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# GEOMORPHIC INFLUENCES OF THE CLIFF FORMATION AND DESTRUCTION IN VARKALA COAST, KERALA

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#### Abstract:

Coastal geomorphology is the study of the morphological development and evolution of the coast as it acts under the influence of winds, waves, currents and sea level changes. The cliff is the most important erosional feature of the coast and coastline is eroded to form a cliff. Sea cliffs are formed by the erosional process of coast. The most widespread landforms of erosional coasts are sea cliffs. Varkala is a major commercial, tourism region in Thiruvananthapuram district. Varkala is located between 8° 43' 59.88" N and 76° 43' 0.12" E. The main objectives of the study are to analyse the formation of Varkala cliff and to identify the main reasons for cliff destruction in Varkala coast. Both primary and secondary data are used for conducting the study. This study mainly focuses on the formation and destruction of cliff in Varkala coast. Warkalli formation is mainly based on the geology, and then geographically, hydrologically cliff formation is based on the geographical factors and geomorphologic factors. Physical actions are mainly affecting the formation and destruction of cliff. Temporal changes of cliff destruction from 2003 to 2019. With the help of photographs the main difference between the cliffs, destruction of cliff could be identified.

#### Keywords: cliff, destruction, physical activities, geologic, geomorphic actions.

#### Introduction

Geomorphology is defined as the science of landforms with an emphasis on their origin, evolution, form and distribution across the physical landscape. Geomorphologic features are coast, shore, and cliff which are constantly shaping by geographic process. Coastal geomorphology is the study of the morphological development and evolution of the coast as it acts under the influence of winds, waves, currents and sea level changes.

The cliff is the most important erosional feature of the coast and coastline is eroded to form a cliff. Sea cliffs are formed by the erosional process of coast. The most widespread landforms of erosional coasts are sea cliffs. These very steep to vertical bedrock cliffs range from only a few meters high to hundreds of meters above sea level. Their vertical nature is the result of wave induced erosion near sea level and the subsequent collapse of rocks at higher elevation. Many coastal locations, there is a thin, narrow form of sediments forming a beach along the base of sea cliffs. Cenozoic sedimentary formation cliffs are a unique geological feature on the flat Kerala coast.

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#### Location of the study area

Varkala is a major commercial, tourism region in Thiruvananthapuram district. It is located between 8° 43' 59.88" N and 76° 43' 0.12" E. Varkala is a coastal town and elevation is 191m.



# Source: prepared by the investigator (On basis of the Mphil dissertation 2018-2019.) Objectives

- To analyze the geomorphic influence for the formation of Varkala cliff.
- To identify the main reasons for cliff destruction in Varkala coast.
- To measure the changes of cliff destruction from 2000-2019.

# Methods and Techniques

Primary and secondary data are used for the study. Primary data includes toposheet - for base map preparation (1:25000, 1:50000), satellite images - Landsat 4 to 8 series for analysing the shoreline changes. Questionnaire survey was carried out for analyzing the problems and population pressure on cliff destruction. Secondary data such as census, technical reports and other statistical data are used for interpreting the study.

# Characteristics of the study area:

Varkala is the only place in Kerala where cliffs are found adjacent to the Arabian Sea. Cliff are a unique geological feature on the flat Kerala coast, are known among geologists as Varkala Formation and a national geological monument as declared by the Geological Survey of India for their protection, maintenance, promotion and enhancement of ecotourism. Varkala is an important place as far as Kerala Geology is concerned as it exposes sedimentary rocks belonging to the Cenozoic age, popularly known in the Geological literature as the Warkalli formation. Varkala has a moderate humid climate. It has heavy rains during June to August due to a southwest monsoon. In summer, the temperature rises to a maximum of 32°C and 31°C in the winter time. The Varkala Municipality has population of 40,048 of which 18,312 are males while

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21,736 are females. The cliff is located at the papanasam beach side and is adjacent to the north to south portion of the varkala beach.

#### **Results and Discussion**

Mainly the formation and destruction of cliff are due to physical activities, especially geologic, geographic and hydrologic activities.

#### • Formation and Destruction of Varkala cliff

The formation of the cliff is mainly in three forms. These are geologically, geomorphologically and hydrologically. All three are interconnected and inter linked.



Source:

# Prepared by the investigator (On the basis of the Mphil dissertation 2018-2019.)

The Cliff is unique Geomorphological feature and the formation is based on the Geology. Varkala and adjacent areas form a part of Kerala Khondolite Belt of the Southern Granulite Terrain of India. Three geological formations are formed in the tertiary periods. Main formations are Vaikom formation, Quilon formation and Warkalli formations. The Tertiary sedimentary formations of Kerala basin uncomfortably cover the Precambrians. The name Kerala Basin denotes the southernmost division of a great sedimentary zone spread over a major part of the western continental margin of the Peninsula.

Constructive waves and Destructive waves are regularly formed in the Varkala coast. The name indicated that the Constructive waves are constructing many land forms and Destructive waves destructing the landforms. Destructive waves are common in Varkala, because erosional action is high in waves. Destructive waves are formed the cliff, because the destructive waves are creating the erosional landform. It is the most important problem is affected into the cliffs. As the waves move and break against the cliffs, some features are formed and the landform is wave-cut-notch and it is the base of the cliff. Wave action is mainly affected the formation of coast and its landforms. The water of the oceans is in constant motion. The gravitational pull of the sun and moon oscillates the surface of the Oceans twice a day while the wind agitates it into waves. Coastal currents are generally joined to winds, waves and land formations. Wind is the most powerful agent; it forms currents, tides and waves. Currents and the currents create the tides

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and waves. These things are mostly affect the coast and forming the landforms. Tidal currents happen to stronger near the coast and play and more and more significant role in narrow movement. Mainly trade winds or easterlies are affecting the Kerala coast and the after effects are landform formation and landforms destruction in slowly.

# **Physical Activities**

Cliff is a physical feature and natural one. Cliff is formed by the some physical activities like currents, tides, waves and wind. These activities are mainly affected the formation and destruction of Varkala cliff. Especially geological, geographical and hydrologic actions are due to the formation and destruction of cliff. Many physical activities are affecting the destruction of cliff are given below;

# • Geology

With the presence of warkalli formation in area is capped by hard laterites. These are formed during the second laterisation cycle observed in Kerala. North cliff exposed to wildly wave action. North cliff exposes carbonaceous clay witness in Kerala. This soft sandstone is distant eroded by seawater and creation the top laterite overhangs the cliff face. Varkala cliff faces the tension cracks enlarge in the surface which eventually leads to erosion. Sometimes geological tension cracks leads to landslide. Geology of the cliff plays a significant role in formation the cliff. The rock is highly weathered and the soft rocks are eroded and the base rock is consisting the remaining portion.

# • Waves Action

Wave action is related to hydrologic activity and mainly Varkala beach is affected by destructive and constructive waves. Destructive waves are high frequency waves and erosional action is high in the coastal areas. The Varkala beach has high waves, due to strong winds. High tides are affecting the cliff area and slowly eroding periodically. Then the soft rocks are suddenly moving to the sea.

# • Rainfall

Rainfall is the major geographical action of the destruction of cliff, because the laterite soil is suddenly subjected to leaching and moving. The average annual rainfall is 1900mm and in some instances the area experiences more than 2500mm of rainfall. The south east and north east monsoon is highly influenced in the cliff structure and shape. Carbonaceous clay and laterite soil are highly leached soils and rigorous erosion is happened in the cliff.

# • Slope

Slope gradient is a critical factor controlling the distribution of cliff destruction and failure occurs only on slopes exceeding the critical angle for the materials to be moved. Varkala cliff is nearly in vertical shape and formed due to west coast faulting. Weathering is mainly attacks the gently slopes and the affected area become weaker and weaker.

# • Ground water

Ground water is the hydrological action for cliff destruction. The most significant attraction of Varkala cliff is a natural mineral spring. Water springs are naturally occurred in the cliff and

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cliff is a hill, therefore, ground water is contact between the laterite and carbonaceous clay; this is the main reason for the destruction of cliff.

# • Soil erosion

Soil is mainly eroded due to the action of waves, rainfall, and weathering. Geographically weathering is affected by the soil and soil erosion is suddenly happened by erosion.

# Temporal changes of cliff destruction from 2000-2019

Temporal change refers to the time period activities. This means the interval between the time to time changes. Temporal maps and photographs of the different periods, helps to identify the changes occurred. The map shows the time difference from 2000 to 2019. There have been many changes identified from each year. As mentioned the changes of Varkala cliff are mainly due to the physical activities and anthropogenic activities.

# Analysis of Temporal changes through maps

The following table and map shows the temporal changes of the Varkala cliff from 2003-2019. This map has prepared to show the temporal changes of Varkala cliff for 2003, 2009, 2013 and 2019. Every year several changes is occur the cliff. In 2003 the total area of the cliff was 0.042884sq.km. Minute changes are identified the cliff area. It is considered as the actual area of the cliff. Destruction of the cliff is due to physical as well as anthropogenic activities. In the cliff erosional activity is high due to the destructive waves.

Year	Actual area of Cliff(Sq.km)	Change of Cliff area(Sq.km)
2003	0.042884 Sq.km	_
2009	0.042752 Sq.km	0.000132 Sq.km
2015	0.042504 Sq.km	0.000248 Sq.km
2019	0.042481 Sq.km	0.000023 Sq.km

# Table: 1.1 Temporal change in cliff area (Sq.km)

Source: Computed and calculated by the investigators (On the basis of the Mphil dissertation

2018-2019)



Source: Prepared by the investigators (On the basis of Mphil dissertation 2018-2019.)

# Image: Old and new photographs of varkala cliff (On the basis of Mphil dissertation 2018-2019.)

The above map indicates the major changes occurred in the cliff from 2003 to 2019. Shops, resorts and constructional works are found between the gap of the cliff. Physical and anthropogenic activities are responsible for the changes in the cliff. During this, the area under cliff was decreased and beach area increased. Minute changes can be shown in 2003 and 2009 but in 2015 and 2019, the bulged portion of cliff in the southern area was broken down to narrow strip along the coast.

# Conclusion

This paper deals with the geomorphic influences are affecting the formation and destruction of varkala cliff. This study mainly focuses on the formation and destruction of cliff in Varkala coast. Warkali formation is mainly based on the geology, and then geographically, hydrologically cliff formation is based on the geographical factors and geomorphological factors. Physical factors and anthropogenic activities are responsible for the destruction of cliff. Cliff formation is the very slowly process, but destruction is the much hidden process. Population pressure is the severe problem on the cliff and constructional works in the surroundings of the cliff area. Important constructional activities are resorts, stairs and shops. Besides of the above reasons are the anthropogenic activities are equally affecting the Varkala cliff destruction. From 2003 to 2019, there is a change in the cliff area is getting reduced to 0.042481 sq km. With the help of photographs the main difference between the cliffs, destruction of cliff could be identified.

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