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Physico-Chemical Characterization of Laterites of Mallampalli Subgroup, Mid- Proterozoic Pakhal Basin, Telangana, India

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Abstract: *The Pakhal outcrops occur in three patches extending from Sirpur at the northern border of Telangana to Kothagudem in NW-SE direction. Pakhal sediments are exposed over a length of 350 km along the strike direction of major geological groups parallel to the direction of the Godavari valley which is NW to SE. The Pakhal Basin extends in three districts namely Warangal, Karimnagar and Adilabad districts of Telangana. Pakhal is 1600 m thick consisting of arenaceous, argillaceous and calcareous rocks. The Mallampalli group is exposed between the Maneru river and the Pakhal lake area. In this group, oldest formation is the Mallampalli conglomerate, which consists of boulder conglomerate, arkose and quartzite. Mallampalli conglomerate is overlained by the Mallampalli dolomite unit which consists of dolomite and dolomitic limestones with interbeds of grit, arkose, glauconitic sandstone, chart, shale and calcarenite. This dolomite grades into a shale forming the top unit of the Pandikunta shale. The laterites of Mallampalli are in the form of capping, having an aerial spread ranging from 20 to 25 sq. km and varying thickness of 5 to 10 m. The study area falls in tropical and subtropical climate and experience an annual temperature range of 25 -30^{0C} and rainfall 50-200 cm per annum. It is aimed here to discuss the physico-chemical parameters and product of lateritization with particular reference to Mallampalli Laterites and their economic potentialities in this paper. The Laterites in the area are dominantly composed of iron bearing minerals such as goethite and limonite. Frequently quartz is seen as a relict mineral present in the lateritization profile. The chemical analyses of Laterites reveal a high percentage of Fe_2O_3 fallowed by Al_2O_3, and SiO_2 and all the samples recorded a high value of LOI. These four components together constitute 98.53% of the total composition of the laterite.The study substantiates that the Laterites are the products of chemical weathering process, under tropical climatic conditions, by concentration of Iron and Aluminum in the near surface horizons while removal of soluble elements especially, alkalies.*

I. Introduction

Laterite is used as a petrographic term for a rock, generally cavernous and vesicular, rich in hydrated iron and aluminum oxides and depleted of bases and aluminum [1] [2]. The aggregate chemical and mineralogical composition of the entire residual blanket in Mallampalli conforms to a typical laterite [3].

Indian laterite occupies a place of special geological significance. It is wide spread as a rock crust. Its economic potential is great, being the source of industrial minerals like bauxite, manganese ores etc. It has been the source of iron ore for the indigenous smelting industries from time immemorial. Recognition and description of laterite in India conform to certain basic features. The cardinal features for deriving the basis of the definition are: (1) presence of a large amounts of iron, aluminum and manganese oxides and titania all in varying proportions, (2) depletion of free silica (quartz), (3) higher percentage of alumina than necessary to combine with silica to form kaolin, (4) negligible or no bases and alkalies and (5) hardening on exposure to air.

Laterites and Lateritic bauxites occur extensively on Indian Peninsula [4] [5]. They occur as disconnected capping or blankets ranging in elevation from almost sea level. The thickness varies from 0.20 m to 15 m rarely exceeding 30 m. These Laterite deposits are known to derive from varied geological formations of different ages. Laterite deposits occurring on a particular geological formations show compositional variation with altitude. Laterites occurring on the slopes of the hills and on the plain areas are known to be enriched in iron content, even though the process of lateritization has taken place on the same type of rock and in the same climatic zone. Considerable work has been carried out by various researchers [6] [7] [8] [9] [10] [11] [12 [13] in the Laterites of Eastern Ghats.

The compositional variation has led the author to make through investigation on the Laterite patches of high iron concentration in the study area. Laterite is a blanket type deposit and has a thickness of 2 to 5 m in the entire study area. The study area (Fig. 1) comes under Mallampalli Group of Pakhal Super Group having Middle Proterozoic age. The Mallampalli Group is exposed in the Maner River on the Pakhal lake area. The study area is represented by ferruginous shale which is the bed rock and highly weathered and decomposed resulting in the formation of Laterite (Fig. 2). The Laterite contains average weight parentage of Fe_2O_3 - 30.77 %; Al_2O_3 - 20.42.%; SiO_2 - 35.78% with LOI - 13.03% (Table II).

II. Geology of the area

Most of the Proterozoic basins in India, viz., the Vindhyan, Cuddapah and Pakhal basins have experienced long hiatus between the Upper and Lower Group of rocks [14].

The Pakhal basin, along the Godavari Graben that consists of Pakhal Super Group of rocks, largely comprises of mafic intrusions and metasedimens of Palaeo-Proterozoic and Sullavai Group of metasediments of Neo-proterozoic age [15]. Godavari Proterozoic Belt separates the Bhandra - Bastar and Dharwar Cratons to the NE and SW respectively. It also represents a proterozoic collision zone [16] between these two cratons with granulite belts of about 1.6 and 2.4-2.2 Ga along its NE and SW margins which are known as Bhopalpatnam and Karimnagar granulite belts respectively [17].

Pakhal Group of rocks is exposed on either sides of the NW-SE trending Gondwana rift within the confines of the Godavari graben. Based on the intensity of deformation, grade of metamorphism and their geographic distribution, the rock types in the southwestern sector of the Pakhal basin can further be subdivided into two different litho-tectonostratigraphic units. They are represented by: (1) an unmetamorphosed siliciclastic-carbonate association representing the platformal assemblages either lying unconformably over or along a faulted contact with the older gneisses and metamorphites of the Eastern Dharwar craton in the west, and (2) a strong deformed and metamorphosed metasedimentary assemblage, earlier designated as Mallampalli and Mulug Formation of lowermost Pakhal, along with occasional granitic basement inliers, in the east. An elongate body of mylonitised granite, likely to be emplaced syntectonically along a ductile shear zone, occurs in between these two tectono- stratigraphic units.

Determination of the age of sedimentation by 40Ar/39Ar analyses of early authigenic glaconite suggest an age of 1686±6 Ma for Mallampalli Group and 1620±6 Ma for its equivalent Somalpalli Group on the northern side of Godavari graben [18]. The Mulug Group was deposited around 1565 Ma while the overlying Sullavai Group was deposited at around 870 Ma [19] [20] [18].

Mallampalli Laterites lying between the Latitudes: 18º05’00’’ - 18º10’00’’ and Longitude: 79º50’56’’ - 79º55’56’’E and falls on Survey of India Toposheet no. 56N/16. The Mallampalli Laterite area is situated in Warangal District, Telangana State (Fig. 2).

The study area is represented by shale of Mallampalli Group which is the bed rock and is highly weathered and decomposed resulting in the formation of Laterite (Fig. 3a-b). The lateritization in the area has taken place during Proterozoic age continued intermittently upto the recent period.

The regional stratigraphy of the area is given in **Table-I.**

Sullavai Group	Quartzite sandstone (including arkosic and conglomeratic beds)
Mulug Group	Shale (with intercalated quartzite) Quartzite Shale (partial calcareous, with inter beded limestone and calcarenites) Limestone (with nodules of chert and stromatolitic beds) Bedded chert and siliceous shale Arkose (with limestone, siltstone and glauconitic beds) Conglomerate.
Mallampalli Group	Laterite Shale Limestone (stromatolitic with interbeded arkose, glauconitic beds, chert and shale) Conglomerate.

The Mallampalli Group is composed essentially of shale and carbonate with a basal conglomerate. The deposition of these sediments took place in a continental, lacustrine to fluvial environment with possible incursion of the sea periodically shown by glauconitic arenites and stromatolitic carbonates (shallow water).

The Mallampalli Group again show similar environmental conditions being a sucession of clastics with some chemical formations included. The stromatolitic beds were formed in intertidal zone and the chert beds and nodules are also as shallow water. It is possible that rifting was activated from time to time during the deposition of entire Mallampalli Mulug sequence. The Sullavai Group of rocks was deposited in a terrestrial milieu cross-bedding and ripple marks are extensively developed in these clastics. Laterite occurs as a blanket like deposit overlying shales in the entire study area which has slightly undulating topography. Laterite is well exposed and has a thickness of 2m to 5m in the entire area.

III. Environmental Controls and laterite formation:

The passage of time and recognition of the characteristics of the laterite profile, it became necessary to evoke an in situ weathering mechanism that would not only explain the formation of laterite from diverse parentage but also the chemical reggregation in the resultant residuam.

The stage of reggregation in a profile may define the degree of their maturity. Lateritization is a process involving continuous leaching of alkalies, bases and silica with relative concentration of ferric oxide, alumina and titanium in the residuum. Tropical weathering (Lateritization) is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and mineralogy of the resulting soils [21]. The initial products of weathering are essentially kaolinised rocks called saprolites [1] [22] [1] [2]. A period of active lateritization extended from about the mid-Tertiary to the mid Quaternary periods (3.5 to 1.5 million years ago [21].

The absence of laterite on hills that fall below a particular level corresponding to an ancient peneplane could be accounted for by denudation. A more interesting observation is that of Middlemiss [23] [22] in the Eastern Ghats where bare gneissic peaks that rise up over the level (about 1,065 m to 1,220 m) are devoid of laterite, indicating that a peneplane or flat surface is perhaps necessary for lateritization.

The literature on Indian laterite is devoid of laterite from the Deccan trap basalt. Observers were aware from the very early days that laterite also occurs on several diverse rocks and far removed from any trap exposure. This peculiarity of a fairly uniform type of laterite capping occurring over so many kinds of rock prompted to consider them as sedimentary. But it is now conceded by different kinds of workers that laterite could be formed by weathering of different kinds of rocks and that in India such types as sandstone, limestone, shale, schist, epidiorite, granitic rock, basalt, kondalite, leptynite, charnokite, etc., have give rise to laterite [3].

Though visually and physically similar, residual laterite of diverse parentage does show some chemical variations. The titania content in residual laterite derived from pyroclastics [23], khondalite [24], gneisses [25] and leptynites [26] is in general much lower than in those derived from basalt [27] [28] [29]. Similarly certain differences in the iron content of the profile are present, not to speak of the trace element distribution and other minor chemical constituents [23] [29]. It also obvious that the chemical and mineralogical character of a laterite profile depends on its age and maturity [25] and hence there are bound to be certain differences in laterites formed from different parent rocks and under diverse terrain condition. Available information indicates that the general upper limit of the thickness of laterite capping on plateau areas is about 30 m, inclusive if the uppermost pisolitic laterite and the lithomarge at the base.

Many observations spread over a large part of the country attest to the fact that the exact spatial position of the bauxite zone is variable within the laterite profile. In parts of Ranchi plateau, bauxite is seen immediately overlying the lithomarge while in many parts of central Indian highlands the bauxite zone is nearer the upper portion of the laterite column. The cause for this is not clearly understood and any theory of origin should take cognizance of this feature.

[28] [29] have attempted to trace the volumetric and gravimetric changes involved in the transformation of thoeiitic basalt and the entire laterite profile. Their main conclusion is that lateritization of basalt can be achieved by a mere leaching (65% by weight) of certain constituent and that such alteration would produce laterite only two-third the thickness of the basalt thus transformed. Volume reduction appears to be a significance to be a feature of the lateritization process.

The exact mechanism of the formation of a bauxite layer, generally sandwiched between typical ferruginous laterite, is still not clearly understood. The suggestion [25] that the alumina - rich material behaving like a semi-permeable membrane permitting one-way transfer and accumulation of iron oxide above and silica below is untenable because ferruginous laterite is commonly found below and above the bauxite layer also.

IV. Mineralogy and geochemical characterization of Mallampalli Laterites

In Mallampalli the lateritic cover can be seen upto a depth of 4.5m. Mineralogically, the laterite in this area is essentially a mixture of varying proportions of Limonite and Goethite. The lateritic blanket is rich in iron.

The analysis of the lateritic samples is provided in Table II. It is evident that the Fe_2O_3% of Mallampalli Laterites varies from 24.35 to 43.22. The mean Fe_2O_3% of 32.96 and mean SiO2% of 29.45 makes this laterite suitable for the cement industry.

The depth wise analysis of the Mallampalli Laterites is shown for one section (Fig. 4) and the same is provided in Table III. The binary plot of the profile analysis data (Fig. 5) shows that at the transition from ferruginous to aluminous laterite there is gradual increase in alumina content from sample 4 to 7. Sample 8 to 12 show sudden increase of silica content with decrease of Al and Fe. From sample 13 where shale starts again there is sudden increase of silica content with further decrease of Al and Fe showing original composition of parent rock. The wireframe diagram showing the variation of Al_2O_3, Fe_2O_3 and SiO_2 % are shown in Fig. 6, 7 & 8. In binary plot of the distribution of SiO_2 and Al_2O_3 shows reverse relation with Fe_2O_3 (Fig. 9)

The Laterites of Mallampalli falls into moderate to strong Lateritization category based on Schellmans Classification of Laterites which is shown in Fig. 10 [1].

1.1 Pore types and pore fillings

Macro pores are dominated by fracture pores which are oriented both parallel to bedding and perpendicular to bedding. Visible matrix pores are partially to completely occluded with translocated pedogenic clays.

4.2 Bulk density and bulk porosity characterization

Bulk density of Mallampalli shale saprolite was determined using the wax coated clod method of [30].The highest bulk density of 2.0 g/cm^3 was measured from the unweathered shale sampled at ~450 cm depth.

The bulk densities decrease upwards to a lowest of 1.36 g/cm^3 at ~50 cm depth. The decrease in the bulk density towards surface could be due to dissolution and removal of rock mass during weathering as well as the accompanying formation of matrix pores and fracture macro pores.

Bulk porosity was calculated from the bulk density measurements by difference and assuming average grain density of 2.6 g/cm^3 for the saprolite samples. The highest bulk porosity of 47 % was measured in the shallowest samples ~ 50 cm depth with gradual decline in porosity to 25 % at a depth of ~450 cm depth.

V. Discussion and Conclusion

It has been aimed in this brief review, to highlight the role of the major physico- chemical parameters in the processes of lateritization. Climate, pH, Eh, ionic mobility, ionic potential and rock chemistry are among the essential factors in controlling primary lateritization, it is basically a chemical weathering process concentrating aluminum and iron in near surface horizons while removing soluble elements, especially the alkalis.

The pH of the Lateritic weathering environment controls the solubility of the components. Iron dissolves at an increasing rate as the pH decreases. Silica, which is negligibly soluble at pH 7, dissolves very rapidly between pH 8 and 10. Alumina solubility is very high at about pH 4 (which is rare in nature) & pH 10 and the redox potential which determines the ease with which reduction and oxidation reactions occur, is lowered by increasing pH. Within Lateritic weathering systems, the mobility order of the more commonly occurring element is found to be as follows: Al < Fe < Si < Ca < Na < K.

Lateritization is a complex of processes leading to the removal of alkalies and the concentration of Fe and Al in the near surface horizons .In Mallampalli, lateritization has resulted in reddish to orange or brownish mass of rocks of variable hardness and texture and composed largely of oxides and/or hydroxides of iron and aluminum (rarely).

The formation of iron oxides and hydroxides in Mallampalli is occasioned by redox reaction during the hydrolysis of mafic minerals. Complex reactions produced ferri-ferro hydroxides which then crystallized into Goethite- FeO (OH) and Hematite-Fe_2O_3, depending on temperature in Mallampalli area. At pH 10 goethite crystallized out, whereas below this Hematite occurs.

The Laterites of Mallampalli falls into Moderately Lateritized category based on Schellmans Classification of Laterites.

The study of laterite deposits of Mallampalli area shows that the laterite manifests continuous high Silica, high Iron and low Alumina. These vast spread of laterites are found promising and suitable from industrial point of view i.e., Cement Industry.

The Laterites of this study area are found amenable to simple beneficiation by crushing and dry screening and the grade can be appreciably improved by rejecting selected fractions based on the economics of mining and processing.

References

[1]. W. Schellmann, A new definition of laterite, *Natural Resources and Development Tubingen, 18,* 1983, 7-12.

[2]. W. Schellmann, A New Definition of Laterite – Laterisation Processes, *Mem. Geol. Surv. India 120,* 1986, 1-7.

[3]. M.K. Roy Chowdhury, V. venkatesh, Andalwarma and D. Paul, Recent concepts on the origin of Indian laterite. *Report Geological survey India, Calcutta,* Retrieved April 17, 2010.

[4]. P.G. Bhukte, M.J. Chadda, and J. Mukhopadhyay, (2008). Bauxite technical data bank of India. Its significance for the country, *Proc, ICSOBA,* 2008, 24-29.

[5]. P.G. Bhukte and M.J. Chadda, Geotechnical Evaluation of Eastern Ghats Bauxite Deposits of India, *Journal Geological Society of India, 84,* 2014, 227-238.

[6]. G. Krishna Rao and C. Borreswara Rao, A Geochemistry study on the Bauxite deposits of Shevaroy and Kotti hills, Tamil Nadu State, Inter. Symp. Recent Res & Appl. of Geochemistry, 1974.

[7]. K. Suryanarayana and G. Krishna Rao, Bauxitisation in Eastern Ghats of India - Effects of environment, *5th International Congress of ICSOBA,* 1983.

[8]. A. Verraju and C. Borreswara Rao, Formation of Bauxite from Khondalite. *Acta Geolica Acad Miae Scientiarum Hungarocae, 24 (2-4),* 1971, 223-228.

[9]. P.K. Ramam and P. Prakash, Bauxite prospects on Chittamgondi plateau, Visakhapatnam District, Andhra Pradesh. *Indian Minerals, 27(1),* 1973, 101-104.

[10]. P.K. Ramam, Bauxite deposits of Ananthagiri Visakhapatnam District, Andhra Pradesh, *Jour. of Geol. Soc. of India, 17(2),* 1976, 236-244.

[11]. P.K. Ramam and R. Vaidyanathan, Laterites and Laterisation over Easter ghats and Coastal plains in North Coastal Andhra Pradesh, India; Laterisation process, *Oxford and IBH Co. New Delhi,* 1981, 295-301.

[12]. P.K. Ramam, Mineral Resources of Andhra Pradesh, *Geological Society of India, Banglore,* 1999, 59-70.

[13]. K.A. Subramaniam and G. Mani, Genetic and Geomorphic aspects of Laterites of high and low landforms in parts of Tamil Nadu, India. *Proc. of International Seminar on Lateritization processes, 1979, Trivandrum. India.*

[14]. D.C. Mishra, Long Hiatus in proterozoic sedimentation in India. Vindhyan, Cuddapah and Pakhal Basin- A platetectonic model, *Jour. Geol. Soc. India, 77,* 2011, 17-25.

[15]. T.S. Rao, The Pakhal Basin- A perspective, *Mem. Geol. Soc. India. No.6,* 1987, 161-187.

[16]. D.C. Mishra Building blocks and crustal architecture of Indian peninsular shield-craton and fold belt and their intraction based on the geophysical data integrated with geological information, *Jour. Geol. Soc. India, 68,* 2006, 1037-1057.

[17]. M. Santhosh, K. Yokoyama and S.K. Acharyya, Geochronology and tectonic evolution of Karimnagar and Bhopalpatnam Granulites Belt, Central India, *Gondwana Res., 7,* 2004, 501-518.

[18]. J.E. Conard, J.R. Hein, A.K. Chaudhruy, Patrana bis-Deb, S. Mukhopadhyay.J.Deb. G.K and N.J. Beukes. Constraints on the development of proterozoic basins in Central India from 40Ar/39 Ar Aanlysis of authigenic glauconite minerals, *Geological Society of America, Bull., 123,* 2010, 11-12.

[19]. S.M. Mathur, Precambrian sedimentary sequences of India: Their geochronology and correlations, *Precambrian Research; 18,* 1982, 139-144.

[20]. A.K. Chaudhuri and J.D. Howard, Ramagundam Sandstone ; a middle Proterozoic Shoal-bar sequence, *Journal Sediment petrol, 55,* 1985, 392-397.

[21]. Dalvi, D. Ashok, W. Bacon, Gordon; Osborne, C. Robert (March 7-10, 2004). The past and the future of Nickel Laterites (Report) PDAC 2004 International Convention, Trade show& Investors Exchange, Retrieved April 7, 2010.

[22]. T.H. Holland, *Gen. Rep. Geol. Surv. India for 1902-03,* 1903b.

[23]. T.S. Sahasrabudhe, Bauxite deposits of the Kutch district, *Unpublished Rep. Geol. Surv. India,* 1961.

[24]. M.S. Krishna, Laterisation of Khondalite, *Rec. Geol. Surv. India, 59 (4),* 1935, 419-422.

[25]. C.S. Fox, Bachanan's laterite of Malabar and Kanara, *Rec. Geol. Surv. India. 69 (4),* 1936, 389-422.

[26]. S. Krishnaswamy, A report on the aluminous Laterite and bauxite occurrence in the Shevaroy hills near yercaud, salem district, *Unpublished Report, Geological survey of India,* 1957.

[27]. M.K. Roy Choudhury, Bauxite in Bihar, Madhya Pradesh, Vindhya Pradesh, Madhya Bharat and Bhopal, *Mem. Geol. Surv. India, 85,* 1958, 1-271.

[28]. M.K. Roy Chowdary, V. Venkatesh and D.K. Paul, Final report on the detailed investigation of the bauxite deposits of the Amarkantak area, Madhya Pradesh in connection with the Indo-Hungarian Project, *Unpublished Report, Geological Survey of India,* 1964a.

[29]. M.K. Roy Chowdary and M.A. Andalwar, Parent rock of Laterite and bauxite of Phutka pahar, Bilaspur district , Madhyapradesh, India. *22nd International Geological Congress, New Delhi,* 1964b.

[30]. G.R. Blake and K.H. Hartge, Bulk density in Klute,A.(ed) Methods of soil analysis part I- Physical and mineralogical methods: *Soil Science Society of America, Agronomy, Monologue 9 (2nd edition),* 1986, 363-375.

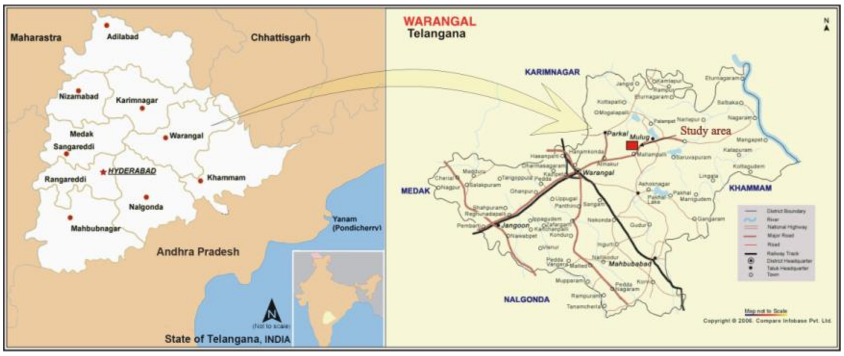


Figure 1 Location map of the study area.

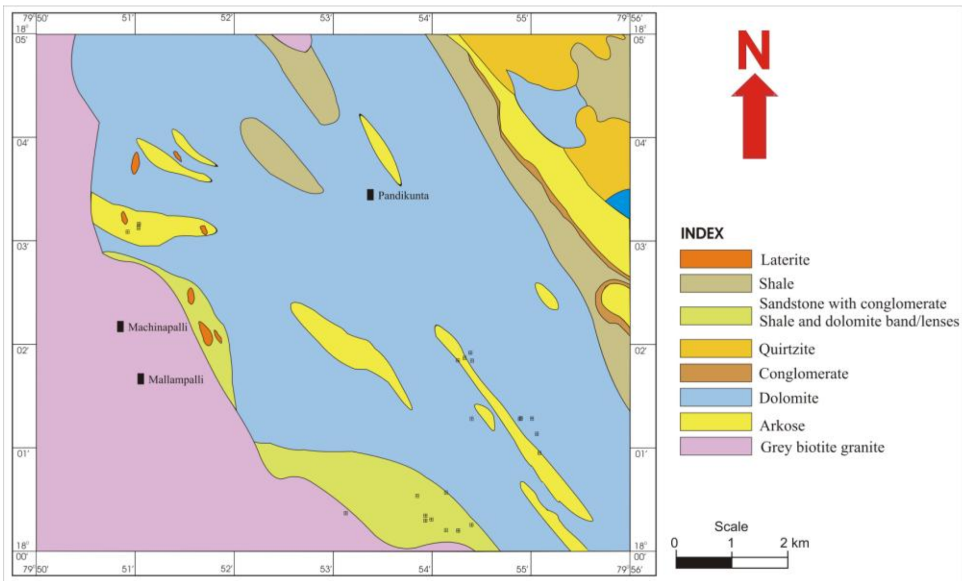


Figure 2 Geological map of Mallampalli study area showing sample locations.

Figure 3a-b: (a) Field photo showing lateritization in Mallampalli. (b) A section showing lateritization in Mallampalli.

Figure 4 Trench in the study area for profile sampling of different litho units.

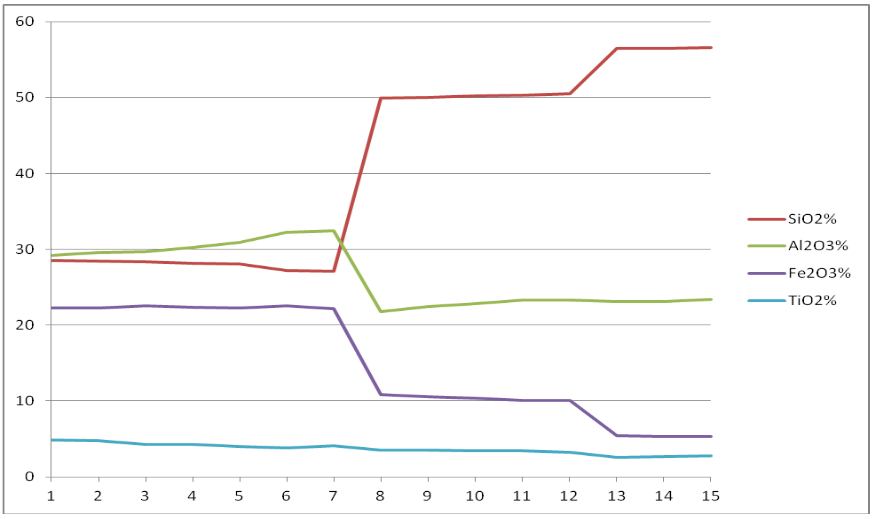


Figure 5 Variation of $Si0_2$, Al_2O_3 and Fe_2O_3 along the laterite profile of Mallampalli area showing distinct variation along the lithological changes.

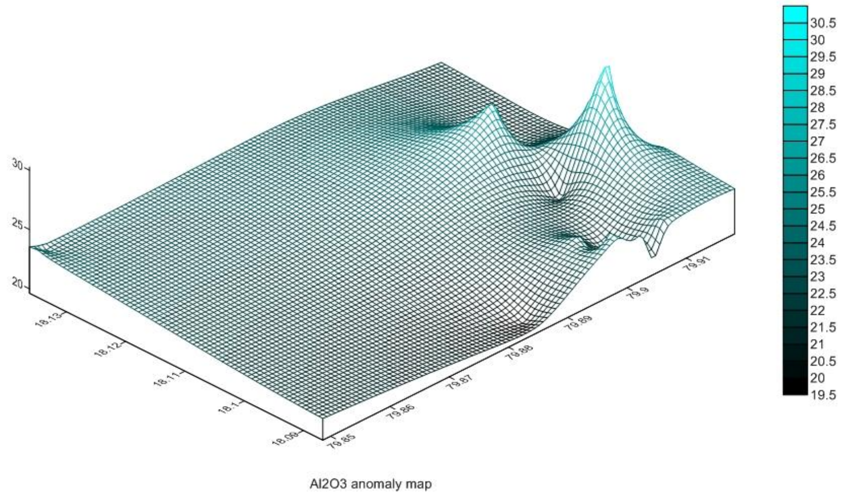


Figure 6 Wireframe diagram showing the variation of Al_2O_3 in the study area.

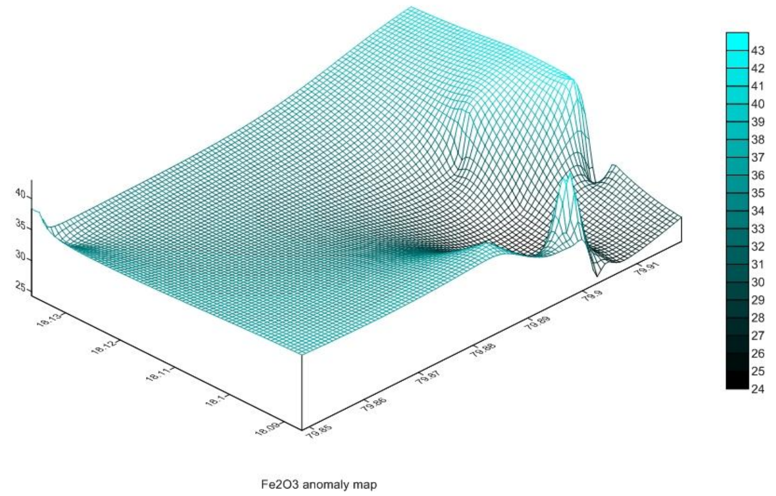


Figure 7 Wireframe diagram showing the variation of Fe_2O_3 in Mallampalli study area.

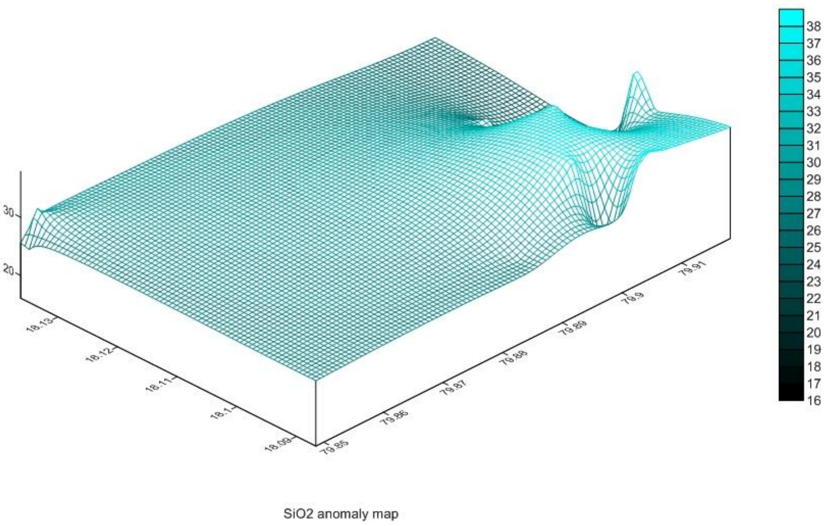


Figure 8: Wireframe diagram showing the variation of SiO_2 in Mallampalli study area.

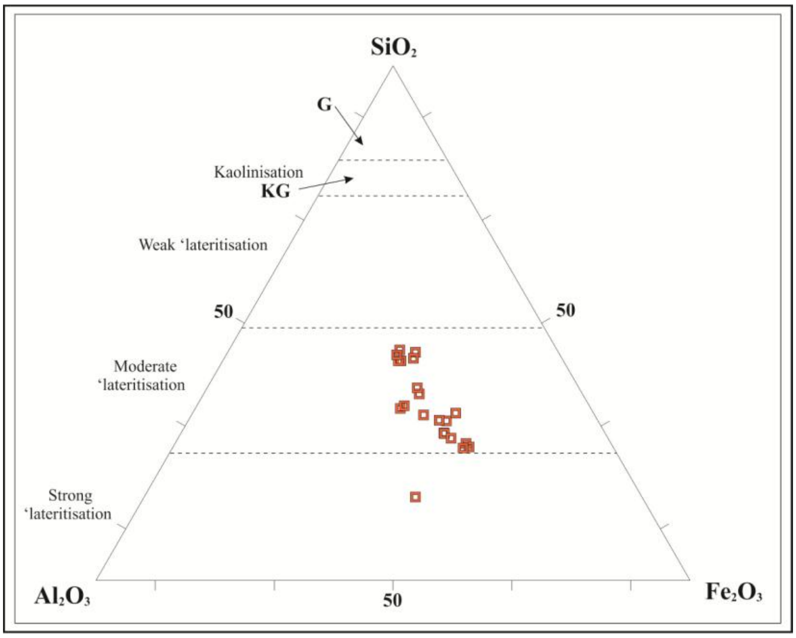
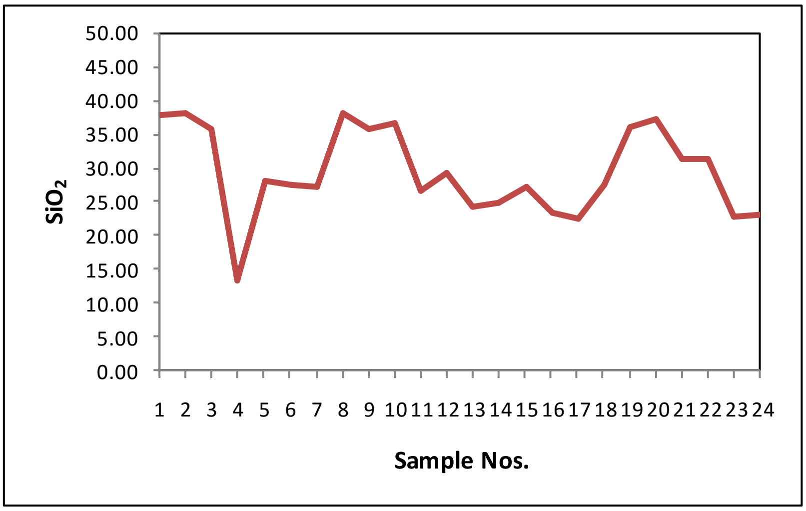
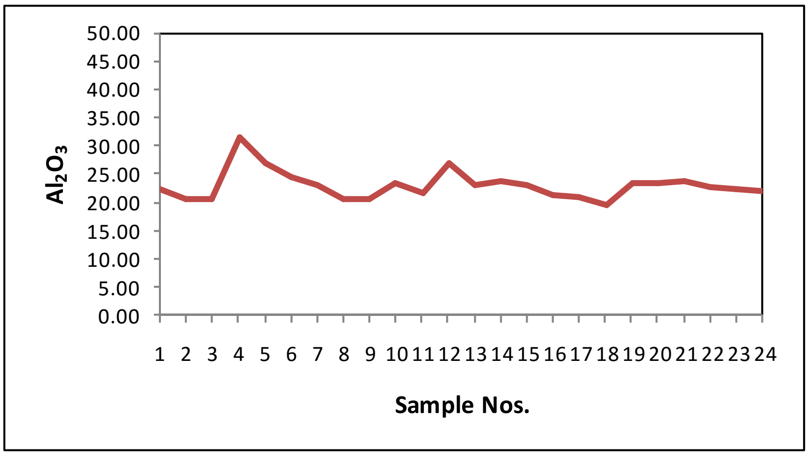


Figure 9 Ternary plot of Schellman (1983) showing distribution of collected samples from Mallampalli area and extent of lateritization.





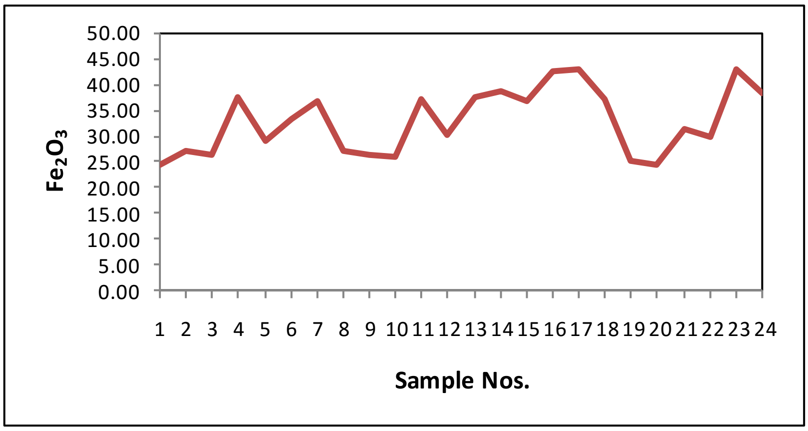


Figure 10 Binary plot showing variation of SiO_2, Al_2O_3 and Fe_2O_3 content within samples of Mallampalli Laterites.

Table II: Chemical analysis data of laterite samples from Mallampalli area.

S.No.	Latitude	Longitude	Al2O3%	Fe2O3%	SiO2%	LOI%
1	18°06'08.5"	79°55'03.7"	22.40	24.35	37.92	13.46
2	18°05'12.3"	79°54'16.00"	20.70	27.15	38.11	12.14
3	18°06'17.35"	79°54'24.2"	20.80	26.50	35.92	14.88
4	18°06'17.25"	79°54'53.4"	31.60	37.80	13.40	
5	18°06'51.20"	79°54'15.8"	27.13	29.20	28.27	13.18
6	18°05'18.15"	79°53'56.10"	24.60	33.40	27.50	12.26
7	18°08'10.40"	79°51'02.1"	23.26	36.80	27.16	10.61
8	18°05'12.30"	79°54'16.00"	20.70	27.15	38.11	12.14
9	18°05'34.40"	79°54'08.70"	20.80	26.50	35.92	14.88
10	18°05'15.60"	79°54'24.10"	23.50	25.84	36.72	12.32
11	18°06'55.70"	79°54'23.50"	21.83	37.20	26.54	12.06
12	18°06'52.60"	79°54'19.80"	26.93	30.20	29.40	11.52
13	18°06'51.00"	79°54'24.40"	23.05	37.60	24.36	12.50
14	18°08'05.90"	79°50'55.30"	23.66	38.80	24.93	10.59
15	18°08'10.40"	79°51'02.10"	23.26	36.80	27.16	10.61
16	18°05'18.80"	79°53'59.70"	21.42	43.00	23.37	10.20
17	18°05'21.00"	79°53'56.10"	21.01	43.20	22.48	11.44
18	18°05'22.50"	79°53'07.80"	19.60	37.39	27.45	11.80
19	18°05'12.50"	79°54'08.70"	23.60	25.10	36.28	13.23
20	18°05'32.50"	79°53'51.20"	23.30	24.35	37.20	13.27
21	18°05'57.40"	79°55'05.40"	23.88	31.54	31.51	13.25
22	18°08'08.10"	79°51'01.90"	22.86	29.70	31.42	12.37
23	18°06'17.40"	79°55'00.80"	22.38	43.22	22.73	12.52
24	18°06'17.55"	79°54'54.20"	22.03	38.33	23.02	11.80

Table III: Chemical Analysis of different Litho units in the Lateritic Profile of the Study Area

Sample No	Depth (meter)	Litho Units	SiO_2%	Al_2O_3%	Fe_2O_3%	TiO_2%	LOI%
1	3.00	Laterite Ferruginous	28.56	29.17	22.25	4.82	15.2
2			28.45	29.56	22.29	4.79	14.91
3			28.35	29.67	22.59	4.29	15.1
4	4.00	Laterite Aluminous	28.18	30.27	22.35	4.31	14.89
5			28.08	30.89	22.25	4.03	14.75
6			27.19	32.29	22.59	3.78	14.15
7			27.15	32.48	22.12	4.12	14.13
8	5.00	Lithomarge Clay	49.89	21.82	10.89	3.51	13.89
9			49.98	22.43	10.55	3.49	13.55
10			50.19	22.84	10.39	3.43	13.15
11			50.34	23.26	10.12	3.39	12.89
12			50.49	23.29	10.11	3.25	12.86
13	3.00	Altered Shale	56.45	23.13	5.38	2.53	12.51
14			56.52	23.14	5.35	2.63	12.36
15	1.00	Shale	56.63	23.43	5.33	2.79	11.82