CHAPTER IX

TERRAIN CLASSIFICATION

IX.1 SCOPE AND PURPOSE

Any scientific investigation and classification of one or more terrain attributes of an area, could be defined as Terrain Evaluation. The main purpose behind such investigations is to collect, and collate in nutshell all the vital terrain data, suitably classified. Terrain Evaluation aims at developing schemes of storage and retrieval of terrain data so that knowledge and experience gained

at one place can be applied at other. All schemes of terrain classification studies are based on the assumption that similar climate acting on similar rocks in areas of similar tectonic history, gives rise to similar terrain attributes.

Terrain Evaluation studies can be useful in two ways. Firstly, the data obtained from the terrains actually studied, and classified, can be properly stored for all future references. Secondly, the stored information of the terrain class it may represent, can be applied to other identical but uninvestigated terrains for predicting their characteristics. The aim of such studies is to make useful statements about the suitability of a particular terrain for specific purposes, and thus Terrain Evaluation finds extensive utilisation in agricultural, industrial, civil engineering, town planning and defence activities. The scope of its utilisation is quite vast.

Terrain Evaluation systems aim at 1) the recognition of different kinds of terrain, and 2) knowing the properties of each type of terrain, once it has been recognised. The terrain data obtained,

classified and stored, could then be utilised for various purposes. One may identify the type of terrain encountered at an unknown site and then apply to it all the information present in the 'pigeon-hole' for that terrain type.

A system of evaluation for obtaining useful and precise data about terrain conditions must comprise :

1) a comprehensive terrain classification, the classes of which can be identified in any area of interest by means of air photography and minimal ground check.

2) the terrain unit must be recognisable without ground check, by means of air photographs, geological maps and climatic factors of the region in which the unit occurs.

3) the information storage is such that items of terrain information can be classified and recorded in easily recoverable form, and each indexed on its content and on its terrain class

In India, the Terrain Evaluation work has been taken up almost exclusively for defence purposes, though the ultimate aim is to utilise the results for other applications also.

The Terrain Evaluation Cell of the Ministry of Defence is attached to the Directorate of Engineering of the Research & Development Organisation, and this Cell has been doing pioneering work towards defence oriented terrain studies. In our country, the system of Terrain Evaluation as developed in U.K. is followed with some modifications, suited to the specific needs of our country.

IX.2 PROCEDURE OF TERRAIN EVALUATION

The author has followed the standard procedure for terrain classification as under :

1) Gathering all available background information on geography, geology, climate and other environmental factors pertaining to the area under investigation.

2) Sub-dividing the area into regions having uniformity in determinants like climate, geology, relief, soils, drainage, vegetation and land-use.

3) Making a preliminary ground reconnaissance.

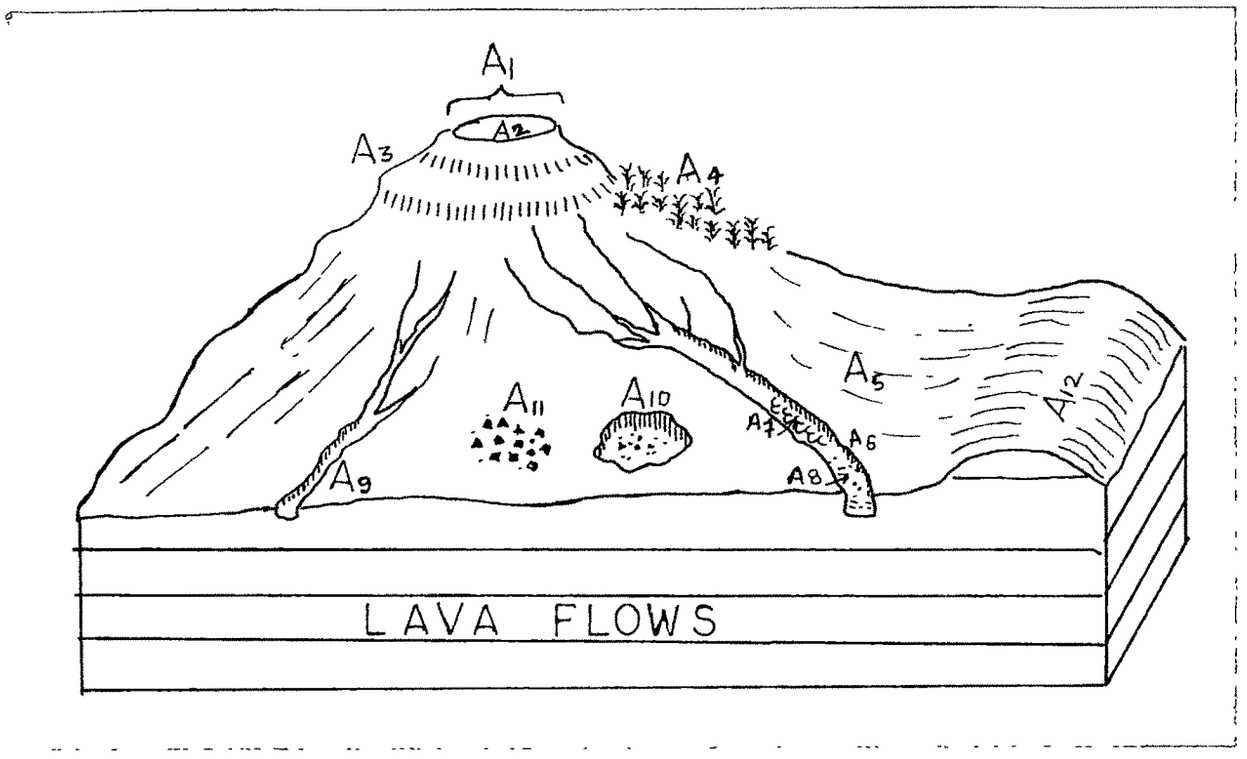
4) Studying aerial photographs and making a preliminary list of patterns and facets.

5) Delineating maps showing these patterns and facets.
6) Carrying out detailed field work checking actual facet delineations on the ground, record their attributes, associations, and collect all data required for the various types of Information Cards.
7) Modifying and finalising pattern and facet delineations.
8) Carrying out relevant laboratory testing of rocks and soil samples.
9) Writing final report, annotating topographical maps and aerial photographs, preparing block diagrams and filling up all Information Cards.

The various terrain attributes, appropriately classified and catalogued, have been described as Patterns and Facets. On account of security requirements, the T.E. Cell Numbers and locations of the individual Pattern and Facet have not been given, and instead, the various patterns have been designated alphbetically and the facets have been serially numbered and described. In all, the study area has been classified into 6 patterns and 40 facets (Appendix - A).

PATTERN A

NAME	:	Deccan Trap	DEFINED BY	:	Geology Dept. M.S. Uni. Baroda
CLIMATIC REGION	:	Humid, Semi arid, Average annual rainfall : 400 to 500mm.	DATE	:	March/April 1977
RAINFALL PERIOD	:	June to Sept.	RELIEF	:	40 to 50 m.
TEMP.	:	Winter: 6^{o} C. Summer: 36^{o} C.	COUNTRY ROCK	:	Deccan Trap
VEGETATION	:	Sparse; in patches Cultivated lands.	PHYSIOGRAPHY	:	Low hills, narrow valleys and plains
GEOREF	:	Jammagar District 41 J/2 41 J/3	TECTONICS	:	Layered lava flows
			ALTITUDE	:	Upto 200 m. above M.S.L.



Facets :

A_1	Convex topped parabolic hill
A_2	Hill top (barren)
A_3	Hill slope (barren)
A_4	Hill slope (vegetated)
A_5	Gentle sloping plain ground
A_6	River bank
A_7	River bed (rocky-sandy)
A_8	River bed (clayey vegetated)
A_9	Shallow stream channels
A_{10}	Stone quarry
A_{11}	Stony wasteland
A_{12}	Ridge.

Distinctive and Associated features :

Morphology : The pattern comprises a hilly and rugged terrain with 'V' shaped narrow valleys. The low isolated hills ranging in height from 40-50 m are interspersed in a rocky wasteland. The plains are dissected by stream and river channels and show undulating surface. River banks are both vertical as well as sloping with sandy, rocky or clayey beds. Plain areas are sometimes cultivated.

Geology : This pattern is developed entirely on Deccan Trap lava flows. The flows are horizontal. The rock is dark gray and fine grained basalt. Vesicular and amygdaloidal varieties are also common. The rock is highly joined, fractured and fissured.

Soil cover, wherever present, is of black cotton variety. Soil thickness varies from place to place, and could be as much as 1 m in areas of cultivation. Soils near the foot of the hills are generally transported, while those on plain ground and agricultural land are residual. Black cotton soil is highly fertile. Soils are fine grained homogeneous. Barren land soils are mixed with rock fragments. Hill tops and all elevated areas are rocky; slopes are made up of exposed rock with rock debris and locally weathered material in pockets. The down hill slopes and adjoining gently sloping plain have boulders and pebbles mixed with soil. The valley floors have stony soils derived from surrounding elevated region.

Drainage : Drainage is mainly dendritic characterised by irregular branching of tributary streams in many directions and almost at acute angles.

Land use : Some of the plain ground is cultivated, irrigated locally by well water. Rest is barren and used as pastures. At some places stone quarries are observed. Vegetation occurs in patches, with a coverage of about 25-50% of the total pattern area. While bushes are seasonal flourishing only in rainy seasons. Grass gets dried immediately after monsoon. Cactus, Babul, Ber, Nim etc. are the common trees scattered in patches or isolated all over the pattern.

Airphoto Interpretation Aids :

High undulating terrain shows different tones for various features like hill, hillslope, river, wasteland, agricultural land, etc. Drainage pattern is dendritic. Hill tops are seen to be circular, oval or elongated. The airphoto reveals the extent of the pattern to cover an area over 5-10 sq.km.

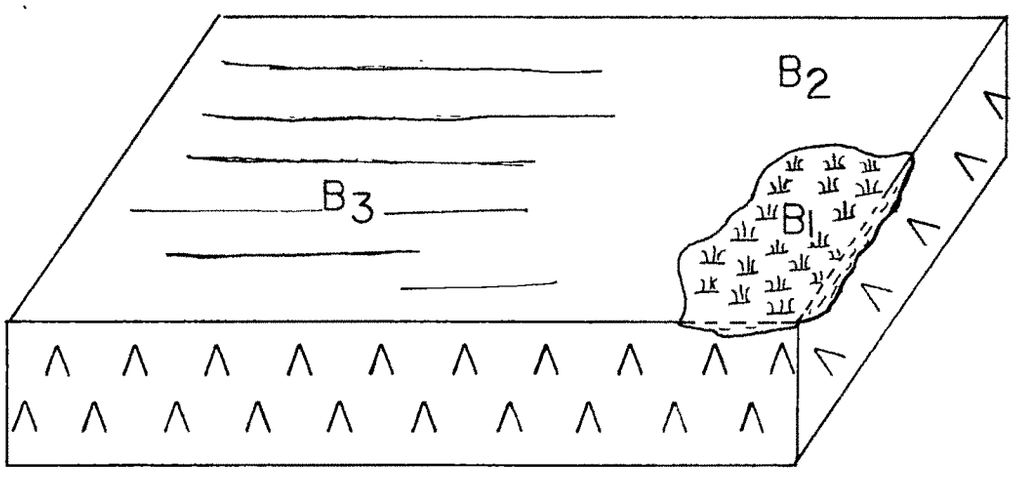
Comments and Reference :

Pattern is recognised on the Toposheet Nos. 41 J/2, J/3, F/15 and F/16.

In case of larger size pattern, the constituent facets also show larger dimensions, and are farther from one another with intervening agricultural land. The pattern is typical of the regions away from the coastline.

PATTERN B

NAME	:	Alluvial Plain
CLIMATIC REGION	:	Humid, Semi-arid
ANNUAL AVERAGE RAINFALL	:	200 to 300 mm
RAINFALL PERIOD	:	June to Sept.
TEMP.	:	Winter 13°C Summer 33°C
VEGETATION	:	Absent
ALTITUDE	:	Occurs near the sea level
GEOREF	:	Jamnagar district 41 F/3 F/4
DEFINED BY	:	Geology Dept. M.S. Uni. Baroda.
DATE	:	March/April, 1977
RELIEF	:	Nil. Pattern is almost at sea level
COUNTRY ROCK	:	Alluvium
PHYSIOGRAPHY	:	Plain
TECTONICS	:	-



Facets :

B_1 Marshy land

B_2 Plain barren land

B_3 Rann

Distinctive and Associated Features :

Morphology : Forms a nearly flat terrain almost at the sea level. The area is under the influence of tidal incursions and gets partially flooded during high tides. The Okha Rann is an important and extensive facet of this pattern. Locally, on the trappean mainland as well as on the limestones of Okha Mandal Block, these plains are also developed along the coastal areas. Ground water is very close to the surface and is saline.

Geology : The pattern is developed both on the Deccan Trap lava flows, and on limestones by deposition of mud and clay. The particle size of the deposited material varies between very fine sand to clay and mud. This material is brought partly by the sea and partly added from the surrounding area. Thickness of this soil cover is several metres in the centre. Soil is homogeneous light gray to dark gray coloured, some times mixed with country rock fragments.

Drainage : External drainage is absent in the main body of the pattern. Small tidal channels are however present near the low water line. Mostly, the soil being loose, considerable vertical percolation takes place.

Land use : Soil being saline and under the influence of sea water, is unsuitable for cultivation. Man made embankments 1-2 m high are used for trapping sea water for the production of salt. Dry surface is motorable for light vehicles only.

Vegetation : The pattern is devoid of any sort of vegetation.

Airphoto Interpretation Aids

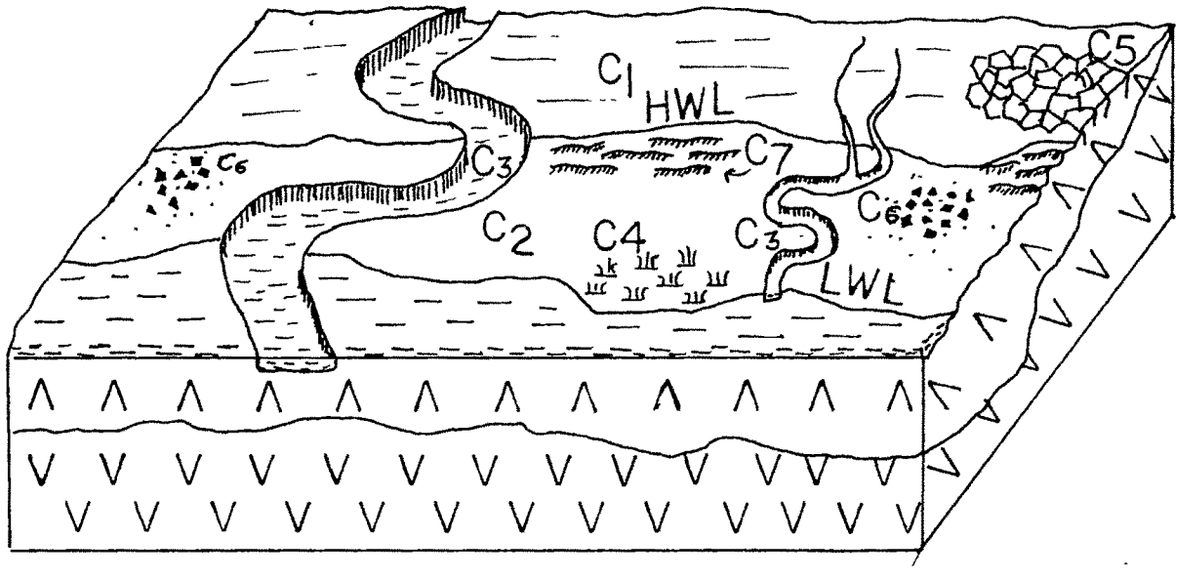
Mostly light gray tone (at places slightly dark gray); Almost flat topography devoid of vegetation and stream channels. No geomorphic features, characteristically more or less parallel drainage lines near low water line.

Comments and Reference :

There are great differences between this pattern and the other patterns, on account of the presence of wide extensive flat alluvial plain devoid of streams, marshes and absence of hills, lack of cultivation. Gets flooded during monsoon.

PATTERN C

NAME	: Muddy Shore	DEFINED BY	: Geology Dept. M.S. Uni. Baroda.
CLIMATIC REGION	: Humid, Semi arid	DATE	: April, 1977
ANNUAL RAINFALL	: 400-500 mm	RELIEF	: 3 to 4 m
RAINFALL PERIOD	: June to Sept.	COUNTRY ROCK	: Alluvium
TEMP.	: Winter 6° C. Summer 36° C.	PHYSIOGRAPHY	: Muddy plains dissected by shallow channels.
VEGETATION	: Sporadic evergreen patches of algae and mangrove.	TECTONICS	: Submerging coast
GEOREF	: Jamnagar District 41 J/2 41 F/14 41 F/15 41 F/11 41 F/7	ALTITUDE	: Low - level



Facets :

C_1 Backshore mud-flat

C_2 Foreshore mud-flat

C_3 Nars or tidal channels

C_4 Mud-flat with mangroves

C_5 Mud-flat with mud-cracks

C_6 Mud-flat with rock waste

C_7 Mud-flat with ripple marks.

Distinctive and Associated Features :

Morphology : Gently undulating plain dissected by tidal channels, creeks, estuaries and lagoons. Ripple marks are present in channel beds. The thickness of mud varies from a few cm to almost 20 m. Areal extent is very large, the width vary between 500 m to 10 km and length more than 100 km extending from Jamnagar to the northern tip of the Okha Rann. Channels are meandering and branching landward side. Depth of channels is between 1-2 m with almost vertical banks occasionally from 7 to 10 m (for example Bedi Bandar creek).

Geology : The coastline is formed by the deposition of Sub-Recent to Recent muds and clays on Deccan Trap. The mud is fine-grained, homogeneous, dark gray coloured,

sometimes mixed with rock fragments and sand particles. The mud and clay are brought from the land as well as from the offshore zone. The coastline typically shows a variety of depositional features.

Drainage : The drainage is of dendritic type; irregular branching of tributary streams in several directions and almost at acute angles. Branching is on landward side. Drainage channels always remain under the influence of tidal water.

Land use : Pattern is a wasteland. Being saline and under influence of sea water, it is neither cultivable nor trafficable.

Vegetation : Vegetation is patchy and dense, mainly consisting of mangroves. Patches are separated by open spaces and channels. Height of mangroves varies between 30 to 40 cm. Their concentration is mainly in the tidal zone. Areal extent of these mangrove patches varies from 10 sq.m. to more than 5 sq.km.

Airphoto Interpretation Aids

The pattern shows a smooth, plain medium to dark gray tone. The tree like appearence of dentritic drainage pattern is characteristically recognised. Channels have

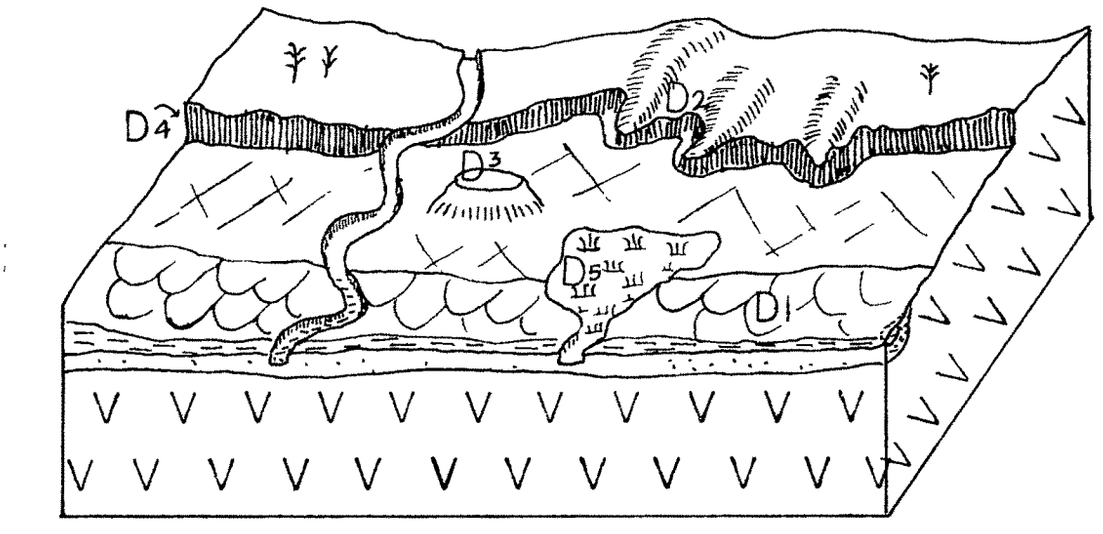
their courses meandering; vegetation patches give dark gray tone. Surface dried clays give light gray tone. The pattern is bounded by higher land on one side and the sea water on other side.

Comments and Reference :

The pattern is typical of the coastline where the shore is muddy. The dendritic sinuous drainage is a characteristic feature.

PATTERN D

NAME	:	Trap coastline	DEFINED BY	:	Geology Dept. M.S. Uni. Baroda.
CLIMATIC REGION	:	Humid, Semi arid	DATE	:	March/April, 1977
ANNUAL RAINFALL	:	400-500 mm	RELIEF	:	10 to 12 m.
RAINFALL PERIOD	:	June to Sept.	COUNTRY ROCK	:	Deccan Trap
TEMP.	:	Winter 6° C. Summer 36° C.	PHYSIOGRAPHY	:	Sea-level to 10 m. height
VEGETATION	:	Algae, grasses, shurbs and trees	TECTONICS	:	-
GEOREF	:	Jamnagar District 41 F/15	ALTITUDE	:	Less than 30 m; lowland plain



Facets :

D_1 Rocky foreshore

D_2 Broken ground

D_3 Small mounds

D_4 Coastal cliffs

D_5 Water estuaries

Distinctive and Associated Features :

Morphology : The irregular coastal cliffs varying in heights are present in the backshore zone. At places, these cliffs are steeply sloping. Some scattered elevated features called coastal mounds are present sporadically. Their areal extent varies between few sq.m. to some tens of sq.m. The cliff surfaces face the sea. Because of stream and channel cutting, the face is turned landward sides. Absence of vegetation and soil is the characteristic feature of the pattern.

Geology : The pattern is developed on basaltic lava flows, the rock being fine grained, jointed and fractured. Surface is partly weathered. Weathering is both mechanical and chemical, the soil cover being of residual type. Near the foot of the cliffs, collapsed debris is accumulated. The pattern comes under the influence of sea water under abnormal

tidal and current conditions. No drainage is seen. It is a waste-land with little vegetation, but the landward top surface may grow some grass and bushes during monsoon. The vertical cliffs are non-trafficable. The plain backshore is smooth, and when dry, is motorable. Coastal mounds being far away from each other do not provide any obstacle.

Associated Features : Most of the facets of this pattern landward side gradually merge with other facets, while they face the open sea on the other side.

Airphoto Interpretation Aids :

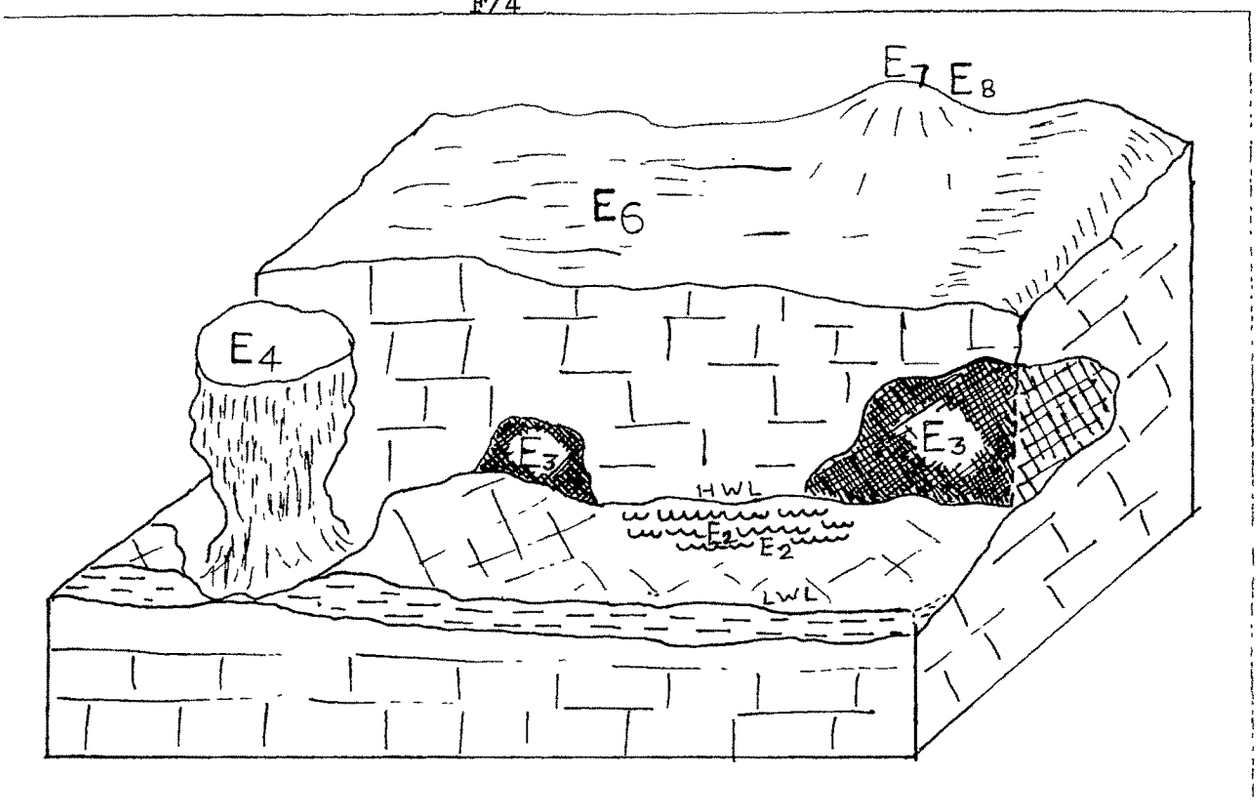
An elongated rocky cliff facing sea on one side and land on the other, demarcated by plain smooth clayey ground of light gray toned zone of beach and very light gray tone of wasteland with shrubs and rock waste on landward side. Total absence of drainage. Length varies between a few m to a few km.

Comments and Reference :

Presence of cliffs, absence of dendritic sinuous drainage, lack of mangrove vegetation are some of the diagnostic characters of this pattern in contrast to the muddy coastline.

PATTERN E

NAME	:	Limestone Coast	DEFINED BY	:	Geology Dept. M.S. Uni. Baroda
CLIMATE	:	Humid, Semi arid	DATE	:	March/April 1977
AVERAGE ANNUAL RAINFALL	:	200-300 mm	RELIEF	:	11 m
RAINFALL PERIOD	:	June to Sept.	COUNTRY ROCK	:	Limestone
TEMP.	:	Winter 12°C Summer 33°C	PHYSIOGRAPHY	:	Coastal plain and erosional features
VEGETATION	:	Sparse, open scrubs of cactus interspersed with Babul trees and bushes	TECTONICS	:	Uplifted terrain
			ALTITUDE	:	Low
GEOREF	:	Jamnagar District 41 B/15 41 B/16 41 F/3 F/4			



Facets :

E_1 Rocky foreshore

E_2 Karst foreshore

E_3 Wave-cut caves

E_4 Stacks

E_5 Island

E_6 Plain Barren land

E_7 Limestone hill top

E_8 Limestone hill slope.

Distinctive and Associated Features :

Morphology : The pattern comprises a coastal plain with coastal cliffs, wave-cut caves, stacks and broken ground. Topography is rugged with steep slopes, small mounds and depressions. The rock faces in the intertidal zone show a Karst topography. The heights of cliffs range between 2 to 11 m and the lengths from a few metres to a km or two. Karst surface is about 10 to 15 m wide and nearly a km long. At place, the foreshore rock is smooth and plain, gently to highly inclined.

Geology : The pattern is developed on Tertiary limestones of light brown to light gray colour. Fossils are very common. Surface is partly weathered, and shows extensive joints, horizontal, vertical and inclined.

Surface deposits : Surface is covered by a light coloured soil mixed with sand. The soils are transported as well as residual. The land is barren and covered with boulders and pebbles and scattered rock waste.

Vegetation : Vegetation comprises scattered patches of cactus with small Babul trees and bushes. Grass appears only during monsoon, which dries up in summer. This vegetation is mainly on landward surface of the coast.

Drainage : Being very near the coast, no prominent drainage channels are developed. Water-flow is mainly along the entire surface.

Land use : It is a waste-land.

Airphoto Interpretation Aids :

The rugged topography is recognised by different shades in light gray tone. Various features are distinctly marked. Agricultural land shows a bit darker tone than waste land.

Comments and Reference :

Being a limestone area, surface is highly rugged. Surface drainage is absent. Non trafficable either for men or for vehicles.

PATTERN F

NAME : Sandy Coastline

CLIMATE : Humid, Semi-arid

AVERAGE ANNUAL RAINFALL : 200-400 mm

RAINFALL PERIOD : June to Sept.

TEMP. : Winter 12°C
Summer 33°C

VEGETATION : Sparse, Open Scrub of Cactus intespered with Babul trees and bushes

GEOREF : Jamnagar District
41 F/3
41 B/15
41 B/16
41 F/4

DEFINED BY : Geology Dept. M.S. Uni. Baroda.

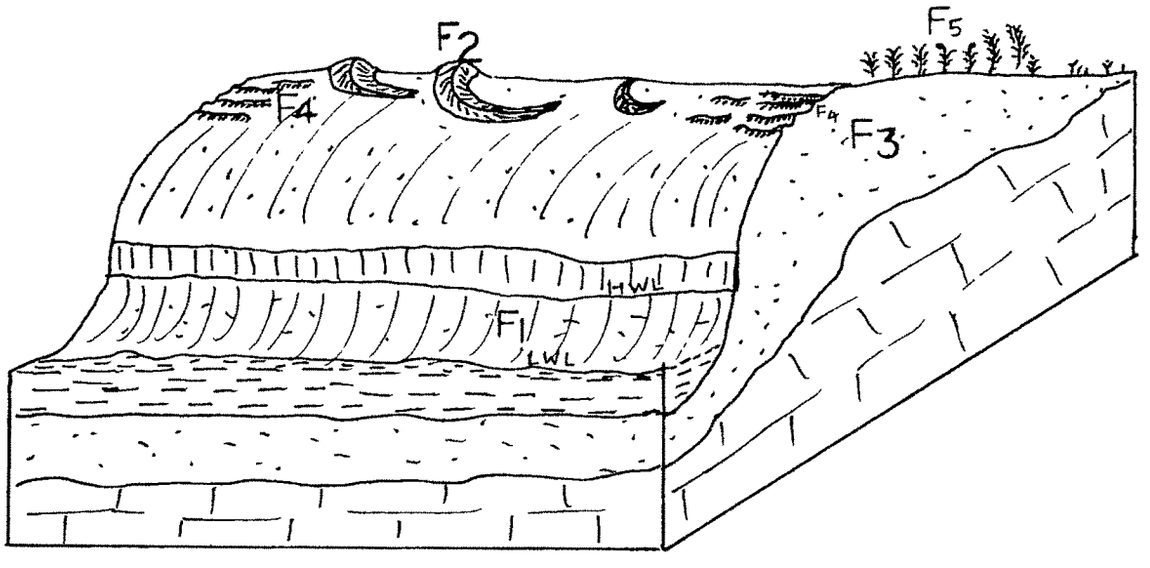
DATE : April, 1977

RELIEF : 7 to 11 m

COUNTRY ROCK: Limestone

PHYSIOGRAPHY : Coastal plain with depositional features

ALTITUDE : Low



Facets :

F_1 Sandy foreshore

F_2 Sand dune

F_3 Sandy ridge

F_4 Aeolian ripple marks

F_5 Vegetated sandy terrain

Distinctive and Associated Features :

Morphology : The pattern comprises a long ridge extending along the waterline. This ridge is dissected by creeks at a number of points. General surface is convex, seaward side sloping steeply and landward side sloping gently. The sand-spread extends landward side for about 100 or more m. Sand is loose, sometimes mixed with clay and shell fragments.

Geology : The sands are recent accumulations deposited by the combined activities of sea waves and wind. Sands are calcareous, derived from the limestone country rock on which it is present. The area remains dry during fair weather. Percolation of water takes place very easily i.e. it shows high porosity and permeability.

Vegetation : Small flowering plants grow on the surface during monsoon which dry out in the summer. Sometimes small bushes may grow on the surface.

Land use : It is a barren pattern which can't be cultivated. It is also a bit difficult to walk over, nor it is trafficable.

Airphoto Interpretation Aids :

The pattern shows a very light gray tone for sand extending along the shore line, whereas water and land show darker tones in comparison to the sandy ridge. The ridge is dissected by creeks of dark tone which form water estuaries.

Comments and Reference :

A white shining narrow wall like feature can easily be identified in the field. Its existence is exclusively along the coastline.