CHAPTER II

PREVIOUS WORK

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In the past, most of the geological investigation were based mainly on the palaeontological aspects of the Mesozoic and Tertiary formations. A few workers had dealt with (1) seismicity of the region, (2) nature and origin of the Rann, (3) the Deccan Trap activity, (4) general stratigraphy and structure of the rocks of Kutch, (5) the economic aspects of minerals, including coal, lignite, petroleum, ground water, bentonite and bauxite.

Medlicott (1829), was the first person to work out the geology of Kutch region. Fox (1829), reported the occurrence of coal seams in the Cretaceous rocks of Kutch.

Grant (1837), gave the geology of Kutch and his report was accompanied by map-plates and list of fossiles.

Blandfird (1867), had taken a number of rapid N-S traverses and reported the existence of an E-W fault along the northern fringes of the Charwar-Katrol hill ranges. He also stated that the

terrestrial rocks were actually intercalated with the marine Jurassic rocks.

Wynne (1869), has correlated the plant beds of Kutch with the Rajmahal series (upp. Gondwana) on the basis of a few forms of ptilophylum found common in both formations.

Wynne (1872), gave a comprehensive account of the geology of Kutch and published a detailed geological map of the region for the first time. He described the bentonite and associated rocks of Kutch as "Volcanic Tertiaries" formed during Eocene times. He also made a reference to laterite and untouched aluminous rocks. He opined that the pyroclastics of Kutch might have been formed in subaqueous conditions and that their condolidation must have takens place beneath the water. The geological sequence worked out by him is as follows :

FORMATION	SUB-DIVISIONS	PERIODS
Recent	Alluvium, blown sand & sub-recent deposits	Pleistocene
	Upper Tertiary	Miocene or Upper Eocene
---------- Unconformity ----------		
Tertiary	Argillaceous group (fossiliferous) Arenaceous group Nummulitic group Gypseous shales	Eocene
Volcanic Tertiary	Sub-nummulitic Stratified Traps and associated intertrappean beds, Infratrappean beds.	
---------- Unconformity ----------		
	Upper Jurassic group Lower Jurassic group	Oolitic Jurassic

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Metamorphic Crystalline	Syenite
Trappean	Intrusive Traps

Middlemiss (1921), discussed the geology of mainland Gujarat.However, he did not report the occurrence of bauxite.

Gupta and Mukherje (1938), in their classic report on "The geology of Gujarat and Rajputana" recorded the occurrence of bauxite for the first time near Kapadvanj in Kheda district. They considered the laterite/bauxite as homotaxial with Ahmednagar sandstone series viz. Infratrappean.

Krishnan (1953), believed that the dykes in Kutch were the feeder of trap flows while Auden (ibid) considered these as the earliest eruptions during the upper most Cretaceous to earliest Eocene.

Poddar (1953), recorded the occurrence of aluminous laterite near Manafara of Bhuj taluka in Kutch district. He described this rock as "blotchy, aluminous, mottled clay", overlain by ferrginous laterite. According to him, the aluminous laterite was highly siliceous (35-49% Si_2O) and with a low alumina content (34-42% Al_2O_3), hence could not be classified as bauxite.

Taylor and Oza (1964), made a passing reference to the laterites of the Dudhai area in eastern Kutch. According to them, the position of this laterite horizon was as follows :

Upper Manchhar Series

---------- **Unconformity** ----------

Eocene (?) 0 to 6m +- Aluminous,ferruginous laterite derived from Deccan Trap and shales and/or sandstone of the upper Bhuj series.

Deccan Trap

Poddar (1955), while mapping parts of Mandvi and Anjar talukas, recorded for the first time occurrence of bauxite near Anjar and laterite near Tumdi and Ramania of Mandvi taluka. He proposed the following geological sequence for these localities :

Alluvium to Sub-Recent	... Post Tertiary
Siwaliks (?)	... Pliocene
Laterite	... Lower Eocene
---------- **Unconformity** ----------	
Traps	... Cretaceous - Eocene

Venkatappaya (1955), pointed out that the Deccan traps were observed in the parts of Bhuj taluka and that the laterites rested on sandstones of upper Bhuj series. He proposed the following stratigraphic sequence :

Manchhar beds	.. Pliocene	)
----------Unconformity----------		)
Supra-trappean clays and laterite	.. Eocene	) Tertiary
----------Unconformity----------		)
Basic Intrusives	.. In Mesozoic rocks only	)
Upper Bhuj Series	.. Lower to Middle .. Cretaceous	) Mesozoic
----------Unconformity----------		)
Katrol Series)	.. Upper Jurassic	) Mesozoic
----------Unconformity----------		)
Chari Series)		)

Poddar (1959,63), once again reviewed and summarized the Tertiary stratigraphy of Kutch and attempted to build up a complete chronological sequence.

During the period ranging from 1963-70, officers of the Directorate of Geology and Mining, Government of Gujarat, worked on different localities in Kutch and described in detail the bauxite deposits as below :

			Taluka	
1.	Desai	Geologist	Mandvi, Lakhpat	1963-64, 64-65
2.	U.D.G. Rao	Sr. Geologist	Abdasa,Nakhatrana Mandvi	1964-65
3.	H.R. Vyas	"	Nakhatrana, abdasa Bhuj, Anjar Mandvi	1964-65 1965-66 1967-68
4.	N.V. Shah	Asst."	Mandvi	1967-68
5.	J.M. Parikh	" "	Mandvi Abdase,Nakhatrana	1967-68 1968-69
6.	J.V. Bhatt	" "	Mandvi	1967-68
7.	N.J. Patel	" "	Abdasa,Nakhatrana	1969-70

The reserves of bauxite as determined after the above studies was around 27.85 million tonnes.

Sahasrabudhe (1964,66), carried out a systematic geological mapping of the bauxite areas of kutch, jamnagar, bhavnagar, sabarkanth, kheda and valsad districts. On the basis of his studies, he published a paper in 1964 and later submitted a doctiral thesis on "The geology and genesis of bauxite deposits of gujarat". He mainly carried out his studies on the bauxite deposits ofkalyanpurmahal of the jamnagar district and a few

lelected localities of the other parts of gujarat . He regarded the bauxite deposits of saurashtra as having a brecciated or tuffaceous appearance. Three types of bauxite deposits were recognised by him in gujarat. His type 1 were the bauxites that apper to have been formed during the alteration of the pyroclastic facies of the deccan lava flows. These pyroclastic rocks were thought to have been emplaced through cryptovolcanic structure or diatremes during the deccan volcanic activity and by sub-aqueous explosions connected with the above volcanism phase. The type II of bauxite bearing laterites represented the transported and reworked facies of the first type and showed typical sedimenar depositional features. The type III of bauxite deposits occur as elongaated and funnal shaped irregular pockets resting over the uneven surface of limestone and clays, filling depressions, formed during minor deformation during the tertiary period. These also characteristically exhibit the secondary depositional features. He further suggested that the bauxite deposits of saurashtra and kutch are of type I and II while those of sabarkantha, kheda and valsad districts are of type III.

He modified the geological sequence of kutch originally proposed wynne (1872), as follows :

Alluvium, blown sand and sub-recent deposits.	---Recent - Pleistocene
Upper Tertiary	---Miocene

----------unconformity----------

Argollaceous group (fossiliferous)
Arenaceous group
Nummulitic group
Gypseous shales
Laterite,pyroclastic and)
Volcanoclastic sedimants)

(sub nummulitic)) Deccan
stratified trap and associated trap
inter -trappean beds etc.) (Lower Eocene)
)

Infra-trappen grits

----------unconfoemity----------

Upper Jurassic group
Lower Jurassic group

Biswas (1965,71), following the stratigraphic code recommended by the american commission of stratigraphic nomenclature (AAPG 1961), proposed a time-rick classification. He opine that the Tertiary sediments were deposited on the eroded surface of the trap flows and on mesozoic sedimentary rocks. According to him, remarkable uniform condition prevailed during the Tertiary sedimentation, whichbegan with the marine transgression during the Lower Eocene and ended in Pliocene. He grouped bentonites and associated formations viz. the laterites and bauxites together and designated them as Madh series. This series is believed to rest unconformably over the basalts of Upper Cretaceous to Palaeocene age. According to him, trap wash and volcano-clastic sediments were deposited in a continental to supralittoral environment which gave rise to Madh series during the Palaeocene period. The classification proposed by him is as follows :

Table - 1

Age	Series	Stage	Lithology
Holocene	Recent	-----	Alluvium, Rann silts and blown sands.
Pleistocene	Milliolite formation	-----	Oolitic,calcareous sandstone.
	----------UNCONFORMITY----------		

Pliocene	Kankawati	-----	Grey sandstone, pink fossiliferous Calcgrits, and conglomerates.
	----------DISCONFORMITY----------		
Miocene	Khari Series	Vinjhan stage	Grey and Khakhi clay, fossiliferous calcgrits,
		Aida stage	Variegated silt-stone.
	----------UNCONFORMITY----------		
Oligocene	Bermoti	Waoir stage	Dirty white and yellow banded mar 1 and impure
		Ramania stage	Limestone.
	----------PARACONFORMITY----------		
Eocene	Berwali	Babia stage	Silty limestone, fossiliferous calcerous clays and shales.
	----------DISCONFORMOTY----------		
		Khakdi stage	Grey shales and red laterite . Brown gypseous shales and green glauconitic shales with thin fossiliferous marls and mud balls. Locally gypseous shales with red ochre and black shales with lignite beds.
	----------DISCONFORMOTY----------		
Palaeocene	Madh	--------	Laterite conglomerates, laterites, bauxites, tuffaceous shales, sandstone and grites, bentonite and ferruginous clays with volcanic ash.
	----------UNCONFORMITY----------		
Upper	Deccan	--------	Dark green basalts, alternating flows of columnar and amygdaloidal basalts, locally intertrappean beds are present.

Jean Sabot (Pechiney's Grance), during his visit to the bauxite areas of Kutch in 1966 (in Rao 1976), suggested that the bauxite in Kutch were the result of weathering of the underlying Traps

and were therefore entirely ferruginous in nature. He was of the opinion that the bauxite patches in laterites were formed due to defferrication of the original material by percolating waters. "Whenever there was deep and free penetration of water owing to the presence of the joints, fractures etc., a good, thick bauxite layer was formed and where it remained more or less the same. The high iron content of some lithomarge may due to impregnation of ferric oxide by percolating waters as mentioned above".

Talati (1966), carried out petrographic analysis of bauxite samples collected from various localities in Kutch. His study revealed that the mineraloid cliachite was predominant and monohydrates (oehmite, diaspore) were also present in bauxite.

Krishnan (1958), opined that the lowest Teritiary beds lying over the Deccan Traps were the Madh Series of Palaeocene age, composed of 30-49 m of laterite or tuffaceous or bentonitic clays of bright colour and were probably derived from the erosion of Deccan Traps. He put forward the following classification :

Porbandar series (15-20 m)	- Pleistocene
Kankawati series (370 m)	- Pliocene
Khari series	
Khari stage (upper - 340 m)	- Burdigalian
Waior stage (lower - 10 m)	- Aquitanian
Lakhpat series (10-12 m)	- Oligocene
Berwali series (130 m)	- Kirthar
Kakdi series	- Laki
Madh series (30-40 m)	- Laterite, tuffaceous clays, bentonite clays, pyritic and gypsiferous sandstones. Palaeocene.

Balasundarama (1970), reviewed and summarised the work done on the geological set up, distribution, mode of occurrence and norms of exploitation of bauxite deposits of western region of India.

Rao (1975,76), while prospecting and estimating the bauxite reserves in Kutch recognised two different laterite/bauxite horizons. According to him, one horizon was of Palaeocene age while the other was of Miocene (Pre Gaj to Post Laki age). However, he did not demarcate the exact localities of field occurrences. He classified the bauxite deposits of Kutch into three : (1) massive blanket type, (2) bouldery type and (3) earthy type. He opined that the bauxite deposits were formed from Deccan Trap as well as from supra-trappean sediments. According to him, massive blanket type bauxite deposits were reworked and transported facies while the earthy bauxite deposits belonged to the second laterite horizon. X-ray diffraction and infrared absorption spectroscopy carried out by him, revealed that meniralogically, Kutch bauxite contains mainly gibbsite, with sub-ordinate bowhmite, goethite, hematite, anatase, kaolinite and quartz while caalcite occurs as an accessory. He also estimated gradewise reserves of Kutch bauxites. On the basis of field observations, he proposed the following stratigraphic sequence and publlished a geological map :

Alluvium, blown sand etc.		- Recent
Miliolite limestone,		- Pleistocene (1)
Nummulitic limestone, shales, Yellowish limestone Sandstone	Manchhar Gaj Kirthsr (Upper Eocene)	- Miocene to Pliocene

----------Unconformity----------		
Bauxite/Laterite		- Pre Gaj/post Laki (?)
----------Unconformity----------		
Sand-beds, shales Carbonaceous shales/lignite seams sandstone		- Lower Eocene to middle Eocene - Laki formation
----------Unconformity----------		
Bauxite/Laterite Lithomarge and feffuginous clays Stratified Basaltic lava flows	Deccan Trap	- Palaeocene - Supra-trappean formation - Upper Creataceous to to Lower Eocene.

Nene at. el. (1976), studied the occurrence of bentonitic deposits and their relations to the Deccan basalts. In their opinion, the bentonite deposits area lower Teritiary in age. They suggested that majority of Kutch bentonite deposits were derived by the in-situ alteration of tholeiitic basalts under marine conditions and are congenetie with basalts. They gave the following stratigraphic sequence for the nentonite areas :

Recent to Sub-recent	- Soil cover aand blown sand	
Lower Tertiary	- Gritty sandstones, shales) limestone, white greys) sandstone and bentonite) beds. Basalts conglomerates - ferruginous sandtone, plastic clay beds and tuffaceous sandstones	All the units forming bauxite & latirate
Palaeocene	- Bentonite Deposite	
Upper Cretaceous	- Balast flows.	

Balasubramaniam and Sabale (1976), after studying profiles at Wandh, Goniasar and Jhulrai-Saran in Kutch, concluded that the bauxite of Wandh-Goniasar wa of inditu origin while the Khulrai-Saran bauxite was formed under conditions much similar to mioeugeosynclinal zones of U.S.S.R., as reported by Bushinsky (1971).

Deisken et. al, (1976), mapped the area around Wandh of Mandvi taluka and suggested that the laterite were supratrapiean in age. They considered the bentonite deposits to be formedd by the auto-hydrothermal deuteric alteration of the basalt pillows.

Patel (1978), studied the geology of the bauxite deposits of Kutch and Valsad districts (Gujarat State) and gave their mode of occurrence and genesis.

Based on field observations, he classified the bauxite deposits of Kutch into four types ; each having distinct characters and definite genetic relations.

Type I : Invariably these deposits occurred on the top, crests and upper slopes of hills and formed long, linear pockets. These bauxites were hard, massive and mostly ferruginous in nature.

Type II : These types of deposits were generally located on the lower slopes of hills, in depressions and in valleys. These wrer not uniform in lateral extent and formed irregular, elliptical and flat lying bodies. The boulders of bauxite wrer embedded in clays and had a semi-conglomeratic to semi brecciated appearance.

Type III : These types of deposits generally occurred as beds and lenses within a sedimentary sequence. The boulders and nodules of bauxite, laterite with lithomargic clay were embedded in a gritty matrix and formed a peculiar whitish coloured rock. These types of deposits were observed instream sections and were of no economic importance.

Type IV : These deposits wre characterised by a soft, earthy nature and they had high silica and titania content. They formed small pockets of irregular dimensions and wre overlain by Tertiaries. They were found associated with beds of lignite,

gypsum, etc.

Nayak recognized one principal geological aspect regarding the distribution of bauxite deposits, viz., most bauxite deposits were located on and around the contact of Deccan Trap basalts and the Tertiary sequence.

He carried out petrography, scanning electron microscopy. x-ray diffraction, chemical analyses and trace element analyses of samples collected by him from typical sections of the area.

In the genetic model postulated by him, a generalfererence has been made to the traditional requirements of climate, relief,parent rock, H, water table fluctuation, predominance ofchemical weathering over physical weathering and time for the formation of bauxite.

With the aid of the laboratory data he had postulated that :

(a) Type I bauxite deposits were insitu alteration of Deccan Trap basalt. But the mechanism suggested by him is not clear, though chemical progressions have been given.

(b) Type II bauxite deposits were reworked and transported facies of Type I bauxite deposits. The poor sorting of the gravels and boulders and quick lateral changes obseerved in the profiles indicaated short, quick and turbulent transport and sedimentationclose to the shoreline.

(c) Type III bauxite depostis represented the Tertiary sedimentary bauxite and were deposited along with Laki shale.

(d) Type IV bauxite depoosits were formed due to transportation in a colloidal state by streams and deposited in land locked basins.

The model as suggested by him does not take into account the

relationship between laterite and bauxite, giving more emphasis on the formation of the alucrete while giving a passing reference to the laterite. Hence the model suffers from the fact that it does incorporatd any mechanism which gives the differentiation of the alucrete and ferricrete formed by insute geochemical processes acting over the parent Deccan Trap Basalts. Further, it is not clear from the genetic model whether the enrichment of A1 and Fe are due to relative or absolute accumulation.

Valeton (1983), studied the laterites of Kutch andsuggested how high level bauxites were formed in coastal plains. She also seccribed how palaeoclimate, palaeoshoreline, relief, palaeogeography, the then prevalent geochemical environment, the level and direction of flow of groundwater all played their roles in the formation of laterites of Kutch.

She described the formation of lateritic bauxites in the Tertiary coastal plains of Kutch in the form of elongate belts, hundreds of kilometres long, parallel to Lower Tertiary shorelines. Their distibution was not dependent on a particular mineralogical composition of the parent rock. She considered the lateritic bauxite to be part of an alteration balnket, which formed by insitu pedogenic processes leading to extremely intensive geochemical separation of Si, Ti, A1 and Fe culminating in a veritical division into three major siuk horizons :

Horizons rich in oxides	B_{ox} (Fe, A1)
Horizons rich in silicates (saprolite)	B_{v}
Horizon of fresh parent rock	C

This vertical division was brought about by the lateral movement of the major elements A1, Si, Fe, Ti, which was dependent on a high level and flow of groundwater. Varying

efficiency of subsurface drainage produced lateral facies variations along both the strike anddip of the lateritic bauxite belt with swells and basins caused by synpedogenetic movements. The dufferentiation along the strike of the belt was marked by two facies types :

(i) Low-silica type with a kaolinitic saprolite.

(ii) High-silica type with a bentonitic and kaolinitic saprolite.

After the Soil Taxonomy of the US Department of Agriculture (1965), these types of lateritic bauxites belonged to the sub group of aquox in the group of oxisols which were soft diring time of formation. During uplift above the groundwater level, the Fe-rich parts formed hard ferricretes, whereas the Al-rich parts become hard alucretes (Goudie 1973).

Further, for the translocation of the major and minor elements within the bauxitic alteration blanket, the following groundwater conditions must be fulfilled :

(1) net folw towards the sea :

(2) groundwater levels must be high and oscillatory in nature ;

(3) E_h conditions must be reducing.

All the above took place in a marine/continental facies which indicated a sea-land transition zone where the type of sediments also varied with minor tectonic movements or sea levelchanges. Valetonalso stressed that many high-level bauxites were formed in coastal plains and that they were subsequently uplifted to their present altitude.

This model has several shortcomings which have been very

effectively raised by McFarlane (1983). This has been discussed in chapter VI describing the genesis of laterite.

Sychanthavong and Patel (1987), have given a very good account of the relevence of the drift tectonics of the Indian plate to the formation fo laterites in northwest India.