Monitoring Vertical Cliffs, Embayments and Shore Platform Morphology in Parts of Neil Island, South Andaman using Spatial Information Technology

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KEY WORDS: Vertical cliffs , Landsat, Spatial diversity , Shoreline morphodynamics and Limestones .

ABSTRACT:

The southern shores of Neil Island are fringed with vertical cliffs, embayments and near horizontal platforms on the rocky coast of windward side dominated by limestones, calcareous siltstones and biocalcarenites. The uppermost shell limestones, massive limestones and coralline limestones (Neil formation) are unconformably lying over the calcareous siltstones and limestones with ash layers in this part of the sequence (Archipelago Group). Sequences of erosional landforms such as caves, notches, arches, stacks, geos, rockfalls and solution pits have been appeared to offer insight into the pattern of progressive change on the cliffed coastline of the island. The height of the cliffs ranges from 8 - 21 meters along the shoreline and they appear to represent successive stages of erosion that produced small embayments, bays and coves in between the resistant headlands. The wave attack on headlands, water layer weathering, successive wetting and drying and having presence with sufficient zones of weakness into the near vertical slopes of the cliff are the main causes for the gradual change in morphology. At the base of cliffs in entire parts of the island, near horizontal shore platforms are well developed within the intertidal zone ranging between 30 - 100 meters in width and extended seaward upto the margins of coral bank with descending slope. The rate of cliff retreat and its spatial diversity as well as the resultant shoreline types are estimated with the LANDSAT ETM+ images of 2005 and 2015 for the above study. However, the morphology of shore platforms and cliffs is studied with the delineation of features from satellite images and temporal field verifications over the period between 2014 and 2017. The study reveals the nature of shoreline morphodynamics of the cliffed coasts of limestone rocks in the oceanic island.

Introduction

The Neil Island of South Andaman constitute various topographic surfaces bounded by 10m, 20m and 80m contours with area of km2 land platform over the Andaman sea. The intertidal shore platform and the island platform are distinctly separated by contrasting shoreline cliff morphology on the windward sides and low height shoreline bluff morphology with unconsolidated sediment deposits on the leeward side. Geologically, the island is made up of various limestone's, white clay stones, calcareous mudstones, calcareous sandy beach rocks and bioclastic fossiliferous beach rocks. The vertical cliff sections represent the exposure sites of limestones, white clay stones and bio calcarenites with reef terraces.

Varying rock strength and relative effectiveness of marine and subaerial processes of erosion with limestone desolution have produced diverse cliff morphology along the shoreline. The height of the cliff wall is ranging from 16m to 25m from the immediate shore platform base with erosional signatures at the base.

The shoreline configuration types of various sections represent diverse cliff morphology and stages of development. Major shoreline types are identified as bays, caves, headlands, promontories, embayments, shoreline bluffs, straight shorelines. Steep cliffs are developed under wide and open exposurs of the coast to the wind ward sides of marine environment and general convex cliffs are visible on the coastal parts in which subaerial processes dominate in the island. In such exposed areas of the coast, the repeated wave sprays in high tides, high evaporation and salt crystallization alternate wetting and drying, corrosion, and other weathering processes helped to develop the vertical slopes and protected vegetation growth on the cliff faces.

Study area:

The study area is Neil Island in South Andaman has been selected for its dynamic nature of morphological character of shoreline. It is located at 11˚83'29.19''N and 93˚05'26.12''E. The rimmed shelf of Neil Island is an extensive carbonate platform with pronounced break of slope at shallow depth that extends into deep water.

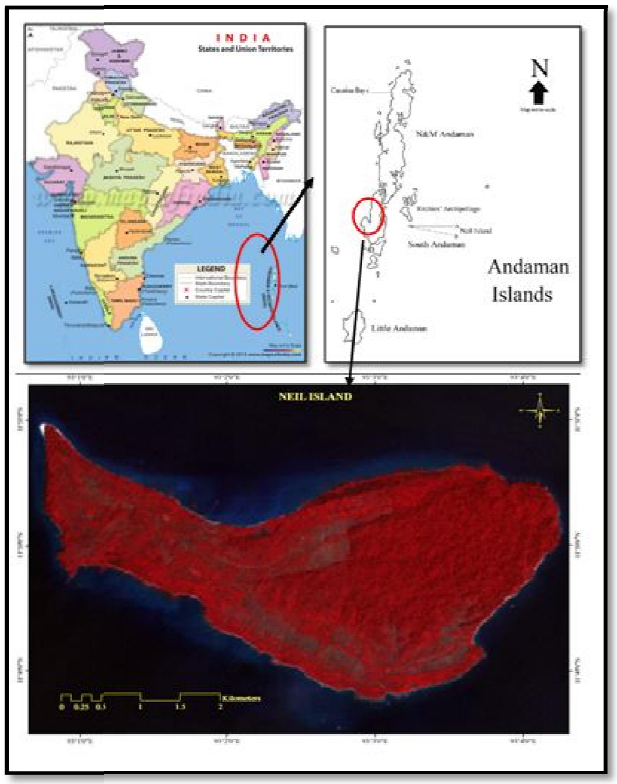

Fig:1

Objective of the study:

1 . The main objective of the paper is to study the nature of shoreline morphodynamics of the cliffed coasts of limestone rocks in the Neil Island, South Andaman.
2 . To Identify and consider the physical parameters for assessing cliff morphology
3 . To explore the database of the study area using with geospatial technology and field survey
4 . To prepare a map to show the exposure and coastal forms with older and younger carbonate platforms of Neil Island

Methods of the study:

The base map is prepared from the temporal images (LANDSAT ETM + 2005 and 2015) for the identification of the nature of shoreline morphodynamics of the study area. Field verification is done for the validation of the geomorphological map and morphological zonation diagrams of Nothern and southern shore of Neil Island, South Andaman.

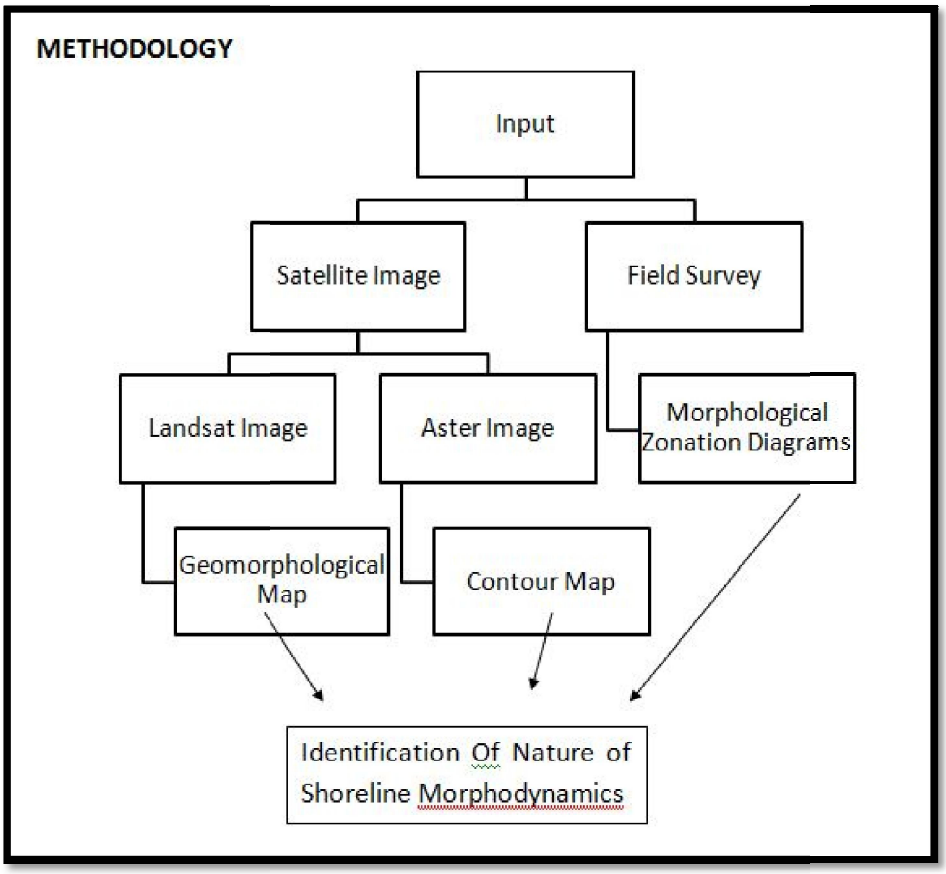

Fig:2

Results and Discussion:

In this present study the shoreline morphological features have been taken into consideration for the better understanding of the dynamic nature of Neil Island, South Andaman.

Physical Parameters for Assessing Cliff Morphology:

There are ample of physical parameters for assessing cliff morphology. The shore platform elevation and slope characters, relative exposure of the shoreline, differential dissolution, wave energy variation at the high tides and low tides, configuration of the shorelines and climatic characteristics of the region have also played a major role in the formation and modification of cliff morphology. The tilting of the cliff line and shore platform rocks are produced by earthquake of 2004 in few parts of the island. (Paul, Ashis kr. 2005)

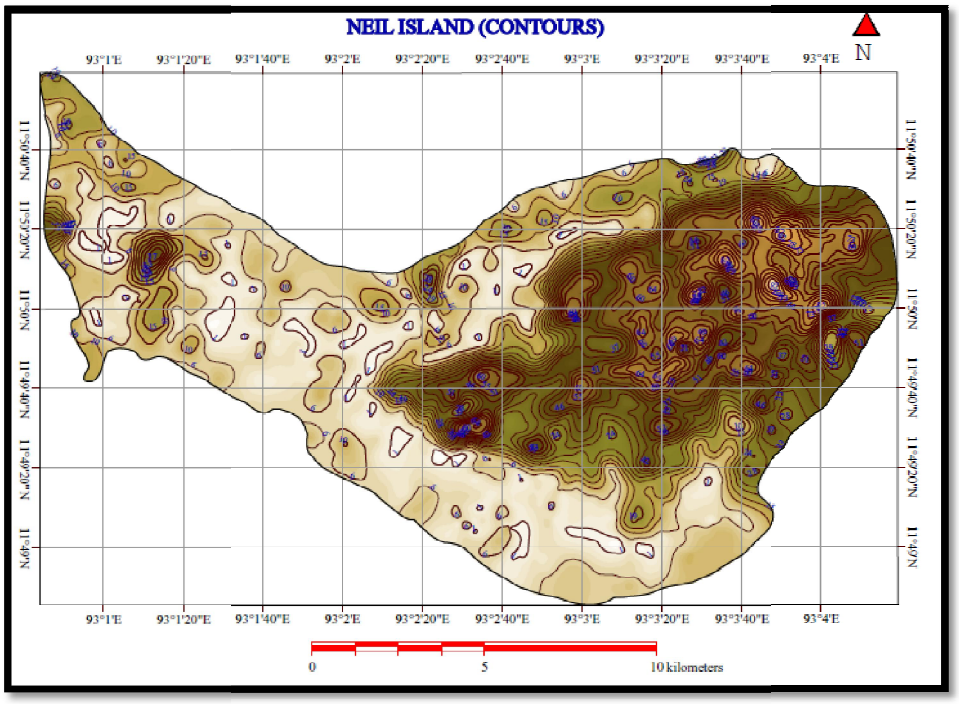

Fig:3

The foot of shoreline cliffs is subject to marine processes under high tides, otherwise the cliff of the island are modified by subaerial processes. A schematic cross section of the subhorizontal shore platform near Laxmanpur II high lights the morphological features of cliffed wall and shore platform. Intensity of wave action at the high tide scarp and low tide scarp increases during high tides. However, subaerial exposure of the shore platform has produced several features related to weathering activities due to alternate wetting and drying. Lappies, coastal karren, Tafoni, Potholes, Rampat etc. features have been developed by salt weathering process.(Thomas , Michael F. 1994)

The caves are well developed at the base of the cliff wall dominated by massive limestones at or near Laxmanpur II site by active dissolution process.

- Subaerial/Marine processes
- Relative resistance of limestones
- Variation in wave energy
- Tidal range with differential impact in upper inter tildal, supratidal mid tide zone, low tide zone
- Differential dissolution
- Relative exposure of the shoreline
- Morphologic diversity
- Climatic characteristic
- Shore platform elevation and slope characters
- Wave energy variation
- Shoreline types
- Processes and rates of erosion

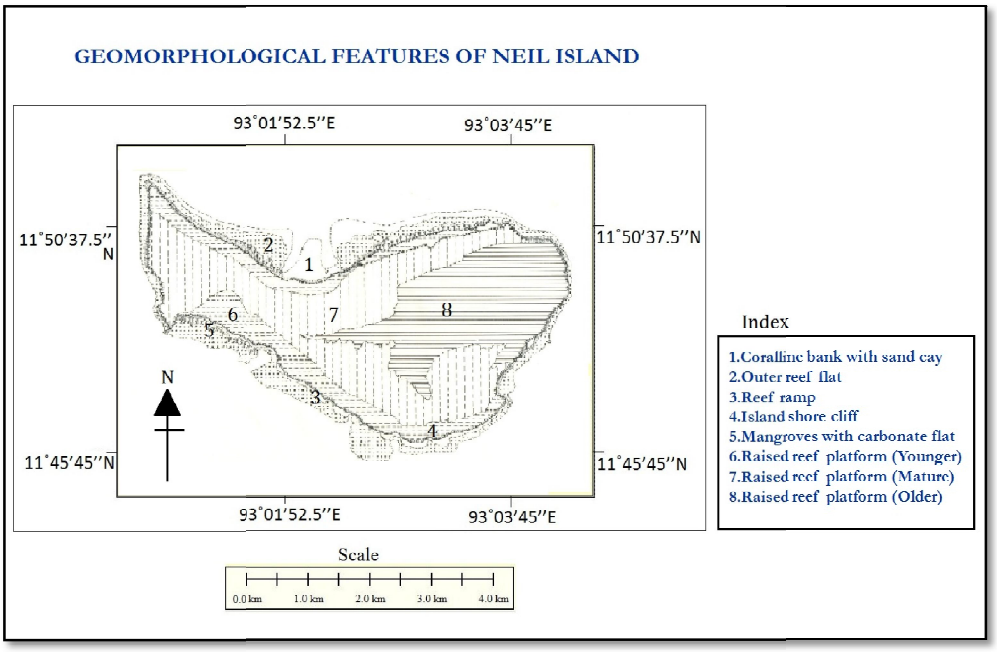

Fig:4

Relative resistance of limestones along the shoreline has played a significant role in differences of cliff types. (Sharma,V. and Srinivasan, M.S. 2007)The homogeneous white claystone dominated shoreline of Sitapur site is dissected by marine processes. The vertical cliff wall is modified with caving at the base, debris fall at the foot slope, wave erosion at the cliff wall and location of stacks and islands at the near shores. However, the calcareous mudstones and reef terrace margines of Sitapur are marked by low height cliff (1.5m to 1.8m), coral sands at the base and reef rocks at the shore platform. The wave breakers of the high tide levels have produced a variety of karstic features on the reef terrace banks.

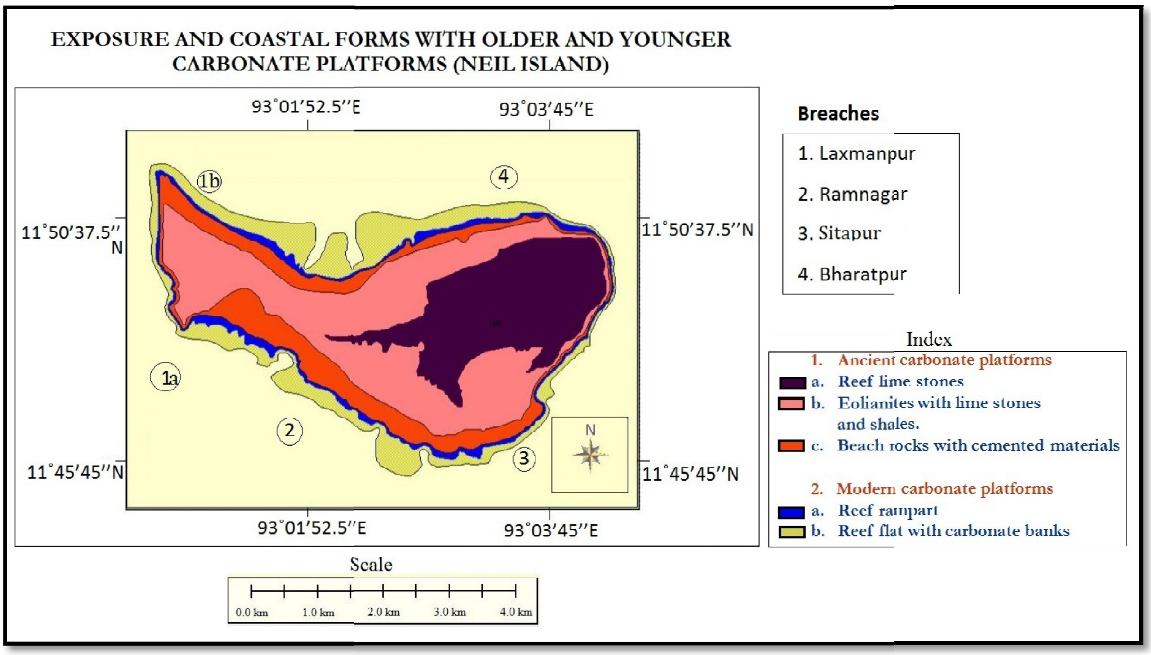

Fig:5

Cliff Types:

The shape of the cliff profiles with structural weakness and other geological factors is classified by several researchers (Emery and Kuhn 1982, 1980., Trenhaile 1987, 1997) in the past. All the cliffs of convex types, near vertical slope types and composite cliffs types are visible in different sections of Neil Island. By accumulating sands along the sheltered areas of curved shorelines, the low cliffs are gradually replaced by convex slopes. The beaches and wide shore platforms are extended at the foot of cliffs. Exposures of fractured cliff with lithological materials of biocalcarenites are found on the western shores of Neil Island.

1. Homogeneous, 2. Resistant at top, 3. Resistant at base

Varying rock strength and Relative effectiveness of marine and subaerial processes of erosion. Hydraulic action, mechanical action, physiochemical action, biological action, subaerial slope processes Bay, cove, Headland, promontory, Embayment, straight.

Cliff Erosion:

The rate of cliff erosion is measured by comparing temporal images (2005-2016) for three sites (Laxmanpur-I, Laxmanpur-II, and sitapur) in the island. The study reveals that the relative rock resistance, exposures of cliffed shores to the wave attack, episodic wave energy during cyclones and 2004 Tsunami Incidence and subaerial weathering processes are jointly interacting to produce cliff recession in the tropical coast.

Areas of jointed and fractured rocks with weathering intensities by rain water seepage and chemical dessolution have produced landslides, debris fall, notching and caving at the foot of cliff walls. Dissection of headlands by wave energy variations has also produced cliff recession in other areas of island shores. Short term effects of coastal dynamics on cliff erosion are studied by Sunamura 1992 in pacific coast. By the study it is observed that frequency of higher waves is capable of causing erosion in which coast compressive strength of the rocks decreased.

Cliff Morphology:

The morphological features of the shore cliffs are categorized into subaerial processes and marine processes dominated features on the basic of the relative rotes of marine and subaerial processes in determining cliff morphology (Woodroffe, Colin D. 2002). Features related with the influences of subaerial processes include joints, fractures, solution pits, clefts, roof roof collapses and debris falls etc. in the shore fringe areas of Neil Island.

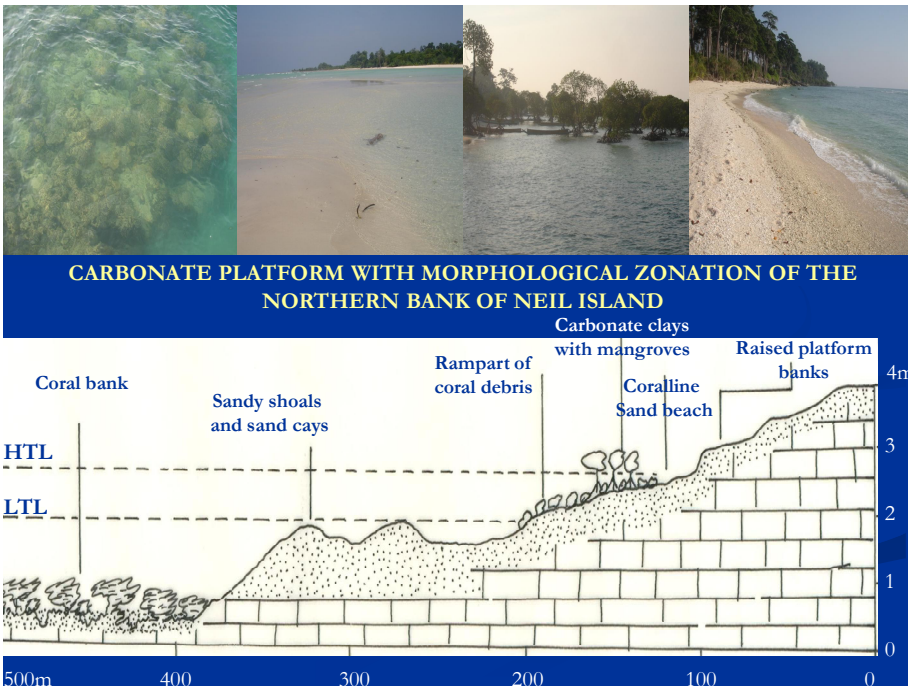

Fig:6

In the Northern Bank of Neil Island, Morphological features like Coral Bank, Sandy Shoals and Sand Clays, Rampart of Coral Debris, Carbonate Clays with Mangroves, Coralline Sand Beach and Raised Platform Banks are observed.

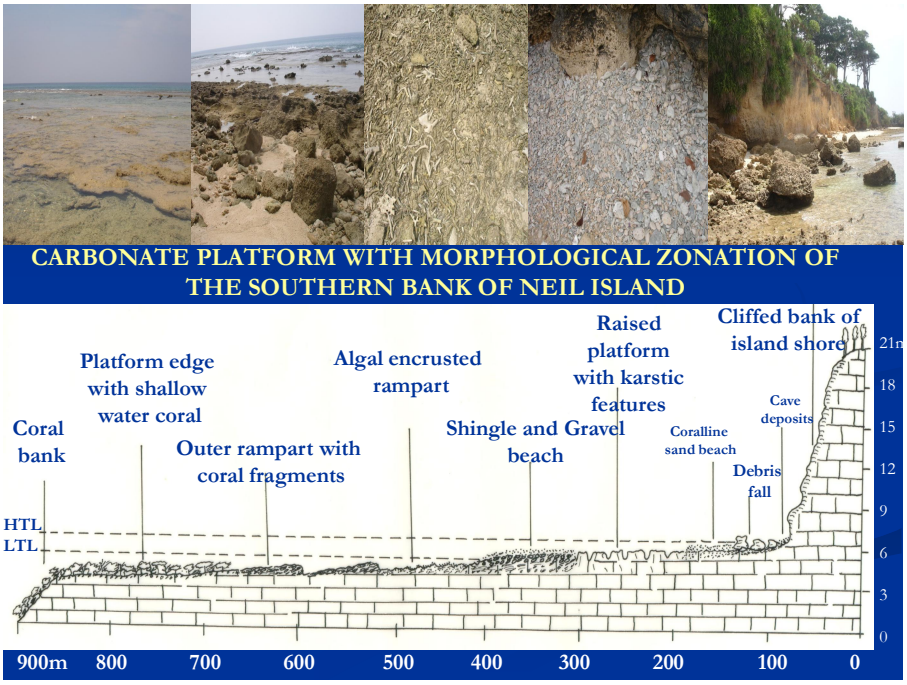

Fig:7

In the Southern Bank of Neil Island, Morphological features like Coral Bank, platform edge with shallow water coral, Outer Rampart with Coral fragments, Gravel beach, Algal encrusted rampart, Cliffed bank of island shore, debris fall, cave deposits, Coralline Sand Beach and Raised Platform with Karstic features are observed.

Other features of cliffed coast:

Small bays, narrow inlets, caves, arches and stacks are usually the result of erosion along structural weakness, particularly bedding, joint and fault planes and in the fractured and crushed rock produced by faulting. They are uncommon in weak or thinly bedded rocks with dense joint systems (Trenchaile 1987).

In many areas, erosional processes are modifying elements of cliffed coasts, that were inherited partly inherited from the past (Bryant et.al 1999). In raised beach topography under tectonic instability several evidences have existed along the shoreline of Neil Island which indicates the removal of rocks by fairly rapid wave erosion at the present level of the sea.

Steeper upper slope is recorded in few places of the cliffed coasts, in which landsliding is initiated after 2004 earthquake. However, the hill wash, slope wash and soil creep gradually converted the bluffs of northeastern shorelines into a series of undulations and then into smooth slopes.

Erosion of cliff face has occurred in the areas of steeper slopes in which part of the shoreline high tide wave base advances to the foot of the cliff wall to produce rapid wave erosion at present condition. Some cliffs are associated with inclined layered structures in antidip conditions towards the sea differences in resistance with developed solution pipes, joints, planes of weakness, and variable lithology. Stacks are developed along such shorelines due to the result of the dissection of the coast along joints and also due to the collapse of the roofs of arches. The plain shape of crenulated coasts may eventually attain an equilibrium state.

Conclusion:

The shelf margin is a high energy area subject to considerable wave activity, storms and often tidal currents, and the warming and CO2- degassing of oceanic water as it passes onto the shallow shelf creates an environment that promotes rapid rates of in-situ carbonate production. The rimmed shelves of Neil Island can be divided further into those that are:

1. Accretionary- which shows a lateral migration (progradation) of shallow shelf margin reefs and carbonate sand bodies over fore- reef and reef slope deposit.
2. Bypass- rimmed margins that deposit little sediments on the shelf slope, because shelf margin sedimentation is able to keep pace with rising sea level but insufficient sediment is deposited on the slope for any significant lateral accretion.
3. Erosional- rimmed margins which occur in areas with storm tides or ocean currents such that cliff or escarpments characterize the shelf slope.

A ramp may develop into a rimmed shelf as a result of long term prograding reef growth, or a shelf may become a ramp due to differential subsidence or drowning. The ancient carbonate platforms of Neil Island are developed due to raised reef terraces in geological past.

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