CHAPTER VII

RESUME

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This chapter contains a resume of the research work carried out on the geology, occurrence, geo-chemistry and genesis of the Palaeocene laterite deposits of Kutch district, Gujarat State, India.

Geology

The laterite exposures of Kutch are mainly confined to the Madh Series Rocks (Biswas, 1971) which has been assigned a Palaeocene age.

According to the present author, the generalized stratigraphy of the laterite bearing areas is as follows (after Biswas and Deshpande, 1970) :

	Alluvium, blown sand, etc.	..... Recent
Porbander series	Arenaceous limestone	..... Pleistocene
Kankawati Series	Gritty sandstone, clays and conglomerates	..... Pliocene
---UNCONFORMITY---		
Khari Series	Shales with intercalations of fossiliferous limestone	..... Miocene

UNCONFORMITY			
Bermoti Series		Dirty white and yellow banded marl and impure limestone	..... Oligocene
PARACONFORMITY			
Berwali Series	Babia Stage	Fragmental fossiliferous (nummulitic) limestone	..... Upper Eocene
	Kakdi Stage	Buff coloured clays, marls sandstones and shales with flakes of gypsum and intercalated laterite/ bauxite	... Middle ... Eocene to ... Upper Cretaceous
DISCONFORMITY			
Madh rocks		Laterite/bauxite Ferruginous and lithomarge clays, bentonitic clays	... Lower Eocene
UNCONFORMITY			
		Deccan Trap lava flows	..... Lower Eocene to Upper Cretaceous
UNCONFORMITY			
Upper Bhuj Series		Felspathic sandstone	..... Upper Cretaceous
Lower Bhuj Series		Shale, ferruginous sandstone	..... Lower Cretaceous

Occurrence :-

The Palaeocene laterites of Kutch are confined to a long, narrow (1-2 km wide) and arcuate belt which extends from Anjar in the east to Panandro in the northwest of the Kutch peninsula. This belt is 20 - 40 km inland from the coast, fringing the lower Tertiary shoreline while remaining parallel to the present coastline.

The laterite occurs in a single, gradational, residual weathering profile of Palaeocene age, developed over basalts of Cretaceous -

Eocene age. This profile consists of several members :

Soil	-	Top
Laterite/bauxite		
Kaolinite		
Bentonite		
Deccan Trap Basalt	-	Bottom.

All these constitute, what is popularly known as an "alteration blanket". Extensive exposures of laterite are found in nearly all talukas of Kutch district with the exception of Rapar and Bhachau talukas, where only minor exposures are found. Each exposure was studied and the weathering profile, where available described as per the norms of the Soil Taxonomy of the U.S. Department of Agriculture (1965). Sampling of the section was only carried out where complete weathering profiles were available. In this work, the laterite has been considered to be part of an alteration blanket, which is formed by insitu pedogenic processes. This has led to a vertical division into three major soil horizons :-

Horizon rich in oxides	-	B_{ox} (Fe,Al)
Horizon rich in silicates (saprolite)	-	B
Horizon of fresh parent rock	-	C

The A - horizon is nearly always eroded. The Soil Taxonomy of the U.S. Department of Agriculture (1965), has placed this type of laterite in the aquox sub-group in the group of oxisols which are soft during time of formation. During uplift above the groundwater level, the Fe-rich parts form hard ferricretes, whereas the Al-rich parts become hard alucretes (Goudie, 1973).

The salient field characters of the laterite occurrences in Kutch are as follows :-

1) The laterite occurrences are confined to a narrow, elongate Palaeocene belt, a few hundred metres to 1-2 kilometers wide, hundreds of kilometres long, running parallel to the Lower Tertiary shore line. This belt is sandwiched between the Cretaceous-Eocene Deccan Trap basalts and the subsequent Tertiary sequence.

2) This belt is characterized by low-lying, elongated laterite ridges separated by broad, intermittent valleys, which are generally 10-15 m deep. Deeply incised valleys are absent.

3) The generalized section in the laterite area is as follows :

Horizon rich in Oxides	B_{ox} (Fe,Al)
Horizon rich in Silicates (Saprolite)	B
Horizon of fresh Parent rock	C

Within this major section there are two types of sub-sections present, viz...

a) The High Silica Type (HST), and
b) The Low Silica Type (LST)

HST		LST
Laterite/bauxite	- B_{ox} (Fe,Al)	-laterite/bauxite
Kaolinite)) Saprolite Bentonite)	- B	-Kaolinite
Deccan Trap basalt	- C	-Deccan Trap basalt

4) Both the above mentioned sequences are continuous, gradational and residual in nature with no signs of sedimentary reworking.

5) This laterite sequence constitutes what is popularly known as an alteration blanket. Normally the soil sections are truncated with the A - horizon always eroded.

6) The HST type of sequence is generally located along the Trap/laterite contact, while the LST type occurs towards the Tertiary contact.

7) The lower most zone in both the HST and LST sequences is composed of Deccan Trap basalt. Exposures of this are limited in the laterite bearing areas. Either they are confined to the lowest zones of the lateritic profile, viz., in the pit and mine sections or on the surface at some places, eg., Mata-on-Madh. Typical spheroidal texture is exhibited.

At Mata-no-Madh, the complete section is surficially exposed.

8) The saprolite (zone B), consists of two layers, as stated above. In the HST type of section, the bottom-most layer is composed of wet, sticky bentonite. The colour of the bentonite varies from bottle green, lavender, buff, light red to dark red. This zone usually retains the original structure and texture of the underlying basalt. Relict amygdaloidal texture and exfoliation structures are common. The exfoliation structure is of two types, viz., (a) where the core of the exfoliated basalt and the outer rims are completely bentonitized, and (b) the inner core is of hard basalt while the outer rims are bentonitised. The relict textures present in the bentonite zone, are indicative that this zone was the first alteration product in the weathering of the underlying Deccan Trap basalts.

The bentonite layer is nearly always traversed by numerous thin veins and encrustations of calcite and gypsum.

9) The kaolinite layer in the HST as well as the LST sections is usually buff to grey coloured with occassional patches and spots of bright red colour. The boundary separating the kaolinite and the underlying bentonite (in the case of HST section), and basalt (in the case of LST section), is gradual with tongues of each member penetrating into one another. This transition, though gradual is quite well defined. The relict textures of the underlying basalt which are so well preserved in bentonite are either missing or ill-preserved in the kaolinite layer. The calcite and gypsum veins and encrustations so common in the bentonite zone, are either absent or present in negligible quantities

The boundary separating the kaolinite and the overlying laterite is also gradual but quite well defined.

10) Reddish to purplish red, hard concretionary or angular blocky or blackish laterite overlies the kaolinite with a gradual boundary.

11) The laterite contains large reserves of economically workable bauxite. These deposits are located on the Tertiary contact of the laterite belt.

12) Further, the laterite profile, viz., the saprolite zone is a good source of high grade bentonite clay. The occurrences are near the Deccan Trap basalt/laterite contact. In fact, Kutch district is one of the largest producers of bentonits in India.

13) From the above two points, it is very clear that bauxite and

bentonite cannot occur toghther. They are found occurring on opposite ends of the nearly 2 km wide laterite belt. Lateritization usually produces high grade bauxite deposits, but the occurrence of large reserves of bentonite as a part of the lateritic profile makes this quite unique in itself.

14) The intermittent low grounds between the hillocks of laterite are usually covered with boulders and debris of laterite. Rounded bits and pieces of various forms of crypto-crystalline silica are also found in the reddish soil.

Geochemistry:-

Systematic sampling was done at nearly all major exposures of laterite in Kutch. Where complete HST and LST types of sections were available, care was taken in sampling, so that each identifiable horizon described was represented.

The samples collected were then subjected to intensive laboratory investigations including major oxide, trace element and XRD analyses.

Chemical Analysis

Major Oxides and Trace elements

Normal silicate analysis of nearly 130 samples representing various horizons in the laterite profiles at various locations was done. Variation diagrams of the major oxides and trace elements versus depth have also been given.

The following vertical bedrocks thicknesses were consumed in the formation of the 8 LST and 2 HST sections under study :-

					Reduction in bedrock in m.
a)	Satapar (Anjar taluka)	-	LST type section	-	140 m.
b)	Goniasar mota & nana (Mandvi taluka)	-	LST type section	-	160 m.
c)	Hamla (Mandvi taluka)	-	HST type section	-	160 m.
d)	Chiyasar (Abdasa taluka)	-	LST type section	-	175 m.
e)	Nandra (----- " -----)	-	------- " ------	-	180 m.
f)	Nundhatar(----- " -----)	-	------- " ------	-	160 m.
g)	Naredi (----- " -----)	-	------- " ------	-	190 m.
h)	Balachor (----- " -----)	-	------- " ------	-	160 m.
i)	Wamoti (----- " -----)	-	------- " ------	-	180 m.
j)	Mata-no-Madh (Lakhpat taluka)	-	HST type section	-	160 m.

From the mass balance model studies of the above mentioned 10 profiles, one can easily conclude that enrichment of Fe and Al occurred due to vertical downward shrinking of the bed-rock and not due to the process of upward enrichment. This is further supported by the behaviour of the major and trace elements.

XRD :-

From the XRD analyses of samples from complete HST Type section from Hamla (Mandvi Taluka) and Mata-no-Madh (Lakhpat Taluka) and LST type section from Wamoti (Abdasa Taluka) the following conclusion can be drawn :

B_{OX} - Ferricrete

The zone of absolute enrichment of Fe with minor amounts of Al, kaolinite and with quartz as a constant. TiO_2 is also present in a little quantity. Quartz is constant.

B_{ox} -Alucrete

This zone represents the absolute enrichment of Al with minor amounts of Fe and kaolinite, Quartz remains constant.

B - Kaolinite

This zone which overlies the zone of bentonite represents the alteration of the montmorillonite minerals into kaolinite. Development of iron minerals is also seen.

B - Bentonite

This zone is the one overlying the Deccan Trap basalt and represents the first stage in the alteration of basalt. Together with montmorillonite minerals viz. montmorillonite, beidellite, etc. there is also initial development of kaolinite with traces of iron minerals. Quartz is also present.

C - Deccan Trap Basalt

This is the zone of fresh/partly altered parent rock viz. Deccan Trap Basalt. XRD reveals that the common Trap minerals are partly present in an unaltered form. Quartz is present.

Genesis of laterite :-

A general definition for laterite is that they "are superficial accumulation of the products of rigorous chemical selection, developing where conditions favour greater mobility of alkalies, alkali earth and Si than of Fe and Al (Norton, 1973)".

In order to achieve such a selection, several physical and chemical factors come into play, and they are :-

a) Climatic conditions, b) morphology, c) drainage, d) parent rock, e) chemistry of weathering of Deccan Trap basalt, and f) the process of lateritization.

Each of the above six factors have been discussed in detail, and following conclusions can be drawn regarding the optimum conditions required for the formation of laterite over Deccan Trap basalt :

a) **Climatic conditions** :-

The climatic conditions during the formation of these Palaeocene laterites was of the tropical type with alternating wet and dry conditions.

b) **Morphology** :-

The Palaeocene or Early Teritiary landsurface is present as relics on hilly areas, whose accordance indicates the presence of an extensive pediplain that was heavily lateritised (Biswas, 1974). This planation bevelled across the Deccan Trap (Upper Cretaceous to Palaeocene), matches with the terrestrial lateritic deposits of Palaeocene age. These deposits were laid down during the Palaeocene denudation when a near-perfect pediplain acquired an armour of duricrust, much of which has been eroded off during the subsequent cycles. These laterites constitute a part of an alteration blanket which was developed over the peneplaned surface of Deccan Trap basalts which had a weak relief seawards.

C) **Drainage** :-

The laterites of Kutch are found on continental margins where there was the interfingering of marine, fluvial and terrestrial sediments in this lateritic belt (Valeton, 1983), indicating that the alteration from Deccan Trap basalts to laterite took place in a near-shore environment.

For the formation of both HST and LST types of sections within one laterite belt, varying differences in drainage intensities is essential. Poor drainage conditions lead to a high-silica type whereas good conditions produce the low silica type.

For the solution, migration and precipitation of major and minor elements within this lateritic blankets, the following groundwater conditions must be fulfilled (Valeton, 1983) :

1) Net flow towards the sea.
2) Groundwater levels must be high and oscillatory in nature.
3) E_h conditions must be reducing.

d) **Parent rock** :-

The parent rock of the laterites in Kutch is Deccan Trap basalt. It is reddish-brown to brownish in colour with numerous amygdaloidal cavities filled with secondary minerals like zeolites, secondary silica etc.

Encrustations of gypsum are common. Extensive joint paterns are seen. This has facilitated the rapid chemical disintegration of the rock by providing access to the groundwater.

Microscopy reveals that the rock is usually hemicrystalline in nature with a good amount of glassy material present. The bulk of the rock is made up of a fine - grained mixture of groundmass of plagioclase felspars (labradorite) and augite. Phenocrysts of labradorite are very common. Olivine is present in the form of large to medium - size phenocrysts as will as in the groundmass. Sometimes, olivine is seen altered to serpentine of foxy-red iddingsite. Augite, the next important constituent is present as small grains in the ground-mass. Magnetite is abundantly disseminated throughout the ground-mass.

e) **Chemistry of weathering of Deccan Trap basalt** :-

The weathering of all igneous rocks maybe defined as the response of mineral assemblages which were crystallized in equilibrium at high pressure and temperature within the earth's crust to new conditons at or near the contact with air, water and living matter, giving rise to their irrevocable changes from the massive to the clastic or plastic state involving increases in bulk, decreases in density and particle size, and the production of new minerals more stable under the new conditions (Chorley, 1975). In this process, water plays a dominant role. The process of disintegration/ weathering of the parent minerals of the Deccan Trap basalt viz. (labradorite, olivine, augite and magnetite have been discussed in detail, and the following conclusions can be drawn regarding the intermediate and end products of each mineral under the tropical wet and dry physico-chemical conditions :

i) **Plagioclase felspar (Labradorite)** :-

Inadequate leaching conditions prevalent at the base of the laterite profile are incompetent to remove the magnesium and ferrous ions as rapidly as they are released from the break down of associated minerals. These ions tend to be 'fixed' by the broken framework structure of labradorite and polymerize into sheets, and montmorillonite results (Chapman and Greenfield, 1949; Smith (1957); Craig and Loughnan,1964.)

ii) **Olivine** :-

Olivine decomposes rapidly. However, the rate of release of the silica may exceed its rate of solution, in which case the residual silica polymerizes into sheets and apparently 'fixes'some of the magnesia, yielding serpentine as the crystalline phase (Loughnan, 1969). As the weathering intensity increases, magnesia is preferentially leached from the serpentine which becomes progressively unstable and is converted to a new silica-enriched phase, saponite (a montmorillonite group mineral). Ultimately, saponite becomes unstable, leaving a residue of oxides and hydroxides of iron (Loughnan,1969).

iii) **Augite** :-

The chain structure of augite breaks down and polymerizes into sheets incorporating residual alumina and magnesia, forming chlorite or montmorillonite, or both. As the intensity of weathering increases, all the lime and magnesia are lost together with the silica not required to saturate alumina, and oxides and hydroxides of ferric iron (Loughnan, 1969).

iv) **Magnetite** :-

The mineral oxidizes during weathering to yield hematite, maghemite, and (or) goethite.

Genetic Model :

The initial belt which underwent lateritization was, as discussed earlier, highly jointed and with many pillow structures due to rapid cooling. This physical condition of the parent rock made it amenable to rapid chemical deterioration,with differential intensities on either ends of the width of the laterite belt.

This is attributed to the slight slope, seaward (5-10^{o}) of the Deccan basalt on the one hand, and the presence of intensely pillowed and jointed basalt seaward which would facilitate free drainage. Inland, near the contact of the Palaeocene lateritic belt and the Deccan Trap basalt, the drainage, near the weathering front would be sluggish.

In fact, within a width of 1-2 km, two different types of drainages can be seen. This in turn, led to the evolution of two kinds of geochemical weathering environments viz., one with a free drainage and oxidising conditions, i.e., near the sea, and the second, with a sluggish drainage and reducing conditions, inland.

Hence, in this laterite belt, due to the differing geochemical environments on either side of the width, attributable to the topography, both relative and absolute accumulations have taken place. The inland positions are predominatly sites of relative accumulation, as there is maximum potential for surface lowering.

Nearer the sea, downslope mechanical movement of residua from higher topographic positions is more common.

In the laterite belt, material escaping retention in topographically higher positions inland would move downprofile and downslope and tend to be precipitated in slope-bottom situations where the water-table approaches the landsurface near the sea. There is also downslope mechanical movement of residua from higher topographic positions. Since in the early stages of lateritization, when the slopes were relatively steep, downslope movement was most favoured, slope bottom situations were usually the first to show accumulation, and with progressive slope reduction the accumulation in effect extended upslope to cover the interfluve.

In short, within this narrow laterite belt, there are areas in which relative and absolute accumulation predominate and are identifiable.

Represents the initiation of weathering of the edge Deccan Trap basalt having an elevation range between 140-190 m. The original elevations have been calculated from Cr-retained mass-balance models of the various complete LST and HST profiles in the area. Inland, percolation exceeded run-off, whereas, it was inverse seawards. This resulted in residual accumulation inland with mechanical movement downslope, seawards.

The earlier stated slightly acidic rain water initiated the hydrolysis of the parent rock mineral assemblage of labradorite-olivine-augite below the water table. This produced Mg, Fe, Al, montmorillonite minerals (bentonite zone) as alteration products. The most mobile elements were evacuated by the seawards moving ground water.

The bentonite zone occurred at progressively lower levels as the weathering front lowered below the ground water table level. The other profile interfaces including the overlying kaolinite, laterite and the landsurface interface followed suit above the groundwater table level. The products of each stage of weathering provided parent material for the succeeding stage and the accumulation of the most resistant components which characterized the laterite zone thus derived from an overhead source.

Because the interface was moving vertically downwards, relatively resistant residua must, of necessity, accumulated there. In effect, the landsurface was "shrinking like a rotten apple" and lateritic residua were trapped at the lowering interface (McFarlane, 1987).

From the Cr-retained mass balance studies of selected LST and HST profiles, it is seen that Fe and Al behave antipathetically. Geochemical laws fail to explain the mobilities of both in these profiles and this will be discussed later on in detail.

The bentonite, which occurred below the groundwater table level started decomposing into kaolinite above the water table due to freer drainage conditions, by intracrystalline leaching of interlayer cations and tetrahedral silica layers as has been suggested by Altschuler et.al. (1953). This consisted of :

(1) Acid leaching of interlayer cations and synchronous or immediately subsequent hydration and stripping (leaching of interlayer cations and synchronous or immediately subsequent hydration and stripping) (leaching of silica layers.

(2) Relapacement of vacant tetrahedral oxygen sites by hydroxyls to create a highly polar kaolin-like arrangement in the residual 1 : 1 sheet.

(3) The highly charged outside layer of hydroxyl protons contracts the interlayer space of that of kaolinite by identical charge polarity.

(4) Extension of the kaolin-like sheet laterally by epitaxial growth of true kaolinite anddevelopment of hexagonal modification outgrowths at the edges of the montmorillonite flakes.

(5) The primitive kaolinite crystals are nourished and enlarged as the montmorillonite continues to break down. New layers of kaolinite are added.

The formation of the kaolin belt marked the threshold for lateritization. The then kaolinized saprolite, must have been dominated by kaolinite, quartz, iron and aluminium minerals. This saprolite could only be lateritized if the kaolins broke down and quartz was leached out. McFarlane (1987), has stated that "the removal of quartz is common to both iron and aluminium enriched residua. It is the nature of dissolution of the kaolinite which is central to the question of whether the lateritic residuum is enriched in iron or aluminium. In the case of iron rich resudua, kaolinite is congruently dissolved, Si abd Al are both evacuated. For the development of an aluminium-rich resuduum, kaolinite is incongruently dissolved, Si is leached out and Al remains as gibbsite. This is accompanied by leaching of Fe". The question of where bauxitization is achieved therefore requires an assessment of the criteria which control these two routes, beyond the kaolinization stage, into lateritization.

Although some extremely resistant primary minerals survive in the residuum, it is ultimately dominated by iron minerals (especially goethite and hematite) or aluminium minerals (especially gibbsite). The number of stages in the progression varies, apparently with leaching intensity, as is evident in Kutch with the HST profiles have an extra bentonite zone with the same missing in the LST profiles. The variation in the number of stages in the progression within one laterite belt can be attributed to leaching intensity (McFarlane, 1983 a).

In the case of Fe enrichment, the most common kind of lateritization, congruent kaolinite dissolution is necessary, yet there is no known means by which both Al and Si can be evacuted in solution. Even if Al is present only in trace amounts, this causes immediate co-precipitation of Si and Al (Okamoto et.al. 1957). In the case of bauxitization, although congruent kaolinite dissolution can be achieved, the removal of Fe with the Si can not. Extensive leaching experiments concerned with extraction of Al from kaolinitic materials, inevitably with Fe as a contaminant, have shown that the Fe and Al are inseparable. Yet in nature this separation is common with Fe and Al behaving antipathetically (McFarlane, 1987), as is the case in Kutch. It is hypothesised that Fe enrichment (laterite protore formation) came first , followed later on by Al enrichment due to favourable environmental conditions.

All along, the process described continuing, with further reduction of landsurface accompanied by retreat. The slope bottom absolute Fe accumulation crept upslope to such an extent, that it covered the entire slope and part of the crest also. That gave an apparent illusion that the Fe crest was residual in origin formed by the upward migration of Fe. reveal that there are top horizon gains of Fe with underlying horizons having less Fe, giving an illusion of upward migration. During this time the Al was retained in the kaolinite zone.

Much is known about the factors effecting the formation of metallic oxides and hydroxides in the weathering profile (Segalen, 1971). Selective removal or retention depends in large part on the pH and Eh (Berge, 1971, Norton, 1973), organic complexing (Huang and Keller, 1970) and rates of reactions. However, attempts to explain the mineral and chemical assemblage in each horizon of the lateritic profiles in Kutch in terms of pH and Eh have met with considerable frustration. Norton (1973), observed that the assemblages of minerals in many laterites do not conform with the stable assemblages which should occur under the varying conditions of pH and Eh which are held to define the limits of mineral stablility. The main reason for this appears to be the inheritance effect in which weathering products of each horizon may survive into higher-lying horizons where more advanced chemical selection and its products predominate (McFarlane, 1983). This is adequately demonstrated in both LST as well as HST profiles in Kutch, as revealed, by x-ray studies. There are no zones of pure products, but remnants or neo-formed products of preceeding or succeeding stages respectively are seen interspersed with the main mineral constituent of that particular zone. Further proof of the inheritance effect, is evident in the proliferation of relict parent rock textures, in the bentonite zone with gradual destruction of the same upwards in the profile.

This process of inheritance has resulted in a structural and mineralogical assemblage which is not in a state of equilibrium at any particular horizon, an assemblage which can not be explained in terms of a single set of hydrological history (McFarlane,1983).

Failure of geochemical explanations for the varying mobilities in the LST and HST sections of Kutch for both Fe-enriched and Al-enriched residua following the above mentioned kaolinite dissolution leads one to point towards an important biological control (McFarlane, 1987). Geochemical constraints do not apply to Si, Fe and Al co-moblilties when biologically complexed material come into the picture. Hence, biological activity seems to be the obvious choice. Humus complexing is unlikely to be the main mechanism since lateritic profiles are notoriously poor in humus and efficient nutrient re-cycling is essential to the maintenance of plant communities in humid tropical areas(Kronberg and Melfi, 1987). Microbial complexing would seem the best candidate. Field evidence in support of a microbial role has long existed in the form of casual observations. The waters issuing from the base of profiles may be strongly carbonated (Fox,1927). Local bauxitization is not explained by continuous pisolithic textures across the boundary of the bauxitized zone, influence of parent rock,protore texture, climate or vegetation, hence an extremely repeated local and subtle factor must have been in operation; microbial activity appears to be the only reasonable explanation (McFarlane, 1987).

The suggested role for microbial complexing in the progress of lateritization faced an initial objection from the earlier work of soil scientists, which had led to the belief that below about 1 m, microbial activity is negligible or non-existent for want of a nutrient supply, provided at and rapidly exploited near the surface. Lateritized and bauxitized profiles extend to tens of metres in depth (McFarlane, 1987). This objection is no longer valid.Micro-organisms have been successfully isolated from lateritic and bauxitic profiles at various depths far in excess of 1m (Button, 1981, Williams, 1981, Perviz, 1983).

As concerns the mobility of Fe in lateritic profiles microbiologists have long known that even where Fe is in abundance in soil profiles, the supply in ionic form does not satisfy the metabolic requirements of the microbial population and an ability to attack already formed iron hydroxides has been deduced (McFarlane, 1987). The ability results from the secretion of special chelating agents with a high specific affinity for iron, the hydroxanates and phenolates ("catechols") (Byers,1974). We know therefore that iron minerals can be broken down by microbial activity. We also know that some micro-organisms are capable of precipitating iron from solution. Iron is clearly mobilised in contexts geochemically unconducive to mobilisation and micro-organisms which are capable of iron mobilisation exist there (McFarlane, 1987).

In Kutch the bauxitization of the lateritic protore must have been initiated during the Eocene marine transgression, with an enhancement of this activity during the post-Tertiary to pre-Recent times. This is attributed to the fault which had displaced the entire Tertiary sequence, and resulted in the present topographical position of the Palaeocene belt. From. it can be seen that a majority of the HST profiles are located between the 60-80 m contours, while the LST profiles are found between 80-140 m contours.This elevational change of LST profiles could have been another cause of enhancement of bauxitization, but, during a much later period , when traditionally speaking, the conditions were inconducive for bauxite formation. This makes one wonder whether the genesis of LST profiles matured during the Quaternary time.