CHAPTER - II

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B A C K G R O U N D I N F O R M A T I O N

OUTLINE OF GEOLOGY AND GEOMORPHOLOGY OF GUJARAT

On the basis of geology and geomorphology, Gujarat is divisible into following three main units :

i) The Mainland Gujarat
ii) The Saurashtra peninsula, and
iii) The Kutch

The Mainland Gujarat extends from Ambaji in the north to Umbargaon in the south and comprises rocks ranging from Precambrian banded gneissic complex to Recent deposits. This unit forms mostly an alluvial basin and is bounded by estuarine tracts of Tapi and Narmada in the south and extends for abouut 400 km northwards merging into the desertic plains of Rajasthan and Rann of Kutch. The width is about 120 km. The eastern border is bounded by Aravalli, Vindhya, Satpura and Sahyadri hill ranges. The eastern part of S. Gujarat, bordering the alluvial tract mostly forms a typical Deccan Trap topography. The patchy exposures of sedimentaries of Bagh and Lameta, to the north of

Narmada, form a tableland with low hills. The drainage is mainly south westerly to westerly, which is evidenced by the flow of rivers like Tapi, Narmada, Mahi, Sabarmati etc. The Saurashtra peninsula is bound on three sides by sea except in the northeast, where it is flanked by the alluvial plains of the Mainland Gujarat; its rocks range from Juro-Cretaceous (sedimentary and volcanic) to Recent coastal deposits. The central part of the region forms an elevated trappean tableland from where most of the rivers rise and flow radially. The terrain generally slopes gently towards the coast in the N,W,S, and SE, and also merges with the alluvial tracts of N Gujarat in the E and NE. The Kutch region forms the northwestern part of the Gujarat state; its northern limit is marked by the international border with Pakistan. To the south and west of Kutch lies the Arabian sea while in the east it is bounded by the Rann of Kutch. The rocks of Kutch show a fairly wide geological range. Over a Precambrian basement rests a striking and almost unbroken Mesozoic (Jurassic-Cretaceous) and Cenozoic (Tertiary-Quaternary) sedimentary sequence. Its central part forms a tableland sloping on all sides. There are several E-W trending hill ranges; north flowing rivers disappear in the Ranns while other join the sea to W and S. The Rann of Kutch is a dry bed of the remnant of an arm of the sea which formerly connected the Narmada rift with Sindh and separated Kutch and Saurashtra from the Mainland. In the historic past, Indus and Saraswati were flowing into the sea here. It is now a saline desert for the greater part of the year and marshy during the monsoon. The Rann is divided into two, viz; Great

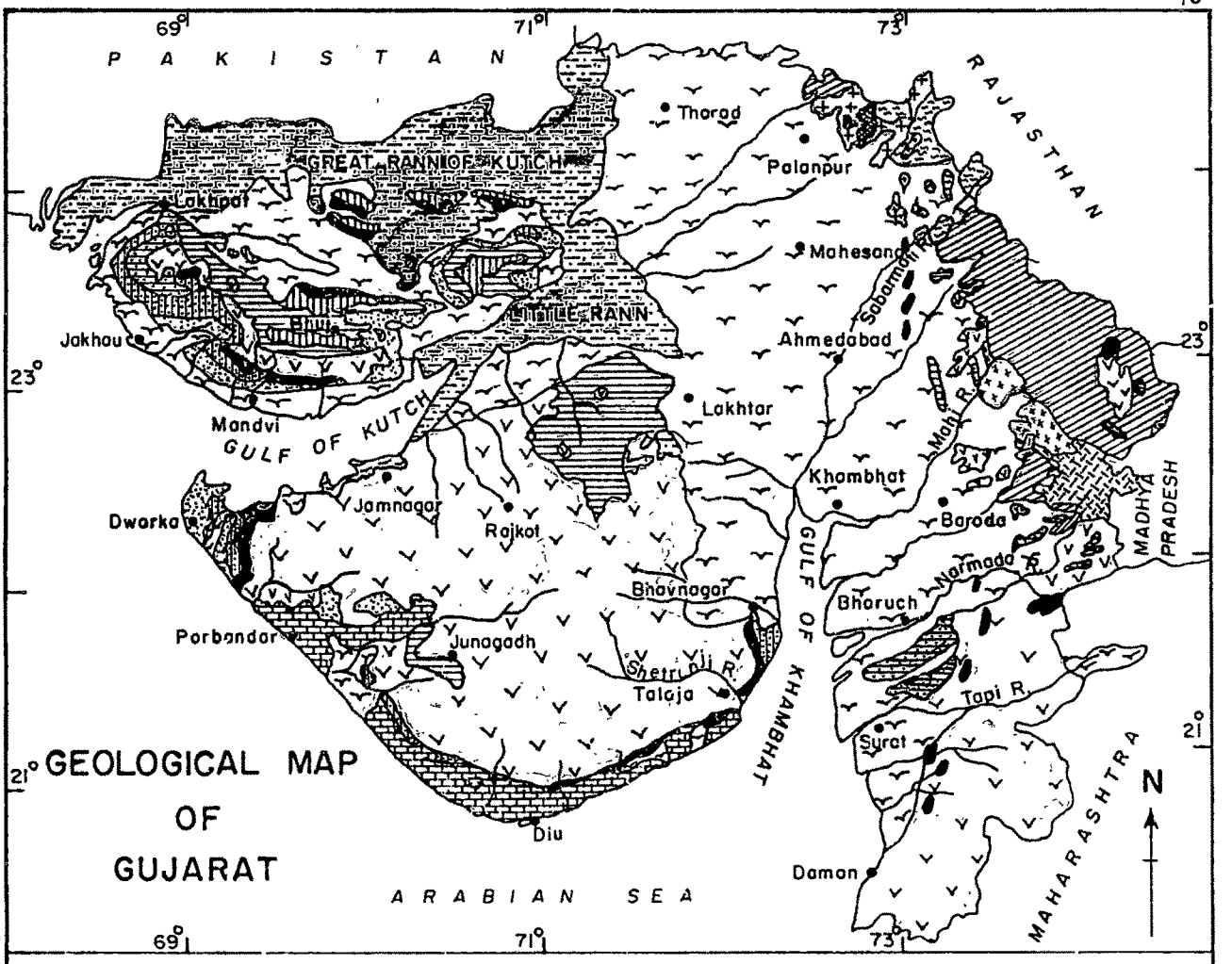
Rann and Little Rann. During late Quaternary, the Gulf of Cambay and the Rann of Kutch were connected by a shallow sea.

Within a relatively small areal extent comprising the state of Gujarat, its three main constituent units show considerable geological and structural diversity, pointing to evolutionary histories for each unit, quite distinct from one another. The details of the various geological formations occurring in the three geomorphic units (Fig. II .1) are summarized in the accompanying table (Table II .1).

TECTONIC FRAMEWORK

The three geomorphic-geologic units are obviously the reflections of the regional structural and tectonic framework. All throughout the Mesozoic and Cenozoic, crustal tectonics of the western continental margin have caused subsidences, uplifts, tilting of blocks, and these were affected by marine transgressions and regressions. Diastrophic movements along a few major lineaments have acted differently in the three units thereby giving rise to quite distinct geological and geomorphic features for each of them (Biswas,1987).

Tectonically too, the area of Gujarat is complex, wherein various forms of positive and negative structures have originated all throughout its protracted geological history. The northeastern part of Gujarat exhibits Precambrian, Delhi and Aravalli foldings. Tectonically controlled ridges and depressions



LEGEND

Rann Soil (Salt Encrusted)	Recent & Sub Recent	Deccan Trap	Cretaceo-Eocene (Effusive Rocks)
Alluvium & Blown Sands		Bagh Beds Lameta Beds Wadhawan Sandstone	Cretaceous
Miliolite	Pleistocene	Himatnagar Sandstone Nimar Sandstone Umia & Bhuj Beds Dhrangadra Sandstone	
Laterite	Tertiary	Katrol Series Chori Series Patcham Series	Jurassic
Dwarka Manchhar Beds			
Gaj Series			
Kirthar-Laki Beds			

Basic Intrusives	Pre-Cambrian
Acid Intrusives	
Delhi System	
Aravalli System	
Granites And Gneisses	

0 40 80 Km.

Fig: II.1

GEOCHRONOLOGIC UNIT		MAINLAND GUJARAT		SAURASHTRA		KUTCH	
PERIOD	EPOCH	FORMATION	LITHOLOGY	FORMATION	LITHOLOGY	FORMATION	LITHOLOGY
QUATERNARY	HOLOCENE	ALLUVIUM	Neo alluvium, Mudflats, Beaches Dune sands & Soils	ALLUVIUM	Alluvium, Mudflats, Beaches and Dune sands soils	ALLUVIUM	Alluvium Sands and Clay Soils rannclays etc.
	PLEISTOCENE	OLDER ALLUVIUM & LATERITIC ROCKS	Sands & Clays, Alluvium, Laterites	AGATE, CONG AND SANDSTONE MILIOLITE	Agate, Conglomerate and associated Sandstones, Calcarenite, Calc-Rudite with intercalation of Clays	MILIOLITE FORMATION	Clay Arenite and Oomicrites
TERTIARY	PLIOCENE			DWARKA FORMATION	Silty clays, Gypsious, Calcareous clays & Marls, Arenaceous - limestone, Fossiliferous conglomerates	KANKAWATI SERIES	Sandstones Fossiliferous Calc Grits and Conglomerates with Shales
		JAGADIA FORMATION	Calcareous and Micaceous Sandstones and Sands	PIRAM BEDS	Grits and Sandyclays, Sandstone and Conglomerates		
	MIOCENE	KHAND FORMATION	Limestones and Ferruginous Agate, Conglomerates	GAJ FORMATION	Fossiliferous Grits, Gypseous clays with Thin bands of Limestone	KHARI SERIES	Gray clay with Fossiliferous marl variated Siltstones
		TARKESWAR FORMATION	Silty clays with lenses of Laterites				
	OLIGOCENE					BERMOTI SERIES	Silty shale Marl Sands Limestones Calc clays Shales
	EOCENE	NUMMULITE FORMATION	Ferruginous clays & Limestone with Bentonitic bands			BERWALI SERIES	Limestones Clays Laterites Lignite and Black shale
		VAGAD-KHOL FORMATION	Trap wash, Ferruginos sandstone	LATERITIC ROCKS	Red brown Laterites, Bauxite, Tuffacious material	MAD SERIES	Laterites Tuffacious shales Bentonitic clays Volcanic ashes
	PALEOCENE	DECCAN TRAP	Basalts with all alkaline varieties & Dykes	DECCAN TRAP	Basalts, Plutonic masses and Dykes, Thin Intertrappean bands	DECCAN TRAP	Massive basalts & Amygdaloidal basalts with inter trappean beds
CRETACEOUS		INFRATRAPPEAN LAMETA BEDS	Sandstone	WADHWAN SANDSTONE	Sandstones with Intercalation of clays		
		BAGH BEDS	Limestones & Sandstones				
		HIMATNAGAR SANDSTONE	Sandstones	DHRANGADHRA FORMATION	Sandstone, Grits, Carbonaceous Shales with Coal & Plant remains	BHUJ FORMATION	Sandstones Conglomerates and Shales
JURASSIC						JHURAN F.M	Sandstones and Shales
						JUMARA F.M.	Shales and Limestones with Oolitic bands
						JHURIO F.M	Limestones
PRE-CAMBRIAN		ERINPURA GRANITE	Ultra basic, Basic and Acidic intrusives				
		DELHI SYSTEM	Quartzites, Phyllites and Schists				
ARCHEAN		CHAMPANER SERIES (ARAVALLI SYSTEM)	Granites, Phyllites, Schists Dolomites, Quartzites				
		BANDED GNEISSIC COMPLEX	Granitic gneisses and Mica schists				

(Compiled after Krishnan, 1968; Shrivastava, 1968; Biswas, 1971)

TABLE : II.1 GENERALISED STRATIGRAPHIC SUCCESSION OF GUJARAT

are seen in the Kutch and Banni areas, which provide a good instance of Mesozoic upheavals. Saurashtra encompasses a large part of western Gujarat and is seen bounded by major fractures. The North-South trending Cambay graben is located in the central part. A principal deep seated geofracture is indicated along the trend of the Narmada river extending WSW, cutting across the Mainland and extending along the southern margin of Saurashtra through the Gulf of Cambay. Various major and minor faults are also indicated trending ENE-WSW up to Surat and beyond.

According to ONGC work (Biswas, 1987), the older structural trends which cut across the centrally located Cambay graben are of mainly Delhi folding. The younger tectonic lineaments of Broach Surat area consist of WSW structural trends of Narmada Tectonic Belt (Fig. II.2). These older and younger structural trends cut across the Gujarat area, and have given a varied look to the structure and tectonics, and have generated interesting geomorphological expressions that reveal evidence of neotectonic activities involving Quaternary sediments.

DECCAN TRAP

As the laterites in Gujarat are derived from the underlying basalts of the Deccan Trap which constitute a major rock formations of Gujarat, it is appropriate to highlight the salient features of this formation by way of providing a suitable background. These trappean rocks comprise horizontal lava flows and cover large portions of Saurashtra and South Gujarat. In

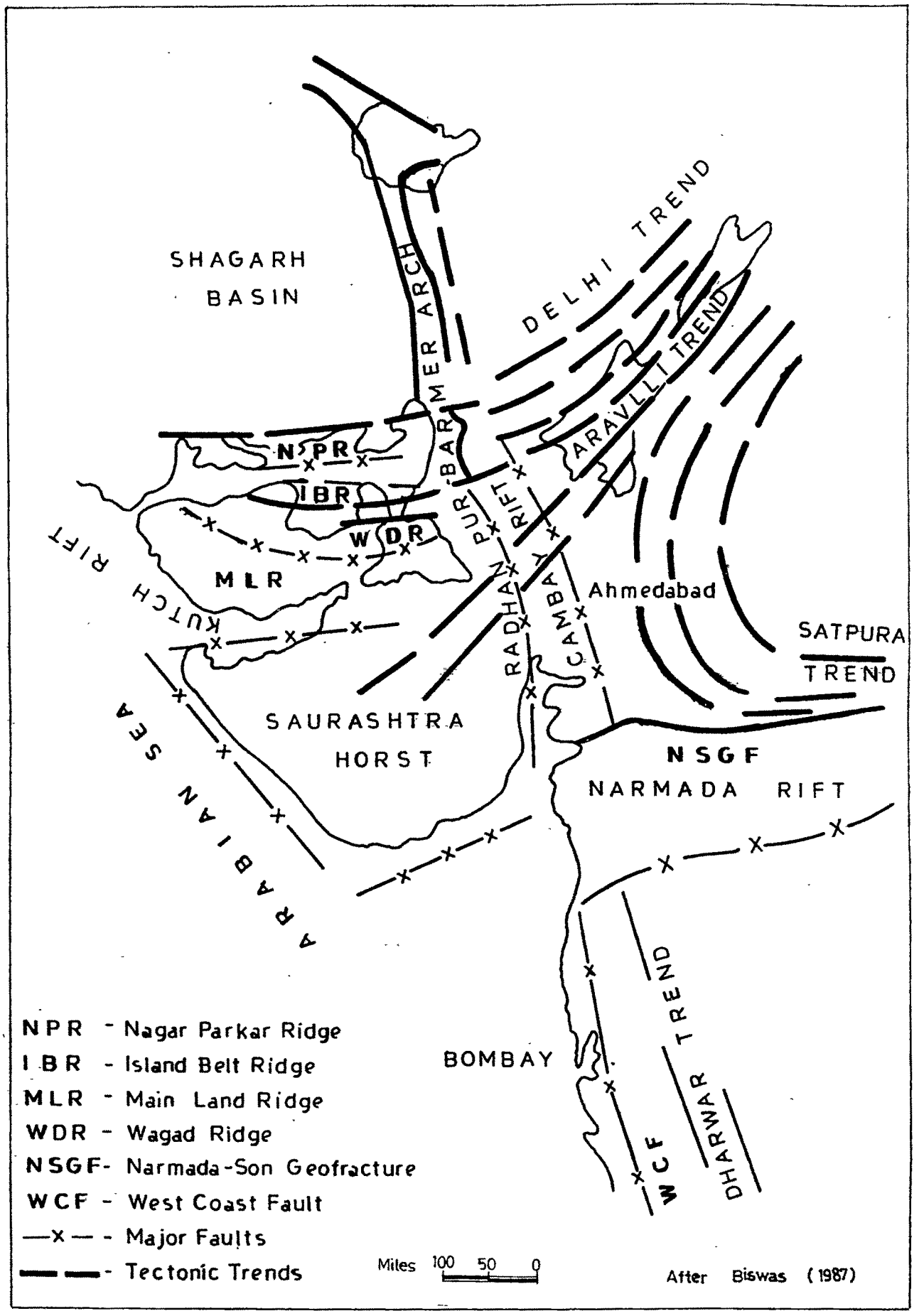


Fig: II.2. PERICRATONIC RIFT BASINS WITH MAJOR STRUCTURAL LINEAMENTS

central Gujarat, they occur in sub-surface. They are compound flows and each flow unit consists of different subflows. Due to variation in the hardness of the different flows, the traps show flat-topped hills. The traps attain their maximum elevation near the border of Gujarat and Maharashtra. Here they show escarpments of about 1200 m height. Lava-flows comprise dark grey basalts of several varieties, quite often amygdaloidal and/or porphyritic. The trappean rocks are highly jointed showing several sets, mainly ENE-WSW to E-W and NNE-SSW to N-S directions. Intrusive dykes within the basalts are quite common, and show ENE-WSW, N-S and NW-SE trends (Blanford, 1869; Krishnamacharlu, 1972; Krishnan, 1982). Recently on the basis of the morphotectonic analysis of the South Gujarat Trappean landscape, Alavi (1990) has highlighted the role of uplifts and subsidences along these pre-existing fractures.

DSS studies carried out by Kaila et al. (1981,1988) have shown that the maximum basalt thickness is around 1.1 km. in the Ankleshwar region, of South Gujarat.

The entire Deccan Trap thickness has been (Pascoe, 1964; Krishnan, 1982) classified into Upper,Middle and Lower as under :

Upper traps (450 m thick)	----------	Maharashtra and Gujarat; with numerous inter-trappean beds and layer of volcanic ash.
Middle traps	----------	Madhya Pradesh (Malwa); with numerous ash beds in the upper portion and practically devoid of inter-trappeans.
Lower traps	----------	Part of Madhya Pradesh and Andhra Pradesh with inter-trappean beds,but rare ash beds.

The more recent work on the Deccan flood basalts is presented by Subbarao (1988) in Memoir 10 of the Geological Society of India. This author has summarised the various aspects related to the stratigraphy, structure, geochronology, palaeomagnetism, mineralogy and petrology of these basalts, and a map compiled by him and Hooper (Subbarao and Hooper, 1988) shows following classification of the Deccan basalt group.

Group	Sub-Group	Formations	
DECCAN BASALT	Wai	Desur	
		Panhala	
		Mahabaleshwar	
		Ambenali	
		Poladpur	
	Lonavala	Bushe	
		Khandala	
	Kalsubai	Bhimashankar	} Upper
		Thakurvadi	} Middle
		Neral	} Lower
		Igatpuri	
		Jawhar	

Although his trap does not include Gujarat basalts, but it is obvious that the trappean rocks of Gujarat comprise the lowermost portion correlatable with the Jawahar and Igatpuri Formations.

The trap weathers with a characteristic spheroidal exfoliation which gives rise to large rounded boulders on the outcrops. Another product of chemical weathering is laterite.

LATERITE OCCURRENCES OF GUJARAT

Laterite rocks are widely distributed in Kutch, all the three units of Gujarat. Whereas these rocks associated with rich bauxite deposits are very well developed in Kutch and Saurashtra, thier occurrences on the Mainland are less impressive and have remained somewhat neglected.

Sahasrabudhe (1964, 1978) has given a good account of the various laterite occurrences of Gujarat, and the following summaries the details given by him.

Kutch laterite ~~peninsula~~, forms a 100 km long and 3 to 4 km wide strip along the southern flank of the peninsula overlying the basalts. The constituent rock is a porous, pitted clayey rock with red, yellow, brown, grey and mottled colours, depending in some measure or the composition. It varies somewhat in texture, but pseudo-brecciated, concretionary and conglomeratic appearance is most common. It often contains pieces of agates, chalcedony or quartz. The reddish to brown laterites, which are highly ferruginous, appear to be somewhat different than the fawn-grey laterites which exhibit a characteristic glossy sheen. The reddish varieties are earthy, soft and exhibit pockets of red and yellow ochres, while the fawn-grey laterites are generally hard, massive and bouldery in appearance. The laterites are about 3 to 4 m thick and gradually pass into clayey zones varying

from 2 to 10 m in thickness. The lithomargic clays exhibit conspicuous liesegang lines simulating current bedding in sedimentary rocks. The pseudo-brecciated concretionary appearances are believed to be relict textures of the original rocks presumably representing pyroclastic facies of Deccan lava flows. Considering the fact that the pyroclastics have been lateritised without any signs of lateritization in the overlying Eocene and succeeding Tertiary sediments, the laterite under consideration will have to be considered early Eocene in age.

In Saurashtra laterite forms almost a continuous zone between the Gaj beds and the underlying lava flows. The width of this zone is about six kilometres between Mewasa and Habari and is less than one kilometre near Rann, Harmatia and Lamba. It also forms several small patches along the coastal margins of Saurashtra between Bhavnagar and Amreli, Junagad and Jamnagar districts. These laterites fall into three distinct types, viz., (i) lavender-grey coloured and earthy, with clay patches; (ii) concretionary, nodular; and (iii) gritty with tuffaceous appearance, the bauxite deposits representing the last variety. The laterite, with average thickness rarely exceeding 7.5 m, appears to have been subjected to considerable denudation prior to the deposition of the Gaj beds. Wherever the denudation of the concretionary variety of laterite is complete, the underlying bauxite zone has exposed. In such cases there is no overburden of ferruginous laterite, the whole material being bauxite.

Mainland Gujarat laterites occur along a discontinuous zone running parallel to the 73 longitude for a length of 105 km and falling within the boundaries of the Sabarkantha, Kaira, Broach and Surat districts. Laterites occur along the western margins of the Deccan Trap forming small isolated humps near Harsol in Sabarkantha district, near Khanpur, Taiabpur, Kapadvanj, Mirapur, Dhanakpura, Salod, Kajipur and Dakor in the Kaira district, over a length of 50 km. Several exposures of laterite amidst soils are noticed over a total distance of 225 km between Narmada and Tapi rivers in the Broach and Surat districts. The laterite is a porous, pitted clayey rock with red, yellow, brown, fawn grey and mottled colours depending in some measure on the composition. The siliceous laterites are relatively hard, brittle and break with sub-conchoidal fractures. These laterites, as a whole, exhibit brecciated or concretionary structures. They are three to four metre thick and gradually merge down into two to ten metre thick clayey zones. A fairly extensive development of fine, plastic clays are noticed below the laterite cap near Valia, Vagalkhod, Bhivada, Dharoli, in the Bharuch district and Tadkeshwar, Munjlau, Ajrai and Pathri in the Surat district. They perhaps represent the bauxite deposits associated with sedimentary clays.