

PHYSICAL GEOLOGY OF GUJARAT *

V.N. Kulkarni

Sr. Geologist

Engineering Research Institute, P.W.D., Gujarat State

1. INTRODUCTION

The scenery of the earth surface today is the result of various geological processes working for millions of years. Physical geology is governed by the working of all the terrestrial agents and the effects brought about by them. Changes of all kinds have been going on continuously throughout the lifetime of the Earth-that is, for something like 4,500 million years.

Till over 100 million years back, the land-masses of India, Australia, South America, Antarctica, South Africa and Madagascar were together as established on the basis of fauna and flora, and were known as the Gondwanaland. During that period there was an arm of the sea extending from Rajasthan and Kutch into the Narmada Valley, the remnants of which seen today are the "Nal" lake covering an area of 130 sq. km between Saurashtra and Ahmedabad districts, and the Rann of Kutch.

Gujarat State spreads over an area of 1,87,091 sq. km; it is bounded in the west by the Arabian Sea and in the north by the Rann of Kutch and Rajasthan desert; to the NE and east its limits are marked by the Aravali ranges, and the hills of Vindhya. Satpura and Western Ghats extending upto Umbergaon and Dadra Nagar Haveli at the Southern tip.

Geology controls the features of the land-mass and is well marked by dividing Gujarat state physiographically into the following three distinct geographical units:

- (a) Main land Gujarat,
- (b) Peninsular Gujarat (the Saurashtra), and
- (c) Kutch.

2. MAINLAND GUJARAT

Mainland Gujarat extends from Umbergaon (Maharashtra border) in the south to Mt. Abu (Rajasthan) in the north, and from hill ranges with forests in the east to the Arabian Sea, Gulf of Cambay, Saurashtra and Rann in the west.

* A paper published in 'Navnirman' Special Issue by Irrigation, R & B Deptt., Gujarat State during July-December-1985 vol.xxvi-No.2

Physiography

Physiographically, the Mainland Gujarat comprises a vast alluvial plain covering nearly 83,528 sq. km with a hilly terrain in the east. This alluvial plain is mainly formed by the rivers Indus, Sabarmati, Mahi, Narmada and Tapi. During historic times, the river Indus discharged its waters at first into the Gulf of Cambay and then into the Rann of Kutch. The Saraswati (the Kamna) and the Sutluj too at a time flowed independently of the Indus to the sea, i.e., the Rann of Kutch. The alluvial plain stretches northwards for over 400 km, and merges into the Rann of Kutch and the desert of Rajasthan it widens northwards as much as 120 km, and very gradually rises above the sea level. The thickness of alluvium is maximum near Cambay; the oil-wells have established the thickness of alluvium as 100 m near Ankleshwar, 700 m near Cambay and 400 m near Kalol. The basement of Tertiary rocks in the Central and South Gujarat is Deccan trap which is at a depth of 1792 m at Kim, 2040 m at Cambay, 3040 m at Sanand, and in the Kalol area of Mehsana district, it is not touched up to 3029 m.

The Aravali range enters Gujarat near Abu and after zigzagging all along the northeastern and eastern part of the State upto Shivrajpur merges into Vindhya hills. The Aravali owes its origin to an uplift in the Earth's crust and is thus a "Tectonic mountain". The ranges are with steep slopes and without any plateau at the top. They are mainly composed of Quartzites, phyllites, schists, calc-gneisses, granites, etc. These hill-range follow flexures of fold. In the Palanpur-Danta-Idar area, the Aravali range is broken into long and narrow hills. In Mehsana, the hills are known as Taranga Hills; on one of the peaks, there are beautiful Jain Temples.

The Vindhya range gains in height east of Chhota Udepur. The Amba Dungar near Chhota Udepur came into limelight recently because of the occurrence of fluorite-an important economic mineral. Fluorite is used as flux in steel plants in optical industry, for the manufacture of acid, in atomic plants, etc. The Satpura hills are separated from Vindhya hills by the Narmada river flowing majestically through them. The Rajpipla hills, the western-most spurs of the Satpura mountains lie to the south of the Narmada river and form a watershed between Narmada and Tapi basins. Both these hills are of the "relict" type formed by circumdenudation; those are not mountains in the true sense, but are mere outstanding portions of the old plateau of the Peninsula that have escaped weathering of ages that has cut out "tors" or blocks of the old plateau. The main rock types in these hills are quartzite and traps.

In Panchmahals, the Shivrajpur hills are rich in minerals, particularly manganese. The most conspicuous hill in the area is "Pavagadh" rising above the plain to 823 m above m.s.l. Geologically this hill is interesting because it is composed of rocks ranging from acidic to basic by the magmatic differentiation; this is uncommon in the trap area. Phenai Mata is another hill in this area giving varieties of trap rock.

Across the Tapi lie the ranges of Sahyadri, the Western Ghats, which also are of 'relict' type. Among the hilly tract of Gujarat, the Sahyadri receives higher rainfall, and thus many rivers rise on its western slopes, which are covered with dense forests, like the one of Dangers; these areas are known for their scenic beauty. Many hills in the Narmada and Tapi valley are unlike the trap hills with a step-like scenery; these have hog-back shaped features as those are composed of large dykes intruded into the traps.

Drainage

The rivers of the mainland originate in north-eastern and eastern highlands are after flowing southwesterly and westerly empty either in the Arabian Sea, Gulf of Cambay or disappear in the Rann of Kutch.

In the north, river Banasa which rises in the Sirohi hills of Rajasthan flows south-west and is lost eventually in the Rann of Kutch; its major tributary is Sipu that joins near Deesa. A dam has already been constructed across the Banas near Dantiwada for harnessing the river. The Saraswati, a sacred river-flows past Sidhpur and Patan and disappears in the Rann, Sabarmati rising in the Udepur hills flows southwards draining into Gulf of Cambay; its tributaries are Khari, Meshwa, Hathmati, Harnav, Majham and Watrak. The construction work on Sabarmati dam is now begun, while dams have been built across Meshwa and Hathmati. Mahi rising in the Malwa Plateau in Madhya Pradesh forms the eastern border of Kaira district, and discharges itself into the Gulf of Cambay; its main tributaries are Shedhi and Panam. The construction of dams across Mahi as well as on Panam river is in progress. The Dhadhar river joints the sea further south of the Gulf, Narmada and Tapi rising in the hilly region of the Madhya Pradesh flow due west, draining into the Gulf of Cambay. Their courses follow rift valleys, as can be seen from their unusual straight course. The Narmada, which should prove to be boon to mankind, has remained unharnessed because of the dispute about sharing of its waters. The reservoir formed by the Ukai dam is now full; the gates are yet to be installed. The rivers Orsang, Karjan etc., are the tributaries of Narmada river. The areas on the banks of Narmada, Mahi and Sabarmati in the lower reaches are cut up into deep ravines (locally known as kotars).

South of Tapi, there are westerly flowing rivers like Purna, Ambica, Par, Kolak, Damnganga etc; these rise in Sahyadri ranges (the Western Ghats) and Join the Arabian sea. The weir on Damanganga river near Vapi is nearing completion and has already stored some water for the industrial complex nearby.

Rainfall

The annual average rainfall in the southernmost part of the Mainland, i.e., in Surat and Bulsar Districts varies from 1525 to 1780 mm; in Dangs District it is as high as 2550 mm.

In Baroda, Broach and Panchmahals Districts the variation of rainfall is from 760 to 1525 mm. In Ahmedabad, Mehsana, Sabarkantha and Banaskantha districts, it is between 510 and 760 mm in a year.

3. PENINSULAR GUJARAT

Saurashtra (earlier known as Kathiawar), the Peninsular Gujarat, is bounded on three sides by waters of sea, viz. In the north by the Gulf of Kutch with some part by the Little Rann, in the west and south by the Arabian Sea, and in the Southeast by the Gulf of Cambay; while in the east is the alluvial tract of the Mainland of Gujarat. The area covered by Saurashtra is 59,360 sq. km.

Physiography

Saurashtra has a characteristic physiography. The geological characteristic is indicative of cone and crater type of origin of a number of hills. Geologically, those are very much interesting on account of formation of a series of different rock types from one lava mass due to magmatic differentiation. The central highland with the Girnar hill is very prominent. It is believed that the basaltic flows of this area were domed up by later intrusive. The domed up portion of the flows has been eroded away in the centre, exposing an intrusive mass of diorite-monzonite below. The highest peak in this area is Guru Goraknath 1117 m, above m.s.l. while other peaks are Dattatraya and Ambaji. The hills are more elevated in the south and west, while in the north and east they are low. Along with its group of hills, it covers about 166 sq. km area. Most of the rivers in Saurashtra rise from this central tableland. The terrain very gently slopes outwards, i.e. towards, coastal plains. Thus, drainage in this region is typically radial.

The Gir range is the Southeast extension of Girnar, and trends almost east-west, it bears a good forest with famous wild life; Gir is the home of lions.

Near Palitana is the Shetrunjaya Mountain (498 m) which is a sacred shrine of Jains. The Chamardi-Chogat hill mass is roughly of the same dimensions as Girnar and shows some differentiated rock types. The hills of Talaja Lor and San are known for Buddhist caves. In central Saurashtra, there is a group of hills, the highest one being near Sanosra. Chotila, another hill here, rises 357m above MSL. The miliolite limestone at the top of this hill indicates that in recent times, the sea level was higher than this hill and the coast was further east.

Low knolls, elongated mounds or serrated ridges attaining heights of about 75 to 80 m above the ground level are formed on account of intruded basic dykes cutting radially through traps from the centre of eruption.

Drainage

Saurashtra has a typical radial drainage system on account of its configuration. The northerly flowing important rivers draining into the little Rann are Aji near Rajkot, Machhu near Wankaner, Morvi and Malia, Bambhan and Phulka near Dhrangadhra. The other small rivers joining Gulf of Kutch are Und, Dhrol, Rangmati, Sasoi, Phulzer and Ghi.

The river Bhadar in the Southwestern parts passes near Jipur, Kutiyana and joins the sea near Navibandar. Other rivers are Bhogat, Wartu, Ozat, Maduvanti, Megal, Hiran, Saraswati and Shingoda.

Among easterly flowing rivers, there are two Bhogawo rivers (one passing Near by Muli and Wadhwan, and the other nearby Limdi), Sukhbhadar near Ranpur and Dhandhuka, Kalubhar near Umralla and Shetrunji near Amreli, Balitana. Talaja join the Gulf of Cambay. Goma, the tributary of Sukhbhadar joins it near Ranpur. Southeasterly or southerly flowing small rivers are Malan near Mahuva, Rawal, Machhundri and Dhatarwadi near Rajula.

Rainfall

The average annual rainfall is 510 to 760 mm; however, in the central party around Junagadh, it is as much as 1300 mm.

4. KUTCH

The region of Kutch in the north-eastern part of Gujarat State forms an independent geographical and geological unit. It has an international border in the north with Pakistan, making it strategically important. The area covered by Kutch is 44,203 sq km.

Kutch is rich in its mineral wealth like bauxite, gypsum, agate, limestones etc. What is required is fresh water supply for the development of this region.

Physiography

The Kutch region itself comprise of two physiographical units:

- (1) Mainland Kutch
- (2) The Rann

The mainland of Kutch is an isolated and detached crescent shaped land- mass bounded by the Great Rann in the north, while in the east and south-east by the little Rann. In its south lies the Gulf of Kutch, and to the south west and west is the Arabian Sea. The Central portion of Kutch forms a table land sloping on all sides; the shape of the region is like a turtle, and thus the name Kutch is derived. The landmass is broadly made up of three east-west hill ranges; the narrow and

more lofty range on the north is known as Chorar. It is a broken hill forming islands in the Rann like Pachham, Khadir and Bela and constitutes hills like Rajpara Makki, Bhanjara, Dhola, Vilva etc. One of its hills, Kala Parvat (Black mountain) is 315 m high, while Dinodhar hill north-north-east of Nakhatrana is 377 m high. The central ridge trending ESE-WNW from Lakhpat comprises hills like Jogika Bhiru, Kira, Jhara, Halai and Kaisan.

The southern range begins at Madh on the west and extends up to Raha with hills like Dhabwa, Madvalki etc. The strip of land lying between the Rann and the mainland is known as Banni area. It is formed by the sediments deposited by northerly flowing rivers and is composed of good soil.

The trend of hill ranges in the east-west direction with steep slopes in the north and gentle slopes south owe their origin to faults running in the east-west direction.

The Rann is a dry bed of the remnant of the sea, which earlier connected the Narmada rift with Sind, and separated. Kutch from the mainland. During historic past, the Indus and Saraswati of Vedic times flowed into the sea here. It is now a saline desert for the greater part of the year, and marshy during the monsoon, when a vast sheet of water inundate it. When dry, the surface is covered by a layer of salt and shingle. The rann consists of fine silt and clays. It does not support any vegetation except in a few small raised areas where some fresh water is available.

The central strip in the east-west direction consisting of Bhuj sandstones has formed a good reservoir of ground water under hydrostatic pressure. Over 150 tube-wells have been drilled turning this area green.

Drainage

There are numerous small rivers in the Kutch region. Those flowing north disappear in the Rann. While the remaining Join either the sea or the Gulf of Kutch. Some of the main rivers are Khari, Kaila, Niruna, Nara, Matiweriwali, Rukmavati, Kankavati, Bhukhi, etc. There are dams across Khari, Kaila, Niruna etc. and the other rivers are also prepared to be harnessed by having storage schemes to tide over scarcity conditions affecting this region quite frequently.

Rainfall

Kutch has a dry and hot climate. The monsoon is very irregular and the annual rainfall varies from a few mm to 900mm the average being 400 mm. However, it was 1150 mm in 1967, which was an exception.

The distribution of rainfall is very erratic. The scanty rainfall is a regular feature of this region.

5. EARTHQUAKES

The Kutch area in the State falls in the seismic zone and is often subjected to earthquake. The most disastrous earthquake took place on 16th June, 1819 at 6-45 p.m. Bhuj, the district town was damaged severely, killing 2,000 people. The recent earthquake in Kutch was at Anjar on 21st July, 1956 at 3.32 p.m. and its magnitude was 7.

Recently there was an earthquake near Broach on 23rd March 1970 at 7-21 a.m. The magnitude on Richter scale was 5.7 and maximum intensity was VII on M. M. Scale.

In the Indian Peninsula, the frequency of strong earthquakes is small. Strong shocks in the Peninsula occur once every twenty years on an average. The next earthquake will normally be in the new areas. At the same place, strong earthquakes usually recur in the Peninsula after many hundreds of years.

6. ACKNOWLEDGEMENTS

1. I offer my sincere thanks to Shri B.C.Shah, Director, Engineering Research Institute, Baroda, for constant encouragement and useful suggestions in the preparation of this article.

