp 188-191.

Katupotha, J. (2013). Palaeoclimate change during Glacial Periods: Evidence from Sri LankaJournal of Tropical Forestry

and Environment Vol. 3, No. 01 (2013) 42-54Survey Department of Sri Lanka, 2007: National Atlas of Sri Lanka, 2007.

Katupotha, J. (2013). Planated Surfaces and Erratic Boulders of Sri Lanka. Proceedings of 29th Technical Sessions of Geological Society of Sri Lanka, 2013, 91-94. Published Online 22nd February 2013 (http://www.gsslweb.org).

Katupotha, J. and Kusumsiri Kodituwakku (2014). Diversity of vegetation types of the Pidurangala Granitic Inselberg, near Sigiriya, Sri Lanka: a Preliminary Study.

Katupotha, J. (2019). Pearl Fishery Industry in Sri Lanka. Wildlanka.Vol.6, No.4, pp. 213 - 230, 2018, Copyright, Department of Wildlife Conservation, Sri Lanka.

Kehelpannala, K.V. Wilbert. (2003). Structural evolution of the middle to lower crust in Sri Lanka: Journal of the Geological Society of Sri Lanka, v. 2., p. 45-85.

Kehelpannala, K.V. Wilbert. (1997). Deformation of a High-Grade Gondwana Fragment, Sri Lanka. International Association for Gondwana Research, Japan. Vl, No. I, pp. 47-68.

Kehelpannala, K.V. Wilbert and Collins S. Alan. (2006). The role of Sri Lanka and associated continental blocks in the assembly and breakup of Rodinia and Gondwana: Introduction (Editorial), Journal of Asian Earth Sciences v, 28 p. 1–2

Kleinschrodt R, Voll G, Kehelpannala, W. (1991). A layered basic intrusion, deformed and metamorphosed in granulite facies of the Sri Lanka basement. Geologische Rundschau 80/3, 779-800. Stuttgart 1991.

Kenneth A.R. Kennedy, S. U. Deraniyagala, William J. Roertgen, John Chiment, Todd Disotell. Upper Pleistocene fossil hominids from Sri Lanka. American Journal of Physical Anthropology · Volume 72, Issue 4.

Kröner, A., Cooray, P.G., and Vitanage, P.W. (1991). Lithotectonic subdivision of the Precambrian basement in Sri Lanka. In: Kroner, A. (ed.). The crystalline crust of Sri Lanka. Part 1: Summary of Research of the German-Sri Lanka consortium, Geological Survey Department of Sri Lanka, Professional Paper. 1991; pp. 5-21.

Kubalíková Lucie. (2013). Geomorphosite assessment for geotourism purposes. *Czech Journal of Tourism*, **2(2):** 80-104. DOI: 10.2478/cjot-2013-0005.

Kumar Ajit, (2013). Decoding the meaning and beliefs associated with petroglyphs in Edakkal rock shelter, Kerala, India. XXV Valcamonica Symposium 2013.

Manchanayake Palitha and Madduma Bandara CM. (1999). Water Resources of Sri Lanka. National Science Foundation.

Nurlisa Ginting and Febriandy. (2018). Implementation of geotourism concept in developing natural tourist attraction at Parbaba village, Toba's caldera. To cite this article: IOP Conference Series: Earth and Environmental Science, 1-9.

Oshan Wedage, Noel Amano, Michelle C. (2019). Specialized rainforest hunting by Homo sapiens ~45,000 years ago. Nature Communications, 1-8.

Oshan Wedage, Patrick Roberts, Patrick Faulkner *et al*. (2020). Late Pleistocene to early-Holocene rainforest foraging in Sri Lanka: Multidisciplinary analysis at Kitulgala Beli-lena. Quaternary Science Reviews.

Premarathne D.M.U.A.K., Noriyuki Suzuki1, Nalin Prasanna Ratnayake *et al.* A Petroleum System in the Gulf of Mannar Basin, Offshore Sri Lanka.Proceedings to 29th Technical Sessions of Geological Society of Sri Lanka, 2013, 9-12 Published Online 22nd February 2013 (http://www.gsslweb.org)

Ranasinghe, N. S. (1987). Serpentinites associated with the Precambrian of Sri Lanka. Geological Society of Sri Lanka Special Publication No. 3. Geological Survey Department, Colombo, Sri Lanka.

Ratnayake Amila Sandaruwan and Sampei Yoshikazu. 2015. Preliminary prediction of the geothermal activities in the frontier

Mannar basin, Sri Lanka. Journal of Geological Society of Sri Lanka Vol. 17 (2015), 19-29 J.W. Herath Felicitation Volume 19

Ratnayake, A.S., Sampei, Y., Ratnayake, N.P., Roser, B.P. (2017). Middle to late Holocene environmental changes in the depositional system of the tropical brackish Bolgoda Lake, coastal southwest Sri Lanka. Palaeogeography, Palaeoclimatology, Palaeoecology 465, 122-137.

Silva, E.I.L., Katupotha, J Amarasinghe, O., Manthrithilake H. *et al*. (2013). Lagoons of Sri Lanka: From the Origins to the Present IWMI 2013.

Silva, Iven and Katupotha, J. 2018. Estuaries of Sri Lanka. Final Report submitted to International Union for Conservation of Nature, Colombo, Sri Lanka and Government of Sri Lanka.

Sumanarathna, A. R., & Fernando, G. R. (2017, January 19). An Assessment Of Geological Formation Of The Rakwana-Pannila Mountain Of Sri Lanka. Retrieved January 19, 2017, from http://ecoastronomy.edu.lk/component/content/article/9-journal-vol-01/17-an-assessement-of-geological-formation.

Sumanarathna, A. R., Madurapperuma, B., Kuruppuarachchi, J., Katupotha, J., Abeywardhana, S., & Jayasinghe, P. (2016). Morphological Variation and Speciation of Acavidae Family: A Case Study from Fossil and Living Species of Batadombalena Cave Pre-historic Site in Sri Lanka. Annals of Valahia University of Targoviste, Geographical Series, 16(2), 59-68. Doi:10.1515/avutgs-2016-0005.

Sumanarathna, A. R. (2016, June 24). Batadobalena Cave as a Tourism Attraction Place: A review. Retrieved June 24, 2016, https://www.researchgate.net/publication/305719603.

Survey Department of Sri Lanka 2007). National Atlas of Sri Lanka.

Weerabaddana W.M.M., P.N. Ranasinghe, Y. P. S. Siriwardhana et al. Reconstruction of Mid-Holocene Paleoceanographic Conditions in Northern and Southern Sri Lanka using modern analogues. Proceedings of the 33rd Technical Session of Geological Society of Sri Lanka, (2017). Published Online - 24th February 2017 (http://www. gsslweb. org) 33 GSSL-2017- (D2-SIII)-R1/03.

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