CHAPTER - IV

M O D E O F O C C U R R E N C E

GENERAL

LOCALITYWISE DESCRIPTION

NORTH GUJARAT

SOUTH GUJARAT

M O D E O F O C C U R R E N C E

GENERAL

Laterite occurrences of the Mainland Gujarat, when studied in isolation, do not reveal much, but the synthesized information collected at all the localities throws valuable light on the vexed question of the origin of laterite in general and of Mainland Gujarat in particular. On the basis of detailed field work and visits to the various reported and unreported occurrences, and a critical appraisal of bore hole data, the present author has been able to recognise almost all the horizons that are typical of a laterite sequence. He has observed that in all localities, the parent rock has been the Deccan basalts. For the purposes of description, he has followed the universally accepted terminology based on U.S. Soil Survey Staff (1960), Valeton (1972), Thomas (1974), McFarlane (1976), Aleva (1986). The integrated and idealised laterite profile valid for the Mainland Gujarat as worked out by him, is given in Table IV.1

Table IV.1 Integrated and Idealised Laterite Sequence in Mainland Gujarat

Soil	Latosol	
Laterite	Duricrust Unindurated Laterite Bauxitic Laterite Lateritic Bauxite Bauxite Lithomarge Mottled zone	Horizon rich in oxides (Box)
Saprolite	Kaolinite Bentonite Weathered Basalt	Horizon rich in silicate (B)
	Deccan Basalt	Parent rock (c)

The following diagnostic features of the various zones, based on colouration, field characters, chemical and mineralogical analyses, are given for the purpose of outcropwise description :

Saprolite zone : A generalised term saprolite, includes the zones of weathered basalt, bentonite and kaolinite. Together they comprise the zone of leaching.

Weathered basalt horizon: Subaerially altered portion generally forming the top of basalt. Somewhat soft and friable, it has still preserved various basaltic features and relicts of spheroidal weathering.

Bentonite horizon : A horizon rich in montmorillonite, generally white in colour. The constituent rock of the zone has large expansion capacity on absorbing water. This rapid change in volume is a peculiar characteristic of this horizon.

Kaolinite horizon : Comprising kaolinite mineral, this zone is pale coloured and rather sticky when wet. It differs from bentonite horizon in that, it does not expand with moisture.

Laterite zone : This zone marks the upper portion of the profile and includes oxidising horizon consisting of Mottled zone, Lithomarge, Bauxite, Lateritic Bauxite, Bauxitic Laterite, Unindurated Laterite, and Duricrust.

Mottled horizon : Horizon between saprolite and laterite, marking the transition from zone of leaching to that of precipitation. It is easily recognised in the field by a characteristic mottling - brownish Fe rich pisoliths embedded in a greyish mass, which is a mixture of kaolinite and aluminous materials.

Lithomarge : Overlying the mottled zone, it is dominantly a product of precipitation, consisting of light brown constituents which are mainly oxides of Fe; generally does not show any well-defined structure.

Bauxite horizon : This horizon typically represents the Aluminium - rich zone of precipitation. Brownish red to yellow in colour, it is quite hard and often shows pisolithic structure. The mineral identified is mostly gibbsite.

Lateritic bauxite horizon : A yellowish red horizon, its recognition in the field is somewhat difficult. Identified mainly on the basis of chemical and mineralogical data. The horizon is rich in gibbsite, boehmite, and halloysite, as compared to goethite, hematite, and maghemite.

Bauxitic laterite horizon : Pale brown in colour, this horizon is almost identical to the above zone in the field, with which it has a diffused boundary. It has been identified mostly on the basis of chemical and mineralogical

characters, the horizon being rich in goethite, hematite, and maghemite as compared to gibbsite, boehmite and halloysite.

Unindurated laterite horizon : Laterite horizon of brown colour and rich in Fe, which has not been exposed to subaerial processes. Hence it has not become hard and compact.

Duricrust : The term has been used for the topmost portion of the profile. The laterite being exposed to subaerial weathering has become further oxidised and has become very hard. Buff to deep brown in colour, the duricrust has a high content of Fe. The presence of pisoliths and ooliths are common feature in this zone.

Latosol : It comprises the 'insitu' product of weathering of the topmost Fe rich horizon. In colour, this soil is reddish brown to dark brown.

LOCALITYWISE DESCRIPTION

As stated earlier, most of the laterite profiles are fragmentary, but at a few places, they do show reasonably good profiles, especially in N.Gujarat. In most occurrences, only 2 or 3 horizons could be ascertained. But the integrated picture is quite revealing and the field data, when considered along with

the laboratory analyses on chemistry and mineralogy has enabled the author to arrive at a number of important conclusions.

In all, following 45 occurrences distributed in various localities of North and South Gujarat, have been described.

NORTH GUJARAT :

Sabarkantha district

1. Harsol - Sultanpur
2. Ankhol
3. Chandrej
4. Amliyara bridge
5. Amliyara quarry
6. Amliyara bore hole site
7. Pavdi
8. Pavdi bore hole site

Kheda district

9. Matipura, Jagrupur, Dholiwav
10. Sultanpur
11. Kapdavanj
12. Mohamadpura
13. Mirapur
14. Soneri, Denga na Muwada
15. Salod
16. Dana
17. Devnagar

18. Porda, Haripura, Amratpura
19. Ranchhodpura

SOUTH GUJARAT

Bharuch District

1. Muljipura
2. Bhilwada
3. Ratanpur
4. Bhuri
5. Bhuri GMDC Lignite Mine
6. Panwadi
7. Dharoli
8. Bhilod
9. Vagalkhod
10. Valia
11. Bhilvada

Surat District

12. Nogama
13. Tadkeshwar
14. Nani Naroli
15. Roswad
16. Munjlau
17. Khutai Mata Temple
18. Chikhli
19. Niol
20. Tarbhon

Valsad District

21. Manekpur
22. Pathri
23. Ajari - Pathri Road
24. Ajari
25. Khergam
26. Vegni Khadi

Of these, reasonably good sections are recorded at four localities, Harsol-Sultanpur and Amliyara in North Gujarat and Munjlau and Tarbhon in South Gujarat.

NORTH GUJARAT

SABARKANTHA DISTRICT

Various localities of laterite occurrences are shown in Fig. IV.1.

Harsol - Sultanpur (110 m above MSL)

About 1/2 km from Harsol towards Sultanpur, a good exposure of laterite is seen on the right bank of Meshwa river (Plate IV.1). The profile is about 11 m thick and shows following zones:

Latsol	0.5 m
Duricrust and Unindurated laterite	4.5 m
Bauxitic laterite	1.0 m
Lateritic bauxite	1.5 m
Kaolinite	3.0 m
Weathered basalt	0.5 m
Deccan basalt (Not exposed)	

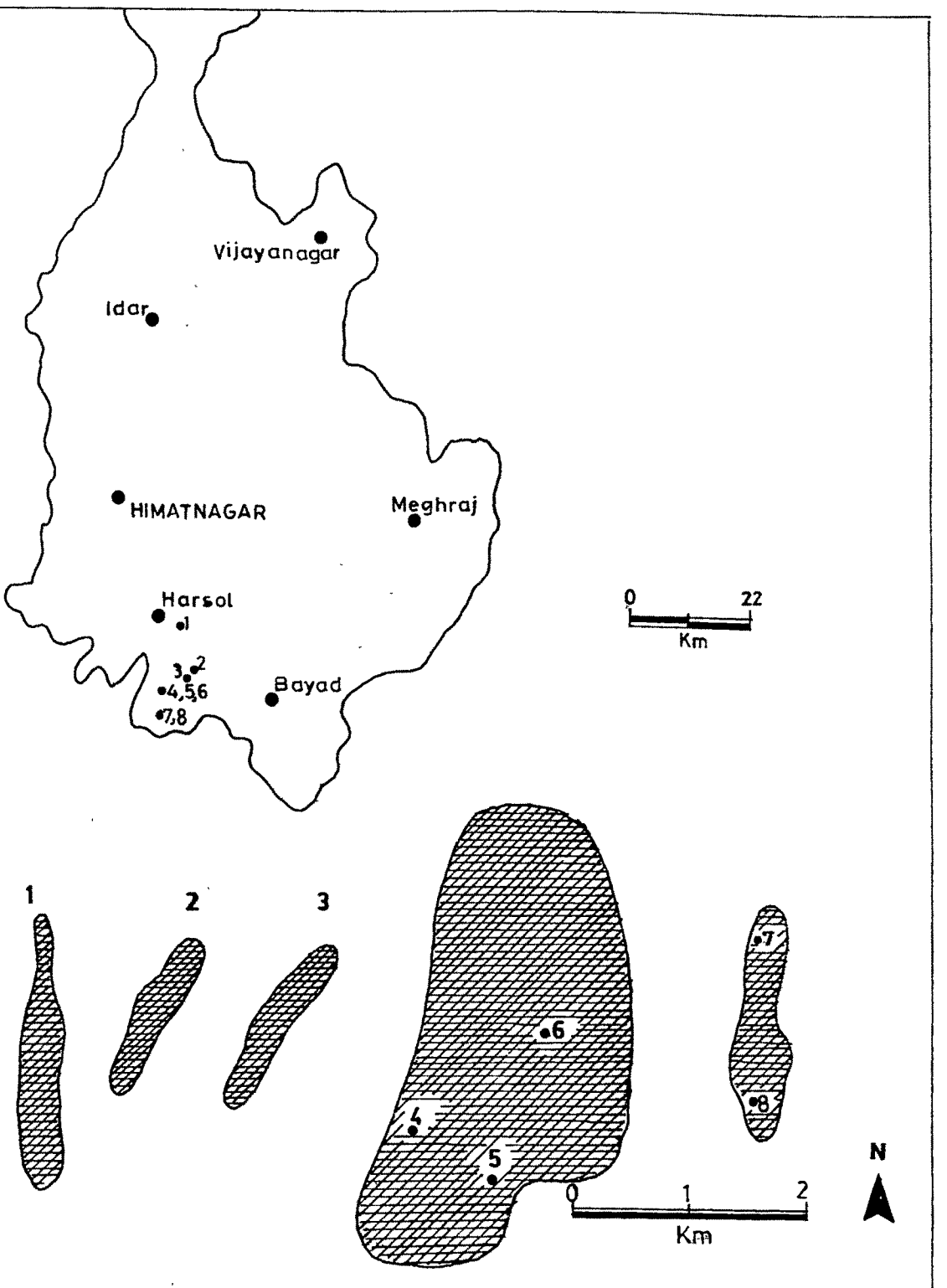

Fig: IV. 1. SHAPES AND SIZES OF EXPOSED OCCURRENCES OF LATERITE IN SABARKANTHA DISTRICT

Plate IV.1 General View of a laterite expsoure at Harsol-Sultanpur looking towards west.

Plate IV.2 Basalt showing spheroidal weathering in the basal part of the laterite profile at Harsol-Sultanpur.

In the basal zone, spheroidal weathering of basalt is ideally preserved (Plate IV.2) which is seen to merge to kaolinite upwards. The overlying kaolinite zone is observed to show a transitional contact with the weathered basalt below. Upwards, this zone gives place to a zone of lateritic bauxite, which in turn, is overlain by bauxitic laterite. The two respective Al and Fe rich varieties are demarcated on the basis of colouration; the lateritic zone is brownish whereas the bauxitic zone is pinkish. The top of the profile, just beneath a thin veneer of residual latosol, is characterised by a thick zone of unindurated laterite and duricrust. The entire profile is intensely fractured and in the lower horizons, fractures and joints are seen filled with calcareous material (Plate IV.3). The duricrust shows typical pisolithic structure, the cavities are filled with alternating layers of Fe and Al materials.

A number of broken blocks of duricrust, transported down the slope, are strewn over the river bed, the pisolithic structure is very well exhibited in these blocks because of the washing away of the cavity filling material.

Ankhol (100 m above MSL)

About 55 km north of Amliyara near the village Ankhol, good laterite sections are exposed on both the banks of the river Majham (Plate IV.4). The base of the section is marked by a typical weathered basalt, the upward sequence is as under :

Plate IV.3 A close view of kaolinite horizon which shows fractures & joints filled with calcareous material at Harsol-Sultanpur.

Plate IV.4 General view of a laterite exposure looking towards North at Ankhol.

Plate IV.5 Complete laterite section at Ankhol A. weathered basalt B.Kaolinite C. Mottled Zone D. Lateritic bauxite & Duricrust.

Latosol	0.5 m
Duricrust and lateritic bauxite	2.5 m
Mottled zone	0.5
Kaolinite	1.5 m
Weathered basalt (base not seen)	> 1.5 m

This exposure is a south south easterly extension of the Harsol outcrop, and the sequence is almost identical, except that here a mottled zone intervenes between kaolinite and the lateritic bauxite zones (Plate IV.5). This mottled zone, obviously points to a mixed zone, wherein kaolinite material is interspersed within aluminous and ferruginous constituents, the mottled appearance is due to pisolithic bodies of iron rich material. The thicknesses of the various zones are also variable. Secondly, this outcrop occurs at an altitude 10 m lower than the previous one.

Chandrej (100 m above MSL)

Near Chandrej village, in the Majham river section, 4 km north of Amliyara, laterites are exposed on the left bank. About 10 m thick, in this section only the following horizons are recorded :

Latosol	3.0 m
Unindurated laterite	1.5 m
Lateritic bauxite	2.5 m
lithomarge (base not seen)	> 4.0 m (exposed portion)

The lithomarge is quite thick here and forms the base of the section; underlying zones are not exposed. There is no significant development of duricrust and the latosol rests directly over the unindurated laterite. The zones of bauxitic laterite and lateritic bauxite are not well-defined and as such the rock is mined for road construction purposes only.

Amaliyara (100 m above MSL)

A good exposure of laterite is seen at the road bridge over Majham river, about 1 km from the village Amliyara towards Degam (Plate IV.6). The outcrop is 4 km long and 2.2 km wide, extending in a N-S direction along the river course. The sequence as seen in cliff sections, is as under :

Latosol	0.40 m
Duricrust	3.60 m
Bauxitic laterite	1.50 m
Bauxite	0.40 m
Ferruginous kaolinite	0.50 m
Bentonite	4.25 m
Weathered basalt	0.20 m
Deccan basalt	> 0.40 m (exposed portion)

Here the profile is more or less complete, and shows a full zonal sequence from unaltered basalt to the topmost duricrust. The zones of weathered basalt, bentonite, ferruginous kaolinite, bauxite, bauxitic laterite, duricrust and latosol are all quite

Plate IV.6 A panoramic view of the Amilyara exposure looking west.

well defined and easily identifiable. The presence of a bentonite horizon here is significant. It is quite thick and appears for the first time; further south it continues to occur at many places. The kaolinite zone is ferruginous, showing a light brown colouration; its junction with the overlying bauxite zone is rather sharp and well-defined (Plate IV.7). A very striking feature of the bauxite zone is the vertically protruding narrow bodies of ferruginous kaolinite into the bauxite above, as if the material has arisen along pre-existing fractures. Differential erosion of the kaolinite zone by the river action, has given rise to numerous cave-like hollows along the cliff sections, with overhanging roof of bauxite followed by bauxitic laterite. The bauxitic laterite is overlained by a thick horizon of duricrust (Plate IV.8) which on top is capped by a relatively thin horizon of latosol.

Amliyara Quarry (85 m above MSL)

A quarry section, 1 km south of Amliyara on Bayad-Degam road, is interesting from the point of view of the deposits of reworked laterite. Here, the laterite is seen to underlie alluvium and gravel beds, broadly showing the following succession :

Alluvium (gravel, sand)	40 m
Heterogeneous laterite and bauxite mass	3.50 m
Basalt	0.50m(exposed portion)

Plate IV.7 Contact between laterite and saprolite in the Amliyara exposure.

Plate IV.8 Thick duricrust horizon in the topmost part of Amliyara exposure.

The lateritic material rests with a sharp contact on the basalt exposed in the quarry section. The overlying material is a random mass of bauxitic and unindurated lateritic boulders with calcareous, clayey and siliceous material as infilling between the boulders and fractures (Plate IV.9 and 10). Obviously, this occurrence forms a reworked deposit comprising material transported from some nearby source overlained by alluvium (Plate IV.11).

Amliyara bore hole site (The ground level 90 m above MSL)

From a drilling site 1 km north of Amliyara, very valuable and dependable information is provided by the cores obtained from a bore hole drilled upto a depth of 15 m . Following sequence is revealed.

Duricrust	5.45 m
Unindurated laterite	2.05 m
Bauxitic laterite	1.30 m
Ferruginous kaolinite	1.20 m
Weathered basalt	1.00 m
Fractured basalt	base

Drilling data in the neighbourhood has shown that the lateritisation is confined to the upper 15 to 20 m depth only; below this depth basalt is unfractured and fresh (Plate IV.12). The partly weathered basalt is of greyish colour with numerous brownish spots indicating incipient nucleii of transformation

Plate IV.9 Gypsum and calcareous material along fractures in bauxite in the Amilyara quarry.

Plate IV.10 Boulders of reworked laterite and bauxite with inter stitial spaces filled with calcareous and clayey material in the Amliyara quarry.

Plate IV.11 Reworked laterite and bauxite beneath a thick alluvial cover in the Amliyara quarry.

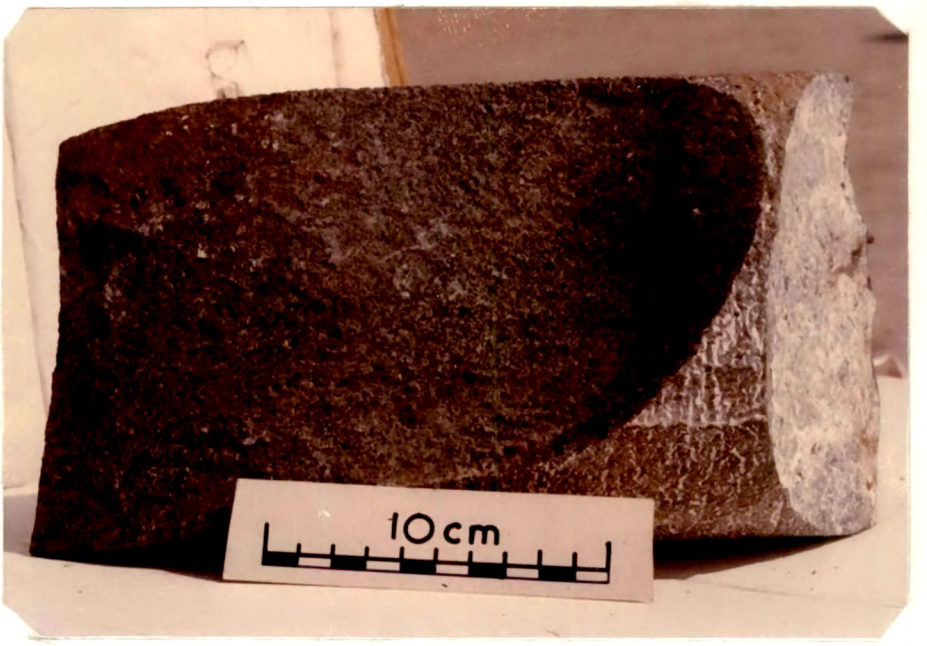

Plate IV.12 Unweathered and unfractured basalt at 60 m depth from a drill site near Amliyara.

Plate IV.13 Core of weathered and fractured basalt at 12 m depth showing numerous brownish spots from Amliyara drill site.

(Plate IV.13). The overlying kaolinite horizon is of dirty white soft material. Lithomarge is of light brown colour, bauxitic laterite shows typical pisolithic structure (Plate IV.14), the basal part being transitional. The core of unindurated laterite is full of small cavities (Plate IV.15) pointing to removal of aluminous material from them by groundwater. The duricrust is of reddish brown colour with pisoliths of yellow coloured aluminous material, enclosed within covers of Fe oxides (Plate IV.16 and 17).

Pavdi (80 m above MSL)

A thick laterite section is exposed on the right bank of Vatrak river near the village Pavdi (Plate IV.18). Only lithomarge and duricrust are seen as under :

Duricrust	3.50 m
Lithomarge (base not seen)	> 1.50 m

The lithomarge horizon is very well developed and extends for almost 2.5 km along the right bank of the river (Plate IV.19). It shows colouration that varies in shades of pink, yellow and brown. The upper portion of the lithomarge zone (about 1 m thick) is characterised by a network of narrow intersecting veins and stringes (Plate IV.20) of Fe rich material criss-crossing with kaolinite. Due to water action of the river, the kaolinite has been washed away thereby giving rise to a characteristic appearance to this zone, hollows mark the

Plate IV.14 Core of bauxitic laterite showing pisolithic structures from Amilyara drill site.

Plate IV.15 Core of unindurated laterite with numerous small cavities from Amliyara drill site.

Plate IV.16 Duricrust with pisolithic structure from Amliyara drill site.

Plate IV.17 Duricrust showing growth of Iron oxides (Maghemite) along cavities from Amliyara drill site.

Plate IV.18 A panoramic view of Pavdi exposure on the right bank of the Vatrak river.

Plate IV.19 Contact between lithomarge and duricrust near Pavdi.

Plate IV.20 Lithomarge showing a network of narrow intersecting veins and stringes near Pavdi.

kaolinite areas while the linear ribs comprise hard iron rich portion. The colour tends to become light to dark brown upward. The overlying laterite zone is now represented by the duricrust.

Pavdi bore hole site (The ground level 80 m above MSL)

Bore hole data based on the cores from a drilling site 2 km east of the village Pavdi show the following sequence :

Duricrust	3.00 m
Unindurated laterite	1.00 m
Lithomarge	1.00 m
Kaolinite	2.00 m
Weathered basalt	1.00 m
Basalt	base

The kaolinite zone is dirty white whereas the lithomarge shows a pinkish colour, and contains numerous veins of kaolinite (Plate IV.21). The unindurated laterite is of usual brown colour (Plate IV.22). The duricrust is brown and tends to become dark brown upward. Another characteristic feature of the duricrust is the presence of veins of Al and calcareous materials (Plate IV.23 and 24) criss-crossing in all directions.

KHEDA DISTRICT

Various localities of laterite occurrences are shown in Fig. IV.2.

Plate IV.21 Core of lithomarge showing numerous veins of Kaolinite from Pavdi bore hole.

Plate IV.22 Core of unindurated laterite from Pavdi bore hole.

Plate IV.23 Core of duricrust showing numerous cavities with layers of Al and calcareous materials from Pavdi bore hole.

Plate IV.24 Core of duricrust showing veins of Al material, becoming thinner towards top, Pavdi bore hole.

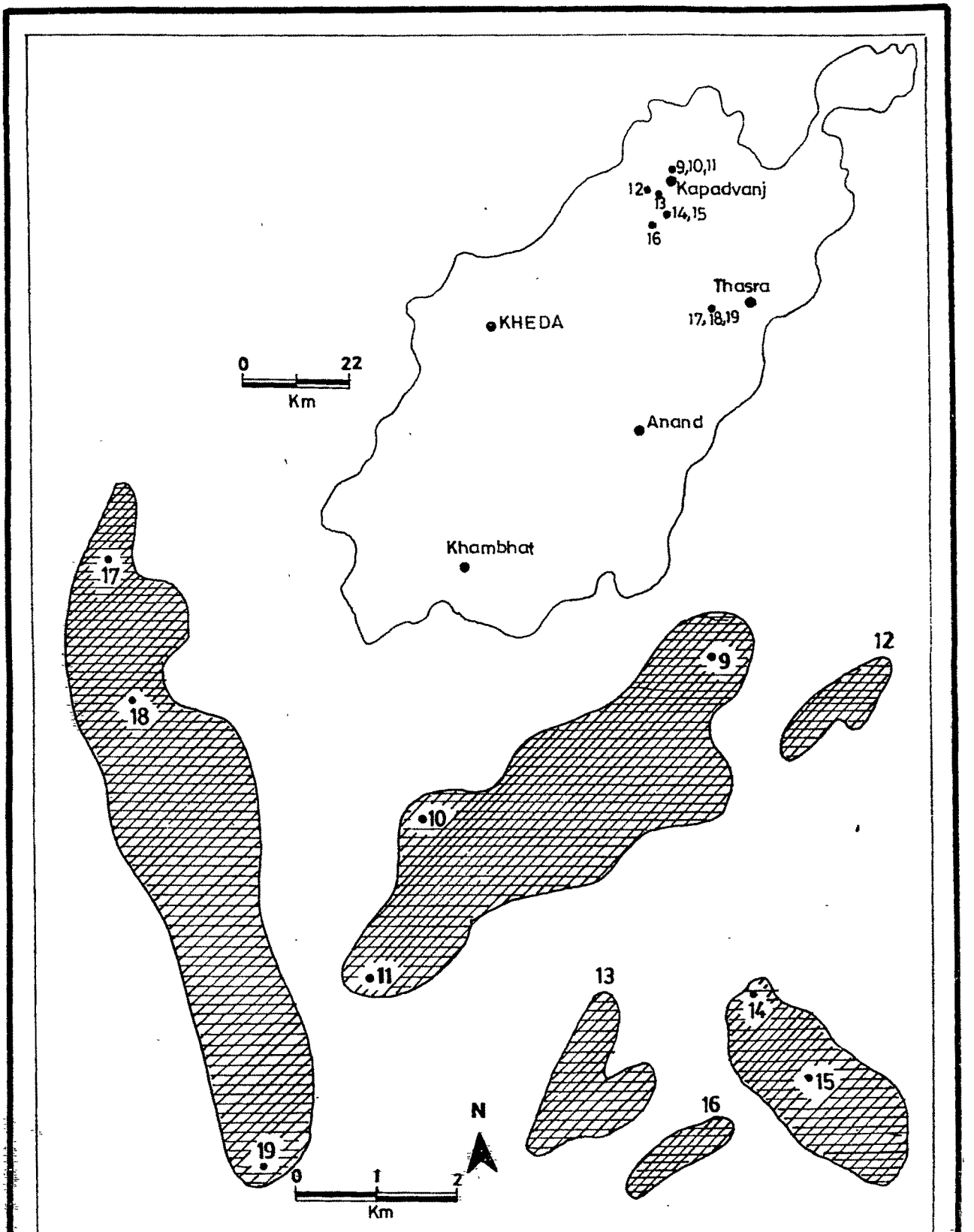

Fig: IV.2. SHAPES AND SIZES OF EXPOSED OCCURRENCES OF LATERITE IN KHEDA DISTRICT

Matipura, Jagrupur and Dholiwav (80 m above MSL)

In various well sections in the above villages, 4 km north of Kapadvanj, bauxitic laterite is encountered at a depth of about 10 m . Following sequence is recorded.

Alluvium	10 m
Bauxitic laterite	2 m
Deccan basalt	> 1 m (base)

The nature of the contact between the basalt and the laterite could not be observed.

Sultanpur (80 m above MSL)

Just east of Sultanpur village towards Mohor Nadi, reworked laterite occurrence is recorded in a bore-hole 3 km north of Kapadvanj. The sequence is as under :

Alluvium	12 m
Laterite and bauxite boulders	1 m
Basalt	base

The contact between laterite and the basalt is quite sharp.

Kapadvanj (75 m above MSL)

One km west of Kapadvanj town on the banks of Mohar Nadi, exposures of laterite are recorded in the river bed and also on both the banks. Only duricrust is seen. The section shows following sequence.

Alluvium	2 m
Duricrust (base not seen)	> 8 m

The thick duricrust typically shows dark brown to reddish brown colour and abundant pisolithic structure.

Mohamadpura (70 m abvoe MSL)

Just south of this village, north of the railway track, lateritic rocks have been recorded in a few quarries. At some places, only bentonite is exposed (Plate IV.25), while in a quarry further south, a very thick horizon of unindurated laterite (Plate IV.26) is observed.

The sequence worked out is as under :

Latosol	0.5 m
Unindurated laterite	7.0 m
Bentonite (base not seen)	> 1.5 m

Mirapur (65 m above MSL)

A quarry located on the Kapadvanj - Dakor road near the village Mirapur (2 km south of Kapdavanj), shows a 3 m thick lateritic section as under :

Latosol	1.0 m
Reworked laterite	1.5 m
Bauxite (base not seen)	1.0 m (exposed portion)

Plate IV.25 Bentonite quarry at Mohamadpura.

Plate IV.26 Distant view of a thick horizon of unindurated laterite south of Mohamadpura.

The contact between the laterite and bauxite is sharp (Plate IV.27) and the lateritic portion is seen to comprise a randomly oriented aggregate of derived fragments of varying sizes, transported from elsewhere. Boulders as big as 1 m diameter are quite common. The fragments are mostly of duricrust with a small proportion of those of unindurated laterite as well. The entire mass is intimately mixed with latosol which also forms a thin capping. The bauxite layer is typically of light pink colour whereas the bouldery laterite is reddish to reddish brown. The transported laterite mass, appears to have come from the nearby Kapadvanj exposures, which are at a higher level.

Soneri and Denga Muwada (70 m MSL)

These two villages quite close to each other are located 5 km south of Kapadvanj. Several small quarries (Plate IV.28) are located here, and show following sequence :

Latosol	0.5 m
Duricrust	1.0 m
Unindurated laterite	0.5 m
Bentonite (base not seen)	> 0.5 (exposed portion)

Bentonite is of whitish and light yellow colour, typically showing depletion of Fe. The bauxite and kaolinite are absent, and the bentonite is quite rich in silica, thus rendering it of inferior quality from the economic point of view. The absence of these two horizons is significant and has some bearing on the

Plate IV.27 Contact between bauxite and reworked laterite boulders near Mirapur.

Plate IV.28 Exposed sequence in a quarry between Soneri and Denga Muwada. A. Bentonite B.Unindurated laterite C.Duricrust.

genetic processes during laterite formation. The factors involving the development of the zones of kaolinite and bauxite, have been discussed in the pages to follow.

Salod (6 m above MSL)

Eight kilometers to the south of Kapadvanj, this village supports a number of quarries, where bauxite is being mined. Here a heterogeneous mass of laterite and bauxite is overlain by a rather thick zone of brown soils (Plate IV.29). The sequence is as under :

Brownish (Transported) mixed soils	3 m
Reworked laterite and bauxite (base not seen)	2 m (exposed thickness)

The laterite-bauxite horizon is bouldary and consists of pieces and fragments of varying shapes and sizes of bauxite and laterite intimately mixed with clay and calcareous matter. The bauxite boulders are mostly covered with yellowish cutane. The overlying soils rest with a sharp contact and are obviously of transported variety.

Dana (60 m above MSL)

Dana outcrop is located 7 km south of Kapadvanj, on the left bank of Kavara Nadi. Here following sequence is observed :

Plate IV.29 Contact between reworked laterite and bauxite boulders and the over lying brownish soil near salod.

Plate IV.30 General view of unindurated laterite covered with latosol near Devnagar.

Latosol	0.5 m
Unindurated laterite	1.0 m
Bentonite (base not seen)	> 0.5 m (exposed portion)

Bentonite is being quarried from this locality. Grey colouration of the bentonite indicates its derivation from the underlying basalt. This fact has been confirmed in the bore hole data provided by the Directorate of Geology and Mining, from adjoining locations, where weathered trap has been observed to change into grey-bentonite.

Devnagar (65 m above MSL)

10 km north of the town of Dakor, at the village Devnagar, laterite is exposed in a section on the road to Padra. It is a relatively minor occurrence showing only following horizons :

Latosol	1.0 m
Unindurated laterite (base not seen)	> 1.0 m

The sequence of unindurated laterite and latosol (Plate IV.30) is observed to be 'in situ' and the two horizons have the various diagnostic features. Interestingly, though the duricrust is not seen developed here, quite a few boulders of the indurated variety are strewn all over the area. This duricrust must have been transported from elsewhere.

Padra, Haripura and Amratpura

Quarries located in these villages, 6 to 8 km north of Dakor, show unindurated laterite with a veneer of latosol and alluvium (Plate IV.31). The lateritic component appears to be 'in situ' whereas the gravelly portion comprises transported material. It is observed that the gravels have been deposited over an uneven latosol (Plate IV 32). Bauxite zone is also observed. The total sequence is as under :

Alluvium (gravel, sand) and latosol	1.0 m
Unindurated laterite	0.5 m
Bauxite (base not seen)	> 0.5 m

Ranchhodpura (60 m above MSL)

A very conspicuous outcrop of laterite is recorded near the village Ranchhodpura, 1 km north of Dakor on the right side of the road (Plate IV.33). In an about 3 km long and 1 km wide low mound extending in a NNW-SSE direction this occurrence is ideally studied in quarry sections. There is a slight rise in the height of the mound southwestward; as a results in the higher portions are exposed good sections, comprising following horizons :

Alluvium (gravel, sand) and latosol	0.5 m
Unindurated laterite	1.0 m
Bauxite	1.0 m
Kaolinite (base not seen)	> 0.5 m

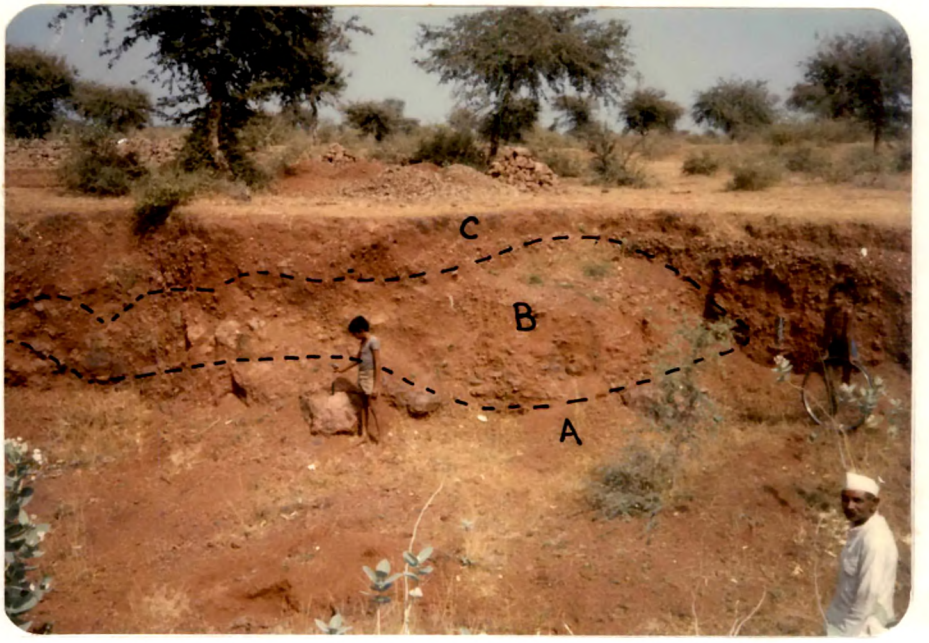

Plate IV.31 The exposed sequence in a quarry near Padra. A Bauxite B. Unindurated laterite C. Latosol.

Plate IV.32 Contact between latosol and alluvium near Padra.

Plate IV.33 A panoramic view of the Ranchhodpura exposure looking towards south.

Plate IV.34 Contact between Kaolinite and alluvium near Ranchhodpura.

Kaolinite which forms the base is easily recognised by its pinkish white colour (Plate IV.34). Bauxite and laterite zones are also distinctly identifiable.

SOUTH GUJARAT

BHARUCH DISTRICT

Various localities of laterite occurrences are shown in Fig. IV.3.

Muljipura (40 m above MSL)

About 1 km west of the village Muljipura (7 km NE of Jhagadiya) laterites are exposed on the right bank of a stream (Plate IV.35). The outcrop is 1 km long and 1/2 km wide and shows following sequence :

Latosol	0.5 m
Unindurated laterite	1.0 m
Kaolinite (base not seen)	> 4.5 m

The Kaolinite horizon is well developed, and is easily recognised by its white colour. It is found to be highly siliceous and is extensively quarried for refractory purposes. The overlying laterite zone is rather thin and duricrust is absent; instead there occurs a latosol at the top.

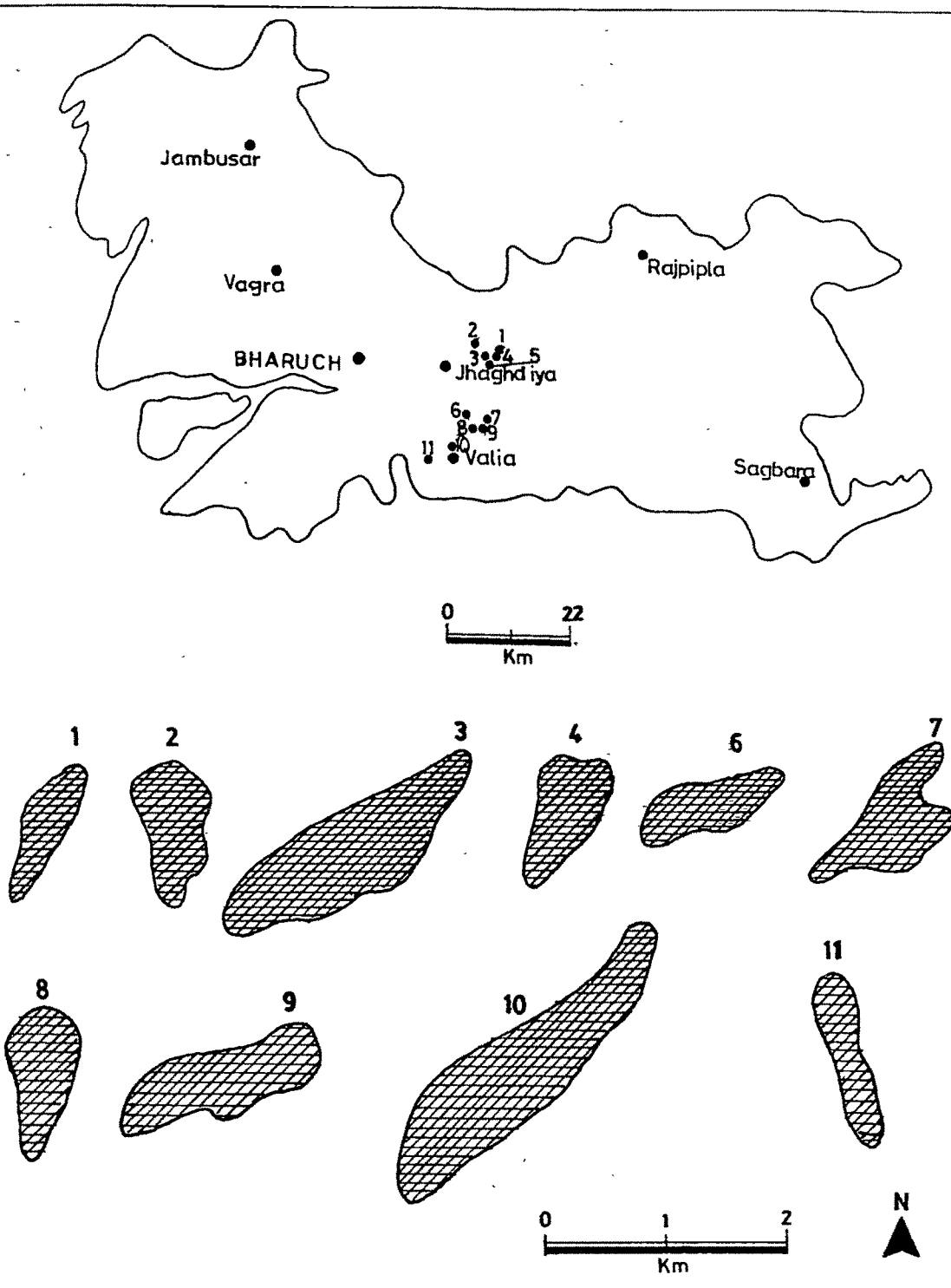

Fig:IV.3. SHAPES AND SIZES OF EXPOSED OCCURRENCES OF LATERITE IN BHARUCH DISTRICT

Plate IV.35 A view of the Muljipura quarry.

Plate IV.36 Development of Kaolinite near Bhilwada.

Bhilwada (40 m above MSL)

A small mound about 1.5 km long and 0.5 km wide near the village Bhilwada, 4 km NE of Jhagadiya, shows lateritic rocks almost identical to the one seen at Muljipura. Extensively exposed veneer of reddish brown lateritic soil is underlain by the siliceous kaolinite zone, several meters thick, though the development is less prominent here (Plate IV.36).

Ratanpur (60 m above MSL)

Laterites are exposed in a hillock, 1 km east of Ratanpur (3 km NE of Jhagadiya). The outcrop is small, about 1/2 km long and 30 m wide and shows a reasonably good development of a profile, with following sequence.

Latosol		0.5 m
Unindurated laterite		1.0 m
Kaolinite (base not seen)	>	2.0 m

Bhuri (40 m above MSL)

At the village Bhuri, 8 km east of Jhagadiya, an exposure of weathered basalt changing over to Kaolinite is seen (Plate IV.37). Although the lateritisation phenomenon here is not very prominent yet the outcrop ideally shows the transformation of basalt into kaolinite. Vertical cuttings reveal grey weathered basaltic masses enclosed within pale - coloured kaolinite material.

Plate IV.37 Basalt seen changing over to Kaolinite at Bhuri.

Plate IV.38 Lignite mine near Bhuri.

Bhuri - GMDC Mine (60 m above MSL)

In the lignite mine (Plate IV.38) area, lateritic rocks reveal an interesting mode of occurrence. Here, the lignite occurs at a depth of 65 m, overlain by a huge thickness of grey impure clays. Within which occur a few lensoid bands of reworked laterite (Plate IV.39) the laterite occurs as 1/2 to 1 m thick layers extending laterally for 10-15 meters and then pinching out. The lenses show an overall dip of 15-20 due east. These lenses comprise strings of small boulders of fairly well rounded laterite (Plate IV.40) in intimate association with blocks and fillings of kaolinite; obviously these lenses comprise transported material. In opened up quarry faces, at least 3 such laterite layers have been recorded.

Panwadi (50 m above MSL)

A small hillock (1000 m x 300 m) rising 3 m above the ground level, 1 km SE of village Panwadi (7 km north of Valia) shows following sequence :

Latosol	0.5 m
Unindurated laterite (base not seen)	> 1.5 m

The laterite is of brown colour pointing to a higher Fe content.

Plate IV.39 Lensoid bands of reworked laterite with 15-20° dip at Bhuri lignite mine.

Plate IV.40 Lenses of rounded reworked laterite associated with Kaolinite at Bhuri lignite mine.

Dharoli (60 m above MSL)

Along the road from Panwada, on the right side near the village Dharoli (9 km NE of Valia) laterite is exposed as a 3 m thick duricrust forming an uplifted fault block, extending in a NE-SW direction for almost 2 km right upto Amravati river (Plate IV.41). The width of the outcrop is around 60 m. The constituent rock is a typical dark brown indurated Fe rich laterite showing pisolithic structure and other characteristic structures. The base of the duricrust is not seen but the colour grades into lighter shades downwards (Plate IV.42). It is overlain by the river alluvium.

Bhilod (50 m above MSL)

Around the village Bhilod, 5 km NE of Valia, latosol occurs as a peneplain forming a patch 2 km long and 1/2 km wide (Plate IV.43). This soil horizon is more than 1 m thick but the precise thickness is not known. Their light brown to brown colour is most striking. Perhaps they are underlain by unindurated laterites.

Vagalkhod (60 m above MSL)

An exposure of laterite, 1 km NE of Vagalkhod (6 km NE of Valia) is quite interesting. It forms an elongated exposure extending in a NE-SW direction, 2 km long and 0.5 km wide. It is laterally bisected into two parts; the northern part is

Plate IV.41 Duricrust showing upliftment along NE-SW direction near Dharoli.

Plate IV.42 Change in the colour from base towards top of Duricrust near Dharoli.

Plate IV.43 A peneplain of latosol near Bhilod.

Plate IV.44 The duricrust upliftment along a NE-SW fault near Vagalkhod.

represented only by a duricrust. An exposed thickness of 1.5 m is observed, perhaps it is underlain by unindurated laterite and bauxite in turn. The duricrust gets abruptly truncated (Plate IV.44) along a NE-SW line (? fault), beyond which to the southeast, is encountered the following sequence (Plate IV.45) :

Black cotton soil	2.0 m
Reworked laterite and bauxite	1.0 m
Lithomarge	0.5 m
Kaolinite	> 0.5 m
(base not seen)	

Valia (50 m above MSL)

The Valia town itself is located on laterites. The exposed portion forms a plain ground about 3 km long and 1 km wide extending in a NE direction. The main constituent rock is unindurated laterite, overlain by a thin (0.5 m) latosol. The thickness of laterite is not known.

Bhilvada (40 m above MSL)

Near Bhilvada village, just below the bridge on the Valia - Ankleshwar road laterites are exposed (Plate IV.46) in a nala section. These comprise boulders of duricrust, transported from elsewhere. On account of water action, the pisolithic infilling material has been washed away, leaving numerous cavities.

SURAT DISTRICT

Various localities of laterite occurrences are shown in Fig.IV 4.

Plate IV.45 Exposed section in quarry at Vagalkhod. A. Kaolinite B. Lithomarge C. Reworked laterite & bauxite D. Black cotton soil.

Plate IV.46 Exposure of reworked laterite below the bridge near Bhilvada.

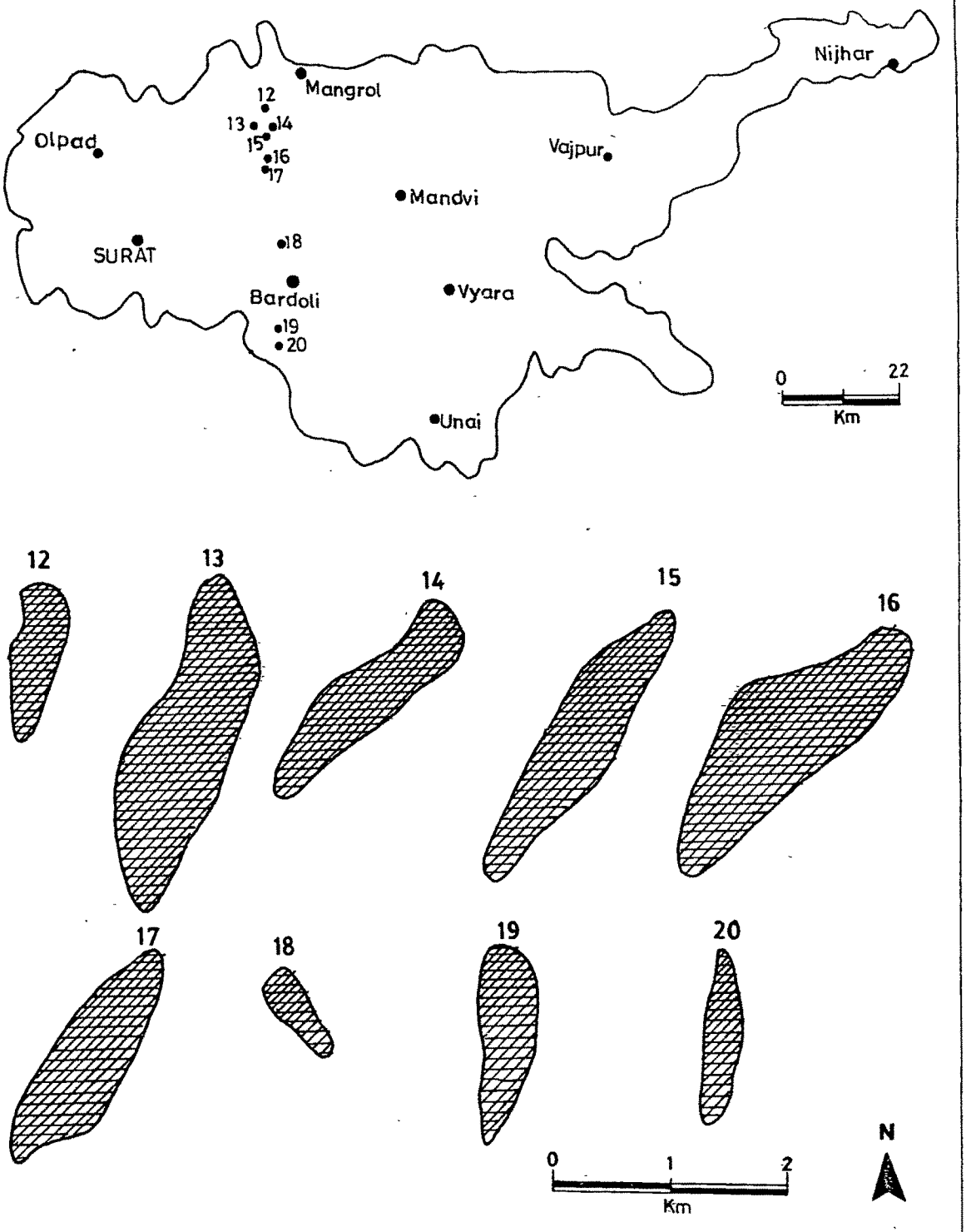

Fig:IV.4. SHAPES AND SIZES OF EXPOSED OCCURRENCES OF LATERITE IN SURAT DISTRICT

Nogama (30 m above MSL)

Near the village Nogama, 6 km NE of Tadkeshwar, laterites are exposed in a tributary of river Kim. About 1/2 km long and 100 m wide, stretching in N-S direction, the exposed section consists of following two horizons only :

Latosol	1.5 m
Unindurated laterite (base not seen)	> 1.0 m

The laterite is typically reddish brown and grades into brownish 'in situ' latosol upwards.

Tadkeshwar (35 m above MSL)

The town itself is situated over laterites, comprising a peneplain typically showing a brown coloured latosol, unindurated laterite under them. The outcrop area is 3 km long and 1/2 km wide, the sequence is as under :

Latosol	0.5 m
Unindurated laterite (base not seen)	> 1.5 m

Obviously, this occurrence is the southwestern continuation of the Nogama patch.

Nani Naroli (40 m above MSL)

At the village Nani Naroli, 5 km east of Tadkeshwar, an elongated exposure extending NE-SW is recorded. The outcrop is 1.5 km long and 300 m wide, and is represented only by the duricrust and latosol (Plate IV.47). In an abandoned quarry following sequence was seen :

Insitu latosol	1 m
Duricrust (base not seen)	> 1 m

The intervening zone of latosol shows a somewhat gradational contact with the underlying duricrust from which it has been derived.

Roswad (40 m above MSL)

About 2 km east of Roswad village along the Mandvi - Kim road, laterites are exposed on both the sides of the road. The road is cutting across the length of the outcrop which is 3 km long and 1/2 km wide. The following horizons are observed :

Latosol	0.5 m
Unindurated laterite (base not seen)	> 1.0 m

The laterite is dark brown pointing to a high Fe content.

Plate IV.47 The contact between duricrust and latosol at Nani Naroli.

Plate IV.48 General view of the terrain near Manjlau showing a series of hills in NE direction looking due north.

Munjlau (40 m above MSL)

Near Munjlau (1/2 km to the west of the village) is recorded one of the few fine and well developed laterite occurrences. It forms a series of low hill, extending in NE-SW direction (Plate IV.48), measuring an area of about 3 sq.km. It supports numerous quarries (Plate IV.49). In one of the quarry, following sequence is ideally seen :

Latosol	0.25 m
Duricrust	2.00 m
Bauxitic laterite	0.50 m
Lateritic bauxite	3.00 m
Lithomarge	2.50 m
Transitional zone	0.50 m
Kaolinite	0.25 m
Bentonite	0.40 m
Bentonite with spheroidal structure	0.75 m
Weathered basalt	0.50 m
Deccan basalt	base

The precise delineation of the various zones has been made available taking into consideration the subsequent chemical analysis, petrography and XRD studies.

The basalt, through a zone of weathered basalt upwards has given rise to bentonite. The basalt portion of the bentonite

Plate IV.49 Exposed laterite quarry at Manjlau

layer typically shows relicts of spheroidal wheathering. The colour of bentonite is grey at the base and white in the upper portion. Kaolinite zone rests over bentonite and is easily identified by its yellowish colour. Upwards, the transitional zone is pink while the overlying lithomarge is reddish brown in colour. Further up, the oxidised horizons comprising laterite bauxite and bauxitic laterite, topped by a well developed duricrust are present. The rocks at all horizons shows intense fracturing and a high level of water table (about 6 m from the ground surface even during summer month is a characteristic feature.

Khutai Mata Temple (50 m above MSL)

The temple is located on a small hillock of laterite, 2 km west of Bodhan village on Bodhan - Ghala road (north of the road). The laterite hill extends in a NE-SW direction and is approximately 2 km long and 1 km wide.

The laterites here are cut by a NE-SW fault, such that the faulted blocks show only partial sequences as under :

SE block (downthrown)		NW block (upthrown)	
Transported latosol with gravelly sand	1.00 m	latosol 'insitu'	1 m
Duricrust	1.50 m		
Unindurated laterite (base not seen)	> 1.00 m	Unindurated laterite	2 m
		kaolinite	1 m
		Weathered basalt with relics of basalt	> 1 m

Considering both the sections, it is observed that quite a few horizons are represented and the laterites are products of basalt (Plate IV.50). The duricrust appears to have developed subsequent to the faulting. It is not so well developed and gives an impression that it was in the process of formation when the latosol, was brought and dumped over it (Plate IV. 51).

Chikhli (20 m above MSL)

A small hill (400 m x 150 m) near Chikhli (Over which a temple is built) 9 km north of Bardoli, contains laterite. The hillock trends NNW-SSE, and shows following sequence :

Latosol	0.5 m
Unindurated laterite	1.0 m
Kaolinite (base not seen)	> 0.5 m

Kaolinite is typically white to brown grading upward into laterite of brown colour.

Niol (30 m above MSL)

Laterite rocks occupy a plain ground, forming a patch 1.5 km long and 1/2 km wide, extending in N-S direction. The sequence observed is as follows :

Latosol	0.5 m
Unindurated laterite (base not seen)	> 1.0 m

Plate IV.50 Typical spheroidal weathering in basalt at the base of laterite profile near Khutai Mata temple.

Plate IV.51 Duricrust overlain by latosol near Khutai Mata temple.

The laterite is typically brown, whereas the overlying soil is dark brown in colour.

Tarbhon (30 m above MSL)

At Tarbhon village, 12 km SW of Bardoli, good exposures of laterite are seen in numerous quarries (Plate IV.52) located on a N-S elongated (1 km x 1/2 km) hillock. These quarries reveal one of the finest sequence, pointing to a well developed horizons as under :

Latosol	0.5 m
Duricrust	2.5 m
Unindurated laterite	2.0 m
Lithomarge	2.5 m
Ferruginous kaolinite	0.5 m
Transitional zone	0.5 m
Bentonite	> 0.6 m (exposed portion)

{The above zones have been delineated and confirmed with the help of laboratory studies viz. chemical, petrographic and XRD.}

It is found that the parent rock was basalt. The zone of bentonite is conspicuous, and is recognised by its pale colour. Upward, through a transitional zone of grey colour it changes over to a zone of ferruginous kaolinite (reddish white). The zone of lithomarge which overlies the Kaolinite zone (Plate IV.53) is quite thick. The zone of kaolinite and lithomarge show typical veriform structures (Plate IV.54) which are vertical to

Plate IV.52 General view of Tarbhon quarry.

Plate IV.53 The contact between lithomarge and kaolinite in Tarbhon quarry.

Plate IV.54 Veriform structures in saprolite horizon in Tarbhon quarry.

inclined, and these structures become scanty in Box horizons above. The veriform infilling is of kaolinite and Al-rich materials. Unindurated laterite overlies the lithomarge. The duricrust is also well developed. The water level was observed to be only a few meters below the ground level.

VALSAD DISTRICT

In this district, laterite sequences do not show good developement , and it is not possible to distinguish between kaolinite and bentonite horizons because both occur together in varying proportions. The author has therefore used a more comprehensive term "saprolite" to describe this horizon. Various localities of laterite occurrences are shown in Fig. IV.5.

Manekpur (15 m above MSL)

At the village Manekpur, laterite is exposed in a quarry face (Plate IV.55). The section is about 11 m high, and most part of it is an undifferentiated saprolite, the total sequence being as under :

Transported latosol	1.5 m
Lithomarge	0.5 m
Saprolite	> 9 m

The saprolite zone is water saturated and of pinkish white colour replete with vertical fractures and joints.

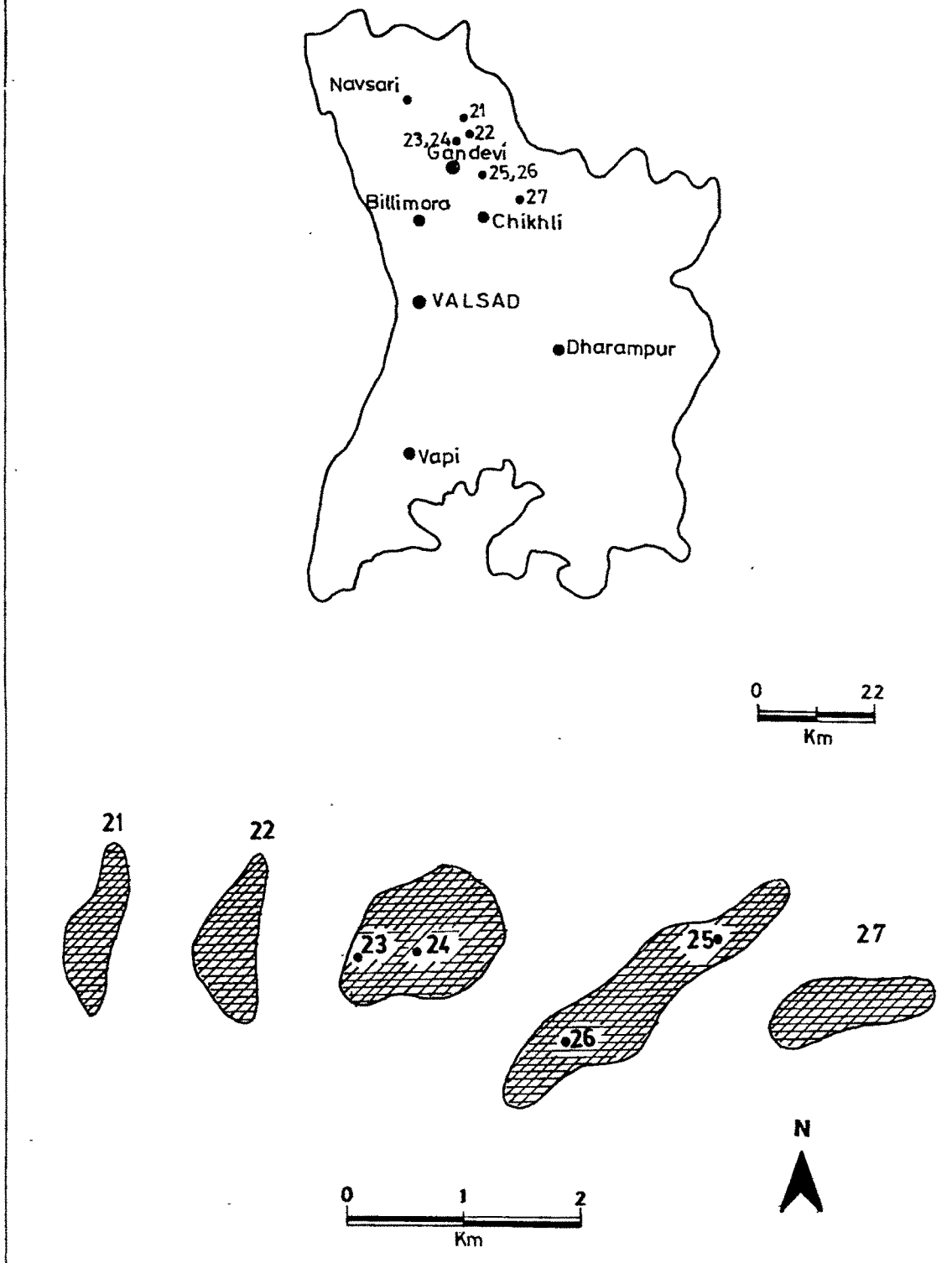

Fig:**IV.5.** SHAPES AND SIZES OF EXPOSED OCCURRENCES OF LATERITE IN VALSAD DISTRICT

Plate IV.55 Section in a quarry near Manekpur. A. Saprolite B. Lithomarge C. Transported latosol.

Plate IV.56 Quarry face at Pathri A. Ferruginous saprolite B. Unindurated laterite C. Latosol.

It may be relevant to point out that the base of the quarry is just 5 m above the MSL.

Pathri (20 m above MSL)

A quarry at the village Pathri, 3 km NE of Gandevi, shows following sequence (Plate IV.56).

Latosol	0.5 m
Unindurated laterite	3.5 m
Ferruginous saprolite (base not seen)	> 6 m

The ferruginous content in the saprolite is quite high thereby imparting a brownish colour. Boulders of duricrust are strewn all over the surface, and they appear to have been transported from elsewhere.

Ajari - Pathri Road (15 m above MSL)

Laterites are exposed along the southern flank of the road, below the bridge 2 km north of Gandevi. The horizons recorded are as follows :

Alluvium	0.5 m
Mottled zone	0.5 m
Kaolinite (base not seen)	> 2.5 m

Kaolinite zone is well developed and is easily recognised by its dirty white colour, overlained by mottled zone. Laterites -

indurated or unindurated, are absent, and the mottled zone is directly capped by alluvial deposits.

Ajari (15 m above MSL)

About 2 km north of Gandevi on the right side of the road, a WSW-ENE trending zone of broad ridges of laterite, 3 to 4 km long and 2 km wide is recorded. A NNE-SSW fault along which Ambica river flows, truncates these ridges such that the laterites abruptly terminate along the river and do not occur on the right bank. The sequence in the quarries is as under :

Latosol	0.5 m
Duricrust	1.0 m
Unindurated laterite (base not seen)	> 1.0 m

Collapsed boulders of duricrust are seen scattered at lower levels (Plate IV.57).

Khergam (15 m above MSL)

A hillock near the village Khergam 3 km east of Gandevi (Plate IV.58) reveals a section comprising only the upper horizons as under :

Latosol with boulders of duricrust of varying sizes	5 m
Unindurated laterite	> 4 m

Plate IV.57 The boulders of duricrust scattered over a low ground near Ajari.

Plate IV.58 Latosol with boulder of duricrust near Khergam.

Vegni Khadi (15 m above MSL)

Along the Vegni Khadi stream, near the overhead tank, 2 km SSE of Gandevi, laterite rocks are exposed. They are not well developed, showing mainly undifferentiated saprolite zone, overlain by brownish colour transported soil.

SALIENT OBSERVATIONS

The laterite occurrences in North and South Gujarat, though widely separated by the alluvial plains of central Gujarat, show considerable similarity and point to numerous features of genetic significance. Although the full laterite sequence has been rarely encountered, yet quite a few localities amply establish that the parent rock was basalt, and the alteration processes were initiated in altered basalt showing diagnostic spheroidal weathering. The varying sequences of horizons encountered at different localities, have been tabulated to provide a synoptic view (Table IV.2,3). The table ideally illustrates the local differences in the process of lateritisation, as revealed by the presence or absence of one or the other horizons. Also it has enabled the author to visualise unexposed sequences on the basis of the likely extension of the horizons in nearby occurrences.

Field studies, have established following facts :

1. That the intensity of lateritisation was not the same everywhere, is also supported by the fact, that at many

TABLE IV.2 A SYNOPTIC VIEW OF THE HORIZONS DEVELOPED IN THE VARIOUS LATERITE SEQUENCES AT DIFFERENT LOCALITIES IN NORTH GUJARAT

HORIZON \ LOCATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Duricrust	x	x	—	x	—	x	x	x	—	*	x	—	—	x	—	—	—	—	—
Unindurated laterite	x	—	x	—	*	x	—	x	—	—		x	*	x	*	x	x	x	x
Bauxitic laterite	x	—	—	x	—	x	—	—	x	—		—	—	—	—	—		—	—
Lateritic bauxite	x	x	x	—	—	—	—	—	—	—		—	—	—	—	—		—	—
Bauxite	—	—	—	x	*	—	—	—	—	*		—	*	—	*	—		x	x
Lithomarge	—	—	x	—	—	—	x	x	—	—		—		—		—			—
Mottled zone	—	x		—	—	—		—	—	—		—		—		—			—
Kaolinite	x	x		x	—	x		x	—	—		—		—		—			x
Bentonite	—			x	—	—		—	—	—		x		x		x			
Weathered basalt	x			x	—	x		x	—	—									
Basalt				x	x	x		x	x	x									

x — Horizon developed
——— Horizon not developed
═══ Exposed base of the profile
* Reworked

TABLE IV.3 A SYNOPTIC VIEW OF THE HORIZONS DEVELOPED IN THE VARIOUS LATERITE SEQUENCES AT DIFFERENT LOCALITIES IN SOUTH GUJARAT

HORIZON \ LOCATION	1	2	3	4	5	6	7	8	9a	9b	10	11	12	13	14	15
Duricrust	–	–	–	–	#	–	X	X	X	*	–	#	–	–	X	–
Unindurated laterite	X	X	X	–		X				–	X		X	X		X
Bauxitic laterite	–	–	–	–						–						
Lateritic bauxite	–	–	–	–						–						
Bauxite	–	–	–	–						*						
Lithomarge	–	–	–	–						X						
Mottled zone	–	–	–	–						–						
Kaolinite	X	X	X	X						X						
Bentonite				–												
Weathered basalt				X												
Basalt																

X – Horizon developed
—— Horizon not developed
▬▬ Exposed base of the profile
\# Reworked

Contn'd. TABLE IV.3 A SYNOPTIC VIEW OF THE HORIZONS DEVELOPED IN THE VARIOUS LATERITE SEQUENCES AT DIFFERENT LOCALITIES IN SOUTH GUJARAT

HORIZON \ LOCATION	16	17a	17b	18	19	20	21	22	23	24	25	26
Duricrust	X	—	X	—	—	X	—	—	—	X	*	—
Unindurated laterite	—	X	X	X	X	X	—	X	—	X	X	—
Bauxitic laterite	X	—		—		—	—	—	—			—
Lateritic bauxite	X	—		—		—	—	—	—			—
Bauxite	—	—		—		—	—	—	—			—
Lithomarge	X	—		—		X	X	—	—			—
Mottled zone	—	—		—		—	—	—	X			—
Kaolinite	X	X		X		X	X	X	X			X
Bentonite	X	—				X	X	X				X
Weathered basalt	X	X				X						
Basalt	X					X						

X – Horizon developed
—— Horizon not developed
—— Exposed base of the profile
* Reworked

localities, laterites and saprolite zones are not distinguishable (Viz. Manekpur, Pathri, Ajari). In south Gujarat, a number of exposures show the initial stages of lateritisation (Viz., Bhuri, Khergam). Moderate to strong lateritisation is confined to some exposures in south Gujarat (Viz. Munjlau, Tarbhon) as well as North Gujarat (Viz. Harsol-Sultanpur, Amliyara, Pavdi).

2. A most significant observation is that pertaining to the role of fracture in lateritisation. Several exposures (Harsol-Sultanpur, Amliyara, Manjlau, Tarbhon, Khutai Mata) typically point to the fractures being an important controlling factor in advancing the process of lateritisation.

3. The better developed laterite horizons, practically all over Mainland Gujarat are those comprising unindurated laterite and the overlying duricrust. Similarly in the saprolite zone, kaolinite has almost universally developed.

4. Development of bentonite is somewhat erratic and appears to occur as lenses. In North Gujarat, it is thicker (4 m) in the northern parts of Kheda, tending to thin out southward to as less as 0.5 m. In South Gujarat, its occurrence is patchy, never exceeding 1 m.

5. In a general way, it has been recorded that the formation of bentonite zone has inhibited the development of bauxite, obviously the bentonite itself being rich in Al, Si etc.

6. The kaolinite horizon, is developed all over. It is quite thick in North Gujarat tending to thin out southward. It is 3 m thick at Harsol - Sultanpur, gradually thinning out to about 0.5 m at Ranchhodpura. In South Gujarat, it is 4.5 m thick at Muljipura; it progressively thins out southward, being only 0.5 m at Tarbhon.

7. Bauxite horizon is discontinuous and appears to have formed as lensoid pockets, about 1 m thick. In North Gujarat, it occurs between Amliyara and Devnagar to Ranchhodpura and in South Gujarat, it extends from Dharoli to Vagalkhod.

8. Lithomarge horizon is also discontinuous in the sense that at many places it is difficult to identify and demarcate. Mottled zone is also locally recorded and its development is feeble. The overlying horizons, viz., bauxite, lateritic bauxite and bauxitic laterite vary from locality to locality and it is seen that the variation and the development of the different horizons and their mutual relationship depends on the intensity of the lateritisation processes.

9. Post lateritisation uplift of North Gujarat is indicated in the altitudes of the some outcrop in North Gujarat as compared to those of South Gujarat whereas the former occur within the altitude range of 60 to 100 m, the latter are restricted to 10 to 60 m.

10. Reworked laterite occurrences are easily identifiable. They do not follow the expected sequence, and in most cases they are observed to have been derived from some nearby 'insitu' laterites. Sharp contacts with the parent rock are the diagnostic features of the reworked laterites.