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Danigala Alien Mountain and Petroglyphs: A Multidisciplinary Investigation into Astrotourism, Geotourism, and Archeological Significance – Unlocking Sustainable Development Opportunities in Sri Lanka

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ABSTRACT

Danigala Circular Rock (7°40'50.24"N, 81°12'48.32"E), located near Kandegama in the Polonnaruwa District of Sri Lanka, is a distinctive geological formation characterized by its semicircular morphology, shaped by long-term geological processes and weathering. This site lies within a region of exceptional geodiversity, featuring diverse geological and geomorphological formations spanning from the Precambrian Era to the present. Beyond its geological significance, Danigala holds archaeological, astronomical, biodiversity, and cultural value, making it a unique multidisciplinary heritage site. On July 28, 2020, a discovery of previously undocumented petroglyphs was made on the northwestern slope of Danigala during a preliminary archaeoastronomical and geological survey conducted by the Central Cultural Fund (CCF—Polonnaruwa Alahana Parivena Project) in collaboration with the Department of Research Innovation, Eco Astronomy Inc. The petroglyphs, particularly the bind runes, exhibit unique symbolic representations not previously recorded in Sri Lanka or the broader South Asian region, suggesting a novel archaeological and cultural narrative influenced by natural and anthropomorphic factors. Given its geological uniqueness, archaeological rarity, and potential astro-tourism value, Danigala Circular Rock warrants recognition as a key geoheritage and cultural heritage site. This study advocates for a sustainable management framework integrating geotourism, astro-tourism, archaeo-tourism, and adventure tourism through a multidisciplinary approach. Such initiatives should prioritize ecological conservation, community well-being, and responsible tourism development, ensuring the preservation of Danigala's scientific, historical, and cultural legacy for future generations.

Article information | Key Words: Danigala, petroglyphs, geoheritage, archaeoastronomy, geotourism, astrotourism, sustainable tourism, Sri Lanka.

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INTRODUCTION

Sri Lanka, an island nation renowned for its rich cultural heritage and diverse natural landscapes, has long been a focal point for historians, archaeologists, and geologists. Ancient cities such as Anuradhapura and Polonnaruwa, along with iconic landmarks like Sigiriya, stand as testaments to the island's historical significance. However, amidst these well-documented sites lies Danigala, often referred to as "Alien Mountain," a location that presents a unique convergence of geological wonders, archaeological mysteries, and local folklore. This site garners increased attention from researchers across multiple disciplines, yet a comprehensive understanding of its significance remains fragmented.

Danigala Circular Rock represents a prominent inselberg, a class of isolated rocky outcrops predominantly composed of Precambrian formations. Geologically, this unique structure is situated within the Vijayan Complex, a key subdivision of Sri Lanka's crystalline basement. The Vijayan Complex is characterized by an amphibolite-facies suite, primarily consisting of granitoid gneisses, migmatites, minor meta-sedimentary xenoliths, and calc-silicate rocks (Cooray, 1984; 1994; Dahanayake & Jayasena, 1983). These lithological components suggest a dynamic tectono-metamorphic history, indicative of high-grade regional metamorphism and partial melting events during the Precambrian.

Danigala's geomorphological expression classifies it as a bare rock mound or turtleback inselberg. These types of features are commonly associated with the II - Second Planated Surface (Katupotha, 2013a). The persistence of such inselbergs against prolonged erosional processes is attributed to their resistant granitic composition, particularly their high quartz content. Quartz, being one of the most chemically and mechanically durable rock-forming minerals, significantly enhances the structural integrity of these outcrops (Cooray, 1984).

The distinct morphology of Danigala—marked by its circular structure and pronounced elevation—provides critical insights into differential weathering patterns, erosional resistance, and long-term landscape evolution. Its geological resilience makes it an exceptional natural laboratory for studying:

- granitic weathering dynamics under tropical conditions;
- tectonic uplift and exhumation histories;
- geomorphological stability in planated surfaces; and
- biotic interactions on isolated rock ecosystems.

Further geochronological and petrogenetic investigations could elucidate the precise emplacement mechanisms and metamorphic overprints that shaped Danigala, offering broader implications for understanding Precambrian crustal evolution in Sri Lanka.

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Key Research Directions:

1. Spectroscopic and X-ray Diffraction (XRD) Analysis

Conduct quantitative mineralogical analysis to determine quartz-feldspar ratios and assess weathering rind development.

Apply advanced spectroscopic techniques (e.g., Raman spectroscopy, FTIR) to characterize surface alterations and pigment residues on petroglyphs.

Correlate weathering patterns with estimated age, cultural context, and scholarly interpretations of petroglyphs.

2. Digital Conservation and 3D Documentation of Petroglyphs

Utilize high-resolution photogrammetry (e.g.: digital stitching, photometric stereo imaging) for non-invasive documentation.

Employ structured-light 3D scanning (e.g.: EinScan Pro) to generate precise digital replicas for archival and restoration purposes.

Develop machine learning-based degradation models to predict long-term preservation needs.

3. Structural and Geomechanical Mapping

Conduct detailed fracture (joint) mapping using LiDAR and drone-based photogrammetry to analyze jointing patterns.

Investigate the role of tectonic stress fields and erosional processes in inselberg formation.

Assess rock mass stability and exfoliation mechanisms contributing to the geomorphological evolution of Danigala.

4. Comparative Geomorphological Studies

Perform a systematic comparison with other Sri Lankan inselbergs (e.g., Sigiriya, Ritigala) and global analogues (e.g.: Devils Tower, USA; Edakkal Caves, India).

Evaluate lithological, structural, and erosional controls on inselberg morphology to establish regional and global geomorphological trends.

5. Petroglyph Typology and Cross-Cultural Analysis

Compare Danigala's petroglyphs with local and international examples (e.g.: bind runes, runic carvings, cupules, and engraved motifs).

Apply stylistic and iconographic analysis to infer cultural exchanges, symbolic meanings, and chronological sequencing.

6. Sustainable Tourism Model Development

Benchmark Danigala's tourism potential against successful heritage sites (e.g.: Sigiriya, Sri Lanka; Edakkal Caves, India; Son Doong Cave, Vietnam; Karain Cave, Turkey; Madeira, Portugal; Mana Pools, Zimbabwe).

Integrate geospatial analytics to optimize visitor flow, minimize ecological impact, and enhance interpretive infrastructure.

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7. Astrotourism Potential Assessment

Evaluate night sky visibility metrics (e.g., Bortle scale, atmospheric transparency) for stargazing suitability.

Analyze accessibility, light pollution levels, and infrastructure requirements for establishing an astrotourism hub.

Collaborate with astronomical societies to develop educational and observational programs.

8. Geotourism and Geoheritage Valuation

Assess Danigala's geological uniqueness (e.g.: lithological composition, weathering features, structural significance) for geoheritage designation.

Design interactive educational modules (virtual and on-site) to highlight its geoscientific and cultural importance.

Propose UNESCO Global Geopark integration based on comparative geoheritage significance.

Figure 01: Aerial view of Danigala, a prominent inselberg characterized by its semi-circular shape, formed through prolonged geological weathering. Composed of erosion-resistant granitic rocks with high quartz content Cooray, 1984), this landform exhibits exfoliation processes, where pressure release triggers the detachment of curved rock sheets. Erosional unloading removes overburden, inducing expansion fractures and concentric sheeting. Beyond its geological significance, Danigala's striking morphology has inspired rich mythological narratives. CCF Polonnaruwa & Aravinda Ravibhanu ©2020.

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Danigala Rock, also referred to as *Kandegama Rock*, is a prominent geological formation located in the Polonnaruwa District of Sri Lanka. Situated along the boundary of the Maduru Oya archaeological reserve, it occupies a transitional zone between the Polonnaruwa and Ampara districts, underscoring its cross-district ecological and cultural importance. With an elevation of 280 meters (919 ft), Danigala provides expansive panoramic views and is accessible via the Kandegama Danajaya Rajamaha Viharaya or the CCF—Polonnaruwa Alahana Parivena Project site.

The site features approximately 50 caves, some of which date back to the Second century BCE, suggesting early human habitation and potential archaeological significance. Furthermore, Danigala is associated with multiple cultural narratives, including:

> ***Alien Mountain:*** Due to an alleged incidence of unidentified aerial phenomena (UAP), its flat summit has bred speculation of it being a potential extraterrestrial landing site.
>
> ***Star Gate of King Ravana:*** Linked to Sri Lankan folklore, particularly the mythos surrounding King Ravana's legendary aircraft (*Dandu Monara*).
>
> ***Danigala Vedda:*** A reference to the indigenous Vedda community, whose oral traditions suggest ancestral connections to the caves of Danigala.

This study explores Danigala's potential as a site for **astrotourism** and **geotourism**, aiming to bridge gaps between geological, archaeological, and cultural research while promoting sustainable tourism development. The findings provide actionable insights for policymakers, tourism developers, and local communities to preserve and responsibly manage Danigala's natural and cultural heritage. By integrating scientific inquiry with indigenous knowledge, this research contributes to a holistic understanding of Danigala's role in Sri Lanka's ecological and historical landscape.

GEOLOGY OF SRI LANKA

Sri Lanka's geological framework is predominantly underlain by Precambrian strata, with some formations dating back approximately two billion years. The Highland Complex, composed primarily of granulite facies rocks (including gneisses, sillimanite-graphite gneisses, quartzite, marbles, and charnockites), constitutes the bulk of the island, while the Vijayan Complex, characterized by amphibolite facies gneisses, migmatites, granites, and granitic gneisses, dominates the eastern and southeastern lowlands. Minor Jurassic sedimentary deposits are found near the western coast (Vanni Complex), whereas Miocene limestones underlie the northwestern region, extending southward along a

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narrow coastal belt. The metamorphic basement originated from the recrystallization of ancient sediments under high-temperature and high-pressure conditions during orogenic events.

Plate tectonic reconstructions indicate that Sri Lanka and southern India were once part of Gondwanaland. The breakup of this supercontinent, initiated around 200 million years ago, led to the northeastward drift of the Indian plate, culminating in the Himalayan orogeny following its collision with Eurasia approximately 45 million years ago. Due to its intraplate position, Sri Lanka remains seismically stable, devoid of significant earthquakes or volcanism. Sedimentary deposits on the island are limited, with sparse Jurassic remnants in the Puttalam District and more extensive Miocene-Pleistocene carbonate sequences along the northwest coast. The region forms part of the deep Cauvery (Kaveri) Basin, a major depocenter accumulating erosional products from both Indian and Sri Lankan highlands since Gondwana fragmentation. (Sumanarathna, 2017a; 2017b; 2017c; 2018a).

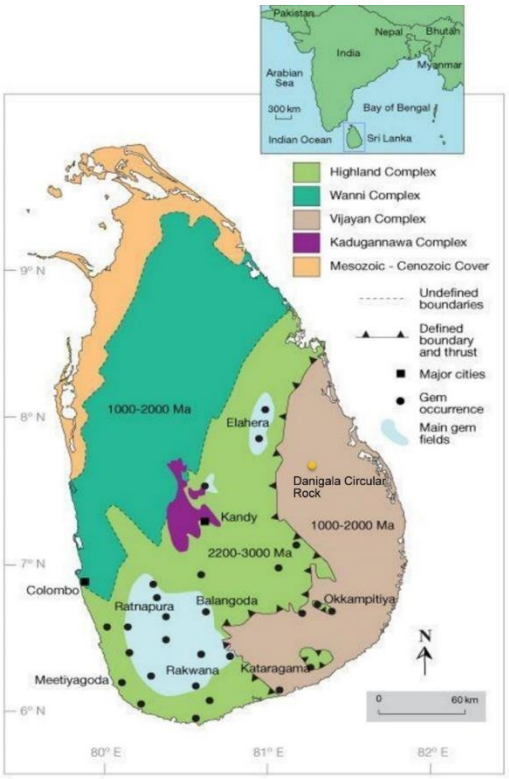

Figure 02: Map illustrating the main geological zones of Sri Lanka, incorporating relative dating.

The lithotectonic subdivision is based on Cooray (1984, 1994), highlighting key structural and compositional variations. The yellow dot denotes the location of Danigala within this geological framework.

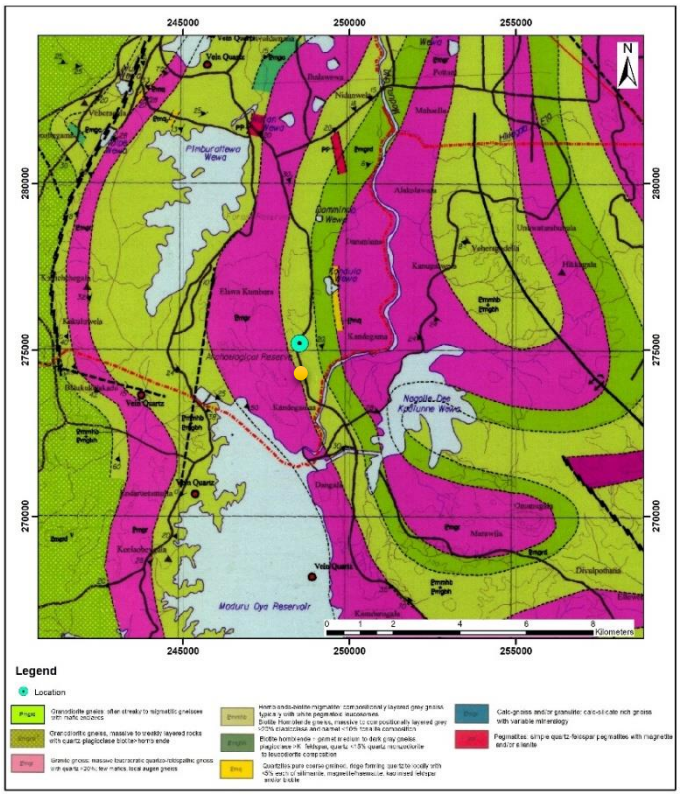

Figure 03: Geological map illustrating distinct rock units (right panel) in the vicinity of Danigala Circular Rock. The yellow dot denotes the location of Danigala. © Eco Astronomy Inc. 2020.

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Figure 04: Google satellite imagery (© Google Earth 2018) depicting the geomorphological features of Danigala Circular Rock, highlighting the structural and erosional characteristics of the second planated surface in an aerial perspective.

DANIGALA CHITHRA LENA PETROGLYPHS

The northwestern slope of Danigala inselberg (7°41'0.44"N, 81°12'45.66"E) hosts a significant collection of petroglyphs at Chithra Lena. While some engraved motifs exhibit similarities with other Sri Lankan sites – such as the linear compound patterns observed in Dorawakakanda Cave and Hakbelikanda Cave (Somadeva, 2019) – the Chithra Lena petroglyphs remain systematically distinct from known rock art in the region. Preliminary comparative analysis suggests potential parallels with petroglyph sites across South Asia, particularly in their symbolic composition.

Following archeoastronomical methodologies (Sumanarathna, 2016, *Trail Dots of Archeoastronomy in Asia* [unpublished]), the Chithra Lena engravings share notable morphological resemblances with those of Edakkal Caves in Wayanad, Karnataka, India. The Edakkal Caves, rediscovered by Fawcett 1901, are attributed to Neolithic communities and feature analogous symbolic configurations (Figs. 22, 23). The Danigala petroglyphs, however, display a richer diversity of motifs, surpassing those documented at Edakkal. These engravings represent cultural vestiges with potential archeoastronomical significance, reflecting the cosmological and religious frameworks of their creators. While their exact meanings remain enigmatic, comparative ethnography suggests that some motifs may derive from primal belief systems preserved in contemporary ethnic traditions.

STRUCTURAL AND PRESERVATION CONTEXT

The primary petroglyph panel at Chithra Lena, located on the left wall of a linear rock chamber, measures approximately 25 ft in length and 16 ft in height (Figs. 05–14). The engravings exhibit weathering,

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complicating their full interpretation. The rock shelter consists of two granitic walls, separated by less than 30 cm at the base, likely resulting from physical weathering processes (Fig. 05). Despite partial decoding efforts, no complete composite image of the petroglyphs has yet been reconstructed.

The Danigala Chithra Lena rock shelter exhibits distinctive geological and archeological characteristics. The structure features a few individual erratic boulders positioned atop the walls, forming a hood-like overhang. This formation functions as a natural shelter, though it does not fully open to the sky, unlike the Edakkal Cave (Figures 05-14 &,22-23). Such geological formations are likely the result of natural cave development, possibly triggered by seismic activity (Shyju, 2019).

From an archeological perspective, engravings are predominantly found on the right walls of the shelter. These petroglyphs depict a variety of motifs, including anthropomorphic figures, peacocks, plants, dogs, ladders, arrows, bows, and geometric symbols (Figures 05–14). Further decoding analysis is required to fully interpret these inscriptions. Some of the geometric patterns and bind codes may represent early astronomical counting systems.

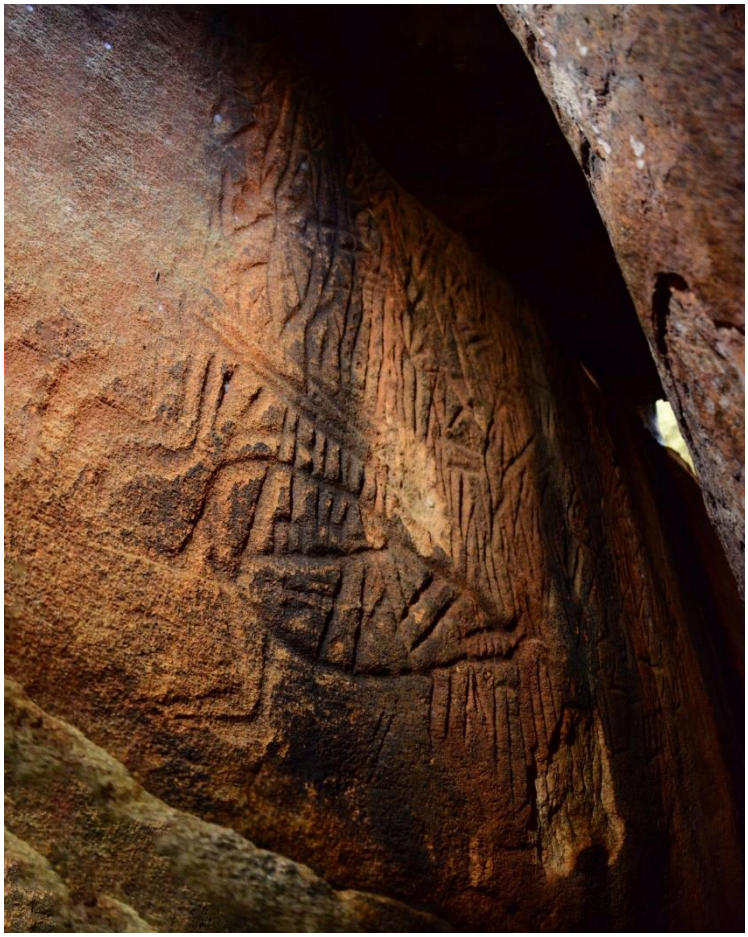

Figure 05: Entrance and left wall of the linear chamber at Danigala Chithra Lena, displaying petroglyph sections featuring anthropomorphic figures. Image credit: © Aravinda Ravibhanu 2020 | Contract image: Jason Kennedy.

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Figure 06: Internal to external perspective of the linear chamber within Danigala Chithra Lena, showcasing its geological and structural features. Image credit: CCF-Polonnaruwa | Eco Astronomy Inc, 2020.

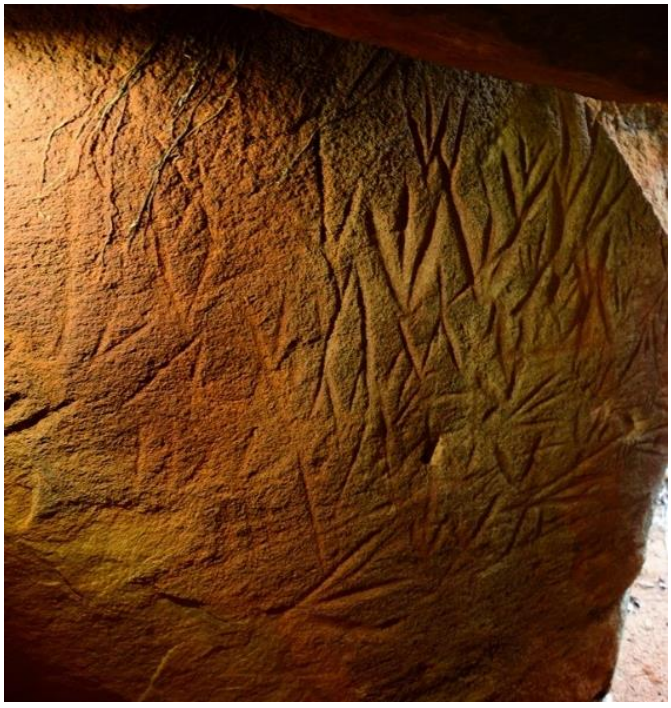

Figure 07: Left-side wall of the far end of the linear chamber, depicting anthropomorphic figures. Image credit: © CCF-Polonnaruwa | Eco Astronomy Inc. 2020.

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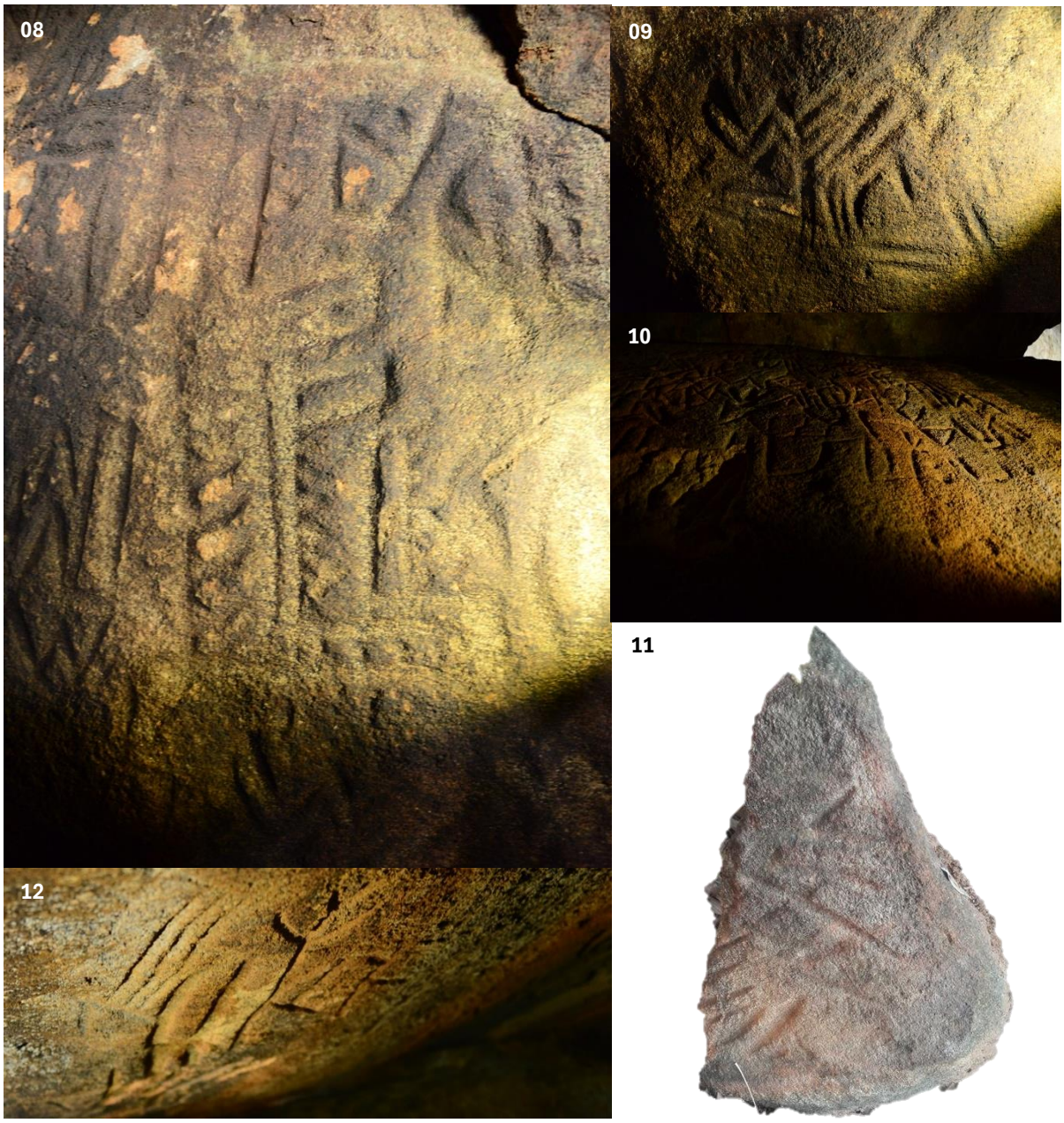

Figure 08: Left-side wall at the mid-section of the linear chamber, depicting anthropomorphic figures resembling ladder-like formations. Image credit: CCF-Polonnaruwa, Eco Astronomy Inc © 2020.

Figure 09: Left-side wall at the mid-section of the linear chamber, depicting anthropomorphic figures with a 'blind code' motif, potentially representing ancient non-human gradience or symbolic communication. Image credit: CCF-Polonnaruwa, Eco Astronomy Inc © 2020.

Figure 10: Left-side wall at the mid-section of the linear chamber depicting anthropomorphic figures, including human-like representations, alongside an encoded motif potentially symbolizing the 'mastermind' or central authority. The imagery suggests ritualistic or symbolic significance within the chamber's context. Image credit: CCF-Polonnaruwa, Eco Astronomy Inc © 2020.

Figure 11: Fragment of a petroglyph depicting anthropomorphic figures, illustrating ancient artistic expression. Image © KDV.

Figure 12: Left-side wall of the linear chamber depicting anthropomorphic figures, including a humanoid representation and symbolic imagery of a bow and arrow, suggesting potential ritualistic or cultural significance. Image credit: CCF-Polonnaruwa, Eco Astronomy Inc © 2020.

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Figure 13: Partial Reconstruction and assembly of anthropomorphic figures (assembled using a photo-stitching application). Image © Aravinda Ravibhanu, 2020.

Figure 14: Left-side wall of the linear chamber depicting anthropomorphic figures, including representations of 'Crooked,' 'Mastermind' (first man), and 'Protector,' as denoted by BR Code. Image © Aravinda Ravibhanu, 2020.

Additionally, at the far end of the chamber, a separate petroglyph panel is located on the left wall. This panel contains numerous anthropomorphic finger markings, an incomplete ladder-like structure, as well as depictions of animals and plants (Figure 08). The presence of these engravings suggests ritualistic or symbolic significance, though further study is needed to ascertain their cultural and chronological context.

ERRATIC BOULDERS AND GEOLOGICAL VIEW AROUND DANIGALA CIRCULAR ROCK

The Danigala rock area exhibits notable geological features, including tor formations and erratic boulders, which are indicative of past glacial activity. An erratic is a glacially transported rock fragment that differs in size and lithology from the native bedrock upon which it rests. These erratics can vary significantly in scale, ranging from small pebbles to massive boulders weighing hundreds to thousands of metric tons (Benn & Evans, 2010). Geological identification of erratics involves comparative analysis of their composition and structural orientation relative to the surrounding rock formations. (Figs 15, 16, 19).

In Sri Lanka, evidence of Pliocene-Quaternary glacial activity is scarce, as earlier glacial sedimentary deposits have been eroded or obscured over time. Although no Pleistocene glacial deposits have been

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documented in the region, isolated erratic boulders and remnants of ice-rafted deposits suggest the presence of pre-Pleistocene glacial influences (Katupotha, 2013b). Additionally, landforms resembling outwash plains are observable within the *Second and Third Planated Surfaces*, while valley terrains are prominent in the upper *Third Planated Surface* and the *Rugged Central Highland* region.

Figure 15: Erratic Boulders near Chithra Lena, Danigala Circular Rock – Geological evidence of past glacial or fluvial transport processes. Image © KDV.

Figure 16: Erratic boulders scattered around the base of Danigala Circular Rock, an escort inselberg in Sri Lanka. These boulders, transported by ancient geological processes, highlight the dynamic erosional history of the region. Image © KDV.

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Figure 17: Geological formations and vegetation patterns observed on Danigala Circular Rock, showcasing unique ecological adaptations. Image © KDV.

Figure 18: Weathering features and glacial erratics observed near NKD Wewa, with the prominent Danigala Circular Rock visible in the background. This geological formation provides insights into erosional processes and past glacial activity in the region. Image © KDV.

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Figure 19: An abstract aerial perspective of Pimburattewa Tank Reservoir, observed from the geological marvel of Danigala Circular Rock. The image highlights hydrological dynamics and landscape interactions in Sri Lanka's dry zone. Image © Aravinda Ravibhanu 2020.

Figure 20: Geological tor formation observed around Danigala Circular Rock, Sri Lanka. Study by Ravibhanu (2020) highlights the erosional processes shaping this unique landscape. Image © Aravinda Ravibhanu 2020.

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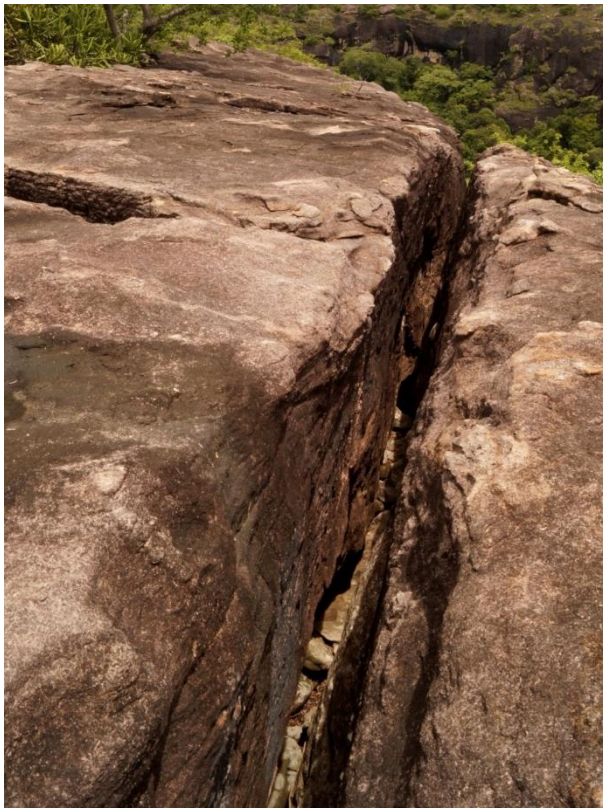

Figure 21: This image illustrates a striking example of physical (mechanical) weathering on a large boulder near Danigala Chithra Lena. Unlike chemical weathering, physical weathering breaks down rocks without altering their chemical composition, resulting in smaller fragments of the original rock *in situ*. The primary cause here is freeze-thaw weathering (frost shattering), where water infiltrates rock fractures, freezes, and expands, exerting pressure that eventually splits the rock. Repeated cycles of this process lead to progressive fragmentation. Image © Aravinda Ravibhanu (2020).

Figure 22: Anthropomorphic stone carving discovered at the Kandegama Archeological Site, Sri Lanka, possibly representing ritualistic or symbolic artistry from an ancient civilization. Further research is needed to determine its cultural and chronological context. Image © Aravinda Ravibhanu, 2020.

COMPARATIVE ANALYSIS OF THE DANIGALA CHITHRA-LENA PETROGLYPHS: CULTURAL DISCUSSION AND ARTISTIC PARALLELS

The engravings found at Danigala Chithra Lena were not created as artistic expressions in the modern sense but rather as symbolic representations of the belief systems and cultural practices of their creators. As such, their true significance remains elusive, accessible only through interpretative frameworks. Despite this limitation, the process of deciphering and attributing meaning to these enigmatic symbols remains a compelling and intellectually rewarding endeavor in archeological and anthropological research.

A systematic comparative analysis of bind rune encodings from Aztec, Shamanic, and Norse cultures alongside those present in the Danigala Chithra Lena petroglyphs reveals partial similarities. Preliminary interpretations suggest that some of these bind runes and engravings may correspond to conceptual

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representations such as: Mastermind, Day, Life, Heritage, Estate, Possession, Ride, Open, Crooked, Animals, Humans, Plants, Birds, Bow, and Arrows. (Fig 05-14).

Fig 23: (A) Depiction of an ancient bird (possibly a stork-like species) being venerated by humans. **(B)** Rock art at Kurullangala showing a similar bird holding a newborn baby's head in its claws. **(C)** Engraving of a large bird at the entrance of Danigala rock shelter (left wall). **(D)** Additional avian rock art at Kaudagala. These sites – located within the Vijayan Complex and eastern Sri Lanka – consistently portray a large bird, possibly representing an extinct giant marabou stork (*Leptoptilos robustus*) ? . Further research is needed to confirm species identity and cultural significance. (Sumanarathna et al, 2018b & Thantilage et al.,2016).

These findings indicate that the Danigala petroglyphs may encode a strategic and non-linear archeoastronomical process through bind rune symbolism. However, given the complexity and cultural specificity of such encoding systems, a comprehensive and methodical decoding effort is essential before definitive conclusions can be drawn. Further interdisciplinary research – incorporating epigraphy,

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comparative symbology, and archeoastronomy – is necessary to fully unravel the semantic and functional dimensions of these ancient inscriptions.

The petroglyphs at Danigala Chithra Lena, Sri Lanka, exhibit anthropomorphic figures delineated in a linear yet articulate manner. The precision in symmetry and form suggests that the outlines of these figures were initially sketched before being etched or grooved deeper into the rock surface. Most depictions consist of single-grooved lines, though some feature double-grooved outlines. These engravings are attributed to the ancient Vedda people, particularly the Girigama Vedda (or Danigala Vedda), who likely created them as votive offerings over successive periods, evidenced by variations in stylistic execution and depth (Hettiarachchi, K., 2020, unpublished).

The motifs predominantly feature anthropomorphic and zoomorphic representations, possibly reflecting totemic associations of the Girigama Vedda community. Notably, the site includes multiple depictions of ladder or stretcher-like symbols, while wheel motifs – present in other regional petroglyphs such as those at Edakkal – are absent. A comparative analysis with Buddhist iconography reveals that ladder motifs often symbolize spiritual ascent, paralleling the depiction of Buddha's descent from heaven via a staircase (Cunningham, 1879). This suggests a potential funerary association, where the ladder represents the soul's journey to the afterlife.

Figure 24: Documenting mechanical weathering processes at Edakkal Caves, Wayanad, Karnataka – Asia's most significant Neolithic petroglyph site. The erosion patterns provide insights into long-term preservation challenges of ancient rock art.

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Figure 25: The Edakkal Caves feature ancient petroglyphs dating back approximately 8,000 years, offering a rare glimpse into Neolithic rock art. These formations are not true caves but rather fissures in the rock, preserved as a UNESCO World Heritage Site.

The caves in question were rediscovered in 1894 by F. Fawcett, a British officer, who noted their potential use by Neolithic communities (Sajit & Janardhanan, 2009). These natural caves, possibly formed through seismic activity or natural geological processes, consist of three large boulders and contain three distinct chambers. Structurally, the cave system is divided into two levels: the lower chamber measures approximately 18 feet in length, 12 feet in width, and 10 feet in height, while the upper level extends about 96 feet in length, 22 feet in width, and 18 feet in height.

The caves hold significant archeological value due to the presence of intricate engravings on the rock shelter walls. The left wall features depictions of humans, animals (including peacocks), plants, and floral motifs, while the right wall displays geometric patterns and additional human figures (Sajit & Janardhanan, 2009). These engravings are believed to represent ritualistic scenes, providing insight into the cultural and religious practices of the indigenous tribes that once inhabited the region.

The Danigala Chithra Lena Petroglyphs in Sri Lanka exhibit intricate double engraving lines, suggesting advanced technological and artistic capabilities among their creators. The Vedda people, recognized as multidisciplinary experts in traditional knowledge systems (Punchihewa, 2011), may have ancestral ties to these engravings. Furthermore, recent studies propose a possible cultural linkage between Sri Lankan

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Figure 23: Prehistoric Artistry: Anthropomorphic carvings and Stone Age petroglyphs in the Edakkal Caves, Wayanad, Karnataka. These ancient rock engravings, dating back to the Neolithic and possibly Mesolithic periods, offer insights into early human symbolism and cultural expression. Image © Aravinda Ravibhanu.

engravings and the Edakkal petroglyphs in Kerala, India, given the lack of explicit reverence for the Edakkal engravings among the local Kurumba tribe (Kumara, 2020). This raises the hypothesis that an external group, potentially linked to Sri Lanka, may have contributed to the Edakkal engravings. According to the Geomorphological Evidence for Migration Between Sri Lanka and India, the Adam's Bridge (Rama Setu) sandbar likely facilitated human migration between Sri Lanka and India during periods of lower sea levels in the late Holocene.

Radiometric dating (Katupotha, 1988a; 1988b) indicates intermittent openings of the land bridge at:

- 5830 ± 90 and 6000 ± 90 yr BP
- 5590 ± 80 and 5840 ± 80 yr BP
- 5910 ± 70 and 5600 ± 70 yr BP

Additionally, between 11,500–12,800 yr BP, a pronounced drop in relative sea level (~25 ± 5 m below present levels) would have rendered Adam's Bridge a dominant migration route (Mann et al., 2019). This period coincides with significant prehistoric human movements in South Asia.

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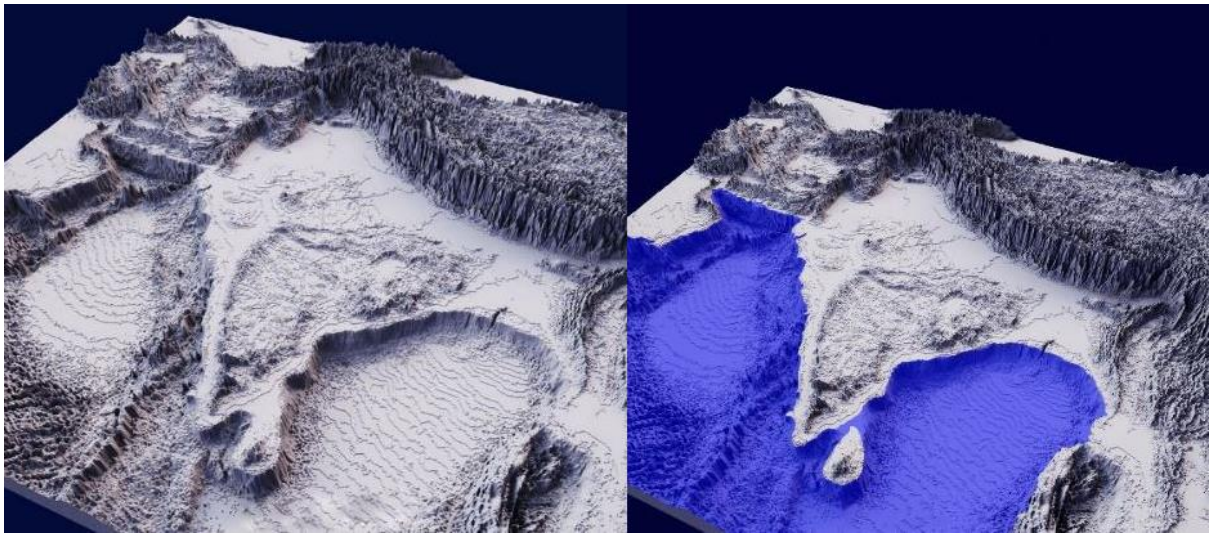

Figure 24: Simulation model depicting average sea-level fluctuations in South Asia during the period ~12,800–12,000 yr. BP. Left: Glacier model illustrating cold-phase conditions. Right: Warm interglacial model highlighting contrasting hydrological dynamics. Image © Aravinda Ravibhanu 2020.

Apparently, the main anthropomorphic figures at *Danigala* are not carved with pure or traditional beliefs and iconography of the gods worshipped in the temples. They are in fact, reflective of a synthesis of rituals and beliefs – such as death, life after death, and beneficial ancestral spirits who could be approached and appeased in exchange for the protection from evil spirits, diseases, and calamities. The petroglyphs in all possibilities represent ancestral spirits and deities of the *Vedda* people at *Girigama* and are votives symbolic of honor offerings. Many of the symbols carved adjoining the main figure have a votive value, and some of them possibly denote death and the transmigration of the soul into the realm of the dead or heaven and related concepts.

The Danigala inselberg is a geomorphologically and archeologically significant site, exhibiting a high potential for prehistoric cultural heritage. Its unique environmental and geological setting suggests that it may have served as a focal point for ancient human activity, possibly functioning as a place of worship or veneration for indigenous communities during the Neolithic and Megalithic periods in Sri Lanka (Sumanarathna et al., 2016).

Comparative analysis of petroglyphs and rock engravings found at Danigala, particularly those featuring geometric patterns, aligns with similar prehistoric sites documented in the *Conservation and Management of the World's Petroglyph Sites*. These include similarities with rock art in Cheonjeon-ri (Korea), the Amur-Ussury region (Russia), Lianyungang (China), Sa Pa (Vietnam), and the Funnel Beaker Culture's stone slabs in Sweden, which date from a settlement layer belonging to the Early-Middle Neolithic transition, approximately 5200 BP. When conducting a comparative analysis of analogies, the primary focus is attributed to the petroglyphs found in the Edakkal Caves of India. These ancient rock

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engravings hold significant archeological and anthropological importance, providing valuable insights into prehistoric human expression and cultural practices. The Edakkal Caves, located in the Indian state of Kerala, are renowned for their intricate carvings, which date back to the Neolithic and Mesolithic periods. As such, they serve as a critical reference point in the study of early symbolic communication and art. Therefore, based on relative dating methods and cross-site comparisons with twenty analogous locations, the estimated age of these engravings ranges between 4,500 BP and 11,500 BP for petroglyphs at Danigala.

This chronological framework underscores the site's importance in understanding early human cultural and symbolic practices in South Asia. Further archeological investigations, including systematic excavations of burial pits, microlithic tools, pottery fragments, and other prehistoric material remains, could yield significant insights into the region's ancient socio-cultural dynamics. Such research would not only enhance the understanding of Danigala's historical context but also contribute to broader archaeological discourse on early human settlements and ritual practices in Sri Lanka.

Danigala presents a significant opportunity for tourism development, as highlighted in Table 01. With its unique natural and cultural attractions, the region has the potential to become a key destination for both domestic and international travelers by leveraging its scenic landscapes, biodiversity, heritage, geotourism, and astrotourism.

Astrotourism has gained global attention as travelers seek destinations with pristine night skies for stargazing, meteor showers, and celestial events. Sri Lanka, situated near the equator, offers excellent conditions for observing both northern and southern celestial hemispheres Danigala, a circular rock formation surrounded by myths of extraterrestrial activity, provides an ideal location due to its low light pollution, clear atmospheric conditions, unique geological features, and rich cultural narratives. Preliminary assessments classify Danigala as a class 3 (rural sky) on the Bortle Scale, making it a prime spot for observing phenomena such as the Milky Way core, zodiacal light, and meteor showers. With strategic development focused on sustainability and community engagement, Danigala has the potential to become South Asia's leading astrotourism destination while preserving its natural and cultural heritage.

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Figure 25: AI-generated simulation of stargazing activities around Danigala Circular Rock, superimposed upon a photograph captured by Aravinda Ravibhanu © 2020. This visualization blends imagination with reality, showcasing the celestial wonders above Ranbanda Chena Cultivation. (Sumanaratha, 2017a; 2017b; 2017c; 2018a; 2018b).

Similarly, Sri Lanka holds significant untapped potential for geotourism, a niche that emphasizes geology and landscape as the foundation for visitor engagement and education. Sites like Adam's Peak, Horton Plains, and Sigiriya showcase the country's rich geodiversity and cultural connections, providing a strong foundation for geotourism development. Danigala, with its unique geological formations and mythical allure, aligns perfectly with this concept. By integrating Danigala into a broader national geotourism strategy – such as thematic routes linking key geological sites – Sri Lanka can attract environmentally conscious travelers, diversify its tourism offerings, and promote sustainable regional development. Recognizing and marketing these distinctive sites will position Sri Lanka as a premier destination for both astrotourism and geotourism on the global stage. (Katupotha and Sumanarathna, 2020).

A fundamental commitment to sustainable tourism practices is essential to mitigate potential negative impacts on Danigala's delicate natural environment. This involves implementing responsible waste

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management systems, conserving water and energy resources, and adopting proactive measures to prevent pollution. Given the area's unique geological formations, rich biodiversity, and the presence of fragile archeological sites, the integration of environmentally sound practices is paramount to preserving its ecological and cultural integrity. To ensure the long-term preservation of Danigala's geoheritage – including its distinctive rock formations and cave systems, as well as its archeological sites, such as petroglyphs, inscriptions, and potential ancient settlements – targeted conservation strategies must be implemented. These may include establishing clearly demarcated protected zones with regulated visitor access, enforcing measures to prevent erosion, damage, or vandalism, and undertaking ecological restoration efforts where necessary.

Effective management of tourist volumes and permitted activities is crucial to maintaining the site's ecological and cultural carrying capacity. By preventing overdevelopment, habitat degradation, and overcrowding, sustainable tourism practices can safeguard both the natural environment and the quality of the visitor experience. Balancing accessibility with conservation will ensure that Danigala remains a treasured destination for future generations.

By integrating environmental sustainability into the core of all tourism planning and management for Danigala, it is possible to ensure the long-term viability of the site as a tourism destination while simultaneously preserving its invaluable natural and cultural resources for future generations to appreciate and learn from.

Aspect	Strategy	Potential Benefits	Potential Challenges
Astrotourism	Develop designated dark sky viewing areas with minimal infrastructure (e.g.: platforms, directional signage, red-light-compliant pathways).	Attracts niche market, extends visitor stays into the night. Generally low environmental impact if managed properly.	Requires careful planning to minimize light pollution from infrastructure. Potential for disruption to nocturnal wildlife. Safety concerns for nighttime access.
Geotourism	Establish educational trails with interpretive signage explaining geological formations and processes. Offer guided tours led by trained local guides or geologists.	Enhances visitor understanding and appreciation of natural heritage. Promotes educational tourism. Can be combined with hiking.	Trail erosion due to increased foot traffic. Need for accurate and engaging interpretive materials, ensuring guides have adequate geological knowledge.

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Archeology	Create a small interpretive center or museum near the site showcasing information about petroglyphs, inscriptions, and other archaeological findings. Develop guided tours to archeological areas with trained guides emphasizing preservation.	Educates visitors about the site's history and cultural significance, generates interest in archeology, provides a controlled environment for viewing and understanding fragile heritage.	Risk of vandalism or damage to archeological sites due to increased visitor access, need for expert curation and interpretation, potential for disturbing undiscovered archeological layers.
Community	Involve local communities in providing guiding services, accommodation (homestays), and selling locally produced crafts, food, and beverages to tourists. Establish benefit-sharing mechanisms to ensure tourism revenue contributes to community development projects.	Provides direct economic benefits to local residents. Fosters cultural exchange and authentic experiences for tourists. Promotes local ownership and stewardship of the site.	Ensure equitable distribution of benefits among community members. Potential for cultural commodification if not managed sensitively. Need for training and capacity building within the community.
Environment	Implement comprehensive waste management and recycling programs for visitors and local communities. Establish clear guidelines for visitor behavior to minimize environmental impact (e.g.: no littering, staying on marked trails). Promote the use of sustainable transportation options to access the site.	Preserves the natural beauty of the site, minimizes pollution and habitat degradation, protects biodiversity, and enhances the overall visitor experience.	Requires visitor cooperation and adherence to guidelines, enforcement of regulations, investment in waste management infrastructure, and sustainable transportation.

Table 1: Potential Sustainable Development Strategies for Danigala | Comparative development by using Kerala tourism for Edddkal cave. Aravinda Ravibhanu © 2018. (Sumanarathna, 2018b).

SUMMARY

The Danigala inselberg in Sri Lanka represents a site of profound archaeological, cultural, and geological significance, offering unique insights into prehistoric human activity and symbolic expression. The presence of burial pits, microlithic tools, pottery, and petroglyphs—particularly the recurring depiction of

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a large bird, possibly the extinct *Leptoptilos robustus?* —suggests ritualistic and possibly sacrificial practices by ancient Vedda communities. Relative dating methods [based 23 sties analogies data and sea level; fluctuation data) estimate the petroglyphs to be between 4,500 and 16,500 years old, aligning with periods of significant climatic and environmental change. The petroglyphs, potentially created using iron meteorite-based tools, exhibit weathering and displacement, necessitating further geochemical analysis (e.g., XRD) to confirm material composition and carving techniques. Archaeoastronomical interpretations indicate that these engravings may have held cosmological or shamanistic significance, though their exact meaning remains obscured due to the disappearance of their creators. Danigala's multidisciplinary value—spanning geology, archaeology, anthropology, and astronomy—positions it as a prime candidate for sustainable geotourism and astrotourism. However, future research must prioritize: 1, Advanced dating and material analysis to refine chronologies and technological methods. 2. Comparative studies with analogous sites to contextualize symbolic and cultural practices. 3. Community-inclusive tourism frameworks to preserve heritage while fostering local engagement. By adopting an evidence-based management approach, Danigala can serve as a model for balancing scientific exploration, cultural preservation, and responsible tourism, ensuring its legacy for future research and education.

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