MICROMORPHOLOGY AND MINERALOGY OF THE SOILS OF MAJOR LAND RESOURCE AREAS OF KERALA

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
COLLEGE OF AGRICULTURE
VELLAYANI – THIRUVANANTHAPURAM

1996

DECLARATION

I hereby declare that this thesis entitled "MICROMORPHOLOGY AND MINERALOGY OF THE SOILS OF MAJOR LAND RESOURCE AREAS OF KERALA" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society

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CERTIFICATE

Certified that this thesis entitled "MICROMORPHOLOGY AND MINERALOGY OF THE SOILS OF MAJOR LAND RESOURCE AREAS OF KERALA" is a bonafide record of research work done independently by Anup.V.M., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him

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ACKNOWLEDGEMENT

I wish to acknowledge with deep sense of gratitude my indebtedness to

Dr. M.Subramonia Iyer, Associate Professor, Regional Agricultural Research Station, Kumarakom, Kottayam(*Chairman,Advisory Committee*) for suggesting the programme of research and for his sustained help, inspiring guidance and valuable suggestions at every stage of this investigation and in the preparation of this thesis.

Dr.P.Padmaja, Professor and Head of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Thiruvananthapuram, (*Member,Advisory Committee*) for her valuable help in the compilation of this thesis.

Dr.Thomas Varghese, Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani(*Member,Advisory Committee*) for the inspiring advise and valuable suggestions at every stage of research and in the preparation of this thesis.

Dr.P.Saraswathy, Professor and Head, (*Member,Advisory Committee*) Department of Agricultural Statistics for her valuable help in the preparation of this thesis.

The staff of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, for the kind help rendered.

The staff of the various Research Stations of the Kerala Agricultural University for their sincere co-operation in the collection of soil samples.

The staff of the State Soil Survey Organization for providing the concept of the Major Land Resource Areas(MLRA's) of Kerala and for the encouragement given while selecting the programme of research of thesis work.

And above all, I bestow my heartfelt gratitude upon my wife and kids for their endurance and motivation, but for which this thesis would never have materialised.

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INTRODUCTION

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Major Land Resource Areas (MLRA's) are important for agricultural as well as interstate, regional and national planning. MLRA's consist of geographically associated soils which have broadly similar patterns of climate, water resources and land uses. Along with detailed soil survey information, MLRA's are most suitable for farm level evaluations. With the advent of Geographic Information Systems (GIS) and the Systems Approach to Agricultural Research and Development, base line informations become critical to the implementation or application of the recent information technology for practical farming purposes.

The concept of sustainable agriculture calls for a maintenance of the resource base. The resource concern is mostly soil and indirectly all the components of the environment. MLRA's play a major role in evaluating the current constraints or limitations of knowledge of soil resources, which directly influence sustainable agriculture. Major land resource areas of a region needs to be known as a pre-requisite of implementing sustainable agricultural programmes to facilitate technology transfer to neighbouring regions and similar agroecological zones elsewhere. MLRA maps can be used at national level as a basis for making decisions about agricultural issues, as a framework for organising and conducting resource conservation programmes, geographic organization of research, co-ordinating technical guides between states and districts of a nation and between countries, organizing, displaying and using data in physical resource inventories and to aggregate natural resource data. The MLRA information provides preliminary base-line data for selection of areas for development programmes.

In order to strengthen the detailed base-line information of the inherent soil characteristics a microlevel soil information is highly essential. Micromorphology is a technique for the identification, description, interpretation and measurement of components, features and fabrics in soils at microscopic level and to understand the processes involved in soil formation. Soil micromorphology can be viewed as the study of soil morphology in the size range where optical aid is needed for the naked eye. A soil type that develops is generally a reflection of the balance between the processes of soil formation. The descriptive side of micromorphology is also vital to provide a sound basis for the classification of soils and to compare the properties of different soils within an order, suborder or great group, or even at lower levels in the classification system such as soil series.

The technique of soil micromorphology has aided in the microscopic investigation of soils for making it a more useful tool for studying the processes involved in soil formation. Much of the micromorphological study has been designed to aid in the understanding of soil genesis. Micromorphological identification of illuvial argillans has been made part of the criteria for the identification of argillic horizons in soils. The nature of the parent material and a large variety of changes due to soil forming process and land use can be properly evaluated through thin section studies.

The information gained through micromorphological studies is also important for the classification of soils. Special aspects of soils, viz., void systems, their stability and permeability, impact of irrigation on soil and nature and extent of weathering of minerals, rock fragments etc. can be effectively studied through micromorphology.

The present study aims to characterise the micromorphological and mineralogical properties of the diagnostic horizons of the soils of the MLRA's of Kerala, for refined profile description and classification and to understand the inherent detailed information of the soil heterogenity.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The available relevant and related literature on morphology, granulometry, mineralogy and micromorphology with respect to the present study are given below.

1.Morphology

1.1. Soil Colour

The colour of laterite soils is imparted by the oxides and hydroxides of iron. (Satyanarayana and Thomas, 1961).

In the Varkala beds, there is not much difference in colour in different horizons while the midupland region of Chingavanam showed variation within and between horizons (Gopalaswamy, 1969).

The colour of laterite soils at the surface is red in most cases, changing to reddish yellow and finally yellow in deeper layers (Govindarajan and Gopala Rao, 1978).

In a toposequence of Oxisols developed from basalt in the Central Plateau of Brazil, the moist colour of dark yellow, 2.5 YR 3/4, in the upper slope changed to yellowish brown in the lower strata, 10 YR 4/4 (Curi and Franzmeir, 1984).

1.2. Soil Structure

The main physical properties of laterite soils are structure, consistency and colour. For Malabar and South Canara region where laterite occurs below a soil cover, the top portion of laterite is brittle and shatter when cut and crumble to irregular masses. The structure changes to vermicular with depth. (Satyanarayana and Thomas, 1961).

Ultisols of the hill districts of Assam are very deep, well structured soils which exhibit moderate to well developed argillic horizon (Chakravarthy and Barua, 1983).

Certain soils of Varanassi district of Uttar Pradesh are classified as Entisols, Inceptisols and Alfisols, due to the presence of argillic horizon and medium to coarse structure (Singh et al, 1989).

Dominant hill soils of Nilgiri classified as Inceptisols are granular to blocky in structure. Presence of a lithic contact within forty centimetres of soil depth classifies the Guheda Series as Lithic Eutrochrepts (Sannigrahi et al, 1990).

1.3. Soil Texture

A soil succession in Australia showed appreciable variation in the mechanical composition of the soils on the slopes. The coarse fraction decreased and fine fraction increased from top to bottom. Silt reached a maximum in the middle portion. These varations are correlated with the effect of land use on erosion. (Gibbs, 1938).

In a mid-tertiary surface near Salisbury, the landform and rock indicated a two-cycle landscape. The three profiles occurring at the highest levels were fine textured while others were coarse textured. Sandy top soils were found to be a feature of the catena (Watson, 1964).

Studies on the catenary soils of Kurnool district showed that the machanical eluviation of clay from the profile at the mound and its deposition at the foot slope were responsible for the sandy clay loam texture of the former and clay texture of the latter. Further movement of clay was more in the mound profile in which a zone of clay accumulation was observed. (Biswas et al, 1966).

Red hill soils on the Oregon coast revealed textural discontinuities as evidenced primarly by stone lines and stone content which tended to decrease with depth. This was attributed to geomorphic surface and slope gradient. (Parsons *et al*, 1966).

Systematic investigations of hill slopes of North Eastern Iowa from summit to alluvial position revealed that particle size variations within `A' horizon were due to sedimentological sorting. Profile characteristics indicated little development, many of the soil properties being inherited from the sedimentary nature of the hillslope surficial sediment (Kleis, 1970).

Laterite soils show a decrease in sand fraction with depth. In South Indian laterites clay content increased with depth in the subsurface horizons with continuous clay films in the same pedon while it was absent in some others (Gowaikar and Dutta, 1971).

Clay is the dominating particle size fraction in Kari, Kole and Kayal soils. Silt and clay are the dominant fractions in Karapadom soils. Kole soils have the highest percentage of clay (Sreedevi *et al*, 1975).

Kayal soils of Kerala are clay loam throughout the profile while Karapadom soils are with clay loam texture for surface soils and silty loam for lower layers. Kari soils have silty clay surface with clay textured subsurface (Soil Survey Staff, 1978).

Physical properties of wet land soils become only of secondary importance when there is copious water for crop production (Kyuma, 1981).

Coastal and midupland laterites contained more gravel than the forest upland. More fine sand fraction is found in the coastal region. The coarse fraction decreased with depth. High land laterites contained more amount of clay in the surface layers. In the coastal areas B horizon contained more clay (Thomas Varghese, 1981).

The textural changes of wet land soils of Ranchi district of Bihar were irregular with depth indicating that these soils were developed on different sedimentary parent materials over a long period. Clay content and water holding capacity increased with depth (Ali et al, 1983).

Physical properties of wet land soils revealed that in most profiles there was a very large variation of physical properties and organic matter content with depth (Jackson, 1984).

Wet land soils with aquic moisture regimes had strong textural differenciation between surface and subsurface horizons due to illuviation of clay into finer textured subsoils (Wilding and Rehage, 1985).

Two typical soils of the warm temperate humid region of the Central Himalyas (Himachal Pradesh) were fine sandy loam to silty loam (or silty clay loam). One, a mountain soil occurring on slopes has a mollic epipedon underlain by a cambic horizon. The other, a valley soil shows a clay enriched Bt horizon and an organic matter rich mollic or mollic-like ochric epipedon. On the basis of Soil Taxonamy these soils have been classified as Typic Hapludolls and Mollic Hapludalfs respectively (Sehgal et al, 1986).

The predominent textural class of Kuttanad soils is clay to clay loam. Sandy pockets are common in Kari soils of Kuttanad (Raju, 1988).

Oxisols of the Northern Plateau Zone of Orissa are well defined and have no mottles in the matrix. The texture is finer down with depth with more than twenty percent gravels in all the horizons. The soil is clayey throughout the profile. But there is no evidence of clay cutans (Sahu et al,1990).

The soil texture of the acid sulphate Kari soils of Kuttanand ranges from sandy clay to clay with intermediate textures of silty clay loam and clay loam. The surface horizons are coarser and lower horizons are finer. Sand pockets are frequented in the solum (Soil Survey Staff, 1992).

The representative soils studied at Kottarakkara, Vellanikkara, Kunnamangalam, and Pilicode are gravelly in nature with an average gravel content of 60 percent. The soil texture at Kottarakkara ranged from gravelly sandy loam to gravelly clay loam while at Vellanikkara it ranged from gravelly sandy loam to gravelly clay loam. At Kunnamangalam the soil texture ranged from gravelly sandy loam to gravelly sandy clay loam while at Pilicode it ranged from gravelly clay loam to gravelly clay (Bindukumari, 1993).

2. Mineralogy

2.1. Mineralogy of Fine Sand Fraction

The common light minerals observed in the soils of the upper Vindhyan Plateau were quartz, feldspars and mica. The percentage of light minerals was more or less uniform in all the horizons whereas the variation in the content of heavy minerals was not regular (Agarwal et al, 1957).

Quartz constituted the major portion of the fine sand fraction of the catenary soils of Madhya Pradesh. These soils are of a residual nature (Singh and Gangawar, 1971).

Iron bearing minerals were appreciably high in laterites with limonite being characteristic of low level laterites. Micaceous minerals were present in appreciable amounts in the fine sand fractions of the soils of South India. Red soils had low ferromagnesian minerals and traces of micas. (Sankar and Raj, 1973).

In Oxisol and Ultisol toposequences of Brazil, quartz was the dominant mineral in the sand fractions varying from 62-97% percent. Heavy opaques were the second most common minerals and their content decreased from top to bottom. (Lespsch and Buol, 1974).

Light mineral portion in the catenary soils developed under basalt was constituted by stained and angular feldspars. Quartz is angular and subangular without inclusions. The heavy mineral fraction was constituted by haematite, magnetite, sillimanite, epidote, chlorite, hornblende and zircon. (Gaikwad et al, 1974).

The predominance of quartz was observed in the sand fractions of the rice soils of Wayanad. (Saratchandran Nair, 1977).

The fine sand mineralogy of the east-coast laterites in India showed a pattern of mineral distribution containing quartz, iron minerals, zircon, garnet, rutile, anatase and ilmenite (Manickam, 1977).

The lighter fractions in the soils of Southern India were dominated by quartz and feldspars. The heavy minerals consisted mainly biotite and magnetite (Murali et al, 1978).

Sand fractions of the ferruginous layers of laterite soils of Eastern Mysore Plateau had considerable amounts of haematite. The silt fraction was dominated by mica and quartz (Rangaswamy et al, 1978).

The primary mineral suite of sodic and non-sodic soils of Indo Gangetic alluvial plains had sand fraction consisting of quartz, feldspars, micas, chloritised biotite, tourmaline, zircon, and hornblende. Feldspars and other basic primary rock minerals form the source for saline-alkali soils. (Sidhu and Sehgal, 1978; Bhargava and Bhattacharjee, 1982).

Quartz constituted the light mineral fraction with little amounts of feldspars and mica in the soils developed under different climate and topography in the southern bank of Brahmaputra river. Zircon, chlorite, biotite, amphibole, garnet etc. constituted the heavy mineral fraction. Weatherable minerals like feldspars and mica were observed in the upland soils. These minerals increased with depth while quartz decreased with depth (Chakravarthy et al, 1979).

Laterite and red soil associations of Kerala revealed quartz as the dominant light mineral fraction in the fine sand. Mica and zircon were present in traces (Subramonia Iyer, 1979).

Quartz was the dominant light mineral in the midupland laterite regions of Kerala. Heavy mineral fraction was comparatively less and showed no regular trend in profile. More percentage of haematite was observed in the upper slopes, and its content decreased with decrease in elevation. No variation in zircon was observed at different locations. (Venugopal and Koshy, 1982).

Feldspars were the dominant minerals in the fine sand of Vertisols of Andhra Pradesh, followed by quartz and mica. The occurrence of easily weatherable minerals indicated the low degree of weathering and high nutrient reserves of some profiles (Subbaiah and Manickam, 1985).

The sand fraction of an yellow quartzitic ferallitic soil from Isla de lar Juventud contained ilmenite, tourmaline, disthene and sphene in the heavy fraction and quartz and mica in the light fraction (Fundora et al 1987).

Quartz was the most ubiquitous mineral in the forest soils of the Lesser Himalayas. It occurred as stained, dull and frosted in pedons of sandstones, shales, limestone, granite, phyllite and slate whereas quartz occurred as shining grains with plagioclase feldspar in the pedons of volcanic rocks. Calcite and dolomite occurred in limestone soils while soils on sandstone and shales were characterized by muscovite and biotite. (Dhar et al, 1988).

The dominant mineral in the fine sand fraction of the soils of South Kheri forests of Uttar Pradesh is found to be quartz. Muscovite is the second most abundant mineral. The amount of feldspar is very little. Only traces of tourmaline, zircon, sphene, staurolite and apatite were observed. (Raina et al, 1989).

Quartz, micas and feldspars were the main constituents of the sand fraction in the soils of Assam, representative of hillslope, valleys, foot hills, flood plain and terrace soils. (Bhattacharya and Sidhu, 1989).

In an Alfisol derived from granite gneiss, quartz was the dominant mineral followed by feldspar and kaolinite. In the C_2 horizon diaspore appeared as a major mineral, whereas in other layers its content was relatively low (Bhattacharya and Gosh, 1990).

Laterites show successions of horizons of different induration and sequence of minerals in different hydration status. Distribution and thermodynamic stability of Al haematite and Al geothite showed that the chemical composition of geothite, haematite and kaolinite is controlled by equilibrium with other phases, silica activity, temperature and by the activity of water (Tardy et al 1990).

The sand fractions formed from plinthite over granite gneiss in the lateritic soil tracts of Sivagangai taluk in Tamil Nadu were found to contain light minerals because of their relative resistance to weathering. Quartz was the dominant light mineral. Feldspar content was very less. Plinthite fragments predominated among the heavy minerals. There was a slight decrease in the light mineral content with depth (Mayalagu and Paramasivam 1990).

Quartz and orthoclase feldspar constitute the dominant minerals in the fine sand fraction of the soils of the Northern Plateau Zone of Orissa (Sahu et al, 1990).

Fine sand fractions of the soils in Madhya Pradesh are rich in weatherable minerals like plagioclase, chlorite and hornblende. (Totey and Bhawmik, 1990).

Quartz was the preponderant detrital mineral in the fine sand fraction of alluvial soils of South Kheri forests, Uttar Pradesh. Muscovite type mica was the next most common mineral. Heavy minerals included chlorite, iron ores and tourmaline. Zircon, sphene, staurolite, apatite, garnet, hornblende, kyanite and epidote were present in very small quantities. (Banerjee et al, 1990).

Sand fraction of associated Inceptisols in the South Balaghat forest division, Madhya Pradesh, contain quartz, hornblende, biotite, tourmaline, garnet, staurolite, kyanite, epidote, chlorite and opaques as major minerals. Orthoclase showed kaolinization and biotite altered to chlorite. (Dhar et al, 1990).

The sand mineralogy of Trivandrum series, Nedumangad series and Palode series of Thiruvananthapuram district of Kerala revealed the presence of quartz, leucoxene, haematite, biotite and sillimanite indicating the uniformity of the parent material (Ashraf, 1992).

The dominant mineral in the plinthite containing Alfisol located in the forest (Isoya), Nigeria, were kaolinite, haematite, magnetite/ilmenite with smaller amounts of quartz, feldspars and goethite. In the northern Guinea Savanna (Samaru), the dominant minerals were quartz and kaolinite. Feldspars, illite, muscovite, haematite and magnetite/ilmenite occurred in decreasing order of abundance. (Kparmwang and Esu, 1992).

The sand mineralogy of a lateritic soil series from Tamil Nadu, revealed quartz as the predominant mineral followed by feldspars. Of the heavier minerals, muscovite was followed by plinthite and limonite (Mayalagu et al, 1994).

The sand mineralogy of Entisols from West Bengal revealed quartz, feldspars and mica as the dominant silicate minerals. (Adhikari and Si, 1994).

2.2. Mineralogy of Clay Fraction

Laterite soils having the same chemical properties have a different mineralogy. The dominant minerals observed in laterite soils include kaolinite, gibbsite, halloysite, boehmite, haematite, goethite and residual iron oxides like magnetite, limonite together with zircon, anatase, quartz etc. (Joffe, 1949).

X-ray diffraction techniques showed that red and laterite soils contained mainly kaolinite. The laterite soils from Belgaum contained both kaolinite and goethite. (Bagchi, 1951).

Mineralogical properties of podsol soils were closely related to the soil redox conditions. Kaolinite was observed in all horizons. Chlorite and lattice expansible minerals were observed in surface horizons. The general weathering trend suggested the alteration of mica to a lattice mineral and further alteration of montmorillonite. (Mc Keague, 1965).

High rainfall favoured crystallisation of aluminium hydroxide in gibbsite in laterite soils. Drainage and ionic concentration of the percolating water are the main factors determining mineralogy (Maignien, 1966).

The major clay mineral in the soils of the hilly regions of Himalayas is chlorite (Sehgal and de Conink, 1971).

Kaolinite is the dominant clay mineral in the laterite soils under all moisture regimes in the central regions of Western hills sloping westward in Kerala and Mysore. Small quantities of quartz were observed in the clay fraction. Gibbsite occurs in high rainfall areas, but was absent in low rainfall areas. (Gowaikar, 1972).

Certain soils of Varanasi district of Uttar Pradesh are classified as Entisols, Inceptisols and Alfisols. Zircon was present in the clay fractions of all these soils (Sankar and Raj, 1973).

Chlorite, in the soils of Punjab under different moisture regimes, is the weathering product of illite via vermiculite and chloritized vermiculite stages. (Sehgal, 1974).

X-ray patterns of the clay samples from the B horizons of the soils of Himachal Pradesh and Punjab, showed the presence of mica, vermiculite and chlorite. Other minerals observed were feldspars and quartz. (Sehgal et al, 1974).

An unusual association of haematite with montmorillonite was observed in the red and black soils of Australia. The clay fraction of the black soils contained higher amounts of montmorillonite and higher amounts of haematite than the red soils of the region. The study was based on the genesis of red and black soils of Australia (Beckman et al, 1974).

The presence of vermiculite in sand sized brown biotite flakes was observed in the alluvial soils of Indo-Gangetic plain. But its presence was not observed in the clay fraction. The clay sized chlorite is the result of simple machanical breakdown of sand and silt-sized chlorite and is trioctahedral in nature. (Sidhu and Gilkes, 1977).

The crystallinity of iron oxides decreases down the profile, in a deep weathering profile on granite in peninsular Malaysia. Free iron oxides were found in the lower horizons of a recent alluvium and grey brown soils. Clays from non-calcic brown and brown soils were predominantly montmorillonite type. (Eswaran and Wang Chaw Bin, 1978).

Clay had considerable amounts of amorphous ferri alumino silicates (AFAS) in the ferruginous soils of Karnataka. Kaolinite was the dominant clay mineral, with iron as the structural component. Smectite content was considerable only in the clays of the profile with impeded drainage. (Rengaswamy et al, 1978).

The major constituent in the clay fraction of ferruginous soils in South India is Kaolinite, followed by amorphous ferrialuminosilicates. (Murali et al, 1978).

Kaolinite in the soils of Himachal Pradesh is inherited from the alluvium because the present weathering environment is neither conducive for its neosynthesis from the complete hydrolysis of feldspars, nor can it support the desilication and disintergration of 2:1 minerals to form kaolinite (Ghabru and Gosh, 1983).

Clay fraction of an Entisol and an Inceptisol in the low hill zone of Kangra, Himachal Pradesh, was dominated by mica followed by Kaolinite, intergrade minerals and pedogenic chlorite. Mica in the clay was of detrital origin whereas kaolinite was neoformed from feldspar hydrolysis. Mica underwent weathering through the intergrade minerals to smectite and to vermiculite which later got transformed into pedogenic chlorite. The absence of a free leaching environment in the Inceptisol profile is clearly reflected in the clay mineral composition. (Ghabru and Ghosh, 1984).

Kaolinite had appreciable amounts of iron substitution in the octahedral layers in the clay fraction of lateritic soils of Goa (Rao and Krishnamurthy, 1985).

Mica is the dominant mineral in clay fraction in the brown forest soils of the mountain tract of Darjiling, Himalayan region. The presence of a mica-vermiculite regularly inter stratified mineral with spacing at 12 A^{o} is the characteristic mineralogical feature. Small amounts of vermiculite, chlorite and kaolinite also occur in the clay fraction. Chlorite and mica in clay are derived from the parent material whereas the interstratified mica-vermiculite and vermiculite are the weathering products of biotite mica. (Sahu and Ghosh, 1986).

Clay fraction of two Alfisols from Dhauladhar Range of

Middle Siwaliks was dominated by mica, with kaolinite, pedogenic chlorite and mixed layer minerals with some smectite, vermiculite, quartz and feldspars. Coarse clay consisted of quartz, with some mica, feldspars and chlorite. Mica in clay was of detrital origin while kaolinite was neoformed after hydrolysis of feldspar. (Ghabru and Ghosh, 1986).

Large amounts of goethite and haematite was observed in the laterite soils of Western Australia, developed from dolerite. Haematite and goethite contents differed with parent material. (Anand and Gilkes, 1987).

Clay silicates disintegrate in the eluvial horizons of grey forest soils. Agrillization in these soils proceed more rapidly in the A1 and A2 horizons and consists of the physical breakdown of micas and chlorites in the large fractions. (Zvyagin et al, 1987).

Illite, chlorite, vermiculite, kaolinite and chloritevermiculite mixed layers occurred in the clay fraction of the soils under forests in the Lesser Himalayas (Dharmasala area, Himachal Pradesh). Chlorite alters to chlorite-vermiculite mixed layers and then to vermiculite under slightly acid to neutral condition. Biotite alters to biotite-vermiculite and biotite-smectite mixed layers. (Dhar et al, 1988).

The clay mineralogy of two Entisols situated on the flat plain and high land of the Maraudi basin was dominated by feldspars, epidote and smectite and smectite, illite, mica and kaolinite respectively. The former was classified as Typic Ustifluvent and the latter as Typic Ustorthent. (Sahu et al, 1988).

The clay mineralogy of two Ultisols developed from glauconitic sediments revealed the intense weathering to which the parent sediments have been subjected, with the release of large quantities of iron and alteration of glauconite sequentially to vermiculite-smectite-hydroxy inter layered vermiculite (Nash et al, 1988).

X-ray diffraction of soil clays from five pedons selected in the South Kheri forests revealed kaolinite as the dominant silicate mineral, both at the surface and subsurface. Small amounts of goethite, gibbsite and intergrade micaceous minerals were also identified. (Banerjee et al, 1989).

Illite was the most dominant clay mineral identified in the Vertic Ustochrepts in the Varanasi district of Uttar Pradesh.

Smectite was also found in considerable amounts. Smectite, chlorite and vermiculite along with several mixed intergrade minerals were also found. Some of the soils also contained a little kaolinite. (Singh et al 1989).

Illite and kaolinite were present in the clay fraction of five typical soils of Assam, representative of hill slope, mountain valley, foothill, flood plain and terrace soils. Minor amounts of goethite were present in hill soils whereas vermiculite and feldspars were identified in the clay fractions of alluvium derived soils only. Smectite was present in the terrace and foot soils. Trioctahedral chlorite was present in the flood plain soil. Illite appeared to be dioctahedral. (Bhattacharya and Sidhu, 1989).

Coarse clay contained more K_2O and less Al_2O_3 than fine clay, in the clay fraction derived from residual soils on granite, observed using chemical, X-ray diffraction analysis and infrared spectroscopic analysis. Vermiculite and illite were the dominant minerals in both size fractions. (Um et al, 1990).

Laterite soils from Goa have matured to the extent of producing gibbsitic clay in the surface, with increase in the amount of goethite and haematite. (Maurya and Karkore, 1990).

In an Inceptisol, Johdpur pedon (Orissa), soil clays were dominated by kaolinite along with illite in appreciable amounts, together with quartz, goethite and gibbsite. (Sahu et al, 1990).

Udic and Typic Ustochrepts occur in association with one another in the South Balaghat forest division, Madhya Pradesh. Both kaolinite and illite occur in the clays of the two soils as detrital minerals. The former is also partially of authegenic origin. In the typic subgroup, montmorillonite is a neoformation due to the weathering of illite through illite-vermiculite,vermiculite and illite-montmorillonite mixed layers under alkaline environmental conditions. (Dhar et al, 1990).

The 14 A^o minerals identified in the clay fraction of alluvial soils from the semiarid submountain region of Punjab were vermiculite, smectite and chlorite with small amounts of 10-14 A^o phase. Vermiculite, smectite and interstratified 10-14 A^o phase appeared to originate from alteration of biotite. Chlorite which constituted a small portion was presumambly a primary mineral. (Jassal and Sidhu, 1991).

The clay minerals in the soils developed on various parent rocks of Kangra district, Himachal Pradesh, included interstratified minerals viz., chlorite-vermiculite and mica hydrobiotite as well as chlorite, mica and vermiculite. Kaolinite was not apparently inherited. The main effect of pedogenisis on inherited clay minerals was the transformation of mica and chlorite to give expansible and intergradient minerals. The transformation was usually more advanced in the A or B horizons and sometimes even at the top of the C horizons. The easily weatherable minerals in sand and silt fractions provided basic elements for stabilizing 2:1 and 2:2 type of clay minerals even in the strongly acid soils. (Gupta et al, 1991).

X-ray diffraction of the clay samples from two laterite pedons classified as Rhodic Paleustalf and Plinthic Haplustalf from the Estern Ghat region of Orissa, with abundant low activity clays, revealed that the soil clays are dominated by the kaolinite group, followed by illite. (Sahu and Patnaik, 1991).

Kalonite is the major clay mineral in the salt affected, coastal soils of Orissa (Sahu and Dash, 1991).

Clay fraction of the soils from Haryana, Agricultural University was dominated by mica (60-80%), followed by kaolinite (15-20%). Smectite, chlorite, vermiculite, quartz and feldspars were present in minor amounts (5-10%). The presence of minor amounts of interstratified minerals indicated the transformation of mica to smectite or vermiculite. (Shanwal et al, 1991).

Clay minerals in the Alfisols and Oxisols of the Northern plateau zone of Orissa are dominantly kaolinitic along with illite in appreciable quantities. (Sahu and Dash, 1991).

In the saprolite zone of the soils formed on marine clay deposits, recent alluvial terraces, older river terraces, sandy marine deposits and upland insitu weathered rocks of Peninsular Malaysia, feldspars altered to halloysite, gibbsite and kaolinite. Biotite altered to halloysite, kaolinite and goethite. Petroplinthites are composed mainly of goethite and haematite. (Zauyah et al, 1991).

B horizon of Kandiustults developed from metamorphosed granite in South Korea had partly weathered feldspars. Chlorite under a well drained acid humid temperate to semitropical environment was completely weathered to halloysite, haematite, goethite, gibbsite and chlorite -

vermiculite intergrade, probably hydroxy-interlayered vermiculite. Some dioctahedral mica appeared to be resistant in the soil. (Cho and Mermut, 1992).

The clay fractions of all horizons in a reddish brown lateritic soil from Lophanuri Province, Thailand, consisted of kaolinite, smectite, kaolinite-smectite randomly mixed layers, vermiculite and quartz. Haematite was the dominant free iron oxide in soil. (Virakornphanich et al, 1992).

The dominant mineral in the clay fraction of Entisols from West Bengal was mica in association with kaolinite, smectite, vermiculite, chlorite and microcline, coupled with a high proportion of amorphous minerals. Parent materials provided the sources of mica, feldspars and chlorite. (Adhikari and Si, 1994).

Illite and kaolinite were the major clay minerals in the Ultisols and Alfisols in Kenting region of Southern Taiwan. Gibbsite, vermiculite, quartz and irregular interstratified clay minerals were also present. The iron oxides in the clay fraction were predominantly goethite with some lepidocrocite and haematite. (Chen and Liu, 1994).

3. Micromorphological Evidences of Soil Taxonomy and Pedogensis

The technique of soil micromorphology has aided in the microscopic investigation of soils for making it a more useful tool for studying the processes involved in soil formation (Kubiena, 1938; Brewer, 1964).

Thin section studies and mineralogical analysis of hard and softened boulders of some laterites revealed an increase in porosity, removal of gibbsite near large pores and cavities, appearance of trace of kaolin and conspicuous arrangements of constituents in the softer specimens. Some parts were highly depleted of iron while other parts were densely impregnated suggesting that the softening was associated with a decrease in continuity of the impregnating material. (Alexander et al, 1956).

The gridlike network of oriented materials in the matrix of many hard specimens of laterite composed principally of goethite and haematite. (Sivarajasingham, 1961).

Argillan formation may result from the processes such as illuviation, fluvial sedimentation or by insitu weathering of mica minerals, although environment may influence the nature and fabric of illuvial features formed (Bullock and Mackney, 1970; Mermut and Pape, 1972).

Indo-Gangetic alluvial soils of Punjab and Haryana contained silasepic, agglomeratic fabric on the surface grading to loose, skel-insepic, intertextic in the B and mixed, silasepic and crystic in Cca horizons. Discontinuous, weakly oriented clay cutans and argillaceous glaebules in the B horizon were observed. (Sehgal, 1970; Sehgal and Stoops, 1972).

Mollisols are characterised by a mollic epipedon, udic moisture regime, and high water table for most part of the year. (Deshpande et al 1971 a and b).

Much of the micromorphological study has been designed to aid in the understanding of soil genesis (Eswaran, 1972).

Micromorphological identification of illuvial argillans has been made part of the criteria for the identification of argillic horizons in soils (Miedema and Slager, 1972; Soil Survey Staff, 1975).

Shining ped faces in Inceptisol pedons are related to the insitu weathering of biotite mica which on desication get oriented along the primary grains giving shining appearance to the ped faces. (Sehgal and stoops, 1972; Karale et al, 1974).

The microfabric of Natrustalfs of Uttar Pradesh exhibits mostly asepic domains which implies the retention of original sedimentary structure in the parent material. (Karale, 1972).

The process of clay migration in Oxisols in the tropics is not an active one. Relic features in thin sections indicate that the Oxisols had undergone through an Ultisol stage of soil formation. (Eswaran, 1972).

SEM studies of petroplinthite samples from Bangalore Plateau revealed that the laterite formation from kaolinite mass was by the absolute enrichment of iron oxyhydroxides. The network of iron is formed by closely crystallising goethite. (Eswaran and Raghu Mohan, 1973).

The higher water holding capacity of Oxisols and Ultisols of Hawai is attributed to the presence of intra-aggregated void spaces. (Tsuji <u>et al</u>, 1975).

Clay migration studies in Ustic soils under varying moisture regimes revealed that clay cutans are rather weakly developed and have high content of dispersible clay in the surface horizon. (Sehgal <u>et al</u>, 1976).

Skeleton grains in the Hapludolls of mountain valleys of Himalayan regions comprise of lithorelics, micas, quartz and feldspars. (Sehgal and stoops, 1976).

Paleustalfs occurring in many parts of South India consists of an A horizon followed by a thick argillic B horizon, quite often a resistant ferruginous layer, a pallid zone and a saprolite. (Rengaswamy et al, 1978; Venugopal, 1986).

The present day climate is too dry for the high concentration of iron oxyhydroxides seen in Rhodustalfs. They must have been formed under more humid climatic conditions of the past (Rangaswamy et al, 1978).

Plinthustalfs of Goa contained ring like argillans overlying a bright coloured goethan in B2t and B3 horizons. The plasma is yellow with low birefringence (Raghu Mohan, 1978).

Some Inceptisols in Andhra Pradesh have developed on calcareous shales. The splotchy lime showed neo-calcitans and diffuse concretions where as some halpludalfs of Guddapah basin showed illuviated clay in the textural B horizon resulting in lattisepic plasmic fabric with the occurrence of gibbsite. (Rao 1981).

The thin ferriargillans occurring in some Inceptisols are due to the weathering of mica, while the carbonate formation is a result of current process (Kooistra, 1982).

A variety of minerals and rock fragments at different stages of weathering and at different depths were observed in the Dystrochrepts of Kerala. Thin argillans in the ground mass as well as in the voids were observed. These argillans are often associated with thin ferrans or mangans in the lower layers. (Kooistra, 1982).

The occurrence of weathering cutans suggests in place alteration of mica. (Kooistra, 1982).

The skeleton grains in Vertisols mainly comprise of quartz and lithorelics of the rock corresponding to the region. The plasma is fine, yellowish brown to dark grayish brown, generally yellowish in Chromusterts and grayish in Pellusterts. The elementary structure is planar, porphyric with vo-masepic to omnisepic plasmic fabric. The accumulation of angular soil fragments in voids at greater depths formed as a result of shrinkage, the roundness of large carbonate modules, orientation of clay domains resulting in moderate ma-vosepic plasmic fabric and the decrease in faunal activity with depth may be attributed to vertic process. (Kooistra, 1982).

The Ustipsamments of Rajasthan and Haryana revealed thin and discontinuous ferriargillans around mineral grains and packing voids, formed due to insitu weathering of mica. The ground mass of `A' horizon showed remnants of a geogenetic lamination in which laminae, with higher contents of fine material alternate with laminae practically free of fine material. (Kooistra, 1982).

The related distribution pattern of the forest and hilly soils of Dhumakot pedon is porphyric and the plasmic fabric is mainly skel-insepic. Elementary structure is weak to moderately pedal, pedotubulic and skel-insepic. The pedological features included thin argillans and papules, voids filled with mineral and organomineral faecal pellets, organic fragments in mull-humus form, iso and striotubules, neo-sesquans and few sesquioxide nodules. (Kooistra, 1982).

The skeleton grains in Hapludalfs consist mainly of quartz with some weatherable minerals. The plasma is yellowish brown, the plasmic fabric varies from asepic to insepic and argillasepic with porphyric related distribution pattern. The elementary structure in cutanic, vughy, asepic to argillasepic. Pedological features include thick, laminated cutans, argillans, papules and Fe-Mn glaebules. (Kooistra, 1982).

The skeleton grains of Rhodustalfs are mainly quartz with very few weatherable minerals. The ferro-manganese nodules are of common occurrence in the S-matrix. The plasma is reddish brown to dark reddish brown with kaolinitic clay. The related distribution pattern in the A horizon is primarily gefuric where the skeleton grains predominate over plasma. The B horizon has undulic to weak reticulate b-fabric and porphyric related distribution where the plasma and voids predominate over skeleton grains. The `C' horizon has weak, reticulate b-fabric. The elementary structure is pedal, cutanic, pedotubulic and porphyric. (Kooistra, 1982).

The features relating to clay illuviation in many Haplustalfs are historical and are being destroyed by faunal activity. The changes induced by faunal activity necessitates revision in the classification of many of the Ustalfs in Southern India (Kooistra, 1982).

A close correlation occurs between the undulic fabric and relative proportion of the iron oxides in the Ultisols of Goa. The low degree of anisotropism in the plasmic fabric is attributed to the presence of high proportion of amorphous or very finely crystalline, unoriented iron oxides or hydroxides, while the undulic fabric is more associated with the lenticular bodies or intercalations of banded haeamatite quartzites which occur extensively with phyllites. The ferrans, neo-ferrans as well as the diffuse iron show iron segregation during plinthite formation which corresponds to rubification. (Raghu Mohan, 1982).

Torrifluvents with calcareous alluviums derived from Siwaliks occur on old flood plains of Ghaggar Valley in Rajasthan. The colour of the plasma is dark yellowish brown. Elementary structure is weakly pedal, vughy with moderately developed skelsepic plasmic fabric. The skeleton grains predominate over plasma throughout and calcium carbonate nodules with crystals ranging from 15μm to 150μm are common. (Murthy et al, 1982).

Humitropepts along the steep hills in Tamil Nadu contain a variety of minerals with moderate alteration. The plasmic fabric ranges from isotropic to argillasepic. The elementary stucture is cutanic, vughy, porphyric and isotropic to argillasepic. The common pedological features include thin ferri-argillans, sesquioxide nodules and mineral excrements. (Murthy et al, 1982).

The dominent Entisols observed are Psamments, Aquents and Fluvents. Entisols of Indo-Gangetic alluvium are formed in young river flood plains or on sand dunes or on other aeolian deposits. These soils are characterised either by the absence of a diagnostic horizon or have only fragments of diagnostic horizons which are discernible. (Dhir and Jain, 1982).

The Inceptisols occurring in the laterite regions of Goa come under Dystropepts and Dystrochrepts. The plasmic fabric ranges from skel-masepic to lattisepic and the related distribution pattern is porphyric. The common pedological features include voids filled with mineral excrements, mangans and papules. The alteration of feldspars to gibbsite is observed in the `B' horizon of some Oxic Dystrochrepts. Plinthustalfs from Banglore plateau contain dark brown to tan brown plasma with concentration of iron oxides. The Haplustalfs revealed the occurrence of hialine to straw yellow plasma which can be attributed to the mobility of plasma in these soils. The Rhodustalfs have a bright red plasma than the Haplustalfs. This suggests an advanced stage of rubification in the Rhodustalfs (Raghu Mohan, 1978 and 1982).

Haplustalfs, along with Rhodustalfs and Paleustalfs are of common occurrence in South India. Morphologically and micromorphologically, these three Great Groups show similar characteristics, but for colour. The elementary structure is pedal, cutanic, pedotubulic and porphyric. The skeleton grains which predominate over plasma in Ap horizon decrease with depth. (Murthy et al, 1982).

Micromorphology of Xerochrepts and Xerorthents soils developed on alluvial sediments of the Maipo river, Chile, showed little weathering of skeletal grains and only incipient development of the plasmic fabric, indicated by the absence of plasmic concentrations or separations. The Xerorthents lacked cutans, but sesquioxide glaebules were present throughout the profile. Iron deposits were observed on the surface skeleton grains in Xerochrepts. The occassional presence of normal, thin and discontinuous void argillans and the incipient formation of illuviation cutans demonstrated the slightly higher degree of development of these soils in comparison with the Xerochrepts. (Honorato and Nunezm, 1982).

In the Indo-Gangetic alluvial soils, illuviation features and matrans decreased with increased rainfall. (Manchanda and Hilwig, 1983).

The movement of other materials along with clay influence the fabric of the cutan. (Bullock et al, 1985).

The alteration of microlaminations of lympid and speckled clays (rich in ironoxides) with low to medium birefringence and weak extinction showing ageing characteristics is the result of wetting and drying conditions. (Fedoroff and Eswaran, 1985; Bullock et al, 1985; Brewer, 1960).

Mangans were observed in the argillic horizon of a Typic Haplustalf in Guddapah basin. Such mangans serve as cutanic surfaces for establishing the argillic horizon in the soils derived from granite. (Rao et al, 1985).

A number of different fabric elements which included porphyroskelic zones with amorphous silica in the s-matrix were observed in the thin sections of the hard pan horizons of New South Wales. Zones composed almost entirely of amorphous silica, chlamydic zones with clay coatings on skeleton grains and calcareous materials filling the fissures. (Chartres, 1985).

The soils on mountain slopes formed from the chlorite schist under deciduous forest in the warm and humid regions of Central Himalayas are characterised by a mollic epipedon, underlain by a cambic horizon. The elementary structure is pedotubulic, vughy, agglomeroplasmic to porphyro-skelic. The important pedological features are orthoaggrotubules, humified faecal pellets, Fe-humus nodules and Fe-oxyhydrate nodules. (Sehgal et al, 1986).

A close relationship between the pedofeatures and the parent material was observed in the formation of a Chromustert from limestone in Paluad basin in Andhra Pradesh. The presence of calcitans, manganese glaebules, pedotubules and silasepic plasmifabric were taken as criteria in establishing the insitu development of the pedon. (Rao et al, 1986).

Four Vertisol pedons from Karnataka, Andhra Pradesh and Maharashtra contained black and white $CaCO_3$ glaebules. The micromorphological and C14 analysis indicated that the calcitic nodules identified were of pedogenic origin. The X-ray and chemical analysis suggested that the concretions comprise mainly of calcite and other primary minerals as inclusions. (Mermut and Dasog, 1986).

Notable changes were observed in morphological features, associated with fabric rearrangement as reflected in increased compaction and decreased porosity under cropping and fallowing. Development of banded fabric and broken down basic mull-granic fabric units were also observed under forest cover. (Pawluk, 1986).

Two podsolic soils in Canberra showed fine grained void cutans and grain capping in A and upper B horizons. They consisted of quartz, mixed clay minerals and traces of feldspars, iron and titanium. Illuvial clays in the lower B and C horizons consisted of clear reddish orange ferri-argillans (Chartres, 1987).

The deposition of organic mineral compounds in the B horizon gave different kinds of micro-structures depending upon the intensity of podsolisation processes and on the texture and mineralogical composition of the mineral mass of the horizon. Strong podsolisation in a sandy quartzitic material led to a coated microstructure. A micro aggregated microstructure of biological origin would form if a weak podsolisation process occurred. In loamy materials rich in weatherable minerals such as biotite, vermiculite or chlorite, a micronodular structure of physico-chemical origin was formed. (Righi, 1987).

Lateritic pallid zones derived from granite and dolerite were almost identical in their quartz content and consist of a matrix of tubular halloysite crystals and kaolinite plates. The dominant microfabric of the exterior and fracture surface of peds consist of randomly oriented crystals, although small domains of strongly oriented halloysite are found. (Mc Crea and Gilkes, 1988).

With increasing iron content, the plasma tends to aggregate to give a distribution pattern termed agglutanic. The largest grains are not affected by this aggregation until the microstructure coalesces to a pellety form. In such conditions the boundaries of the aggregates are clearly visible and may show a yellow rim. The high sesquioxide content also gives particular properties to the plasmic fabric which is isotic and argillasepic. (Cardoso and Eswaran, 1988).

Particle size distribution had a large effect on subsoil micromorphology of some tropical udults. Argillic horizon fabric within the finest grained pedon was mostly mosepic with few discrete cutans suggesting that insitu weathering is a dominant clay forming process. Coarser textured pedons had well oriented argillans in the skelvosepic to vomasepic fabric of the argillic horizons. (Wadsworth et al, 1988).

Micromorphology of Vertisol transects from different parts of South India revealed that Inceptisols with vertic characters are characterised by agglomeroplasmic fabric while Vertisols have vo-masepic plasmic fabric. Vertisols from different parts of India showed specific differences in the S-matrix, nature of skeleton grains and secondary formations. The presence of lithorelics, crystallaria, neo-cutans and the nature of fabric signifies their variations in relation to genesis (Kalbande et al, 1988)

The occurrence of shells and snails in some Vertisols suggest their fluvial origin (Dasog et al, 1988).

Micromorphology of four main groups of skeletal soils in Malaysia revealed that iron-coated parent material occur as platy fragments showing relict schistocity, parallel bands of crystalline goethite and void neo-ferrans (Zauyah et al, 1988).

Micromorphological studies of an Aquic Ustrochrept (paddysoil) from Karnataka have revealed well developed gleyans and grain cutans in the subsoil, which are very similar to argillans. Their formation is attributed to the movement of finer materials during flooding. The S-matrix consists of subangular, weakly altered quartz, mica, hornblende and a few heavy minerals. The abundance of mica has resulted in stipplespeckled or silasepic b-fabric. (Venugopal et al, 1989a).

The nature of biotite weathering and kaolinite formation in a shrink-swell soil formed on biotite gneiss around Nagpur has revealed that the climate of the region had changed from humid to arid. (Venugopal et al, 1989b and Pal et al, 1989).

Homogenisation of soil material down to the C horizon by biological activity is observed in the soils of Bangalore Plateau, Karnataka. Inspite of deep weathering and kaolinitic mineralogy, the pedons still contained abundant weatherable minerals such as mica and feldspars suggesting that the deeply weathered soils of pre-pleistocene period have been rejuvinated by exposures of granites or metamorphosed intrusive rocks. The soils exhibit abundant ferri-argillans and insitu weathering cutans. Ferruginous soils revealed the dominance of microlaminated textural pedofeatures (ferri-argillans), matrix or unsorted clay pedofeatures (matrans) and fragments of clay pedofeatures embedded in soil matrix (papules) upto 150cm depth. Impure clay pedofeatures (insitu weathered cutans), lympid clay pedofeatures (argillans) and fragments of clay pedofeatures embeded in the soil matrix, neo-ferrans and neo-cutans with common typic, crescentic hypo-coatings and infillings, below 150cm. Density distribution of these features at different depths suggests that alternate wetting and drying, weathering and biological activity operated during different periods of soil formation. (Venugopal et al, 1990).

Vertisols from sub-humid regions contained porostriated b-fabric. In the semi-arid and arid regions it was either mosaic speckled or granostriated, indicating weak plasma separation due to restricted swelling of clays. (Kalbande et al, 1992).

Two typical pedons of arable and non-arable land of Himachal Pradesh, India, showed little horizon differentiation. The soil formed on steep slopes over granite/gneiss parent material under mixed coniferous and deciduous vegetation had an ochric inter- grading to mollic epipedon. Soils on gentle slopes over similar parent material and used to cultivate potato had mollic epipedon underlain by a cambic horizon. The soils were classified as Mollic Udorthent and a Fluventic Hapludoll respectively (Kaistha and Gupta, 1994).

MATERIALS AND METHODS

MATERIALS AND METHODS

Kerala State, having an area of 38,855 sq.km is located between 8°18' - 12°48' north latitude and 74°52' - 77°22'east longitude. Earlier, separate geological studies were made for Malabar (Logan, 1887) and for Travancore (Nagam, 1906 and Velupillai, 1938). High hills, valleys and plains which represent the major physiographic features of the state suggest that considerable mountain building activity followed by erosion- deposition have taken place. The configuration of the present day landscape is accounted for by the upliftment of the Western Ghats during the Miocene-Pliocene epoch. The chronological succession of the four major geological formations identified in the state (NBSS & LUP 1993) is as follows.

1. Crystalline rocks of Archean age.
2. Sedimentary rocks of Tertiary age.
3. Laterites capping the crystallines and sedimentary rocks, and
4. Recent and subrecent sediments in the low lying areas and valleys.

Annual rainfall of Kerala ranges between 1000 mm at Chinar to about 5000 mm at Neriyamangalam, with two distinct peaks of rainfall in June-July and October-November. North Kerala receives heavy precipitation during June-July only (CESS, 1990). In the high ranges mean annual temperature is less than 22^{o}C. Palakkad plains have mean annual temperature of 27.8^{o}C and the coastal plains have an average of 27.5^{o}C. In other parts the temperature ranges between 22^{o}C to 27^{o}C.

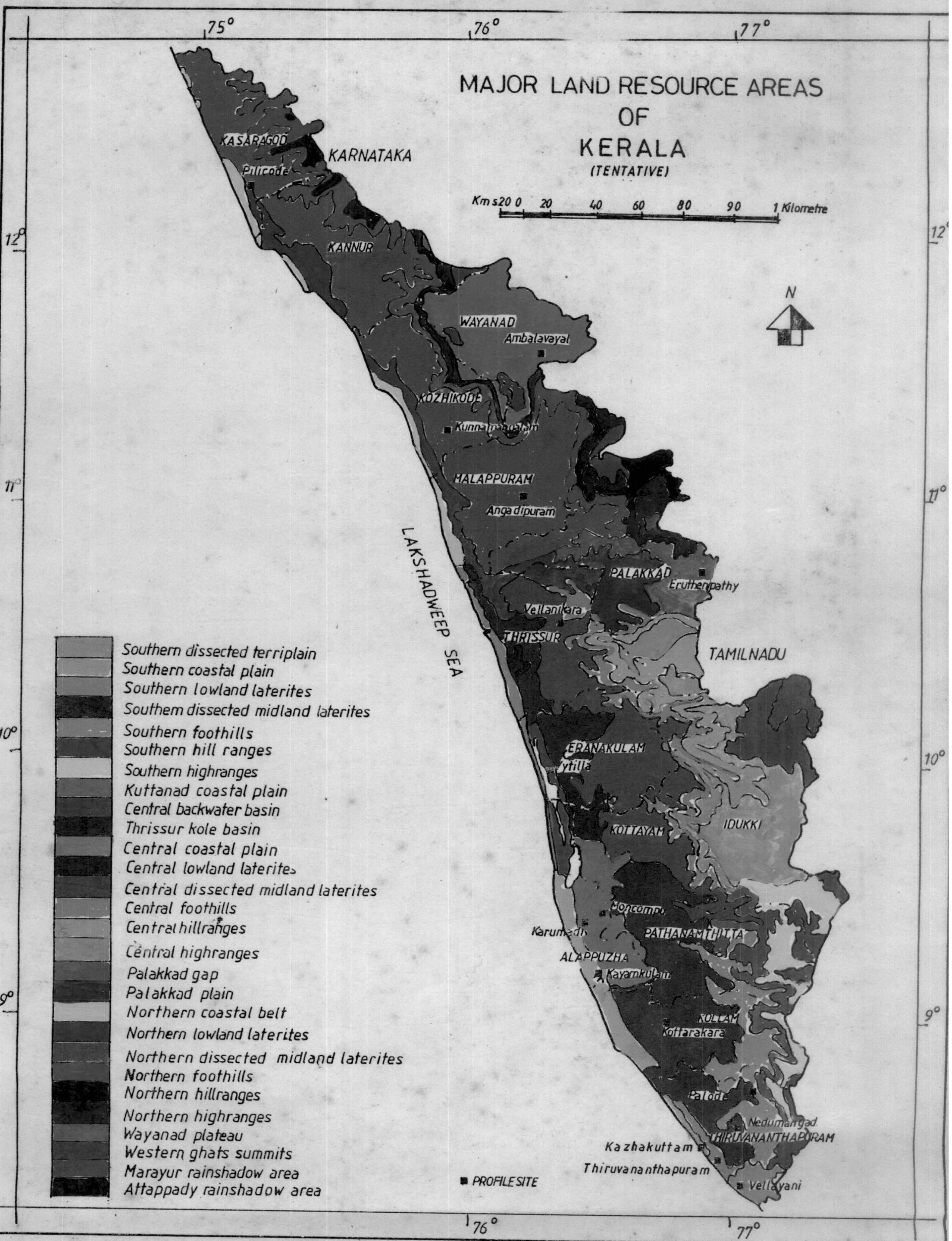
Lithosequence in Kerala includes the extremely acidic Khondalite group of rocks in the south which grades into acidic - charnokites in Central Kerala and intermediate and basic rocks in the north. Intrusions of dolerite, gabbro and dunite are frequented in the archean crystalline formations (Thampy, 1992).

These variations in the climate, geology, geomorphology and vegetation, have necessitated the identification of geographically associated soils, the majority of which have broadly similar patterns of climate, water resources and land uses, for refined profile description and classification. MLRA information provides preliminary baseline data for selection of areas for development (David and Eswaran, 1990). Accordingly, in confirmation to geomorphic surfaces and ecovariations with altitude ten major geomorphic divisions are identified in Kerala, which are further classified into MLRA units based on the magnitude of spatial variability in these geographic entities (Soil Survey Staff, 1993).

1. Soil Profile Studies

In order to characterize the micromorphological and mineralogical properties of the diagnostic horizons of the soils of the major land resource areas of Kerala, ecozones with geographically associated soils, similar pattern of climate, water resources and land use were selected. Sixteen sites (representing eleven MLRA's of Kerala), selected for the purpose of this study are listed below, with the respective MLRA unit.

Site	MLRA unit
1.Vellayani	Southern dissected terriplain
2.Thiruvananthapuram	Southern low land laterites
3.Kazhakuttom	Southern coastal plain
4.Nedumangad	Southern dissected midland laterites
5.Palode	Southern foot hills
6.Kottarakkara	Southern dissected midland laterites
7.Kayamkulam	Southern coastal plain
8.Karumadi	Kuttanad coastal basin
9.Moncompu	Kuttanad coastal basin



MAJOR LAND RESOURCE AREAS OF KERALA
(TENTATIVE)
Kms 20 0 20 40 60 80 90 1 Kilometre
N
75°
76°
77°
12°
11°
10°
9°
KARNATAKA
TAMILNADU
LAKSHADWEEP SEA
KASARAGOD
Pilicode
KANNUR
WAYANAD
Ambalavayal
KOZHIKODE
MALAPPURAM
Angadipuram
PALAKKAD
Eruthenpathy
Vellanikara
THRISSUR
ERANAKULAM
IDUKKI
KOTTAYAM
Karumadi
PATHANAMTHITTA
ALAPPUZHA
Kayamkulam
KOLLAM
Kottarakara
Palode
Nedumangad
THIRUVANANTHAPURAM
Kazhakuttam
Thiruvananthapuram
Vellayani
PROFILE SITE
Southern dissected terriplain
Southern coastal plain
Southern lowland laterites
Southern dissected midland laterites
Southern foothills
Southern hill ranges
Southern highranges
Kuttanad coastal plain
Central backwater basin
Thrissur kole basin
Central coastal plain
Central lowland laterites
Central dissected midland laterites
Central foothills
Central hillranges
Central highranges
Palakkad gap
Palakkad plain
Northern coastal belt
Northern lowland laterites
Northern dissected midland laterites
Northern foothills
Northern hillranges
Northern highranges
Wayanad plateau
Western ghats summits
Marayur rainshadow area
Attappady rainshadow area

10.Vytilla	Central backwater basin
11.Vellanikkara	Central dissected midland laterite
12.Eruthenpathy	Palakkad gap
13.Angadipuram	Northern dissected midland laterite
14.Kunnamangalam	Northern dissected midland laterite
15.Ambalavayal	Wayanad plateau
16.Pilicode	Northern dissected midland laterite

A representative profile per location was dug and described as per F.A.O. guidelines (1990) upto 2 meteres or upto a lithic or paralithic contact whichever is shallower. After demacrating the horizons for field morphological description as per the Guidelines for the description and coding of soil data (van Waveren and Bos, 1991), samples were collected for granulometric analysis and mineralogical and micromorphological studies. Soil colour was recorded under field moisture conditions using Munsell Soil Colour Chart (USA, 1975). Soils were tentatively classified in the field itself as per Keys to Soil Taxonomy (SMSS Technical Monograph No.19, 1994).

2.Collection of Soil Samples

2.1 Granulometric Analysis

Bulk soil samples were collected from all the horizons of the 16 profiles for granulometric analysis. The samples were collected in polythene bags and labelled with regard to site and pedounit number and depth of horizon in pedounit.

2.2 Mineralogical Analysis

Bulk soil samples were collected from the diagnostic epipedon and endopedons of all the 16 profiles for mineralogical studies of the fine sand and clay fraction. Samples were collected in polythene bags and labelled with regard to site and pedounit number.

2.3 Micromorphological Analysis

After demarcating the horizons, undisturbed soil samples were collected from the diagnostic epipedon and endopedon of all the sixteen profiles for micromorphological studies. Kubiena boxes of size 10x5x3.5cm with detachable top and bottom lids were used to collect undisturbed soil samples in the case of soft coherent soil materials. Soil samples from the diagnostic horizons were collected with as little disturbance as possible. Both lids were removed from the box and by exerting a little pressure and cutting around the outside with a knife, the box was gradually forced into the soil until it was full. The soil around the outside of the frame was removed and the top lid was placed in position.

Then the frame was removed with about 1-2cm of soil projecting on the other side. This excess soil was then gradually removed and the second lid was replaced in position. The box was then sealed with tape. Both lids were labelled with regard to site and pedounit number, and orientation. Such undisturbed soil samples were collected from the diagnostic horizons of all the profiles having soft and coherent materials.

In the case of hard soil materials where the Kubiena box could not be pressed into the soil, a block or clod of the material was collected from the diagnostic horizons by appropriate means such as chipping it out. Its orientation was marked and then bound completely with tape and labelled.

3.Laboratory Studies

3.1 .Granulometric Analysis

The bulk samples from all the horizons of the 16 profiles were air dried, crushed with wooden mallet and passed through a 2mm sieve. The gravel retained in the 2mm sieve was weighed and expressed as percentage. The mechanical composition of the soil was determined by Robinson's International Pipette Method (Piper, 1967).

3.2. Mineralogy

3.2.1. Fine Sand Mineralogy

Preliminary treatment and separation of fine sand was conducted during mechanical analysis by the International Pipette Method (Piper, 1967). The dried samples were used for the separation of light and heavy mineral fractions using bromoform of specific gravity 2.8 following the method outlined by Carver (1971). The separated fractions were thoroughly washed in alcohol, followed by distilled water and dried.

The light and heavy mineral fractions thus separated were mounted on microscopic slides using canada balsam, avoiding air bubbles. Excess resin was removed by carefully washing with xylene. The prepared slides were then examined under a petrological microscope. The minerals were identified on the basis of shape, colour, pleochroism, relief, isotropism, anisotropism, angle of extinction and twinning. Quantitative estimation of minerals was carried out following the method outlived by Carver, (1971).

3.2.2. Clay Mineralogy

The clay for X-ray diffraction analysis was separated by the method outlined in the Soil Survey Investigation Report No.1 (Soil Conservation Service, USDA, 1967). The clay samples.

were thoroughly washed with distilled water and then with methanol. The X-ray diffraction was carried out in a Philips 1140 X-ray diffractometer using copper Kα radiation. An ion filter with a scanning speed of 5 degree per minute was used. Estimation of clay mineral composition by determination of relative areas of the diffraction peaks was made (Black et al, 1965)

3.3. Micromorphology

The procedure described in the Soil Survey Investigation Report No.1 (Soil Conservation Service, USDA 1967) was followed for studying the micromorphology of the diagnostic horizons.

Undisturbed Kubiena box soil samples as well as clods of convenient size from the diagnostic horizons were collected from the sixteen locations. The samples were treated with epoxy resin diluted using absolute alcohol and allowed to stand at constant temperature of 50^{o}C for 48 hours in an oven to ensure that the resin has completely filled the voids. After 48 hours the soil block was taken out and a chip of convenient size was cut using hacksaw blade. Outside of the chip was ground with carborundum 60,120,400 and 600 grade powders, in the increasing order of grades. The final polishing was done with aloxite 800 and 1000 grade.. The polished smooth surface was fixed to a glass slide using Lakeside cement No. 70. The otherside of the chip was then ground using carborundum 60,120,400 and 600 grade powders in the increasing order of grades. The final polishing was done with alloxite 800 and 1000 grade till the chip attained a thickness of 20μ. A cover glass was fixed on the polished chip using molten canada balsam, avoiding air bubbles. Excess canada balsam was removed by carefully washing with xylene. The slide thus prepared was placed under a polarised microscope and observations were recorded under plain and polarised light. Photomicrographs were taken under both systems of light and interpretations made.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Major land resource areas are representative planning units for the development of agriculture and allied fields, and have geographically associated soils having broad similarities with respect to climate, water resources and land uses. The MLRA information provide preliminary base line data for developmental programmes. Such a detailed base line information requires an indepth knowledge of the soils which can be effectively attained through micromorphological studies. Soil micromorphology can be viewed as the study of soil morphology in the size range where optical aid is needed for the naked eye (Buol *et al*, 1980). The information gained through micromorphology and mineralogy, especially of the diagnostic horizons, help in the perfect taxonomic classification of soils. In order to achieve this aim the diagnostic horizons of the representative profiles from sixteen sites falling under ten major land resource areas of the state were studied in detail, for refined profile description and classification, considering the microvariability of the soils.

1. Morphology

1.1. Site and Soil Characteristics

1.1.1. Geographic Distribution of Sites

The profile studied at Vellayani, Thiruvananthapuram, Kazhakuttom, Nedumangad, Palode and Kottarakkara falling within $8^{O}25'$ and $8^{O}58'$ north latitude and 76^{O} $49'$ and $77^{O}2'$ east longitude represent the MLRA units southern dissected terriplain, southern low land laterites, southern coastal, plain southern dissected midland laterites, southern foot hills and southern dissected midland laterites respectively. The profile sites at Kayamkulam, Karumadi, Moncompu and Vytilla lie between $9^{O}10'$ and $10^{O}1'$ North latitude and $76^{O}21'$ and $76^{O}31'$ east longitude. Kayamkulam represents the southern coastal plain whereas the sites at Karumadi and Moncompu are representative of the Kuttanad coastal basin. Vytilla represents the Central backwater basin area. The MLRA units of Central dissected midland laterites, Palakkad gap and northern dissected midland laterites are represented by the profile sites at Vellanikkara, Eruthenpathy and Angadipuram respectively, falling between 10^{O} $33'$ and $10^{O}58'$ north latitude and $76^{O}11'$ and $76^{O}53'$ east longitude. The profiles studied at Kunnamangalam, and Ambalavayal, representing the northern dissected midland laterites and the Wayanad plateau respectively lie within $11^{O}18'$

and 11°36' north latitude and 75°53' and 76°12' east longitude and that at Pilicode falling at 12°12' north latitude and 75°10' east longitude represent the northern dissected midland laterites.

1.1.2. Elevation and Water Table

MLRA units represented by Vellayani and Thiruvananthapuram lie at about 30 metres above mean sea level while Nedumangad, Palode and Kottarakara are at about 60 metres above mean sea level, and Kazhakuttom less than 10 metres above mean sea level. Moncompu, Karumadi and Vyttila remain unique and are located about 1 to 2.5 metres below mean sea level while Kayamkulam is located at an elevation of less than 5 metres above mean sea level. Vellanikkara, Eruthenpathy, Angadipuram and Kunnamangalam are at an elevation ranging from 50 to 117 metres above mean sea level, while the major land resource area of Wayanad plateau represented by Ambalavayal is at an elevation of more than 800 metres above mean sea level. Pilicode, representing the northern dissected midland laterite, is located at about 20 metres above mean sea level.

The studied representative profiles of the different MLRAs lying within 8°25'-12°12' north latitude and 75°10'-77°2' east longitude are located at different elevations, resulting in varying land forms, topography, physiographic units and slope.

They have also developed from varying parent materials with slight to high degree of weathering. Topography, physiographic unit and slope (ranging from less than 1 percent to 30 percent) are the significant factors governing profile development, resulting in MLRAs with slight to severely eroded, moderately deep to very deep profiles. The unique land form, topography, physiographic unit and slope have also resulted in poorly drained to well drained soils with shallow to deep water table, in the various MLRAs. The wet land profiles of the Kuttanad basin are located at an elevation of about 1 to 2.5 metres below mean sea level resulting in very high water table, which remains at or near the soil surface for most periods during the year, whereas in the case of Vellayani, representing the Southern dissected terriplain, the water table is deep.

1.1.3. Soil Moisture and Temperature Regimes

All the MLRAs studied fall within isohyperthermic temperature regime but with aquic, udic and ustic moisture regimes, resulting in profiles with high variability in morphology and pattern, because of the lesser variation in soil temperature regime and marked variation in soil moisture regime imparted by varying land form, physiography, slope, natural vegetation and land use.

1.1.4. Diagnostic Horizons

The major epipedons identified, irrespective of the MLRAs, keys into the ochric, which is the characteristic surface diagnostic horizon expected in a humid tropical situation with long dry spells. The highly leached surface horizon with least organic matter content is also due to undulating topography and higher cropping intensity. At Palode the major diagnostic surface horizon is mollic with a tendency of argillic horizon formation in deeper layers. It is observed that even the mollic features are being lost, leading to an ochric epipedon in steep sloping areas with lesser natural vegetation.

Irrespective of the major land resource areas is the formation of ill developed to well developed argillic horizon. The main factors influencing clay migration leading to the formation of argillic horizon are favoured by slope (8-16%) extent of forest cover and cropping intensity. Other important factors of its formation are the percolation of water and soil texture. At Karumadi, Vytilla and Moncompu, the soils are with sulphidic materials even within 0-50 centimetre depth. Pedoturbation and diagenic soil formation are observed at Eruthenpathy.

1.1.5. Local Nomenclature

The local nomenclature of the soils of the MLRAs are based on soil colour (red soil for the soils studied at Vellayani, black soil for Eruthenpathy, greyish onattukara for Kayamkulam), soil texture (gravelly soil for Thiruvananthapuram, Nedumangad, Palode, Kottarakkara, Vellanikkara, Angadipuram, Kunnamangalam, Pilicode,Karimannu for Karumadi and Moncompu), system of cultivation and dominant crop cultivated (Pokkali soil for Vytilla, cotton soil for Eruthenpathy) and soil formation (laterite soils for Thiruvananthapuram, Nedumangad, Palode, Kottarakkara, Vellanikkara, Angadipuram, Kunnamangalam and Pilicode).

1.1.6. Morphological Description of Profiles

The brief macromorphological description of the representative profiles from the selected MLRAs at Vellayani, Thiruvananthapuram, Kazhakuttom, Nedumangad, Palode, Kottarakkara, Kayamkulam, Karumardi, Moncompu, Vytilla, Vellanikkara, Eruthenpathy, Angadipuram, Kunnamangalam, Ambalavayal, and Pilicode are presented below

PROFILE No. 1

SITE CHARACTERISTICS

Location : Vellayani, College of Agriculture campus.

Latitutde : $8^{o}35'N$ Longitude: $76^{o}59'E$ Altitude: 25m above MSL

classification :
USDA : Fine loamy mixed isohyperhermic Rhodic Haplustox.
Diagnostic horizons : ochric, argillic.
Local classification : Red loam.

General Land form : low hill Topography : flat or almost flat

Physiographic Unit: flat
Slope: Gradient/Aspect/Form : 1% N undulating.

Position of site : flat
Surfacee characters:
Rock outcrops : none Stoniness : none

Cracking : nil Salt : nil alkali: nil
Slope Processes-Soil erosion: slight sheet.

Parent Material : eolian deposits. Derived from : basic gneiss

Weathering degree : high Texture : sandy
Resistance : high

Effective soil depth : 2.00 m.

Hydrology:
Water table depth : 25 m
Drainage : well
Permeability : moderate
Flooding frequency : nil. Run off : medium

Land use : medium level arable farming coconut based mixed crop.

Vegetation : grasses, shrubs.

Soil Moisture Regime : Ustic.
Soil Temperature Regime : Isohyperthermic.

PROFILE DESCRIPTION

Ap	0-25 cm	2.5 YR 5.0/6.0 moist; sandy loam; very fine, very weak granular; non sticky non plastic, friable; many finepores; many fine and medium roots; p^H5.1 clearsmooth boundary to
AB	25-60 cm	2.5 YR 4.0/8.0 moist; sandy loam; fine to medium granular; non sticky non plastic friable; many fine interstitial exped pores; few fine roots; p^H5.2; diffused wavy boundary to
B_{t1}	60-109 cm	2.5 YR 3.0/6.0 moist; clay loam; fine to medium granular; slighty sticky non plastic; friable; many fine interestitial exped pores; few fine roots; p^H 4.8; diffused smooth boundary to
B_{t2}	109-150 cm	2.5 YR 3.0/6.0 moist; clay loam; fine to medium granular; slightly sticky non plastic; friable; many fine interstitial exped pores; few fine roots; p^H 5.1

PROFILE No. 2

SITECHARACTERISTICS

Location : Thiruvananthapuram, Mannanthala.
Latitutde : 8^{o}33N Longitude : 76^{o}56'E Altitude: 30m above MSL

Classification :
USDA: Fine kaolinitic isohyperthermic Plinthic Kandiustults.
Diagnostic horizons : ochric, Argillic,
Local classification: Gravelly laterite.

General Land form : Low hill Topography: rolling
Physiographic Unit: undulating-rolling hillocks, dissected:
Slope: Gradient/Aspect/Form: 14% E convex

Position of site: Crest
Surface characters:
Rock out crops : None   Stoniness: Stony
Cracking : nil   Salt : Nil   Alkali : Nil

Slope Processes : Soil erosion: moderate rill

Parent Material : residual (insitu) weathered material   Derived from: Metamorphic-sedimentary
Weathering degree: High   Texture : gravelly
Resistance : moderate

Effective soil depth: 150 cm

Hydrology:
Water table depth : 15 m
Drainage : well
Permeability : moderate
Flooding frequency : nil   Run off: rapid

Land use : Mixed farming medium level, coconut based.
Vegetation : herbaceous unspecified

Soil Moisture Regime : Ustic
Soil Temperature Regime: isohyperthermic

PROFILE DESCRIPTION

Ap 0-13 cm. 5.0 YR 4.0/4.0 moist, clay loam, very gravelly; fine weak granular and medium weak subangular blocky; slightly friable, many fine and meduim pores; common fine and medium roots; p^H4.8; clear wavy boundary to

BA 13-40 cm 5.0 YR 5.0/8.0 moist, clay loam, very gravelly; medium, moderate subangular blocky; slightly hard, friable many fine and medium pores, common fine roots; P^H 5.1 gradual wavy boundary to

B_{t1} 40-69 cm. 5.0 YR 6.0/8.0 moist; clay, very gravelly; medium weak subangular blocky to fine weak subangular blocky; slightly hard and friable; many fine and medium pores, thin clay films on faces of peds, few fine roots, pH 5.3; clear wavy boundary to

B_{t2} 69-101 cm. 5.0 YR 6.0/8.0; clay, very gravelly; medium fine subangular blocky to fine weak subangular blocky; slightly hard, friable;, common fine and medium pores, thin clay films on faces of peds, few fine roots; pH 5.3 diffused smooth boundary to

BC 101-150 cm. 5.0 YR 6.0/8.0; clay, very gravelly, moderate coarse subangular blocky; slightly hard, firm; common fine and medium pores; thin clay films on faces of peds, few medium roots. pH 5.1

PROFILE No. 3

SITE CHARACTERISTICS

Location : Kazhakuttom.
Latitutde : 8°34'N Longitude: 76°52'E, Altitude:<10m above MSL

Classification :
USDA : Sandy mixed isohyperthermic Ustic Quartzipsamments
Diagnostic horizons : ochric.
Local classification: Sandy soil.

General Land form : coastal plain Topography: flat or almost flat
Physiographic Unit: Plain
Slope: Gradient/Aspect/Form: < 2% straight west.
Position of site: flat.
Surface characters:
Rock out crops: nil. Stoniness: nil
Cracking : nil. Salt : nil Alkali: nil

Parent Material : Coastal alluvium Derived from: Coastal sand deposits.
Weathering degree: partial Texture : sandy
Resistance : high

Effective soil depth: 2m

Hydrology:
Water table depth : 3 m
Drainage : well
Permeability : rapid
Flooding frequency : nil   Run off: medium

Land use : coconut
Vegetation : herbs, shrubs.

Soil Moisture Regime : Ustic
Soil Temperature Regime: isohyperthermic.

PROFILE DESCRIPTION

Ap 0-24 cm. 7.5 YR 5.0/4.0 moist, loamy sand, weak fine granular;loose; very friable, non sticky non plastic;many medium tubular vertical discontinuous exped pores; common fine to medium roots; p^H 5.0; diffused smooth boundary to

AC1 24-83 cm. 5.0 YR 4.0/4.0 moist; loamy sand; weak medium granular loose; friable; non sticky non plastic; many fine to medium tubular vertical discontinuous exped pores; few medium rots; p^H4.8; diffused wavy boundary to

AC2 83-150 cm. 5.0 YR 4.0/6.0 moist, loamy sand; weak medium granular loose, friable; non stricky non plastic; many fine interstitial vertical, discontinuous exped pores; few medium roots; p^H 4.9.

PROFILE No. 4

SITE CHARACTERISTICS

Location : Nedumangad.
Latitutde : 8°35'N . Longitude:77°1'E Altitude: 60 m above MSL

Classification :
USDA : Fine skeletal kaolinitic Plinthic Haplustults, .

Diagnostic horizons : Ochric, argillic.
Local classification : Gravelly laterite

General Land form : low hill   Topography : rolling.
Physiographic Unit : hill
Slope: Gradient/Aspect/Form : 16-30% convex east :
Position of site : crest.
Surface characters,
Rock out crops : nil   Stoniness : stony
Cracking : nil   Salt : nil   Alkali: nil
Slope Processes-Soil erosion: moderate rill

Parent Material : residual (insitu) weathered   Derived from:metamorphic rocks, gneiss

Weathering degree : moderate   Resistance : low.

Effective soil depth : 1.3 m

Hydrology:

Water table depth : 20 m
Drainage : well
Permeability : moderately rapid.
Flooding frequency : nil   Run off: rapid

Land use : Coconut, tapioca
Vegetation : shrubs, trees.

Soil Moisture Regime : Ustic
Soil Temperature Regime: Isohyperthermic.

PROFILE DESCRIPTION

Ap 0-23 cm. 10.0 YR 4.0/3.0 moist; clay loam, gravelly; moderate, medium, crumb; slightly hard, friable slightly sticky non plastic, many fine to medium interstitial random discontinuous exped pores; common fine to medium roots; PH 5.4 gradual smooth boundary to

AB 23-54 cm. 10.0 YR 4.0/4.0 moist, clay loam; gravelly, moderate, medium, sub angular bLocky; slightly hard, firm slightly stickly non plastic,many fine to medium interstitial random discontinuous exped pores; few medium to coarse roots; pH 5.4 gradual wavy boundary to

B_{t1} 54-81 cm. 10.0 YR 5.0/6.0 moist; clay loam; gravelly; moderate medium to coarse, subangular blocky; hard; firm slightly sticky non plastic; many fine to medium interstitial random discontinuous pores; few coarse roots; pH 5.2 gravdual wavy boundary to

B_{t2} 81-150 cm. 5.0 YR 6.0/6.0 moist, clay, gravelly; strong, coarse, subangular blocky; hard; firm; sticky slightly plastic; many fine interstitial random discontinuous pores; very few coarse roots; pH 5.3.

PROFILE No.5.

SITE CHARACTERISTICS

Location : Palode
Latitutde : 8°43'N Longitude:77°2' E Altitude:60m above MSL

Classification :
USDA : Fine skeletal mixed isohyperthermic Typic Hapludolls.
Diagnostic horizons : mollic, argillic.
Local classification : forest loam.

General Land form : Hill. Topography : rolling.
Physiographic Unit : rolling hills.
Slope: Gradient/Aspect/Form: 25% NE convex.
Position of site: Crest.
Surface characters:
Rock out crops: Rocky. Stoniness: stony
Cracking : nil Salt : nil Alkali: nil

Parent Material : Insitu weathered Derived from: Metamorphic Sedimentary rocks.
Weathering degree : medium. Resistance : Nil
Slope process : Erosion - moderate rills

Effective soil depth : 90 cm.

Hydrology:
Water table depth : 20 m
Drainage : Well
Permeability : moderate
Flooding frequency : nil   Run off: rapid

Land use : fruit trees.

Vegetation : grasses, forest.

Soil Moisture Regime : udic.
Soil Temperature Regime: Isohyperthermic.

PROFILE DESCRIPTION

A_p 0-10 cm. 10.0 YR 3.0/1.0 moist; silty clay loam, gravelly; weak to moderate, medium subangular blocky: friable, slightly sticky non plastic; very fine to medium, interstitial random, discontinuous exped pores; very fine to medium roots; p^H 5.4: gradual wavy boundary to

AB 10-28 cm. 10.0 YR 4.2/2.0 moist; silty clay loam, gravelly; moderate; medium, subangular blocky; friable, slightltly sticky non plastic; many fine to medium, interestitial random discontinuous exped pores; many medium roots; p^H 5.6; gradual smooth boundary to

B_{t1} 28-47 cm. 10.0 YR 5.0/4.0 moist, clay, gravelly; moderate coarse subangular blocky; firm, slightly sticky non platic; many, fine, interestitial, vertical discontinuous exped pores; few medium and coarse roots; PH 5.3; gradual smooth boundary to

B_{t2} 47-93 cm. 10.0 YR 5.0/6.0 moist; clay, gravelly; moderate coarse subangular blocky; firm, slightly sticky slightly plastic, few coarse roots, PH 5.3 diffused irregular boundary to

BC 93-150 cm. 7.5 YR. 5.0/8.0 moist, clay, gravelly; moderate coarse subangular blocky; firm sticky slightly platic; gneissic rock in different stages of weathering

PROFILE No. 6

SITE CHARACTERISTICS

Location : Kottarakkara, Sadanandapuram, NARP Station.
Latitutde : $9^{o}00'$N Longitude : $76^{o}37'$E Altitude:91m above MSL

classification :
USDA : loamy skeletal kaolinitic isohyperthermic Typic Plinthustults
Diagnostic horizons : ochric, argillic.
Local classification : Gravelly laterite.

General Land form:low hill Topography : undulating/rolling
Physiographic Unit : Rolling hillocks, degraded.
Slope : Gradient/Aspect/Form : 15% NE undulating.
Position of site : Lower slope
Surface characters;
Rockoutcrops : None Stoniness : very few stones
Cracking : nil Salt : nil Alkali: nil
Slope Processes-Soil erosion : moderate rills.

Parent Material:residual material. Derived from:metamorphic/ Sedimentary

Texture : Gravelly
Resistance : high
Weathering degree: high

Effective soil depth: 130 cm.

Hydrology:
Water table depth : 30 m
Drainage : well
Permeability : moderate
Flooding frequency : nil.
Run off:medium

Land use : medium level arable farming, coconut, terracing.
Vegetation : Grass lands, modified

Soil Moisture Regime : Ustic.
Soil Temperature Regime: Isohyperthermic.

POFILE DESCRIPTION

A_{p1} 0 - 5 cm. 5.0YR 3.0/2.0 moist; clay loam, very gravelly, herbacious fragments, highly decomposed, medium moderate granular, slightly sticky slightly plastic firm loose, many very fine vertical continuous inped tubular pores; highly porous; many very fine roots in mat at top of horizon, frequent concretions and frequent noodles, nil fraagments; frequent worm channels and termite channels, pH.4.8; abrupt irreegular boundary to.

A_{p2} 5 - 30 cm. 5.0 YR 4.0/4.0 moist, clay loam, very gravelly, herbacious fragments, highly decomposed coarse moderate granular; slightly sticky slightly plastic very firm very hard; common fine oblique continuous exped tubular pores; many very fine roots between peds; frequent concretions and frequent nodules, nil fragments, frequent worm channels and termite channels' pH 5.0, diffuse wavy boundary to

AB 30-57 cm. 2.5 YR 3.0/1.0 moist; clay, very gravelly; herbacious fragments, highly decomposed; coarse to very coarse strong subangular blocky, slightly sticky slightly plastic, very firm veryhard; many fine oblique continuous exped tubular pores; many very fine roots between peds, very frequent concretions and frequent nodules; nil fragments, frequent termite channels; pH 5.1 gradual wavy boundary to

B1 57-130 cm. 7.5 YR 4.0/3.0 moist; clay, very gravelly; very coarse strong subangular blocky; slightly sticky slightly plastic, very firm hard; few fine faint diffuse mottles, common very fine oblique continuous exped tubular pores; moderately porous; few very fine roots; very frequent concretions and very frequent modules ; very few fine weathered fragments; frequent termite channels and krotovinas; pH 5.3; gradual wavy boundary to

B2 130-165 cm. 7.5 YR 4.0/3.0 moist; clay, very grvelly; very coarse strong subangular blocky; slightly sticky slightly plastic, firm; few fine faint diffuse mottles; patchy moderately thick clay cutans on slickensides; few micro vertical continuous inped pores; nil roots; frequent small spherical hard ferruginous nodules and frequent small spherical hard ferruginous concretions. pH 5.3.

PROFILE No.7

SITE CHARACTERISTICS

Location : Kayamkulam, Rice Research Station, KAU, Rice land, North Block

Latitutde : 09°30'N Longitude:76°20'E Altitude:<10m above MSL

classification :
USDA : Sandy mixed isohyperthermic Tropic Fluvaquents
Diagnostic horizons : ochric,
Local classification : Greyish Onattukara loamy sand.

General Land form : coastal alluvial plain Topography:flat
Physiographic Unit: Bunded rice lands, low lands
Slope : Gradient/Aspect/Form : 1% W straight.
Position of site : flat.
Surface characters:
Rock out crops: none Stoniness : none
Cracking : nil Salt : nil Alkali: nil
Slope Processes-Soil erosion: slight sheet.

Parent Material:Coastal alluvium Derived from:Coastal alluvial sediments,
Texture : Sandy
Weathering degree: slight Resistance : very high

Effective soil depth: 120 cm.

Hydrology:

Water table depth : 125 cm.
Drainage : somewhat excessive
Permeability : rapid
Flooding frequency : yearly, fresh water. Run off : slow.

Land use : medium level arable farming rice, seasonal irrigated,
crop rotation continuous.
Vegetation : grasslands, modified.

Soil Moisture Regime : Udic.
Soil Temperature Regime : Isohyperthermic.

PROFILE DESCRIPTION

Ap 0-25 cm. 10.0 YR 4.0/1.0 moist; loamy sand; herbaceous fragments, highly decomposed; fine weekly coherent massive, non sticky non plastic loose; nil mottles, common medium random discontinuous exped vesicular pores; highly porous; common fine roots throughout; very frequent worm channels, p^H (field): 5.5; gradual smooth boundary to

C1 25-74 cm. 10.0 YR 4.0/3.0 moist; loamy sand; fine, weakly coherent subangular blocky; non sticky non plastic loose; few fine faint clay mottles; common medium random exped vesicular pores, few fine roots between peds; few discontinuous worm channels, p^H (field): 5.5; gradual irregular boundary to

C_{g1} 74-125 cm. 10.0 YR 5.0/8.0 moist; loamy sand; fine to medium moderately coherent porous massive, non sticky non platic very friable; few fine faint mottles, common medium random discontinuous exped vesicular pores, moderately porous; nil roots; p^H (field): 5.8, gradualwavy boundary to

C_{g2} 125-155 cm. 5.0 Y 6.0/1.0 moist, loamy sand; decomposed, fine to medium weakly coherent single grain; non sticky non platic loose; few fine faint diffuse mottles; common medium random discontinuous exped vesicular pores; highly porous, nil roots, P^H (field) 6.0.

PROFILE No.8

SITE CHARACTERISTICS

Location : Karumadi
Latitude : 9°24'N longitude : 76°22'E Altitude:2m below MSL

Classification:
USDA : fine mixed isohyperthermic Histic Sulfaquents.
Diagnostic horizon : histic, argillic
Local classification : Kari soils.

General land form : basin land Topography : flat or almost flat
Physiographic unit : coastal basin
Slope-Gradient/Aspect/Form : <2% South West concave
Position of site : flat
Surface characters :
Rock outcrops : nil Stoniness : nil
Cracking : nil Salt : nil Alkali : nil
Slope processes-soil erosion : slight, sheet

Parent material: Organic sediments Derived from:Woody materials
Weathering degree:moderate Resistance : moderate

Effective soil depth : 50 cm

Hydrology :
Water table depth : < 1 metre
Drainage : poorly drained
Permeability : slow
Flooding frequency : yearly Run off : ponded

Land use : paddy
Vegetation : grass, mangrove

Soil Moisture Regime : Aquic
Soil Temperature Regime : Isohyperthermic

PROFILE DESCRIPTION:

A_{p1} 0-25 cm 2.5 Y 4.0/0 moist, silty clay loam, coarse prismatic, very sticky and plastic, hard when dry; few fine and medium discontinuous horizontal inped and exped pores; concretions and nodules present; partially decomposed wood fossils; relics of lime shells; many fine and medium rice roots; p^H (field) 3.9; gradual smooth boundary to

A_{p2} 25-80 cm 2.5 Y 3.0/0 moist; silty clay; coarse prismatic; very sticky and plastic; hard when dry; few medium, discontinuous, horizontal inped and exped pores; concretions and nodules present; partially decomposed wood fossils; relics of lime shells; many medium roots; p^H (field) 4.0; gradual wavy boundary to

Ag 80-125 cm 2.5 Y 2.0/0 moist; silty clay, moderate medium subangular blocky; few oblique inped and exped pores; partially decomposed wood fossils; jarosite mottles 2.5 Y 7.0/4.0 and 2.5 Y 6.0/6.0 observed; relics of lime shells; few medium roots; p^H 4.4; gradual wavy boundary to

C_1 125-150 cm 2.5Y 2.0/0; silty clay; moderate medium few oblique inped and exped pores subangular blocky; partially decomposed wood fossils, relics of lime shells; nil roots; p^H 5.5

REMARKS

Black and grey coloured, silty clay to clay soil with partially decomposed wood under different stages of decomposition. Pale yellow jarosite mottles present within 50 cm. Other mottles present are dark yellowish brown to olive yellow in colour. Decayed iron oxide coated mangrove plant parts are present throughout the profile. The soil is moist throughout the profile with ground water below 75 cm.

PROFILE No. 9

SITE CHARACTERISTICS

Location :Moncompu, Rice Research station, KAU.
Latitude :9°26'N Longitude :76°26'E Altitude: 1.5m below MSL

Classification:
USDA : Fine mixed isohyperthermic Histic Sulfaquents.
Diagnostic horizon : histic, cambic
Local classification : Kari soil.

General land form : basin land Topography : flat or almost flat
Physiographic unit : coastal basin.
Slope-Gradient/Aspect/Form : <2% South West : concave
Position of site : flat
Surface characters :
Rock out crops : nil Stoniness : nil
Cracking : Small cracks. Salt : Slight Alkali:nil

Slope processes-Soil erosion : Slight sheet

Parent material :Organic sediments Derived from: Woody material.
Weathering degree : moderate Resistance : moderate

Effective soil depth : 50 cm.

Hydrology :
Water table depth : < 1 m.
Drainage : poorly drained.

Permeability : slow
Flooding frquency : yearly Run off: ponded

Land use : Bulk rice cropped fields.
Vegetation : grasses, mangrove

Soil Moisture Regime : Aquic
Soil Temperature Regime: Isohyperthermic.

PROFILE DESCRIPTION:

A_{p1} 0-20 cm 2.5 Y 2.0/2.0 moist, silty clay loam, coarse prismatic, wet very sticky and plastic, hard when dry; few, fine and medium discontinuous horizontal and oblique inped and exped vesicular open and closed pores; many fine and medium roots; mottlings 10YR 4.0/4.0 and 7.5 YR 4.0/4.0; P^H (field) 5.0; gradual wavy boundary to

Ap_2 20-74 cm 10YR 2.0/2.0 moist; silty clay loam; coarse prismatic; very sticky and platic; few fine discontinuous horizontal and oblique inped and exped vesicular open and closed pores; many fine and medium roots; mottings 10YR 4.0/4.0; P^H (field) 5.0, gradual smooth boundary to

Ag 74-130 cm 2.5 Y 2.0/0 moist; silty clay; moderate; medium subangular blocky; very sticky and plastic; few fine discontinuous horizontal inped and vesicular closed pores; few fine and medium roots; pale yellow relics of lime shells; jarosite mottles, pyrite; P^H (field) 5.6; gradual smooth boundary to

C_1 130-150 cm 2.5 Y 2.0/0 moist; silty clay; moderate medium subangular blocky; sticky and plastic; gleying and mottles, pale yellow jarosite mottles and pyrite present. P^H 5.8

REMARKS:

Deep poorly drained, dark grey to very dark grey with silty clay loam surface and silty clay subsurface horizons. Subsurface horizons show thick iron ochre on profile face. Gleying and abundant mottles. Pale yellow jarosite mottles and pyrite present.

PROFILE No. 10.

SITE CHARACTERISTICS

Location:Vytilla, Rice Research station, KAU.
Latitude:10^{o} 1'N Longitude :76^{o} 21'E Altitude 2.5 m below MSL

Classification:
USDA : Fine mixed isohyperthermic Histic Sulfaquents
Diagnostic horizon : histic, sulfuric/ cambic.
Local classification: Pokkali soil.

General land form : Coastal plain Topography : flat or almost flat
Physiographic unit: low lands(back water basin)
Slope-Gradient/Aspect/Form : 1% straight north-west.
Position of site : Closed depression.
Surface characters:
Rock outcrops : nil Stoniness : nil
Cracking : small cracks

Salt : moderate Alkali : nil
Slope processes : Soil erosion ; slight sheet

Parent material :estuarine sediments Derivedfrom:Sedimentary woody material
Weathering degree : Moderate Resistance : Moderate.

Effective soil depth : 50cm

Hydrology :
Water table depth : 60 cm
Drainage : Poorly drained
Permeability : Slow
Flooding frquency : Yearly Run off: Very slow

Land use : bulk rice cropped fields
Vegetation : grasses, mangrove

Soil Moisture Regime : Aquic
Soil Temperatre Regime: Isohyperthermic

PROFILE DESCRIPTION:

Ap_1 0-11 10.0 YR 2.0/2.0 moist; clay; coarse prismatic, very sticky and plastic, hard when dry; broken and continuous,moderate, organan, feriargillan and sodium sulphate cutans on ped faces, many fine to medium discontinuous, and continuous vertical and horitioznal inped and exped vesicular open pores, fine to medium roots; mottling 10YR 4.0/4.0; P^H 4.4; gradual wavy boundary to

Aj 11-48 7.5 YR 3.0/0.moist; clay, coarse prismatic to subangular blocky; very sticky and plastic, hard when dry; broken and continuous, moderate, organan, ferriargillan and sodium sulphate cutans on ped faces; many fine to medium discontinuous and continuous vertical and horizontal inped and exped vesicular open pores; fine to medium roots; mottling 2.5Y 6/4; P^H 4.9; gradual smooth boundary to

Grs 48-60 10 YR 3/1 moist; clay; coarse prismatic to subangular blocky; very sticky and plastic, hard when dry, many fine to medium discontinuous and continuous vertical and horizontal inped and exped open and closed pores; mottlings 10YR 5/8; P^H 5.3 gradual smooth boundary to

60-150 cm 10YR 3.0/2.0 moist; clay; moderate coarse subangular blocky; very sticky and very plastic, very hard when dry; few fine to medium discontinuous vertical and horizontal inped and exped open and closed pores, mottling 2.5Y 4.0/4.0, P^H 5.5

REMARKS:

Deep, poorly drained, highly saline, very dark gray to dark greyish brown coloured soil with clay texture throughout the profile, Fair amounts of decaying organic matter present throughout. The profile is soft, plastic, sticky with shining ped faces. Very few yellowsih brown, olive brown and brownish yellow mottlings in subsurface horizons. Jarosite mottle laden layer (2.5 Y 7/4 and 2.5 Y 6/4) is present below 50 cm. Very few fossil pnematophores within 30 cm. depth.

PROFILE No. 11.

SITE CHARACTERISTICS

Location : Vellanikkara
Latitude : 10^{o} 33'N Longitude : 76^{o} 16'E Altitude:50m above MSL

Classification:
USDA : Fine loamy skeletal isohyperthermic Typic Plinthustults
Diagnoistic horizon : Ochric, argillic
Local classification: gravelly laterite

General land form : Low hill. Topography : Undulating/rolling
Physiographic unit: laterite hill/mound
Slope-Gradient/Aspect/Form : 12 % convex east
Position of site : crest
Surface characters:
Rock outcrops : nil Stoniness : Stony
Cracking : nil Salt : nil Alkali : nil

Parent material:residual insitu weathered. Derived from: metamorphic rocks.
Weathering degree : high Resistance: low
Slope processes-Soil erosion: moderate rill.

Effective soil depth : 100cm

Hydrology :
Water table depth : 30 m
Drainage : Well
Permeability : Moderately rapid
Flooding frquency : Nil Run off: rapid

Land use : coconut
Vegetation : grasses, herbs

Soil Moisture Regime : Ustic
Soil temperatre Regime: Isohyperthermic

PROFILE DESCRIPTION:

Ap 0-10 cm. 5.0 YR 3.0/3.0 moist, clay loam, gravelly; weak; medium, subangular blocky; soft; friable; nonsticky non plastic; many, fine and medium, interstitial vertical discontinuous exped pores; many fine roots, pH 5.4; gradual wavy boundary to

AB 10-37 cm 5.0 YR 5.0/4.0 moist; clay loam, gravelly; moderate medium sub angular blocky; friable; non sticky non plastic; many fine and medium interstitial vertical discontinuous exped pores; few medium roots; pH. 5.1; gradual wavy boundary to

Bt_1 37-60 cm 5.0YR 5.0/8.0 moist, clay loam, gravelly; moderate medium subangular blocky; very friable, non sticky non plastic; many medium interstitial vertical discontinuous exped pores; pH 5.4; gradual wavy boundary to

Bt_2 60-96 cm. 5.0 YR 5.0/6.0 moist, clay loam, gravelly; moderate, coarse sub angular blocky; very friable, slightly sticky non plastic, many medium interstitial vertical continuous exped pores; pH 5.3; gradual wavy boundary to.

Bt_3 96-150 cm. 5.0 YR 5.0/8.0 moist; clay, gravelly, moderate coarse subangular blocky; very friable, sticky slightly plastic; many fine and medium interstitial vertical continuous exped pores; pH 5.3.

PROFILE No. 12

SITE CHARACTERISTICS

Location : Eruthenpathy.
Latitude : $10^o44'$N Longitude : $76^o53'$E Altitude :100 m above MSL

Classification :
USDA:Fine montmorillonitic isohyprthermic Petrocalcic Chromusterts

Diagnostic horizon :umbric, argillic
Local classification: Black cotton soil.

General land form : lava plain   Topography : undulating.
Physiographic unit: low hill
Slope-Gradient/Aspect/Form : 3% undulating SE.
Position of site : flat
Surface characters:
Rock outcrops : nil   Stoniness : very few stones.
Cracking : small cracks   Salt : nil   Alkali:slight
Slope processes-Soil erosion : slight sheet.

Parentmaterial:volcanic ejecta. Derived from:Igneous/Sedimentary rocks
Weathering degree : high   Resistance : low

Effective soil depth : 100 cm.

Hydrology :
Water table depth : 3 m
Drainage : Imperfectly drained.
Perm:eability : slow.
Flooding frquency : yearly.   Run-off : Ponded

Land use : cotton.
Vegetation : grasses, parthenium.

Soil Moisture Regime : Ustic
Soil Temperature Regime : Isohyperthermic.

PROFILE DESCRIPTION:

Ap 0-10 cm   10.0 YR 3.0/4.0 moist; clay, weak, medium, subangular blocky; friable, sticky and slightly plastic many fine and medium discontinuous hortizontal and oblique inped and exped vesicular open and closed pores; few fine and medium roots; p^H 5.6; clear smooth boundary to

B_{t1} 10-85 cm 5.0 YR 3.0/4.0 moist; clay; moderate, medium subangular blocky; firm, sticky and plastic, many fine and medium discontinuous inped and exped pores, few coarse roots; p^H 5.6; gradual wavy boundary to

B_{t2} 85-125 cm 5.0 YR 3.0/3.0 moist; clay; moderate coarse subangular blocky; very firm, very sticky and very plastic; few medium discontinuous inped and exped pores; roots nil; p^H 5.6; diffuse smooth boundary to

B_{t3} 125-150 cm 5.0 YR 3.0/4.0 moist; clay; moderate coarse subangular blocky; very firm, very sticky and very plastic; few fine discontinuous inped and exped pores; roots nil; p^H 5.6

PROFILE No.13

SITE CHARACTERISTICS

Location : Angadipuram, Eranthode, Malappuram.
Latitude : 10°58'N Longitude : 76°11'E Altitude: 117m above MSL

Classification:
USDA : fine skeletal mixed isohyperthermic Typic Plinthustults.
Diagnostichorizon : ochric, argillic
Local classification : laterite, gravelly.

General land form : hills Topography : rolling.
Physiographic unit : laterite mounds
Slope-Gradient/Aspect/Form : 12% convex north East
Position of site : lower slope
Surface characters:
Rock outcrops : nil Stoniness : stony
Cracking : nil Salt : nil Alkali : nil
Slope processes -Soil erosion : severe sheet, rill.

Parent material :residual insitu weathered. Derived from : Sedimentary/metamorphic.
Weathering degree : high Resistance : low

Effective soil depth : 50 cm.

Hydrology :

Water table depth : 15-20 m.
Drainage : well drained.
Permeability : moderate.
Flooding frequency : nil. Run off : rapid.

Land use : coconut, banana.
Vegetation : grasses, herbs, shrubs.

Soil Moisture Regime : ustic.
Soil Temperatre Regime : Isohyperthermic

PROFILE DESCRIPTION:

Ap. 0-17 cm. 5.0 YR 5.0/8.0 moist; clay loam, very gravelly;weak medium subangular blocky; slightly hard,friable, slightly sticky non plastic; many very fine vertical continuous exped tubular pores; porous; many very fine roots throughout; frequent concretions; moderate permeability; p^H 5.8; gradual smooth boundary to

B_{t1} 18-32 cm. 5.0 YR 5.0/4.0 moist; clay loam; very gravelly, weak, medium subangular blocky; slightly hard friable; slightly sticky non plastic; many fine to medium interstitial random continuous exped pores; highly porous; common fine to medium roots throughout; frequent concretions; moderate permeability; p^H 5.6; gradual wavy boundary to

B_{t2} 32-49 5.0 YR 4.0/6.0 moist; clay; gravelly; moderate medium subangular blocky; hard, firm sticky slightly plastic; many very fine to fine interstitial random discontinuous exped pores; highly porous; few medium roots between peds; frequent concretions; moderately slow permeability; PH 5.7, grdual smooth boundary to

C Laterite quarriable.

PROFILE No.14

SITE CHARACTERISTICS

Location : Kunnamangalam, CWRDM campus, Kozhikode.
Latitude : 11°10'N Longitude:75°53'E Altitude:100 m above MSL

Classification:
USDA:Fine skeletal kaolinitic isohyperthermic Typic Plinthustults
Diagnostic horizon : ochric, argillic.
Local classification: Gravelly laterite

General land form : hills. Topography : rolling
Physiographic unit: undulating rolling hillocks dissected.
Slope-Gradient/Aspect/Form : 15% NE convex.
Position of site : middle slope.

Surface characters:
Rock outcrops : few Stoniness : stony
Cracking : nil. Salt : nil. Alkali : nil.
Slope processes - Soil erosion : moderate rill.

Parentmaterial:Residual(insitu weathered) Derived from:Sedimentary/Metamorphic.
Texture : gravelly.
Weathering-degree : high Resistance : moderate.

Effective soil depth : 121 cm.

Hydrology :
Water table depth : 30 m.
Drainage : well
Perm eability : moderate.
Flooding frquency : nil. Run off : rapid.

Land use : afforestation - accassia
Vegetation : natural vegetation, grasses, herbs.

Soil Moisture Regime : Ustic.
Soil Temperatre Regime : Isohyperthermic.

PROFILE DESCRIPTION:

Ap 0-18 cm. 2.5 YR 4.0/6.0 moist; clay loam, gravelly; fine weak granular, hard and friable; many medium roots,iron and quartz gravels about 50% by volume, many fine discontinuous vertical tubular pores; P^H 5.4; clear smooth boundary to

B_{21} 18-51 cm. 2.5 YR 3.0/6.0 moist, clay, gravelly; fine weak subangular blocky; fine weak granular hard, firm, sticky and plastic, common fine roots, 2 to 5 mm. size iron and manganese concretions about 5% by volume, 5 to 25 mm. size gravel about 50% by volume, many fine discontinuous vertical tubular pores; 1 to 4 cm size;krotovinas;P^H 5.4; diffuse smooth boundary to

B_{22} 51-99 cm 2.5 YR 3.0/6.0 moist, clay, gravelly; moderate medium subangular blocky; hard; firm, sticky and plastic, 2 to 5 mm size iron and manganese concretions about 5% by volume, 5 to 25 mm. size gravel about 30 to 40% by volume, many fine discontinuous vertical tubular pores; 1 to 4 cm.size krotovinas; P^H; 5.6, clear wavy boundary to

B_{23} 99-121 cm. 2.5 YR 4.0/6.0 moist, clay, gravelly; weak medium subangular blocky, hard, firm and sticky, 2 to 5 mm size, iron and manganese concretions about 5% by volume, 5 to 20 mm size gravels about 50 to 65% by volume; P^H. 5.8

PROFILE No. 15

SITE CHARACTERISTICS

Location : Ambalavayal, KAU Res. Station, Wayanad.

Latitude : $11^{o}36'$N Longitude : $76^{o}12'$E Altitude: 880 m above MSL

Classification:

USDA : Fine loamy mixed isohyperthermic Typic Ustorthents

Diagnostic horizon : ochric,

Local classification: red loam.

General land form : plateau   Topography : rolling
Physiographic unit: rolling hills.
Slope-Gradient/Aspect/Form : 10% convex south.
Position of site :Upper side slope
Surface characters:
    Rock outcrops : little rocky.   Stoniness : nil.
    Cracking : nil   Salt : nil   Alkali : nil
Slope processes -Soil erosion : moderate, sheet/rill.

Parent material:Colluvial deposits.Derived from : Sedimentary/ Metamorphic rocks.
Weathering degree : moderate   Resistance : moderate.

Effective soil depth : 1.5 m.

Hydrology :
 Water table depth : 20 m
 Drainage : well
 Permeability : rapid.
 Flooding frequency: nil   Run off : medium.

Land use : horticultural crops.
Vegetation : grasses, herbs.

Soil Moisture Regime : Ustic.
Soil Temperature Regime : Isohyperthermic.

PROFILE DESCRITION:

A_{p1} 0-16 cm. 2.5 YR 5.0/8.0 moist, clay loam; fine to medium, granular, slightly sticky non-plastic, friable, many fine to medium exped pores; many fine roots throughout p^H 5.5; diffused smooth boundary to

A_{p2} 16-46 cm. 2.5 YR 4.0/8.0 moist, clay loam; fine to medium granular, slightly sticky non-plastic, friable, many fine interstitial exped pors; many fine roots throughout, p^H 5.2; diffused smooth boundary to

AB 46-86 2.5 YR 5.0/8.0 moist; sandy loam, very fine very weak granular, non sticky non plastic; friable, many fine pores; many fine and medium interstitial exped pores; few fine and medium roots throughout, pH 5.3; diffused smooth boundary to

B_{t1} 86-150 2.5 YR 3.0/6.0. moist; clay loam; fine to medium granular, slightly sticky non plastic; friable; many fine interstitial exped pores; nil roots, pH 5.5.

PROFILE No.16

SITE CHARACTERISTICS

Location : Pilicode, KAU, Research Station & College.
Latitude : 12°12'N Longitude : 75°10'E Altitude : 20 m above MSL

Classification:
USDA :Fine skeletal mixed isohyperthermic Plinthic Kandiustults
Diagnostic horizon : ochric, argillic
Local classification: gravelly laterite

General land form : Hill Topography : rolling
Physiographic unit: rolling hills
Slope-Gradient/Aspect/Form : 12% undulating.
Position of site : upper slope.
Surface characters:
Rock outcrops : nil. Stoniness : stony.
Cracking : nil. Salt : nil Alkali : nil
Slope processes - soil erosion : moderate, rills

Parent material:residual insitu weathered Derived from : Sedimentary/ Metamorphic rocks.
Weathering degree : Moderate/high, Resistance : moderate

Effective soil depth : 80 cm.

Hydrology :
Water table depth : 15 m.
Drainage : well
Permeability : moderately rapid.

Flooding frequency: nil. Run off : medium.

Land use : coconut
Vegetation : grasses, shrubs.

Soil Moisture Regime : Ustic.
Soil Temperature Regime: Isohyperthermic.

PROFILE DESCRIPTION:

Ap 0-12 cm. 5.0 YR 5.0/4.0 moist, clay loam, gravelly; fine, weak, fine, subangular blocky, slightly hard, friable, slightly sticky non plātic, many fine to medium vesicular random discontinuous exped pores; common fine and medium roots, p^H.5.4; clear wavy boundary to

AB 13-39 5.0 YR 5.0/6.0 moist, clay loam; gravelly; weak fine subangular blocky; slightly hard friable non sticky non plstic; many medium vesicular vertical discontinuous exped pores; few fine and medium roots throughout, p^H 5.3; gradual wavy boundary to

B_{t1} 40-74 5.0 YR 6.0/8.0 moist, clay loam, very gravelly; moderate medium subangular blocky; hard, firm, sticky slightly plātic; many medium interstitial vertical discontinuous exped pores; few medium roots between peds; p^H 5.3; diffused wavy boundary to

B_{t2}- 74-120 5.0 YR 6.0/6.0 moist, clay, very gravelly; moderate medium subanugular blocky, hard firm,stkicy slightly plastic, many fine to medium interstitial vertical discontinuous exped pores; nil roots, p^H 5.2.

1.1.7. Soil Colour

The major land resource areas having wide differences in geographic locations, represented by Vellayani, Ambalavayal and Kunnamangalam, exhibited a soil hue of 2.5 YR. 5 YR is the hue of almost all the similar geographically located MLRAs, represented by Thiruvananthapuram, Kottarakkara, Vellanikkara, Angadipuram and Pilicode. The southern coastal plain represented by Kazhakuttom has the same subsurface hue with a surface hue of 7.5 YR. At Kottarakkara, the surface hue is 5 YR with subsurface horizons of 2.5 YR and 7.5 YR. The soil hue at Nedumangaad, Palode, Kayamkulam, Moncompu and even the black soils of Eurthempathy are dominantly 10 YR. The soil hue of 5 YR is also observed in subsurface layers at EYUthenpathy. Karumadi and Moncompu have a dominant soil hue of 2.5 Y while, Vytilla soils exhibit a hue of 10 YR and 7.5 YR.

Lack of organic matter and proper drainage have imparted the oxidised soil mineral hue of 2.5 YR, 5 YR and 7.5 YR. The soil mineral hue of 10 YR is indicative of organic matter coating and presence of opaque minerals (at Moncompu and Eruthenpathy). The soil hue of 2.5 Y of the wet land areas of the Kuttanad basin are indicative of the enrichment of jarositic materials. The soil hue difference observed at Kazhakuttom, Kotarakkara, Moncompu and Eruthenpathy are due to differences in redox situation and soil material (Eruthenpathy). At Eruthenpathy, a blackish 10 YR soil hue material is noticed to be overlying the red coloured 5 YR material. Within the profiles, irrespective of the MLRAs, the value and chroma exhibited lesser differences, except in unique horizons and mottles.

1.1.8. Soil Texture

Texturally, the soils of the southern dissected terriplain, represented by Vellayani, are sandy loam to sandy clay loam. Soils of the Wayanad plateau, occurring at very high elevation represented by Ambalavayal, also exhibit a dominant soil texture of sandy clay loam, whereas the major soils of the southern low land laterites (Thiruvananthapuram), southern dissected midland laterites (Nedumangad), southern foothills (Palode), and the northern dissected midland laterites (Angadipuram, Kunnamangalam and Pilicode) are gravelly to very gravelly, with a soil texture ranging from sandy clay loam to clay. Depth wise differences are noticed at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara, Angadipuram, Kunnamangalam and Pilicode. Soils of the southern coastal plain have a texture of sand to loamy sand at Kazhakuttom while it is predominantly loamy sand at Kayamkulam. Soils of the Kuttanad basin, represented by the wet lands of Karumadi and Momcompu have a texture ranging from silty clay loam to clay. Predominant clay texture is observed in the soils of the central backwater basin, represented by Vytilla. The textural expression is also indicative of the type of parent material and the nature of geological formation.

1.1.9. Soil Structure

The soil structure observed in the representative sites at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara and Pilicode ranges from fine, weak granular to medium/coarse, moderate subangular blocky. Weak, medium sub angular blocky structure is observed in the related land resource areas represented by Vellanikkara, Angadipuram and Kunnamangalam. Very fine, weak granular structure is characteristic of Vellayani soils, while at Ambalavayal, it is fine, medium granular.

In the case of southern coastal plain, a medium weak granular structure is observed at Kazhakuttom, while at Kayamkulam it is fine, weakly coherent, massive and porous. In the Kuttanad basin and the central backwater basin, irrespective of the sites at Karumadi, Moncompu and Vytilla, a massive soil structure is noticed. At Eruthenpathy, representing the Palakkad gap, the soil structure is moderate, medium to coarse, subangular blocky.

A developed, structural argillic horizon is expressed in the soils at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara, Vellanikkara Angadipuram, Kunnamangalam and Pilicode. Very fine, weak to moderate granular structure noticed at Ambalavayal, Vellayani, Kazhakuttom and Kayamkulam are indicative of higher sand content. At Eruthenpathy, the moderate, medium to coarse medium subangular blocky structure is due to active pedoturbation.

1.1.10. Organic Matter Content

At Vellayani, Thiruvananthapuram, Kottarakkara, Vellanikkara, Angadipuram, Kunnamangalam and Pilicode the soils are highly leached, and devoid of decomposing or partially decomposing organic matter, but the presence of such features is characteristic of the soils at Palode, Nedumangad and Ambalavayal.

Though the soils of the southern coastal plain (Kazhakuttom and Kayamkulam) are comparatively sandy in texture, the surface horizons are moderately supplied with visible organic matter. The wet lands of Karumadi are rich in fossil organic matter at different stages of decomposition even in the surface horizon. At Moncompu, the organic matter is highly decomposed, but retain the cellular features in the subsurface horizons. Similar observation is also made at Vytilla. At Eruthenpathy, though the surface soil is rich in partially decomposed as well as decomposed organic matter, the black colour is mainly due to the presence of magnetite and other opaque minerals. The decomposed organic matter present are highly colloidal in nature.

1.1.11. Soil Consistency

The soil consistency expressed in the different land resource areas are variable indicating the differences in soil texture, structural development, bulk density and their differential behaviour to moisture because of the varied chemical composition. Soils of the southern dissected terriplain, southern coastal plain and Wayanad Plateau are loose to friable with non sticky to slightly sticky and non plastic soil consistency while the soils of the Kuttanad coastal basin and the central backwater basin are very sticky and plastic and hard when dry. At Eruthenpathy the soils have a sticky and slightly plastic surface horizon underlain by sticky and plastic subsurface horizons. All the other studied MLRAs have a friable to firm, slightly sticky to non/slightly plastic surface horizons with firm, sticky to slightly plastic/plastic subsurface.

1.1.12. Mottles

At Palode, Nedumangad, Thiruvananthapuram, Kottarakara, Vellanikkara, Angadipuram, Kunnamangalam and Pilicode, mottlings are observed in the subsurface horizons are indicative of earlier, prolonged redoximorphic changes. Such features are absent at Vellayani, Eruthenpathy and Ambalavayal indicating the high and prolonged oxidic environment in these areas. In the southern coastal plain, no mottlings are observed at Kazhakuttom, whereas at Kayamkulam, the mottles present in the subsurface horizons are indicative of the difference in mineralogical composition and redoximorphic state respectively. The source of lateritic alluvial material, their redoximorphic changes especially the variable extent of ferrolysis is indicated by the subsurface mottling in the wet land soils of the Kuttanad basin and the central backwater basin, namely, Karumadi, Momcompu and Vytilla.

1.1.13. Root Distribution

Irrespective of the land resource areas of the state, both upland and wet land soils are subjected to intensive cropping or are with natural vegetation for many years. The root distribution pattern observed in the various soils clearly indicate the type of vegetation and land use prevalent in each area.

1.1.14. Soil Boundary

The occurrence of gradual wavy to diffused wavy soil boundaries give an indication of the topography, slope gradient, accelerated soil erosion and clay migration, which are the principal soil developmental processes. Moreover, the presence of less weathered saprolitic material of variable bulk density contribute to the soil boundary expression. At Kazhakuttom and Kayamkulam, the soil texture, organic matter, mineral type and the redoximorphic state of minerals contribute to diffused wavy to gradual wavy or irregular boundaries. Poor drainage and reduced slow pedogensis contribute to the gradual smooth boundary of the wet land soils, while the gradual wavy boundary, observed at Karumadi and Moncompu, is contributed by fossiliferous organic material and goethite and haematite conversion in and around fossiliferous roots and root channels of mangroves (indicated by thick iron ochre in subsurface horizons).

2. Granulometric Analysis

The detailed grannulometric analysis including gravel fraction and textural classification of the representative profiles of the MLRAs are presented in table 1.0.

2.1. Distribution of Gravel Fraction

The soils of the southern coastal plain, at Kazhakuttom and Kayamkulam and those of the Kuttanad basin and the central back water basin at Karumadi, Moncompu and Vytilla, are non gravelly, sedimentary materials while the soils at Vellayani, Eruthenpathy and Ambalavayal are slightly gravelly in nature. Soils of all the other studied locations are highly gravelly in nature. The gravel content is in the increasing order from Kottarakkara, Vellanikkara, Kunnamangalam, Pilicode, Angadipuram, Nedumangad, Thiruvananthapuram and Palode. The gravelliness at Nedumangad, Thiruvananthapuram and Palode are almost similar indicating the related geological formation of these adjacent MLRAs, whereas Angadipuram exhibits a near similarity with Pilicode occurring in the same MLRA with respect to gravel content. Kottarakkara, Vellanikkara and Kunnamangalam

Table 1.0. GRANULOMETRIC COMPOSITION OF SOIL PROFILES

Sl No.	Location	Depth (cm)	Gravel (%)	Percentage				Textural class
				Coarse sand	Fine sand	Silt	Clay	
1.	Vellayani	00-25	5.07	48.70	26.90	10.00	14.40	Sandy loam
		25-60	4.77	53.20	23.00	11.30	12.50	Sandy loam
		60-109	7.70	37.60	18.40	17.50	26.50	Clay loam
		109-150	6.50	38.50	19.20	15.50	26.80	Clay loam
2.	Thiruvanantha-puram	00-13	73.40	42.00	14.25	10.00	33.75	Gravelly clay loam
		13-40	60.00	46.40	11.10	9.00	33.50	Gravelly clay loam
		40-69	70.00	35.30	9.20	8.00	47.50	Gravelly clay
		69-101	72.50	36.15	9.60	5.50	48.75	Gravelly clay
		101-150	71.20	37.85	11.10	4.30	46.75	Gravelly clay
3.	Kazakuttom	00-24	Nil	65.80	24.20	6.10	1.80	Loamy sand
		24-83	Nil	54.90	23.75	20.00	1.35	Loamy sand
		83-150	Nil	48.35	31.70	18.45	1.50	Loamy sand
4.	Nedumangad	00-23	73.47	32.60	21.40	17.00	29.00	Gravelly clay loam
		23-54	63.86	26.96	26.04	15.00	32.00	Gravelly clay loam
		54-81	61.72	32.80	22.20	11.00	34.00	Gravelly clay loam
		81-150	77.12	29.75	21.40	6.85	42.00	Gravelly clay

Sl No.	Location	Depth (cm)	Gravel (%)	Percentage				Textural class
				Coarse sand	Fine sand	Silt	Clay	
5.	Palode	00-10	75.50	25.75	21.85	30.25	22.15	Gravelly silty clay loam
		10-28	66.00	27.23	7.70	26.72	38.35	Gravelly silty clay loam
		28-47	68.50	29.60	7.40	17.81	45.19	Gravelly clay
		47-93	70.20	30.60	7.40	16.50	45.50	Gravelly clay
		93-150	69.50	30.95	10.30	15.25	43.50	Gravelly clay
6.	Kottarakkara	00-05	40.75	42.15	20-65	13.45	23.65	Gravelly clay loam
		05-30	48.14	38.25	24.15	12.35	25.10	Gravelly clay loam
		30-57	36.50	30.45	13.65	13.70	42.20	Gravelly clay
		57-130	42.25	31.35	10.25	13.10	45.30	Gravelly clay
		130-150	52.65	20.15	21.20	10.20	48.40	Gravelly clay
7.	Kayamkulam	00-25	Nil	52.64	31.19	9.27	6.90	Loamy sand
		25-74	Nil	44.65	39.65	8.50	7.20	Loamy sand
		74-125	Nil	42.38	42.70	5.60	9.32	Loamy sand
		125-150	Nil	41.46	40.68	9.37	8.49	Loamy sand
8.	Karumadi	00-25	Nil	5.50	18.20	36.80	39.50	Silty clay loam
		25-80	Nil	11.70	12.80	25.70	49.80	Silty clay
		80-125	Nil	11.50	15.50	27.00	46.00	Silty clay
		125-150	Nil	12.60	14.80	29.50	43.10	Silty clay
9.	Moncompu	00-20	Nil	8.00	11.00	46.00	35.00	Silty clay loam
		20-74	Nil	9.00	10.50	42.50	38.00	Silty clay loam
		74-130	Nil	3.20	3.00	43.30	50.50	Silty clay
		130-150	Nil	2.00	2.10	43.20	52.70	Silty clay

Sl No.	Location	Depth (cm)	Gravel (%)	Percentage Coarse sand	Fine sand	Silt	Clay	Textural class
10.	Vytilla	00-11	Nil	14.50	16.50	22.50	46.50	Clay
		11-48	Nil	9.80	13.70	22.30	54.20	Clay
		48-60	Nil	5.80	13.10	23.30	57.80	Clay
		60-150	Nil	2.50	16.70	21.80	59.00	Clay
11.	Vellanikkara	00-10	39.26	41.50	23.50	10.10	24.90	Gravelly clay loam
		10-37	45.90	37.50	24.50	11.50	26.50	Gravelly clay loam
		37-60	59.50	39.50	24.50	9.00	27.00	Gravelly clay loam
		60-96	43.50	30.25	23.50	11.10	35.15	Gravelly clay loam
		96-150	45.40	40.22	19.50	1.51	38.77	Gravelly clay
12.	Eruthenpathy	00-10	6.00	23.10	20.35	18.35	38.20	Clay
		10-85	5.40	21.90	17.50	19.10	41.50	Clay
		85-125	4.66	11.70	20.55	20.25	47.50	Clay
		125-150	11.25	16.05	20.15	18.55	45.25	Clay
13.	Angadipuram	00-17	58.80	30.49	28.51	18.00	23.00	Gravelly clay loam
		17-32	63.50	19.80	19.70	23.50	37.00	Gravelly clay loam
		32-49	68.20	14.50	13.00	9.00	63.50	Graavelly clay
		>49	Laterite					
14.	Kunnamangalam	00-18	48.15	37.50	15.40	9.50	37.60	Gravelly clay loam
		18-51	46.90	25.90	13.60	9.00	51.50	Gravelly clay
		51-99	65.50	16.50	6.50	14.50	62.50	Gravelly clay
		99-150	35.40	22.10	6.10	11.00	60.80	Gravelly clay

Sl No.	Location	Depth (cm)	Gravel (%)	Percentage				Textural class
				Coarse sand	Fine sand	Silt	Clay	
15.	Ambalavayal	00-16	Nil	41.50	20.70	14.20	23.60	Clay loam
		16-46	Nil	41.10	22.50	14.00	22.40	Clay loam
		46-86	Nil	41.50	29.50	11.50	17.50	Sandy loam
		86-150	13.50	31.50	24.50	15.00	29.00	Clay loam
16.	Pilicode	00-12	42.10	36.15	15.25	21.50	27.10	Gravelly clay loam
		12-39	49.50	25.00	21.50	22.00	31.50	Gravelly clay loam
		39-74	71.50	35.80	13.00	14.70	36.50	Gravelly clay loam
		74-150	70.60	32.00	11.50	14.00	42.50	Gravelly clay

coming under southern dissected midland laterites, central dissected midland laterites and northern dissected midland laterites respectively, have a more or less similar gravel content in the soil. In the studied MLRAs no regular profile trend in gravel distribution in noticed at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara, Vellanikkara and Kunnamangalam whereas at Angadipuram a regular increase in gravel content with depth is noticed. At Pilicode a regular increase in gravel content is noticed in the first three horizons, but it shows a decrease in the fourth. At Ambalavayal, gravels are noticed in the last two horizons only.

2.2 Distribution of Coarse Sand Fraction

The average coarse sand content of the studied profiles are in the increasing order from Vytilla, Moncompu, Eruthenpathy, Angadipuram, Kunnamangalam, Palode, Nedumangad, Kottarakkara, Pilicode, Ambalavayal, Vellanikkara, Thiruvananthapuram, Vellayani, Karumadi, Kayamkulam and Kazhakuttom. At Thiruvananthapuram, the coarse sand content decreases from first to the second horizon, but shows a regular increase in the subsequent layers. Coarse sand content of the soils at Eruthenpathy and Kunnamangalam show a regular decrease from the first to the third horizons, with a slight increase in the fourth layer whereas at Ambalavayal the coarse sand content remains almost same in the first three horizons, but with a decrease in subsequent layers. The soils at Kazhakuttom, Kayamkulam, Vytila and Angadipuram exhibit a regular decrease in coarse sand content with depth while at Palode, the coarse sand content shows a regular increase with depth. In the case of the soils studied at Vellayani, Nedumangad, Kottarakkara, Karumadi, Moncompu, Vellanikkara and Pilicode no regular profile trend in coarse sand distribution is noticed.

2.3 Distribution of Fine Sand Fraction

The average fine sand content of the soils of the studied MLRAs are in the increasing order from Kunnamangalam, Palode, Thiruvananthapuram, Moncompu, Vytilla, Pilicode, Karumadi, Kottarakkara, Angadipuram, Eruthenpathy, Vellayani, Nedumangad, Vellanikkara, Ambalavayal, Kazhakuttom and Kayamkulam. At Vellayani, the soils show a regular decrease in fine sand content with depth from the first to the third layer, but with a slight increase in the fourth. The soils studied at Kayamkulam and Ambalavayal show a regular increase in fine sand content with depth from the first to the third horizons, but with a slight decrease in the fourth layer at both locations. At Ambalavayal, the subsequent layer shows a slight increase in the fine sand content. At Palode, Vytilla and Eruthenpathy the fine sand content decreased from the first layer downwards. But it is almost similar in the second, third and fourth layers at Palode and in the third and fourth horizons at Eruthenpathy. At Palode, the fine sand content increases in the fifth horizon. The fine sand content of the soil at Pilicode shows an increase from the first to the second horizon, but with a regular subsequent decrease down the profile. At Moncompu, Angadipuram and Kunnamangalam, the soils exhibit a regular decrease in fine sand content with depth whereas at Thiruvananthapuram, Kazhakuttom, Nedumangad, Kottarakkara, Karumadi and Vellanikkara no regular profile trend in fine sand distribution is observed.

2.4. Distribution of Silt Fraction

The average silt content of the soils of the studied MLRAs are in the increasing order from Thiruvananthapuram, Kayamkulam, Vellanikkara, Kunnamangalam, Nedumangad, Kottarakkara, Vellayani, Ambalavayal Kazhakuttom, Angadipuram, Pilicode, Eruthenpathy, Palode, Vytilla, Karumadi and Moncompu. At Kayamkulam the silt content decreases from the top to the third layer, but an increase is observed in the last layer, whereas at Moncompu eventhough the silt content shows a decrease from the top to the second horizon, it remains more or less same in the subsoil. At Vellanikkara, the silt content increases slightly from the first to the second horizon, but a subsequent regular decrease is observed in the subsurface horizons, while at Kunnamangalam the soil shows a near similar silt content in the first and second horizon, but no regular profile trend is observed downwards. The soil at Ambalavayal shows a regular decrease in silt content from the first to the third layer, but no regular profile trend is noticed subsequently, whereas the soil at Pilicode shows an increase in silt content from the first to the second horizon, but with a regular decrease downwards. The soils studied at Vellayani, Kazhakuttom, Kottarakkara, Karumadi, Vytilla, Eruthenpathy and Angadipuram do not show any regular profile trend in the distribution of the silt fraction, while at Thiruvananthapuram, Nedumangad and Palode, the soils exhibit a regular decrease in silt content with depth.

2.5 Distribution of Clay Fraction

The average clay content in the soils of the studied MLRAs are in the increasing order from Kazhakuttom, Kayamkulam, Vellayani, Ambalavayal, Vellanikkara, Pilicode, Nedumangad, Kottarakkara, Palode, Angadipuram, Thiruvananthapuram, Eruthenpathy, Moncompu, Karumadi, Kunnamangalam and Vytilla. At Kayamkulam, Eruthenpathy and Kunnamangalam the clay content shows a regular increase from the top to the third horizon, with a slight decrease in the last layer, whereas at Palode, a regular increase in clay content with depth is noticed till the fourth horizon, with a subsequent decrease in the last layer. At Thiruvananthapuram the clay content remains almost same in the first two horizons with a regular increase in the third and fourth layer and a subsequent decrease in the last layer whereas at Ambalavayal, a regular decrease in clay content is noticed from the surface to the third layer and an increase in the subsequent layers. The clay content of the soils studied at Nedumangad, Kottarakkara, Vellanikkara, Angadipuram, Pilicode, Moncompu and Vytilla increases regularly with depth while at Karumadi the clay content increases from the first to the second layer, but with a regular decrease thereafter down the profile. At Vellayani the clay content decreases from the first to the second layer and thereafter regular increase is noticed. At Kazhakuttom, no regular profile trend in clay distribution is observed.

Among the studied profiles of the Kuttanad basin and the central backwater basin, Karumadi soils are with higher coarse sand content than the soils at Moncompu and Vytilla, whereas the coarse sand content of the soils of the southern coastal plain, at Kayamkulam and Kazhakuttom, is higher than that at Karumadi. At Eruthenpathy in the Palakkad gap, the soil shows a comparatively lesser coarse sand content, than the Kuttanad basin, central backwater basin and the southern coastal plain soils. In the studied profiles of the MLRAs at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara and Vellanikkara the near similar average coarse sand content indicate the similarity in their geological formation. A similar observation is made in the case of the profiles studied at Angadipuram, Kunnamangalam and Pilicode. Also a near similarity in coarse sand content is noticed in the soils of the southern dissected terriplain at Vellayani, and at Ambalavayal representing the Wayanad plateau, though located at entirely different geomorphic positions.

In the soils of the Kuttanad basin the average fine sand content is more or less similar with maximum at Karumadi and minimum at Moncompu, whereas in the soils of the southern coastal plain no such similarity is observed in fine sand distribution at Kazhakuttom and Kayamkulam. At Vellayani and Ambalavayal, a near similar average fine sand content is noticed, indicating the similarity in the formation of these soils, though located at wide geomorphic positions. The soils at Thiruvananthapuram, Nedumangad, Palode, Kottarakkara and Vellanikkara have a near similar fine sand content indicating the similarity in the geological formation. Such an observation is also made in the soils of the northern dissected midland laterites. At Eruthenpathy, the average fine sand content is more than that of the soils of the Kuttanad coastal basin and the central backwater basin.

The pattern of fine sand, silt and clay distribution is different from the coarse sand distribution. Among the studied profiles Moncompu and Karumadi soils exhibit maximum silt content followed by Vytilla. The profile studied at Thiruvananthapuram exhibit the least average silt content. In the southern coastal plain soils, Kazhakuttom has more average silt content compared to Kayamkulam whereas the soil of the southern dissected terriplain (Vellayani) and the Wayanad Plateau (Ambalavayal) though located at widely different geomorphic positions have more or less similar average silt content. At Nedumangad, Palode, Kottarakkara, Vellanikkara, Angadipuram, Kunnamangalam and Pilicode, the soils show a near similarity in the average silt content showing the contribution of the parent material in the formation of these soils.

3. Mineralogy of Fine Sand Fraction

The fine sand mineralogy of the diagnostic horizons of the representative profiles of the studied MLRAs are given in table 2.0. and the photomicrographs of the horizons are presented in Plates 1 to 64.

3.1. Southern Dissected Terriplain

At Vellayani representing the southern dissected terriplain, quartz is the major mineral in the light mineral fraction of both the diagnostic horizons. In the epipedon, quartz is followed by haematite. Ilmenite, magnetite and zircon in equal amounts follow haematite in abundance and kyanite occures as the least abundant mineral. In the endopedon quartz is followed by magnetite, ilmenite and zircon, sillimanite and rutile in equal amounts and by garnet in least abundance. In the heavier fraction quartz and haematite dominate in the epipedon and endopedon respectively. In the epipedon quartz is followed by ilmenite, haematite and magnetite in equal amounts and by kyanite and sillimanite in equal, least abundance. In the endopedon, quartz follows haematite. Quartz is followed by ilmenite, titanium and magnetite and rutile in equal amounts, in the decreasing order of abundance (Plates 1 to 4).

3.2. Southern Low Land Laterites

At Thiruvananthapuram representing the southern low land laterites quartz remains the dominant light mineral in both the diagnostic horizons. In the epipedon quartz is followed by magnetite, haematite, sillimanite, rutile, zircon and ilmenite in equal amounts, in the decreasing order of abundance. In the endopeden, quartz is followed by magnetite, ilmenite, zircon and sillimanite in equal amounts and rutile and staurolite in equal amounts, in least abundance. In the heavier fraction, magnetite is the dominant mineral in the epipedon, while in the endopedon magnetite along with quartz in equal amounts dominate over other minerals. In the epipedon magnetite is followed by haematite, quartz, ilmenite, sillimanite and zircon in the decreasing order of abundance. Haematite, ilmenite and sillimanite in equal amounts and zircon in least abundance follow quartz and magnetite in the endopedon (Plates 5 to 8).

3.3. Southern Coastal Plain

In the southern coastal plain, quartz is the dominant light mineral in both the diagnostic horizons in the profiles studied at Kazhakuttom and Kayamkulam. At Kazhakuttom, ilmenite follows quartz in the epipedon. In the endopedon quartz is followed by ilmenite, haematite and sillimanite in equal amounts and by zircon in least abundance. At Kayamkulam, quartz is followed by ilmenite, sillimanite and magnetite in the decreasing order of abundance in the epipedon. In the endpedon sillimanite, ilmenite and magnetite follow quartz. In the heavier fraction ilmenite is the dominant mineral in both the diagnostic horizons at Kazhakuttom and in the epipedon at

Kayamkulam. In the both the sites the least abundant heavy mineral is monazite. In the epipedon at Kazhakuttom quartz, sillimanite and monazite follow ilmenite, while in the endopedon ilmenite is followed by quartz and monazite in the decreasing order of abundance. At kaymkulam, quartz and monazite follow ilmenite in the epipedon. In the endopedon quartz dominates, followed by ilmenite and monazite (Plates 9 to 12 and 25 to 28).

3.4. Southern Dissected Midland Laterites

In the southern dissected midland laterite area, quartz is the dominant light mineral in both the diagnostic horizons of the profiles studied at Nedumangad and Kottarakara. At Nedumangad ilmenite follows quartz in both the diagnostic horizons as the least abundant mineral. At Kottarakara, quartz is followed by magnetite, haematite, zircon, ilmenite and graphite in the epipoden and by zircon, haematite, graphite, magnetite and ilmenite in the endopedon in the decreasing order of abundance. In the heavier fraction quartz dominates in the epipedon at Nedumangad and in both the diagnostic horizons at Kottarakara. Quartz is followed by ilmenite, sillimanite and Kyanite in the epipedon at Nedumangad while in the endopeden ilmenite dominates, followed by quartz, sillimanite and zircon in the decreasing order of abundance. At Kottarakkara quartz is followed by zircon and magnetite and ilmenite in equal amounts in the epipedon. In the endopedon, quartz is followed by haematite, ilmenite, zircon, magnetite, rutile and graphite (Plates 13 to 16 and 21 to 24).

3.5. Southern Foot Hills

At Palode representing the southern foot hills, the light mineral fraction reveals quartz as the dominant mineral both in the surface and subsurface diagnostic horizons. Ilmenite follows quartz in abundance in the endopedon. In the heavier fraction also, quartz dominates in the epipedon, followed by ilmenite, kyanite and rutile while in the endopedon sillimanite dominates followed by ilmenite(Plates 17 to 20). Similar observations were reported on these soils by Sivadasan, (1989).

3.6. Kuttanad Coastal Basin And Central Backwater Basin

In the Kuttanad coastal basin and the central backwater basin, quartz is the dominant light mineral in the epipedon at Karumadi and in both the diagnostic horizons of the profiles studied at Moncompu and Vytilla. In the endopedon at Karumadi organic matter content dominates. At Karumadi quartz is followed by spicules and jarosite, organic matter biotite mica, sillimanite and diatoms in equal amounts and magnetite in least abundance in the epipedon. In the endopedon, organic matter is followed by spicules, quartz and biotite mica. At Moncompu, quartz is followed by biotite, feldspars, chlorite, muscovite and zircon in the epipedon and by biotite, muscovite, chlorite, feldspars and zircon in the endopedon in the decreasing order of abundance. At Vytilla quartz is followed by ilmenite and feldspars in the epipedon and by ilmenite, feldspars and goethite in equal amounts and magnetite in least abundance in the endopedon. In the heavier fraction, quartz and iron coated organic matter dominates in the epipedon and endopedon respectively in the profile studied at Karumadi. In the epipedon, quartz is followed by ilmenite, pyrite, sillimanite and feldspars in equal amounts and magnetite in least abundance while in the endopedon, iron coated organic matter is followed by ferrihydrite quartz, and feldspars, plinthite glaebules and wood fossil in equal amounts in the decreasing order of abundance. At Moncompu, ilmenite dominates the heavier fraction in both the diagnostic horizons. In the epipedon, ilmenite is followed by sillimanite, pyrite, monazite, rutile, staurolite, tourmaline, and haematite and garnet in equal, least amounts in the decreasing order of abundance, while in the endopedon ilmenite is followed by sillimanite, pyrite, monazite, rutile, garnet, tourmaline, staurolite and haematite. In the profile studied at Vytilla, quartz is the dominant mineral in the heavy fraction in both the diagnostic horizons followed by ilmenite, biotite mica, feldspars and pyrite in equal amounts and magnetite in the epipedon and by ilmenite, monazite and pyrite in equal amounts, goethite, and feldspars and staurolite in equal amounts in the endopedon in the decreasing order of abundance (Plates 29 to 32 , 33 to 36 and 37 to 40). This is in agreement with the earlier report on these soils (Subramonia Iyer, 1989).

3.7. Central Dissected Midland Laterites

In the central dissected midland laterite region, represented by Vellanikara, quartz remains the dominant light mineral in both the diagnostic horizons whereas in the heavier fraction the dominant mineral is ilmenite. In the lighter fraction, quartz is followed by haematite, ilmenite and plinthite glaebules in equal amounts, and magnetite in least amount in the epipedon, while in the endopedon, quartz is followed by haematite and ilmenite in equal amounts and magnetite, feldspars and goethite in equal amounts as the least abundant minerals. In the heavier fraction of the epipedon ilmenite is followed by quartz, magnetite and zircon whereas in the endopedon quartz, magnetite and haematite follows ilmenite in the decreasing order of abundance (Plates 41 to 44).

3.8. Palakkad Gap

At Eruthampathy in the Palakkad gap, quartz remains the dominant mineral in the light and heavy fractions of both the diagnostic horizons. In the lighter fraction of the epipedon, quartz is followed by ilmenite, magnetite, haematite, and goethite and calcite in equal amounts. In the endopedon quartz is followed by haematite, calcite and ilmenite in equal amounts, and feldspars and magnetite in equal amounts in the decreasing order of abundance. In the heavier fraction of the epipedon, quartz is followed by ilmenite, magnetite and calcite and haematite in equal amounts while in the endopedon magnetite, biotite mica, calcite, and haematite and staurolite in equal amounts, follow quartz in the decreasing order of abundance (Plates 45 to 48).

3.9. Northern Dissected Midland Laterites

In the northern dissected midland laterite region at Pilicode, in the lighter fraction, pilnthic granules ferritic dominates in the epipedon followed by quartz, plinthic granules goethitic and maganetite, while in the endopedon quartz dominates followed by magnetite and haematite. In the heavier fraction also plinthic granules ferritic dominates in the epipedon followed by plinthic granules goethitic, quartz, and magnetite and mica in equal amounts while in the endopedon ilmenite dominates followed by quartz magnetite, zircon and mica in the decreasing order of abundance (Plates 61 to 64). At Kunnamangalam quartz is the dominant light mineral in the epipedon followed by haematite, ilmenite and plinthic glaebules in equal amounts, magnetite and zircon in least amounts while in the endopedon plinthic glaebules dominate followed by quartz, haematite, and magnetite and ilmenite in equal amounts in the decreasing order of abundance. In the heavier fraction quartz dominates in both the diagnostic horizons followed by magnetite, ilmenite and goethite in the epipedon and by haematite, magnetite, ilmenite, zircon and kyanite in the endopedon (Plates 53 to 56). At Angadipuram, haematite is the dominant light mineral in the epipedon followed by quartz, goethite, boehmite and magnetite while in the endopedon staurolite dominates, followed by ilmenite, haematite and rutile in equal amounts and quartz in the decreasing order of abundance. In the heavier fraction of the epipedon, ilmenite dominates,followed by quartz, goethite, haematite, zircon and rutile in equal amounts and kyanite in least abundance. In the endopedon, quartz dominates followed by ilmenite and magnetite (Plates 49 to 52). Similar reports are also available in Karnataka calcites by Venugopal et al (1990).

3.10. Wayanad Plateau

At Ambalavayal representing the Wayanad plateau, quartz is the dominant mineral in the lighter fraction of both the diagnostic horizons. In the epipedon, quartz is followed by haematite, feldspar, magnetite and goethite, while in the endopedon biotite mica, magnetite, goethite and haematite follows quartz in the decreasing order of abundance. In the heavier fraction, quartz is dominant in the epipedon, followed by magnetite, biotite mica, zircon and ilmenite in equal amounts and feldspars while in the endopedon magnetite dominates, followed by quartz, haematite and zircon (Plates 57 to 60).

The primary mineral assemblage clearly establishes the parent material composition which varies in all the major land resource areas investigated. Irrespective of the MLRAs, both the diagnostic horizons are rich in quartz followed by ironoxide and titanium oxide minerals in abundance. This indicate the acid igneous parentage of the materials. Principally each of the MLRAs is unique in its primary mineral assemblage and hence in the potential characteristics of the soils developed (Venugopal, 1994; Das 1983)

FINE SAND MINERALOGY

Site: Vellayani

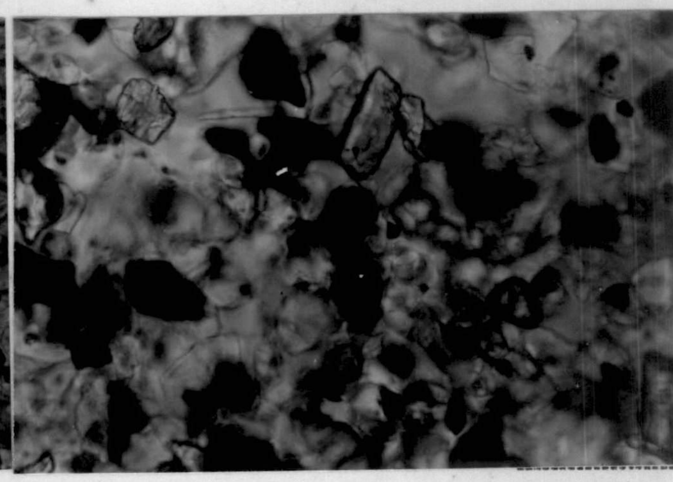
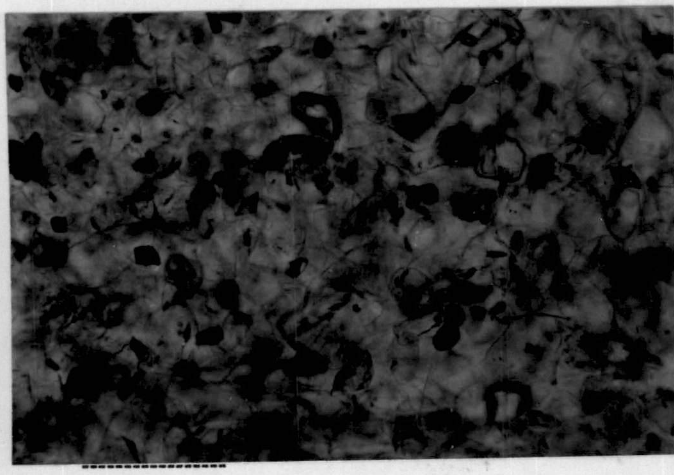


Plate 1
Lighter fraction

EPIPEDON

Plate 2
Heavier fraction



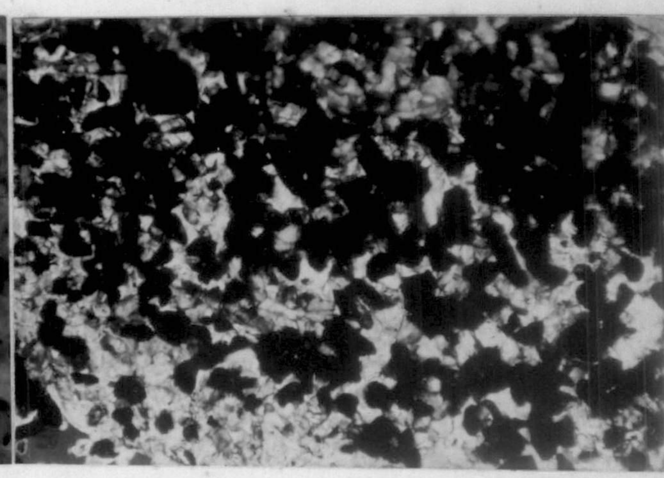


Plate 3
Lighter fraction

ENDOPEDON

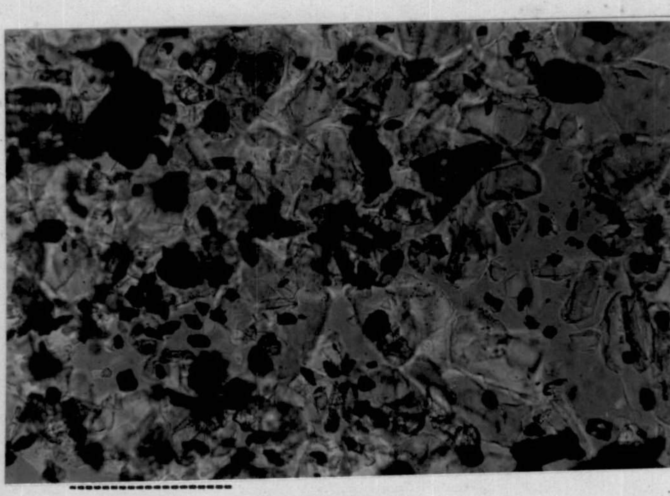
Plate 4
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 1(Plain light) Mgf:x63	Quartz, haematite,ilmenite, magnetite and zircon,kyanite
Plate 2(Plain light) Mgf:x63	Quartz,ilmenite and magnetite,kyanite and sillimanite
Plate 3(Plain light) Mgf:x63	Quartz,magnetite,ilmenite and zircon,sillimanite and rutile
Plate 4(Crossed nicols) Mgf:x25	Haematite,ilmenite,titanium and magnetite and rutile

FINE SAND MINERALOGY

Site: Thiruvananthapuram



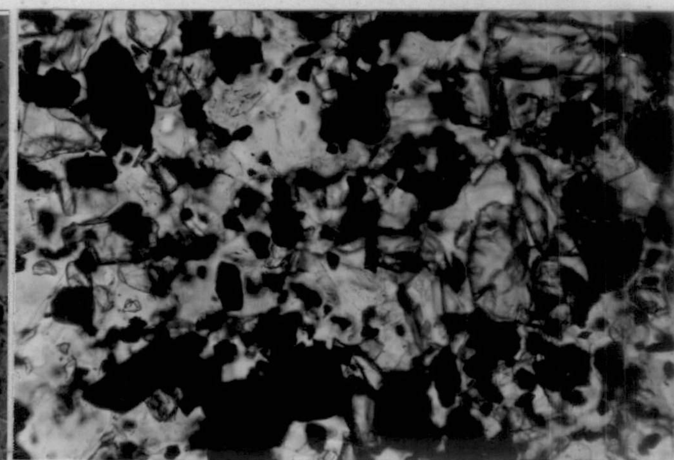
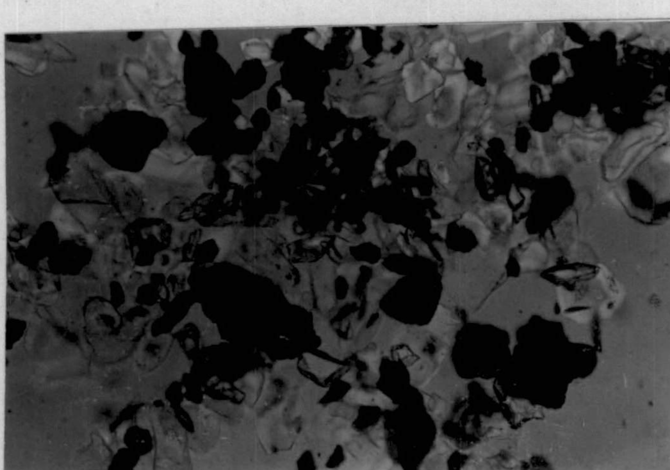


Plate 5
Lighter fraction

EPIPEDON

Plate 6
Heavier fraction



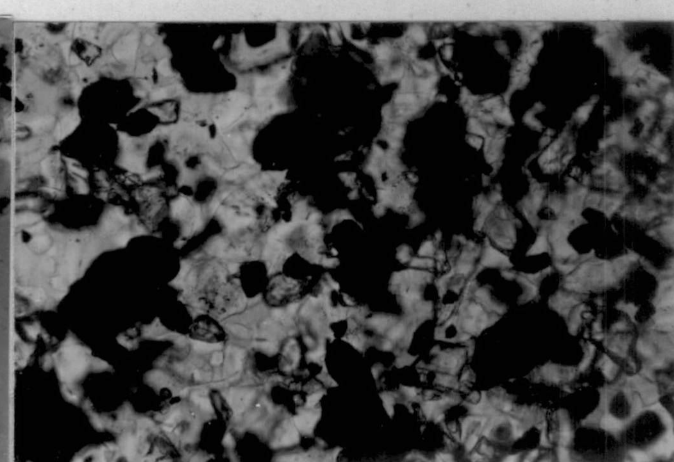


Plate 7
Lighter fraction

ENDOPEDON

Plate 8
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 5(Plain light Mgf:x63)	Quartz,magnetite,haematite,sillimanite,rutile,zircon and ilmenite
Plate 6(Plain light Mgf:x63)	Magnetite,haematite,quartz,ilmenite,sillimanite,zircon
Plate 7(Plain light Mgf:x63)	Quartz,magnetite,ilmenite,zircon and sillimanite
Plate 8(Plain light Mgf:x63)	Quartz and magnetite,haemaetite,ilmenite,sillimanite and zircon

FINE SAND MINERALOGY

Site: Kazhakuttom

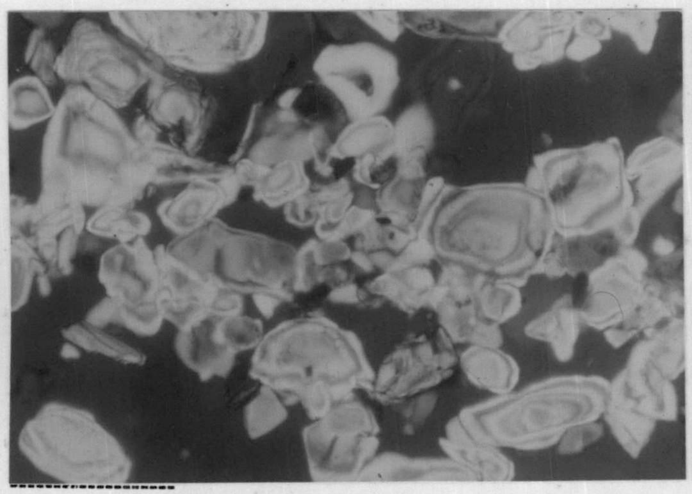


Plate 9
Lighter fraction

EPIPEDON

Plate 10
Heavier fraction

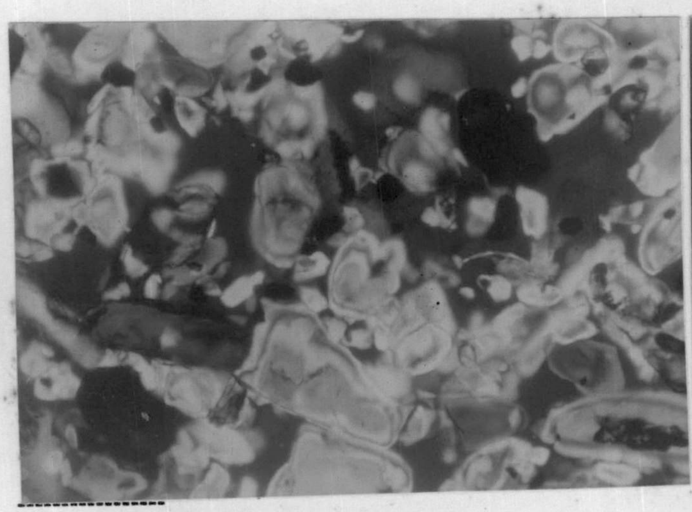


Plate 11
Lighter fraction

ENDOPEDON

Plate 12
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

late 9(Crossed nicols Mgf:x63)	Quartz,ilmenite
late 10(Crossed nicols Mgf:x63)	Ilmenite,quartz,sillimanite,monazite
late 11(Crossed nicols Mgf:x63)	Quartz,ilmenite,haematite and sillimanite, zircon
late 12(Crossed nicols Mgf:x63)	Ilmenite,quartz,monazite

FINE SAND MINERALOGY

Site: Nedumangad

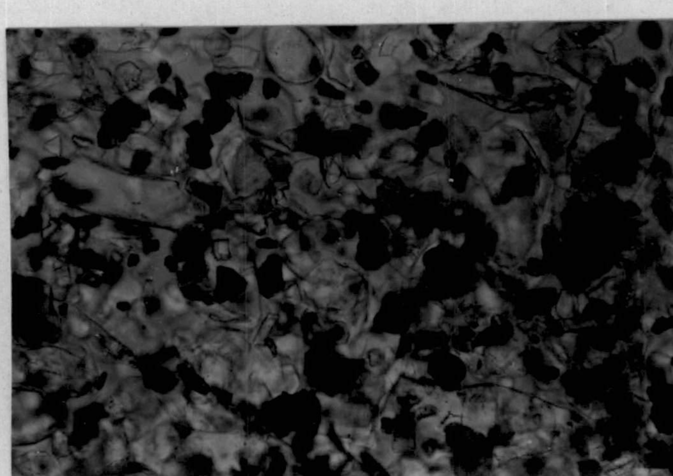



Plate 13
Lighter fraction

EPIPEDON

Plate 14
Heavier fraction

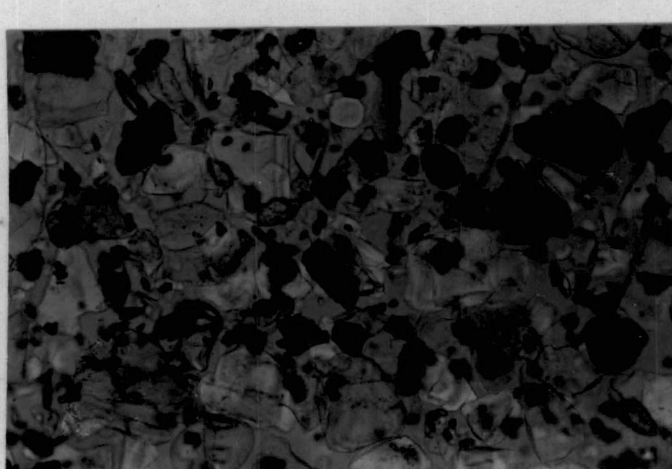
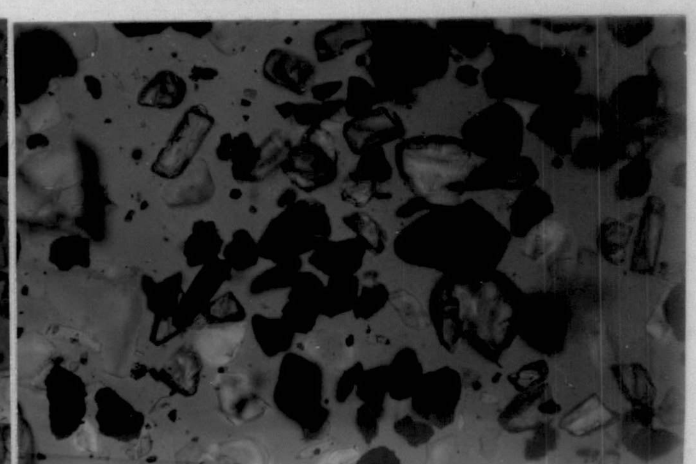



Plate 15
Lighter fraction

ENDOPEDON

Plate 16
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 13(Mgf:x63)	Quartz,ilmenite
Plate 14(Mgf:x63)	Quartz,ilmenite,sillimanite,kyanite
Plate 15(Mgf:x63)	Quartz,ilmenite
Plate 16(Mgf:x63)	Ilmenite,quartz,sillimanite,zircon

FINE SAND MINERALOGY

Site: Palode

Plate 17
Lighter fraction

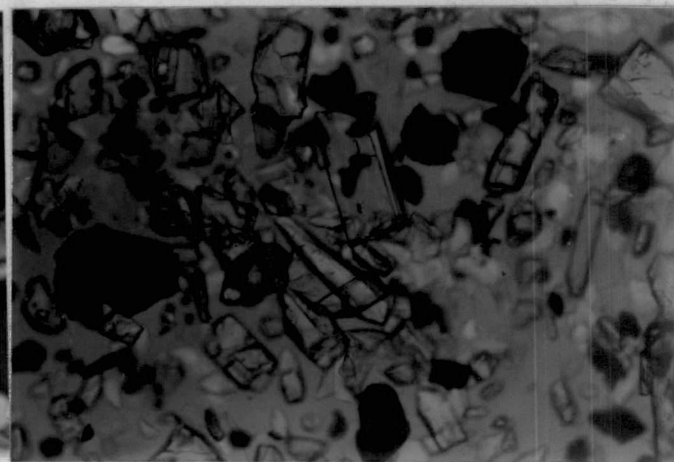


Plate 18
Heavier fraction

EPIPEDON

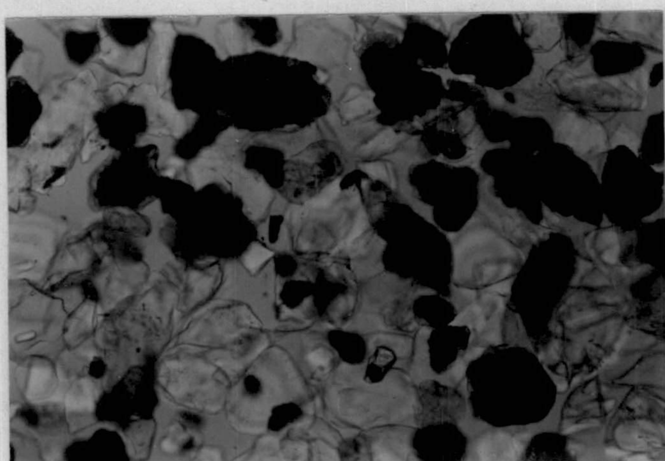


Plate 19
Lighter fraction

Plate 20
Heavier fraction

ENDOPEDON

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 17(Mgf:x63)	Quartz
Plate 18(Mgf:x63)	Quartz,ilmenite,kyanite,rutile
Plate 19(Mgf:x63)	Quartz,ilmenite
Plate 20(Mgf:x63)	Sillimanite,ilmenite

FINE SAND MINERALOGY

Site: Kottarakkara

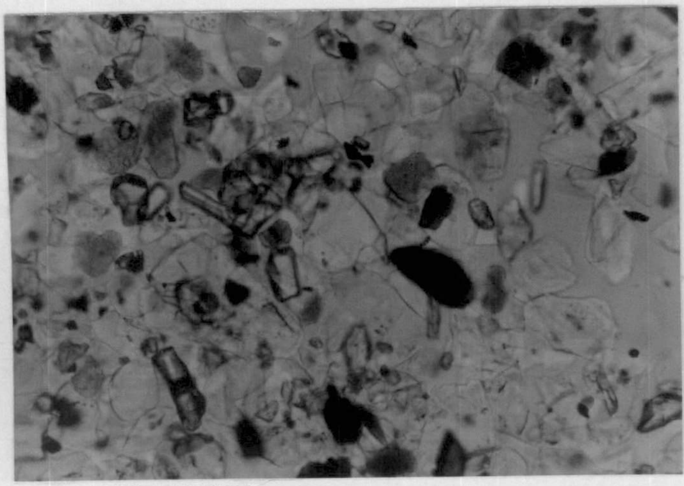
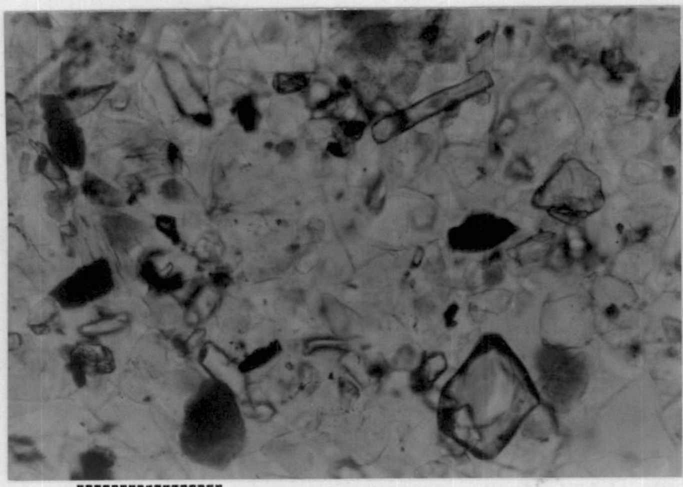


Plate 21
Lighter fraction

EPIPEDON

Plate 22
Heavier fraction



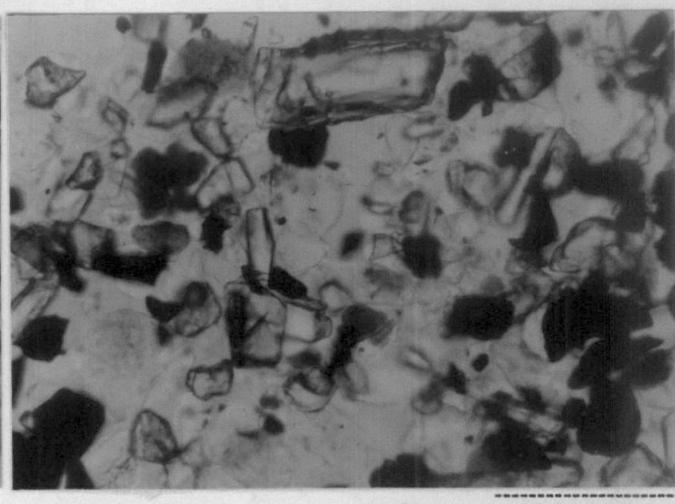


Plate 23
Lighter fraction

ENDOPEDON

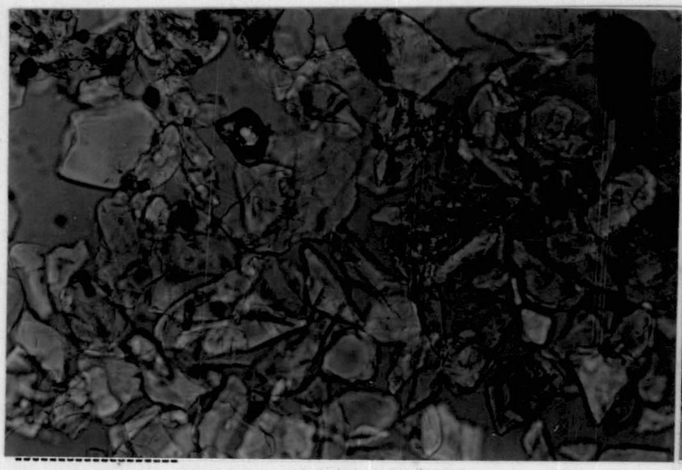
Plate 24
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 21(Plain light Mgf:x63)	Quartz,magnetite,haematite,zircon,ilmenite,graphite
Plate 22(Plain light Mgf:x63)	Quartz,zircon and magnetite and ilmenite
Plate 23(Plain light Mgf:x63)	Quartz,zircon,haematite,graphite,magnetite,ilmenite
Plate 24(Plain light Mgf:x63)	Quartz,haematite,ilmenite,zircon,magnetite,rutile,graphite

FINE SAND MINERALOGY

Site: Kayamkulam



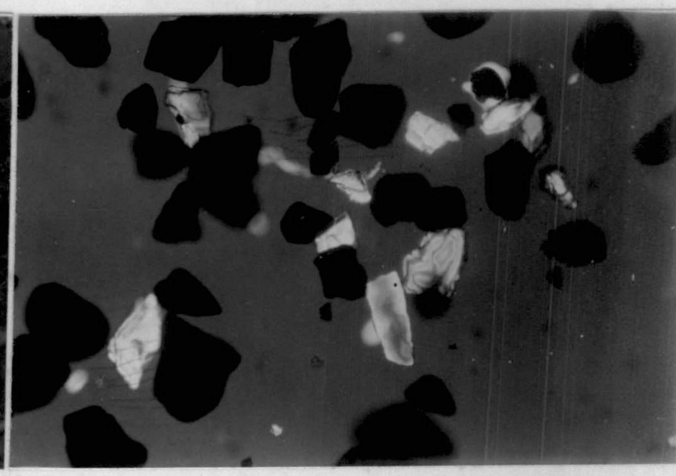


Plate 25
Lighter fraction

EPIPEDON

Plate 26
Heavier fraction

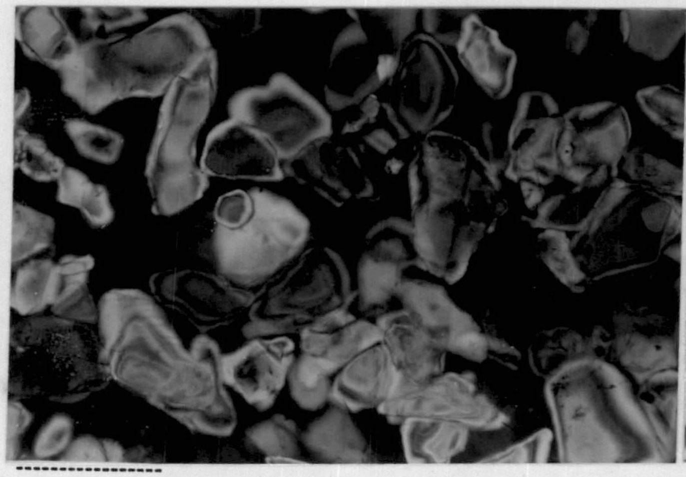


Plate 27
Lighter fraction

ENDOPEDON

Plate 28
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 25(Plain light Mgf:x63)	Quartz,ilmenite,sillimanite,magnetite
Plate 26(Crossed nicols Mgf:x63)	Ilmenite,quartz,monazite.
Plate 27(Crossed nicols Mgf:x63)	Quartz,sillimanite,ilmenite,magnetite
Plate 28(Plain light Mgf:x63)	Quartz,ilmenite,monazite

FINE SAND MINERALOGY

Site: Karumadi

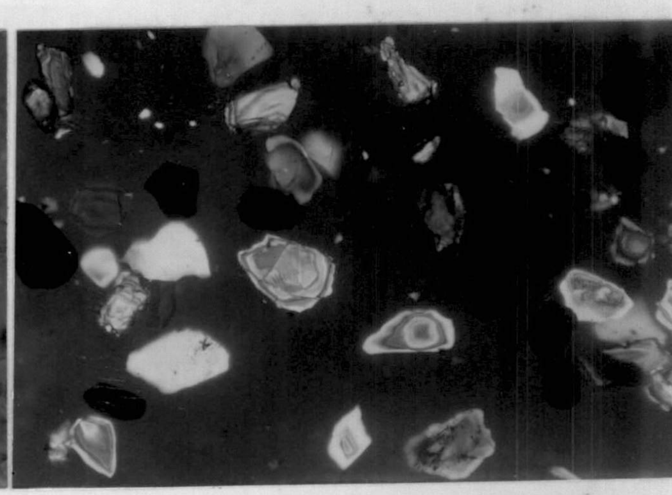
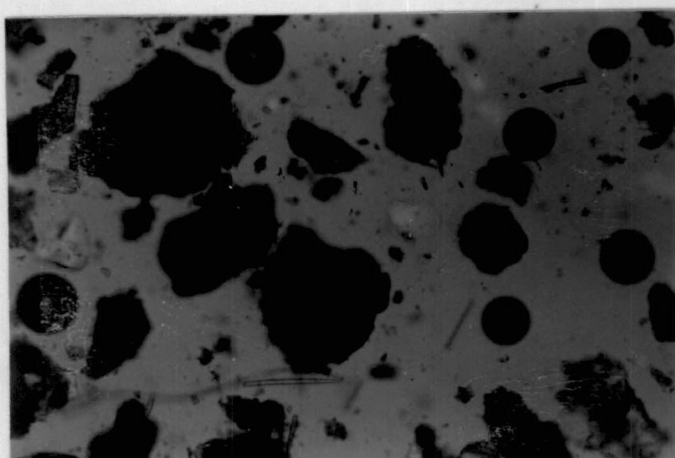


Plate 29
Lighter fraction

EPIPEDON

Plate 30
Heavier fraction



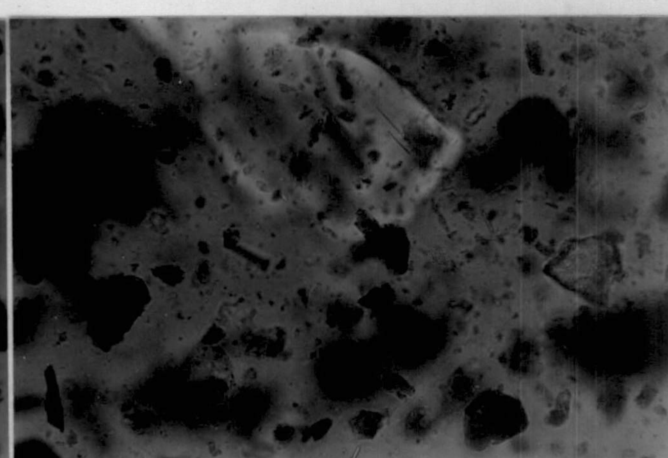


Plate 31
Lighter fraction

ENDOPEDON

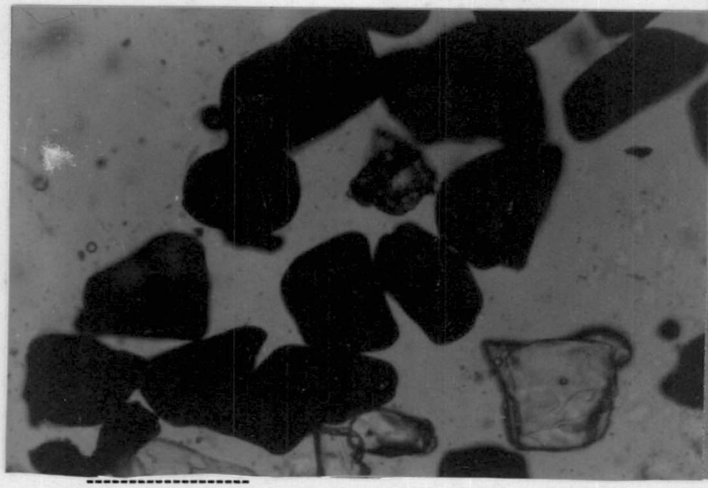
Plate 32
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 29(Plain light Mgf:x63)	Quartz,spicules and jarosite,organic matter,biotite mica,sillimanite and diatoms,magnetite
Plate 30(Crossed nicols Mgf:x63)	Quartz,ilmenite,pyrite,sillimanite and feldspars, magnetite
Plate 31(Plain light Mgf:x63)	Organic matter,spicules,quartz,biotite mica
Plate 32(Plain light Mgf:x160)	Iron coated organic matter,ferrihydrite,quartz and feldspars,plinthite glaebules and wood fossil

FINE SAND MINERALOGY

Site: Moncompu



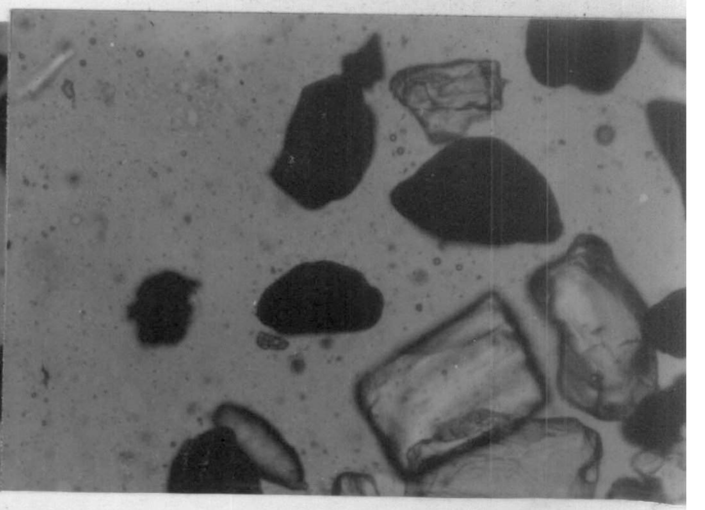
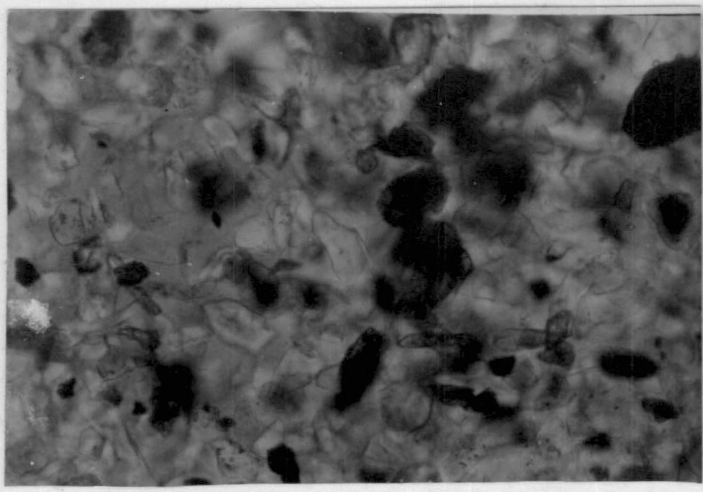


Plate 33
Lighter fraction

EPIPEDON

Plate 34
Heavier fraction



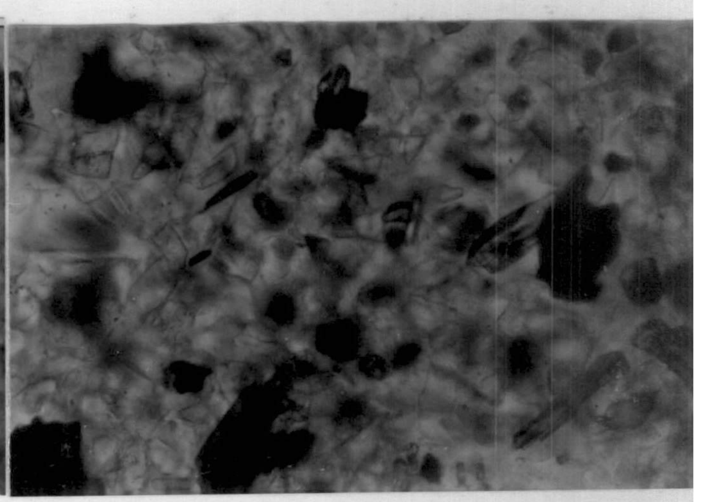


Plate 35
Lighter fraction

ENDOPEDON

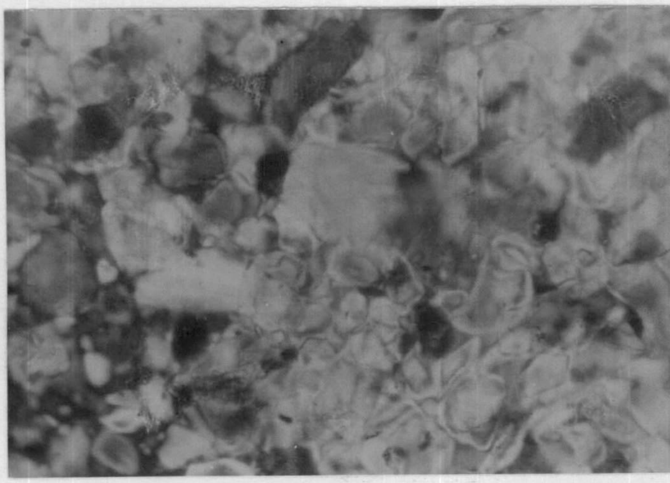
Plate 36
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 33(Mgf:x63)	Quartz,biotite mica,feldspars,chlorite,muscovite,zircon
Plate 34(Mgf:x63)	Ilmenite,sillimanite,pyrite,monazite,rutile,staurolite,tourmaline,haematite and garnet
Plate 35(Mgf:x63)	Quartz,biotite,muscovite,chlorite,feldspars,zircon
Plate 36(Mgf:x63)	Ilmenite,sillimanite,pyrite,monazite,rutile,garnet,tourmaline,staurolite, haematite

FINE SAND MINERALOGY

Site: Vytilla



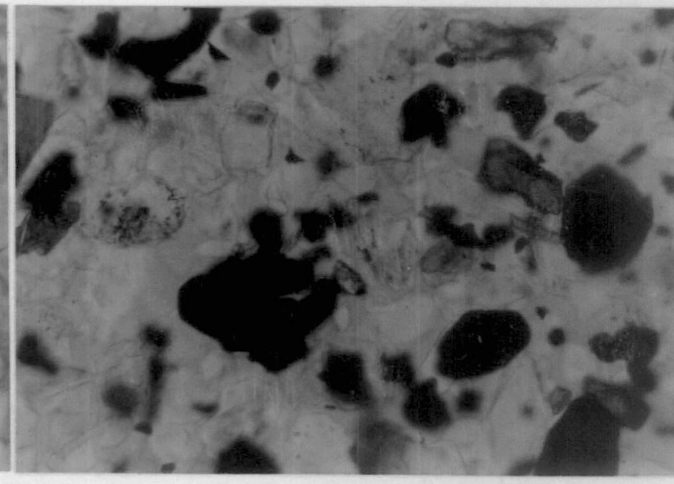


Plate 37
Lighter fraction

EPIPEDON

Plate 38
Heavier fraction

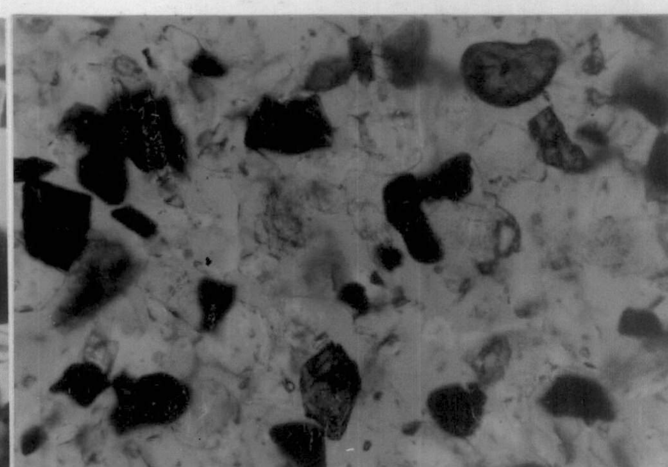


Plate 39
Lighter fraction

ENDOPEDON

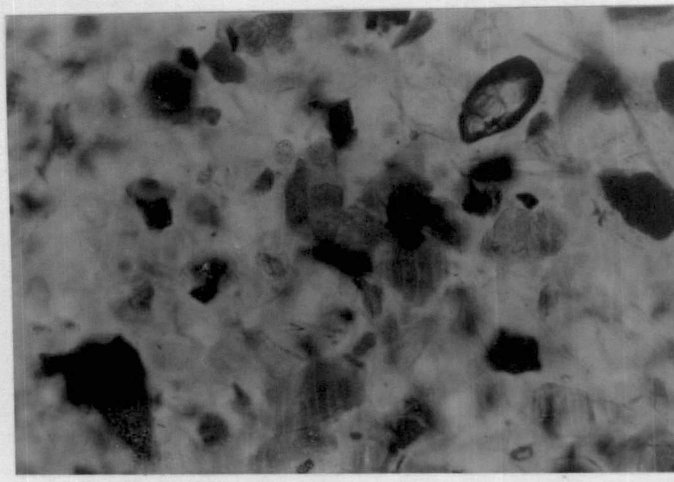
Plate 40
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 37(Crossed nicols Mgf:x63)	Quartz,ilmenite,feldspars
Plate 38(Plain light Mgf:x63)	Quartz,ilmenite,biotite mica,feldspars and pyrite,magnetite
Plate 39(Crossed nicols Mgf:x63)	Quartz,ilmenite,feldspars and goethite,magnetite
Plate 40(Plain light Mgf:x630	Quartz,ilmenite,monazite and pyrite,goethite,feldspars and staurolite

FINE SAND MINERALOGY

Site: Vellanikkara



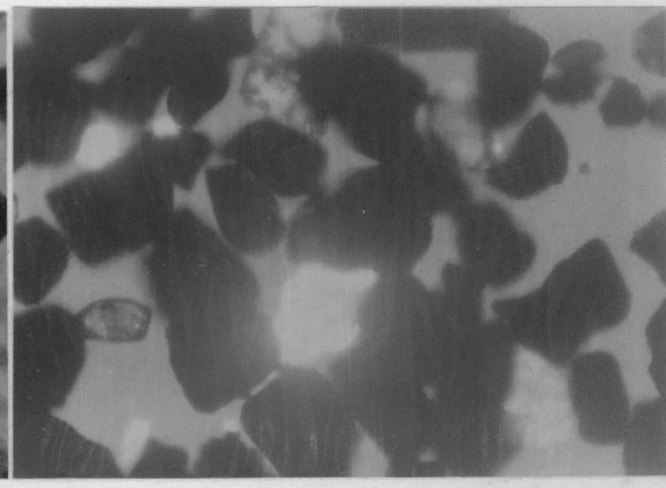


Plate 41
Lighter fraction

EPIPEDON

Plate 42
Heavier fraction

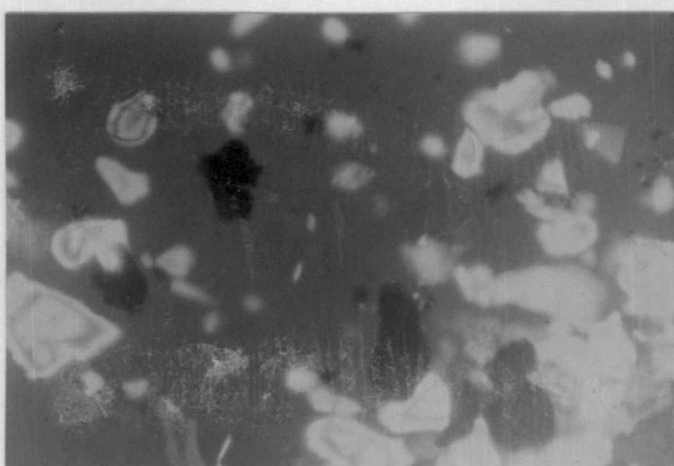


Plate 43
Lighter fraction

ENDOPEDON

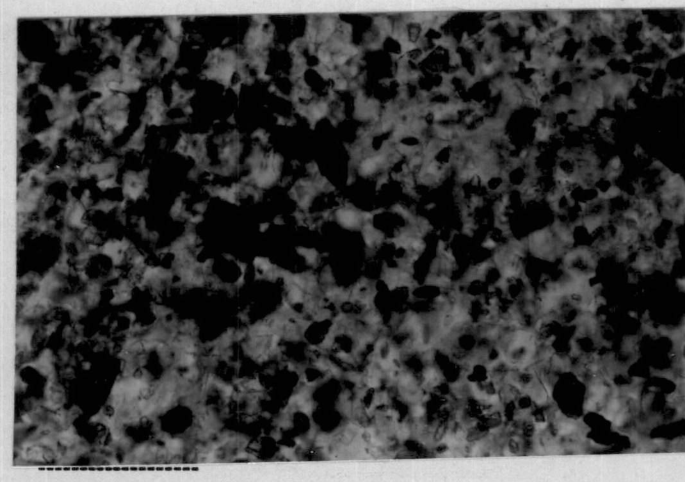
Plate 44
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 41(Plain light Mgf:x63)	Quartz,haematite,ilmenite and plinthic glaebules,magnetite
Plate 42(Crossed nicols Mgf:x63)	Ilmenite,quartz,magnetit,zircon
Plate 43(Crossed nicols Mgf:x63)	Quartz,haematite and ilmenite,magnetite
Plate 44(Crossed nicols Mgf:x63)	Ilmenite,quartz,magnetite and haematite

FINE SAND MINERALOGY

Site: Eruthenpathy



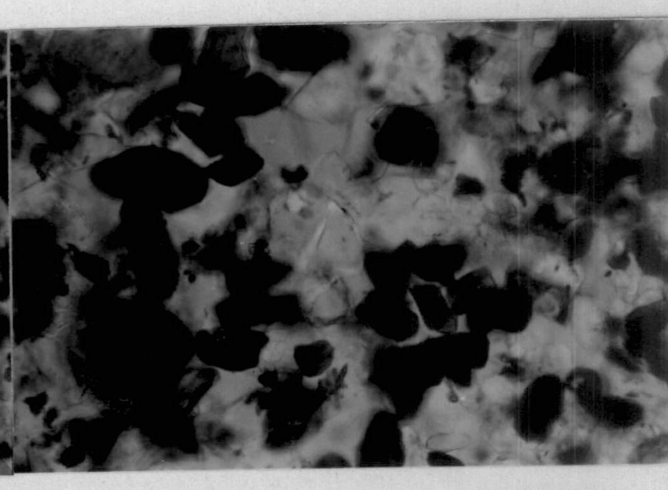
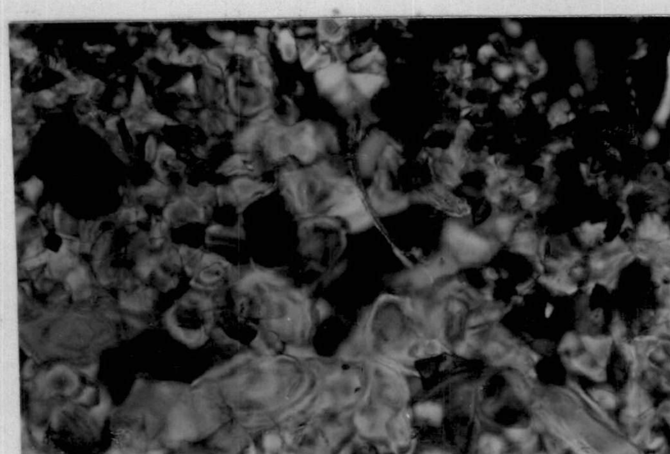


Plate 45
Lighter fraction

EPIPEDON

Plate 46
Heavier fraction



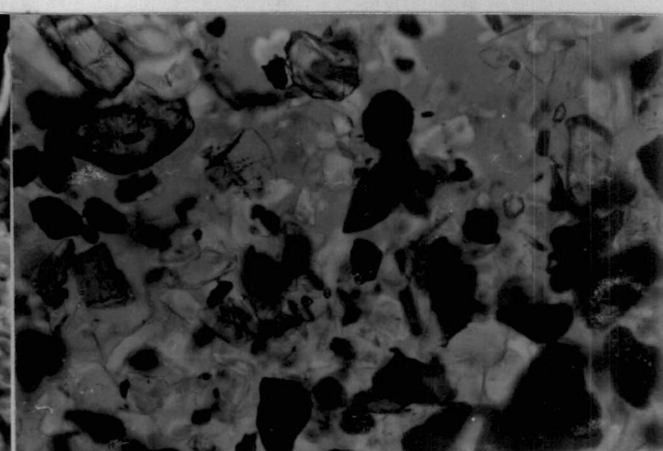


Plate 47
Lighter fraction

ENDOPEDON

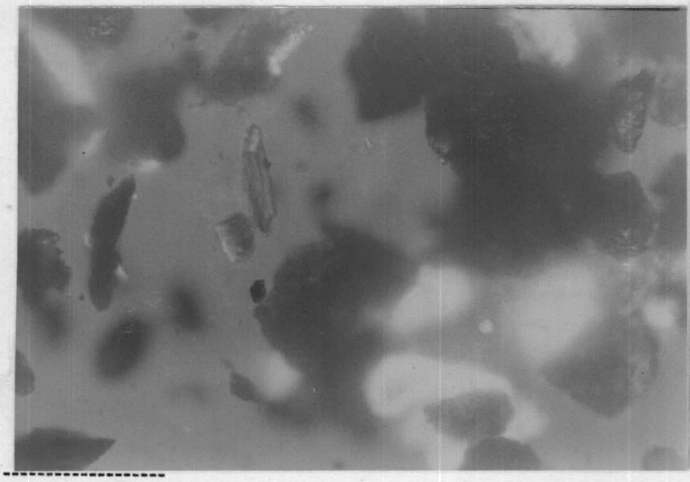
Plate 48
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 45(Plain light Mgf:x63)	Quartz,ilmenite,magnetite,haematite,goethite and calcite
Plate 46(Plain light Mgf:x63)	Quartz,ilmenite,magnetite and calcite and haematite
Plate 47(Crossed nicols Mgf:x63)	Quartz,haematite,clacite and ilmenite,feldspars and magnetite
Plate 48(Plain light Mgf:x63)	Quartz,magnetite,biotite mica,calcite and haematite and staurolite

FINE SAND MINERALOGY

Site: Angadipuram



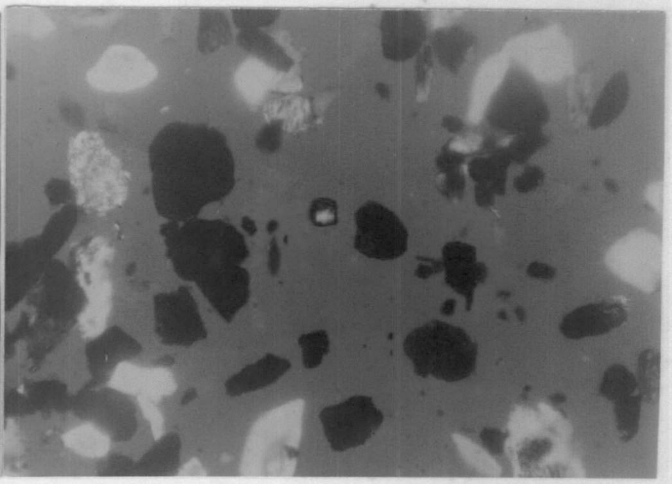
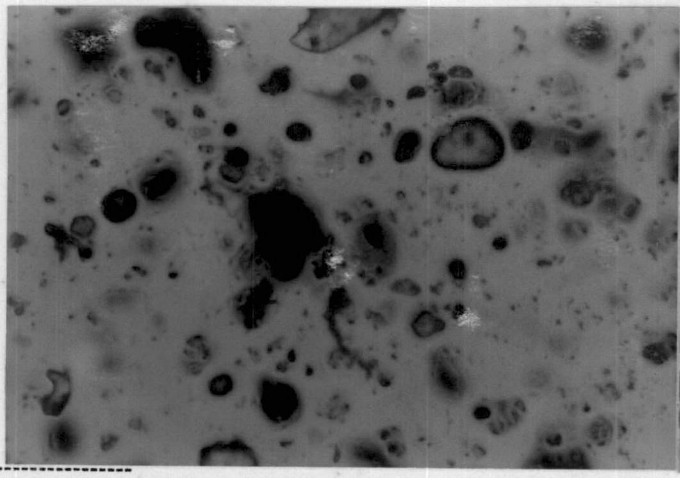


Plate 49
Lighter fraction

EPIPEDON

Plate 50
Heavier fraction



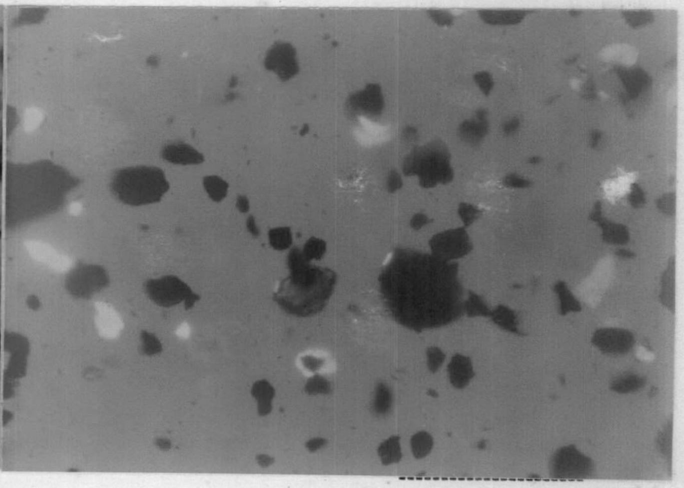


Plate 51
Lighter fraction

ENDOPEDON

Plate 52
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 49(Crossed nicols Mgf:x160)	Haematite,quartz,goethite,boehmite,magnetite
Plate 50(Crossed nicols Mgf:x63)	Ilmenite,quartz,goethite,haematite,zircon and rutile,kyanite
Plate 51(Plain light Mgf:x63)	Staurolite,ilmenite,haematite and rutile,quartz
Plate 52(Crossed nicols Mgf:x63)	Quartz,ilmenite,magnetite

FINE SAND MINERALOGY

Site: Kunnamangalam

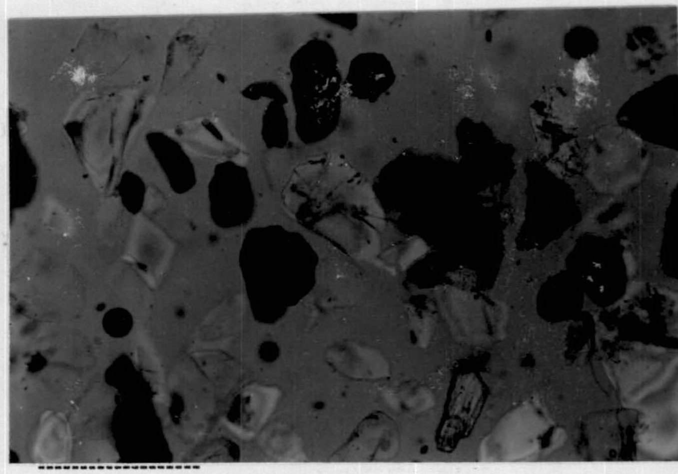
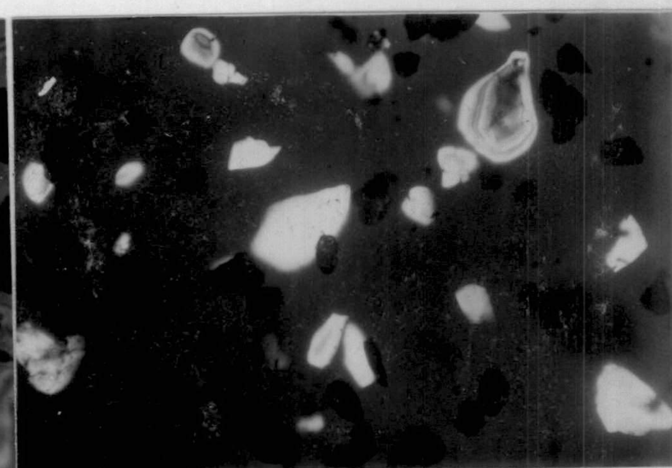



Plate 53
Lighter fraction

EPIPEDON

Plate 54
Heavier fraction

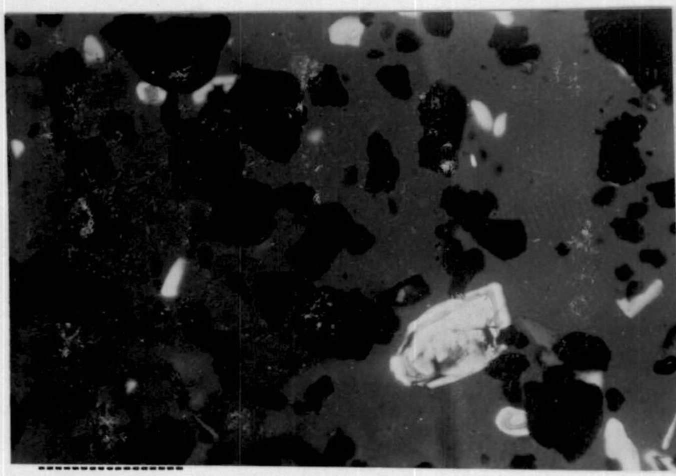
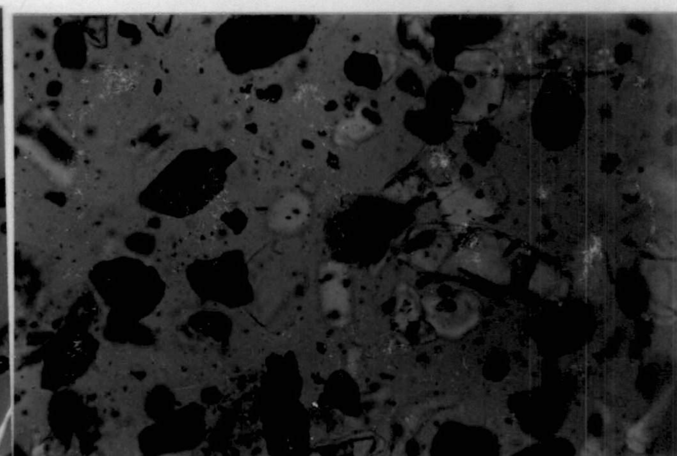



Plate 55
Lighter fraction

ENDOPEDON

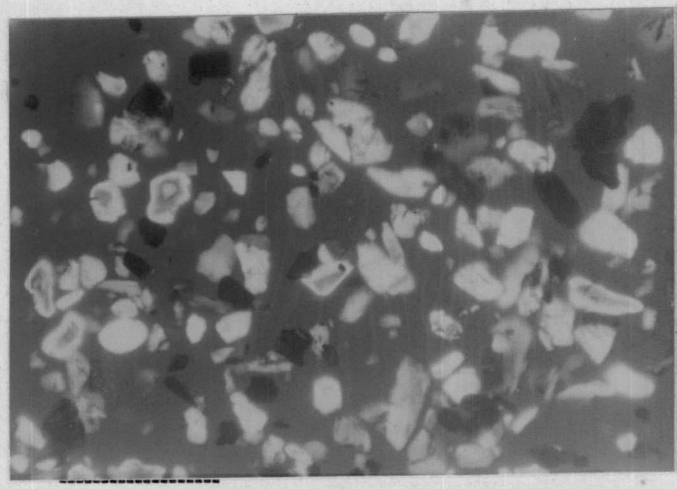
Plate 56
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 53(Plain light Mgf:x63)	Quartz,haematite,ilmenite and plinthic glaebules,magnetite,zircon
Plate 54(Crossed nicols Mgf:x63)	Quartz,magnetite,ilmenite,goethite
Plate 55(Plain light Mgf:x63)	Plinthic glaebules,quartz,haematite,magnetite and ilmenite
Plate 56(Crossed nicols Mgf:x63)	Quartz,haematite,magnetite,ilmenite,zircon,kyanite

FINE SAND MINERALOGY

Site: Ambalavayal



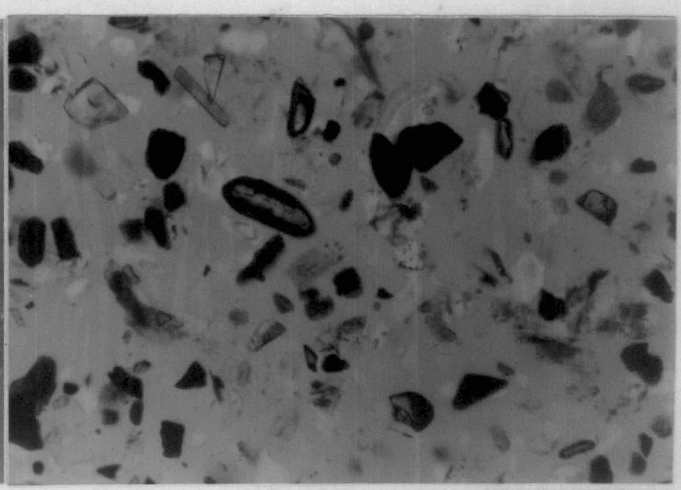
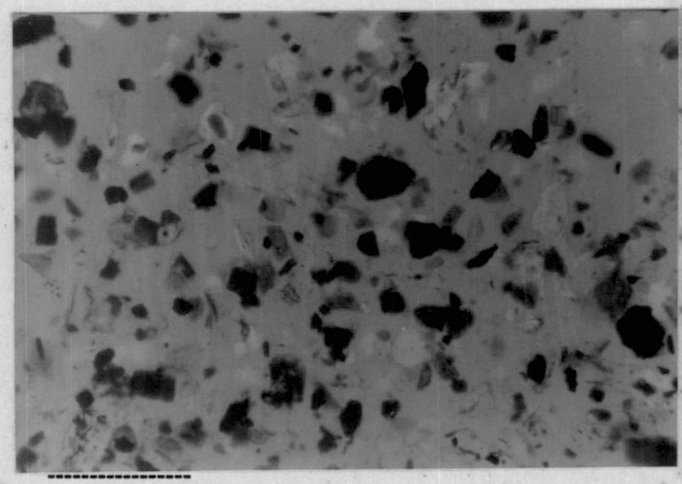


Plate 57
Lighter fraction

EPIPEDON

Plate 58
Heavier fraction



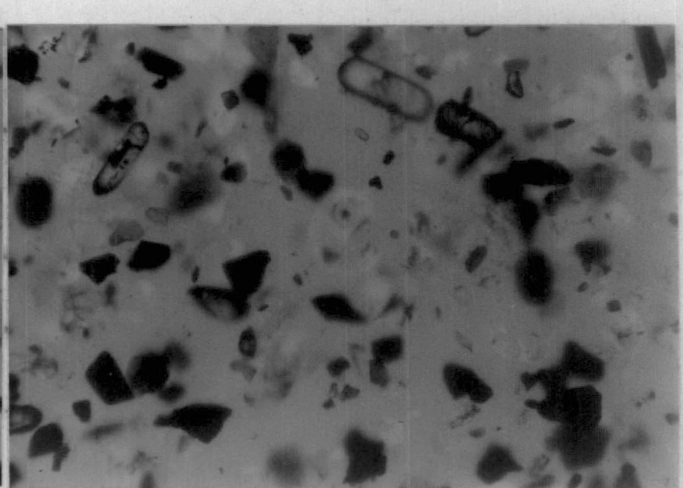


Plate 59
Lighter fraction

ENDOPEDON

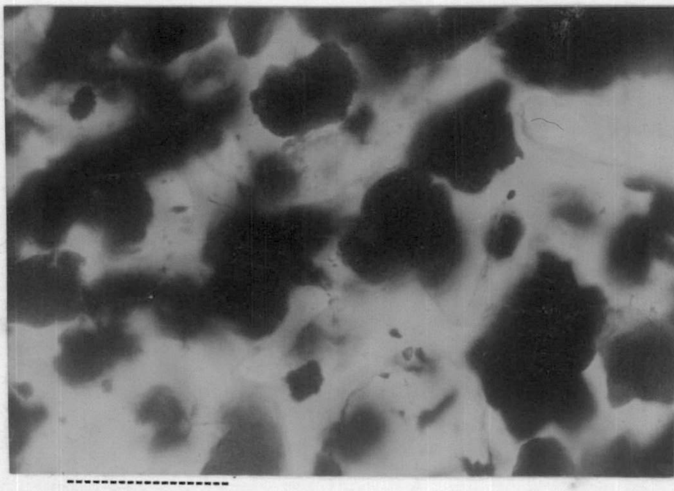
Plate 60
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 57(Crossed nicols Mgf:x63)	Quartz,haematite,feldspars,magnetite and goethite
Plate 58(Plain light Mgf:x63)	Quartz,magnetite,biotite mica,zircon and ilmenite,feldspars
Plate 59(Crossed nicols Mgf:x63)	Quartz,biotite mica,magnetite,goethite and haematite
Plate 60(Plain light Mgf:x63)	Magnetite,quartz,haematite and zircon

FINE SAND MINERALOGY

Site: Pilicode



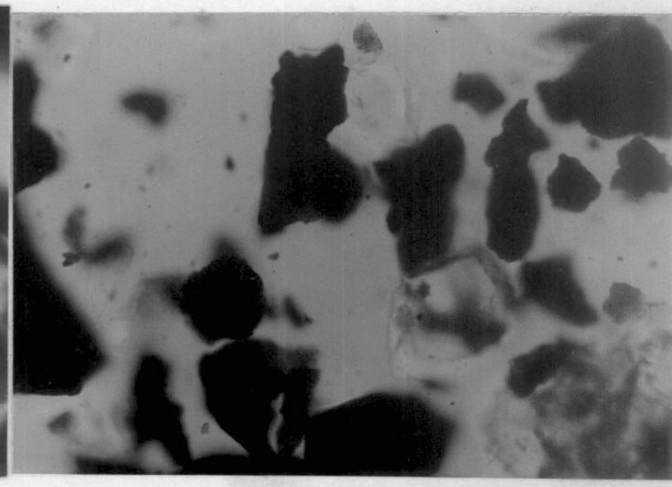


Plate 61
Lighter fraction

EPIPEDON

Plate 62
Heavier fraction

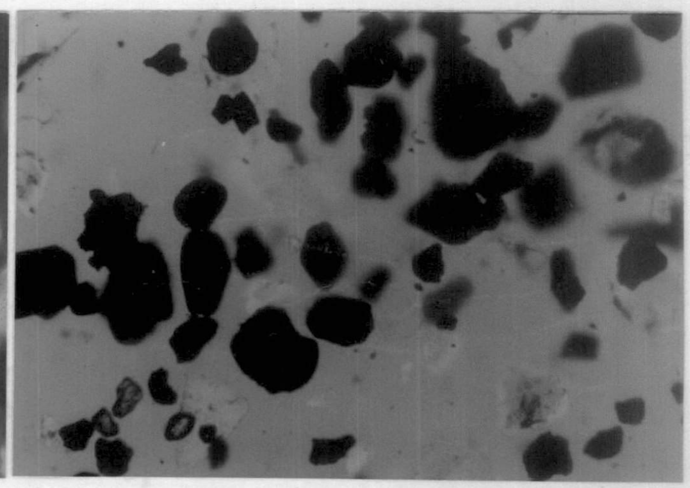


Plate 63
Lighter fraction

ENDOPEDON

Plate 64
Heavier fraction

MINERALS IN THE DECREASING ORDER OF ABUNDANCE

Plate 61(Plain light Mgf:x160)	Plinthic granules ferritic,quartz,plinthic granules goethitic,magnetite
Plate 62(Plain light Mgf:x160)	Plinthic granules ferritic,quartz,plinthic granules goethitic, quartz, magnetite and mica
Plate 63(Crossed nicols Mgf:x63)	Quartz,magnetite,haematite
Plate 64(Plain light Mgf:x63)	Ilmenite,quartz,magnetite,zircon,mica

4. Mineralogy of Clay Fraction.

The X-ray diffractograms of the diagnostic horizons of the representative profiles from the selected major land resource areas are presented in figures 1-32.

4.1. Southern Dissected Terriplain

In the southern dissected terriplain represented by Vellayani, the dominant clay mineral present is Kaolinite, with very strong first order peak of 7.2 A^o. Mixed clay minerals comparatively half the quantity of Kaolinite is also observed. Other minerals present in minor amounts are feldspars and goethite.

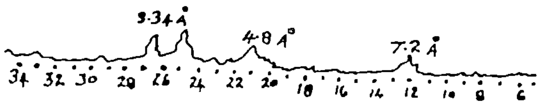
4.2. Southern Lowland Laterites, Southern Dissected Midland Laterites, Central Dissected Midland Laterites and Northern Dissected Midland Laterites

In the southern low land laterite area (Thiruvananthapuram), southern dissected midland laterite area (Nedumangad and Kottarakkara), Central dissected midland laterite area (Vellanikkara) and northern dissected midland laterite area (Angadipuram, Kunnamangalam, Pilicode) the dominant clay minerals present are kolinite and mixed clay minerals with fewer mica, smectite, feldspars, gibbsite and

X-RAY DIFFRACTOGRAMS

SITE-VELLAYANI

Fig.1



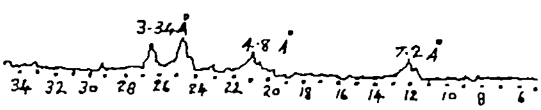
epipedon

Fig.2

endopedon

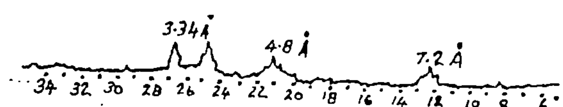
SITE-THIRUVANANTHAPURAM

Fig 3



epipedon

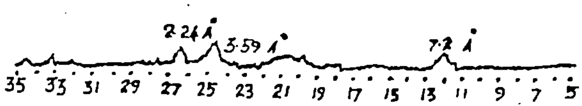
Fig 4



endopedon

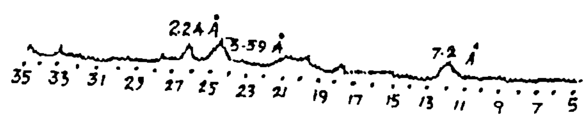
SITE-KAZHAKUTTOM

Fig 5



epipedon

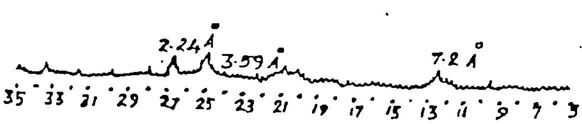
Fig 6



endopedon

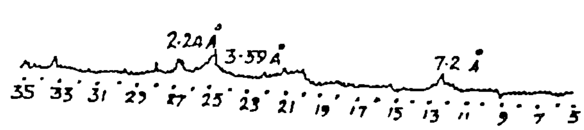
SITE-NEDUMANGAD

Fig 7



epipedon

Fig 8



endopedon

DIFFRACTION ANGLE 2θ

SITE-PALODE

Fig 9

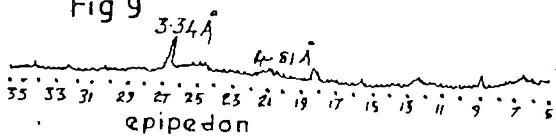
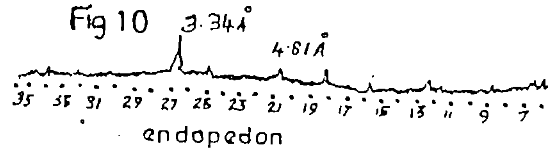


Fig 10



SITE-KOTTARAKKARA

Fig 11

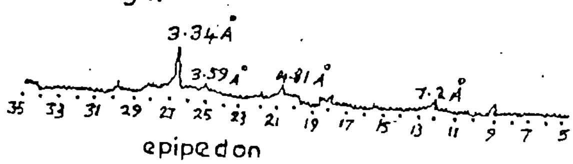
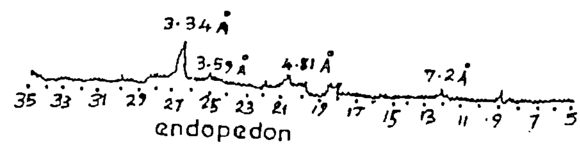


Fig 12



SITE-KAYAMKULAM

Fig 13

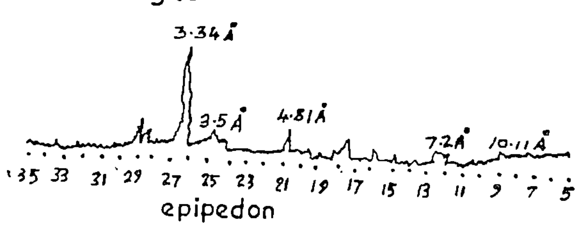
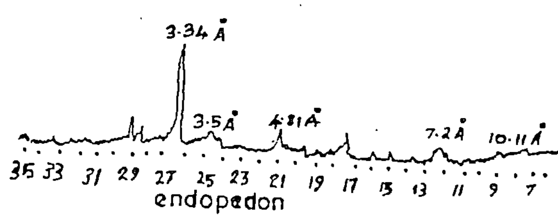


Fig 14



SITE-KARUMADI

Fig 15

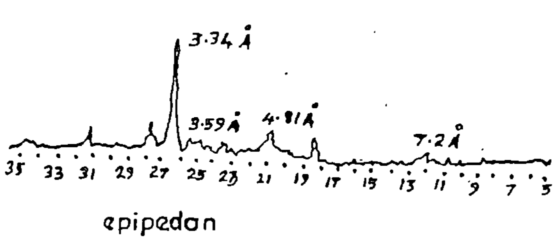
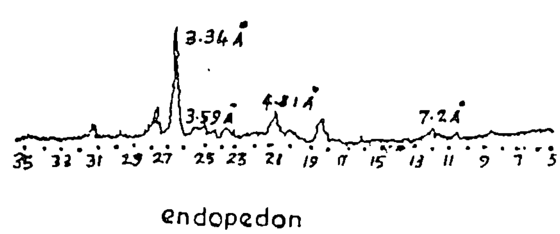


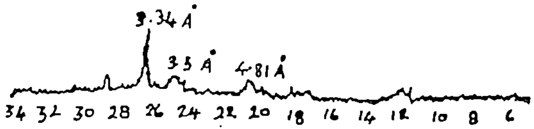
Fig 16



DIFFRACTION ANGLE 2θ

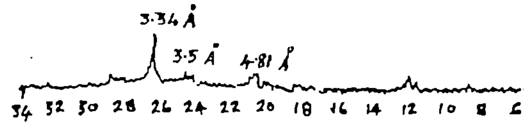
SITE-MONCOMPU

Fig 17



epipedon

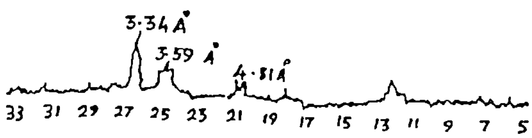
Fig18



endopedon

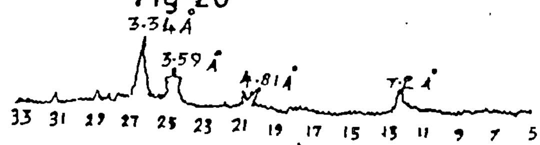
SITE-VYTILLA

Fig 19



epipedon

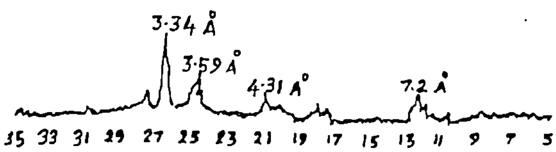
Fig 20



endopedon

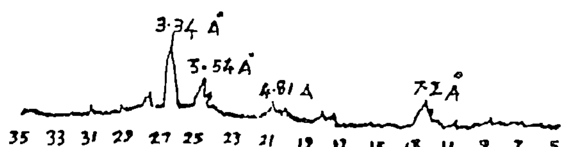
SITE-VELLANIKKARA

Fig 21



epipedon

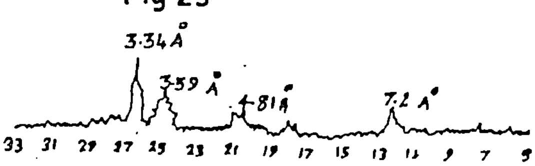
Fig 22



endopedon

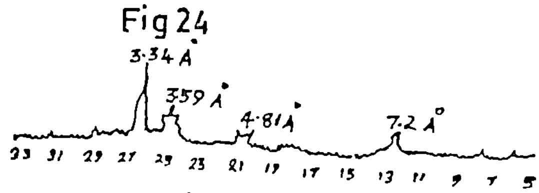
SITE-ERUTHENPATHY

Fig 23



epipedon

Fig 24



endopedon

DIFFRACTION ANGLE 2θ

SITE-ANGADIPURAM

Fig 25

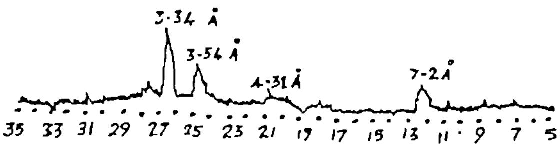
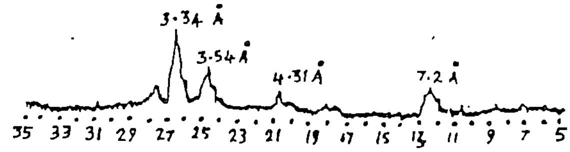


Fig 26



SITE-KUNNAMANGALAM

Fig 27

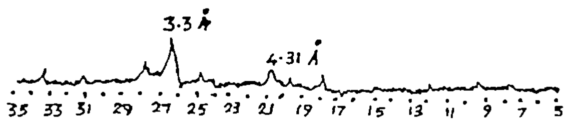
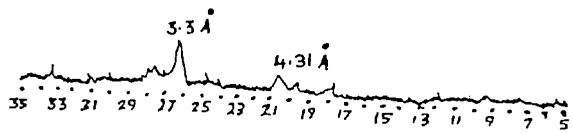


Fig 28



SITE-AMBALAVAYAL

Fig 29

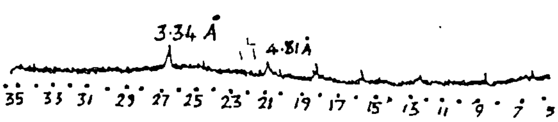
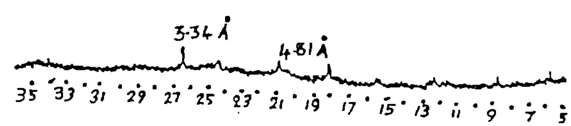


Fig 30



SITE-PILICODE

Fig 31

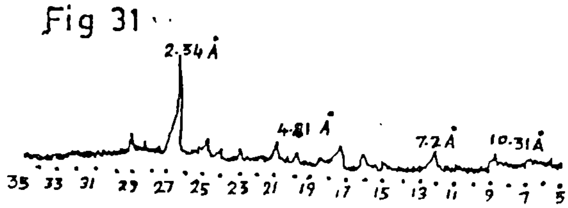
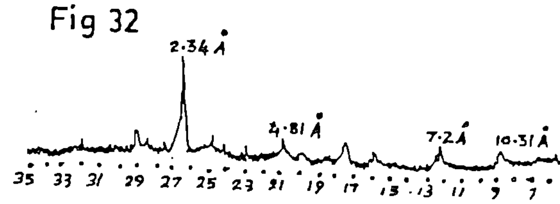


Fig 32



DIFFRACTION ANGLE 2θ

goethite. Bindukumari (1993) has reported similar results in these soils. In the southern coastal plain represented by Kazhakuttom and Kayamkulam, clay fraction is constituted by comparatively lesser quantity of kaolinite and equal quantities of smectite and mixed clay minerals. The presence of minor, equal amounts of mica quartz and goethite is an unique observation in these soils.

4.3. Southern Foot Hills

In the southern foot hills, represented by Palode, maximum quantity of kaolinite is observed, followed by mixed clay minerals and with almost equal amounts of goethite. Feldspar is the least abundant mineral in these soils. Similar results have been reported by Ashraf (1992) in his study of these soils.

4.4. Kuttanad Coastal Basin and Central Backwater Basin

In the Kuttanad coastal basin represented by Karumadi and Moncompu and the central backwater basin represented by Vytilla, the clay minerals observed in the order of abundance are kaolinite and equal amounts of smectite and mixed clay minerals. In the profile studied at Vytilla, smectite clay minerals are almost equal in abundance with kaolinite. The other minerals present are gibbsite and the least in abundance is feldspar.

4.5. Palakkad Gap

In the Palakkad gap represented by Eruthenpathy, the clay minerals present in the increasing order of abundance are mica, illite, mixed clay minerals in equal amounts, kaolinite and smectite. Gibbsite and fledspars are also noticed in minor amounts.

4.6. Wayanad Plateau

In the Wayanad plateau represented by Ambalavayal, kaolinite constitutes the major portion of the clay minerals, followed by mixed clay minerals, mica and illite. The unique observation is the presence of equal quantities of gibbsite and goethite, though their absolute content in less.

Within an MLRA, not much difference in clay mineralogy is observed between the diagnostic horizons. Comparative clay mineralogy of the diagnostic horizons from studied MLRAs indicate that in the upland MLRAs kaolinite is the dominant mineral while in the wet lands it is generally smectite minerals. In the upland MLRAs, kaolinite is followed by smectite, mica, illite, quartz, feldspars, gibbsite and goethite, while in the Kuttanad coastal basin, the central backwater basin and Palakkad gap smectite is followed by kaolinite, mica, illite, mica quartz, feldspars, gibbsite and goethite. Haematite was not noticed in the clay fraction of the diagnostic horizons in the studied MLRAs. Mixed clay minerals observed in the studied upland MLRAs are regular with chlorite-vermiculite composition while that in the wet land profiles, southern coastal plain and Palakkad gap are random with chlorite-smectite composition. The presence of mixed interstratified minerals in the clay fraction can be attributed to the transformation of mica to smectite or vermiculite which may be regular or random. This is in consonance with the observation reported by Shanwal et al (1991).

The genesis of clay minerals of the diagnostic horizons can be explained on the basis of group condusive factors. The soils of the studied MLRAs are grouped under Ultisols, Entisols, Mollisols and Vertisols.

The partial hydrolytic decomposition of feldspars might have led to the formation of mica which is transformed to kaolinite. Slightly alkaline reaction, comparative abundance of Magnesium and poor drainage have accelerated the formation of smectite in the soils of the Palakkad gap irrespective of their geomorphological setting. The presence of illite observed at Karumadi, Moncompu and Vytilla is indicative of the influence of micaceous sedimentary parent material. The restricted drainage and required base status of the endopedons of upland profiles has provided suitable environment for the formation of smectite from the lesser weathered fragments which have supplied Si, Mg and Fe. Therefore kaolinite could not have been formed by the alteration of smectite and hence some of the orthoclase feldspars might have weathered to kaolinite under the prevailing conditions.

The occurrence of kaolinite in the wet land profiles is a neoformation from the lateritic sediments from the nearby older landscapes. There is a probability of them to be nucleated to result in kaolinite also by the current seasonal pedogenesis. Hence the occurrence of kaolinite can be expected to be from a diagenetic material.

The clay minerals of the soils developing from parent materials originating from granite, gneiss, quartz, mica schist and gabbro are both pedogenic and geogenic, irrespective of the MLRAs. Thampy (1992) reported that the lithosequence in Kerala includes the extremely acidic khondalite group of rocks in the south which grades into acidic charnokites in central Kerala and intermediate and basic rocks in the north.

Irrespective of the MLRAs, kaolinite is the dominant clay mineral followed by smectite, mica and illite. The non-clay clay minerals mica quartz, feldspars, goethite and gibbsite are also present. Haematite was not observed in the clay fraction. Smectite and mica are also present even in weathered laterite MLRAs. Diagenesis is observed in the Kuttanad coastal basin, central backwater basin and at the Palakkad gap whereas the other MLRAs are with polygenetic or paleoclimatic influenced soils. Mohr and Van Baren (1954) regarded the present day laterites as fossil, ie., of non-contemporaneous origin and grouped them as senile. Similar observations were also reported by Venugopal (1986) and Pal et al (1989) in their study on red and laterite soils of Karnataka.

5. Micromorphology

The detailed micromorphological descriptions of the diagnostic horizons of the representative profiles from different MLRAs are presented in table 3.0 and the respective photomicro graphs in Plates 65 to 128.

5.1. Southern Dissected Terriplain

At Vellayani representing the southern dissected terriplain, micromorphological studies reveal the presence of highly fractured, fine sand sized to silt sized quartz, many

Table 3.0 DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.1 Location : Vellayani

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Very less plasma present as well aggregated opaque to brownish red colour in patches.	Opaque to brownish red, micro aggregated plasma.
2. Soil fabric	Skelsepic	Skelsepic
3. Skeleton	Highly fractured, moderately coated, subangular to subrounded, fine sand sized to silt sized quartz subangular to subrounded less than silt sized to clay sized opaques.	Fractured, medium reliefed, subangular more than coarse sand sized.
4. R D P	Granic	Granic
5. N R D P	Granic to slightly intertextic	Granic
6. S R D P	Granic	Plasmi-granic
7. Coarser/finer	Coarser 90/10	Coarser 70/30
8. Voids	Non-infilled, non-lympid, medium to big sized non-interconnected vesicles.	Fine to medium sized, many vesicles and Vughs without infillings and lympidity.
9. Humus	Absent.	Absent.

10. Chlamydomorphic coating	Few broken	Absent.
11. Lithorelics	Very few, less than silt sized, high reliefed, opaque Fe-Mn minerals present.	Absent.
12. Cutans	Ferri-mangans and ferrans as discontinuous marginal/skeleton coating.	Opogue to brownish red illuviation ferrans and very few illuviaton argillans on less than silt sized quartz and cracks and notches of larger quartz grains.
13. Special observations	Highly fractured, fine sand sized to silt sized quartz, many less than silt sized opagues and few lithorelics, plasma very less, well aggregated opague to brownish red in patches, bigger vesicles.	More than coarse sand sized to fine sand sized quartz and many less than silt sized to clay sized opagues and coated quartz, micro aggregated, opague to brownish red plasma and illuviation ferrans and argillans on less than silt sized quartz porous with vesicles and vughs.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.2

Location : Thiruvananthapuram

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Opaque to yellowish brown, lympid and micro aggregated.	Less plasma, yellowish grey colour.
2. Soil fabric	Skelsepic to plinthic.	Plinthisepic
3. Skeleton	Few less than fine sand sized subrounded medium to high reliefed, quartz, less than silt sized and clay sized subrounded coated quartz, more than coarse sand sized opaque quartz rich, sharp margined, petroplinthic gravels.	More than coarse sand sized irregular margined plinthic gravels, less than clay sized quartz, with ferran, many plinthic glaebules, medium reliefed, less than silt sized, plinthic gravels and glaebules indicate a tendency of illuviation-iron migration to ferriargillanic organisation.
4. R D P	Plinthi-granic to Plasmi-granic	Plinthi-Plasmic and at micro locations grani-plasmic.
5. N R D P	Plasmi-granic	Plinthi-plasmic.
6. S R D P	Grani-Plinthic	Grani-Plinthic.
7. Coarser/finer	Coarser 70/30	Coarser 90/10
8. Voids	Few fine to medium sized ferriargillan filled lympid vesicles and vughs.	Few fine to medium sized, vesicles, vughs and chambers.
9. Humus	Very few scattered micro aggregated, ferriorganic in combination with ferriangillans.	Absent

10. Chlamydomorphic coating	Absent	Absent
11. Lithorelics	Very few less than silt sized weathered quartzitic gneiss, and less than silt sized many opaques.	Very few opague manganic dominant materials.
12. Cutans	Ferran and ferriargillan and at few places goethans and mangans.	Ferran, ferriargillan and opaque ferrimangans.
13. Special observations	Petroplinthic gravels less than fine sand sized to less than silt sized quartz on opague reddish yellow to brownish yellow plasma with few ferriargillan filled vesicles and vughs.	Highly plinthic illuviated, compact, gravelly and glaebular materials with very few. yellowish brown to yellowish grey coloured plasma and very fine to medium sized vesicles, vughs and chambers.

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No.3 Location : Kazhakkuttom

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Grey to greyish yellow and at few places opaque.	Brown to yellowish brown, thin and transparent.
2. Soil Fabric	Skelsepic	Skelsepic
3. Skeleton	Medium coarse sand sized to find sand sized, medium to high reliefed, slightly pitted, angular to subangular quartz, very high reliefed ilmenite, mangnetite and less than silt sized coated quartz and subrounded to rounded ilmenite.	Coarse sand sized to fine sand sized cracked, angular to subangular quartz, ilmenite, magnetite. The opaques are very high reliefed and non weathered.
4. R D P	Granic	Granic
5. N R D P	Granic	Granic
6. S R D P	Granic	Granic
7. Coarser/finer	Coarser 95/5	Coarser 98/2
8. Voids	Very fine to medium sized interconnected vesicles and planar packing voids.	Many fine planar packing voids and very few interconnected vesicles and vughs.
9. Humus	Absent	Absent

10.	Chlamydomorphic coating	Chlamydomorphic coating of opaque to yellowish brown discontinuous ferran and goethan.	Absent
11.	Lithorelics	Absent	Absent
12.	Cutans	Very thin ferriargillans and thick marginal ferrans on skeleton surface and margin respectively.	Very few thin illuvial ferriargillans and ferrans on the surface of quartz grains.
13.	Special observations	Less plasma, more angular skeletons-quartz, ilmenite and magnetite with few thin illuviation ferriargillans thick incomplete marginal coating of opaque ferrans.	Highly compact angular to subangular coarse sand sized to fine sand sized, non coated slightly fractured quartz and high relief opaques with few illuvial ferran and ferriargillan and fine interconnected vesicles and planar packing voids.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.4 Location : Nedumangad

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Brownish yellow to reddish brown, moderately thin, oriented.	Opaque, reddish brown to brownish yellow ferranic to ferri-argillanic, well oriented and well aggregated.
2. Soil fabric	Skelvosepic	Vo-skelsepic.
3. Skeleton	Subangular to subrounded, coarse sand sized to more than coarse sand sized, fractured, coated, quartzitic gneiss, plinthic glaebules, less than fine sand sized, cracked and fractured, obliquely oriented, slender quartz.	More than coarse sand sized, highly fractured and cracked angular to subangular, high reliefed quartz with ferriargillan infillings in cracks and many less than fine sand sized plinthic glaebules.
4. R D P	Grani-plasmic	Plasmi-granic.
5. N R D P	Grani-plasmic to porphyric	Plasmi-granic
6. S R D P	Grani-Plasmic to porphyric	Plasmi-granic
7. Coarser/finer	Finer 40/60	Coarser 60/40
8. Voids	Bigger vesicles/vughs and few narrow channels and chambers without infillings and non-lympid.	Vesicles and few chambers, non lympid without any infillings
9. Humus	Few plasmified as ferriorganan in combination with ferriargillan.	Absent

10.	Chlamydomorphic coating	Few, discontinuous, oriented.	Absent
11.	Lithorelics	Skeletons are dominantly weathered,more than coarse sand sized, quartzitic gneiss and plinthic glaebules.	Plinthic glaebules of irregular margin and less than fine sand sized
12.	Cutans	Ferri-organan, ferriargillan and ferran	Ferrans and ferri-argillans.
13.	Special observations	Plasma and skeleton well oriented. Plasma ferranic to ferriargillanic and slightly ferriorganic. Quartzitic gneiss, plinthic, glaebules and few lath shaped quartz with oblique orientation. Voids are dominantly vesicular.	Patchy aggregated, vesicular, ferranic to ferri-argillanic plasma with angular to subangular more than coarse sand sized, fractured and cracked quartz and less than fine sand sized irregular margined opaque to reddish brown plinthic glaebules.

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No.5

Location : Palode

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Plasma less, opaque to greyish brown colour.	Opaque to brownish yellow plasma.
2. Soil Fabric	Skelsepic	Skelvosepic
3. Skeleton	More than coarse sand sized many subangular cracked quartz and many subangular to subrounded less than clay sized quartz rich petroplinthic opaque to brownish yellow gravels and glaebules, very few high reliefed, highly fractured and cracked feldspar in micro location.	Irregular shaped, fractured, illuvial cutan coated, very few coarse sand sized quartz, high reliefed, petroplinthic gravels and glaebules with goethan and ferriargillan and many less than silt sized subangular, fractured, non coated quartz and opaques.
4. R D P	Granic	Grani-plinthic
5. N R D P	Grani-plinthic	Grani-plinthic
6. S R D P	Grani-plinthic	Grani-plinthic
7. Coarser/finer	Coarser 95/5	Coarser 85/15
8. Voids	Very few to few channels, vughs and vesicles	Interconnected vesicles, chambers and few non interconnected vughs and vesicles.
9. Humus	Humus few as ferriorganan associated with ferriargillan and are illuviated.	Absent

10. Chlamydomorphic coating	Absent	Absent, but are intertextic.
11. Lithorelics	Few fine sand sized and very few clay sized coated and weathered quartzitic gneiss and garnetiferous quartzitic gneiss.	Few subangular high reliefed less than silt sized, coated, weathering garnetiferous quartzitic gneiss.
12. Cutans	Few illuvial ferriorganan and ferriargillan	Opaque, ferrans, brownish yellow to yellowish brown ferriargillans.
13. Special observations	More than coarse sand sized cracked quartz subrounded, opaque petro-plinthic gravels and glaebules of less than fine sand size with few voids and illuvial ferriorganan and ferri-argallans.	Irregular shaped, more than coarse sand sized, slightly coated quartz, high reliefed, petroplinthic subangular gravels and glaebules and many non-coated fractured quartz

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.6

Location : Kottarakkara

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Less plasma, opaque.	Less plasma, opaque.
2. Soil fabric	Skelsepic-Plinthi quartzitic	Plinthi-skelic to skeli-Plinthi-Skelsepic
3. Skeleton	Many oriented, lympid, medium reliefed to high reliefed, slightly cracked, slightly coated, angular to subangular, sand sized to silt sized quartz, fine sand sized to silt sized, faint margined, subangular to subrounded plinthic gravels and glaebules. Very few less than clay sized opagues.	Oriented, low reliefed, fractured, angular to subangular, coarse sand sized to more than coarse sand sized quartz, many illuvial marginal fine sand sized to silt sized plinthic glaebules, high reliefed subrounded to rounded opaques.
4. R D P	Granic	Grani-plinthic
5. N R D P	Grani-Plinthic	Grani-Plinthic
6. S R D P	Plinthi-granic	Grani-Plinthic
7. Coarser/finer	Coarser 95/5	Coarser 95/5
8. Voids	Few, bigger, lympid, vesicles many fine non-interconnected channels and vesicles.	Very few, big, spherical, and many fine to very fine vesicles and vughs.
9. Humus	Associated with iron oxy-hydrate as Ferri-organan.	Absent.

10. Chlamydomorphic coating	Absent.	Absent.
11. Lithorelics	Absent.	Few to many subrounded to rounded, high reliefed opaques.
12. Cutans	Faint, discontinuous, illuvial ferrans and very few ferriargillans.	Ferrans, and illuvial ferri-argillans.
13. Special observations	Coarse sand sized to fine sand sized quartz and plinthic glaebules to gravel rich, plasma less, with many faint, discontinuous illuviation ferrans and ferriargillans.	Well oriented, packed illuviated fine sand sized to silt sized subangular opaque to brownish yellow plinthic glaebules on low reliefed, cracked, angular coarse sand sized to more than coarse sand sized quartz with few opaque lithorelics, very few fine vesicles and vhghs and very less plasma.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.7

Location : Kayamkulam

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Dominantly brownish yellow to brown and at places greyish brown, forms small portion of the soil mass. The plasma is speckled with less than clay sized non coated angular to subangular quartz grains.	Plasma few, opaque and thick and rarely brownish yellow.
2. Soil fabric	Skelsepic to Skelvosepic	Dominantly skelsepic and at few places without any definite pattern.
3. Skeleton	Angular to subangular, slightly cracked, medium reliefed fine sand sized quartz, less than silt sized, subangular to subrounded opaque medium reliefed ilmenite, less than clay sized, coated, subrounded to rounded quartz grains. In general the grains surfaces are rough translucent with iron oxide deposition in few sutures.	Few subangular to subrounded fractured quartz,many less than very fine sand sized subangular to subrounded even slender, medium reliefed, slightly coated quartz, few to very few subrounded to rounded non coated opaques.
4. R D P	Intertextic to porphyroskelic	Intertextic
5. N R D P	Granic	Granic
6. S R D P	Granic to porphyroskelic	Granic to porphyroskelic
7. Coarser/finer	Coarser, 60/40	Coarser, 80/20.

8.	Voids	Highly porous, bigger pores dominantly planar and packing. Voids are with lympidity of coated less than clay sized subrounded to rounded quartz grains and few opaques.	Vesicles, vughs and interconnected chambers filled with opaque plasma, nonlympid.
9.	Humus	Very few, pale grey coloured plasmified organic matter.	Absent.
10.	Chlamydomorphic coating	Very few, discontinuous, dominantly organic, followed by ferriorganan.	Absent but dominantly intertextic.
11.	Lithorelics	Very few, less than silt sized and opaque present.	Absent
12.	Cutans	Yellowish brown ferri argillans on the plasma and as infillings of voids, opaque ferriorganan as incomplete marginal coating of quartz grains.	Yellowish brown, marginal, illuvial, ferriargillanic cutans on the skeletons is the characteristic feature of the horizon.
13.	Special observation	Highly porous, with common, rough surfaced medium reliefed, noncoated anglar to subangular, even irregular fractured quartz, plasma less, dominantly ferriargillanic, lympidity is observed in plasma, voids and skeletons. Plasmified organic matter very few and localised.	Comparatively less porous, compact, less than very fine sand sized, subangular to subrounded, slightly fractured quartz, with yellowish brown, marginal,illuvial ferriargillans.Voids present are vesicles and interconnected chambers. All the components are non lympid to slightly lympid.

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No.8 | Location : Karumadi

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Yellowish brown, brownish yellow and greyish blue with innumerable, less than clay sized, subrounded to rounded non coated to slightly coated quartz,plasma is lympid.	Mineral plasma is very less and opaque greyish brown to grey. Organic plasma is the plasma proper under various stages of decomposition with retained cellular structure of bark tissue of the mangrove vegetation with rich poly crystalline cluster of jarosite and pyrite framboids.
2. Soil fabric	Plasmic to plasmi-granic	Parallel, striated fabric, plasmic
3. Skeleton	Clay sized to less than clay sized subrounded few to many runic quartz rich in microcrystalline jarosite framboids, associated with decomposed organic matter as organan resulting in organic jarositan. Very few angular to subangular claysized opaques dominantly ilmenite. Noncoated, non weathered feldspars of clay size is also noticed. Few clear margined subangular plinthic glaebules, grey to white oval to tabular diatoms and spongy spicules.	All the skeletons are irregular shaped, faint margined coated or noncoated less than clay sized quartz opaque pyrite framboids and yellowish brown jarosite framboids, opaque to brownish yellow, clear margined slender pieces of mangrove bark tissue.
4. R D P	Plasmic to Vo-sepic	Plasmic
5. N R D P	Plasmi jarositanic	Oragani-plasmic
6. S R D P	Plasmi jarositanic	Jarositanic organi-plasmic
7. Coarser/finer	Finer 5/95	Finer 15/85.

8. Voids	Fine to medium interconnected vesicles, chambers, and fine sand sized vughs with clear grainy margins without inclusions.	Vesicles and chambers interconnected and non interconnected dominantly without inclusions but a few with ferran ferriorganan ferri jarositan to quartzijarositan cutans.
9. Humus	Plasmified and few partially decomposed micro organo-aggregates associated with ferri-jarositan.	Organic matter of mangrove bark associated with micro-crystalline jarosite framboid under various stages of decomposition indicating the fossil cellular fracture,
10. Chlamydomorphic coating	Absent	Absent
11. Lithorelics	Absent	Absent
12. Cutans	Jarositan, ferriorganan, quartzijarositan comprising groundmass occupied by plasma.	Ferriorganan, organi-jarositan, organi-pyritan in plasma and as margins of voids.
13. Special observations	Medium porous, quartzijarositanic plasma with clay sized, non-coated subangular few runic quartz, feldspars, diatoms, spongy spicules, subangular plinthic glaebules and non infilled clear margined chambers and vesicles on greyish brown plasma.	Parallel, striated fabric constituted of opaque to brownish yellow, fossil decomposing mangrove bark cells associated with less than clay sized poly-framboidal pyrite and jarosite in a thin grey to greyish black plasma with chambers and vesicles.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No. 9 Location: Moncompu

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Less plasma, yellowish brown	Reddish yellow, yellowish brown to brownish yellow coloured less plasma
2. Soil fabric	Skelsepic to skel-argillasepic	Vosepic to vo-skelsepic.
3. Skeleton	Finesand sized to less than siltsized sub angular quartz, pyrite and other opaques and very few feldspars.	Few coarse sand sized opaques, pyrite framboids, fractured subrounded quartz many less than silt quartz, mica and cubicular and framboidal pyrite.
4. RDP	Granic	Granular to plasmi-granular
5. NRDP	Grani-plasmic to phyric	Plasmi-granic to intertextic.
6. SRDP	Granic	Intertextic
7. Coarser/finer	Coarser 80/20	Coaser to finer (60/40) (40/60)
8. Voids	Not observable	Channels, vughs and chambers.
9. Humus	Ferriorganan.	Ferriorganan, clusters of plasmified organic matter and opaques with repeated ironoxide deposition on cell walls.

10. Chlamydomorphic coating	Absent	Intertextic to slightly chlamydomorphic
11. Lithorelics	Absent	Absent
12. Cutans	Ferriorganan, Ferrihydrite, jarositan and pyritan.	Jarositan, ferrihydrite, pyrite and phytolith with ferriargillan and ferriorganan
13. Special observation	Ferriargillan coated subangular quartz rich horizon, less plasma partially birefringent, many fine pyrite and jarosite framboids present in the intrangular margins of quartz skeletons.	Granular, reddish yellow coloured less plasma with cubicular jarosite few coarse sand sized ilmenite, pyrite framboid and quartz. Ferrihydrite present along the margins of voids

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No.10

Location : Vytilla

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Brownish yellow and slightly lympid	Opaque to brownish yellow and at few places brownish red and thin.
2. Soil fabric	Skelsepic	Skelsepic
3. Skeleton	Low reliefed, fine sand sized to clay sized subangular to subrounded slightly fractured and pitted quartz, high reliefed ilmenite few feldspars highly fractured and coated quartz grains dominantly runic quartz. Less than silt sized quartz have illuvial ferran and ferriorganan, quartziferrijarositan.	Subangular to subrounded slightly fractured and pitted non coated coarse sand sized to fine sand sized quartz, less than silt sized, coated quartz, opaques, angular (including pitted) and high reliefed crystalline and amoeba shaped pyrite.
4. R D P	Grani-plasmic	Granic
5. N R D P	Grani-plasmic	Granic
6. S R D P	Quartzi-plasmic	Granic
7. Coarser/finer	Finer 5/95	Coarser 60/40
8. Voids	Very few, macro vesicles and few fine vescles	Few, medium to very fine sized vesicles and vughs.
9. Humus	Highly plasmified associated with ferran, goethan, quartzijarositan.	Absent

10. Chlamydomorphic coating	Absent	Absent
11. Lithorelics	Absent	Absent
12. Cutans	Ferrijarositan, ferran, quartzi jarositan and ferri-organan.	Many ferran and ferrijarositan on amoeba shaped pyrite and less than silt sized quartz indicating a tendency of illuviation.
13. Special observations	Yellowish brown lympid plasma associated with low reliefed, less than fine sand sized to silt sized non coated subrounded runicquartz, opaques feldspars, illuvial ferrijarositan coated, less than silt sized quartz with very few to few vesicles.	Opaque to brownish yellow plasma with non coated or slightly coated subangular to subrounded coarse sand sized to silt sized quartz, opaques with few medium to fine sized vesicles and vughs. The quartz are slightly fractured but are conspicuously pitted.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No. 11

Location : Vellanikkara

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Less plasma, opaque, yellowish brown to reddish yellow coloured, lympid, microaggregated.	Opaque to yellowish brown and at microlocations yellow coloured, moderately aggregated, slightly lympid plasma.
2. Soil fabric	Skelsepic.	Asepic to skelsepic.
3. Skeleton	High reliefed, fractured, subangular to subrounded, coarse sand sized to fine sand sized many quartz, less than clay sized highly coated quartz and Plinthic glaebules.	Coarse sand sized to clay sized, angular to subangular, slightly cracked, low reliefed quartz and many angular to subangular silt sized to clay sized opaque and yellowish brown goethitic glaebules.
4. R D P	Granic to grani-plasmic	Plasmi-granic.
5. N R D P	Granic	Plasmi-granic.
6. S R D P	Grani-Plasmic	Plasmi-granic to grani-plasmic
7. Coarser/finer	Coarser 85/15	Finer 20/80
8. Voids	Medium sized vesicles and few vughs without infillings.	Very few, fine non-interconnected chambers and vesicles and bigger interconnected vesicles.
9. Humus	Patchy microaggregated organan associated with iron oxy-hydrates as ferriorganan.	Absent.

10.	Chlamydomorphic coating	Absent.	Absent.
11.	Lithorelics	Very few fine sand sized opaque high reliefed Fe-Mn mineral.	Many less than silt sized angular, high reliefed, opaque iron-manganese mineral.
12.	Cutans	Ferriorganan, ferran and ferriargillan as infillings of skeleton cracks and as marginal smearing.	Mangan, ferran and ferri-argillan.
13.	Special observations	High reliefed, coated, fractured, subangular to subrounded fine sand sized to coarse sand sized quartz with thick opaque ferriorganic to ferranic cutan smearing with few fine sized vesicles.	Reddish yellow to yellowish brown microaggregated plasma with many less than silt sized to clay sized angular to subangular opaque iron manganese mineral and medium reliefed coarse sand to fine sand sized quartz. At few locations plasma less islands are also noticable.

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No.12 Location : Eruthenpathy

Micromorphological properties		Epipedon	Endopedon
1.	Plasma	Opaque, greyish black, brownish yellow and yellow aggregated and oriented.	Patchy, oriented, grey, greyish brown, brownish yellow and whitish grey.
2.	Soil fabric	Skelepic.	Skelsepic.
3.	Skeleton	Coarse sand sized to fine sand sized, many sub-angular to subrounded, highly surface coated quartz, few, less than fine sand sized non coated quartz.	Less than fine sand sized subangular, few quartz and many subrounded to rounded calcite crystals and microlites.
4.	R D P	Granic	Grani plasmic
5.	N R D P	Grani-plasmic	Calci plasmic
6.	S R D P	Grani-plasmic	Calci plasmic to dermatic
7.	Coarser/finer	Coarser 90/10	Finer 5/95
8.	Voids	Channels, chambers interconnected and non inter connected with ferran and ferriargillan and ferricalcitan infillings and sharp margins.	Few fine non-infilled, non-interconnected, at locations intersected channels and few planes.
9.	Humus	Organic matter plasmified and associated with iron oxyhydrates and ferricalcitan.	Absent.

10.	Chlamydomorphic coating	Few discontinuous present.	Absent
11.	Lithorelics	Absent	Absent
12.	Cutans	Rich in ferriorganan, ferri argillan and ferricalcitan and their combination towards margins of skeletons and inside voids.	Calcitan, calciferran and calcimangan, microaggregated and oriented on calcite crystals.
13.	Special observations	Ferriorganan, ferri-calcitan, ferriargillan thick coating on fine sand sized subangular to subrounded quartz skeletons on grey to greyish black plasma. Less porous with cutan infilled channels and chambers.	Compact, less than fine sand sized, subrounded, calcite crystals and microlites coated with ferran and mangan on greyish black thin plasma with fine few channels and planes.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.13 Location : Angadipuram

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Opaque, brownish red to brownish yellow, oriented	Reddish brown, brown, opaqe, aggregated and well oriented dense, slightly lympid.
2. Soil fabric	Skelsepic and at few microlocations skelvosepic.	Skelvosepic.
3. Skeleton	More than coarse sand sized, subangular highly fractured, weathering high reliefed quartz and many less than silt sized oriented, subrounded quartz and few less than silt sized subangular feldspar and opagues.	More than coarse sand sized to fine sand sized, subangular highly coated and factured, quartzitic gneiss, quartz, and less than silt sized, subrounded to rounded plinthic glaebules.
4. R D P	Granic	Plasmi-granic to grani-plasmic
5. N R D P	Granic to intertextic	Grani-plasmic
6. S R D P	Granic to intertextic	Grani-plasmic
7. Coarser/finer	Coarsr 80/20	Finer 45/55
8. Voids	Planar and packing with few channels.	Interconnecting chambers and non interconnecting vesicles and vughs.
9. Humus	Very few as illuvial ferri-organans.	Absent.

10. Chlamdomorphic coating	Very few and discontinuous surrounding bigger quartz grains and lithorelics.	Absent
11. Lithorelics	Highly fractured and weathered quartzitic gneiss, opaques.	More than coarse sand sized to fine sand sized subangular highly coated and fractured quartzitic gueiss, and less than silt sized subrounded to rounded plinthite glaebules with few of hydrated goethite compostion.
12. Cutans	Ferrans ferriargillans	Ferrans and ferri argillans, aggregated and oriented.
13. Special observations	Bigger, more than coarse sand sized, subangular, highly fractured high reliefed quartz and many highly fractured and weathering less than fine sand sized quartz, quartzitic gneiss and opaques obliquely oriented on ferranic to ferriargillanic non lympid plasma.	More than coarse sand sized to fine sand sized subangular, highly coated and fractured, quartzitic gneiss with few quartz, and less than silt sized, subrounded to rounded plinthic glaebules in reddish brown to brown, opaque, aggregated, well oriented, dense and slightly lympid plasma with interconnecting chambers and non inter-connecting vesicles and vughs.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.14

Location : Kunnamangalam

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Opaque, reddish brown, red, brownish yellow and yellow coloured, lympid.	Brownish yellow, yellowish brown, greyish brown coloured patchy and oriented, slightly lympid plasma.
2. Soil Fabric	Vo-sepic, Vo-skelsepic and at microlocations asepic.	Vo-sepic to Vo-skel sepic.
3. Skeleton	Clay sized, subangular to subrounded, low reliefed, Runicquartz few present, angular lympid, plinthite glaebules of clay size, very few present.	Very few, subrounded, slightly fractured, less than silt sized quartz, opaque, less than clay sized, plinthite glaebules.
4. R D P	Aglomeroplasmic to dermatic	Plasmic to plasmi granic.
5. N R D P	Aglomeroplasmic	Plasmigranic to Phorphyric.
6. S R D P	Aglomeroplasmic & slightly dermatic	Plasmigranic and at few places agolmeroplasmic.
7. Coarser/finer	Finer 10/90	Finer 90/10
8. Voids	Vesicles, vughs, chambers and channels without infillings and non lympid.	Vesicles and few vughs,lympid and with discontinuous illuvial ferriargillans.
9. Humus	Absent	Absent

10. Chlamydomorphic coating	Absent	Absent
11. Lithorelics	Less than siltsized, angular to subangular, very few plinthic glaebules.	Opaque, slender and broken, spherical and less than silt sized plinthic glaebules.
12. Cutans	Opaque to reddish brown ferran, brown to yellowish brown ferriargillan with distinct margins and orientation.	Ferrans and ferriargillans.
13. Special observations	Plasma well oriented, lympid, ferranic and ferriargillanic, many voids dominantly vesicles and vughs, nonlympid and without infillings. Skeletons very few, less than silt sized non coated Runic quartz. Plinthic glaebules and plasma indicate a tendency to petroplinthisation.	Plasma oriented, ferranic to ferri-argillanic, with big sized vesicles and vughs and few to very few slightly fractured non coated subrounded quartz. Presence of less than silt sized slender to rounded opaque plinthite glaebules is a characteristic feature.

DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

Profile No.15 | Location : Ambalavayal

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Translucent to transparent, brownish yellow to yellowish brown, patchy, less denser plasma.	Opaque to Brownish yellow, oriented and patchy plasma with slight lympidity.
2. Soil fabric	Vo-skelsepic	Skelvosepic to Vo-skelsepic.
3. Skelton	Skeletons are characteristically weathered and weathering rock pieces of angular to subangular, slightly coated, medium reliefed, more than fine sand sized quartzitic gneiss. The minerals observed are quartz and feldspar.	Subangular to sub-rounded,medium reliefed, fractured and coated, quartzitic gneiss of fine sand size to silt size.
4. R D P	Intertextic to porphyroskelic	Intertextic to porphyroskelic and at locations chlamydomorphic.
5. N R D P	Granic	Granic
6. S R D P	Granic to intertextic and at positions aglomeraplasmic.	Granic
7. Coarser/finer	Coarser 40/60	Coarser 55/45
8. Voids	Vesicles and interconnected chambers with plasma infillings, slightly lympid.	Chambers, channels and vesicles without plasma infillingsand with marginal illuvial ferriargillans.
9. Humus	Present as ferriorganan	Absent

10. Chlamydomorphic coating	Absent but are dominantly intertextic	Continuous to discontinuous very few present.
11. Lithorelics	The skeletons present are dominantly weathered subangular to subrounded slightly coated medium reliefed, more than fine sand sized quartzitic gneiss	Subangular to subrounded medium reliefed, fractured and coated, quartzitic gneiss of coarse sand to fine sand size.
12. Cutans	Ferriargillan and ferriorganan indicating a tendency of marginal illuviation towards the skeleton and voids.	Ferrans and ferriargillans, patchy and oriented, non-lympid.
13. Special observations	Yellowish brown to brown, ferriargillanic, ferri organic, plasma with many more than fine sand sized weathering and weathered, subangular to sub rounded quartzitic gneiss with dominantly intertextic RDP.	Opaque to brownish yellow, oriented and patchy plasma with subangular to subrounded, medium reliefed, fractured and coated, quartzitic gneiss of coarse sand to fine sand size. Chambers, channels and vesicles without plasma infillings and with marginal illuvial ferriargillans.

DETAILED MICROMORPHOLOGICAL DECRIPTIONS

Profile No. 16 | Location : Pilicode

Micromorphological properties	Epipedon	Endopedon
1. Plasma	Opaque to brownish yellow micro aggregated	Reddish brown to brownish yellow
2. Soil fabric	Plinthi-skelsepic	Plinthi-skelsepic to plinthi-sepic.
3. Skeleton	Fine sand sized to clay sized, irregular margined, cracked slightly coated to non coated low reliefed quartz, plinthic glaebules, opaque high reliefed magnetite and ilmenite.	Many less than silt sized and few fine sand sized, fractured, faint marginal, non coated, quartz and runic quartz, plinthic to petroplinthic subangular to subrounded glaebules and very few quartz rich petroplinthic more than coarse sand sized glaebules and angular to subangular opaques.
4. R D P	Plasmi-granic	Plinthi-granic
5. N R D P	Plinthi-plasmi granic	Plinthi-granic
6. S R D P	Plinthi-plasmi granic	Plinthi-granic
7. Coarser/finer	Finer 75/25	Finer 80/20
8. Voids	Very fine and narrow many chambers and planes irregular margined fine channels surrounding plinthic glaebules.	Very fine interconnected and non interconnected ferriargillan and ferran filled channels and planes and few chambers surrounding reddish brown plinthic glaebules.
9. Humus	Absent	Absent

10. Chlamydomorphic coating	Absent	Absent
11. Lithorelics	Absent	Absent
12. Cutans	Few thin pale yellowish brown illuvial ferri argillans. Fine sand sized to silt sized quartz.	Few thin illuvial ferriargillans.
13. Special observations	Compact, plinthic, opaque to brownish red plasma with less than fine sand sized irregular margined low reliefed, few, quartz, magnetite, ilmenite and many less than silt sized subrounded to rounded plinthic glaebules with non interconnected inter angular, fine, channels and planes.	Plasma has reddish brown subangular to subrounded plinthic glaebules with very fine channels, planes and chambers with low relief, noncoated, less than silt sized quartz, angular to subangular opaques and few quartz rich petroplinthic and goethitic macroglaebules.

less than silt sized opaques and few lithorelics in the epipedon having very less plasma with very less well aggregated opaque to brownish red patches and bigger vesicles whereas the endopedon has more than coarse sand sized to fine sand sized quartz and many less than silt sized to clay sized opaques and coated quartz in microaggregated opaque to brownish red plasma. Illuviation ferrans and argillans are observed in less than silt sized, porous quartz, with vesicles and vughs (Plates 65 to 68).

5.2. Southern Low Land Laterites

In the southern low land laterite area, at Thiruvananthapuram petroplinthic gravels and less than fine sand sized to less than silt sized quartz are observed on opaque reddish yellow to brownish yellow plasma with few ferriargillan filled vesicles and vughs in the epipedon. In the endopedon highly plinthic illuviated, compact gravelly and glaebular materials are observed in very few yellowish brown to yellowish grey coloured plasma along with very fine medium sized vesicles, vughs and chambers (Plates 69 to 72).

5.3. Southern Coastal Plain

In the southern coastal plain, the epipedon at Kazhakuttom reveals less plasma, more angular skeletons like quartz, ilmenite and magnetite with few thin illuviation ferriargillans and thick incomplete coating of opaque ferrans, while at Kayamkulam, the epipedon is highly porous with common rough surfaced, medium reliefed, non-coated angular to subangular, even irregular fractured quartz in less plasma, dominantly ferriargillanic. Lympidity is observed in plas ma, voids and skeletons. Very few and localised, plasmified organic matter is also observed. In the endopedon at Kazhakuttom highly compact, angular to subangular,coarse to fine sand sized non-coated, slightly fractured quartz and high relief opaques with few illuvial ferran and feriargillan and fine interconnected vesicles are observed, whereas in the endopedon at Kayamkulam, comparatively less porous, compact, less than very fine sand sized, subangular to subrounded, slightly fractured quartz is observed, with yellowish brown, marginal, illuvial ferriargillans. Voids occur as vesicles and interconnected chambers, and all the components are non-lympid to slightly lympid (Plates 73 to 76 and 89 to 92). Kooistra (1982) reports that the pedological features observed can be due to mica weathering and paleomarine influence. Pedoturbation observed, though little, is influenced by earthworms. This is in agreement with the findings reported by Ponomarenko (1989) on morainal loam of U.S.S.R.

5.4. Southern Dissected Midland Laterites

At Nedumangad representing the southern dissected midland laterites, the plasma and skeleton are well oriented in the epipedon. The plasma is ferranic to ferriargillanic and slightly ferriorganic with quartizitic gneiss, plinthic glaebules and few lath shaped quartz with oblique orientation and dominantly vesicular voids, while the epipedon at Kottarakkara reveals coarse sand sized to fine sand sized quartz and plinthic glaebules in gravel rich less plasma with many faint discontinuous illuviation ferrans and ferriargillans. The endopedon at Nedumangad reveals patchy, aggregate, vesicular ferranic to ferriargillanic plasma with angular to subangular, more than coarse sand sized, fractured and cracked quartz and less than fine sand sized, irregular, marginal, opaque to reddish brown plinthic glaebules, where as at Kottarakara, the endopedon reveals well oriented, packed, illuviated fine sand sized to silt sized subangular, opaque to brownish yellow plinthic glaebules on low reliefed, cracked, angular, coarse sand sized to more than coarse sand sized quartz, with few opaque lithorelics and very few vesicles and vughs in very less plasma (Plates 77 to 80 and 85 to 88).

5.5. Southern Foot Hills

At Palode, in the southern foothills, the epipedon reveals the presence of more than coarse sand sized cracked quartz and less than fine sand sized, subrounded, opaque petroplinthic gravels and glaebules with few voids and illuvial ferriorganans and ferriargillans, while the endopedon shows irregular shaped, more than coarse sand sized slightly coated quartz, high reliefed petroplinthic subangular gravels and glaebules and many non-coated fractured quartz (Plates 81 to 84). Kooistra (1982) reported that very little micromorphological data are available on soils under forest foothills.

5.6. Kuttanad Coastal Basin and Central Backwater Basin

In the Kuttanad coastal basin, the epipedon at Karumady reveals medium porous quartzi-jarositanic plasma. Clay sized, non-coated subangular, few runic quartz, feldpsars, diatoms, spongy spicules, subangular plinthic glaebules and non-infilled, clear margined chambers and vesicles are observed in the greyish brown plasma while at Vytilla, representing the central backwater basin, the epipedon reveals yellowish brown lympid plasma with low reliefed, less than fine sand sized to silt sized non-coated subrounded runic quartz, opaques, felspars, illuvial ferrijarositan coated, less than silt sized quartz with very few to few vesicles. At Moncompu, the epipedon reveals ferriargillan coated subangular quartz rich horizon with less plasma, partially birefringent, many fine pyrite and jarosite framboids in the extra angular margins of quartz skeletons. The endopedon at Karumadi reveals the presence of parallel striated fabric constituted of opaque to brownish yellow, fossil decomposing mangrove bark cells associated with less than clay sized polyframboidal pyrite and jarosite in a thin grey to greyish black plasma with chambers and vesicles while at Vytilla the endopedon has opaque to brownish yellow plasma with non-coated or slightly coated subangular to subrounded coarse sand sized to silt sized slightly fractured and pitted quartz and opaques with few medium to fine vesicles and vughs. At Moncompu, the endopedon has granular reddish yellow coloured less plasma with cubicular jarosite, few coarse sand sized ilmenite, pyrite framboid and quartz. Ferrihydrite is present along the margins of voids (Plates 93 to 96, 97 to 100 and 101 to 104). Kooistra (1982), Subramonia Iyer (1989) have also reported similar observations in their studies on the acid sulphate soils of Kerala.

5.7. Central Dissected Midland Laterites

In the central dissected midland laterite area, represented by Vellanikkara, the epipedon reveals high reliefed, coated, fractured, subangular to subrounded, fine sand sized to coarse sand sized quartz with thick opaque ferriorganic to ferranic cutan, smearing with few fine sized vesicles, whereas in the endopedon, reddish yellow to yellowish brown microaggregated plasma, with many less than silt sized to clay sized angular to subangular opaque, iron-manganese mineral and medium reliefed, coarse sand to fine sand sized quartz, is observed. Plasma less islands at few locations are also noticed (Plates 105 to 108).

5.8. Palakkad Gap

In the Palakkad gap, the epipedon at Eruthenpathy reveals grey to greyish black plasma with ferri-organan, ferri-calcitan, ferri-argillan thick coating on fine sand sized subangular to subrounded quartz. The plasma is less porous with cutan infilled channels and chambers while the endopedon has compact, less than fine sand sized, subrounded calcite crystals and microlites coated with ferran and mangan on greyish black thin plasma with few fine channels and planes (Plates 109 to

112). Kooistra (1982) Mermut and Dasog (1986), Rao *et al* (1986), Kalbande *et al* (1988) and Kalbande *et al* (1992) have also reported similar micromorphological features in Vertisols of Karnataka, Andhra Pradesh and Maharashtra. Detailed review of similar observation also has been attempted by Nettleton and Sleeman (1985).

5.9. Northern Dissected Midland Laterites

In the northern dissected midland laterite area, the epipedon at Angadipuram reveals bigger, more than coarse sand sized, subangular, highly fractured high reliefed quartz and many highly fractured and weathering, less than fine sand sized quartz, quartzitic gneiss and opaques obliquely oriented on ferranic to ferriargillanic, non-lympid plasma, whereas at Kunnamangalam, the epipedon reveals well oriented lympid, ferranic and ferriargillanic plasma with many voids, dominantly vesicles and vughs which are non-lympid and without infillings. Very few skeletons and less than silt sized non coated runic quartz are also observed. Plinthic glaebules and plasma indicate a tendency for petroplinthisation. The epipedon at Pilicode has compact, plinthic, opaque to brownish red plasma with less than fine sand sized, irregular margined, low reliefed, few quartz, magnetite and ilmenite. Many less than silt sized subrounded plinthic glaebules with non-interconnected, interangular, fine channels and planes are also observed. The endopedon at Angadipuram reveals reddish brown to brown, opaque, aggregated, well oriented, dense and slightly lympid plasma with interconnecting chambers and non interconnecting vesicles and vughs. More than coarse sand sized to fine sand sized subangular, highly coated and fractured quartzitic gneiss with few quartz and less than silt sized, subrounded to rounded plinthic glaebules are observed in the plasma. At Kunnamangalam, the endopedon has oriented ferranic to ferriargillanic plasma with big sized vesicles and vughs and few to very few, slightly fractured, non coated subrounded quartz. Presence of less than silt sized slender to rounded opaque plinthic glaebules is a characteristic feature of this diagnostic horizon, whereas at Pilicode, the plasma has reddish brown, subangular to subrounded plinthic glaebules with very fine channels, planes and chambers, with low reliefed non-coated, less than silt sized quartz, angular to subangular opaques and few quartz rich petroplinthic and goethitic macro glaebules (Plates 113 to 116, 117 to 120 and 125 to 128). Petroplinthisation and poly genetic nature of similar soils are also reported by Gopalaswamy (1969), Eswaran and Raghu Mohan (1973), Raghu Mohan (1982) and Kooistra (1982). Petroplinthites observed are mainly composed of goethite and haematite.

5.10. Wayanad Plateau

At Ambalavayal representing the Wayanad plateau, the epipedon has yellowish brown to brown, ferriargillanic, ferriorganic plasma, with many more than fine sand sized, weathering and weathered subangular to subrounded quartzitic gneiss with dominantly intertextic related distribution pattern, whereas in the endopedon, the plasma is opaque to brownish yellow, oriented and patchy with subangular to subrounded, medium reliefed, fractured and coated quartzitic gneiss of coarse sand to fine sand size. Chambers, channels and vesicles without plasma infillings and with marginal illuvial ferrriargillans are observed in the endopedon at Ambalavayal. The two increasing processes observed are horizon differentiation by clay illuviation and homogenisation by biological activity (Plates 121 to 124). Similar evidences have been reported by Pazos and Stoops (1988) in Mollisols from Argentina.

Micromorphological characteristics of the MLRAs indicate the nature and degree of soil weathering and profile development. The southern dissected terriplain evidences the presence of incomplete broken faint argillans and a tendency of its accumulation down the profile, indicate progressive initial stage of argillation. Based on these micromorphological evidences this soil is classified under Oxisols. Similar observation is also seen reported by Camacho and Gonzalez (1987) in their study of red ferralitic soils in Hawana.

At the southern low land laterites the weathering and argillation are less and not active. The presence of petroplinthic micro and macro glaebules indicate the relic features of the paleoclimate the MLRA was subjected to. This soil is classified as Ultisols.

In the southern coastal plain the presence of thin, weak, incomplete ferriargillan and accumulation of similar illuvial argillans indicate the lack of soil composition and environment favouring argillation. Fine sand sized to coarse sand sized non-coated skeletons hinder an active clay migration and cutan formation. Based on these observations these soils are classified under Entisols.

The presence of discontinuous thin to continuous argillans and coating of grains and presence of brightly coloured micro plinthic glaebules observed in the representative profiles of the southern dissected midland laterite indicate an active argillation resulting in the well developed argillic horizon. These soils are classified under Ultisols

Lack of plasma, presence of lithorelics, petroplinthic gravels, nil to few ferriargillans and ferriorganans indicate less weathered soil material of granitic gneiss which is the unique feature of the southern foothills. The presence of ferriorganan and not organan in the diagnostic horizons indicate the tendency of mollic to cambic horizon. This soil is classified as Mollisols.

In the Kuttanad coastal basin represented by Karumadi and Moncompu and the central backwater basin represented by Vytilla, wet land profiles indicate varied extent of hydromorphism and sesquioxide plinthic segregations. They appear as diffuse micronodules and coatings with low chromas. The unique feature of pyrite and its oxidation products namely jarosite, ferrihydrate, haematite and goethite indicate the uniformity of the parent materials, period of formation and type of current pedogenesis. The specific differences like the presence of jarositanic cutans, phytoliths, wood fossils, plinthic glaebules, type of pyrite, colour and birefringence indicate the presence of specific micro environments. These soils key out into Entisols.

In the central dissected midland laterites with reddish yellow, yellowish brown, opaque, coated angular bigger grains, less plasma or plasma islands and lack of well developed argillans indicate lesser weathering and clay migration and qualifies this soils under Ultisols.

The Palakkad gap bordering Tamil Nadu, with vertisol tonguing are with black soils alone and in combination with lateritic materials. The present representative profile is a representative of a situation black over red to brown soil. Ferran, ferriargillan and ferricalcitan, finer fractions, thin plasma qualifies to be the expression of the progressive pedoturbation characteristic of Vertisols. Contrary to the black or greyish black soil colour observed in the field morphology, grey to greyish brown chroma under micromorphology indicate the slow interrupted sesquioxide segregation by hydromorphism, pedoturbation and long dry spells. These observations of the diagnostic horizons qualifies the MLRA as Vertisols micromorphologically.

Northern dissected midland laterite area represented by Angadipuram, Kunnamangalam and Pilicode is a region with comparatively high rainfall and long dry spells. The region is comparatively older as indicated by sequential petroplinthisation, either in the profiles or as relic feature and has hard opaque dense petroplinthitic gravels and glaebules. The presence of very fine voids, bigger angular less coateed to non coated skeletons indicate highly resistant soil material with lesser current weathering processes. Comparatively the current weathering process is active at Kunnamangalam than Pilicode and least at Angadipuram. Above observation qualifies Kunnamangalam, Angadipuram and Pilicode under Ultisols.

Wayanad plateau is an unique MLRA with flat gentle sloping, very deep soil of coarse composition with ferriargillan, ferran and ferriorganan. The oriented patchy plasma, fractured coarser skeletons, intertextic RDP and voids with cutanic infillings indicate slow but steady initial stages of argillisation. The `stone' lining of finer gravels of less coated to non coated quartz, quartzitic gneiss is an unique observation of the MLRA endopedon. These micromorphological evidences qualify the MLRA to be classified under Entisols.

The comparative micromorphological analysis of the diagnostic horizons of the MLRAs of the state qualifies them to key into the Entisols, Oxisols, Ultisols, Mollisols, and Vertisols. The wet land MLRAs are dominantly classified as Entisols while the profile at Palkkad gap which was an earlier wet land is classified as Vertisol. The other MLRAs are principally classified under Ultisols, Entisols and Mollisols. The Mollisols do not satisfy the micromorphological expressions because of progressive Ultic features. The Ultisols of certain geomorphic positions even rule out to be classified under Entisols.

The micromorphological analysis clearly bridges the macro-morphological evidences and analytical parameters required for soil classification. It is an easy, still confirmatory technique to key out soil formations in highly heterogenous geomorphic environments. In our state the main soil forming factors which govern the profile development are the specific geomorphic position, slope, degree and extent of hydromorphism contributed by vegetation and rainfall. The identification of clay films (argillans) in the field and laboratory is necessary to accomodate or differentiate the soils with Alfic, Ultic and Oxic features.

The nature and extent of leaching and lessivage, its frequency, current or past, of the soil material leading to specific profile expressions often affect the complete judgement on the field classification of soils. This is complicated by the specific heterogenity of factors affecting soil formation in our state. Without attempting a detailed chemical analysis, Soil Taxonomy to the level of subgroup is possible with the available micromorphological analysis data of the diagnostic horizons. Similar detailed attempts of the characterisation of the micromorphology of diagnostic horizons in some Egyptian soils (Aridisols) have been reported by Salem and Ennnan (1992) and by Shoba and Gerasimova (1992) in a genetic and diagnostic

MICROMORPHOLOGY

Site: Vellayani

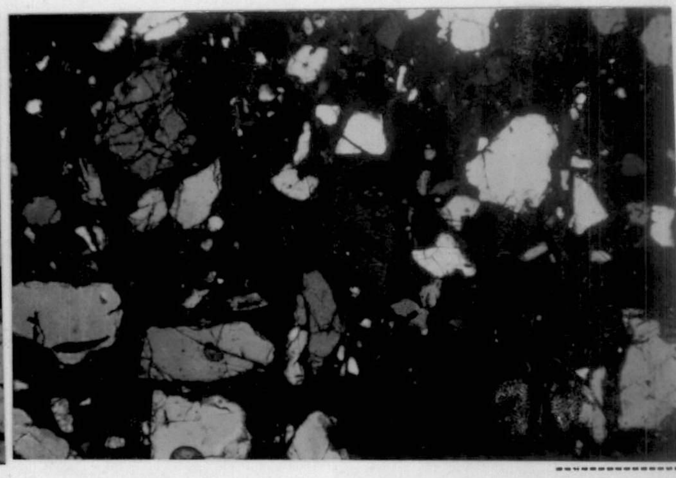
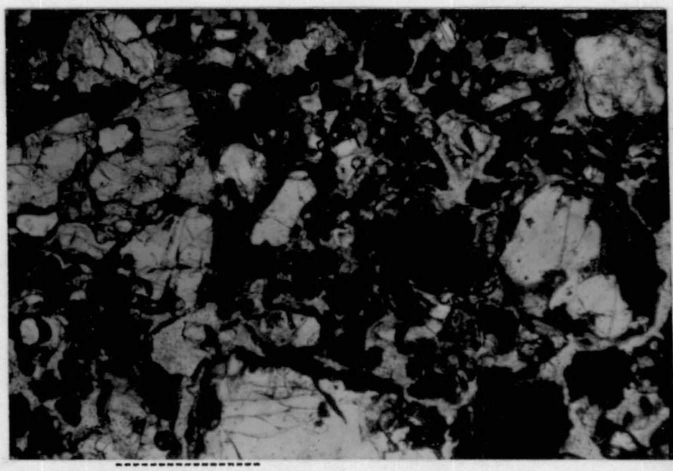


Plate 65
Plain light

EPIPEDON

Plate 66
Crossed nicols



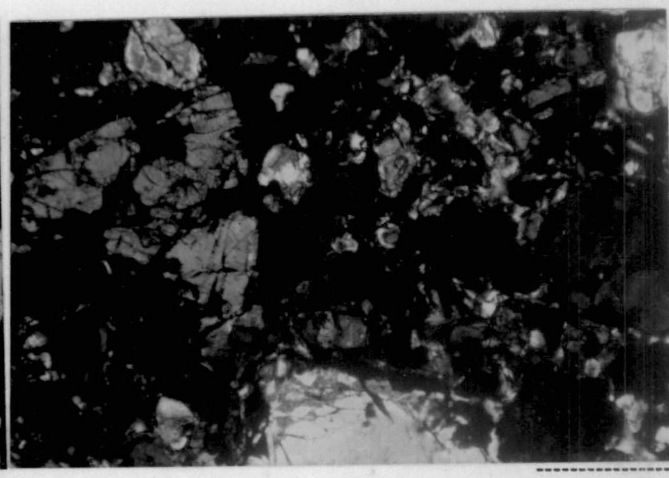


Plate 67
Plain light

ENDOPEDON

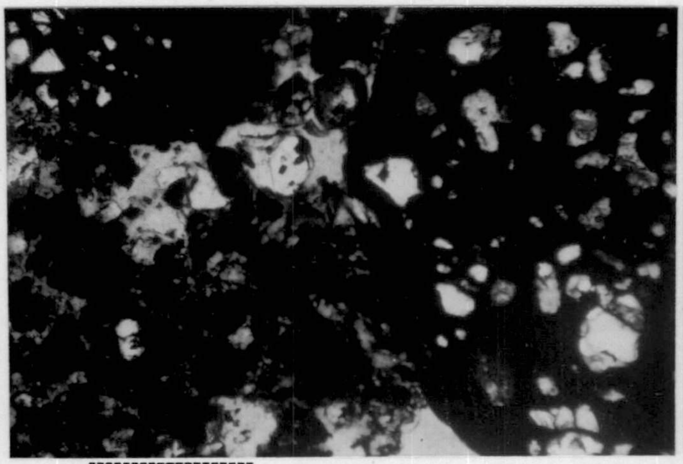
Plate 68
Crossed nicols

Plate 65 and 66 — Highly fractured, fine sand sized to silt sized quartz, many less than silt sized opaques and few lithorelics,plasma very less,well aggregated, opaque to brownish red in patches, bigger vesicles.Mgf:x25

Plate 67 and 68 — More than coarse sand sized to fine sand sized quartz and many less than siltsized to clay sized opaque and coated quartz, micro aggregated, opaque to brownish red plasma and illuviation ferrans and argillans on less than silt sized quartz porous with vesicles and vughs Mgf:x25

MICROMORPHOLOGY

Site: Thiruvananthapuram



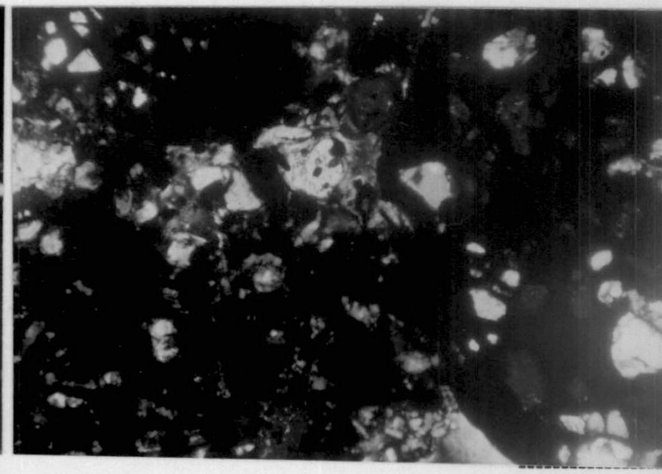
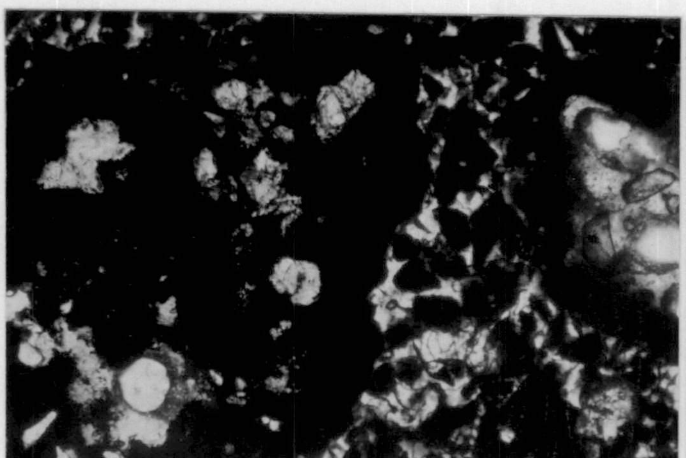


Plate 69
Plain light

EPIPEDON

Plate 70
Crossed nicols



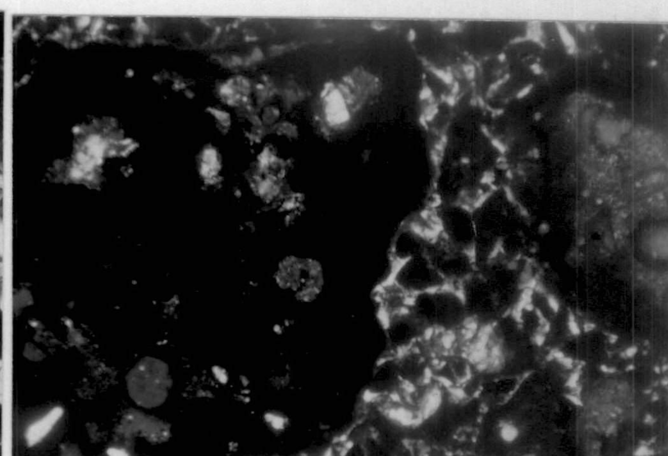


Plate 71
Plain light

ENDOPEDON

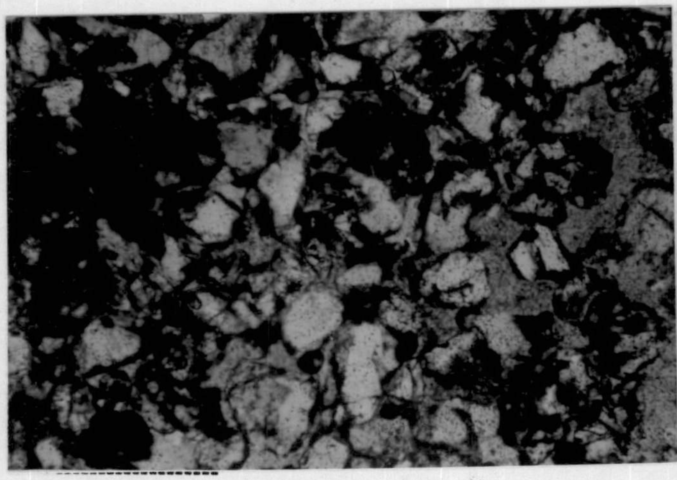
Plate 72
Crossed nicols

Plate 69 and 70 — Prtoplinthic gravels, less than fine sand sized to less than silt sized quartz on opaque reddish yellow to brownish yellow plasma with few ferriargillan filled vesicles and vughs.Mgf:x25

Plate 71 and 72 — Highly plinthic illuviated compact,gravelly and glaebular materials with very few yellowish brown to yellowish grey coloured plasma and very fine to medium sized vesicles, vughs and chambers. Mgf:x25

MICROMORPHOLOGY

Site: Kazhakuttom



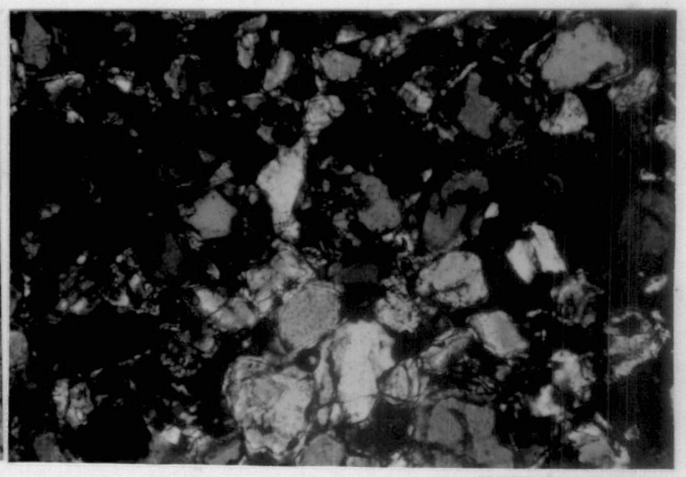
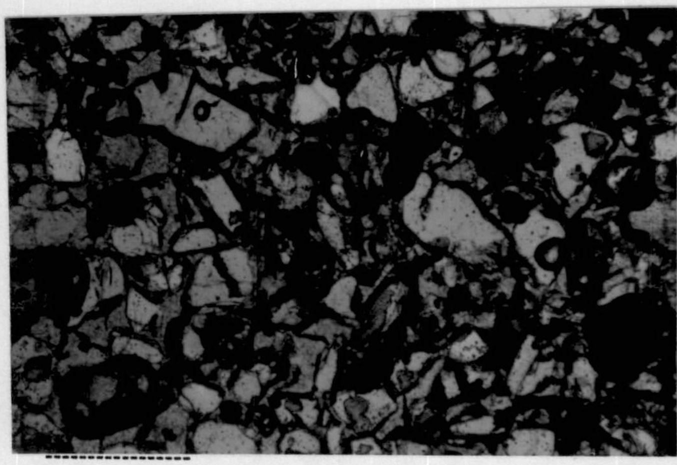


Plate 73
Plain light

EPIPEDON

Plate 74
Crossed nicols



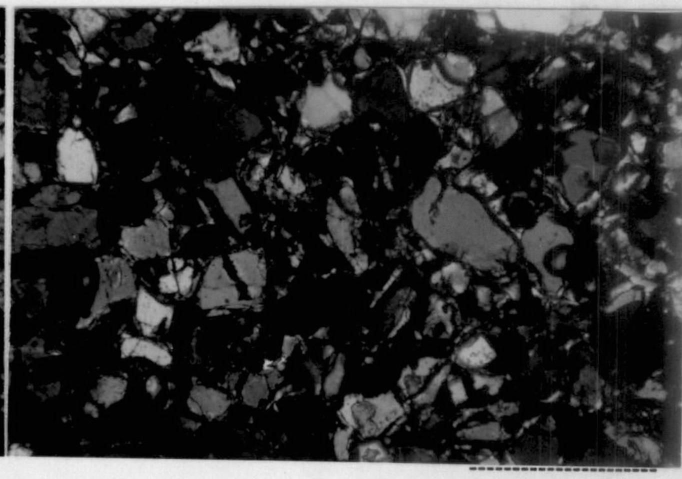


Plate 75
Plain light

ENDOPEDON

Plate 76
Crossed nicols

Plate 73 and 74	Less plasma, more angular skeletons-quartz, ilmenite and magnetite with few thin illuviation ferriargillans, thick incomplete marginal coating of opaque ferrans. Mgf:x25
Plate 75 and 76	Highlt compact, angular to subangular, coarse sand sized to fine sand sized, non coated, slightly fractured quartz and high relief opaques with few illuvial ferran and ferriargillan and fine interconnected vesicles and planar packing voids. Mgf:x25

MICROMORPHOLOGY

Site: Nedumangad

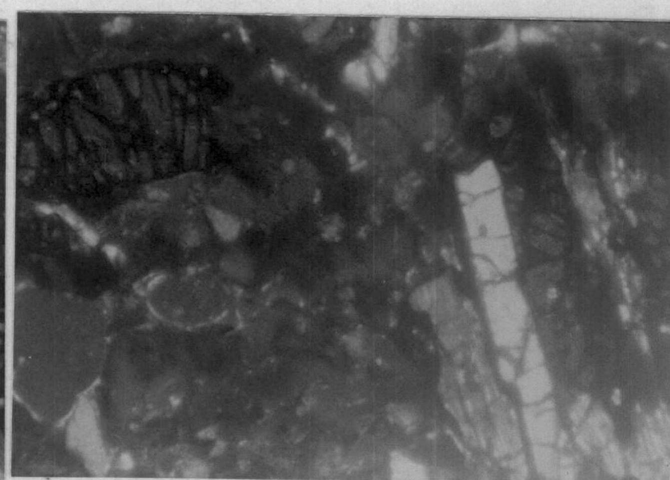
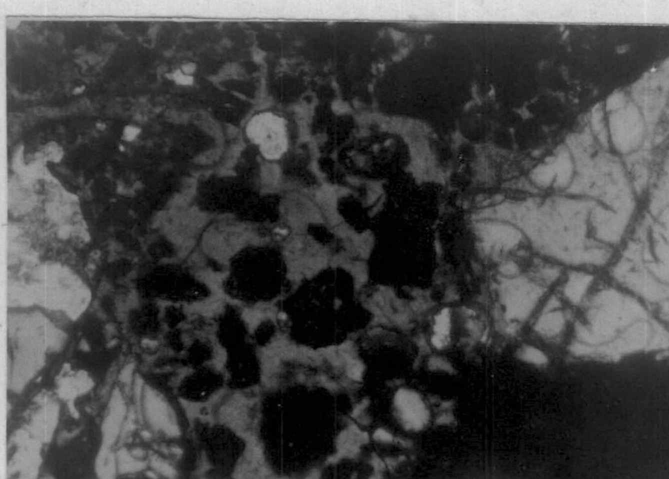


Plate 77
Plain light

EPIPEDON

Plate 78
Crossed nicols



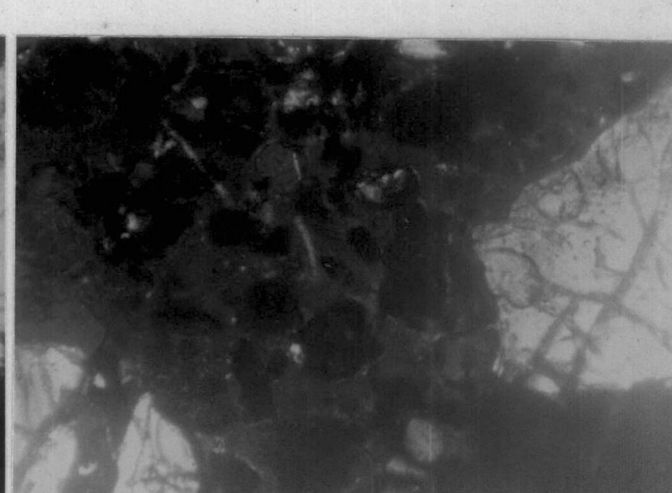


Plate 79
Plain light

ENDOPEDON

Plate 80
Crosed nicols

Plate 77 and 78	Plasma and skeleton well oriented.Plasma ferranic to ferriargillanic and slightly ferriorganic.Quartzitic gneiss, plinthic glaebules and few lath shaped quartz with oblique orientation. Voids are dominantly vesicular.Mgf:x25
Plate 79 and 80	Patchy, aggregated, vesicular, ferranic to ferriargillanic plasma with angular to subangular more than coarse sand sized fractured and cracked quartz and less than fine sand sized irregular margined opaque to reddish brown plinthic glaebules.Mgf:x25

MICROMORPHOLOGY

Site: Palode

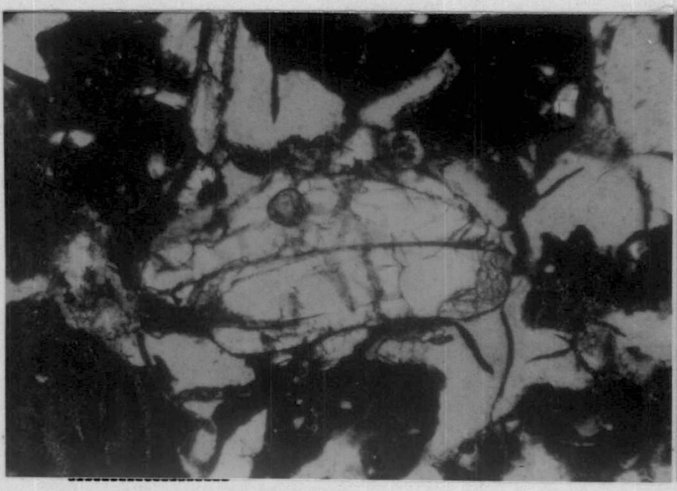
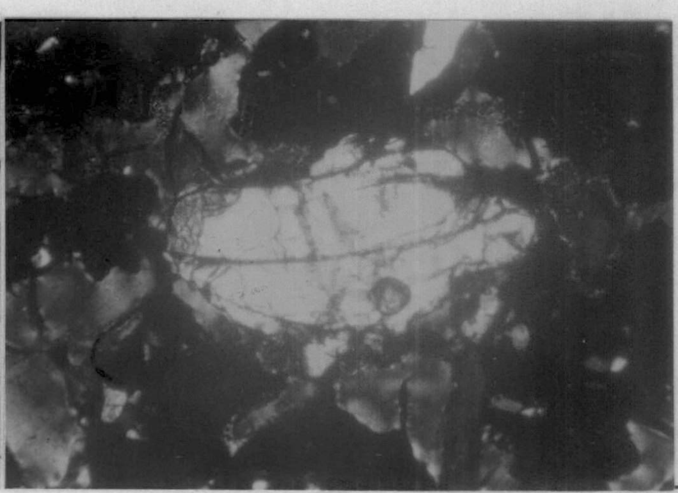



Plate 81
Plain light

EPIPEDON

Plate 82
Crossed nicols

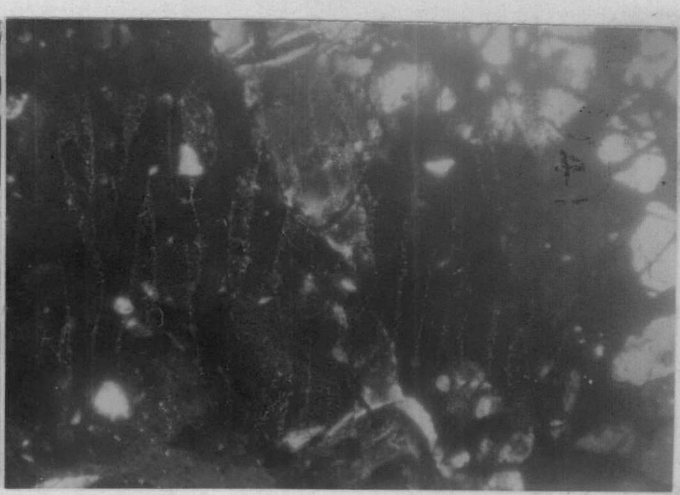
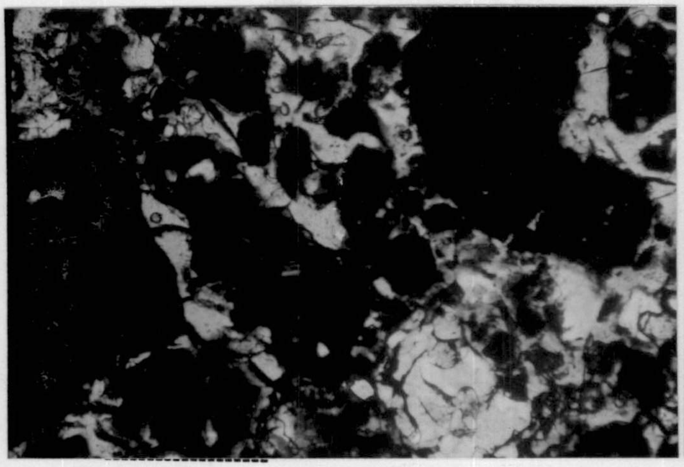



Plate 83
Plain light

ENDOPEDON

Plate 84
Crossed nicols

Plate 81 and 82	More than coarse sand sized cracked quartz, subrounded, opaque, petroplinthic gravels and glaebules of less than fine sand size with few voids and illuvial ferriorganan and ferriargillans.Mgf:x25
Plate 83 and 84	Irregular shaped, more than coarse sand sized slightly coated quartz, high reliefed, petroplinthic subangular gravels and glaebules and many non-coated fractured quartz. Mgf:x25



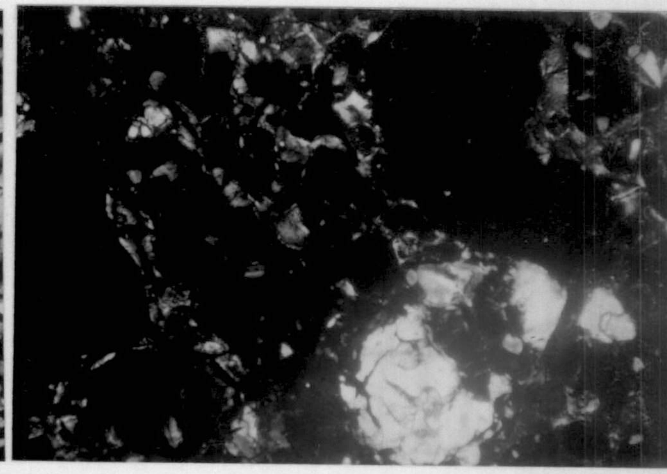
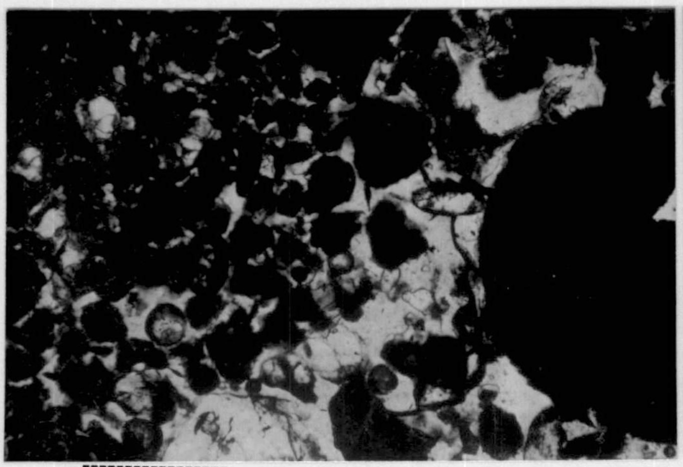


Plate 85
Plain light

EPIPEDON

Plate 86
Crossed nicols



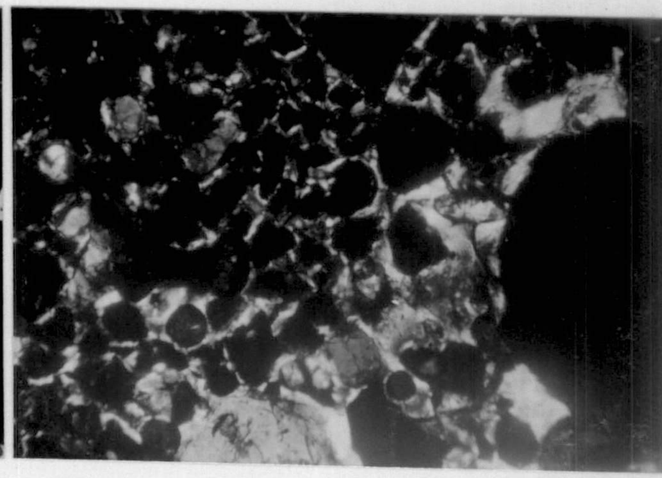


Plate 87
Plain light

ENDOPEDON

Plate 88
Crosed nicols

Plate 85 and 86 — Coarse sand sized to fine sand sized quartz and plinthic glaebules in gravel rich, less plasma, with many faint discontinuous illuviation ferrans and ferriargillans. Mgf:x25

Plate 87 and 88 — Well oriented, packed illuviated fine sand sized to silt sized subangular opaque to brownish yellow plinthic glaebules on low reliefed cracked, angular coarse sand sized to more than coarse sand sized quartz with few opaque lithorelics, very few fine vesicles and vughs and very less plasma.Mgf:x25

MICROMORPHOLOGY

Site: Kayamkulam

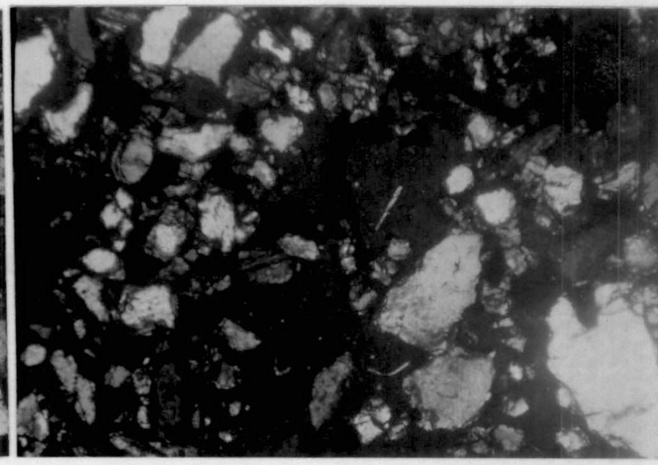
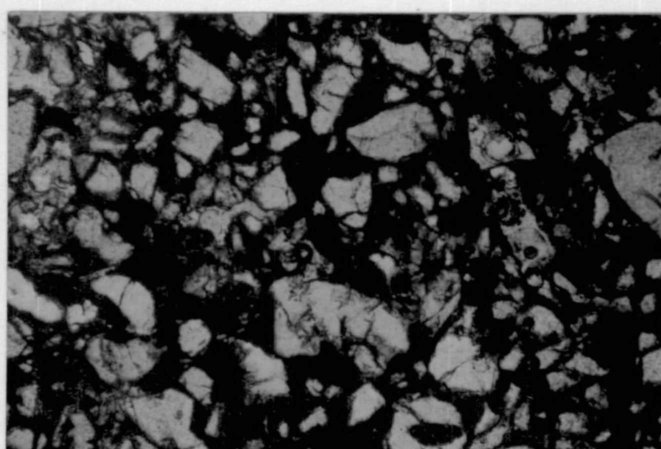


Plate 89
Plain light

EPIPEDON

Plate 90
Crossed nicols



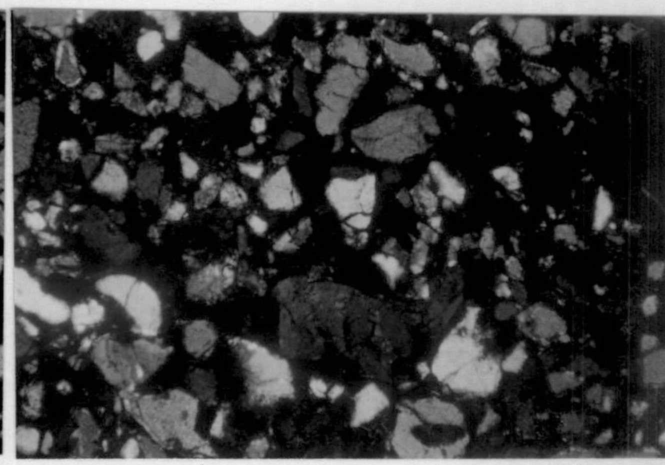


Plate 91
Plain light

ENDOPEDON

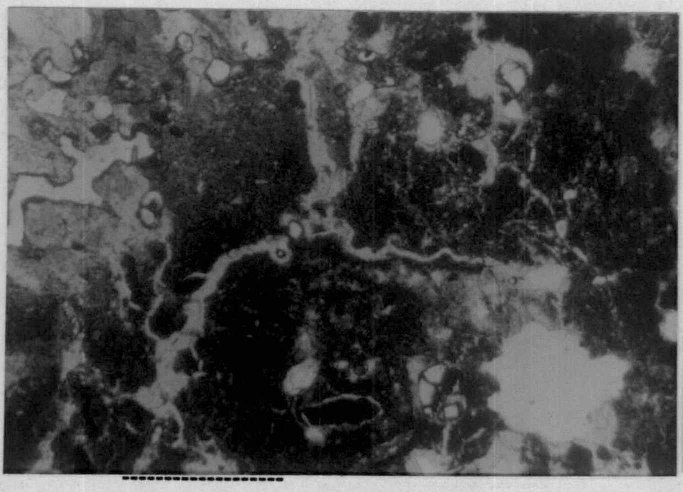
Plate 92
Crossed nicols

Plate - 89 and 90 — Highly porous with common rough surfaced medium reliefed, noncoated angular t subangular, even irregular fractured, plasma less, dominantly ferriargillanic. Lympidit is observed in plasma, voids and skeletons. Plasmified organic matter very few an localised.Mgf:x25

Plate 91 and 92 — Comparatively less porous, compact, less than very fine sand sized, subangular t rounded, slightly fractured quartz, with yellowish brown, marginal, illuvial fer iargillans. Voids present are vesicles and interconnected chambers. All the component are non lympid to slightly lympid.Mgf:x25

MICROMORPHOLOGY

Site: Karumadi



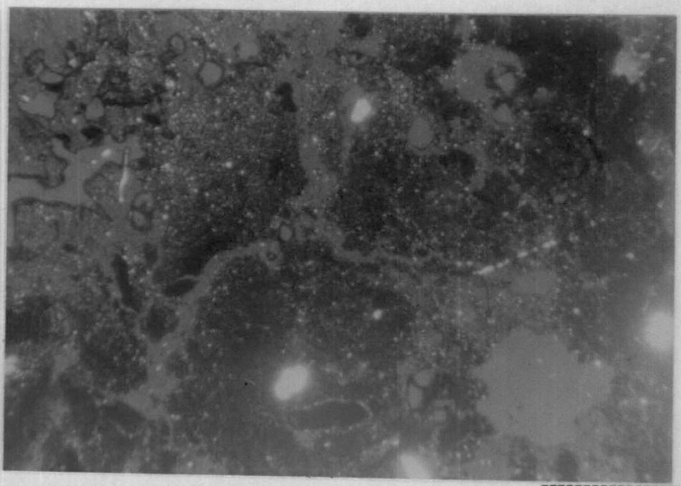
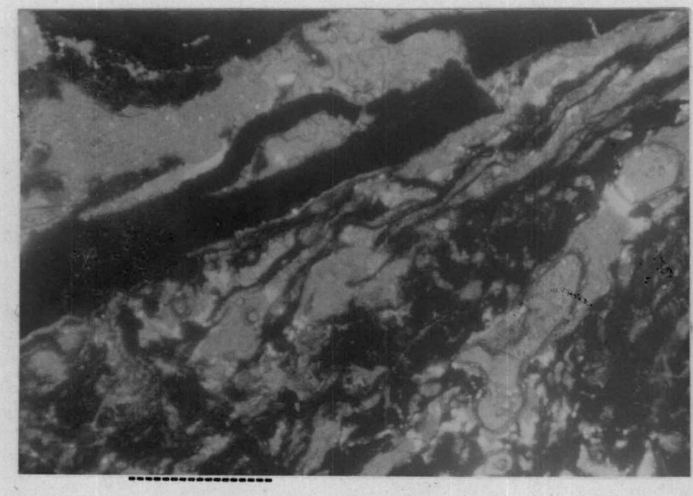


Plate 93
Plain light

EPIPEDON

Plate 94
Crossed nicols



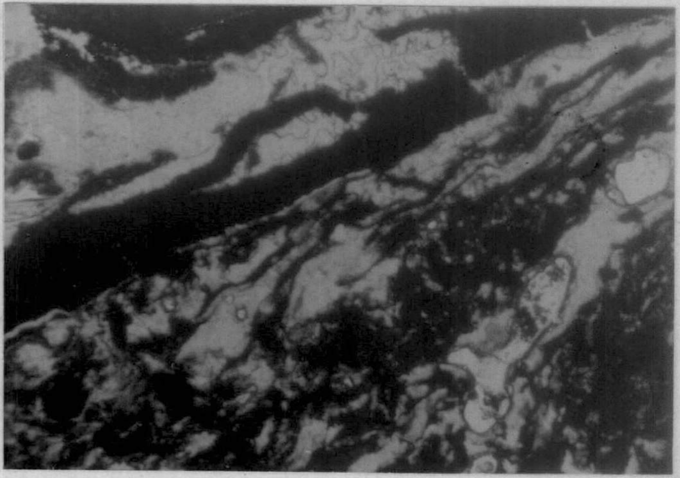


Plate 95
Plain light

ENDOPEDON

Plate 96
Crossed nicols

Plate 93 and 94	**Medium porous, quartzijarositanic plasma with clay sized, non coated subangular few runic quartz, feldspars, diatoms, spongy spicules, subangular plinthic glaebules and non infilled clear margined chambers and vesicles on greyish brown plasma.Mgf:x25**
Plate 95 and 96	**Parallel, striated fabric constituted of opaque to brownish yellow , fossil decomposing mangrove bark cells associated with less than clay sized poly-framboidal pyrite and jarosite in a thin grey to greyish plasma with chambers and vesicles.Mgf:x25**

MICROMORPHOLOGY

Site: Moncompu

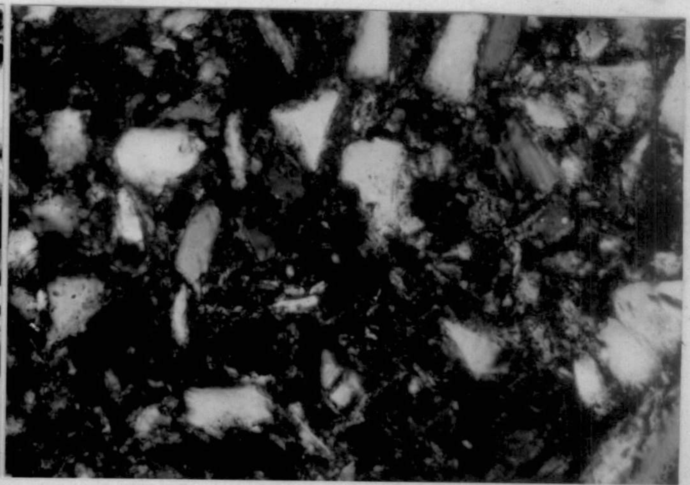
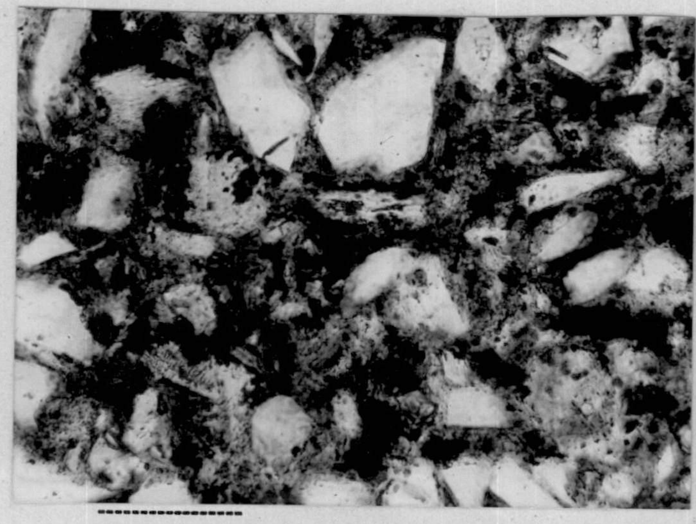


Plate 97
Plain light

EPIPEDON

Plate 98
Crossed nicols



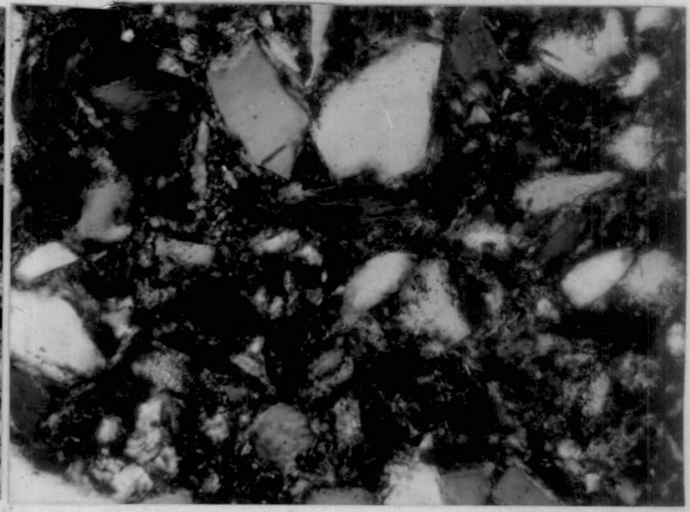


Plate 99
Plain light

ENDOPEDON

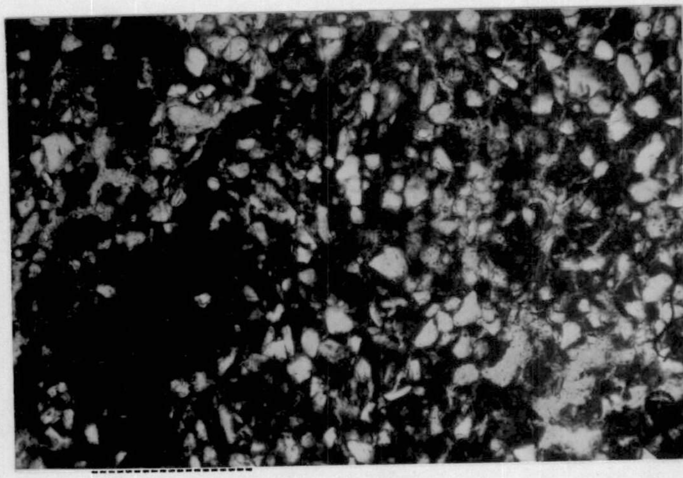
Plate 100
Crossed nicols

Plate 97 and 98 — Ferriargillan coated subangular quartz rich horizon, less plasma partially birefringent, many fine pyrite and jarosite framboids in the intraangular margins of quartz skeletons.Mgf:x25

Plate 99 and 100 — Granular, reddish yellow coloured, less plasma with cubicular jarosite, few coarse sand sized ilmenite, pyrite framboid and quartz. Ferrihydrite present along the margin of voids.Mgf:x25

MICROMORPHOLOGY

Site: Vytilla



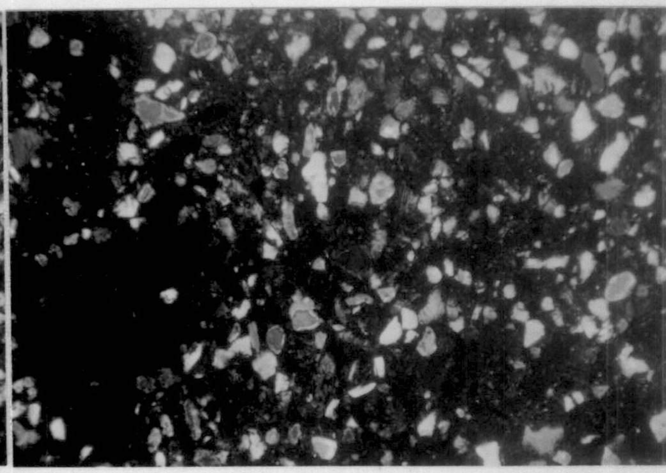
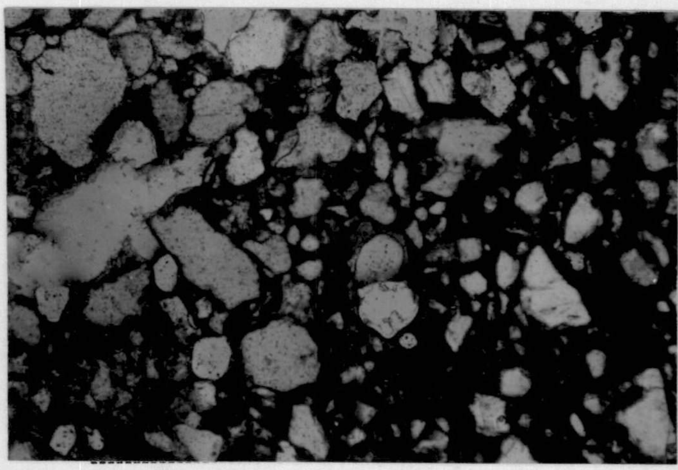


Plate 101
Plain light

EPIPEDON

Plate 102
Crossed nicols



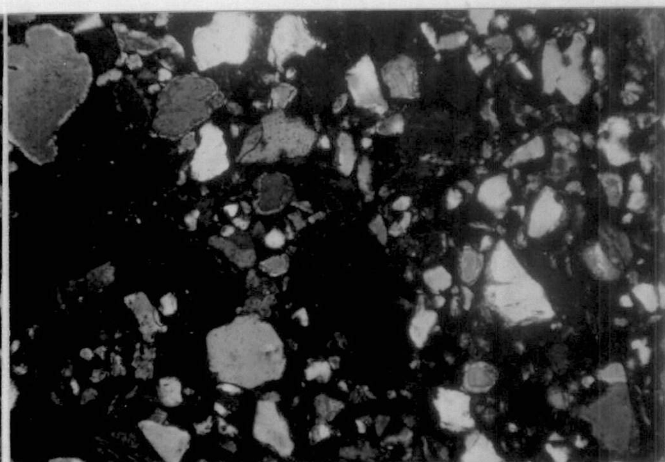


Plate 103
Plain light

ENDOPEDON

Plate 104
Crossed nicols

Plate 101 and 102	Yellowish brown, lympid plasma associated with low reliefed less than fine sand sized to silt sized, non coated, subrounded runic quartz, opaques,feldspars, illuvial ferrijarositan coated, less than silt sized quartz with very few to few vesicles.Mgf:x25
Plate 103 and 104	Opaque to brownish yellow plasma with non coated to slightly coated subangular to subrounded coarse sand sized to silt sized quartz, opaques with few medium to fine sized vesicles and vughs. The quartz were slightly fractured but are conspicously pitted.Mg[illegible]

MICROMORPHOLOGY

Site: Vellanikkara

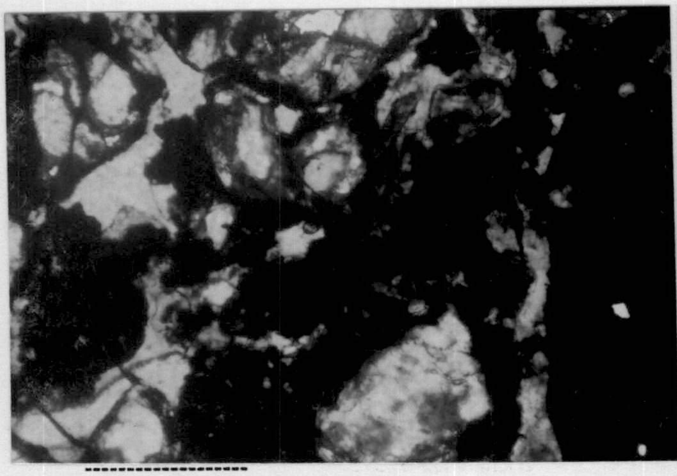
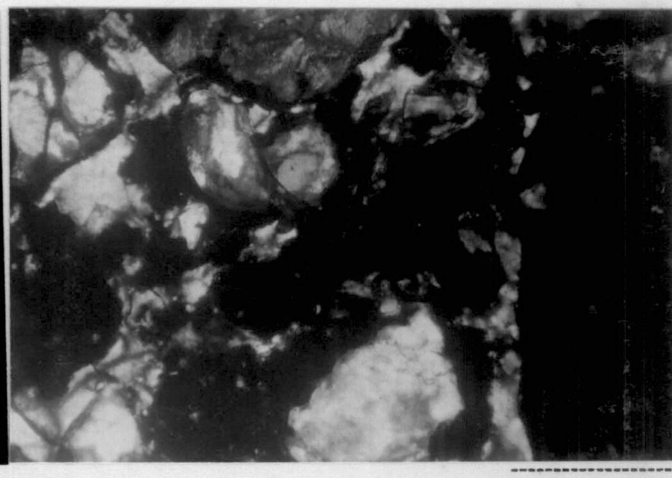



Plate 105
Plain light

EPIPEDON

Plate 106
Crossed nicols

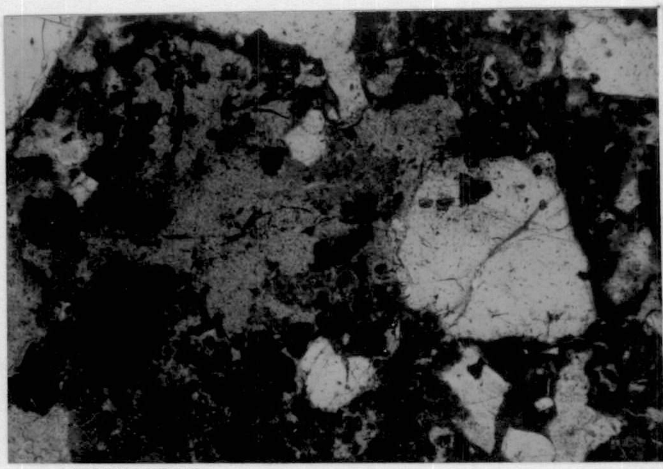
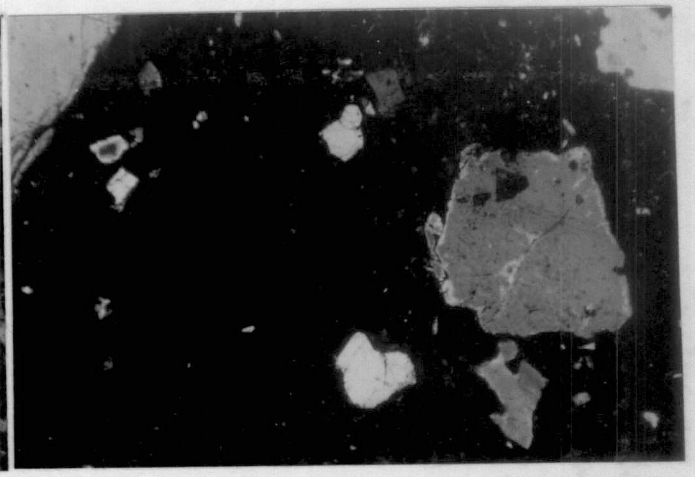



Plate 107
Plain light

ENDOPEDON

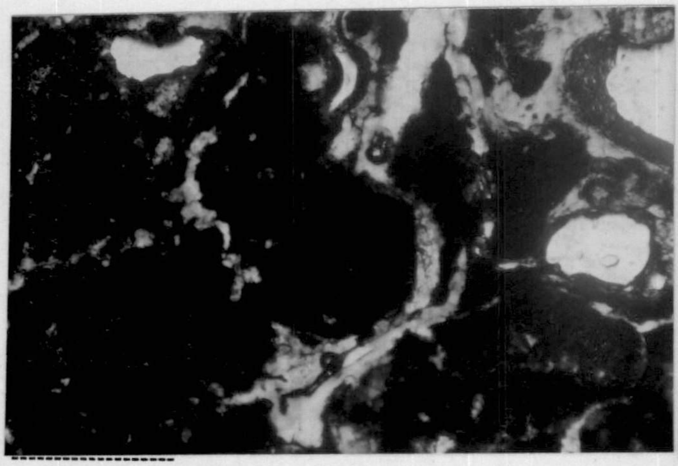
Plate 108
Crossed nicols

Plate 105 and 106 — High reliefed, coated, fractured, subangular to subrounded fine sand sized to coarse sand sized quartz with thick opaque ferriorganic to ferranic cutan smearing with few fine sized vesicles.Mgf:x25

Plate 107 and 108 — Reddish yellow to yellowish brown microaggregated plasma with many less than silt sized to clay sized angular to subangular opaque iron manganese mineral and medium reliefed coarse sand to fine sand sized quartz. At few locations, plasma less islands are also noticeable.Mgf:x25

MICROMORPHOLOGY

Site: Eruthempathy



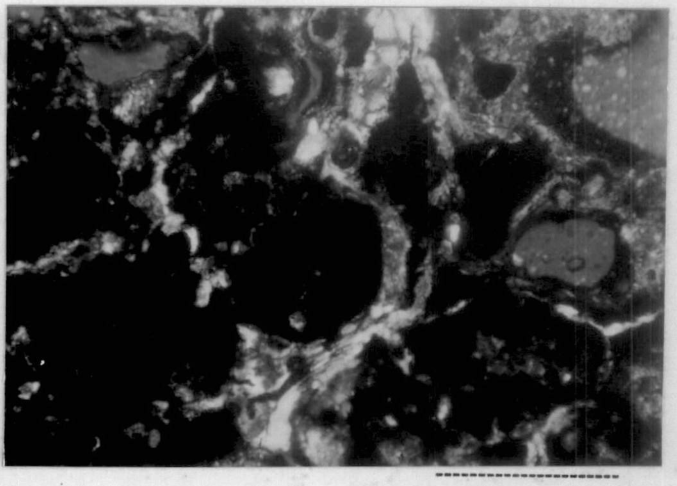
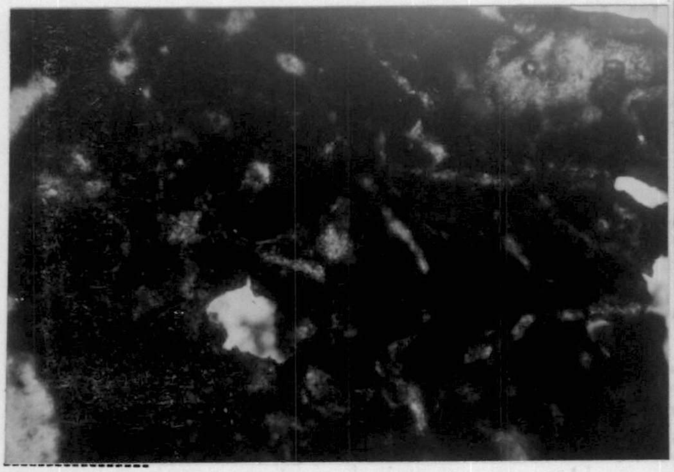


Plate 109
Plain light

EPIPEDON

Plate 110
Crossed nicols



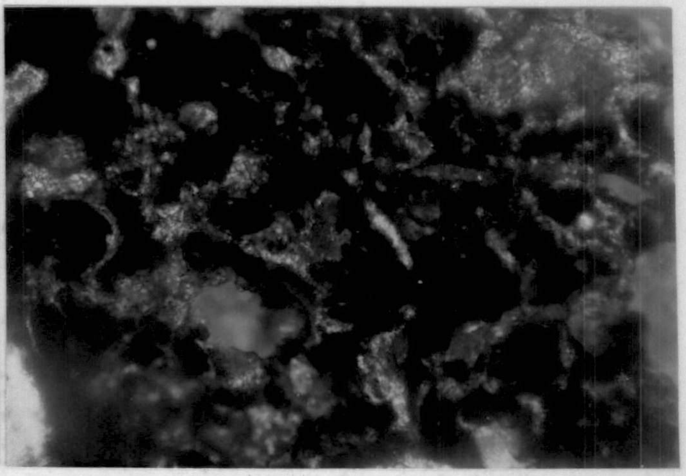


Plate 111
Plain light

ENDOPEDON

Plate 112
Crossed nicols

Plate 109 and 110 — Ferriorganan, ferri-calcitan, ferriargillan thick coating on fine sand sized subangular to subrounded quartz skeletons on grey to greyish black plasma. Less porous with cutan infilled channels and chambers.Mgf:x25

Plate 111 and 112 — Compact, less than fine sand sized, subrounded calcite crystals and mircrolites coated with ferran and mangan on greyish black thin plasma with fine few channels and planes.Mgf:x63

MICROMORPHOLOGY

Site: Angadipuram


Plate 113
Plain light

EPIPEDON

Plate 114
Crossed nicols

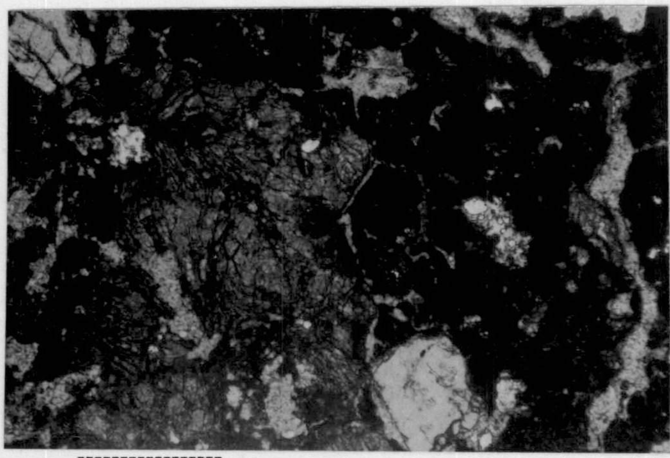
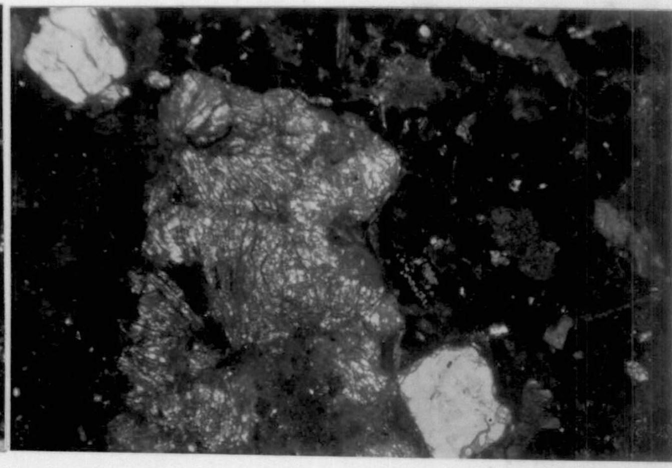



Plate 115
Plain light

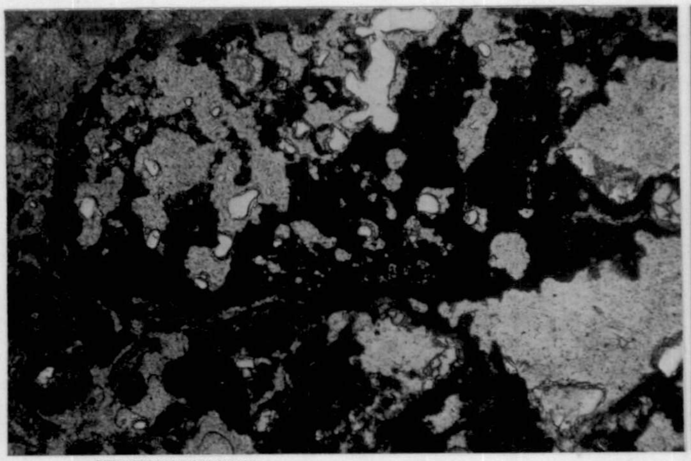
ENDOPEDON

Plate 116
Crossed nicols

Plate 113 and 114	Bigger, more than coarse sand sized, subangular, highly fractured, high reliefed quartz and many highly fractured and weathering less than fine sand sized quartz, quartzitic gneiss and opaques obliquely oriented to ferranic to ferriargillanic non lympid plasma. Mgf:x25
Plate 115 and 116	More than coarse sand sized to fine and sized subangular, highly coated and fractured quartzitic gneiss with few quartz and less than silt sized, subrounded to rounded plinthic glaebules in reddish brown to brown, opaque, aggregated, well oriented, dense and slightly lympid plasma with interconnecting chambers and non interconnecting vesicles and vughs.Mgf:x25

MICROMORPHOLOGY

Site: Kunnamangalam



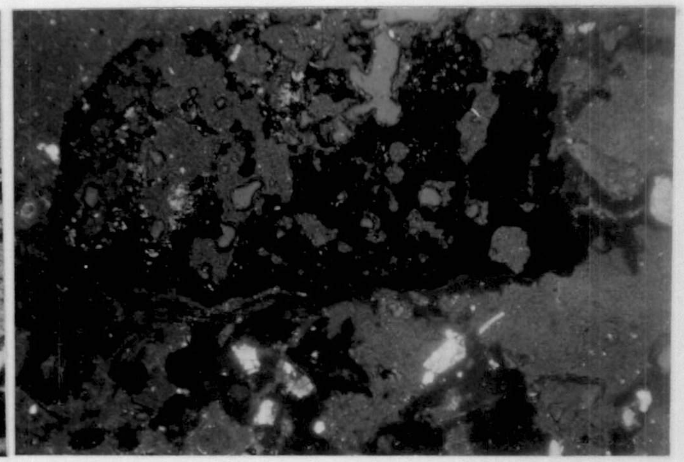


Plate 117
Plain light

EPIPEDON

Plate 118
Crossed nicols

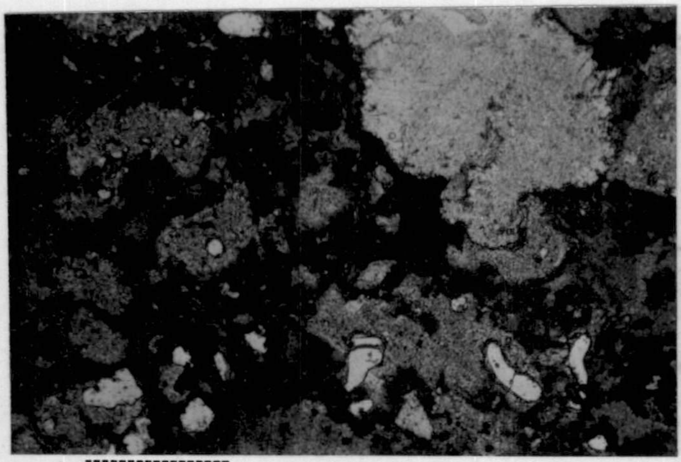


Plate 119
Plain light

ENDOPEDON

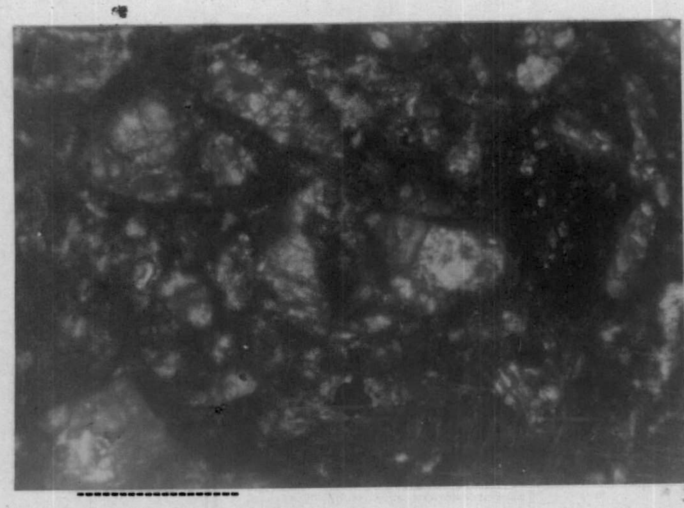
Plate 120
Crossed nicols

Plate 117 and 118 — Plasma well oriented, lympid, ferranic and ferriargillanic many voids dominantly vesicles and vughs, non lympid and without infillings. Skeletons very few, less than silt sized non coated runic quartz. Plinthic glaebules and plasma indicate a tendency to petropilthisation.Mgf:x25

Plate 119 and 120 — Plasma oriented, ferranic to ferri-argillanic, with big sized vesicles and vughs and few to very few slightly fractured non coated subrounded quartz. Presence of less than silt sized slender to rounded opaque plinthite glaebules is a characteristic feature.Mgf:x25

MICROMORPHOLOGY

Site: Ambalavayal



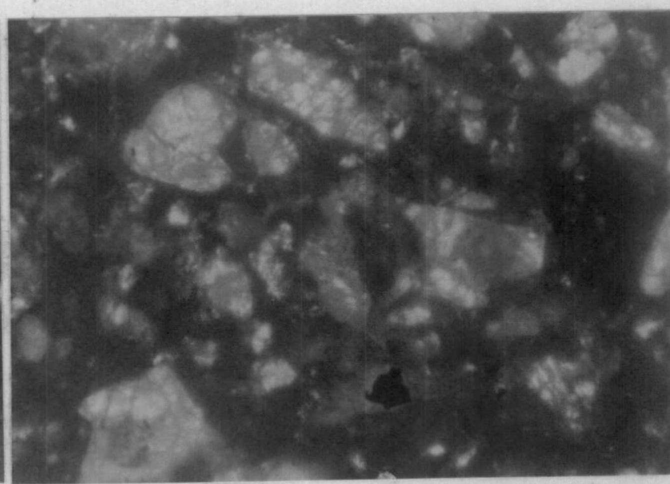


Plate 121
Plain light

EPIPEDON

Plate 122
Crossed nicols

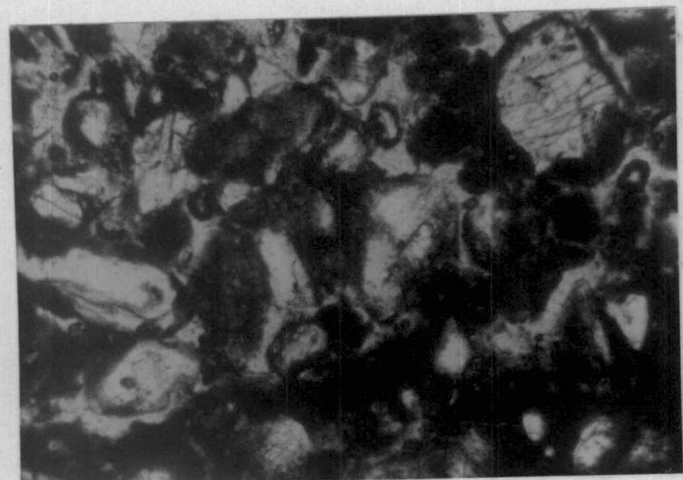


Plate 123
Plain light

ENDOPEDON

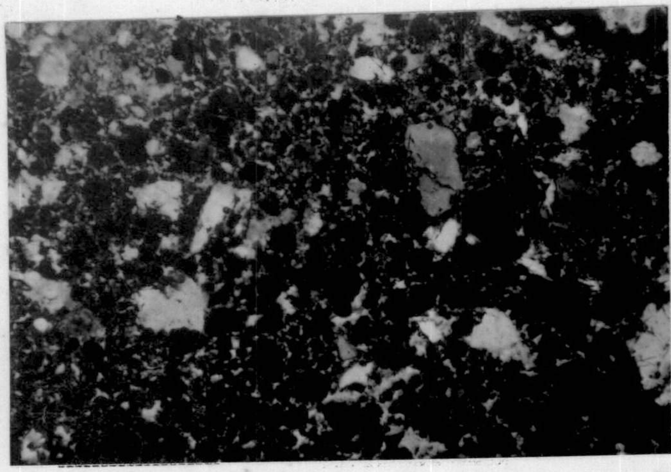
Plate 124
Crossed nicols

Plate 121 and 122 — Yellowish brown to brown, ferriargillanic, ferriorganic plasma with many more than fine sand sized weathering and weathered, subangular to subrounded quartzitic gneiss with dominantly intertextic RDP.Mgf:x63

Plate 123 and 124 — Opaque to brownish yellow, oriented and patchy plasma with subangular to subrounded, medium reliefed fractured and coated, quartzitic gneiss of coarse sand to fine sand size. Chambers, channels and vesicles without plasma infillings and with marginal illuvial ferriargillans.Mgf:x63

MICROMORPHOLOGY

Site: Pilicode



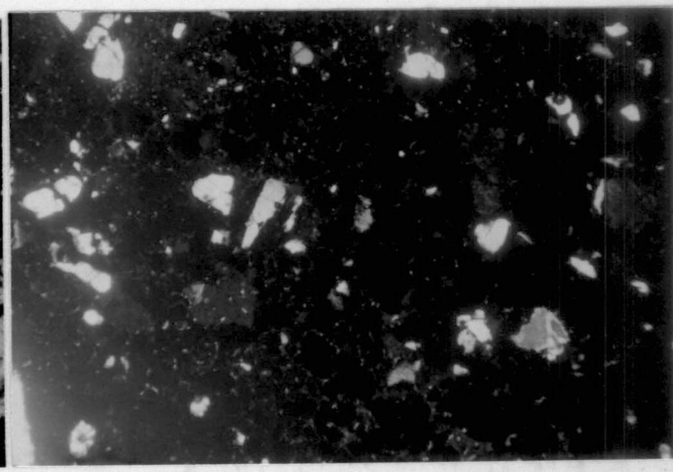
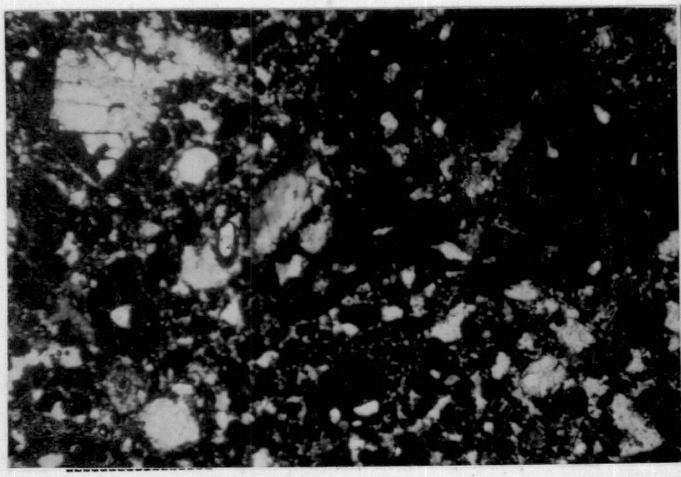


Plate 125
Plain light

EPIPEDON

Plate 126
Crossed nicols



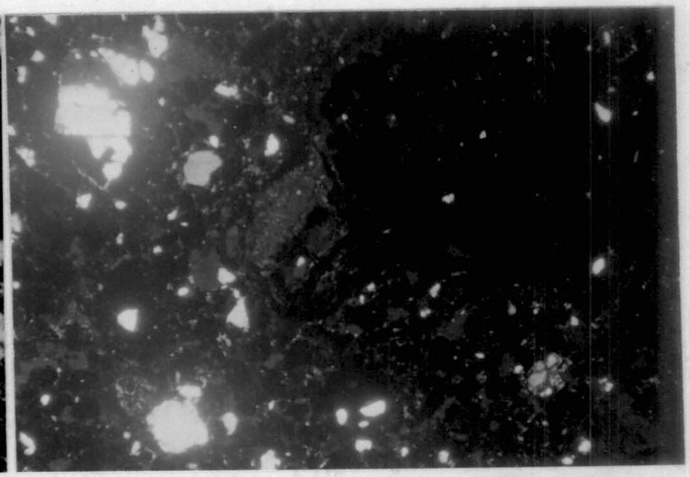


Plate 127
Plain light

ENDOPEDON

Plate 128
Crossed nicols

Plate 125 and 126 Compact, plinthic, opaque to brownish red plasma with less than fine sand size irregular margined low reliefed, few quartz, magnetite, ilmenite and many less tha silt sized subrounded to rounded plinthic glaebules with non interconnected inte angular, fine channels and planes.Mgf:x25

Plate 127 and 128 Plasma has reddish brown subangular plinthic glaebules with very fine channel planes and chambers with low relief, non coated , less than silt sized quartz, angula to subangular opaques and few quartz rich petroplinthic and goethitic macroglaebule Mgf:x25 soil characterisation. The soil fabric change or modification observed in diffeent MLRAs in general is from botton to top of the soil when MLRAs are considered as members of toposequences. This is in agreement with the inference of Tandy et al (1991) Kaolinite occurring in the Kuttanad coastal basin is as detrital minerals and also as partially authigenic origin. The mixed layers found in these soils are also of similar genesis. Dhar et al (1990) also reported similar observations in an organic matter rich Inceptisol association.

6. Soil Classification

With the gathered information on macromorphology, granulometric composition, mineralogy and micromorphology of the diagnostic horizons of the studied MLRAs, the classification of these soils have been safely arrived at (Soil Taxonomy, USDA, 1975, 1994). A table showing the respective MLRA unit, soil temperature regime, soil moisture regime, diagnostic horizons, micromorphology, clay mineralogy and classification as per Soil Taxonomy is given (Table 4.0).

6.1. Southern Dissected Terriplain

In the southern dissected terriplain the soil studied at Vellayani has been classified as fine loamy mixed isohyperthermic Rhodic Haplustox.

6.2. Southern Low Land Laterites

At Thiruvananthapuram in the southern low land laterite area, soil studied is classified under fine kaolinitic isohyperthermic Plinthic Kandiustults.

6.3. Southern Coastal Plain, Southern Foot Hills and Southern Dissected Midland Laterites

In the southern coastal plain the soils studied keys into the order Entisols. The soil at Kazhakuttom is classified as sandy mixed isohyperthermic Ustic Quartzipsamments and that at Kayamkulam as sandy mixed isohyperthermic Tropic Fluvaquents. The soil studied in the southern foot hills at Palode is classified as fine skeletal mixed isohyperthermic Typic Hapludolls while that in the southern dissected midland laterite area at Nedumangad is classified as fine skeletal kaolinitic Plinthic Haplustults and at Kottarakkara as loamy skeletal ishyperthermic Typic Plinthustults. Asharaf (1992) has reported similar results in his study of the soils of Palode

6.4. Kuttanad Coastal Basin and Central Backwater Basin

In the Kuttanad coastal basin and Central backwater basin the soils studied are classified as Fine mixed isohyperthermic Histic Sulfaquents. Similar results were reported by Subramonia Iyer (1989) in the Kuttanad soils.

6.5. Central Dissected Midland Laterites

In the central dissected midland laterite area the soil at Vellanikkara is classified as Fine loamy skeletal isohyperthermic Typic Plinthustults.

6.6. Northern Dissected Midland Laterites

At Angadipuram site representing the northern dissected midland laterite area the soil is classified as fine skeletal mixed isohyperthermic Typic Plinthustults while at Kunnamangalam site it is fine skeletal kaolinitic isohyperthermic Typic Plinthustults and at Pilicode the soil is classified as fine skeletal mixed ishoperthermic Plinthic Kandiustults. This is in agreement with the results reported by BindhuKumari (1993) in similar soils.

6.7. Palakkad Gap

In the Palakkad gap the soil studied at Eruthenpathy is classified as fine montmorillonitic isohyperthermic Petrocalcic Chromusterts.

6.8. Wayanad Plateau

In the Wayanad plateau, the studied soil at Ambalavayal is classified as fine loamy mixed isohyperthermic Typic Ustorthents.

Table 4.0

SOIL CLASSIFICATION

Sl. No.	MLRA Unit	Profile site	Soil temperature regime	Soil Moisture regime	Diagnostic horizon: epipedon	Diagnostic horizon: endopedon	clay mineralogy (decreasing order of abundance)	Micromorphology: epipedon	Micromorphology: endopedon	Classfication (USDA 1975, 1994)
1.	Southern dissected terriplain	1. Vellayani	isohyperthermic	Ustic	Ochric	argillic	Kaolinite >mixed clay minerals > feldspars and geothite.	Veryless plasma, bigger vesicles, well aggregated opque to brownish red patches, frctured quartz and few lithorelics	Microaggrated opaque to brownish red plasma, quartz, opques and coated quartz. Ferrans, argillans in porous quartz with vesicles and vughs	Fine loamy mixed isohyperthermic Rhodic Haplustox
2.	Southern low land laterites	2. Thiruvananthapuram	isohyperthermic	Ustic	Ochric	argillic	Kaolinite> mixed clay minerals > mica > smectite > feldspars > goethite	Fine sand sized to siltsized quartz, opaque reddish yellow brownish yellow plasma, few ferriargillan filled vesicles and vughs.	Highly plinthic illuviated compact gravelly and glaebular materials in yellow brown to yellowish gray plasma very fine medium vesicles, vughs and chambers.	Fine kaolinitic isohyperthermic Plinthic Kandiustults.
3.	Southern coastal plain	3. Kazhakuttom	Isohyperthermic	Ustic	Ochric		Kaolinite > smectite = mixed clay minerals > mica quartz> goethite.	less plasma, more angular quartz, ilmenite, magnetite, thin illuviation ferriargillan thick incomplete coating of opague ferran	Highly compact angular to subangular, coarse to fine sand sized non-coated, fractured quartz. high relief opaques, few illuvial ferrans, ferri argillans, fine interconnected vesicles	Sandy mixed isohypertheermic Ustic Quartzipsamments.

Sl. No.	MLRA Unit	Profile site	Soil temperature regime	Soil Moisture regime	Diagnostic horizon epipedon	Diagnostic horizon endopedon	clay mineralogy	Micromorphology epipedon	Micromorphology endopedon	Classfication (USDA 1975, 1994)
		4. Kayamkulam	Isohyper-thermic	Udic	Ochric.		Kaolinite > smectite mixed clay minerals > mica quartz > goethite.	Highly porous with rough surfaceed, medium reliefed non-coated, angular to subangular fractured quartz, less plasma. Lympidity in plasma, voids, skeletons, localised plasmified organic matter	less porous, compact, very fine sand sized, sub angular to subrounded fractured quartz, yellowish brown, marginal ferriargillans. Voids occur as vesicles and interconnected chambers.	Sandy mixed isohyperthermic Tropic Fluvaquents.
4.	Southern dissected midland laterites	5. Nedumangad	Isohyper-thermic	Ustic	Ochric	Argillic	Kaolinite> mixed clay minerals > mica > smectite > feldspars > gibbsite >goethite	Well oriented plasma and skeletons. Plasma ferranic to ferriargillanic and ferriorganic with quartzitic gneiss. Plinthic glaebules, lath shaped oblique quartz,vesicular voids	Patchy, aggregated, vesicular ferranic to ferriargillanic plasma, angular to subangular coarse sand sized fractured and cracked quartz, fine sand sized irregular plinthic glaebules.	Fine skeletal kaolinitic Plinthic Haplustults
		6. Kottarakkara	Isohyper-mic	Ustic	Ochric	Argillic	Kaolinite>mixed clay minerals>mica>smectite>feldspars>gibbsite> goethite	Coarse sand sized to fine sand sized quartz, plinthic glaebules grvel rich less plasma, many faint discontnuous illuviation ferrans and ferriargillans	Well oriented, packed iluviated fine sand to silt sized, subangular, opaque to brownish yellow plinthic glaebules on low reliefed cracked, angular quartz, few opaque lithorelics, vesicles, vughs in very less plasma.	Loamy skeletal kaolinitic isohyperthermic Typic Plinthustults

Sl. No.	MLRA Unit	Profile site	Soil temperature regime	Soil Moisture regime	Diagnostic horizon epipedon	Diagnostic horizon endopedon	clay mineralogy	Micromorphology epipedon	Micromorphology endopedon	Classfication (USDA 1975, 1994)
5.	Southern foot hills	7 Palode	Isohyper-thermic	Udic	Mollic	Argillic	Kaolinite>mixed clay minerals,goethite > feldspars	Cracked quartz subrounded opaque petroplinthic gravels and glaebules, with few voids and illuvial ferriorganan and ferri-argillan.	Iregular slightly coated quartz high reliefed petroplinthic sub-angular gravells and glaebules and many noncoated fractured quartz.	Fine skeletal mixed isohyper-thermic Typic Hapludolls
6.	Kuttanad coastal basin	8 Karumadi	Isohyper-thermic	Aquic	Histic	Argillic	Kaolinite>smectite, mixed clay miner-als> illite	Medium porous quartzijarositanic plasma. Clay sized non coated subangular runic quartz, feld-spars, diatoms, spongy spicules plinthic glaebules, non-infilled clear margined chambers and vesicles.	Parallel striated fabric opaque to brownish yellow fossil decom-posing barkcells, polyframboidal pyrite and jarosite in thin grey plasma with chambers, vesicles.	Fine mixed isohyperthermic Histic Sulfaquents
		9 Moncompu	Isohyper-thermic	Aquic	Histic	Cambic	Kaolinite>smectite, mixed clay miner-als > illite	Ferriargillan coated subangular quartz rich, less plasma parti-ally birefringent fine pyrite and jarosite framboids	Granular reddish yellow coloured less plasma with cubicular jaro-site, few coarse sand sized ilmenite, pyrite framboid and quartz and ferrihydrite.	Fine mixed isohyperthermic Histic Sulfaquents
7.	Central backwater basin	10 Vytilla	Isohyper-thermic	Aquic	Histic	Cambic	Kaolinite, smectite > mixed clay mineral >illite >gibbsite >	Yellowish brown, lympid plasma, low reliefed, runic quartz, opaques, feldspars, illuvial ferrijarositan coated silt sized quartz and vesicles.	Opaque to brownish yellow plasma slightly fractured,pitted quartz opaques, vesicles and vughs.	Fine mixed isohyperthermic Histic Sulfaquents

Sl. No.	MLRA Unit	Profile site	Soil temperature regime	Soil Moisture regime	Diagnostic horizon epipedon	Diagnostic horizon endopedon	clay mineralogy	Micromorphology epipedon	Micromorphology endopedon	Classfication (USDA 1975, 1994)
8.	Central dissected midland laterite	11 Vellanikkara	Isohyperthermic	Ustic	Ochric	Argillic	Kaolinite>mixed clay minerals>mica >smectite>feldspars >gibbsite>goethite	High reliefed coated fractured subangular to subrounded fine to coarse sand sized quartz with opaque ferriorganic to ferranic cutan, few fine vesicles.	Reddish yellow to yellowish brown microaggregated plasma silt sized to clay sized angular to subangular opaque Fe-Mn mineral, medium reliefed quartz.	Fine loamy skeletal isohyperthermic Typic Plinthustults
9.	Palakkad gap	12 Eruthenpathy	Isohyperthermic	Ustic	Umbric/ melanic	Argillic	Smectite>Kaolinite> mixed clay minerals> illite>mica>gibbsite> feldspars	Gray, grayish black plasma with ferriorganan, ferricalcitan, ferriargillan thick coating on fine sand sized subangular to subrounded quartz. Plasma less porous with cutan unfilled channels and chambers.	Compact subrounded calcite crystals and mycrolites coated with ferran and mangan on greyish black thin plasma with channels and planes.	Fine montmorillonitic isohyperthermic Petrocalcic Chromusterts
10.	Northern dissected midland laterite	13 Angadipuram	Isohyperthermic	Ustic	Ochric	Argillic	Kaolinite>mixed clay minerals>mica>smectite >feldspars>gibbsite> goethite.	Bigger subangular highly fractured high reliefed quartz many weathering quartz, quartzitic gneiss, opaques on ferranic to ferriagrillanic non lympid plasma	Reddish brown to brown opaque aggregated well oriented dense slightly lymipd plasma with chambers,vesicles and vughs quartzitic gneiss, plinthic glaebules in plasma.	Fine skeletal mixed isophyperthermic Typic Plinthustults.
		14 Kunnamagalam	Isohyperthermic	Ustic	Ochric	Argillic	Kaolinite>mixed clay minerals>mica> smectite>feldspars>gibbsite> goethite	Well oriented, lympid ferranic and ferriargillanic plasma with many voids, without infillings. Plinthic glaebules and plasma indicate a tendency for petroplinthitisation.	Oriented, ferranic to ferriargillanic plasma with bigger vesicles,vughs and few quartz Opaque plinthic glaebules present	Fine skeletal kaolinitic isohyperthermic Typic Plinthustults

Sl. No.	MLRA Unit	Profile site	Soil temperature regime	Soil Moisture regime	Diagnostic horizon		clay mineralogy	Micromorphology		Classfication (USDA 1975, 1994)
					epipedon	endopedon		epipedon	endopedon	
		15 Pilicode	Isohyper-thermic	Ustic	Ochric	Cambic	Kaolinite>mixed Clay minerals>mica>smect-ite>feldspars>gibb-site>goethite.	Compact, plinthic, opaque to brownish red plasma with irr-egular margined, low reliefed quartz, magnetite, ilmenite plinthic glaebules with channels and planes present	Redish brown plinthic glaebules in plasma with channels, planes and chambers,low reliefed quartz opaques and quartz rich petro-plinthic and goethitic macrogla-ebules.	Fine Skeletal mixed isohyper-thermic Plinthic Kandiustults
11.	Wayanad plateau	16 Ambalavayal	Isohyper-thermic	Ustic	Ochric		Kaolinite>mixed clay minerals>mica>illite >gibbsite, geothite	Yellowish brown to brown ferri argillanic,ferriorganic plasma with quartzitic gneiss, inter-textic RDP.	Opaque to brownish yellow plasma with quartzitic gneiss. Chambers channels and vesicles without plasma infillings and with margi-nal illuvial ferriargillans.	Fine loamy mixed isohyperthermic Typic Ustorthents

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSIONS

To gather information on the primary mineral assemblage and micromorphology of the diagnostic horizons of the major land resource areas of Kerala, representative profiles from sixteen sites falling under eleven MLRAs were studied and attempted refined confirmatory classification considering the soil micro-variability. The local nomenclature of the soils of the MLRAs are based on soil colour, texture, system of cultivation dominant crop and soil formation. The studied profile sites and their respective MLRA units are Vellayani (Southern dissected terriplain), Thiruvananthapuram (Southern low land laterites), Kazhakuttom and Kayamkulam (Southern coastal plain), Nedumangad and Kottarakkara (Southern dissected midland laterite), Palode (Southern foothills), Karumadi and Moncompu (Kuttanad coastal basin), Vytilla (Central backwater basin) Vellanikkara (Central dissected midland laterite), Eruthenpathy (Palakkad gap), Angadipuram, Kunnamangalam and Pilicode (Northern dissected midland laterite) and Ambalavayal (Wayanad Plateau).

The salient observations from this study are presented below:

1. The studied MLRAs fall within isohyperthermic temperature regime but are with aquic, udic or ustic moisture regimes resulting in high profile variability.

2. The major epipedon identified irrespective of the MLRAs was ochric. In the Southern foot hill MLRA unit represented by Palode, the profile is with mollic to argillic transition horizon.

3. Irrespective of the MLRAs, the argillic horizon observed is either ill-developed or well-developed.

4. In the Kuttanad coastal basin and the cental backwater basin, the soils are with sulphuric horizon or with sulphidic materials while in the Palakkad gap, pedoturbation and associated vertic features are observed.

5. Soils of the southern coastal plain and Kuttanad basin are non gravelly sedimentary materials while the soils of the southern dissected terriplain, Palakkad gap and Wayanad Plateau are slightly gravelly in nature. Soils of the other studied MLRAs are highly gravelly in nature.

6. Texturally the soils of the southern dissected terriplain are sandy loam to clay loam while at the Wayanad plateau it is predominantly clay loam. Soils of the southern low land laterite area, southern dissected midland laterites, central dissected midland laterites, and northern dissected midland laterites are gravelly to very gravelly with a texture ranging

from clay loam to clay, while in the southern foot hill MLRA, the soils are very gravelly with a texture ranging from silty clay loam to clay. Soils of the southern coastal plain are non gravelly with texture of predominantly loamy sand. Soils of the Kuttanad coastal basin and the central backwater basin have a texture ranging from silty clay loam to clay and are non gravelly in nature. Soils of the Palakkad gap are slightly gravelly in nature with predominant clay texture.

7. The average clay content in the soils of the studied MLRAs are in the increasing order from the southern coastal plain, southern dissected terriplain, Wayanad plateau, central dissected midland laterite, northern dissected midland laterite (Pilicode site), southern dissected midland laterite, southern foot hills, northern dissected midland laterite (Angadipuram site), Southern low land laterite, Palakkad gap, Kuttanad coastal basin (Moncompu, Karumadi sites), northern dissected midland laterite (Kunnamangalam site) and the central backwater basin (Vytilla site).

8. Irrespective of the MLRAs, in both the diagnostic horizons, the primary mineral assemblage are rich in quartz followed by iron oxide and titanium oxide minerals. Each of the MLRs have

its own type and distribution of primary minerals and hence the potential characteristics in the soils developed.

9. The comparative micromorphological analysis of the diagnostic horizons from different MLRAs safely qualifies them to key into Entisols, Ultisols and Mollisols in the upland situation, Kuttanad coastal basin soils into Entisols and Palakkad gap soils into Vertisols. Micromorphological analysis confirms the dominant distribution of Ultisols in the state. Mollisols/ Ultisols/ Oxisols of certain geomorpohic positions even rule out to be classified under Entisols. Classification of the soils of the studied MLRAs is given in table 5.0.

10. In Kerala, the main soil forming factors which govern weathering and profile development are in the order of influence- specific geomorphic position, slope and the degree and extent of hydromorphism contributed by varying moisture regimes.

11. The soils are developed from the parent material originated from granite, gneiss, quartzite and mica schist as evident from their fine sand mineralogy.

12. Comparative clay mineralogy of the diagnostic horizons from the MLRAs indicate that in the upland MLRAs kaolinite is

Table 5.0 **SOIL CLASSIFICATION**

Sl. No.	MLRA unit	Profile site	Classification
1.	Southern dissected terriplain	1. Vellayani	Fine loamy mixed isohyper mic Rhodic Haplustox
2.	Southern low land laterites.	2. Thiruvananthapuram	Fine kaolinitic isohyper-thermic Plinthic kandiustults
3.	Southern coastal plain	3. Kazhakuttom	Sandy mixed isohyperthermic Ustic Quartzipsamments.
		4. Kayamkulam	Sandy mixed isohypertherrmic Tropic Fluvaquents
4.	Southern dissected midland laterites	5. Nedumangad	Fine skeletal kaolinitic Plinthic Haplustults.
		6. Kottarakkara	Loamy skeletal isohyperther-mic Typic plinthustults.
5.	Southern foothills	7. Palode	Fine skeletal mixed isohy-perthermic Typic Hapludolls.

Sl. No.	MLRA unit	Profile site	Classification
6.	Kuttanad coastal basin	8. Karumadi	Fine mixed isohyperthermic Histic Sulfaquents.
		9. Moncompu	Fine mixed isohyperthermic Histic Sulfaquents.
7.	Central backwater basin	10. Vytilla	Fine mixed isohyperthermic Histic Sulfaquents.
8.	Central dissected midland laterite	11. Vellanikkara	Fine loamy skeletal Typic Plinthustults.
9.	Palakkad gap	12. Eruthenpathy	Fine montmorillonitic isohyperthermic Petrocalcic Chromusterts
10.	Northern dissected midland laterite	13. Angadipuram	Fine skeletal mixed isohyper thermic Typic Plinthustults.
		14. Kunnamangalam	Fine skeletal kaolinitic isohyperthermic Typic Plinthustults.
		15. Pilicode	Fine skeletal mixed isohyperthermic Plinthic Kandiustults.
11.	Wayanad plateau	16. Ambbalavayal	Fine loamy mixed isohyperthermic Typic Ustorthents.

the dominant mineral. In the wetland MLRAs represented by the soils of the Kuttanad coastal basin and the Central backwater basin, and in the soils of the Palakkad gap, smectite is followed by kaolinite, mica, illite, mica quartz, feldspars, gibbsite and goethite. Haematite was not noticed in the MLRAs clay fractions.

Mixed clay minerals observed in the upland MLRAs are regular with chlorite-vermiculite composition while that at the wetland MLRAs, southern coastal plain and Palakkad gap are random with chlorite-smectite composition. Clay minerals of the soils irrespective of the MlRAs are more of geogenic origin or earlier pedogenic processes with little or least weathering to form clay minerals.

13. The stage by stage macromorphology, granulometric analysis, single grain mineralogy of the primary minerals, detailed micromorphological analysis and qualitative and semi-quantitative analysis of clay minerals of the diagnostic horizons from the major land resource areas of the state helped in formulating refined, characteristic criteria for their description and classification.

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MICROMORPHOLOGY AND MINERALOGY OF THE SOILS OF MAJOR LAND RESOURCE AREAS OF KERALA

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ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
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VELLAYANI – THIRUVANANTHAPURAM

1996

ABSTRACT

An integrated study was conducted on the macromorphology, granulometric composition, primary mineral assemblage, micromorphology and clay mineralogy of the diagnostic horizons from the representative profiles of the major land resource areas of the state for their refined description and classification. The investigated MLRAs of the state are the southern dissected terriplain, southern low land laterites, southern coastal plain, southern dissected midland laterites, southern foot hills, Kuttanad coastal basin, central backwater basin, central dissected midland laterites, Palakkad gap, northern dissected midland laterites and the Wayanad plateau.

All the MLRAs are classified within isohyperthermic temperature regime but with aquic, udic and ustic moisture regimes. The universal observation of ochric horizon and its transition to argillic horizon, ill-developed to well developed argillic horizon, presence of sulphuric horizon or sulphidic materials and vertic features could be safely arrived at with the comparative macro and micromorphology of the soils, supported with clay mineralogy. Wide differences in gravel and clay distribution is another unique observation between the

MLRAs. Primary mineral assemblage indicate granite, qneiss, quartzite, mica schist and gabbro parentage of the soils of the various major land resource areas. Irrespective of the MLRAs kaolinite is the dominant clay mineral followed by smectite, mica and illite. In the Palakkad gap smectite minerals dominate over kaolinite while in the Kuttanad coastal basin kaolinite and smectite are in almost equal amounts. The non-clay clay minerals mica quartz, feldspars, goethite and gibbsite are also present. Haematite was not seen present in the clay fraction. Smectite and mica are also present even in weathered laterite MLRAs. Diagenesis is observed in the Kuttanad coastal basin and in the Palakkad gap whereas the other MLRAs are with polygenetic or paleoclimatic influenced soils.

The study could help in arriving at the safe and refined soil description and classification upto family level on the basis of the results of the investigation. A critical analysis of detailed survey of MLRAs and detailed sampling may be attempted as future line of work with the present investigation as baseline to submit suitable proposals in Soil Taxonomy incorporating detailed soil microfabric criteria as a safe and specific information.