



GOVERNMENT OF KERALA

DISTRICT SURVEY REPORT OF MINOR MINERALS (EXCEPT RIVER SAND)

PALAKKAD DISTRICT

Prepared as per
Environment Impact Assessment (EIA) Notification, 2006 issued
under Environment (Protection) Act 1986
by

DEPARTMENT OF MINING AND GEOLOGY
www.dmg.kerala.gov.in

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DISTRICT SURVEY REPORT OF MINOR MINERALS

PALAKKAD DISTRICT

(This report is to be submitted along with application for Environmental Clearance (EC) for mining of all minor minerals except river sand)

1 Introduction

Palakkad (Palghat) is the land of Palmyrahs and Paddy fields. Palakkad is a major paddy growing area of the State. It is often called as the 'Gateway of Kerala'. There is considerable change in the land use and cropping pattern in the district for the last five years. Due to low income from paddy and coconut, farmers are changing the cropping pattern to cash crops like sugarcane, vegetables and flower cultivation. Over dependence on groundwater for domestic, irrigation and industrial purposes in the district has led to the lowering of water table and water scarcity especially along the eastern parts. In most of the areas especially in eastern part of the district decline of water levels necessitates deepening of existing dug wells and putting deep bore wells thereby increasing cost of pumping and quality deterioration. Local enquiry revealed that farmers have taken loan from the banks for putting bore wells and fitting pump sets for irrigation purposes. The district receives on an average 2362 mm of rainfall annually. During 1998 the district recorded a good rainfall of 2407 mm and subsequently the rainfall has been decreased considerably.

2 Drainage and Irrigation

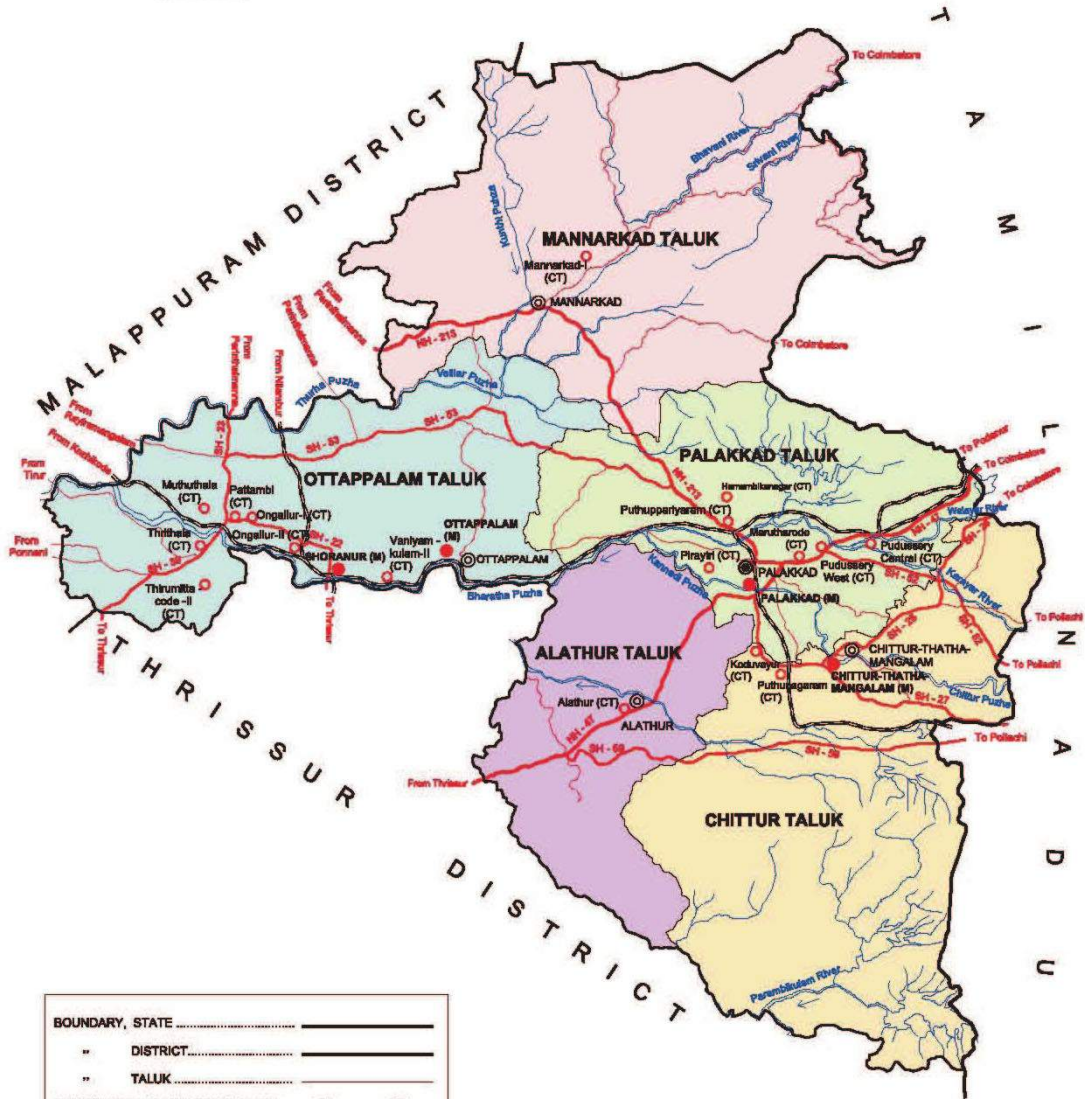
The district is drained mainly by two rivers, viz. *Bharathapuzha* and *Bhavani* Rivers. Of these *Bhavani* is east flowing and form a tributary of the *Cauvery* River. *Bharathapuzha* basin can be divided into 50 watersheds and 290 mini watersheds. Soil erosion is more in the upstream parts of the basin. Dendritic is the common drainage pattern. 75 % of the population is depending on surface water resources for their irrigation needs, mainly from *Bharathapuzha*, its tributaries and other water bodies. There are 12 reservoirs in the district associated with two major rivers and its tributaries viz - *Parambikulam*, *Peruvaripallam*, *Thoonakadavu*, *Chulliyar*, *Pothundi*, *Moolathara*, *Meenkara*, *Walayar*, *Malampuzha*, *Gayathri*, *Kanjirapuzha* and *Mankulam*.

There are number of irrigation projects major and minor, existing in the district. The major projects are Malampuzha, Chittoorpuzha, Kuriar Kutty, Karapara, Kanjirapuzha and Attappady Valley Irrigation Project.

The major irrigation schemes are irrigating about 90,000 hectare of land and minor schemes irrigating about 2000 hectares of land. The main crops grown under the irrigation scheme are paddy, coconut, aracanut, plantain, grams, vegetables etc.

INDIA
KERALA
PALAKKAD DISTRICT

NUMBER OF TALUKS.....	: 5
STATUTORY TOWNS :	4
CENSUS TOWNS :	17
OUT GROWTHS :	0
VILLAGES :	131
TOTAL AREA OF THE DISTRICT :	4480 Sq. Km.



BOUNDARY, STATE	—————
" DISTRICT	—————
" TALUK	—————
HEADQUARTERS : DISTRICT, TALUK	● , ○
NATIONAL HIGHWAY	NH - 213
STATE HIGHWAY	SH - 27
OTHER IMPORTANT ROADS	—————
RAILWAY LINE, BROAD GAUGE	—————
RIVER AND STREAM	~~~~~
STATUTORY TOWN / CENSUS TOWN	● , ○

District headquarters is also the Taluk headquarters

The Shiruvani dam constructed across the river *Shiruvani*, a tributary of *Bhavani* is the source of drinking water for the Coimbatore urban population.

3 Rainfall and climate

Based on Thornthwaite's climatic classifications the district experiences humid type of climate.

The district receives maximum rainfall during the south west monsoon followed by the north east monsoon. The other months receive considerably less rainfall. The temperature is pleasant from December to February. The annual rainfall varies from 1883 to 3267 mm based on long term normal. The district receives on an average 2362 mm of rainfall annually. Major rainfall is received during June to September in the southwest monsoon (71%). The northeast monsoon contributes about 18%. The western part of the district around Pattambi receives the maximum rainfall whereas in the rain shadow area of Chittur in the eastern part receives the minimum rainfall.

At Palakkad the maximum temperature ranges from 28.1 to 37.4⁰C whereas the minimum temperature ranges from 22.2 to 25.3⁰C. The average annual maximum temperature is 32.3⁰C and the average annual minimum temperature is 23.4⁰. The wind is predominantly from west and east during morning as well as in the evening hours. The wind speed is high during August (13.6 kmph). The humidity is higher during the monsoon period i.e. from June to September. It is around 90% during this period. All through the year, the humidity is high during the morning hours.

4 Geology

The district can be broad divided into five geological terranes viz. i) lowland of charnockite country in the west; (ii) Migmatite Complex in the east, extending into adjacent Coimbatore district of Chennai; (iii) Khondalite Group, occurring as linear bodies in the northeastern hill region; (iv) Wynad Group, occurring as high hills in the north in Attapady area and (v) Peninsular Gneissic Complex (PGC) confined to the north of Bharathapuzha river.

The area forms a part of the Precambrian metamorphic shield having a complex geological set up. Wynad Group is represented by rocks of upper amphibolites to lower-granulite facies metamorphism. This complex can be divided into an ultramafic-dominant upper group and amphibolites dominant lower group. The ultramafic group comprises talc-chlorite schist, talc-pyroxene-garnet schist. The amphibolite group consists of hornblende-biotite schist and gneiss with amphibolites bands garnet. These rocks are exposed in the Attappadi area. Hornblende –biotite gneiss and pink granite-gneiss of Peninsular Gneissic Complex are exposed in the north, especially north of

Bharathapuzha river. The Khondalite group, which outcrops northeast of Malalbuzha reservoir, comprises garnet-sillimanite gneiss and calc-granulite. Narrow bands of calc-granulite are exposed along the Walayar river bed. Numerous thin bands of calc-granulite associated with crystalline limestone and calciphyre have been observed in the area. Charnockite group is predominant in the west. This group comprises massive charnockite/gneissic charnockite, pyroxene granulite, pyroxenite and norite and magnetite quartzite amongst which massive charnockite/gneissic charnockite is the most widely distributed. Pyroxene granulite and magnetite quartzite occur as narrow bands. Thin impersistent segregations of pyroxenite and norite occur in the 'Palghat Gap'. The Charnockite Group is succeeded by the Migmatite Complex represented by hornblende-biotite gneiss and quartz-feldspar gneiss. These rocks occupy the eastern part and the 'Palghat Gap'. They are melanocratic and foliated. These rocks are intruded by pegmatites, quartz veins and gabbro and dolerite dykes. Basic intrusives, especially dolerite, have two distinct trends in the district; one being NW-SE, which is common throughout the State and the other NE-SW, seen in the northeastnorth of Attapady. In the westernmost part, south of Bharathapuzha, a few isolated occurrences of Warkalli sediments are noticed capping small mounds. The valleys are occupied by fluvial alluvium of Quaternary age. Lateritisation is widespread in the west (*Figure 1*). The geology of the district given above may be read with the "Geology of Kerala" which is given as Annexure 1 for better understanding of geological succession and stratigraphic sequence.

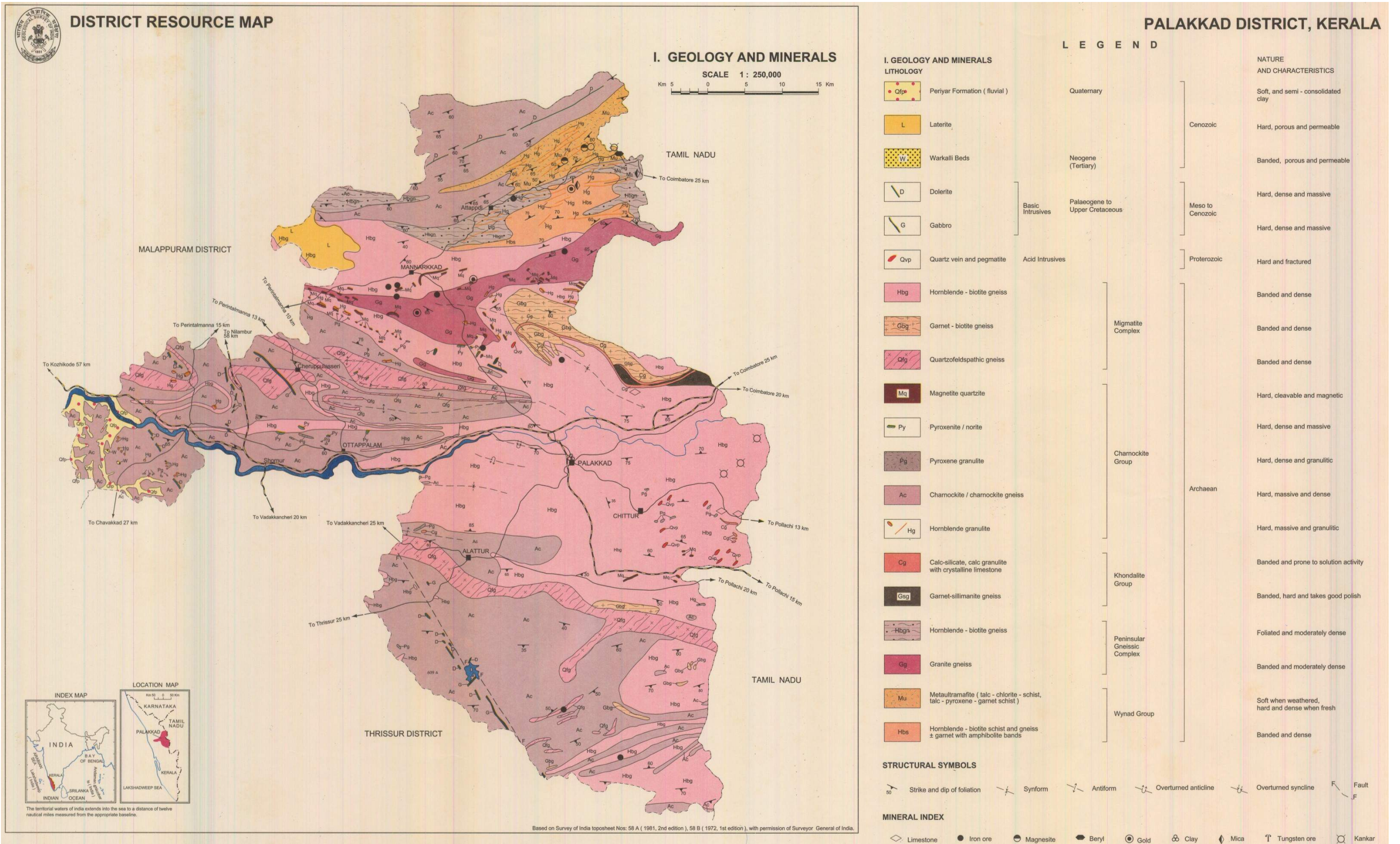


Figure 1: Geology and mineral resources of Palakkad. (Source: District Resource map, Palakkad district, Geological Survey of India)

5 Geomorphology

Physiographically the district is divisible into two zones viz. (i) the high hill ranges of the Western Ghats in the east and (ii) the low lying undulating midland region in the west i.e., the high land and mid land. A conspicuous landmark of the district is the 'Palghat Gap' which is a major E-W trending break, across the NNW-SSE running hill ranges of the Western Ghats. The 'Gap' having an elevation of 70-300m above msl is part of a well-defined low-level landform of the Western Ghats. The 'Gap' is bound by steeply rising Nilgiri hills in the north and Anamalai-Palani hills in the south. The width of 'Palghat Gap' is about 30km. The midland region of the district, of which the 'Palghat Gap' is also a part, represents an area of low undulating relief, with convex gently graded interstream tracts, sloping down to broad valley floors consisting of local erosional remnants. These erosional landforms are often seen interfingered with alluvial plains and lateritic hummocks, and the terrain as a whole represents a dissected pediment. The structural cum denudational hill ranges border the dissected pediment to its north and south. Towards west, the landform is more matured with laterite mesas and laterite interfluvies separated by narrow valley flats and flood plains. Almost levelled and matured topography around 1200m above msl in the north probably represents a planation surface. The elevation of the landforms varies from 20 to 2386 m amsl.

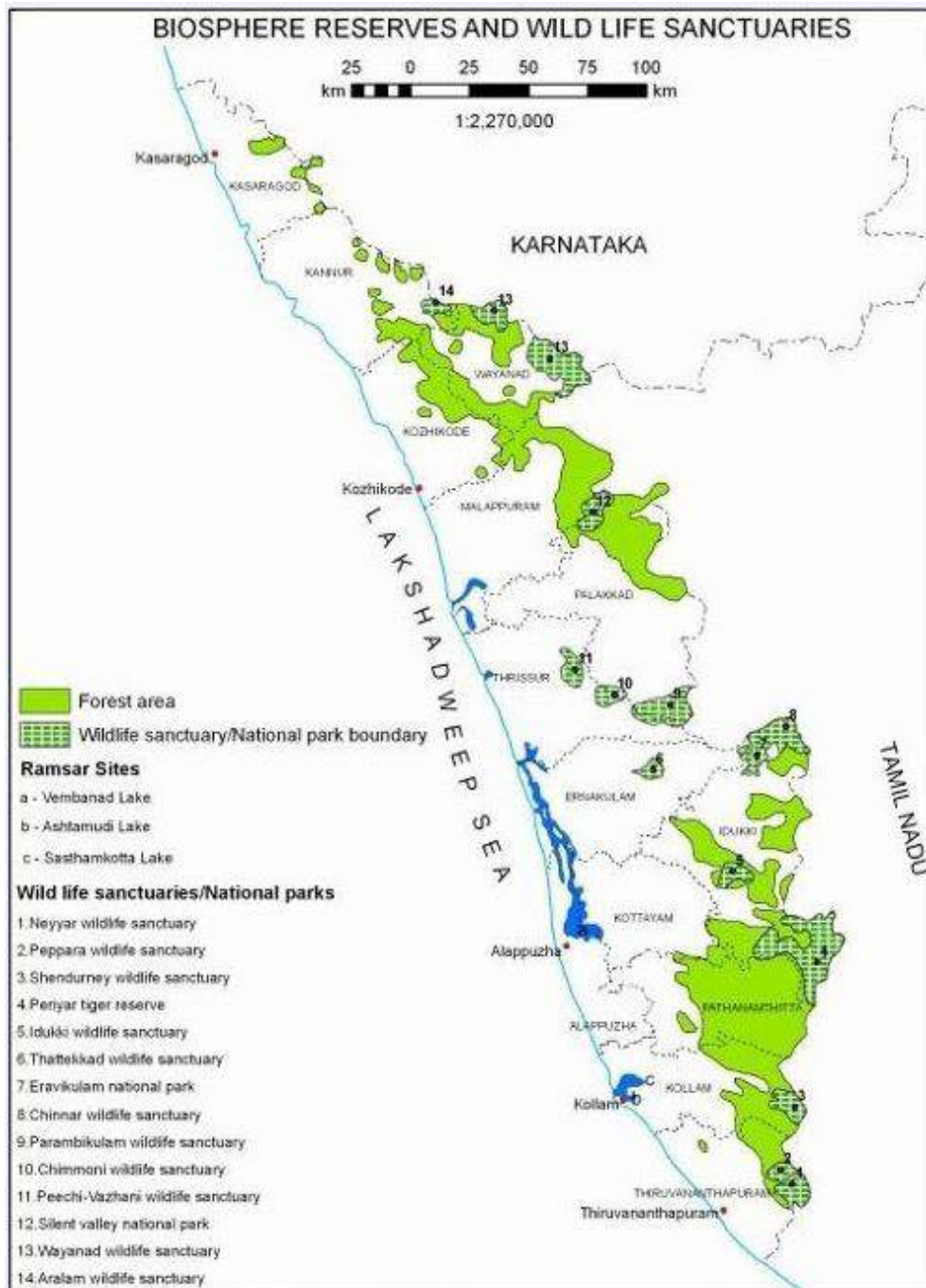
Bharathapuzha is the major river draining the district. Gayathripuzha and Kunthi puzha are the important tributaries of the Bharathapuzha. The Attapady area is drained by Bhavani river, which unlike other rivers of Kerala is one among those three rivers that flows towards east. The district is not blessed with coastal tract and natural lakes. Ottapalam taluk lies completely in the mid land region whereas all other taluks lie both in midland and high land regions.

Morphology of the terrain has played an important role in the potential of groundwater in the district. In the 'Palghat Gap' and in the plains further west, groundwater is available at shallow depths through open dug wells. But the hilly terrain on either side of the 'Gap' is generally unsuitable for groundwater development. The amount of rainfall received in the district is also less compared to other districts of the State because of which scarcity of water is very common and in some parts even drought conditions prevail during the summer months (*Figure 2*).

6 Soil types

There are four types of soil - Laterite soil, Virgin forest soil, Black cotton soil & Alluvial soil.

Laterite soil - Seen in major part of Ottappalam, Alathur, Chittur and Palakkad taluks. These are most predominant soil type in the midland and gap areas. Laterites on high grounds are more compact when compared to the low lying areas.



Source : Department of Forests, Govt. of Kerala, 2010

Virgin Forest Soil - Seen in Mannarkad taluk and in forest areas. They are rich in humus and organic matter.

Black Cotton Soil - Seen in Chittur and Attapady Valley of the Mannarkad Taluk, which is used for the cultivation of cotton. They exhibit mud cracks and have high water retaining power.

Alluvial soils are found along the banks of *Bharathapuzha* and its tributaries. In the Valley portion Valley fill deposits composed of talus and scree material are observed.

7 Land use

Moderate rainfall, thick soil cover and a number of irrigation projects have influenced the development of a particular type of land use in the district. A major portion of the district comes under arable land, which includes both irrigated and unirrigated land. Rice, pulses, vegetables and banana are the major crops grown. The north and south, comprising high hills of the Western Ghats constitute forest land. The area comes under the tropical evergreen forest. Considerable area of the forest land has been converted into plantation for cultivation of tea, pepper, reak and eucalyptus. There are pockets of waste land with thick capping of hard duricrust or exposure of basement rocks (*Figure 3*).

8 Groundwater scenario

Palakkad district is underlain by rocks of Archaean metamorphic complex. They include the granulite group, the gneisses and the schists above which laterite and alluvium are observed. Intrusives of pegmatites and quartz veins are also common in the northeastern parts of the district.

Groundwater occurs in all the geological formation from Archaean crystallines (hard rock) to Recent alluvium (soft rock). The entire district can be divided into three units based on hydrogeological information. 1) Valley fills/Alluvium 2) Laterite terrain and 3) Crystallines.

Groundwater occurs in phreatic condition in the laterite, alluvium and weathered crystallines. It is in semi confined to confined condition in the deep fractured rocks (*Figure 4*).

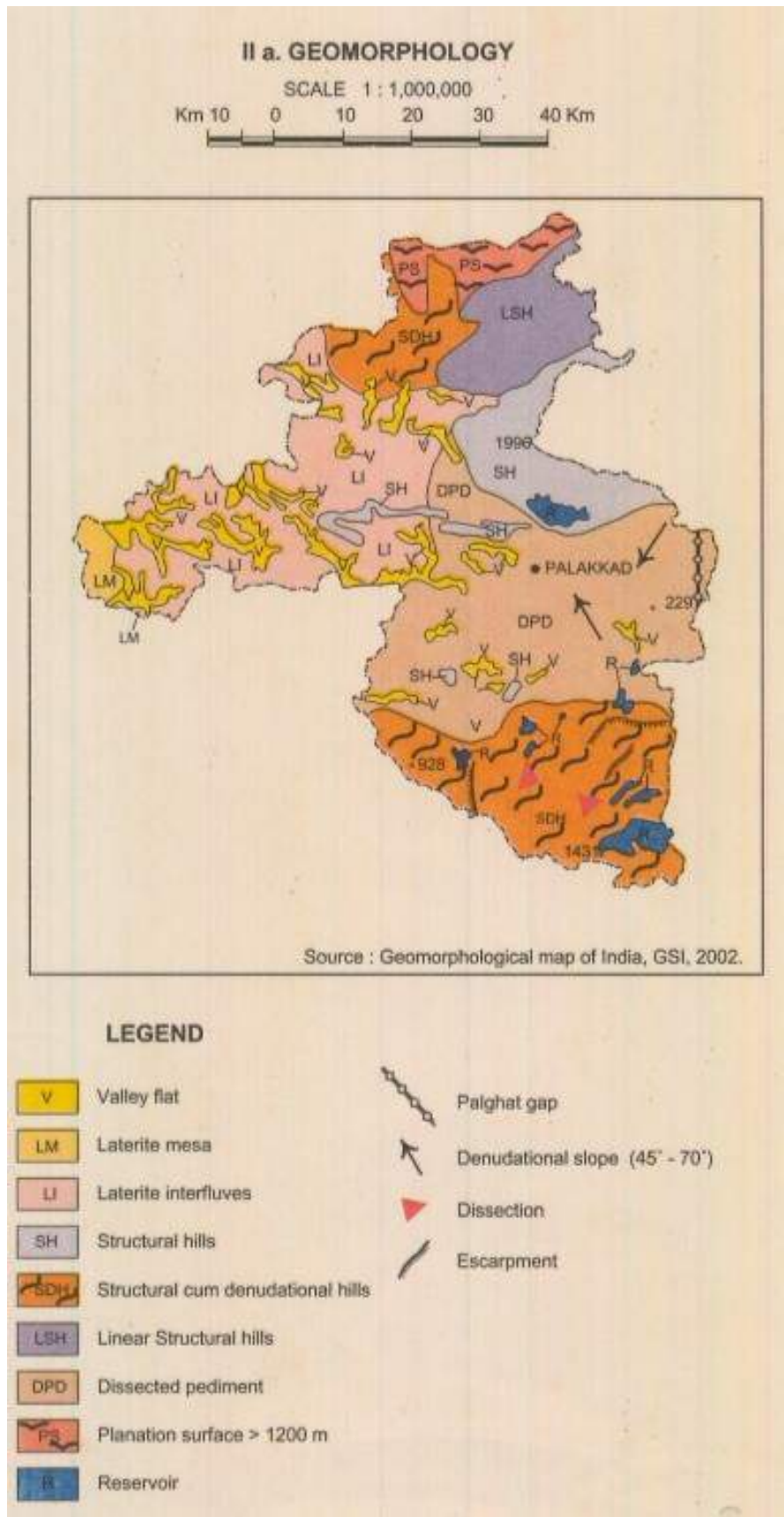


Figure 2: Geomorphology of Palakkad. (Source: District Resource map, Palakkad district, Geological Survey of India)

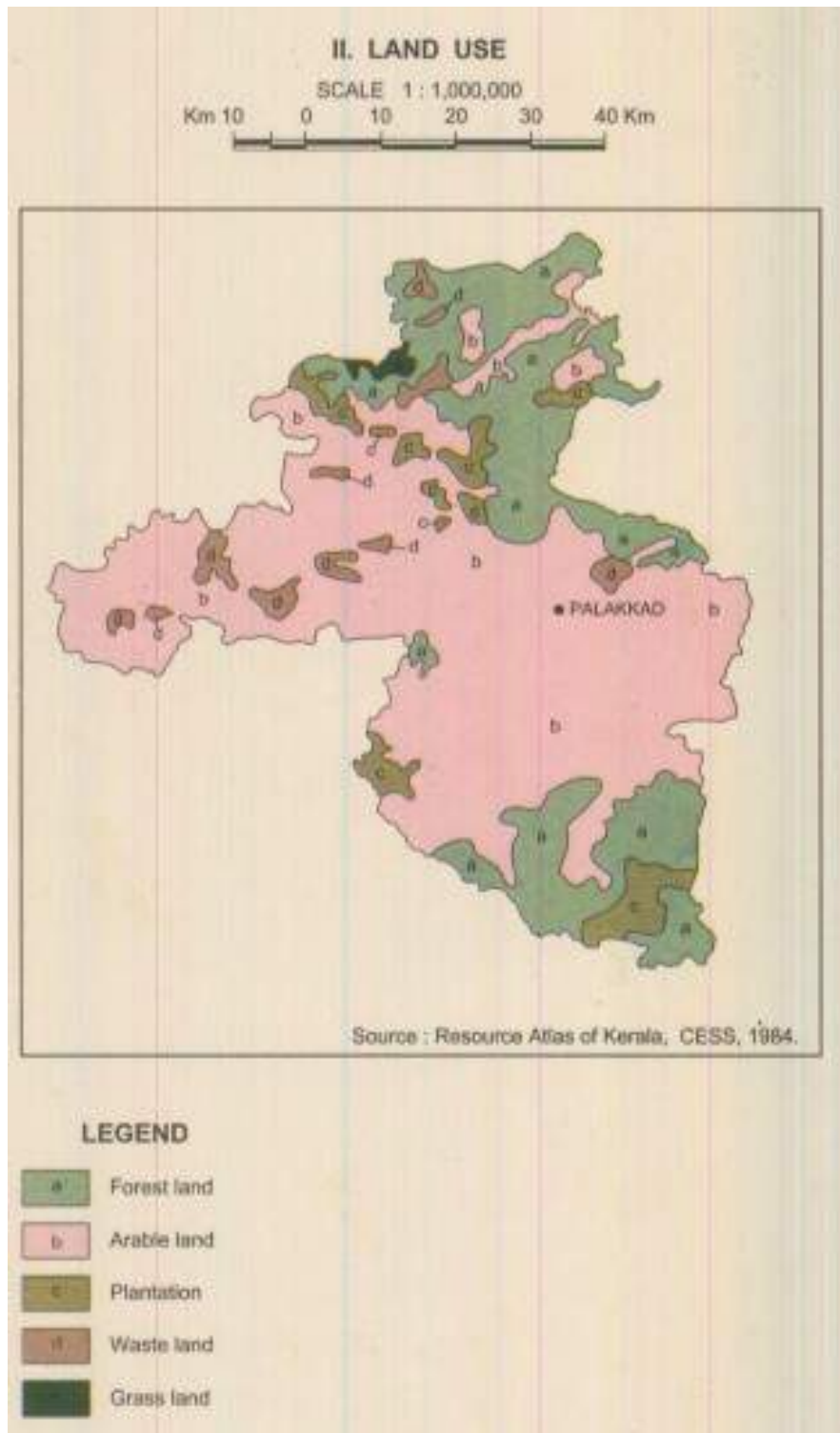


Figure 3: Landuse of Palakkad. (Source: District Resource map, Palakkad district, Geological Survey of India)

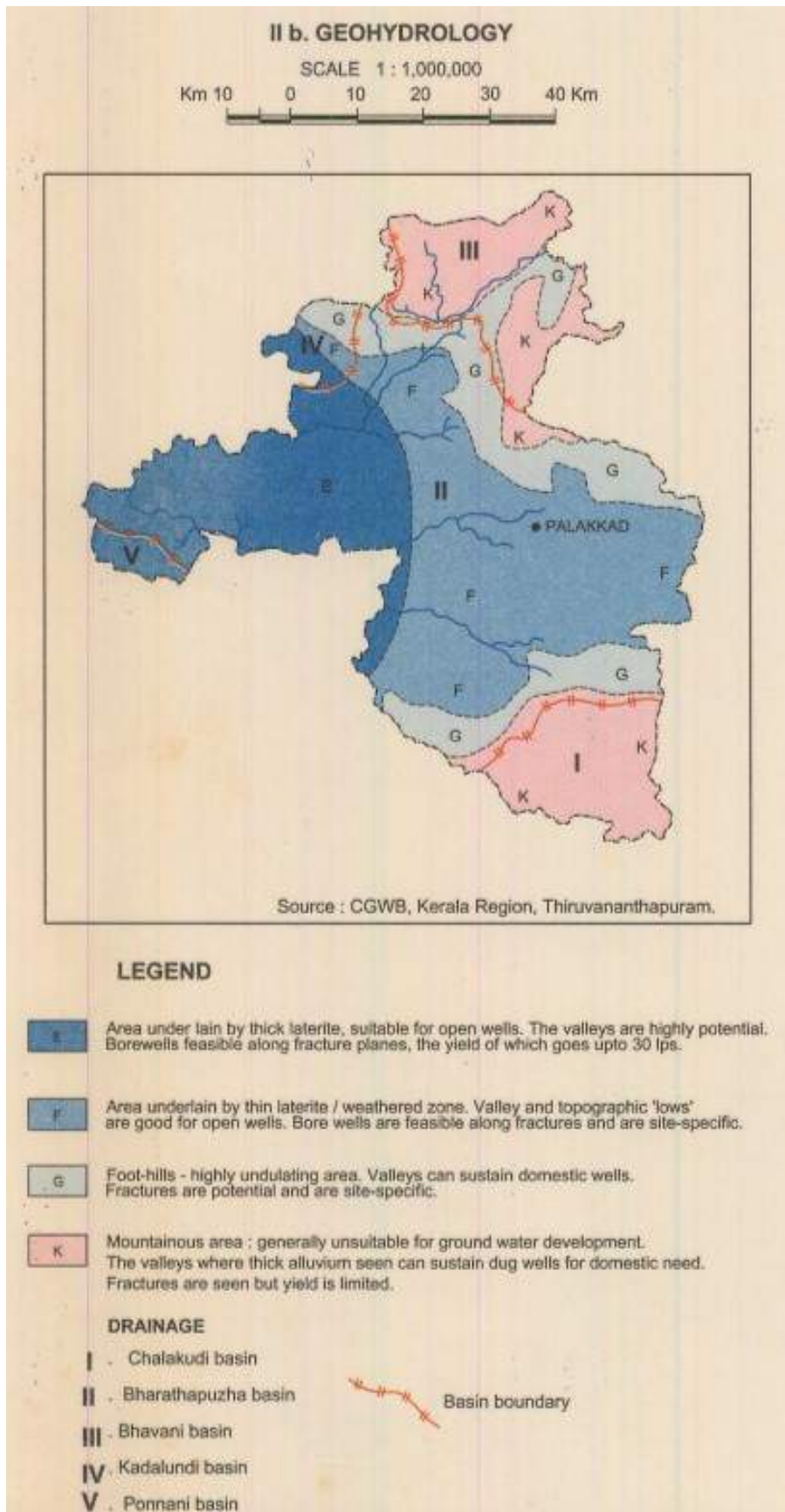


Figure 4: Geohydrology of Palakkad. (Source: District Resource map, Palakkad district, Geological Survey of India)

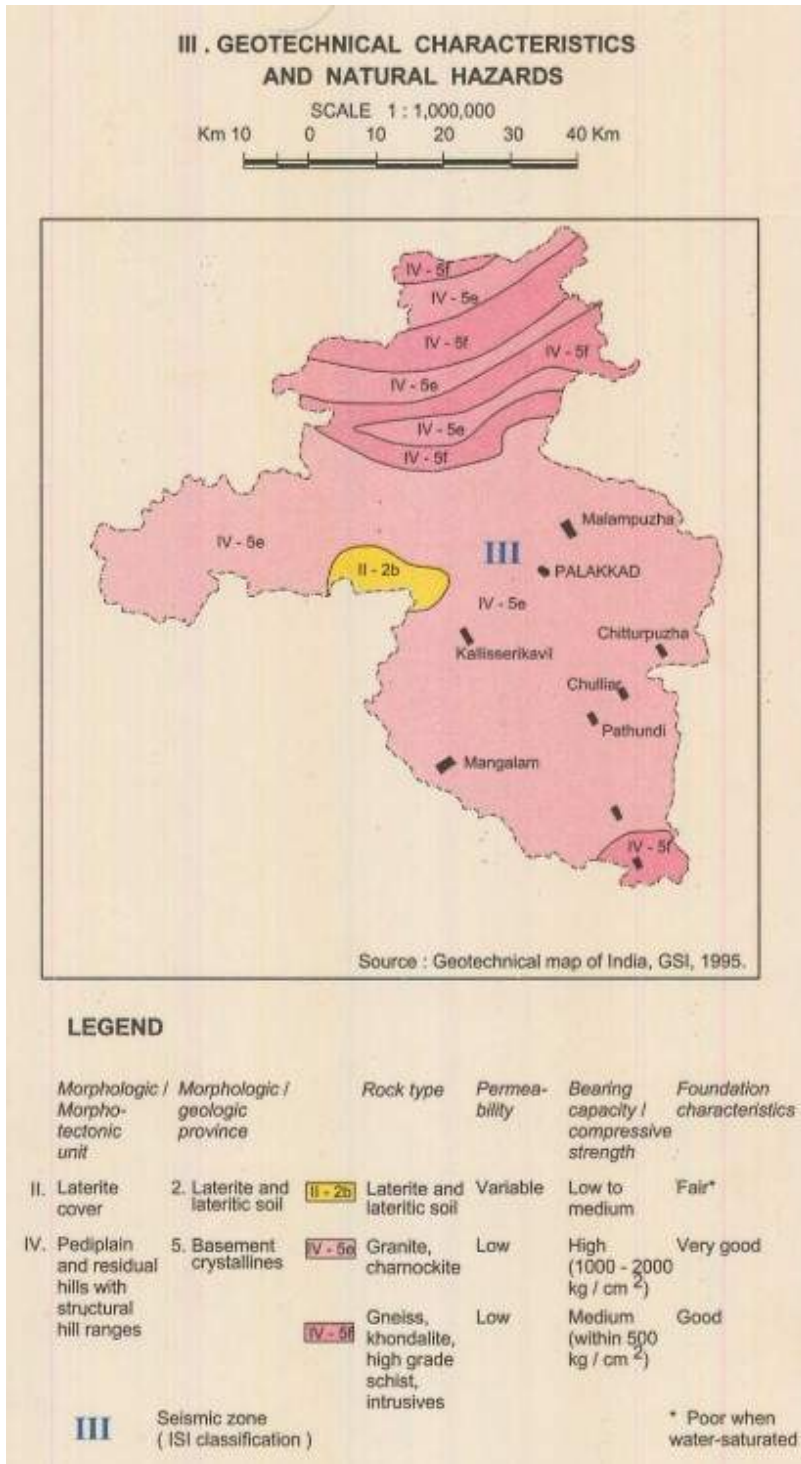


Figure 5: Geotechnical characteristics and natural hazards map of Palakkad.

(Source: District Resource map, Palakkad district, Geological Survey of India)

9 Natural hazards

The area comes under zone III and indicates moderate seismicity (*Figure 5*).

10 Mineral Resources

10.1 Major minerals

Limestone, gold and magnesite are some of the important minerals reported from the district. Crystalline limestone in association with calc-granulite is found at Panda and Vainamadai areas. Epigenetic quartz veins intruding into amphibolites/granite gneiss/quartz-biotite gneiss in Attapady area are known for gold mineralisation. Numerous thin bands of magnetite quartzite (iron ore) are reported from a number of places. Good deposits of kankar occur in Chittur and Kozhinjampara areas. From Attapady valley, magnesite, scheelite, mica, beryl and sillimanite are reported. White to buff coloured china clay occurs within the highly altered gneissic terrain in the vicinity of Palakkad. Iron ore bands occur in the north eastern and southern parts of the district at several places.

In this district the only major mineral that is mined is limestone and the same is mined by M/s Malabar Cements Ltd. Walayar. The mine is operated in 245.69 ha in Malampuzha I and Pudussery East villages of Palakkad Taluk.

10.2 Minor Minerals

10.2.1 Ordinary Earth

Ordinary earth is the common name used for the soils. Soil is made up of three main components – minerals that come from rocks below or nearby, organic matter which is the remains of plants and animals that use the soil, and the living organisms that reside in the soil. The proportion of each of these is important in determining the type of soil that is present. But other factors such as climate, vegetation, time, the surrounding terrain, and even human activities (eg. farming, grazing, gardening, landscaping, etc.), are also important in influencing how soil is formed and the types of soil that occur in a particular landscape. The formation of soils can be seen as a combination of the products of weathering, structural development of the soil, differentiation of that structure into horizons or layers, and lastly, of its movement or translocation. In fact, there are many ways in which soil may be transported away from the location where it was first formed. Soils represent one of the most complex and dynamic natural systems and are one of the three major natural resources, other than air and water.

Knowledge of their chemical, physical and biological properties is a prerequisite both for sustaining the productivity of the land, e.g. agriculture, and for conservation purposes. Soil is an integral part of a terrestrial ecosystem and fulfills numerous functions including the capacity to generate biomass and the filtering or buffering activities between the atmosphere and the groundwater in the biosphere. Soils have many important functions. Perhaps the best appreciated is the function to support the growth of agricultural and horticultural crops. Soil is the mainstay of agriculture and horticulture, forming as it does the medium in which growth and ultimately the yield of food producing crops occurs. Farmers and gardeners have worked with their soils over many centuries to produce increasing amounts of food to keep pace with the needs of a burgeoning world population. The soil's natural cycles go a long way in ensuring that the soil can provide an adequate physical, chemical and biological medium for crop growth. As well as being essential to agriculture, horticulture, forestry and natural and semi-natural systems, soil also plays an important role for our fauna. The soil itself contains millions of organisms, the exact nature and role of which we are still trying to determine. Undoubtedly, the soil flora and fauna play a vital role in cycles which are fundamental to the ability of the soil to support natural and semi-natural vegetation without additions of fertilizer and other support mechanisms. They breakdown plant debris, take in components from the atmosphere, aerate the soil together with many other functions that make the soil such an important medium.

Classification of soils (ordinary earth) commonly found in the district

The topo-lithosequence along with variation in rainfall, temperature and alternate wet and dry conditions particularly from the western coast to high ranges in the east and swift flowing rivers lead to the development of different types of natural vegetation and soil. The soils can be broadly grouped into coastal alluvium, mixed alluvium, acid saline, kari, laterite, red, hill, black cotton and forest soils. Soil map given below may be referred to find out its occurrences.

Mixed Alluvium

These soils are developed from fluvial sediments of marine, lacustrine and riverine sediments or its combinations. They occur below 20m MSL in the lowland plains, basins, valleys and along the banks of major rivers. The mixed alluvium is mainly noticed close to coastal alluvium, Kuttanad and adjacent area and kole lands of Thrissur district. The soils are frequently flooded and submerged. The soils of depressions and broad valleys are subject to occasional flooding and stagnation. The ground water table of these soils is generally high and it reaches above the surface during rainy season. A wide variation in texture is noticed in these soils. Sandy clay loam to clay is the predominant texture. Sandy loam soils are also met with.

Light grey to very dark brown is the common colour of the soil. Paddy, other annuals and seasonal crops like banana, tapioca and vegetables are grown here.

Laterite soil

Laterite and laterite soil are the weathering products of rock in which several course of weathering and mineral transformations take place. This involves removal of bases and substantial loss of combined silica of primary minerals. In laterite and laterite soils, over acidic rocks, induration and zonation are more pronounced. This induration is greater if the iron content is higher. These soils mainly occur in the midlands and part of lowlands at an elevation of 10 to 100m above MSL as a strip between the coastal belt and hilly mid-upland. The area comprises of mounds and low hills with gentle to steep slopes. Laterite soils are generally suitable for most of the dry land crops. It is mainly cultivated with coconut, arecanut, banana, tapioca, vegetables, yams, pepper, pineapple, fruit trees etc. The percentage of gravel content in the soil and reduced soil depth limits the choice of crops. In laterite outcropped area with shallow soils, only cashew can be grown with vegetables.

Black Cotton Soil

These soils are identified in alluvial plains, terraces and undulating plains of Chittur taluk in Palakkad district in patches. The elevation of the area ranges from 100 to 300m above MSL with gentle to moderate slope. These soils are developed on Khondalite suite of rocks traversed by lenticular bands of crystalline limestone and calc-granulites. These soils are very deep, black and calcareous. The texture of the soil ranges from clay loam to clay. They possess high shrink-swell capacity and hence exhibit the characteristic cracking during dry periods. A variety of crops such as coconut, sugarcane, cotton, chilly, pulses and vegetables are grown here.

Hill Soil

The hill soils mostly occur above an elevation of 80m MSL. The area is hilly and has highly dissected denudational hills, elongated ridges, rocky cliffs and narrow valleys. The general slope range is above 10%. The texture of these soils generally ranges from loam to clay loam with average gravel content of 10 to 50%. In addition, stones and boulders are noticed in the subsoil. These soils have reddish brown to yellowish red/strong brown colour. Generally, increase in clay content is noticed down the profile. The depth of the soil varies considerably from 60 to 200 cm depending on erodability of soil and past erosion. These soils are mostly friable and subject to heavy soil erosion. The area is suitable for all dry land crops like rubber, coconut, arecanut and fruit trees based on the topography. Crops such as banana, pepper, pineapple, vegetables can be grown in foot slopes.

Forest Soil

These soils are developed from crystalline rocks of Archaean age under forest cover. They occur along the eastern part of the State, generally above an elevation of 300m above MSL. The area is hilly and mountainous with steep slopes, escarpments, elongated rocky summits and narrow 'V' shaped valleys. The depth of the soil varies considerably depending on erosion and vegetative cover. The soils are generally immature due to slow weathering process. Rocky outcrops and stones are noticed on the surface. Gneissic boulders under different stages of weathering are noticed in the subsoil. The texture of the soil ranges from sandy clay loam to clay with reddish brown to very dark brown colour. Forest trees, shrubs and grasses are grown here.

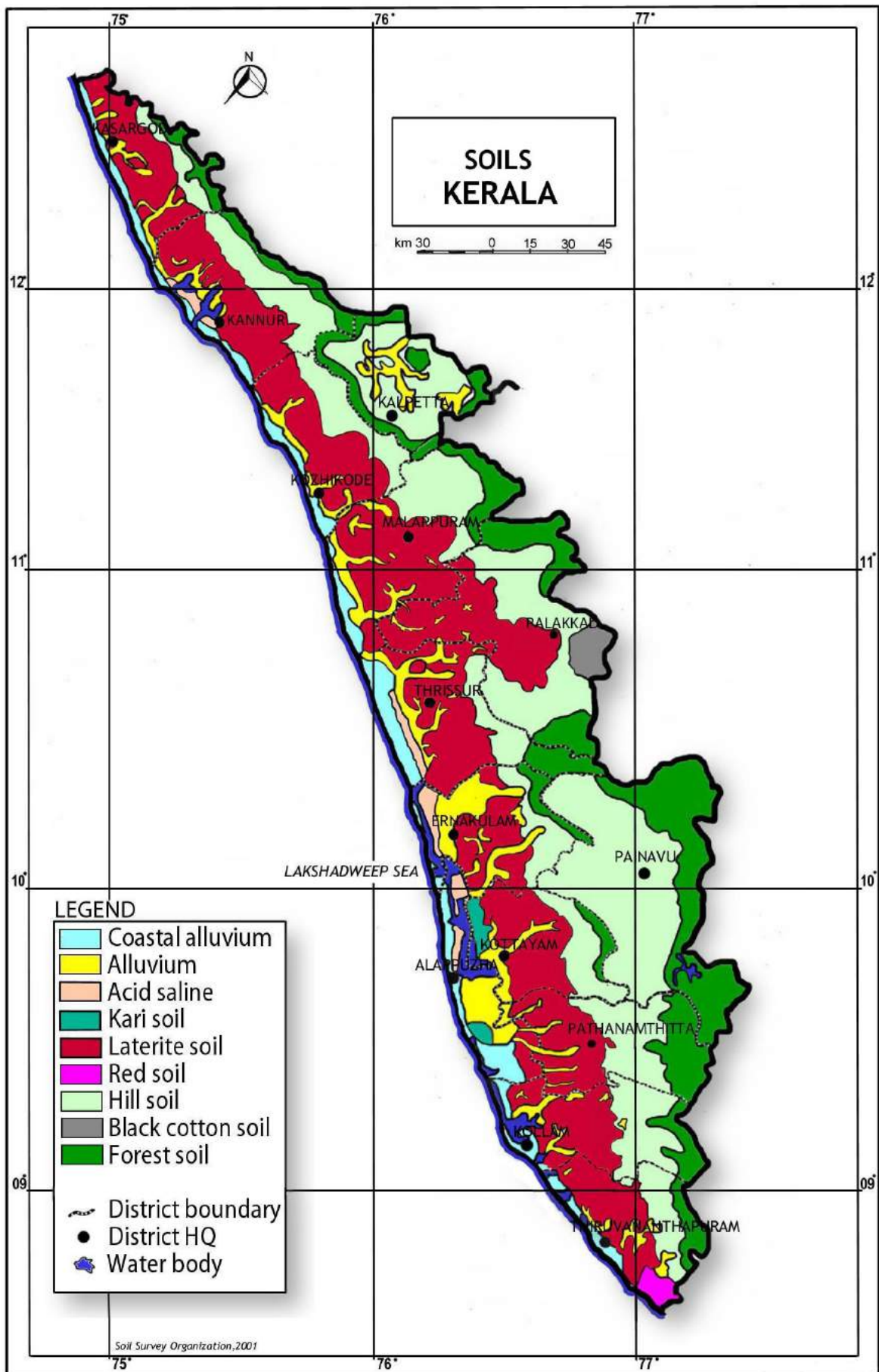


Figure 5: Soils of Kerala

Mining of ordinary earth

Usually ordinary earth is mined for levelling of ground for construction of buildings. Since ordinary earth is very important to mankind, it is not wise to mine ordinary earth for filling purposes alone. However, for the construction of roads and other infrastructure, ordinary earth is mined after obtaining quarrying permit from the Department of Mining and Geology. Mining and transporting ordinary earth/soil without the permission of Department of Mining and Geology is an offence. Department issues pass for transport of ordinary earth. Dealer's license is not issued for ordinary earth as it is not considered as a mineral mined for commercial purposes.

10.2.2 Ordinary Clay (tile/brick clay)

Clays and clay minerals occur under a fairly limited range of geological conditions and are produced by weathering of silicate minerals containing calcium, magnesium, sodium, or potassium reacting with carbonic acid, carbonates, and bicarbonates. These soluble products are removed by ground water, while the remaining elements, aluminium, silicon, and oxygen combine with water to produce stable clay minerals. The environment of formation include soil horizons, continental and marine sediments, geothermal fields, volcanic deposits, and weathering rock formations. Extensive alteration of rocks to clay minerals can produce relatively pure clay deposits that are of economic interest. Clay formed at the site of the parent rock is known as primary or residual clay; the one carried away or transported and deposited elsewhere is known as secondary clay. For obvious reasons, the former is purer with less impurity (5%–15%), while the latter may contain mica, quartz, and iron oxide as impurities. Geological factors such as conditions at the time of deposition and post-depositional changes have an important influence on the properties of sediment.

Buildings and utensils made of clay date back to the earliest periods of man's civilized development, and the use of clay is intimately associated with his history. Tile and brick kilns are closely associated with Kerala's culture and traditional architecture, which is continued in modern buildings as well.

In Kerala, tile/brick clay occurs in the wetlands/paddy fields in the lowlands and midlands. The clay extracted is used for a variety of purposes such as manufacture of roofing, flooring, and decorative tiles, wire cut (mechanically made) and ordinary bricks (manually made), and pottery wares. Studies carried out in clay mining areas of Kerala have proved that unprecedented increase in the development needs of the state and the subsequent increase in the resource extraction scenarios, especially that of clay mining, have led to rapid degradation

of the wetlands (paddy fields), which is significantly reflected in the declining agricultural productivity of the state. Mining of clays several meters below the prescribed levels, water draining from the unaffected paddy lands into the adjacent mine pits, and subsequent pumping of water for further mining impose severe problems on the hydrological regime, lowering the water table and creating severe water shortage problems in the mining areas. The additional expenditure incurred to meet the freshwater requirements of the people living in areas adjacent to mining sites is increasing year after year, which undermines the short-term economic benefits of resource extraction.

Tile and brick clay mining and its processing provide employment opportunities to a considerable section of the people in the midland and lowland areas of Kerala. Adding to this, thousands of labourers in the construction industry also indirectly depend on the products manufactured from these clays. Under these circumstances and also with respect to the demand incurred, complete restriction of extraction activities does not prove to be viable.

In the study report published by National Center for Earth Science Studies on the impact of clay mining, following recommendations were given with respect to tile/brick clay mining:

“It is of imminent importance to regulate random mining from the paddy fields/wetlands of Kerala by allowing only location-specific resource extraction under well-conceived guidelines. It is also crucial to limit the extraction of tile and brick clays to meet indigenous and local demand only. This is to save the prime agricultural land and also to increase the rice production in the area. The depth of mining should be demarcated so as to regulate mining with respect to the water table condition in the summer season. Also, adequate measures are to be taken to regenerate the natural ground water table using the stored water in the clay mine pits for irrigating the agricultural crops of the hinterland areas. This will enhance the net agricultural productivity of the area in addition to saturating the aquifer systems in the hinterlands. Awareness creation among the public about the adversities of clay mining and as well as the economic benefits of using clay bricks for construction purposes will serve in the protection of our wetlands/paddy fields. Recycling of building materials should also be considered in order to reduce mining of tile and brick clays. The abandoned clay mine areas left behind as fallow lands or water logged areas can be used for productive purposes such as fish farm ponds or irrigation ponds that promise some utility to the society. Also, suitable guidelines should be framed to streamline the tile and brick clay mining activities of the state on an eco-friendly basis.”

The Kerala Conservation of Paddy Land and Wetland Act, 2008 and Rules made thereunder which was enacted for conservation of paddy land and wetlands of Kerala imposes restrictions

in mining of tile/brick clays in such areas. The said Act and Rules are implemented by Revenue Department. In addition, Government have setup District Expert Committee to monitor and control the mining activities of ordinary clay. In Kerala Minor Mineral Concession Rules 2015, it is mandated that No Objection Certificate from the District Collector concerned, based on the recommendation of the District Expert Committee constituted by the Government in this regard, is to be produced by the applicant in the case of application for extraction of ordinary clay. In addition, Bank guarantee from any Nationalized or Scheduled Bank at the rate of Rs. 300/- (Rupees three hundred only) per cubic metre for the purpose of reclamation of pits that will be formed after quarrying in the area permitted, in respect of application for extraction of ordinary clay. Based on the request of the entrepreneurs working in tile/brick clay based industry, Government have instructed the Department of Mining and Geology to carry out survey to identify the mineable tile/brick clay deposits of Kerala and the work in this respect is progressing.

10.2.3 Ordinary Sand

In Kerala Minor Mineral Concession Rules, 2015, the ordinary sand is defined as sand used for non-industrial purpose. This includes both river sand and sand excavated from inland areas like palaeo-channels. Since a separate Act has been enacted by Government of Kerala namely, The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001 (hereafter referred to as Sand Act, 2001) and since the mining of river sand is controlled by Revenue Department by virtue of the powers conferred by the said Act and the Rules made thereunder, the Department of Mining and Geology now regulates the mining of sand which do not comes under the purview of Sand Act, 2001.

The ordinary sand (other than river sand) occurs in the palaeo-channels. The word palaeo-channel is formed from the words “palaeo” or “old,” and channel; i.e., a palaeo-channel is an old channel. Palaeo-channels are deposits of unconsolidated sediments or semi-consolidated sedimentary rocks deposited in ancient, currently inactive river and stream channel systems. These are typical riverine geomorphic features in a location representing drainage streams, rivers, rivulets which were flowing either ephemeral or perennial during the past time and now stands either buried or lost or shifted due to tectonic, geomorphologic, anthropogenic process/activities, as well as climatic changes. When a channel ceases to be part of an active river system, it becomes a palaeo-channel. In order to tap the ordinary sand occurring in palaeo-channels, the Department entrusted the study of identification of palaeo-channels in major river basins of Kerala to Geological Survey of India (GSI). GSI resorted to remote

sensing studies using satellite imageries and delineated some of the palaeo-channels. However, since such deposits falls in paddy land/wetlands of Kerala, it is difficult to extract such sand on account of restrictions imposed by various Acts and Rules.

The Kerala Conservation of Paddy Land and Wetland Act, 2008 and Rules made thereunder which was enacted for conservation of paddy land and wetlands of Kerala imposes restrictions in mining of ordinary sands occurring in wetlands and paddy fields. The said Act and Rules are implemented by Revenue Department. In addition, Government have setup District Expert Committee to monitor and control the mining activities of ordinary sand. In Kerala Minor Mineral Concession Rules 2015, it is mandated that No Objection Certificate from the District Collector concerned, based on the recommendation of the District Expert Committee constituted by the Government in this regard, is to be produced by the applicant in the case of application for extraction of ordinary sand. In addition, Bank guarantee from any Nationalized or Scheduled Bank at the rate of Rs. 300 (Rupees three hundred only) per cubic metre for the purpose of reclamation of pits that will be formed after quarrying in the area permitted, in respect of application for extraction of ordinary sand.

The mining of ordinary sand from palaeo-channels also case some environmental concerns. Since sand is a good aquifer, the mining of aquifer system poses threat to ground water availability in surrounding areas. However in certain cases, the mining of such sand from paddy lands increase the productivity of paddy as excess sand in the paddy lands are not good for paddy.

In Kerala, due to shortage of river sand and ordinary sand occurring in palaeo-channels, the construction industry now uses manufactured sand obtained by crushing of crystalline rocks.

It may be noted that since the Revenue Department is taking care of all types of mining activities related to river sand and since sand auditing and other studies are carried out under the aegis of the Revenue Department, this report shall not be used for the purpose of obtaining prior environmental clearance for mining of river sand.

10.2.4 Laterite

Laterite is a soil and rock type rich in iron and aluminium, and is commonly considered to have formed in hot and wet tropical areas. Nearly all laterites are of rusty-red coloration, because of high iron oxide content. They develop by intensive and long-lasting weathering of the underlying parent rock. Tropical weathering is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the

resulting soils. The majority of the land area containing laterites is between the tropics of Cancer and Capricorn.

Angadipuram Laterite is a National Geological Monument identified in Angadipuram town in Malappuram district. The special significance of Angadipuram to laterites is that it was here that Dr. Francis Buchanan-Hamilton, a professional surgeon, gave the first account of this rock type, in his report of 1807, as "indurated clay", ideally suited for building construction. This formation falls outside the general classification of rocks namely, the igneous, metamorphic, or sedimentary rocks but is an exclusively "sedimentary residual product". It has a generally pitted and porous appearance. The name laterite was first coined in India, by Buchanan and its etymology is traced to the Latin word "letritis" that means bricks. This exceptional formation is found above parent rock types of various composition namely, charnockite, leptynite, anorthosite and gabbro in Kerala. The laterite profiles in different types of rocks vary depending on the composition of parent rock. For example in Charnockites, the thickness of the profile ranges from 2 m to 10 m with humus zone on the top with thin pebbly zone (with ferruginous pellets in clayey matrix), underlain by vermicular laterite with tubular cavities of various shapes and size filled with kaolinitic clay. This is followed by thin layer of lithomarge. Further below completely weathered, partly weathered or fresh parent rock occur. In some places one can see hard duricrust at the top.

The mineralogical study of laterites reveals that all the silicate minerals have been transformed to a mixture of goethite, hematite and kaolinite in laterite samples developed over charnockite. Further studies revealed that pyroxenes have been altered to goethite while feldspars gave rise to kaolinite. Quartz is cracked, eroded and disintegrated. Monazite and Zircons are found as accessory minerals.

Laterite and bauxite show a tendency to occur together. Aluminous laterites and ferruginous bauxites are quite common. The most common impurity in both is silica. Laterite gradually passes into bauxite with decrease in iron oxide and increase in aluminium oxide. The laterite deposits may be described on the basis of the dominant extractable minerals in it: (i) aluminous laterite (bauxite), (ii) ferruginous laterite (iron ore), (iii) manganiferous laterite (manganese ore), (iv) nickeliferous laterite (nickel ore) and (v) chromiferous laterite (chrome ore). Laterite with $Fe_2O_3:Al_2O_3$ ratio more than one, and $SiO_2:Fe_2O_3$ ratio less than 1.33 is termed as ferruginous laterite, while that having $Fe_2O_3:Al_2O_3$ ratio less than one and $SiO_2:Al_2O_3$ ratio less than 1.33 is termed as aluminous laterite. Laterite can be considered as poly-metallic ore as it is not only the essential repository for aluminium, but also a source of iron, manganese, nickel and chromium. Furthermore, it is the home for several trace elements like gallium and

vanadium which can be extracted as by-products. In Kerala laterites are extracted as building stones which are used for construction of building. Laterite as a building stone possesses one advantage that it is soft when quarried and can be easily cut and dressed into blocks and bricks which on exposure to air become hard. In addition, laterite (aluminous laterite) is extracted for industrial purposes (for eg. Cement industry). In addition to aluminous laterite, bauxites are also mined in Kerala. Hence, while granting mineral concession for laterite it is necessary to carry out the chemical analysis to establish whether the mineral is bauxite or aluminous laterite.

10.2.5 Granite Dimension Stone and Granite (building stone)

For administrative purpose the hard crystalline rocks which do not have any economic minerals are classified as granite dimension stones and granite (building stones). The definition given in the Kerala Minor Mineral Concession Rules 2015 is as follows:-

‘Granite dimension stones include all types of granites, dolerite, charnockite, leptynite and other crystalline rocks of Acid, Intermediate, basic and ultra basic groups of igneous and metamorphic origin which are suitable for cutting to pre-determined sizes, polishing, carving and amenable for making value-added products in decorative monumental and ornamental fields of industry as a high-value item. Granite (building stone) include all those group of rocks specified above which are not suitable for using as dimension stones as specified therein, but can be used as ordinary building stones, road metal, rubble and ballasts after breaking into irregular pieces by blasting or otherwise as low value item. The Rules insists that the rocks having the quality of granite dimension stone shall not be quarried for granite building stone as these two types of rocks have different values/royalties’.

The major granite dimension stone occurrence in the district forms part of Charnockite-Khondalite belt and has colour ranging from pale green with mottled red, bluish green with cordierite, deep dark green, greyish white.

All Archaean and Proterozoic rocks of Kerala (refer section on Geology of Kerala) which are not listed above as granite dimension stone falls under the category of granite (building stone) and are found below ordinary earth/laterites/and other sedimentary rocks. In some cases such rocks are exposed as hillocks without any overburden.

11 Details of minor mineral concessions and revenue collection

Permission for mining will be granted on case to case basis on ascertaining the availability at the site and only if conditions stipulated in the KMMC Rules 2015 are satisfied (The reader may refer the KMMC Rules 2015 available in the website www.dmg.kerala.gov.in for more details in this regard). The concession will be granted only if other statutory licenses like Environmental Clearance, Explosive Licence, consent to operate issued by State Pollution Control Board, NOC issued by Revenue Department (as the case may be), Dangerous and Offensive Trade Licence issued by Local Self Government Institutions, NOC related to Coastal Regulation Zone (as the case may be), NOC issued by Forest (as the case may be) etc. The mineral concession will not be granted in the ecologically sensitive areas, ecological fragile zones etc.

10.2 Status of mining in Palakkad district

Table1: Details of revenue collection for the period 2013-'14, 2014-'15 and 2015-'16 (amount in Rs.)

MINERALS	2013-'14	2014-'15	2015-'16
MAJOR			
Limestone	2,82,78,054	3,05,45,550	4,92,89,589
Laterite	2,75,000
Total (Major)	2,85,53,054	3,05,45,550	4,92,89,589
MINOR			
Granite Building stone	1,94,86,850	4,65,86,941	9,21,61,393
Laterite	9,90,218	5,40,508	46,50,591
Brick clay/Ordinary clay	65,123	2,24,952	89,400
Ordinary sand	2,90,220	7,81,029	10,32,245
Ordinary Earth	27,63,012	8,20,622	2,71,10,265
River sand	44,74,400	86,46,600	...
Granite Dimesnion stone	...	1,82,464	...
Total (Minor)	2,80,69,823	5,77,83,116	12,50,43,894
Grand Total (Major + Minor)	5,66,22,877	8,83,28,666	17,43,33,483

List of valid mineral concessions

Table 2a: List of Quarrying Lease granted for Granite building stone								
Sl. No.	Concession Holder's Name & Address	Concession No.	Survey No/ Re.Survey No.	Village	Taluk	Area (Ha)	Valid from	Valid to
1	Jacob Barry, Barry Estate, Kattusery(PO), Alathur.	269/2007-08/4448/M3/2007 dated, 20.07.07	Resy.no. 340/2pt	Alathur	Alathur	1 Hectres,	12years, 25.07.07	24.07.2019
2	M.D.Anil kumar, M/s Macadam Granites(P)Ltd, Pannikkode (PO), Palakkad	185/2007-08/4569/M3/2007/Dated, 19.06.07	ReSy.No. 427 pt, 435pt.	Erimayur II	Alathur	3.3630 hectres,	10 Years 21.07.2007	20.07.2017
3	M/s. Sahara Granites, Erimayur P.O, Palakkad	63/2012-13/3857/M3/2012 Dt. 28.04.2012	Sy.No. 35/2 & 35/3	Erimayur-I	Alathur	1.8485 Hectares	12 Years 02/05/2012	01-05-2024
4	M/s. Sahara Granites, Erimayur P.O, Palakkad	65/2012-13/3858/M3/2012 Dt. 28.04.2012	Re.Sy.No. 35/2	Erimayur-I	Alathur	2.4282 Hectares	12 Years 02/05/2012	01-05-2024
5	M/s. Sahara Granites, Erimayur P.O, Palakkad	66/2012-13/3859/M3/2012 Dt. 28.04.2012	Re.SyNo. 35/2	Erimayur-I	Alathur	2.6102 Hectares	12 Years 02/05/2012	01-05-2024
6	Sebi. P.L., S/o P.C. Lonai, Panikulangara House, Fashion Street, Mission Quarters, Thrissur - 5	389/2011-12/7219/M3/2011 dt. TVPM, 24.09.2011	Rsy No. 33/2 and 234/2	Kannambra I	Alathur	1.4504 Hect	12 years, 28.09.2011	27.09.2023
7	M/s Kottukapilly Sand & Metals (p) Ltd.,	298/2011-12/5714/M3/2011 dt. 16.08.2011	Sy No. 3/2	Kizhakkachery II	Alathur	2.8409 Hect	10 Years 23.09.2011	22.09.2021

	Kalpathy P.O., Palakkad.							
8	V.Sasidharan, Propreitor, M/s. SriSri Granites, Peecharoad, Chithali (PO), Palakkad	240/2008-09/6739/M3/08/ dated, 14.07.08	Sy.no.663/4,8,9, 10	Kuthanur.1	Alathur	1.4089 Hectres	10 years 28.07.08	27.07.2018
9	Johsn Thomson, Proprietor, M/s. Tropical Granites, Tropical Estate, Kuthanur. P.O, Alathur, Palakkad	492/2008-09/9439/M3/2008/dated, 15.11.08	Resy.no. 651/8	Kuthanur.1	Alathur	1.9320 Hectres	12 years 05.01.09	04.01.2021
10	P.P. Sebastian, Poovathukaran House, Thalore P.O., Thrissur	329/2010-11/4775/M3/2010 dt. 20.08.2010	Resy.No. 268/2pt	Vadakkenchery I	Alathur	0.4318 Hect	12 Years 27.9.2010	26.09.2022
11	P.T.Davis, Managing Partner, Thomson Metals, Kombidinjamakkal,PO, Thazekkad	58/2011-12/2870/M3/2011 dt.04.05.2011	Re.Sy. Nos. 208/1, 208/3,209/pt.,210/2 ,210/3,210/4,210/5	Muthalamada I	Chittur	4.8366 Hect.	12 Years 13.05.2011	12.05.2023
12	Binil K John, Mg. Director, Valluvanad quarries and Granites(Pvt) Ltd., Angamally, Ernakulam.	747/2010-11/910/M3/2011 dt. 31.01.2011	Resy No. 330/2 pt., 330/3pt; and 331/1 pt.	Ambalappara I	Ottappalam	1.5348 Hect	12 Years 11.02.2011	10.02.2023
13	Ajaiwilson, Managing Partner, M/s Malabar Blue Metal, Vengassery	184/2008-09/7822/M3/2007 dated, 19.08.08	Sy.Nos. 460/5pt, 462/9, 462/5, 106/1 pt	Ambalappara.1.	Ottappalam	1.4164 hectres,	12 years 18.07.08	17.07.2020

	(PO) Ambalappara, Palakkad.							
14	Raphy.P.J., Pudussery pady House, Thrikkur (PO), Thrissur.	296/2008- 09/6890/M3/2008/dat ed, 13.08.2008.	Sy.no. 226/3	Chalavara	Ottappalam	0.8094 Hect.	10 years, 26.09.08	25.09.2018
15	M/s Blue Chips Mines & Industries, Vembalathupadam, Kailiyad P.O., Ottappalam.	Pro.order.No. 668/2008- 09/7814/M3/08 dt Tvpmm, 31.01.2009 and 304/09- 10/7814/M3/08 dt. 14.09.2009 and Re execution vide Pro.No. 268/2011- 2012/7814/M3/2008 dt. 29.07.2011 of DMG	Sy No. 168/ 11 A,	Chalavara	Ottappalam	1.6100 Hect	12 Years 26.08.2011	25.08.2023
16	Geosons Aggregates, Amayur, Pattambi, Palakkad.	32/2006- 07/3471/M3/06 dated, 25.04.06	59/4	Koppam	Ottappalam	0.6070 hectres,	12 years 07.06.2006.	06.06.2018
17	M.K.Joseph, Mg. Partner, M/s. Malabar Granites, Amayur P.O., Pattambi, Palakkad.	792/2010- 11/4999/M3/2010 dt. 24.02.2011	Resy Nos. 365,366 367/5	Koppam	Ottappalam	3.5204 Hect	12 Years 09.03.2011	08.03.2023
18	M/s J & P Construction & J & P Granites, Choorakode P.O., Pattambi, Palakkad.	Pro.order No. 535/2011- 12/7819/M3/2011 dt. 15.11.2011.	Rsy No. 7578/2	Vallappuzha	Ottappalam	1.6190 Hect.	10 Years 30.11.2011	29.11.2021

19	M/s. Malabar Granite Metal, Vaniamkulam Mannannur (PO) Kavalappara, Palakkad	860/2007-08/1283/M3/2008/dated, 28.02.08	SyNo. 39/1pt 39/2pt	Vaniamkulam.2	Ottappalam	1.5702 Hectres	10 years 26.03.08	25.03.2018
20	Binil K John, Managing Partner, M/s. Valluvanad Granites, Nellikkurussi. P.O, Mulanhur, Ottappalam, Palakkad	418/2014-15/9639/M3/2014 Dt. 27/09/2014	Re.Sy.No. 2/2, 5/2	Lakkidi -Perur-1	Ottappalam	1.7822 Hectares	20-10-2014	30-10-2018
21	Smt. Annie Sannie, Mg. Director, M/s Malayakam Aggregates & Sands(P) Ltd, chazhiyattiri (PO), Palakkad	482/2007-08/7505/M3/07 dated, 01.11.07	sy.no. 274 pt.	Thirumittakkode.2	Ottappalam	1.7800 Hectres	12 years 13.11.07	12.11.2019
22	Saji Mon Abraham, S/o Abraham, Palakkattu House, Kummanoor, Kidangoor P.O., Kottayam.	120/2010-11/3355/M3/2010 dt. 26.05.2010	Resy.No: 110/1, 110/3	Akathethara	Palakkad	2.7721 Hect (6.85 acre)	12 Years 11.08.2010	10.08.2022
23	M/s. Royal Sand & Gravels (P) Ltd., Plaza Junction, Dhoni.(P.O), Palakkad	281/2014-15/8473/M3/2014 Dt. 02/08/2014	Sy.No. 2/P, 14/P, 15/P, 16/1P	Akathethara	Palakkad	7.0655 Hectares	12 years 22/08/2014	21-08-2026
24	P.I.Devassia, Arumani Estate, Nochipully, Mundur, Palakkad.	431/2007-08/6475/M3/2007 DATED, 05.10.07	Resy.no. 449/1pt	Mundur.2	Palakkad	0.8174 Hectres	12years, 01.12.07	30.11.2019

25	Sabu Thomas, Kalapurackal House, Ayarkunnam(PO), Kottayam.	200/2007- 08/4819/M3/2007 dated, 25.06.07	Resy.no. 320/2	Puthussery central	Palakkad	1.4165 Hectres,	12 years from 06.08.07	05.08.2019
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Table 2b: List of Quarrying Permit granted for Granite Building Stone

Sl. No.	Concession Holder's Name & Address	Concession No.	Survey No/ Re.Survey No.	Village	Taluk	Area (Ha)	Valid from	Valid to
Alathur Taluk								
1	P.J.Joshy, Managing Partner, M/s. Penta Granites, Neethipuram, Elavampadam	127/GBS/DOP/2429/2015/A1	Re.Sy.No.278/35	Kizhakkanchery-II	Alathur	99.72 Are.	23-11-2015	22-11-2016
2	T.Santhosh, Managing Partner, M/s. Deepam Granites, Muringamala, Vemballur	142/GBS/DOP/1688/2015/A1/CRPS	Re.Sy.No. 435, 437/1	Erimayur-II	Alathur	77.18 Are	07-12-2015	06-12-2016
3	P.J. Joshy, Managing Partner, M/s. Pee Jay Granites, Chittadi. P.O, Palakkad	147/GBS/DOP/2623/2015/A1	Sy.No. 119/1-2	Vandazhy-I	Alathur	100 Are.	14-12-2015	13-12-2016
4	A.G. Madhavan, Managing Director, M/s. Gayathri Aggregates (P) Ltd., Muringamala,	153/GBS/DOP/2622/2015/A1/CRPS	Re.Sy.No 463/7, 8	Thenkurussi-II	Alathur	22.4 Are.	21-12-2015	20-12-2016

	Vemballur. P.O, Thenkurissi, Palakkad.							
5	O.P. Muhammed Rasheed, Managing Partner, M/s. Bestonne Granite Metals Pvt. Ltd., Nochully.P.O, Kuzhalmannam, Palakkad	156/GBS/DOP/2715/ 2015/A1/CRPS	Sy.No 490/1	Kuzhalmannam-I	Alathur	48.56 Are.	23-12-2015	22-12-2016
6	Unnikrishnan. A, Chekkini House, Paruvassery. P.O, Vadakkanchery	157/GBS/DOP/2292/ 2015/A1/CRPS	Sy.No. 1/1, 1/2	Vandazhy-II	Alathur	49.80 Are.	23-12-2015	22-12-2016
7	Vinumani, Managing Partner, M/s. Paramout Granites, Chittady. P.O, Kunnamkulam, Odukoor, Palakkad	160/GBS/DOP/2778/ 2015/A1/CRPS	Sy.No. 223/ pt	Vandazhy-I	Alathur	37.40 Are	13-01-2016	12-01-2017
8	P.P. Vincent, Managing Partner, M/s. Gayathri Rock Products, Pazhambalakode, Palakkad	178/GBS/DOP/2777/ 2015/A1/CRPS	Re.Sy.No. 208/8,9, 209/3	Tarur-II	Alathur	36.43 Are	02-03-2016	01-03-2017
9	T.Santhosh, Managing Partner, M/s. Deepam Granites, Muringamala, Vemballur. P.O, Palakkad	179/GBS/DOP/2732/ 2015/A1	Re.Sy.No. 444/2,3,4	Erimayur-II	Alathur	64.55 Are	08-03-2016	07-03-2017

10	Unnikrishnan. A, S/o. Andi, Pulari House, Chekkini, Paruvassery. P.O, Vadakkanchery	01/GBS/DOP/1690/ 2015/A1/CRPS	Re.Sy.No. 80/1	Vandazhi-II	Alathur	9.71 Are	13-04-2016	12-04-2017
11	Unnikrishnan. A, S/o. Andi, Pulari House, Chekkini, Paruvassery. P.O, Vadakkanchery	02/GBS/DOP/1691/ 2015/A1/CRPS	Re.Sy.No. 80/1	Vandazhi-II	Alathur	9.72 Are	13-04-2016	12-04-2017
12	K.M. Jalal, S/o. Muhammed Haji, Kummenchery House, Puthupallipuram, Kanayannur, Chengampuzha Nagar, Ernakulam	09/GBS/DOP/1055/ 2016/A1	Re.Sy.No. 35/2	Erimayur-I	Alathur	80.97 Are	25-05-2016	24-11-2016
13	K.V. Radhakrishnan, Kundil House, Kuthanoor. Palakkad	13/GBS/DOP/1067/ 2016/A1/CRPS	Sy.No. 471/4	Kuzhalmannam	Alathur	8.09 Are.	01-06-2016	31-05-2017
14	Tomy Joseph, Proprietor, M/s. St. Joseph's Quarry, Chimbukkad. P.O, Palakkad	19/GBS/DOP/1198/ 2016/A1	Sy.No. 279/5	Kuthanur-I	Alathur	100 Are.	15-06-2016	14-06-2017
15	C. Rajeev, Chennathodi House, Edayur P.O, Valanchery, Malappuram.	20/GBS/DOP/1285/ 2016/A1	Re.Sy.No. 361/1, 362	Kuthanur-II	Alathur	68.81 Are.	15-06-2016	14-12-2016
16	Unnikrishnan. A, S/o. Andi, Pulari House, Chekkini, Paruvassery. P.O, Vadakkanchery	40/GBS/DOP/962/ 2016/A1/CRPS	Sy.No. 1/1	Vandazhi-II	Alathur	14.71 Are.	07-07-2016	06-07-2017

17	Unnikrishnan. A, S/o. Andi, Pulari House, Chekkini, Paruvassery. P.O, Vadakkanchery	48/GBS/DOP/1194/2016/A1/CRPS	Re.Sy.No. 182/2	Vadakkanchery-I	Alathur	8.9 Are	11-07-2016	10-07-2017
18	Danny Antony, Managing Partner, M/s. Carmal Granites, Pannikode, Manjapra. P.O.	50/GBS/DOP/1301/2016/A1	Re.Sy.No. 560/5	Kannambra-II	Alathur	56.42 Are.	11-07-2016	10-01-2017
19	A. Unnikrishnan, S/o. Andi, Chekkini House, Paruvassery. P.O, Vadakkanchery.	62/GBS/DOP/1547/2016/A1/CRPS	Re.Sy.No. 180/1	Vadakkanchery-I	Alathur	8.09 Are.	22-08-2016	21-08-2017
20	Unnikrishnan. A, S/o. Andi, Pulari House, Chekkini, Paruvassery. P.O, Vadakkanchery	63/GBS/DOP/623/2016/A1/CRPS	Re.Sy.No.439/3	Vadakkanchery-I	Alathur	9.00 Are	30-08-2016	29-08-2017
21	P.J. Joshy, Managing Partner, M/s. P.J. Granites, Chittadi. P.O.	65/GBS/DOP/2262/2015/A1	Re.Sy.No. 119/1-2, 119/1-3	Vandazhi-I	Alathur	100 Are.	09-09-2016	08-09-2017
22	A.G. Madhavan, Managing Director, M/s. Gayathri Aggregates Pvt. Ltd., Alangad, Vemballur. P.O	79/GBS/DOP/1701/A1/CRPS	Re.Sy.No. 34/5	Kavasseri-I	Alathur	96.27 Are	24-10-2016	06-12-2016

Chittur Taluk

1	S.Jayakumaran, S/o. R. Subbayan, R.M. Nivas, Vithinassery, Nemmara	144/GBS/DOP/2613/2015/A1/CRPS	Re.Sy.No .37/6	Ayilur	Chittur	9.71 Are.	09-12-2015	08-12-2016
2	Muthukumaraswamy, Kalathil House, Anpoor, Ozhalapathy, Palakkad	154/GBS/DOP/2405/2015/A1/CRPS	Re.Sy.No. 21/2	Ozhalapathy	Chittur	49.20 Are.	21-12-2015	20-12-2016
3	Smt. S. Bindu, W/o. K. Santhakumar, M/s. Seethu Granites Pvt. Ltd., Kacheripadam Kalam, Vithinassery, Nemmara	05/GBS/DOP/930/2016/A1/CRPS	Re.Sy.No. 103/1	Vallanghy	Chittur	47.75 Are.	10.05.2016	09-05-2017
4	Krishna Kumar, S/o. Late. Kunchu, Kunnu Parambu House, Vilayamchathanur, Vilayoor. P.O	07/GBS/DOP/1559/2015/A1/CRPS	Re.Sy.No. 298/8	Kollengode-II	Chittur	9.71 Are.	10.05.2016	09-05-2017
5	Krishna Kumar, S/o. Late. Kunchu, Kunnu Parambu House, Vilayamchathanur, Vilayoor. P.O	36/GBS/DOP/1147/2016/A1/CRPS	Re.Sy.No.165/14,15,16,17,18, 19	Koduvayur-II	Chittur	38.24 Are.	22-06-2016	21-06-2017
6	E.M. Pathumbi, Elavamkudi, Muthedath, Ponjassery. P.O	43/GBS/DOP/1393/2016/A1/CRPS	Sy. No. 325/1, 327/5	Pallassena	Chittur	29.54 Are.	07-07-2016	06-07-2017

7	K.P. Davis, Managing Partner, M/s. KGP Granites, Ravanakunnupara, Nattukal. P.O, Palakkad	47/GBS/DOP/1294/2016/A1	Re.Sy.No. 20/1,2	Ozhalppathy	Chittur	98.14 Are	11-07-2016	10-07-2017
8	K. Krishnakumar, S/o. Kunju, Kunhuparamb House, Vilayanchathanoor, Vilayoor. P.O.	49/GBS/DOP/40/2016/A1/CRPS	Sy.No. 295	Kollengode-II	Chittur	14.47 Are.	11-07-2016	10-07-2017
9	P.L. Joji, Managing Partner, M/s. Star Metals, Karamkode, Thenari. P.O, Elappully.	53/GBS/DOP/1350/2016/A1/CRPS	Re.Sy.No. 199/4	Nalleppilly	Chittur	47.00 Are	27-07-2016	28-07-2017
10	C. Gopinath, Managing Partner, Rock & Rock Granites, Kanakkampara, Kuttippallam. P.O	56/GBS/DOP/1395/2016/A1/CRPS	Re.Sy.No. 268/1	Thekkedesam	Chittur	36.75 Are	03-08-2016	02-08-2017
11	S. Jayakumaran, S/o. Subbyyan, R.M. Nivas, Vithinasasseri, Vallanghy, Nenmmara, Palakkad	69/GBS/DOP/1406/2016/A1/CRPS	Re.Sy. No. 37/6,7	Ayilur	Chittur	19.00 Are	23-09-2016	22-09-2017
12	A.K. Sasi, S/o. Krishnan, Athimattathil Veedu, Nellippadam, Nenmmara. P.O	70/GBS/DOP/1403/2016/A1/CRPS	Re.Sy.No. 219/1	Elavanchery	Chittur	45.22 Are	23-09-2016	22-09-2017

13	Krishnankutty, Kulavaramb House, Pallassena, Palakkad	74/GBS/DOP/1443/ 2016/A1/CRPS	Re.Sy.No. 328/2	Pallassena	Chittur	9.71 Are	17-10-2016	16-10-2017
14	Tom George, Managing Partner, M/s. TMT Granites Pvt. Ltd., Vadakkekalam, Mangalam Dam.	75/GBS/DOP/2027/ 2016/A1	Re.Sy.No. 232	Mangalam Dam	Chittur	95.17 Are.	17-10-2016	31-01-2017
15	Tom George, Managing Partner, M/s. TMT Granites Pvt. Ltd., Vadakkekalam, Mangalam Dam.	76/GBS/DOP/2026/ 2016/A1	Re.Sy.No. 232	Mangalam Dam	Chittur	91.06 Are.	17-10-2016	31-01-2017
16	Tom George, Managing Partner, M/s. TMT Granites Pvt. Ltd., Vadakkekalam, Mangalam Dam.	77/GBS/DOP/2028/ 2016/A1	Re.Sy.No. 232	Mangalam Dam	Chittur	95.17 Are.	17-10-2016	31-01-2017
Mannarkkad Taluk								
1	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P). 179, Pullassery. P.O,	135/GBS/DOP/2356/ 2015/A1/CRPS	Sy.No. 1/1	Alanallur-III	Mannarkkad	9.71 Are.	30-11-2015	29-11-2016

2	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P). 179, Pullassery. P.O,	146/GBS/DOP/2334/ 2015/A1/CRPS	Sy.No. 1/10	Thachampara	Mannarkkad	32.38 Are	14-12-2015	13-12-2016
3	Moideen Koya. V.P, M/s. Shad Mahal House, Marakkampoyil, Karaparamba, Kozhikkode	165/GBS/DOP/1116/ 2015/A1/CRPS	Sy.No. 893/3	Agali	Mannarkkad	14.57 Are.	08-02-2016	07-02-2017
4	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P). 179, Pullassery. P.O,	166/GBS/DOP/2673/ 2015/A1/CRPS	Sy.No.242/1A1	Pottassery-I	Mannarkkad	9.71 Are.	08-02-2016	07-02-2017
5	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	04/GBS/DOP/1702/ 2015/A1/CRPS	Sy. No. 208/1	Alanallur-III	Mannarkkad	9.712 Are	02-05-2016	01-05-2017

6	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	11/GBS/DOP/575/ 2016/A1/CRPS	Sy.No. 242/1A1	Pottassery-I	Mannarkkad	9.75 Are	30-05-2016	29-05-2017
7	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	14/GBS/DOP/1111/ 2016/A1/CRPS	Sy.No. 242/1A1	Pottassery-I	Mannarkkad	13.76 Are	01-06-2016	31-05-2017
8	P.T.V Musthafa, M/s. P.T.V Granites, Nattukal. P.O, Mannarkkad.	23/GBS/DOP/1150/ 2016/A1	Sy.No. 347/5	Thachanttukara-I	Mannarkkad	76.518 Are	15-06-2016	14-12-2016
9	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	32/GBS/DOP/1293/ 2016/A1/CRPS	Sy.No.53/4	Thachanattukara-II	Mannarkkad	24.32 Are.	18-06-2016	17-06-2017
10	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	33/GBS/DOP/1296/ 2016/A1/CRPS	Sy.No. 53/5	Thachanttukara-II	Mannarkkad	9.71 Are.	18-06-2016	17-06-2017

11	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	37/GBS/DOP/1107/ 2016/A1/CRPS	Sy.No. 308/2	Thachanattukara-I	Mannarkkad	9.716 Are.	22-06-2016	21-06-2017
12	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	38/GBS/DOP/1108/ 2016/A1/CRPS	Sy.No.339/2A	Alanallur-III	Mannarkkad	8.90 Are.	22-06-2016	21-06-2017
13	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	39/GBS/DOP/1295/ 2016/A1/CRPS	Sy.No. 347/3	Thachanattukara-I	Mannarkkad	13.30 Are.	23-06-2016	22-06-2017
14	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	41/GBS/DOP/1109/ 2016/A1/CRPS	Sy.No.208/1	Alanallur-III	Mannarkkad	9.71 Are.	07-07-2016	06-07-2017

15	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	42/GBS/DOP/1110/ 2016/A1/CRPS	Sy.No. 208/1	Alanallur-III	Mannarkkad	9.71 Are.	07-07-2016	06-07-2017
16	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	52/GBS/DOP/1437/ 2016/A1	Sy.No. 53/2	Thachanattukara-II	Mannarkkad	52.62 Are.	18-07-2016	17-07-2017
17	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	54/GBS/DOP/1447/ 2016/A1/CRPS	Sy.No. 347/2	Thachanattukara-I	Mannarkkad	9.6 Are	03-08-2016	02-08-2017
18	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	55/GBS/DOP/1583/ 2016/A1/CRPS	Sy.No.390/1A	Thachanattukara-I	Mannarkkad	9.6 Are	03-08-2016	02-08-2017
19	Hamsa Pathari, Pathari House, Nattukal. P.O	58/GBS/DOP/1366/ 2016/A1/CRPS	Sy.No.389/7B1	Thachanattukara-I	Mannarkkad	41.3 Are.	08-08-2016	07-08-2017

20	C.H. Sakkaria, President, Mannarkkad Taluk Karinkal Quarry Operators Vyvasaya Sahakarana Sangam Ltd., No. SIND (P) 179, Pullassery. P.O.	78/GBS/DOP/1697/ A1/CRPS	Sy.No. 54/8	Thachanattukara-II	Mannarkkad	9.71 Are	19-10-2016	18-10-2017
Ottappalam Taluk								
1	K.P. Moosakutty Haji, S/o. Mammootty Haji, Kulipilakkal Palliyalil House, A.R Nagar, Thirurangadi.	130/GBS/DOP/1535/ 2015/A1/CRPS	Sy.No.298/4, 297, 296	Cherplassery	Ottappalam	39.44 Are.	25-11-2015	24-11-2016
2	Sudhakaran. C, Changanakkattil, Kundurkunnu. P.O, Mannarkkad	132/GBS/DOP/1635/ 2015/A1/CRPS	Re.Sy.No. 76/pt	Karimpuzha-I	Ottappalam	9.68 Are.	25-11-2015	24-11-2016
3	K.V. Mohanan, S/o. Vijayan, Kuzhiyanvelyil House, Okkal.P.O, Kaladi	158/GBS/DOP/1865/ 2015/A1	Re.Sy.No. 568, 569/4, 576/1	Ambalappara-I	Ottappalam	77.18 Are	11-01-2016	10-01-2017
4	Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P) 176	162/GBS/DOP/2639/ 2015/A1/CRPS	Re.Sy.No. 446/5	Lakkidi Perur - I	Ottappalam	19.42 Are.	01-02-2016	31-01-2017

5	Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P) 176	168/GBS/DOP/2641/ 2015/A1/CRPS	Sy.No.452/3	Lakkidi Perur - I	Ottappalam	9.68 Are.	10-02-2016	09-02-2017
6	Krishnan, Palakkavil House, Adakkapurthur. P.O, Cherpulassery, Palakkad	175/GBS/DOP/1578/ 2015/A1/CRPS	Re.Sy.No. 145/2	Vellinezhi	Ottappalam	16.19 Are.	29-02-2016	28-02-2017
7	Abhilash, Nayakath Parambil House, Njangattiri, Ottappalam, Palakkad	176/GBS/DOP/1634/ 2015/A1/CRPS	Re.Sy.No. 49/13	Vellinezhi	Ottappalam	40 Are.	29-02-2016	28-02-2017
8	Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P) 176	180/GBS/DOP/1692/ 2015/A1/CRPS	Re.Sy.No. 481/1	Vellinezhi	Ottappalam	9.60 Are	09-03-2016	08-03-2017
9	Padmanabhan Nair, Pozhath House, Chunangad, Ottappalam	16/GBS/DOP/1149/ 2016/A1	Re.Sy.No. 330/2pt, 330/3pt	Vellinezhi	Ottappalam	69.00 Are	08-06-2016	07-12-2016
10	Murali. T, Thottingal House, Kadambazhipuram, Palakkad	17/GBS/DOP/1425/ 2015/A1/CRPS	Sy.No. 61/4	Kadampazhipuram- I	Ottappalam	7.7 Are.	08-06-2016	07-06-2017

11	P.K. Abdul Khader, M/s. Fathima Granites, Chunangad.P.O.	22/GBS/DOP/1164/ 2016/A1	Re.Sy. No. 291/3	Ambalappara-I	Ottappalam	65 Are.	15-06-2016	14-06-2017
12	P.K. Abdul Khader, M/s. Fathima Granites, Chunangad.P.O.	24/GBS/DOP/1165/ 2016/A1	Re.Sy.No. 291/3	Ambalappara-I	Ottappalam	60 Are	15-06-2016	14-06-2017
13	P.K. Abdul Khader, M/s. Fathima Granites, Chunangad.P.O.	34/GBS/DOP/1195/ 2016/A1/CRPS	Re.Sy.No. 257/4	Ambalappara-I	Ottappalam	27.53 Are.	20-06-2016	19-06-2017
14	C.K. Kunhipocker, Managing Partner, M/s.Kalpaka Metal Crushers, Kailiyad. P.O	64/GBS/DOP/1832/ 2016/A1	Sy.No. 1/7	Vaniyamkulam-I	Ottappalam	93.08 Are.	07-09-2016	06-09-2017
15	K. Saidhalavi, S/o. Moideen, Kunnath House, Pathamkulam. P.O	68/GBS/DOP/1325/ 2016/A1/CRPS	Re.Sy. No.402	Ananganadi	Ottappalam	100 Are.	19-09-2016	18-12-2016
16	George Joseph, M/s. PPK Granite & Crusher Products, Chunangad, Ottappalam	72/GBS/DOP/1326/ 2016/A1/CRPS	Re.Sy. No. 179/1	Ambalappara-II	Ottappalam	47.04 Are	03-10-2016	02-10-2017
17	K. Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd.,	73/GBS/DOP/34/ 2016/A1/CRPS	Re.Sy.No.188/1	Vellinezhi	Ottappalam	9.42 Are	05-10-2016	04-10-2017

18	K. Hussain, M/s. Mubarak Metal Crusher Unit, Varode. P.O, Ottappalam	81/GBS/DOP/1984/A1	Sy.No. 1/1	Ottappalam-I	Ottappalam	1.00 Hectare	31-10-2016	06-12-2016
19	K.T. Haridas, Karuthedath House, Palappuram, Mangalam, Palakkad	82/GBS/DOP/2112/A1	Re.Sy.No. 456/2	Lakkidi Perur-I	Ottappalam	100 Are.	31-10-2016	06-12-2016
20	P.C. Syed Muhammed, M/s. Crescent Granites Products, Old Lakkidi, Akalur. P.O, Palakkad	83/GBS/DOP/1864/A1	Sy.No. 434/1, 434/2, 437/3	Lakkidi Perur-I	Ottappalam	38.04 Are	31-10-2016	30-10-2017
Palakkad Taluk								
1	P.A. Said Muhammed, Managing Partner, M/s. Korian Granites, Mannur West	128/GBS/DOP/1244/2015/A1/CRPS	Re.Sy.No.201/1	Keralassery	Palakkad	46.55 Are.	23-11-2015	22-11-2016
2	Krishnadas. K, "Krishna", Krishna Nagar, C.N. Puram, Palakkad	161/GBS/DOP/2719/2015/A1	Re.Sy.No. 358/1/1	Pirayiri	Palakkad	63.53 Are	18-01-2016	17-01-2017
3	P.K. Unnikrishnan, Pulayaprambu House, Kodunthirapully, Palakkad	21/GBS/DOP/1168/2016/A1	Re.Sy. No. 75/4	Pirayiri	Palakkad	81.68 Are.	15-06-2016	14-06-2017
4	M.I. Antony, Mangali House, Pathiri Nagar, Dhoni, Palakkad	51/GBS/DOP/1336/2016/A1	Re.Sy.No. 6/6	Pudussery West	Palakkad	93.10 Are	18-07-2016	17-07-2017

5	K.J. Thomaskutty, Managing Partner, Kannanthanam Associates, Kannanthanathu House, Vadasserikkara	71/GBS/DOP/1875/ 2016/A1	Re.Sy.No. 110/1	Akathethara	Palakkad	99.38 Are	03-10-2016	06-12-2016
Pattambi Taluk								
1	M.T. Abdul Shukoor, Mundakkattuthodi House, Mannengode, Prabhapuram, Pattambi.	131/GBS/DOP/1668/ 2015/A1/CRPS	Re.Sy.No. 179/3	Koppam	Pattambi	29.93 Are.	25-11-2015	24-11-2016
2	K.V. Mohammed Ali, Koombra Kannalath Valappil House, Mala. P.O, Kakkattiri, Thrithala, Palakkad	136/GBS/DOP/1820/ 2015/A1/CRPS	Sy.No. 154/1	Pattithara	Pattambi	29.55 Are.	30-11-2015	29-11-2016
3	K.Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND (P). 176	155/GBS/DOP/1459/ 2015/A1/CRPS	Sy.No. 114	Thirumittacode-II	Pattambi	4.85 Are	23-12-2015	22-12-2016
4	Muhammed Musthafa, Joint Managing Partner, M/s. Super Granites, Sankaramangalam. P.O, Pattambi.	163/GBS/DOP/1721/ 2015/A1	Re.Sy.No. 33/3, 33/4	Pattambi	Pattambi	96.32 Are.	03-02-2016	02-02-2017

5	V. Mohanan, Varikkottil House, Malamakkavu, Koodalloor, Palakkad	164/GBS/DOP/2742/ 2015/A1/CRPS	Sy.No. 313/2	Anakkara	Pattambi	9.41 Are.	03-02-2016	02-02-2017
6	Sajeew George, Panjimaram, Melepura Estate, Chazhiyattiri, Peringode, Palakkad	174/GBS/DOP/1105/ 2015/A1/CRPS	Sy.No.114	Thirumittacode-II	Pattambi	9.712 Are.	24-02-2016	23-02-2017
7	P.P. Ashraf, Managing Partner, M/s. Mabrook Granites, Kottappadam, Thrithala.P.O, Pattambi, Palakkad	177/GBS/DOP/1858/ 2015/A1/CRPS	Sy.No. 335/3 A1	Thrithala	Pattambi	13.765 Are	02-03-2016	01-03-2017
8	Sukumaran, President, Ottappalam Taluk Karinkal Quarry Operators Vyavasaya Sahakarana Sangam Ltd., No. SIND(P) 176	181/GBS/DOP/2417/ 2015/A1/CRPS	Re.Sy.No. 299	Ongallur-I	Pattambi	9.712 Are	09-03-2016	08-03-2017
9	Abhilash, Nayakath Parambil House, Njangattiri, Ottappalam, Palakkad	183/GBS/DOP/2780/ 2015/A1/CRPS	Re.Sy.No. 471	Kulukkallur	Pattambi	9.31 Are	14-03-2016	13-03-2017
10	Sajeew George, Panjimaram, Melepura Estate, Chazhiyattiri. P.O, Peringode	06/GBS/DOP/1106/ 2015/A1/CRPS	Sy.No. 114	Thirumittacode-II	Pattambi	14.17 Are.	10.05.2016	09.05.2017

11	C.C. Thoufeeq, Cholakkal Chappala, C.C. Manzil, Valavannur. P.O	12/GBS/DOP/1145/ 2015/A1	Re.Sy.No. 22/3,4,2	Vallappuzha	Pattambi	100 Are.	30-05-2016	29-05-2017
12	Dilipkumar. K, Managing Partner, M/s. Capital Granites, Paruthipra, Shornur	15/GBS/DOP/2364/ 2015/A1/CRPS	Re.Sy.No. 368/3	Ongallur-II	Pattambi	15.25 Are.	01-06-2016	31-05-2017
13	Ahammed Shrief. T, S/o. Abdul Rahiman, Thottingal House, Vilayoor. P.O	25/GBS/DOP/1044/ 2016/A1/CRPS	Re.Sy.No. 471	Kulukkallur	Pattambi	49.50 Are	15-06-2016	14-06-2017
14	K.J. Mathai, Managing Partner, M/s. Three Star Metal Crusher, Choorakode. P.O, Vallapuzha.	26/GBS/DOP/996/ 2016/A1/CRPS	Re.Sy.No. 99/3	Vallapuzha	Pattambi	18.59 Are.	15-06-2016	14-06-2017
15	Sukumaran, President, Ottappalam Taluk Karingal Quarry Operators Vyavasaya Sahakarana Sangam Ltd	57/GBS/DOP/1582/ 2016/A1/CRPS	Re.Sy.No. 141	Ongallur-I	Pattambi	9.71 Are	03-08-2016	02-08-2017
16	Abdul Rahiman, Managing Partner, M/s. Crescent Stone Crusher Unit, Prabhapuram, Mannengode. P.O.	59/GBS/DOP/1209/ 2016/A1/CRPS	Re.Sy.No.180/1	Koppam	Pattambi	100 Are.	08-08-2016	07-08-2017
17	Abhilash. N, Nayakath Parambil House, Njangattiri, Pattambi, Palakkad	60/GBS/DOP/1069/ 2016/A1/CRPS	Sy.No. 33/12	Pattambi	Pattambi	9.31 Are.	10-08-2016	09-08-2017

18	Sukumaran, President, Ottappalam Taluk Karingal Quarry Operators Vyavasaya Sahakarana Sangam Ltd	61/GBS/DOP/1413/ 2016/A1/CRPS	Re.Sy.No. 35/1	Vallappuzha	Pattambi	9.71 Are.	10-08-2016	09-08-2017
19	Abdul Shukoor, Mundakkattuthodi House, Mannengode. P.O, Prabhapuram, Pattambi	66/GBS/DOP/1667/ 2016/A1	Re.Sy.No. 179/3	Koppam	Pattambi	100 Are.	19-09-2016	18-09-2017
20	Sukumaran, President, Ottappalam Taluk Karingal Quarry Operators Vyavasaya Sahakarana Sangam Ltd	67/GBS/DOP/1579/ 2015/A1/CRPS	Re.Sy.No. 322/1	Kulukkallur	Pattambi	9.72 Are.	19-09-2016	18-09-2017
21	K.V. Mohammadali, Kandanath Velath House, Choorakkode. P.O	80/GBS/DOP/1520/ A1/CRPS	Re.Sy.No. 471/1	Kulukkallur	Pattambi	9.02 Are	31-10-2016	30-10-2017
22	Unniyankutty, S/o. Ayamutti, Kaddingal House, Pulasser. P.O, Koppam	84/GBS/DOP/2025/ 2016/A1	Re.Sy.No. 27/3	Koppam	Pattambi	8.10 Are	16-11-2016	06-12-2016
23	Sunil Hassan, Managing Partner, M/s. KMK Granites, Velladikunnu, Nagalasseri	85/GBS/DOP/1120/ 2016/A1/CRPS	Re.Sy.No. 459/3,5	Nagalasseri	Pattambi	38.87 Are	16-11-2016	15-11-2017

Table 2c: List of Quarrying Permit granted for Laterite Building Stone

Sl.No.	Concession Holder's Name & Address	Concession No.	Survey No/ Re.Survey No.	Village	Taluk	Area (Ha)	Valid from	Valid to
Mannarkkad Taluk								
1	Rassak, S/o. Hamsa, Kunnath House, Nattukal, Thachanattukara	31/LBS/DOP/2408/2015/A1/CRPS	Sy.No.105/2	Thachanattukara-2	Mannarakkad	9.71 Are.	30-11-2015	29-11-2016
2	Sakkeer Hussain, Pallath House, Kanjirapuzha, Pottassery, Palakkad	32/LBS/DOP/2387/2015/A1/CRPS	Sy.No. 12/1A	Thachampara	Mannarakkad	9.922 Are	02-12-2015	01-12-2016
3	Muhammed Shameer, Pattambi House, Vazhan Kada, Anamangad. P.O, Malappuram	34/LBS/DOP/2614/2015/A1/CRPS	Sy.No.523/8	Thachanattukara-I	Mannarakkad	9.631 Are	07-12-2015	06-12-2016
4	Muhammed Ali, Chungath House, Nattukal. P.O.	40/LBS/DOP/2603/2015/A1/CRPS	Sy.No.523/8	Thachanattukara-I	Mannarakkad	9.712 Are.	08-02-2016	07-02-2017
5	Noushad. M, Malayil House, Palode, Nattukal. P.O.	41/LBS/DOP/2818/2015/A1/CRPS	Sy.No. 254/4	Thachanattukara-I	Mannarakkad	9.71 Are.	08-02-2016	07-02-2017
6	Muhammed. T.P, Thencheriparambil, Palode, Mannarkkad	42/LBS/DOP/2682/2015/A1/CRPS	Sy.No. 305/2,9	Thachanattukara-I	Mannarakkad	9.712 Are.	08-02-2016	07-02-2017

7	Abdul Rahiman. T.K, T.K. House, Kottiyode, Viyyakurussi. P.O,	01/LBS/DOP/174/ 2016/A1/CRPS	Sy.No. 41/10	Pottassery-II	Mannarkkad	9.72 Are	13-04-2016	12-04-2017
8	Muhammedkutty, Chengodan, Thachanattukara, Mannarkkad	02/LBS/DOP/363/ 2016/A1/CRPS	Sy.No.255/1	Thachanattukara-I	Mannarkkad	9.712 Are	27-04-2016	26-04-2017
9	Bhaskaran. C, S/o. Appu, Changanamkkattil House, Kulikkiliyad	08/LBS/DOP/1204/ 2016/A1/CRPS	Sy.No.157/1	Kottappadam-II	Mannarkkad	9.79 Are	06-06-2016	05-06-2017
10	Hamsa.K, S/o. Syed, Konnadan House, Punnakkode, Thenkara.P.O.	12/LBS/DOP/1681/ 2016/A1/CRPS	Sy.No. 73/9B	Thachampara	Mannarkkad	9.7 Are.	08-08-2016	07-08-2017
11	Anoop, S/o. Krishnankutty, Arakkal House, Thachampara. P.O.	13/LBS/DOP/1662/ 2016/A1/CRPS	Sy.No. 16/5	Thachampara	Mannarkkad	9.72 Are	10-08-2016	09-08-2017
12	Suresh.K, S/o. Ponnu, Kottilamaru House, Pottassery. P.O.	14/LBS/DOP/1647/ 2016/A1/CRPS	Sy.No.9/1A	Karakkurussi	Mannarkkad	9.6 Are.	10-08-2016	09-08-2017
13	Veerankutty, S/o. Alu, Cheriyan House, Thiruvizhamkunnu. P.O	15/LBS/DOP/1660/ 2016/A1/CRPS	Sy.No. 491/5A	Alanallur-3	Mannarkkad	9.71 Are	17-08-2016	16-08-2017
14	M.K. Radhakrishnan, Pariyani. House,	17/LBS/DOP/1715/ 2016/A1/CRPS	Sy.No. 6/1	Karakkurussi	Mannarkkad	9.71 Are	30-08-2016	29-08-2017

	Pullassery. P.O, Mannarkkad							
15	Sainudheen, S/o. Veeran, Kanjirakadayam House, Viyakkurussi. P.O	20/LBS/DOP/1873/ 2016/A1/CRPS	Re.Sy.No. 168/15A1A, 168/15A1B, 186/7	Karimba-II	Mannarkkad	9.71 Are	05-10-2016	04-10-2017
16	Shakkeer Ussain, S/o. Kunhali, Pallath House, Kanjirapuzha, Mannarkkad	21/LBS/DOP/2096/ 2016/A1/CRPS	Sy.No. 12/1A,	Thachampara	Mannarkkad	9.92 Are	17-10-2016	16-10-2017
17	Ashraf. P, S/o. Unnean. P, Pilathara House, Thachampara. P.O	25/LBS/DOP/1811/ 2016/A1/CRPS	Sy. No. 24/1A	Karimba - I	Mannarkkad	10.00 Are.	26-10-2016	25-10-2017
18	Santhosh. P.M, S/o. Narayana Gupthan, Neduvani Veettil, Vakkadappuram. P.O, Karakurussi.	26/LBS/DOP/2164/ 2016/A1/CRPS	Sy.No. 144/1A1	Karakurussi	Mannarkkad	9.80 Are.	26-10-2016	25-10-2017
19	Muhammed Basheer, S/o. Hamsa, Achipra House, Kunthipuzha	31/LBS/DOP/1982/ 2016/A1/CRPS	Sy.No. 107/1	Kottoppadam-III	Mannarkkad	9.72 Are	02-11-2016	01-11-2017
20	Koyamon, S/o. Muhammed, Variyath Valappil, Bheemand, Kottoppadam	33/LBS/DOP/2236/ 2016/A1/CRPS	Sy.No. 146/1,145/1A1B	Kottoppadam-II	Mannarkkad	9.75 Are.	14-11-2016	13-11-2017

21	Salam. E, Chatholi House, Thirivazhamkunnu, Kottoppadam, Mannarkkad	34/LBS/DOP/1349/2016/A1/CRPS	Sy.No. 287/6A1A3	Kottoppadam-I	Mannarkkad	9.76 Are.	14-11-2016	13-11-2017
22	Abu, S/o. Kunhayamu, Kiliyatham Kuzhi, Aliparamb, Malappuram (Dist).	37/LBS/DOP/2252/2016/A1/CRPS	Sy.No. 255/1	Thachanattukara-I	Mannarkkad	9.66 Are	14-11-2016	13-11-2017
23	Muhammed Shameer, Pattambi House, Vazhakkada. P.O	38/LBS/DOP/1966/2016/A1/CRPS	Sy.No. 523/8	Thachanattukara-I	Mannarkkad	9.004	14-11-2016	13-11-2017

Ottappalam Taluk

1	Unnikannan.V, Vettath House, Vellinezhi. P.O, Palakkad	35/LBS/DOP/1711/2015/A1/CRPS	Re.Sy. No.143/2	Vellinezhi	Ottappalam	9.71 Are	07-12-2015	06-12-2016
2	Muhammed Anees. P, Parayan Kallingal House, Poombra, Karimpuzha, Ottappalam	39/LBS/DOP/2406/2015/A1/CRPS	Re.Sy.No. 154/4	Sreekrishnapuram-II	Ottappalam	9.72 Are.	16-12-2015	15-12-2016
3	Ayyappankutty, Naduvil House, Thiruvazhiyode. P.O, Palakkad	03/LBS/DOP/368/2016/A1/CRPS	Re.Sy.No. 32/1	Sreekrishnapuram-I	Ottappalam	9.72 Are	27-04-2016	26-04-2017

4	Muhammed Anees. P, S/o. Syed, Parayan Kallingal House, Pompra. P.O, Ottappalam	04/LBS/DOP/806/2016/A1/CRPS	Re.Sy.No. 136/3	Sreekrishnapuram-II	Ottappalam	9.712 Are	02-05-2016	01-05-2017
5	Showkathali, Venmarathil House, Mulanjoor. P.O, Ottappalam	07/LBS/DOP/762/2016/A1/CRPS	Re.Sy.No. 114/4	Lakkidi-Perur -II	Ottappalam	9.71 Are	01-06-2016	31-05-2017
6	Krishnankutty Nair, S/o.Kuttappan Nair, Kochupurakkal House, Varadiyam, Avannur. P.O, Thrissur.	18/LBS/DOP/1863/2016/A1/CRPS	Re.Sy.No. 169/1	Sreekrishnapuram-I	Ottappalam	9.76 Are.	19-09-2016	18-09-2017
7	Nishad. K, S/o. Kammu, Kanjirathingal House, Karimpuzha. P.O	19/LBS/DOP/1929/2016/A1/CRPS	Re.Sy.No. 228/3	Karimpuzha-I	Ottappalam	9.44 Are	03-10-2016	02-10-2017
8	Babu. K, S/o. Narayanan, Koodanthodi. House, Kottappuram. P.O.	27/LBS/DOP/2093/2016/A1/CRPS	Re.Sy.No. 58/1	Karimpuzha-I	Ottappalam	19.42 Are	26-10-2016	25-10-2017
9	Subramanyan, Thadathil Veedu, Chalisseri, Thanneerkode	35/LBS/DOP/2018/2016/A1/CRPS	Sy.No. 112/12	Vaniyamkulam-I	Ottappalam	9.712 Are.	14-11-2016	13-11-2017
10	Shoukkathali, Parasseri House, Kottoppadam. P.O, Mannarkkad	36/LBS/DOP/2200/2016/A1/CRPS	ReSy.No. 154	Karimpuzha-I	Ottappalam	9.51 Are.	14-11-2016	13-11-2017

Palakkad Taluk								
1	Saidu Muhammed, S/o. Abdul Khader, Poolakkal, Peroor. P.O	29/LBS/DOP/2162/ 2016/A1/CRPS	Re.Sy. No. 87/3, 87/11, 87/15	Mundur-I	Palakkad	9.72 Are	31-10-2016	30-10-2017
Pattambi Taluk								
1	Abdul Majeed. C.P, Cheeram Parambil, Thaneercode. P.O, Palakkad	33/LBS/DOP/2526/ 2015/A1/CRPS	Sy.No.44/2	Chalissery	Pattambi	9.40 Are.	07-12-2015	06-12-2016
2	C.K. Mohammed Ali, Chullikunnath House, Pattithara. P.O, Pattambi, Palakkad	36/LBS/DOP/2404/ 2015/A1/CRPS	Sy.No. 153/1A2	Pattithara	Pattambi	8.903 Are	09-12-2015	08-12-2016
3	K.K. Abdul Razak, S/o. Thenu. K.K, Kolleth Karuvalappil House, Kadampuzhza. P.O, Malappuram. Dist	37/LBS/DOP/2537/ 2015/A1/CRPS	Re.Sy.No. 85/2	Thiruvegappura	Pattambi	9.71 Are	14-12-2015	13-12-2016
4	Manikantan, Bhasmakuzhiyil House, Kalladathur, Kumaranellur (Via), Palakkad	38/LBS/DOP/2354/ 2015/A1/CRPS	Sy.No.307/ 1 A	Anakkara	Pattambi	9.61 Are.	14-12-2015	13-12-2016
5	Anil Kumar, Paramelthodi House, Vadakkumpuram.P.O, Malappuram	43/LBS/DOP/2662/ 2015/A1/CRPS	Sy.No. 160	Anakkara	Pattambi	19.43 Are.	24-02-2016	23-02-2017

6	Narayanan, Machingal House, Vadakkumpuram, Tirur, Malappuram	44/LBS/DOP/2661/ 2015/A1/CRPS	Sy.No.160	Anakkara	Pattambi	9.611 Are.	24-02-2016	23-02-2017
7	Ali, Kunnumpadath, Othalur, Pattambi, Palakkad	45/LBS/DOP/2850/ 2015/A1/CRPS	Sy.No.31/3	Pattithara	Pattambi	9.61 Are.	24-02-2016	23-02-2017
8	Kabeer, S/o. Muhammed, Thacharamkunnath, Trithala, Palakkad	46/LBS/DOP/57/ 2016/A1/CRPS	Sy.No.120/1	Thrithala	Pattambi	9.712 Are.	09-03-2016	08-03-2017
9	Noufal, Pookath House, Angadi, Pattambi	47/LBS/DOP/2715/ 2015/A1/CRPS	Sy.No.18/2	Thrithala	Pattambi	9.71 Are.	09-03-2016	08-03-2017
10	Sundaran. A, Ayakkattil House, Karambathur. P.O, Paradur.	05/LBS/DOP/463/ 2016/A1/CRPS	Re.Sy.No. 77/3	Parathur	Pattambi	9.716 Are.	#####	19-05-2017
11	Anilkumar, Paramelthodi House, Vadakkumpuram, Malappuram	06/LBS/DOP/293/ 2016/A1/CRPS	Sy.No. 307/1A	Anakkara	Pattambi	9.611 Are.	28-05-2016	27-05-2017
12	K.P. Ali, Kunnampadath, Othaloor. P.O, Pattambi, Palakkad	09/LBS/DOP/1335/ 2016/A1/CRPS	Sy.No.307/1A	Anakkara	Pattambi	8.09 Are.	15-06-2016	14-06-2017
13	V. Sadhananthan, Vazhathodiyil House, Malamakkavu	10/LBS/DOP/346/ 2016/A1/CRPS	Sy.No.160	Anakkara	Pattambi	96.82 Are.	18-06-2016	17-12-2016
14	P. Abdul Khadar, S/o. Athen, Pulikkal House, Othallur. P.O	11/LBS/DOP/1485/ 2016/A1/CRPS	Sy.No.284/7	Thirumittacode-I	Pattambi	9.75 Are.	08-08-2016	07-08-2017

15	Madhusoodanan. P, S/o. Narayanan, Poozhikunnath, Pandavoor, Alamkode. P.O.	16/LBS/DOP/1789/ 2016/A1/CRPS	Sy.No. 307/1A	Anakkara	Pattambi	8.09 Are.	22-08-2016	21-08-2017
16	Muhammed Musthafa, S/o. Moidunni, Pallath House, Thanneerkode, Pattithara. P.O	22/LBS/DOP/1457/ 2016/A1/CRPS	Sy.No. 74/2	Chalisseri	Pattambi	9.71 Are	17-10-2016	16-10-2017
17	Rajan Kundil, Akilanam, Chazhiyattiri. P.O, Peringode	23/LBS/DOP/2114/ 2016/A1/CRPS	Sy. No. 100/4	Thirumittacode-2	Pattambi	9.8 Are.	19-10-2016	18-10-2017
18	Anilkumar, Paramelthodi House, Vadakkumbram, Edappal Malappuram	24/LBS/DOP/2055/ 2016/A1/CRPS	Sy.No. 160	Anakkara	Pattambi	19.42 Are	26-10-2016	25-10-2017
19	Ashraf, S/o. Muhammed Kutty Haji, Karuvaramkunnath, Kumaranellur. P.O	28/LBS/DOP/2163/ 2016/A1/CRPS	Sy.No. 160	Anakkara	Pattambi	9.61 Are	26-10-2016	25-10-2017
20	Narayanan, Machingal House, Vadakkumpuram, Tirur	32/LBS/DOP/2165/ 2016/A1/CRPS	Sy.No.160	Anakkara	Pattambi	9.6 Are.	07-11-2016	06-11-2017

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Geology of Kerala

Physiography

Physiographically the state can be divided into four domains from east to west, viz., the Western Ghats, the foothills, the midland and the coastal low-land.

Western Ghats

The hill ranges of the Western Ghats rise to an altitude of over 2500m above the MSL and the crest of the ranges marks the inter-state boundary in most of the places. A breach in the continuity of the ranges marks the Palghat Gap with a sinistral shift of 50 km between the shifted crests. The Wynad plateau and the Munnar (10°57'00": 77°31'00") upland fall within this zone.

Foothills

The foothills of the Western Ghats comprise the rocky area from 200 to 600m above MSL. It is a transitional zone between the high-ranges and midland.

Midland region

This forms an area of gently undulating topography with hillocks and mounds. Laterite capping is commonly noticeable on the top of these hillocks. The low, flat-topped hillocks forming the laterite plateau range in altitude from 30-200m and are observed between coastal low-land and the foothills.

Coastal low-land

Coastal low-land is identified with alluvial plains, sandy stretches, abraded platforms, beach ridges, raised beaches, lagoons and estuaries. The low-land and the plains are generally less than 10m above MSL.

Rivers

Kerala is drained by 44 rivers, many of which originate from the Western Ghats. Except Kabini, Bhavani and Pambar which are east-flowing, the rest of rivers are west-flowing and join the Arabian Sea. A few of them drain into the backwaters. Most important rivers (with their length in km in parenthesis) of the state, are Chandragiri(105), Valapatnam (110), Achankovil (120) Kallada (121), Muvattupuzha (121), Chalakudy (130), Kadalundi(130), Chaliyar (169), Pampa (176), Bharathapuzha (209) and Periyar (244).

Geology

Geologically, Kerala is occupied by Precambrian crystallines, acid to ultra basic intrusives of Archaean to Proterozoic age, Tertiary (Mio-Pliocene) sedimentary rocks and Quaternary sediments of fluvial and marine origin (Fig.I). Both the crystallines and the Tertiary sediments have been extensively lateritised.

Based on the detailed studies by GSI during the last three decades, the following stratigraphic sequence has been suggested.

	Quaternary (Q)	Pebble bed Kadappuram Formation (marine) Periyar Formation (fluvial) Viyyam Formation (fluvio-marine) Guruvayur Formation (Palaeo-marine) Laterite
	Mio-Pliocene (N 12) (Tertiary Tt)	Warkalli Formation (Sandstone and clay with lignite intercalations) Quilon Formation (Fossiliferous limestone and calcareous marl).
	Mesozoic (61-144Ma.)	Gabbro / Dolerite dykes
P	Younger granites (550-390ma)	Alkali granites, granite, Granophyres and other acid intrusives
R		
O	Chamockites (younger) (550Ma)	Massive chamockite, incipient chamockite, Cordierite chamockite
T		
E	Ultrabasic/basics (Younger) (700-600Ma)	Perinthatta anorthosite, Kartikulam gabbro, Adakkathodu gabbro, Begur diorite
R		
O	Basic Intrusives (2100-1600Ma)	Agali- Anakkatti dykes
Z		
O	Migmatite/gneiss/older granitoid (PGC II) (Ptm)(2500-2200Ma)	Gamet-biotite - gneiss with associated migmatites, quartzo-felspathic gneiss, hornblende gneiss, hornblende-biotite gneiss, quartz-mica gneiss
I	Vengad (APtv) Group	Quartz-mica schist and quartzite, conglomerate
C		

A	Charnockite(older) (Ac) 2600Ma	Mafic granulite, pyroxene granulite, Banded magnetite quartzite and gneissic charnockite
R		Quartzite, mafic granulite, calc-granulite garnet-biotite-sillimanite-cordierite gneiss, garnet-biotite-gneiss, leptynite
C	Khondalite Group (Ak)	
H	Peninsular Gneissic Complex (PGC I) (Ap) (3000Ma)	Foliated granite, homblende gneiss, pink granite gneiss, biotite gneiss
A	Layerd ultrabasic - basic Complex (3100- 3000Ma)	Peridotite, dunite, pyroxenite, anorthosite
E		
A	Wynad Schist Complex (Aw) (3200Ma)	Talc-tremolite schist , fuchsite quartzite, amphibolite, calc granulite, quartz sericite schist, kyanite quartzite, garnet - sillimanite gneiss/ schist, magnetite quartzite, kyanite mica schist
N		

Base not recognised

The Archaeans

Rocks of Archaean Era encompass a wide spectrum of litho-assemblages ranging from khondalite, charnockite, gneiss and meta-sedimentary rocks occupying the Western Ghats including the foothill region. The Khondalite and Charnockite Group are correlated with the Eastern Ghat Supergroup based on the overall similarity in lithology and geochronology.

Wynad Supracrustals

The meta-sedimentary, and ultramafic rocks occurring in the Wynad District generated keen interest among the GSI geologists in 1970s. The high-grade Wynad supracrustal rocks are correlated with the Sargur Schist Complex of the Karnataka (Nair, *et al*, 1975; Adiga, 1980). The schistose rocks are characterised by intense deformation, medium to high-grade metamorphism, migmatitisation and lack of sedimentary structures. The schist complex consists of meta-ultramafites, schist, meta-pelites, meta-pyroxenite, serpentinite, talc-tremolite rock and amphibolite.

The meta-sedimentaries occur as thin linear bodies within the migmatites. These consist of pelites, psammopelites and quartzites. The predominant rock types are corundum- mica schist, kyanite schist, quartz- mica schist and iron stone.(Anil Kumar *et al*,1993).

These rocks occur as narrow arcuate belts, lenses, and other forms of enclaves within Peninsular gneisses and charnockite. The group can be divided into medium-to low- grade metasedimentary rocks and meta-mafic and meta-ultramafic rocks. The lithology of the high-grade schists consist of quartz-mica schist with kyanite, quartz-sericite schists, quartzites, magnetite quartzite, fuchsite quartzite and meta-ultramafites. Their contact with the surrounding gneisses are concordant due to later co-folding. Several linear belts of such high-grade schists and ultramafite enclaves occur as isolated bands within the granulite and gneissic terrain of Kasaragod and Kannur districts.

Layered ultrabasic- basic complex

Remnants of layered basic- ultrabasic complex are reported from Attappadi area (Nambiar 1982). The ultramafics are represented by meta-pyroxenite, meta-dolerite, peridotite with chromite and meta-gabbro (Lahiri *et al*, 1975). The anorthosite of Attappadi is only a few metre thick. Occurrences are around Narsimukku, Pudur and Melmulli areas. An east-west trending narrow lenticular body of serpentinitised dunite is reported from Punalur mica mine belt.

A minor body (200 m long and 10-15m wide) of anorthosite was reported within pyroxene-granulite-charnockite terrain from Katanjari *parambu* of Kasargod district (Adiga, 1979).

Another dismembered layered igneous complex consisting of alternate layers of peridotite and pyroxenite within charnockite was traced around Panathadi area of Kannur District (Adiga, 1980).

Peninsular Gneissic Complex- I (PGC-I)

The rocks of Peninsular Gneissic Complex (PGC) are exposed in the northern parts of Kerala adjoining Karnataka. This consists of a heterogeneous mixture of granitoid materials. The equivalent rocks of PGC in Kerala include hornblende-biotite gneiss (sheared), biotite-hornblende gneiss, foliated granite and pink granite gneiss. Granite gneiss is exposed along the intra-State boundary of Palakkad District as well as in Idukki District. Pink granite gneiss, though widespread, is best developed in Devikolam (10°04'00": 77°06'30"), and Udumbanchola (10°00'00":77°15'00") areas of Idukki District.

This consists of gneisses showing preponderance of either hornblende or biotite. The percentage of hornblende and biotite varies from place to place. This can be traced from Manantoddy to further northwest upto the west coast. West of Manantoddy, the rock is hornblende gneiss. It shows coarse granulitic to gneissic texture and is composed of hornblende, feldspar, quartz, pyroxene, biotite and garnet. Alkali feldspar shows alteration to clay and sericite. Biotite is mainly secondary after hornblende.

Around Mahe and Thalasseri, the biotite gneiss (Nair *et al.*, 1974) is medium-grained and gneissose rock consisting of alternate layers of mafics and felsics.

Khondalite Group

The Khondalite Group of rocks include calc-granulites, quartzite and para-gneisses of pelitic parentage. Para-gneisses are ubiquitous and are well-developed in the southern part of the state, particularly, in Thiruvananthapuram and Kollam districts. Calc-granulite and quartzite occur as bands within the para-gneisses and amidst the Charnockite Group and migmatitic gneisses.

Calc-granulite

Calc-granulite occurs as linear bands mainly in the eastern part of Kollam and Thiruvananthapuram District, northeast and east of Munnar in Idukki district and in parts of Palakkad District. The rock is generally medium to coarse-grained, inequigranular and granoblastic in texture. It consists of diopside and plagioclase. Minerals like wollastonite, scapolite, calcite, garnet, spinel, sphene, quartz and apatite are also present in different proportions.

Quartzite

Quartzite occurs as linear bands amidst the khondalitic gneiss, charnockite and migmatitic gneisses. These bands are exposed between Pathanamthitta (9°15'45": 76°47'00"), and Muvattupuzha (9°59'00": 76°35'00") in Ernakulam District. The rock is coarse-grained and generally white in color with a brownish coating on the weathered surface. It consists of granular quartz with subordinate feldspar, garnet and iron oxide.

Garnetiferous biotite-sillimanite gneiss

Garnetiferous biotite- sillimanite gneiss is well-developed in the southern part of the state. It occurs in close association with the migmatitic gneisses, charnockite and charnockite gneisses, mostly as weathered outcrops. Sillimanite- rich bands occur alternating with garnet - rich portions or with quartzo-feldspathic layers. Rutile and iron oxides are the common accessory minerals.

Charnockite Group

Charnockite Group shows great diversity in lithology comprising pyroxene granulite, hornblende pyroxenite, magnetite quartzite, charnockite and hypersthene-diopside gneisses and cordierite gneiss. Charnockite and charnockitic gneiss have preponderance over all other crystalline rocks covering 40 -50% of the total area of the State. The charnockites are well-exposed in the central and northern parts of Kerala including the high-hills of the Western Ghats. Charnockite has lesser predominance in Thiruvananthapuram and Kollam districts. In Attappady, the Bhavani Shear Zone is limited by the charnockite massif of the Nilgiri plateau on the north. Though the interrelationship of the Charnockite and the Khondalite is not clear, in many places there are intercalations rather than interlayering of one with the other. In Palakkad District, the Khondalite Group of rocks structurally overlie the charnockite. The occurrence of pyroxene granulite as fine and linear bodies within the charnockite of Tirur, suggests that charnockite is a product of migmatization of pyroxene granulite (Vidyadharan and Sukumaran, 1978). Charnockite and charnockitic gneiss consist of quartz, feldspar and biotite. Garnet-bearing variants are also observed. The basic charnockite is more granulitic and contains clino- and ortho- pyroxenes, feldspar, biotite and garnet whereas the acid variety (alaskite/ enderbite) is greenish black, coarse-grained, massive to poorly foliated rock consisting of quartz, feldspar and pyroxenes. Basic charnockite has low- potash feldspar and more clinopyroxene. This is devoid of garnet and graphite, but shows a little amount of biotite (Chacko, 1922). Due to the polygenetic nature of the rock, geochemical and

mineralogical variations do exist between charnockites reported from Kerala. In the Periyar valley region, in Idukki and Kottayam districts, pyroxenite and alaskite constitute the Charnockite Group (Nair, and Selvan, 1976).

The available age data indicate that the massive charnockites are older and their ages range between 2155 and 2930 ± 50 Ma (Soman, 1997).

Also charnockite has been subjected to retrogression and migmatization.

Archaean to Palaeo-Proterozoic

Vengad Group

A succession of schistose rocks in parts of Tellicherry taluk in Kannur district is described as Vengad Group of rocks (Nair, 1976). The Vengad Group comprises of basal conglomerate, quartzite and quartz-mica schist. The contacts are highly gradational. The conglomerate shows graded bedding and quartzite shows current-bedding.

An angular unconformity marked by conglomerate horizon extending from Kuthuparamba ($11^{\circ}49'30''$: $75^{\circ}34'00''$) to Vengad ($11^{\circ}53'30''$: $75^{\circ}32'00''$) in Kannur district, separates the younger quartz-mica schist and quartzite from the older schistose and gneissic rocks. The lithology consists of basal oligomictic conglomerate, quartzite, quartz-biotite-muscovite schist and biotite quartzite. The schists are exposed over an area of 300 sq km having a lensoidal shape with its longer axis trending in NW-SE direction. The basement rock is gneissic or migmatitic with relicts of high-grade schists, ultramafites and quartzites of the Wynad Schist Complex. Four major occurrences of conglomerate are noticed in a NW-SE direction over a length of 10 km.

Lack of migmatization, presence of primary structures and low-grade metamorphic minerals characterize these rocks.

Migmatite\ Gneiss\ Granitoid (PGC-II)

Quartzo-feldspathic gneiss

Migmatite includes variety of gneissic rocks which are next in importance to charnockite as a dominant litho-semblage. Quartzo-feldspathic gneiss occurring along the contact zone between garnet-biotite gneiss and garnet-sillimanite gneiss of Thiruvananthapuram area represents an original intrusive phase. It is a feebly foliated, fine-grained, leucocratic granulitic

rock occurring in close association with garnet-sillimanite gneiss and garnet-biotite gneiss with gradational contact relationship in the southern parts of Kerala. The origin of this rock is attributed to stress-induced injection of acid materials into the host rocks (Nageswara Rao and Raju, 1970).

Garnet- biotite gneiss

Garnet-biotite gneiss is well-developed in the northeastern parts of Kollam and Thiruvananthapuram districts. This carries inclusions of pyroxene granulite and disseminations of graphite at many places (Jacob, 1965). It consists of quartz, microperthite, biotite, plagioclase and graphite. This rock also occurs in the northern parts of Palakkad District in close association with khondalite, charnockite and hornblende gneiss. These rocks are subsequently formed by retrogression and migmatization of the Khondalite Group.

East of Kottayam and Idukki districts, light grey, pink garnet-bearing biotite gneiss is widely seen. It is a gneissic granulite. The presence of biotite and concentration of garnet in layers give the rock a banded appearance. (GSI, 1995).

Hornblende gneiss, hornblende-biotite gneiss, quartz- mica gneiss

These rock types occur within the migmatites and associated retrograded charnockite. The naming is purely based on the preponderance of the minerals and these rocks occur in the Periyar valley area east of Thodupuzha. (Nair and Selvan, 1976). These medium-grained, foliated, banded rocks consist of alternate layers rich in hornblende or biotite. Bands of coarse to medium-grained light grey to pink granite traverse these rocks. Hornblende- biotite gneiss showing lit par lit relationship with the granite gneisses is the dominant rock type in the Periyar valley. This is admixed with contorted bands and enclaves of pyroxene granulite, calc-granulite and hornblende- biotite granulite. These are highly deformed.

In the Palakkad gap area, these gneisses occur over a large area, showing migmatitic structures such as agmatites, nebulites, schlierens, ptygmatic folds, quartzo-feldspathic neosomes and ferromagnesian palaeosomes. (Muraleedharan and Raman, 1989).

Proterozoic

Basic intrusives

Basic dyke emplacements within the Archaean crystalline rocks of Kerala are spread throughout the entire length and breadth of the state. Of these, dolerite dyke occurring north of the Palakkad gap had given Proterozoic age whereas in the south this dyke is of Phanerozoic

age. The older basic dykes are metamorphosed along with the country rocks and are now recognised as epidiorite and amphibolite. Another set of dykes, apparently post-dating the regional metamorphic event are subjected to thermal metamorphism. Clouding and sericitisation of feldspars and uralitisation of pyroxenes are common in such dykes. In the absence of chronological data such dykes are considered to be of Proterozoic age. Most of the dykes are vertical in disposition and are traced as linear features. *En-echelon* pattern of some dyke swarms suggests that magmatic intrusion was controlled by shearing of the host rock., Mineralogically, the dykes are made up mostly of plagioclase feldspar and pyroxene(augite and aegirine-augite) with magnetite, apatite and olivine as accessories. The ENE-WSW dolerite dyke swarm of Agali- Anakkati area in Palakkad District within the Bhavani Shear zone showed in isotopic age from 1900 to 2000 Ma (Radhakrishna and Mathew Joseph, 1993). The rock is highly jointed and altered (Jacob, 1965). Similar basic intrusive bodies are traced in the Achankovil shear zone in Vazhamuttam (9°14'00":76°46'40"), Kulasekhara pettah (9°16'00":76°47'45") (Thomas Mathai *et al*, 1984). Sheet-like bodies of fine to medium-grained, dark coloured meta-gabbro occurs in Periyamuli (11°13'00"; 76°43'00") for about 20 km in ENE-WSW direction, Karuvarai (11°04'00"; 76°32'30") and few gabbro bodies south of Thuvapattu (11°06'30"; 76°44'45") in Attapady valley, Palakkad district. Meta-gabbro forms small hillocks east of Payyanam (10°31'00"; 76°21'00"), southwest of Kainur (10°36'00"; 76°09'00") and Chemmannur (10°41'00"; 76°01'00"), Vaga (10°35'00"; 76°06'00") and Arthat (10°37'00"; 76°03'00") in Trichur District (Mahadevan, 1962).

Dykes in north Kerala show , NW-SE, NE-SW and NNW-SSE trends. Host rocks are charnockite, gneisses and supracrustals(Radhakrishna *et al* 1991). Dykes are mainly dolerite but occasional meta-gabbro or meta-norite are also traced. In Agali- Anaikatti area of the Attapadi- Bhavani shear zone, dykes are confined within a 20-25km wide zone and extend from west of Agali to eastward for about 100km following a ENE-WSW direction.(Radhakrishna, *et al*, 1999).

The rock consists of 95% calcic plagioclase, 5% clinopyroxenes and subordinate amounts of magnetite. There are a number of concordant and discordant basic intrusive of dolerite and gabbro,meta-gabbro, meta-norite, meta-pyroxenite and anorthositic gabbro. These are not mappable and are seen in Pappinpra (11°06'20", 76°05'56") Velli(11°04'00":76°07'45"),

Kalpetta (11°04'12":76°05'32"). An extensive basic diorite has been mapped over an area of 25 sq km at Panavalli (11°53'30",76 ° 2'30"; Nair, *et al* 1976).

The rock is composed predominantly of calcic plagioclase (95%) rest clinopyroxene with subordinate amount of magnetite. Another relatively small body of anorthosite is around Kalivalli (11°51'30"; 76°12'30") in south Wynad taluk, Wynad District.

Ultrabasic/ basic intrusive (younger)

Perinthatta Anorthosite

A major elliptical body of anorthosite spread over an area of more than 50 sq.km is reported from Perinthatta (12°10'00":75°17'30";Vidyadharan *et al*, 1977). The anorthosite is with a very irregular border and a tongue-like projection into the country rock of charnockite and pyroxene granulite of Kannur District.The anorthosite is coarse to very coarse-grained, and shows variations from pure anorthosite to gabbroic anorthosite and gabbro from the centre to the periphery suggestive of zoning. The modal composition corresponds to nearly 95% plagioclase (An₅₈₋₇₂) and <10% clinopyroxene, apatite, calcite and magnetite. The gabbroic variants have more of mafics.

The structural configuration suggests that the anorthosite was emplaced in synformal structure as a phacolith. The flow-banding in anorthosite indicates its syntectonic emplacement. The Perinthatta anorthosite is assigned a Proterozoic age.

Ezhimala gabbro-granophyre complex

The major high-relief feature proximal to the Perinthatta anorthosite is constituted by the gabbro-granophyre Complex (Nair and Vidyadharan, 1982). The granophyre massif is fringed by the gabbro to the east and south. The Bavali fault running north of the complex is presumed to have dismembered the body from the Perinthatta anorthosite. Locally, the gabbro has anorthositic differentiates within it. Veins of granophyre traverse the gabbro at places give rise to breccia-like structures. The granophyre shows a sharp contact with the gabbro into which it intrudes. Rapakivi structure is observed within the granophyre. According to Nair and Vidyadharan (1982) rocks of Ezhimala complex display bimodal character with conspicuous basic and silicic components.

Kartikulam and Karraug Gabbro

Two gabbro bodies namely Kartikulam gabbro and Karraug gabbro are located northeast of Manantoddy bordering the Karnataka (Nair *et al*, 1975).The gabbro body at Kartikulam

occupies an area of about 45 sq.km. with an elliptical shape within the gneissic terrain. The actual contact with the gneiss is concealed but it is believed to be sharp. At many places, the gabbro is agmatized by coarse quartzo-feldspathic material.

The gabbro is coarse-grained and of uneven texture consisting essentially of plagioclase and pyroxene. Variation to anorthositic composition is noticed. The plagioclase is of labrodorite composition and shows alteration to sericite at places (Rema Warriar and Venkataraman, 1986). The pyroxenes are uraltized to varying degrees.

The Karraug gabbro body is located east of it and south of the Kabini River. It shows similar features as that of the Kartikulam gabbro. The rock shows phenocrysts of feldspar set in a fine matrix of flaky minerals.

Adakkathodu gabbro

At Adakkathodu(12°31'35"; 75°10'25"), northwest of Manantoddy, a 8 km long meta-gabbro, is intrusive into the basement gneisses on three sides and the Wynad schists in the east. It occurs proximal to the Bavali fault/lineament. It encloses, patches of quartz-sericite schists and biotite gneiss. (Nair *et al*, 1975). The rock is mesocratic to melanocratic, medium to coarse grained consisting mainly of pyroxene and plagioclase. The rock shows sub-ophitic texture and consists of enstatite and intermediate plagioclase of andesine-labrodorite composition (Nair *et al*, 1976). While the gabbro bodies of Kartikulam and Karraug to the east are olivine- bearing, the Adakkathodu gabbro is enstatite- bearing. Olivine, augite and zoned feldspars are recorded from the eastern body while the western body is enstatite- bearing, without the zoning in feldspar.

Begur diorite

An extensive basic diorite body (25 sq.km.) has been traced north of Manantoddy in the Begur Reserve Forest (Nair, *et al*, 1976). It extends from Thirunelli to the Karnataka State border. The southern contact is with augen gneisses indicating emplacement along shear zones while the northern one with sillimanite gneisses. Aplite and dolerite veins are seen traversing the rock mostly parallel to the regional foliation. The rock is mesocratic to melanocratic, coarse-grained and consists of pink to grey feldspar, hornblende and biotite.

The rock is feebly gneissic and at places porphyritic (Rema Warriar and Venkataramana, 1986). The phenocrysts are mostly plagioclase. Mafics at times swerve round the phenocrysts

giving rise to augen structure. Hornblende is altered to biotite and chlorite. Accessories include epidote, apatite, zoisite and opaques.

The diorite shows tholeiitic characteristics. The diorite is considered as a transitional rock from the gabbro with which it is spatially associated in the nearby area with the plagioclase become more sodic.

Charnockites [younger]

The area south of Palakkad exposes charnockite over large areas. The charnockites are represented by acid micropertthitic charnockite and intermediate gneissic charnockite occurring in association with garnetiferous biotite gneiss and khondalite (Narayanaswamy and Purna Lakshmi, 1967). Massive charnockites are developed on a regional scale and occur as mappable litho-units (Raju and Gopalakrishnan, 1972), around Nedumangad. The massive charnockites in majority of the cases are acid and intermediate in composition. The rock is medium to coarse-grained and shows xenoblastic texture. It is composed of quartz, feldspar, pyroxenes, garnet and graphite with accessories like biotite, zircon, apatite and monazite.

Small patches, lenses or veins of charnockite occur in the gneisses of amphibolite facies in the Thiruvananthapuram area (Nageswara Rao and Raju, 1970). Here, the incipient charnockites are thought to have formed by transformation of paragneisses. (Hansen *et al*, 1987; Santosh *et al*, 1990). A few dominant varieties of incipient charnockites have been categorized by Ravindra Kumar and Chacko (1986) on the basis of their mode of occurrence, association and chemical processes involved in their development. At Kottavattom, north of Thiruvananthapuram, the charnockite consisting of quartz, K-feldspar, plagioclase, biotite, garnet and orthopyroxene as essential minerals and graphite, zircon, ilmenite, monazite, apatite, rutile and magnetite as accessory minerals are products of transformation of gneisses into coarse-grained charnockites along a system of conjugate fractures and foliation planes. (Saritha and Santosh, 1996).

Cordierite or Charnockite Gneiss

Cordierite bearing large linear zones of charnockites were reported around Pathanamthitta (Nageswara Rao and Jacob, 1967) area. Cordierite charnockites or orthopyroxene-garnet-cordierite bearing gneisses (Sinha Roy *et al*, 1984; Santosh, 1987) occur as discontinuous bodies in the northern parts of Thiruvananthapuram and in selected stretches further south around Koliakode. The rock is composed of cordierite, orthopyroxene, plagioclase, K-feldspar, spinel and quartz and a little garnet and biotite.

The growth of cordierite and orthopyroxene took place concomitantly during the conversion of gneisses to charnockites. At Nellikala in Pathanamthitta, the cordierite occurs as anhedral grains of variable sizes in the charnockites (Nandakumar, 1996).

Younger granites

The granites and its variants occur around Chengannur in Alappuzha and Pathanamthitta districts, Munnar in Idukki District, Peralimala in Kannur district and Kalpetta and Ambalavayal in Wynad District. Many of these granites occur as later emplacements along crustal fractures and faults. The Achenkovil – Tamraparni tectonic zone, the Attapadi shear zone, Bavali shear zone and the Moyar shear zone are all marked by granitic emplacements

Ambalavayal granite

The Ambalavayal (11°37'15"; 76 °03'30") granite having an oval shape covers an area of 50 sq.km. The granite is light pink in color and is composed of quartz, pink feldspar, hornblende and biotite. The pegmatites traversing the granite show occasional flakes of molybdenite. The Amabalavayal granite occurring in the proximity of the Bavali lineament is thought to be emplaced during its reactivation. The granite is intrusive into the hornblende-biotite gneiss (migmatite) and the Wynad Supracrustals (Anilkumar *et al*, 1993). Four types of granites are recorded, viz., foliated granite, pink granite, grey granite and aplitic granite.

The foliated granite consists of quartz, microcline, orthoclase, plagioclase, biotite, hornblende, chlorite, calcite and zircon. The pink granite is a medium-grained consisting of quartz, microcline, plagioclase, sericite, chlorite, apatite, rutile, zircon and biotite. The grey granite is a medium-to fine-grained rock consisting of quartz, microcline, sericite, biotite, chlorite and calcite. The aplitic granite is a very fine-grained massive rock consisting of quartz, microcline, orthoclase, plagioclase, sericite, biotite, calcite, chlorite, apatite and opaques.

K-Ar age of Ambalavayal granite (560 ± 30 Ma, Nair, *et al*, 1985) is lower than Rb-Sr age (595 ± 20 m.a Santhosh *et al*, 1986), but is higher than that of U-Pb-age (505 ± 20 ma, Odom, 1982). The reason for this variation in the date may be attributed to the different techniques adopted and also to the presence of biotite of multiple generation.

Munnar granite

The Munnar (10°05'00"; 77°05'00") granite with an areal extent of 50 sq km is an E-W trending irregular body emplaced within the migmatite and apophyses extend into the surrounding gneisses. The granite dated to be 740 ± 30 m.y (Odom, 1982) is traversed by pegmatite, aplite

and quartz veins. Three types of granite are recorded. Foliated granite, Coarse pink granite and medium grey granite. The foliated granite consists of stringers and streaks of mafics consisting of biotite, hornblende, chlorite and magnetite alternating with felsics consisting of quartz and potash feldspar. Potash feldspar is predominantly orthoclase. The closely spaced foliations are persistent but discontinuous. This granite forms a domal structure south of Munnar. It has a sharp contact with the migmatite. Coarse pink granite consists of pink feldspar, quartz and a little amount of mafics. Mafics are biotite, sphene and hornblende. Medium grained grey granite, consists of quartz, feldspar, biotite, chlorite, zircon, sphene, epidote, calcite and sericite.

Major element data of Munnar granites do not show any significant variation amongst the three granites. Content of iron is more in medium grey granite and foliated granite. Different variation diagrams reveal a slight tendency towards alkali granite. The foliated granite shows more percentage of orthoclase than the other two granites. (Nair and Anil Kumar, 1990)

Ezhimala granophyre – granite complex

A prominent granophyre body forms the hill known as Ezhimala, covering an area of 20 sq km in Kannur District. The granophyre is associated with gabbro and granite and is traversed by dolerite dykes. Two types of granophyres have been deciphered; coarse-grained leucocratic one and medium-grained one with more mafics. Drusy type, confined to higher elevation contain numerous vug lines with secondary minerals like quartz and calcite. Rocks of Ezhimala Complex display bimodal character with conspicuous basic and silicic components and total lack of rocks of intermediate composition typical of anorogenic suites (Nair and Vidyadharan, 1982). The granophyre is pink to ash grey coloured, massive, fine to coarse-grained, holocrystalline with equigranular texture. The granites are of two types. The major light pink granite with less of mafics show gradational relationships with the more greyish porphyritic variant (Varadan and Venkataraman, 1976).

Granophyre shows a typical granophyric intergrowth of quartz and feldspar forming the ground mass with phenocrysts of potash feldspar and some zoned plagioclase. The groundmass is totally of orthoclase. Augite is the chief ferro-magnesium mineral. Accessories include apatite, sphene, epidote, calcite and magnetite. Texturally the rock shows variation from coarse-grained leucocratic types with less mafics in the southern portion of the hill and medium to coarse grained type towards northern parts.

Minor outcrops of rapakivi granites are recorded within the granophyres of Ezhimala Complex. Anorthosites of Perinthatta and Kadannappally and granite, granophyre of Ezhimala together form the Ezhimala Complex. The light pink granite with less mafics is the major variety showing a gradational relationship with the more greyish porphyritic variety. The porphyritic variety, at places, shows rapakivi structure. The porphyritic granite shows mantled feldspar megacrysts. This variety grades into porphyritic granites without mantled feldspar and at higher levels grades into granophyre. The granite contains 60% of orthoclase feldspar, 5-10% of plagioclase, 20-25% of quartz with 4% of biotite, epidote, magnetite and fluorite. The low initial Sr_{87}/Sr_{86} ratio indicate that the rocks have a relatively minor amount of older sialic material. The Rb-Sr age of the granophyre is estimated to be 678 m.y (Nair and Vidyadharan, 1982). The Ezhimala Complex lies in close proximity to the Bavali lineament suggesting reactivation along the lineament and intrusion of the body.

Kalpatta granite

The Kalpatta ((11°36'15";76°05'15")) granite is an oval- shaped intrusive into the Wynad schist and covers an area of 44 sq km (Rao and Varadan, 1967). The rock is grey coloured, medium-grained, homogenous biotite granite and has sharp contact with the country rock. A feeble foliation is imparted to the granite at places by biotite flakes. Xenoliths of amphibolite / hornblende gneiss are visible near the periphery. Irregular veins of pegmatite / aplite traverse the granite and also the enclaves. The K-Ar age of the biotite from the Kalpatta granite is dated as 512 ± 30 m.a (Nair *et al*, 1985) and 527 m.a (GSI). Presence of enclaves and absence of significant replacement textures along with the geochemical characteristics assign a magmatic parentage for the granite. The proximity of the pluton to the Bavali lineament probably suggests intrusion along this fracture.

Three types of granites such as coarse grained biotite-granite, fine grained biotite granite, and porphyritic granite are mapped on the basis of texture, colour and mode of occurrence. Coarse-grained granite is a massive bluish grey rock with large xenoblasts of quartz and feldspars. The accessories include biotite, zircon, apatite and sphene. Blastesis of feldspar and sphene are common. Microcline, orthoclase, and plagioclase are seen as the major feldspar. Plagioclase composition varies from albite to oligoclase. This rock is exposed in Trikkaiappetta (11°35'04":76°08'41":), Manikkunnu (11°35'41":76° 07'09"), Kuttamangalam (11°30'08":76°07'11":) (Anilkumar *et al*, 1993).

Fine biotite-granite is a fine grained massive rock exposed around Muttimala (76°06'38":11°37'06"). It consists of orthoclase, quartz, microcline, biotite, sericite, zircon, sphene, apatite and opaques. Myrmekitic quartz is recorded. Pophyritic granite consists of myrmekitic quartz, microcline, sericite and biotite. Very coarse grained biotite with included crystals of orthoclase, microcline and albite are common. Except for the texture, all the three granites show similar characters. (Anilkumar, *et al* 1993). Based on Rb-Sr dating , Kalpatta granite is dated 765 Ma. (Odom 1982).

Chengannur granite

The Chengannur (9°18'45"; 76°31'00") granite in Pathanamthitta District is an oval shaped body with the long axis trending in east-west direction covering an area of 15 sq.km in and around Chengannur. The granite is intrusive into the charnockite gneisses. The body is emplaced close to the Achankovil shear zone. K-Ar date of the hornblende indicates an age of 550 m.a (Soman *et al*, 1983). The Chengannur granite is inferred to be a post kinematic granite of magmatic parentage.

Two types of granites are recorded. One is medium-grained pink granite and the other is coarse-grained grey granite. The former consists of quartz, perthitic feldspar, plagioclase, biotite, hornblende, apatite and zircon. The composition of plagioclase varies from albite to oligoclase. Microcline perthite is also seen. The coarse grained grey granite consists of perthite, plagioclase, hornblende, biotite, quartz with occasional occurrence of hypersthene,apatite and zircon. Hornblende and biotite are less common by occurred minerals than hypersthene. Relicts of hypersthene are also seen. This granite may be a product of granitisation of charnockite. K₂O content always exceeds that of Na₂O . The high SiO₂,high alkali, high Fe/Mg ratio, high values of Gallium indicate that the granite belongs to alkali type. It might have an origin from recycled and rehydrated continental crust. (Nair and Anil Kumar,1990).

Peralimala granite

The Peralimala (11°09'19":75°38'46") alkali granite is a linear intrusive body emplaced along the axial trace of a mega fold in EW direction. Peralimala intrusive body occurs as a diatreme of alkali composition with a maximum linear extension of 15 km and a width of 3 km. Based on colour, texture, composition and mode of occurrence four types of granites are identified. These are pink gneissic granite, porphyritic granite, grey granite and pink granite. Pink alkali granite is a coarse-grained rock consisting of microcline, orthoclase, plagioclase, quartz,

hornblende, epidote, aegirine, sphene, calcite, perthite and apatite. Quartz is present in only subordinate amounts. Feldspar content is very high. The preferred orientation of feldspar gives a crude alignment. At Perumpunna, (75°44'00":11°55'28") pink gneissic granite shows preferred orientation of biotite and pyroxene. The porphyritic granite occurs as a lensoidal body containing quartz, feldspar, pyroxene and hornblende. Feldspar forms the phenocrysts in a matrix of quartz-feldspar and mafics. Grey granite is a coarse- to medium- grained rock with microcline, quartz, orthoclase, perthite, hornblende and zoisite. Light grey granite is a medium-grained rock consisting of microcline, orthoclase, plagioclase (albite to oligoclase), epidote, aegirine, hornblende and rutile. The major element chemistry of the granite do not show much variation. The pink granite shows high content of potash. A negative correlation for K₂O content with respect to SiO₂ is very pronounced for pink granite owing to its alkaline nature. Barium and strontium show very high values for Peralimala granite. (Anilkumar *et al*,1993).

Sholayur granite

The Sholayur (11°04'15";76°42'00") granite, is exposed around Kuttiyadikal Mala (11°01'52":76°42'00") and Vachchpathi (11°04'15":76°44'00"). It is a homophanous medium-grained, pink coloured granite, consisting of quartz, orthoclase, microcline, oligoclase, perthite, aegirine augite, biotite, hornblende and sphene. In some places, calcite, apatite, sericite are also observed. The schlierens mark the contact zone of the granites with the host rock. This granite is emplaced within the Wynad supracrustals. SiO₂ varies from 58.76 to 73%, Al₂O₃ 14% to 17%, Na₂O 1.8% to 2.4% and K₂O 0.8 to 1.5%. The distribution of SiO₂ is highly non-uniform within the same type of granite. The pink granite is becoming alkali granite at places.(Anil Kumar and Nair,1992).

Intermediate intrusives

The syenite body at Mannapra (10°30'00";76°32'00") is exposed as an elongated NW-SE trending body covering an area of 8 sq km in Thrissur District. The syenite intrusive, makes sharp contact with the charnockite near the charnockite-migmatite contact. The rock is medium to coarse- grained at its peripheries and tends to be coarse-grained towards the centre. Mineralogically, the rock is composed of alkali feldspar, orthopyroxene, clinopyroxene and amphibole with minor amounts of plagioclase, biotite and opaques. A small syenite (Angadimugar syenite) body is located in Kumbala village (12°35'15"; 76°07'00") and about 20 km east of Kumbala in Kasaragod District. The intrusive body has an elliptical outline and covers an area of 5 sq km. The body is intrusive into the Khondalite Group and encloses

enclaves of amphibolite in the peripheral parts. The rock is medium to coarse grained, light grey and massive.

Mesozoic intrusives

Basic intrusives

Basic intrusives in Kerala, mainly represented by dyke swarms in NNW-SSE to NW-SE trend, cut across all the metamorphic rocks and the earlier structural trends. Their unmetamorphosed nature and stratigraphic relation with the country rocks prompted their correlation to the Deccan Trap volcanism.

The basic dykes have been emplaced into the migmatites and charnockite in NNW-SSE to NW-SE and ENE-WSW directions along distensional and shear fractures respectively. Dolerite dykes of Kerala are mostly quartz tholeiites rarely clinotholeiite. The basic dykes of Pathanamthitta ($9^{\circ}15'45''$: $76^{\circ}45'30''$) are genetically unrelated types. These dykes have not undergone any internal differentiation during intrusion.

The variation in the chemistry of individual dykes may be due to the cogenetic differential sequence. Dolerite dykes intrude the country rocks at an angle greater than 80° . The dolerite dykes of Kuttuparamba ($11^{\circ}49'30''$: $75^{\circ}34'00''$) in Kannur District shows cross cutting relationship with all the formations. The basic dykes of Vamanapuram ($8^{\circ}43'00''$: $76^{\circ}54'00''$) are either gabbroic or doleritic intruding the gneissic rocks. These are trending NNE to SSW and NNW to SSE directions and are unmetamorphosed. Mineralogically all these dykes show more or less same composition except the meta-dolerites. Variation in the trace elements like Ti, Zr can be attributed to the differential degree of partial melting of the mantle material. (Nair and Gopala Rao, 1989).

The unmetamorphosed Idamalayar gabbroic dyke with a NNW-SSE trend is traced for over 80 km in the central part of Kerala. The rock is mesocratic, medium-grained, porphyritic and is composed of plagioclase (andesine to labradorite), hornblende and opaques. The reported age of 75 m.y for the Idamalayar dyke (Subramaniam, 1976) links it in time-relationship with Deccan Trap volcanism.

The NNW-SSE trending leucogabbro dykes in central Kerala dated by whole rock K-Ar method gave an age of 81 ± 2 m.y and the NW-SE trending dolerite dyke 69 ± 1 m.y. The

dolerite dykes are thought to have represented the feeder system for Deccan Trap volcanic sequences (Radhakrishna *et al*, 1994).

Basic dykes of Pathanamthitta area yielded ages of 99 Ma to 117 Ma and there are dykes which have yielded ages 104 ± 5 Ma, $127 \pm$ Ma and $476 \pm$ Ma. These wide variations may be due to a protracted history of emplacement and the effect of Eocambrian to palaeozoic tectonothermal events affecting this region (Sinha Roy and Ramakrishnan, 1983.)

In Thiruvananthapuram District, Anakudi and Nedumannur dolerite dykes are dated by K-Ar method and the whole rock ages are 104 ± 5 Ma and 127 ± 2 Ma respectively (Sinha Roy and Ramakrishnan, 1983).

Tertiary Sedimentary rocks

Mio-Pliocene sedimentary rocks are fairly widespread in the southern coastal belt, their remnants being noticeable in the central and northern coastal areas. These sedimentary rocks consist of a series of variegated clay and sandstones with lenticular seams of lignite, known as Warkalli Formation, underlain by more compact marly sands with shell fragments and thin horizons of limestone (Quilon Formation).

The Tertiary sediments have a gentle dip towards west. The Warkalli Formation extends in a narrow belt from Thiruvananthapuram ($8^{\circ}28'30''$: $76^{\circ}57'20''$) to Kasaragod ($12^{\circ}30'00''$: $74^{\circ}59'00''$) between coastal and midland regions with intervening promontories of the crystalline rocks. The Quilon Formation is mainly seen at Paravur ($08^{\circ}48'00''$: $76^{\circ}40'00''$) Padappakkara ($08^{\circ}58'30''$: $76^{\circ}38'00''$) and some other places around Kollam and Alappuzha districts.

Quilon Formation

The Quilon Formation consisting of fossiliferous shell limestone alternating with thick beds of sandy clays and calcareous clays have been reported from Padappakkara (type locality), Nedumgolam, Edavai ($8^{\circ}45'20''$: $76^{\circ}42'00''$) and Varkala ($8^{\circ}44'00''$: $76^{\circ}43'00''$) and Cherthala ($9^{\circ}41'00''$: $76^{\circ}20'00''$) along the west coast of Kerala. The Quilon limestone contains numerous fossils of foraminifera, corals, echinoids and molluscs. The Lower Miocene age for lower stratigraphic horizons and the Upper Miocene age for the topmost beds of the Quilon Formation indicate the lower and upper age limits of these marine sediments. The

predominance of black clays, sandstone, bluish grey brackish water shell limestone and nodular limestone clearly indicate deposition in a lagoonal condition .

Warkalli Formation

The Warkalli Formation of Mio-Pliocene age extends all along the Kerala coast. The type section of the Warkalli Formation described by King (1882) is from the sea cliff at Varkala. The exposed section at Varkala cliff is 28-30 m thick consisting of unconsolidated sands of variegated clays, white plastic clays, and carbonaceous sandy clays enclosing impersistent seams and lenses of lignite. The carbonaceous clays and lignite are often impregnated with nodules of marcasite.

Fairly thick beds of carbonaceous clays with lignite seams occur around Nadayara kayal, Tamarakulam (9°08': 76°37'), Puliur (9°18'00": 76°35'00"), Payangadi (12°00'20": 75°15'40"), Nileswaram (12°15'00": 75°07'00"), Kanhangad (12°17'40': 75°05'00") and in the cliff sections near Cheruvathur (12°13'00": 75°09'50"). The most characteristic feature of the Warkalli Formation is the impersistent nature of the constituent beds, suggestive of shallow basin margin deposits.

Laterite

Kerala is the home of the laterite as it was first named by the Dutch traveller, Buchanan 1807. Laterite is widespread in its distribution in the midland region of Malappuram, Kannur and Kasaragod districts where it forms well-defined mesas. The Archaean crystalline rocks and the Tertiary sedimentary rocks are extensively lateritised. The laterite has wide areal distribution in the State and occurs at all levels upto 2000 m, height though mostly restricted to an altitude of 50-150 m above MSL. in the coastal and midland region. A few bauxitic patches also occur within the laterites. The thickness of laterite cappings varies from a few metres to 50 metre at places. At Chovvara (8°21'30"; 77°01'30") in Thiruvananthapuram District and Chattannur (8°50'30"; 76°46'30") and Kundara (8°57'00": 76°40'30") in Kollam District, a zone of about 2 m thick bauxite is recognised at the contact between the crystallines and the overlying sedimentary rocks. The overlying sedimentary column is also blanketed by laterite of varying thickness. The bauxite at the base of the sedimentaries indicates an earlier pre-Warkalli spell of lateritisation. Further, the erosional features on the top part of the bauxite horizon corroborates the antiquity of the earlier spell of lateritisation (Mallikarjuna and Kapali, 1980).

Generally, the laterite after the crystalline rocks is compact and the top crust moderately indurated. The dark brown crust passes downward to pink and buff coloured soft laterite. Quartz veins, joints and fractures can be traced from the top to the bottom of the laterite profile. The laterite profile over pyroxene granulites, meta-ultramafites and gneisses are characterised by relict foliation that conforms to those of the subjacent rocks which indicate the *insitu* nature of the laterite. Porous and spongy texture is discernible in laterites, after meta-ultramafites. Laterite after the Tertiary sedimentaries is well indurated at the top for about 2 to 5 m. Downwards, the profile grades into soft laterite with remnants of gritstone and culminates into a zone of variegated clay.

Quaternary sediments

Recent to sub-Recent sediments of coastal sands, sticky black clay with carbonized wood, silty alluvium and lagoonal deposits are observed mostly in the low-lying areas from Kollam (11°27'00": 75°40'30") to Ponnani and between Kannur (11°51'30":75°21'45") and Nileswaram (12°15'30":75°08'16"). Alluvium is observed along the major river valleys. At places, along coastal tracts, there are raised sandy beaches composed of fine grained reddish sandy loam known as "terri" sands. Palaeo-beach ridges alternate with marshy lagoonal clay in the coastal area.

The sandy stretches are widest between Alappuzha (9°30': 76°20') and Kottayam (9°35': 76°31'), upto 25 km inland from the shoreline. The Quaternaries of the coastal plain have been classified into (i) the Guruvayur Formation representing the earlier strandline deposits with an elevation of 5-10 m; (ii) the Viyyam Formation of tidal plain deposits; (iii) Periyar Formation being mainly of fluvial deposits and (iv) the Kadappuram Formation representing the beach deposits (Krishnan Nair, 1989).

A pebble bed is traced in Valapattanam and Taliparamba river banks in Kannur district. It is exposed south of Valapattanam (11°55'30": 75 °21'30"), Kambil maloth (11°58':75 °24'), Morazha (11 °58'30": 75°20'30") and Arathiparamba (12°06'00": 75°15'30"). The size of the pebbles ranges in dimension from 4.5 cm x 3 cm to 7 cm x 3 cm with occasional cobbles of size 13 cm x 12 cm. The base of the pebble bed is generally 20 to 40 m above MSL and at places, the pebble bed directly rests over the basement rocks. The pebbles are mostly of quartz and rarely of granite and pyroxene granulite. The distribution of the pebble bed along the major river banks demonstrate it to be flood plain deposits, probably of early Quaternary period (Nair *et al*, 1976). In Malappuram and Kozhikode districts, the pebble bed is traced in the riverine

terraces at Mavur (11°17'45":75°59'00"), Cheruvannur (11°12'8": 75°49'35") and Chellepparambu (11°14'30":75°59'00"). In Thiruvananthapuram District, the Quaternary pebble bed occurs at an elevation of 45 to 50 m above MSL at Pothenkode (8°37'00": 76°48'56"), Idaikode (8°40'11":76°50'49"), Attingal (8°41'49": 76°48'56") and Andoorakonam (8°36'00": 76°52'30").

Submerged upright tree trunks have been reported from a number of places in the coastal area of Kottayam and Alappuzha districts, indicating neotectonic reactivation in the area. Carbon dating of a sample from the submerged forest at Iravimangalam indicate an age of 7050 ± 130 B.P (Pawar *et al*, 1983).

Structure

The structural grain of the southern Peninsula is controlled mainly by the NNW-SSE trending near longitudinal Dharwarian trend which had folded all earlier structures. Since Kerala State falls in the western limb of the mega-structure almost all the rock distribution is aligned in NW-SE direction. However, detailed structural studies carried out in selected parts of the Kerala (Nair and Nair, 2001) had shown that (a) the earliest folds (F₁) which are represented both on mesoscopic and megascopic scale are tight appressed folds of asymmetrical nature which had given rise to axial plane foliations with characteristic platy mineral alignments (b) the F₂ folds on these foliations (post-folial) are open symmetrical and have developed mainly on megascopic scale and control the disposition of the major lithologies. (c) Subsequent folds (F₃) which deform F₁ and F₂ axial plane traces are broad folds on mega-scale identified with the longitudinal Dharwarian trends and (d) a broad swerve on these Dharwarian trends in ENE-WSW is also decipherable (Fig.2).

Detailed analysis of the remote sensing data had revealed the presence of a number of significant lineament patterns in WNW-ESE, NW-SE, NNW-SSE, NNE-SSW and ENE-WSW directions (Nair, 1990). Mega and intermediate lineaments in WNW-ESE were originally crustal fractures and shears which got sealed or obliterated by a number of igneous emplacements of alkali granite, syenite, gabbro, anorthosite, granophyre etc. The emplacements along the Bavali lineament and those along the Achenkovil lineament both of which trending in this direction had given ages ranging from 500 – 678 Ma. Hence they are identified to be the oldest lineament. The Bavali lineament forms the western termination of the Moyar shear. The NW-SE trending lineaments constitute mega lineaments and coincide with the basic dykes occurring throughout the length and breadth of the state. These dykes have

given ages ranging from 61 to 144 Ma. The NNW-SSE trending lineaments are generally intermediate lineaments and are attributed to fractures, faults and major joint patterns in the area. It is recognized that the NNW-SSE trending lineaments define a weak zone along which the west coast evolved by faulting. The eastern limit of the Tertiary basin is found restricted along this lineament direction. These lineaments occurring along the west coast are active as suggested by the progradation of the coast west of these lineaments (Nair, 1987). The lineaments in NNE-SSW are prominent and are identified with major fractures and this together with those in NNW-SSE are taken to constitute a conjugate system of faults in a N-S compressive regime due to the collision of the Indian plate. The ENE-WSW trending lineaments are intermediate lineaments and are well-developed in the northern parts of the Kerala. Since these lineaments truncate other lineaments as evidenced especially in the coastal stretches it is considered the youngest. Many recent tremors reported are aligned in this direction and hence considered neotectonically active.

Metamorphism

The Precambrian crystalline rocks of Kerala are chiefly metapelites, charnockites with associated gneisses and granulites, schistose rocks with distinct metapelitic and metamafic / ultramafic affinity and granitic derivatives which include the Peninsular gneisses and migmatites. Except the Wynad schists and the Vengad group, the bulk of the crystalline rocks show granulite to upper amphibolite facies of metamorphism. Wynad schist displays a prograde amphibolite facies metamorphism and the retrogression of these rocks leads to lower amphibolite facies metamorphism. The vast charnockite belt occurring on either side of the Wynad schist belt, in north Kerala, shows petrographic evidences of prograde and retrograde reactions (Nambiar, 1996). The rocks of the Vengad Group show greenschist to lower amphibolite facies of prograde metamorphism. The older intrusive bodies show effects of incipient metamorphism, marked by clouding of feldspar and bending of twin lamellae.

Recent investigations on the pressure – temperature range for the formation of characteristic mineral suits within the metamorphic rocks provide a fair idea on the poly-metamorphic history of the rock suits. Rocks of the Khondalite belt of south Kerala indicate a temperature range of 650 to 850°C and pressures 5 to 6 kb (Srikantappa *et al*, 1985). In the Thiruvananthapuram area, the temperature at the peak of metamorphism indicated by the mineral assemblages of the calc-silicate rocks is about 830°C at 5 K bar considering the vapour absent garnet forming equilibria (Satish Kumar and Santosh, 1996). The scapolite equilibria indicates a peak metamorphic temperature of above 800°C. Stable isotopes in the marble bands suggest that there was no

pervasive infiltration of external fluids. Local infiltration of external carbonic fluid took place during decomposition. Synthesis of such data from different lineament/shear bound segments in Kerala indicate varying metamorphic conditions and uplift history. It is also summarised that there is a progressive decline in the uplift of different segments from north to south (Soman, 1997).

Economic minerals

The existing level of information on the mineral resources of the State indicate rich deposits of heavy mineral sands along the coast and rich clay deposits. Other significant occurrences include bauxite, iron ore, graphite, limestone and gold.

Major minerals

They include china clay, Bauxite/laterite, Ilmenite, Rutile, Zircon, Sillimanite, Leucoxene, Monazite, Silica Sand, Lime Shell, Limestone, Quartz, Graphite

Minor minerals

Granite Building stone, Granite dimension stone, Laterite, River sand, Ordinary sand, lime shell, ordinary earth, brick clay

 **SUSTAINABLE DEVELOPMENT GOALS**

