GOVERNMENT OF KERALA

DISTRICT SURVEY REPORT OF MINOR MINERALS

(EXCEPT RIVER SAND)

THRISSUR 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

THRISSUR DISTRICT

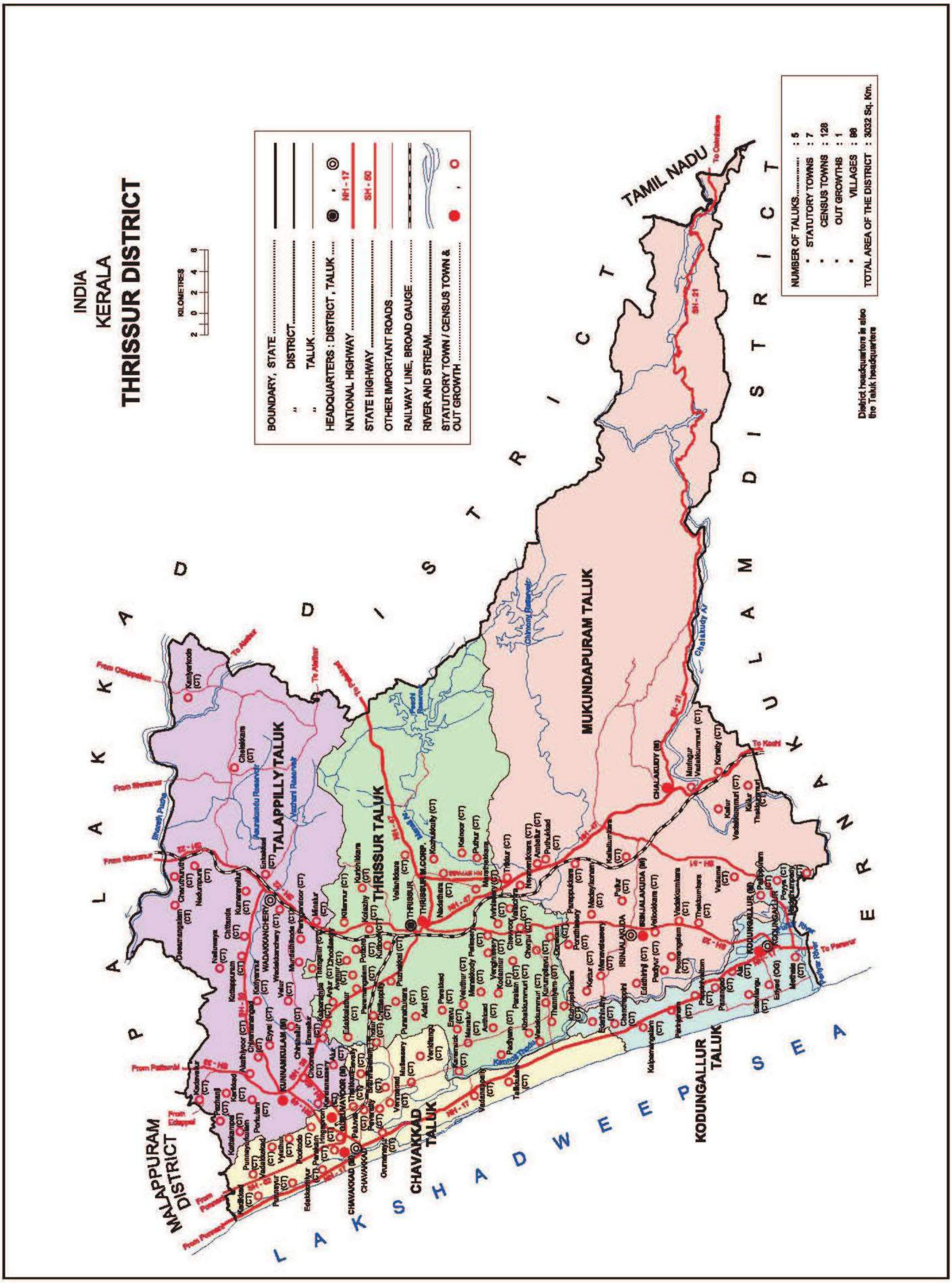
(This report is to be submitted along with application for Environmental Clearance (EC) for mining of all minor minerals except river sand)

1 Introduction

Thrissur is one of the important historical cities of Kerala, which is known as the cultural capital of Kerala. The district has an area of 3032 sq.km and is located in the central part of the State. Thrissur district lies between North latitudes 10°10'22'' and 10°46'54''; and East longitudes 75°57'20'' and 76°54'23'', in the Survey of India Toposheet No. 58 B and 49 N. It is bounded on the north by Malappuram district, northeast by Palakkad district and south by Ernakulam and Idukki districts, touching western part of Tamil Nadu on the east and Lakshadweep Sea on the west. Thrissur district accounts for 7.8% of the area of the State.

The district has five taluks viz. Chavakkad, Talappilli, Thrissur, Kodungallur and Mukundapuram which comprises 17 blocks spread over a total of 97 panchayaths and 7 municipalities. The district Headquarters of the district is accessible from any part of the state by road and rail. The NH-47 connecting Kanyakumari-Salem passes through Thrissur. The coastal National Highway 17 passes through the western fringe of the area connecting Ernakulam to Mangalore. The major towns of the districts are connected by good network of roads. The Trivandrum-Mangalore broad gauge line passes through the district. In the western part of the district where lagoons and back water channels are prominent, country crafts and boats serve as useful means of communication cutting short the distance through roads.

The population of the district is 3,110,327 as per 2011 census and the male population is 1,474,665 while female is contributing 1,635,662. There was change of 4.58 percent in the population compared to population as per 2001. In the previous census of India 2001, Thrissur District recorded increase of 8.66 percent to its population compared to 1991. The initial provisional data suggest a density of 1,026 in 2011 compared to 981 of 2001. Average literacy rate of Thrissur in 2011 was 95.32 compared to 92.27 of 2001.


INDIA
KERALA
THRISSUR DISTRICT
KILOMETRES
BOUNDARY, STATE
DISTRICT
TALUK
HEADQUARTERS : DISTRICT , TALUK
NATIONAL HIGHWAY
STATE HIGHWAY
OTHER IMPORTANT ROADS
RAILWAY LINE, BROAD GAUGE
RIVER AND STREAM
STATUTORY TOWN / CENSUS TOWN & OUT GROWTH
NUMBER OF TALUKS : 5
STATUTORY TOWNS : 7
CENSUS TOWNS : 128
OUT GROWTHS : 1
VILLAGES : 98
TOTAL AREA OF THE DISTRICT : 3032 Sq. Km.
District headquarters is also the Taluk headquarters
PALAKKAD DISTRICT
TAMIL NADU
ERNAKULAM DISTRICT
MALAPPURAM DISTRICT
LAKSHADWEEP SEA
TALAPPILLY TALUK
THRISSUR TALUK
MUKUNDAPURAM TALUK
CHAVAKKAD TALUK
KODUNGALLUR TALUK

2 Drainage and Irrigation

Thrissur district comprises three river basins viz. parts of Ponnani, Keecheri & Karuvannur basins (Kole lands) and Chalakudy. The areal extensions of these basins are 510, 1691 and 1830 sq.km respectively. The Kole lands are situated below mean sea level and are affected by tidal action. The overall drainage patterns of the rivers are controlled by the deformation structures in the basement rocks. The drainage pattern of the rivers are 'trellis' and 'sub trellis' types in the upper reaches and dendritic in coastal plain.

Two major irrigation projects in the district are Peechi and Vazhani. The Peechi project is constructed across the Manali River where as the Vazhani dam across the Keecheri River at Vazhani. These projects operating and supplying water for irrigation from August to December. Another major irrigation project is Right Canal System of Chalakudy diversion constructed across the Chalakudy River, which is irrigating southern part of district.

The minor irrigation projects like gravity flow (diverting water from river through weirs) and lift irrigation (lifting water from rivers) also is being practiced in this district. The irrigation by using ground water is common in valleys and topographically low land. The bore wells constructed along the fracture and lineaments are yielding good amount of water for irrigation. In costal and rural areas the people still depend on ponds and tanks for irrigation purposes.

3 Rainfall and climate

The Thrissur district is characterized by wet type of climate and four types of seasons are identified. The hot summer season from March to May, the southwest monsoon season from June to September, the northeast monsoon season from October to December and a general cool and salubrious climate period during climate period during January and February.

The average annual rainfall ranges between 2310.1 and 3955.3 mm in the district with mean annual rainfall of 3198.133 mm. The maximum rainfall occurs during the period June to September (SW monsoon) and nearly 71.24% of the total rainfall is received during the season. 16.27% of the total rainfall is received during North East monsoon between October and December, 12.1% of the total rainfall is received during March to May and the balance 0.37% is accounted for during January and February months.

The month of July experiences abundant rainfall and is the wettest month. The months of June, August, September and October also receive heavy rainfall.

4 Meteorological Parameters

4.1 Temperature

The maximum temperature ranges from 29.3 to 36.20C where as the minimum from 22.1 to 24.90C. The average annual maximum temperature is 32.300C and minimum temperature 23.30C. Generally March and April months are the hottest and November, December, January and February months are the coldest.

4.2 Relative Humidity

The humidity is higher during monsoon months from June to October and is around 93% during morning hours and 76% during evening hours.

4.3 Wind Velocity

The wind speed is more during December and January months and it is less during October.

4.4 Evaporation

It is high during the months of December to April because of more bright sunshine hours and less number of rainy days. It is less during the monsoon months from June to October. The maximum rate of 7.4 mm/day is recorded in January and the minimum rate of 2.9 mm/day is recorded in July.

4.5 Potential evapo-transpiration

The annual PET for Vellanikara is 1776.3 mm-based on Thornthwaite's method.

4.6 Aridity index

The ratio of potential evaportranspiration to rainfall is known as aridity index and it is around 0.6 for Vellanikara.

5 Geology

Thrissur district can be broadly divided into four geological units:- (i) Charnockite belt which is widespread and most prominent in the district; (ii) Gneissic belt represented by biotite gneiss, hornblende-biotite gneiss and quartzo-feldspathic gneiss, (iii) Granitic gneiss (PGC) restricted to the south eastern part and (iv) the Quaternaries of the coastal tract.

Pink granite (granite gneiss) of Peninsular Gneissic Complex is seen along the south eastern border, the major part of which extends to the adjacent Idukki district in the east. The rock is seen to occur interbanded with the associated rocks. It consists of varying proportions of orthoclase, plagioclase, quartz, green hornblende and brown biotite. Calc-silicate rock belonging to the Khondalite group occurs as small outcrops near Vadakkethara in the north eastern part of the district. The distribution in the area is very limited and it occurs as thin bands within the charnockite. Charnockite is the widespread rock of the area. It is generally massive but when foliated has a gneissic look. Varieties like medium- and coarse-grained, highly feldspathic and migmatitic are also not rare. Pyroxene granulite, a member of the Charnockite Group, occurs as thin bands enclosed by charnockite and/or biotite gneiss. These bands are a few metres in width and a few tens of metres in length. Biotite gneiss of Migmatite Complex is next to charnockite in abundance. This is the major rock in the western part extending from Thrissur in the north to Kottapuram in the south. Small lenticular bodies of biotite gneiss are seen within the charnockite terrain as well. The rock is well foliated and is characterised by banding due to alternate foliae rich in biotite and quartzo-feldspathic material. In places they tend to become massive and granitic. The other members of the Migmatite Group namely quartzo-feldspathic gneiss and hornblende biotite gneiss have restricted distributions. Fairly large area around Vellani Mala and Peechi are occupied by hornblende-biotite gneiss. The major part of the quartzo-feldspathic gneisses seen as linear band in the north eastern part is extending to adjacent Palakkad district in the east. Linear bands of this rock is seen in the south eastern part also. Near Ambalapara in the south eastern part there is a quartz syenite acid intrusive body. It is leucocratic, medium- to coarse-grained, medium- to coarse-grained, composed of feldspars with rare green pyroxene. Dolerite and gabbro dykes are seen cutting across these older rocks and are generally aligned in NNW-SSE trend. Pegmatite s and quartz veins occur within the charnockite and gneisses, mostly as fracture fillings. They are of small dimension and show no concentration in specific locality. A small patch of Warkalli bed is seen

near the coast in the northern part. Unconsolidated Quaternary sediments overlie these basements unconformably. The sediments are classified into different morpho-stratigraphic units based on their lithic content and environment of formation. Guruvayur Formation is an older marine deposit while Periyar Formation, Viyyam Formation and Kadappuram Formation are the contemporary fluvial, fluvio-marine and marine deposits *(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.

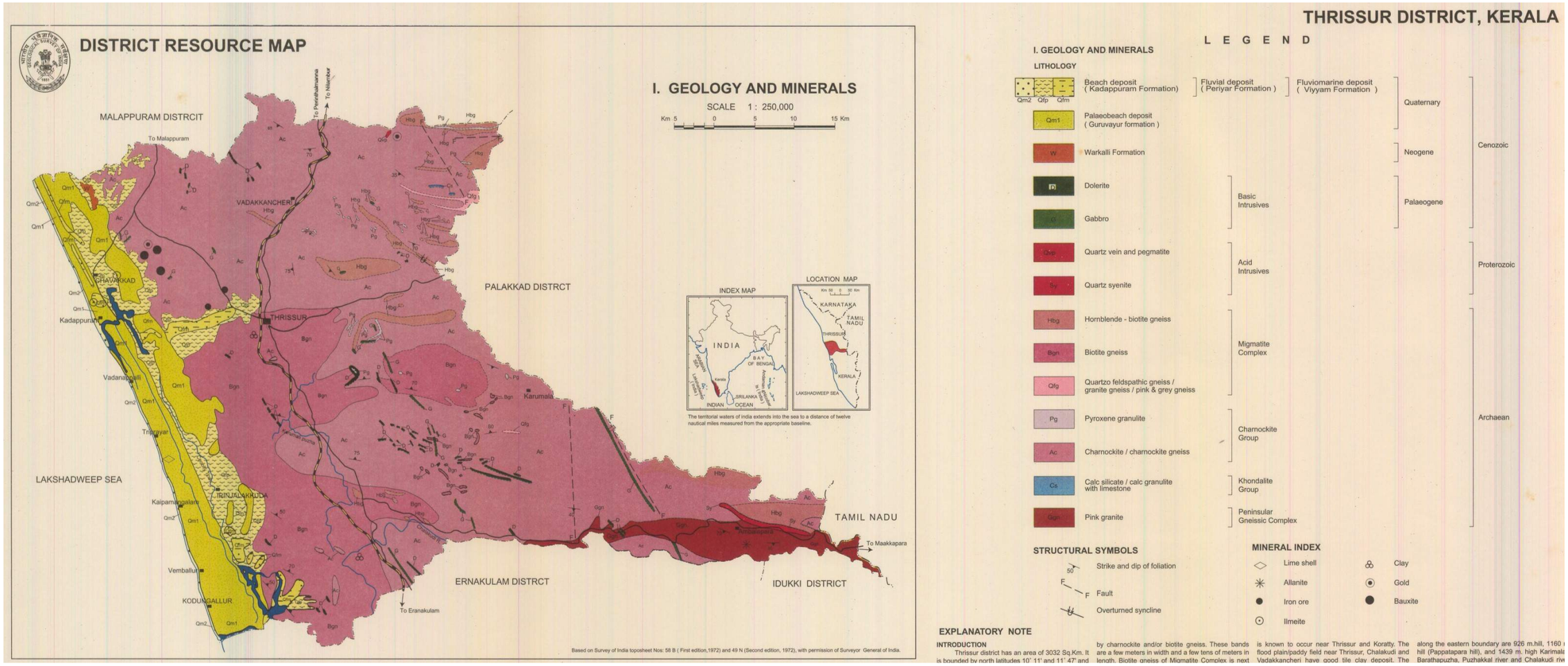


Figure 1: Geology and mineral resources of Thrissur. *(Source: District Resource map, Thrissur district, Geological Survey of India)*

6 Geomorphology

Physiographically the district is divisible into three zones from west to east as the coastal plain, followed by the midland region and then the hilly region. The coastal plain having an average width of 5km and height varying from 0-8m is a depositional landscape characterised by landforms of marine, fluvial and fluvio-marine origin. A number of strandlines (palaeo-beach ridges) alternating with swales, aligned more or less parallel to the trend of present day shore line can be seen in the area which could be representing successive still-stand positions of the retreating sea. The levels of crests of these ridges show an overall descent towards the sea suggestive of progradation of an advancing coast. The Kole land has elevations in the range of 1-2 m amsl and water logged for 5-6 months in a year due to tidal effects. Two geomorphic zones mark the midland region. These are the flat-topped landform covered by a thick blanket of laterite, which is immediately to the east of coastal plain and rises up to 20 m amsl. The laterite is quite thick and in some places attains thickness up to 25 m. The mounds occur all along the midland portion, occasionally rising to 70 m above mean sea level. The midland region has an average width of 30km. The terrain is characterised by laterite mesas and laterite interfluves and has a rolling or gently undulating landscape. The terrain has been dissected to give rise to narrow valley flats. The second geomorphic zone is represented by in-filled valleys, which occur between lateritic mounts and varying in length from 100m to 3.5 km comprising alluvial sediments and are intensively cultivated and get flooded during the monsoon periods. Remnants of four former erosion surfaces ranging in age from Late Tertiary to Early Quaternary have been reported from this area. Along the eastern margin of the midland relatively high and resistant structural hill ranges can be seen. The hill ranges in the easternmost part are the resultant of structural cum denudational processes. This terrain comprises of rocks of Archaean age and has a thin soil cover. Along the north eastern part of the district the topography is highly matured with a very gently sloping terrain. This probably represents a dissected pediment. Some of the highest peaks along the eastern boundary are 926m hill, 1160m hill (Pallatapara hill) and 1439m high Karimalai. Bharathapuzha, Puzhakkal river and Chalakudi river are the major rivers draining the area *(Figure 2)*.

7 Soil types

The soils in Thrissur district have been classified in the following types, based on the morphological features and physiochemical properties.

The laterite Soil

The predominant soil type observed is the lateritic soil, which covers almost the entire midland areas of the district. These soils are in general well drained, low in essential plant nutrients and organic matter. They exhibit very low cation exchange capacity and are generally acidic.

Brown hydromorphic soils

The second prominent soil type is the brown hydromorphic soil. These are confined to the valleys between undulating topography in the midlands and in the low lying areas of the coastal strip in the district. These have been formed as a result of transportation and sedimentations of materials from adjoining hill slopes and also by deposition from rivers. The soils are very deep and brownish in colour. The surface texture varies from sandy loam to clay.

Hydromorphic Saline Soils

Very small patches of hydromorphic saline soils are found in the coastal tracts of the district. They are brownish, deep and imperfectly drained, showing wide variation in texture. In the estuarine areas of the district, these soils are found with wide fluctuations in the intensity of salinity.

Coastal Alluvium

These soils are seen on the coastal tracts stretching from Kodungallur to Chettuvai. These have been developed from recent marine deposits with a texture dominated by partially sorted sand fraction. They are excessively drained with very rapid permeability. Water holding capacity of these soils is low.

Riverine Alluvium

These soils consist of moderately well drained and distributed mainly on the banks of rivers and their tributaries. They are light to medium textured with good physical properties and contain organic matter, nitrogen and potash moderately. They show wide variations in their physic-chemical properties. They are very deep soils with surface texture ranging from sandy loam to clayey loam, predominated by the fine sand fractions.

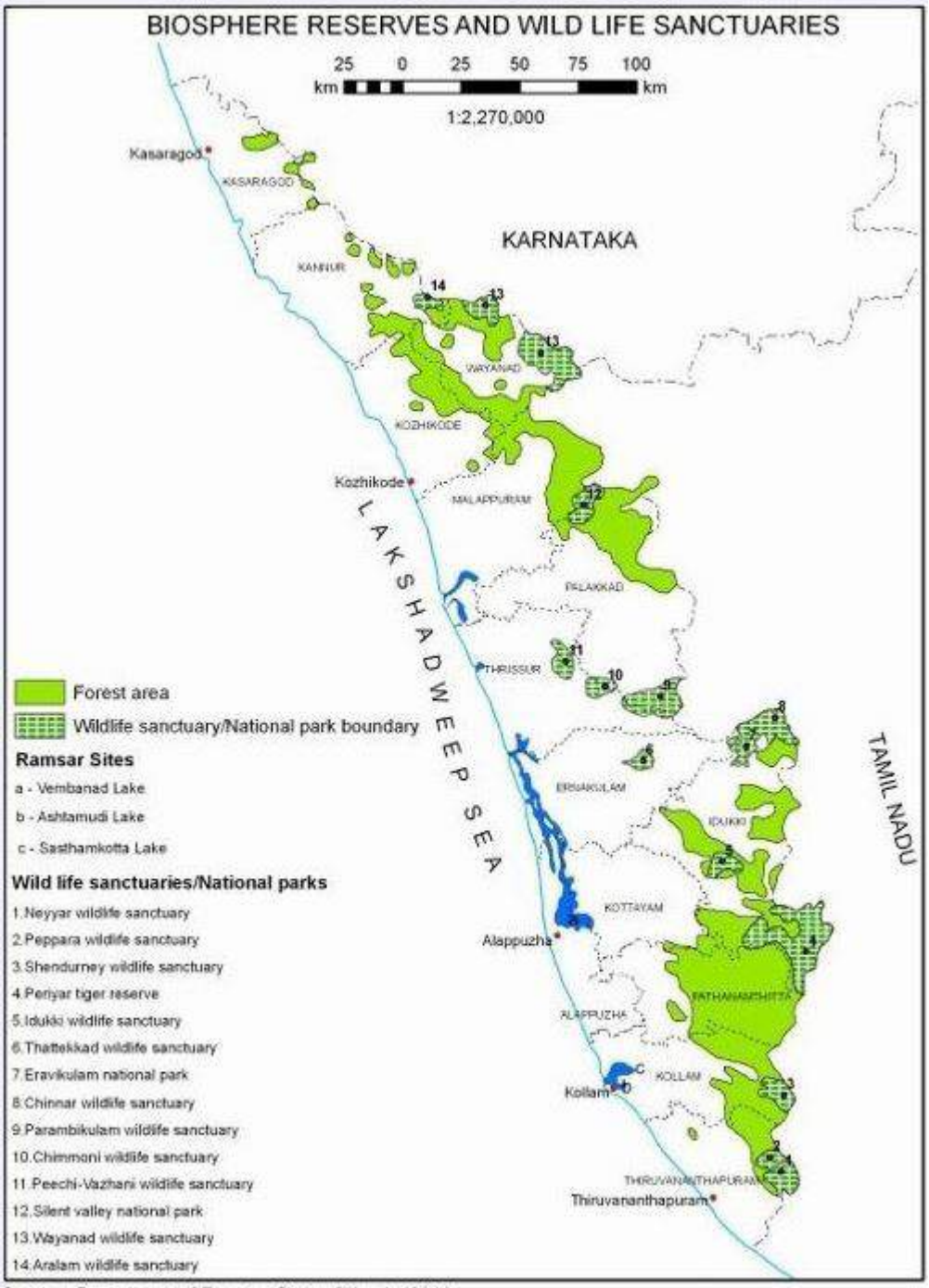
Forest Loamy Soil

These soils are found in the south-eastern hilly areas of the district, bordering Tamil Nadu. These are characterized by a surface layer very rich in organic matter. They are dark reddish brown to black with loam to silty loam texture. The soils are generally acidic *(Figure 5).*

8 Land use

Climate, physiography and soil type have control on the land use pattern of the area. Broadly four categories of land use can be brought out. Major part of the district is

covered by arable land which includes both irrigated and unirrigated land. In the valleys and low-lying areas paddy is cultivated while in the high ground coconut is the main crop. Next to arable land comes the forest land which is widespread in the eastern part. Natural forests in many places are replaced by plantations. Rubber and cashew are the major plantation crops of the area. There are some pockets of waste land with thick capping of hard laterite (*Figure 3).*



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

9 Groundwater scenario

Groundwater occurs under water table conditions in alluvium, laterites and weathered mantle of the crystalline, where as in the deeper fractured crystalline the groundwater occurs under semi confined to confined conditions.

The district can be divided into four provinces based on the groundwater resource and its quality. In the coastal plain the yield of water is high with shallow aquifer but in places the water is brackish. In the midland area with laterite cover dug wells are more promising for domestic needs. The foothills and highly undulating terrain further east can sustain limited domestic wells in selected areas. Here fracture zones are potential but wells are site specific. The easternmost mountainous area is generally unsuitable for good water development *(Figure 4)*.

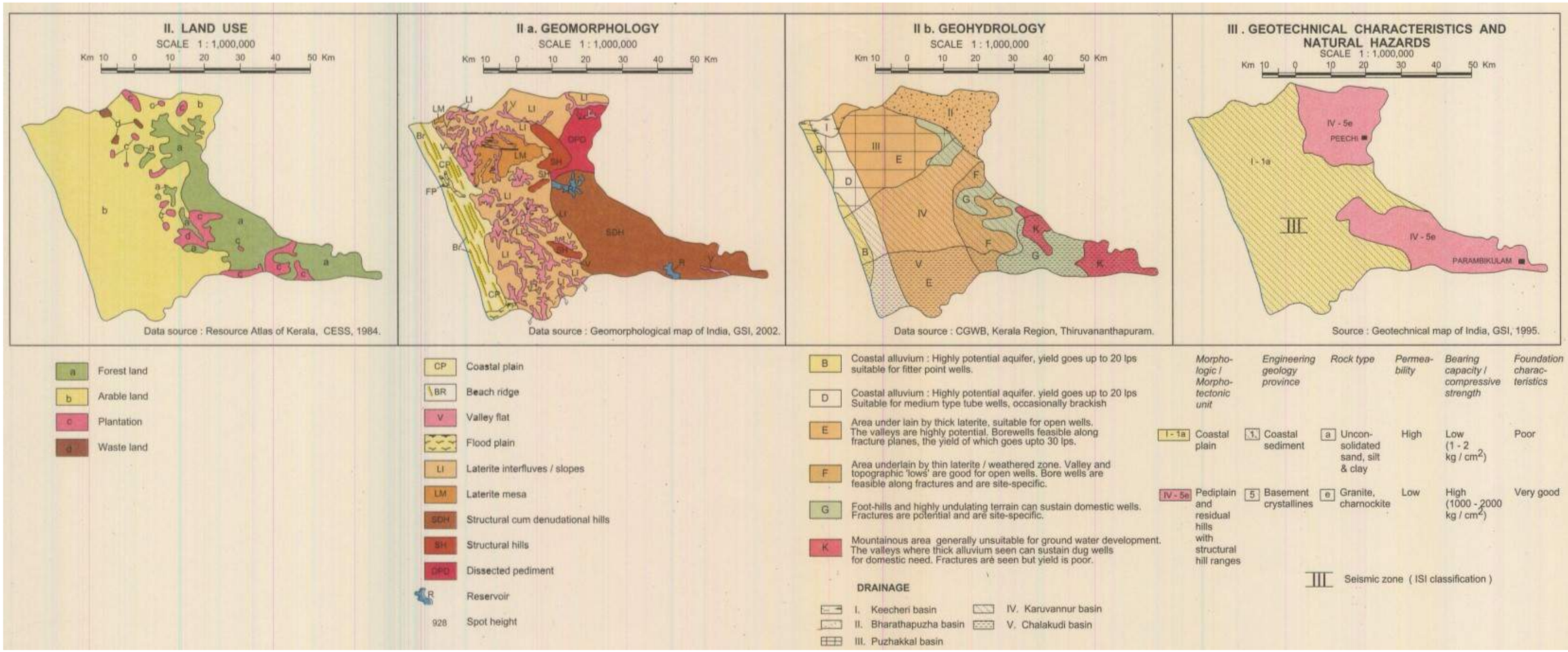


Figure 3: Landuse of Thrissur. (*Source: District Resource map, Thrissur district, Geological Survey of India)*

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

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

Figure 5: Geotechnical characteristics and natural hazards map of Thrissur. (*Source: District Resource map, Thrissur district, Geological Survey of India)*

10 Natural hazards

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

11 Mineral Resources

11.1 Major minerals

The Quaternary clay along the coastal tract near Irumbanallur contains shell deposit. China clay is known to occur near Thrissur and Koratty. The Quaternary deposits of the coastal plain near Chavakkad are reported to have concentration of ilmenite. The laterite capping in the area NW of Thrissur is rich in alumina and in places is bauxitic. Iron ore, allanite and gold are also reported from the district.

11.2 Minor Minerals

11.2.1 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 (e.g. 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 fulfils 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.

Coastal Alluvium

These soils of marine origin are identified along the coastal plains and basin lands as a narrow strip. The elevation of the coastal area is generally below 5m MSL. The area has high water table and in some areas it reaches above the surface during rainy season. The soils of the coastal plains are very deep with sandy texture. The texture generally ranges from sand to loamy sand with greyish brown to reddish brown and yellowish red colour. Sand content ranges from 80% and clay up to 15%. Even though these soils have high water table, the water holding capacity is poor due to the predominance of sand. Coconut is the major crop in the area. Cashew and other fruit trees are also grown.

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.

Acid Saline Soil

Acid saline soils are present throughout the coastal area in patches with very little extent. Major area of this soil is identified in the coastal tract of Ernakulam, Thrissur and Kannur districts. The area under these soils comprise of low-lying marshes, waterlogged and ill drained areas near the rivers and streams, which are subject to tidal waves. Sea and backwater tides make these soils saline. During monsoon season, when rainwater and fresh water from rivers enter the fields, salinity is partially washed off. The area under these soils occur mostly on plains at or below sea level. A wide variation in texture from sandy loam to clay is noticed with dark grey to black colour. Paddy is the only crop that can be cultivated.

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.

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.

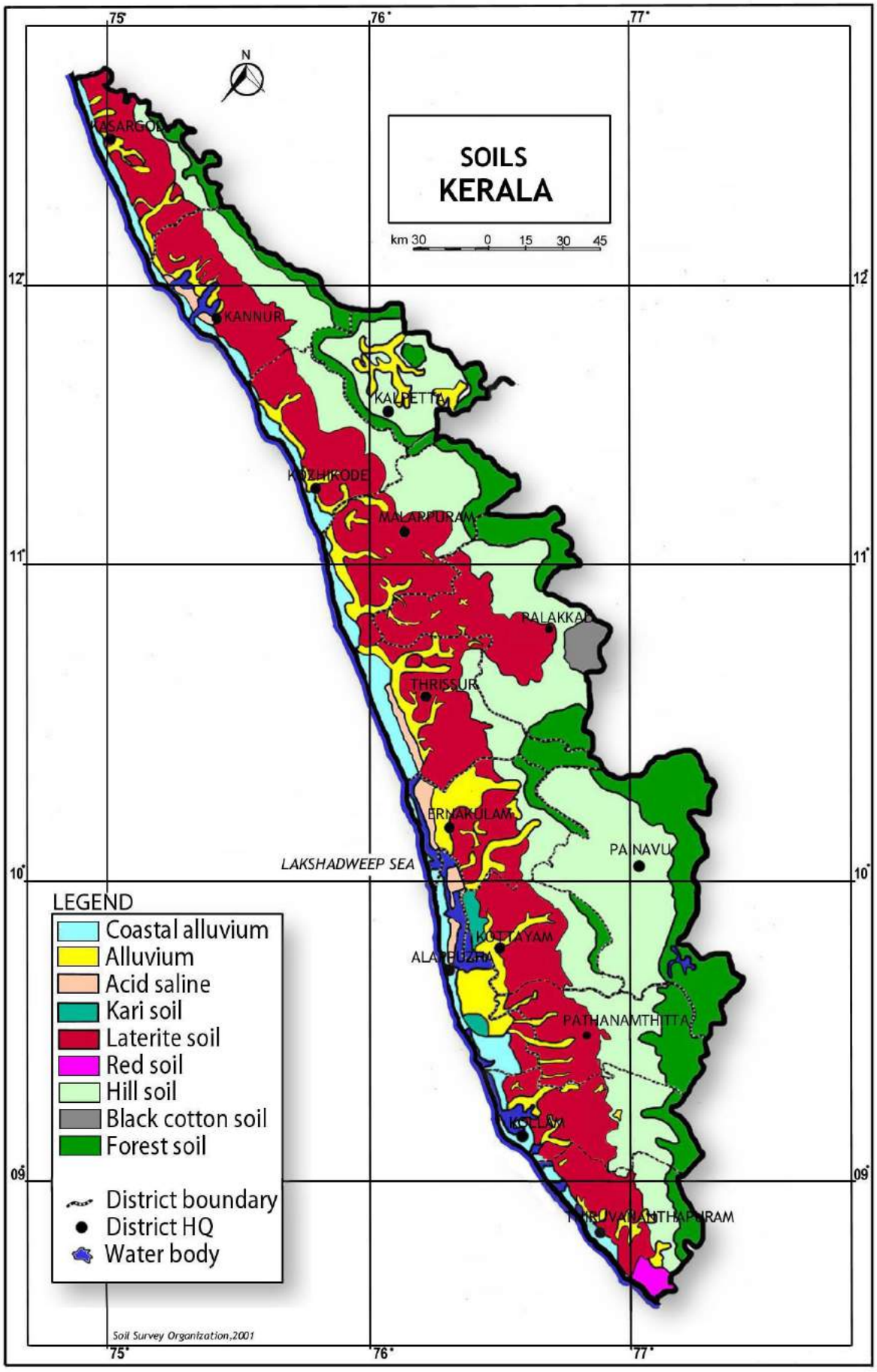


Figure 5: Soils of Kerala

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 as 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.

11.2.2 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. The flood plain/paddy field near Thrissur, Chalakkudy and Vadakkancheri have good tile clay deposit.

11.2.3 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.

11.2.4 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_3ratio 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.

11.2.5 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. The district has rich resource of construction materials like laterite and granite (hard rock).

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.

12 Details of minor mineral concessions and revenue collections

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. The details of valid minor mineral concessions issued by the Department are given in the table below:-

DISTRICT OFFICE OF DEPARTMENT OF MINING & GEOLOGY, THRISSUR

Mineral Wise Revenue Collection (During 2013-2014)

MAJOR MINERALS

No	Particulars	Granite (B/s)	Laterite (B/S)	Ordinary Clay	Ordinary Earth	Ordinary Sand	River Sand	Lime Shell	Total
1	Application fee for Mining Lease	-	-	-	-	-	-	-	-
2	Fee for Prospecting licence	-	-	-	-	-	-	-	-
3	Royalty	-	-	-	-	-	-	-	-
4	Arrear Royalty	-	-	-	-	-	-	-	-
5	Surface Rent	-	-	-	-	-	-	-	-
6	Dead Rent	-	-	-	-	-	-	-	-
7	Penal interest	-	-	-	-	-	-	-	-
8	Compounding	-	-	-	-	-	-	-	-
	Total	-	-	-	-	-	-	-	-

MINOR MINERALS

No	Particulars	Granite (B/s)	Laterite (B/S)	Ordinary Clay	Ordinary Earth	Ordinary Sand	River Sand	Lime Shell	Total
1	Royalty	6,29,600	10,480	15,05,950	26,59,344	1,04,990	78,485	-	49,88,849
2	Arrear Royalty	16,22,492	3,33,600	4,41,500	10,80,510	-	-	-	34,78,102
3	Surface Rent	4,920	890	270	3,169	-	-	-	9,249
4	Arrear Surface Rent	-	-	-	-	-	-	-	-
5	Dead Rent	-	-	-	-	-	-	-	-
6	Arrear Dead Rent	-	-	-	-	-	-	-	-
7	Fee for Quarrying permit	30,000	13,800	6,200	39,200	-	-	-	89,200
8	Fee for Quarrying Lease	-	-	-	-	-	-	-	-
9	Fee for Prospecting Licence	-	-	-	-	-	-	-	-
10	Fee for Dealer's Licence	8,42,000	-	10,000	1,12,000	1,04,000	-	2,000	10,70,000
11	Consolidated Royalty	1,08,30,000	9,95,000	-	-	-	-	-	1,18,25,000
12	Compounding	10,87,552	1,77,240	10,82,560	1,36,03,240	3,15,100	-	-	1,62,65,692
13	Other Departments	-	-	-	-	-	-	-	-
14	Other Receipts	-	-	-	-	-	-	-	-
15	RMCU compounding	1,33,50,000	-	-	-	-	-	-	1,33,50,000
	Total	2,83,96,564	15,31,010	30,46,480	1,74,97,463	5,24,090	78,485	2,000	5,10,76,092
	Grand Total	2,83,96,564	15,31,010	30,46,480	1,74,97,463	5,24,090	78,485	2,000	5,10,76,092

DIST. OFFICE THRISSUR 680 020

Geologist

DISTRICT OFFICE OF DEPARTMENT OF MINING & GEOLOGY, THRISSUR

Mineral Wise Revenue Collection (During 2014-2015)

No	Particulars	Granite (B/s)	Laterite (B/S)	Ordinary Clay	Ordinary Earth	Ordinary Sand	River Sand	Total
1	Application fee for Mining Lease	-	-	-	-	-	-	-
2	Fee for Prospecti ng licence	-	-	-	-	-	-	-
3	Royalty	-	-	-	-	-	-	-
4	Arrear Royalty	-	-	-	-	-	-	-
5	Surface Rent	-	-	-	-	-	-	-
6	Dead Rent	-	-	-	-	-	-	-
7	Penal interest	-	-	-	-	-	-	-
8	Coenpounding	-	-	-	-	-	-	-
	Total	-	-	-	-	-	-	-
No	**Particulars**	**Granite (B/s)**	**Laterite (B/S)**	**Ordinary Clay**	**Ordinary Earth**	**Ordinary Sand**	**River Sand**	
1	Royalty	21,31,060	2,880	6,98,200	53,83,080	5,07,610	1,78,560	89,01,390
2	Arrear Royalty	87,85,624	1,14,400	1,10,930	11,66,990	-	-	1,01,77,944
3	Surface Rent	1,896	545	10	510	-	-	2,961
4	Arrear Surface Rent	-	-	-	-	-	-	-
5	Dead Rent	4,327	-	-	-	-	-	4327
6	Arrear Dead Rent	-	-	-	-	-	-	-
7	Fee for Quarrying permit	25,600	9,800	200	81,600	-	-	1,17,200
8	Fee for Quarrying Lease	4,000	-	-	-	-	-	4,000
9	Fee for Prospecti ng Licence	-	-	-	-	-	-	-
10	Fee for Dealer's Licence	18,38,500	-		6,000	97,000	-	19,41,500
11	Consolidated Royalty	43,75,000	4,20,000	-	-	-	-	47,95,000
12	Coenpounding	10,13,580	77,600	4,80,000	77,00,320	2,08,800	2,03,560	96,83,860
13	Other Departments	-	-	-	-	-	-	-
14	Other Receipts	-	-	-	-	-	-	-
15	RMCU compounding	3,35,75,000	-	-	-	-	-	3,35,75,000
	Total	5,17,54,587	6,25,225	12,89,340	1,43,38,500	8,13,410	3,82,120	692,03,182
	Grand Total	5,17,54,587	6,25,225	12,89,340	1,43,38,500	8,13,410	3,82,120	692,03,182

Geologist

Table 2a: List of Quarrying Lease granted for Granite building stone *(valid as on 31.10.2016)*

Sl.	Concession holder's name and address	Concession No	Mineral	Survey No.	Village	Taluk	Area (ha)	Valid from	Valid to
1	Sunny.E.M., Mg,.Partner, M/S.Victory Granites Metals Mannampetta , Varakara.p.o., Thrissur District	172/05-06/4833/M3/05 dt.25.06.05	Granite	419/P	Mupliyam	Mukundapuram	1.2303 Hectare	28-Jun-05	27-Jun-17
2	M/S.Blue Mountain Granites, Vellikulangara.P.O. Thrissur	215/07-08/4912/M3/07 dt.28.06.07	Granite	1982	Vellikulangara	Mukundapuram	3.5961 Hectare	9-Jul-07	8-Jul-17
3	Shakthi Metals, Aloor	809/07-08/945/M3/08 dt.05.02.08	Granite	1149/1 Pt, 4Pt, 1150/2 Pt, 3 Pt, 5 Pt, 1151/1 Pt, 2 Pt, 3 Pt	Varandarappilly	Mukundapuram	2.7061 Hectare	20-Feb-08	19-Feb-18
4	E.N.Shajan, Edathadan Granites, Mattathur, Mukundapuram	14/08-09/3488/M3/08 dt.04.04.08	Granite	1266/3Pt, 1266/4Pt	Kodassery	Mukundapuram	0.4025 Hectare	15-Apr-08	14-Apr-18
5	E.N.Shajan, Edathadan Granites, Mattathur, Mukundapuram	16/08-09/3489/M3/08 dt.4.04.08	Granite	1265/3 Pt, 1266/1Pt	Kodassery	Mukundapuram	0.4208 Hectare	15-Apr-08	14-Apr-18
6	E.N.Shajan, Edathadan Granites, Mattathur, Mukundapuram	18/08-09/3491/M3/2008 dt.04.04.08	Granite	1267/3, 1267/4	Kodassery	Mukundapuram	0.9920 Hectare	15-Apr-08	14-Apr-18

7	The Managing Partner, Deepthi Granite Metals, Thrikkur.P.O. Thrissur 680 654	325/08-09/7800/M3/08 dt.31.08.08	Granite	66/P	Thrikkur	Mukundapuram	1.7050 Hectare	19-Sep-08	18-Sep-18
8	M/s.Thattil Granites, SMS Road, Thrikkur.P.O.,Thrissur District, Mukundapuram Taluk, Thrikkur Village	327/08-09/7801/M3/08 Dt.31.08.08	Granite	66/P	Thrikkur	Mukundapuram	0.9105 Hectare	19-Sep-08	18-Sep-18
9	K.Janardhanan, Proprietor Jenoos Granites, Thrikkur.P.O.,Thrissur	642/09-10/858/M3/10 dt.11.03.10	Granite	63/p	Thrikkur	Mukundapuram	0.4047 Hectare	17-Mar-10	16-Mar-20
10	Managing Partner, Mattathil Granite Metals Chettikulam.P.O. ,Thrissur	122/10-11/2676/M3/2010 dt.26.05.10	Granite	900/P 904/P	Kodassery	Mukundapuram	0.6204 Hectare	7-Jun-10	6-Jun-20
11	Sijo.C.J., Cheramparambil House, Mupliyam.P.O., Vellarampadam, Thrissur	215/11-12/4818/M3/2011 dt, 11.07.11	Granite	436/P	Mupliyam	Mukundapuram	0.3360 Hectare	22-Jul-11	21-Jul-21
12	M/S.Victory Granites Metals Mannampetta , Varakara.p.o., Thrissur District	166/2011-12/3376/M3/2011 dt.22.06.11	Granite	1427/1, 1428/2	Amballur	Mukundapuram	0.5383 Hectare	24-Jun-11	23-Jun-21
13	Raphy John.P.Pudusserypady House, Thrikkur.P.O.	259/2008-2009/6891/M3/2008 DATED, 24.07.2008	Granite	1096/1, 1095/1	Kallur	Mukundapuram	1.2141 Hectare	29-Jul-08	28-Jul-18

14	Jams Granites (Pvt) Ltd. Malavattom, Thiruvilwamala, Thrissur District	593/04-05/9158/M3/04 dt.17.12.04	Granite	592	Thiruvillwamala	Thalappilly	0.6556 Hectare	20-Dec-04	19-Dec-16
15	M/S.Best Granites Kothachira, Kadangode, Thippillassery.P.O., Thrissur District	29/06-07/3445/M3/06 dt.25.04.06	Granite	1242/1,2,5	Kadangode	Thalappilly	0.8397 Hectare	4-May-06	3-May-18
16	M/S.Best Granites Kothachira, Kadangode, Thippillassery.P.O., Thrissur District	27/06-07/3446/M3/06 dt.25.04.06	Granite	1243/1,3,4,5,6,8	Kadangode	Thalappilly	1,8400 Hectare	4-May-06	3-May-18
17	M/S.Best Granites Kothachira, Kadangode, Thippillassery.P.O., Thrissur District	28/06-07/3447/M3/06 dt.26.04.06	Granite	1247 & 1249	Kadangode	Thalappilly	4.6000 Hect	4-May-06	3-May-18
18	M/S.Best Granites Kothachira, Kadangode, Thippillassery.P.O., Thrissur District	152/07-08/4638/M3/07 dt.05.06.07	Granite	1253/5	Kadangode	Thalappilly	0.5646 Hectare	18-Jun-07	17-Jun-18
19	M/S.Best Granites Kothachira, Kadangode, Thippillassery.P.O., Thrissur District	155/07-08/4639/M3/07 dt.5.6.07	Granite	1251/8	Kadangode	Thalappilly	0.3642 Hect	18-Jun-07	17-Jun-18
20	M/S.Mangalath Granites Kerala (P)Ltd., Chelakkara.P.O.,Thrissur	52/07-08/3547/M3.07 dt.22.04.07	Granite	104/16-2,3, 104/18, 104/20 105/1-1	Venganellur	Thalappilly	3.5329 Hectare	20-Jun-07	19-Jun-17

21	Peacock Rock Products, Vysagiri.P.O., Parlikkad	655/07-08/9536/M3/07 dt.05.12.07	Granite	1275/4 Pt, 1276/Pt, 1441/Pt	Wadakkanchery	Thalappilly	2.5000 Hectare	17-Dec-07	16-Dec-17
22	Chacko.V.J.,Proprietor, M/S.Amala Granites, Parlikkad.P.O.-680 623	257/10-11/5407/M3/10 dt.20.07.10	Granite	563/39, 563/41	Parlikkad	Thalappilly	0.5746 Hectare	16-Jul-08	15-Jul-18
23	Jamshid.T.H., Thattathazhath House, Mezhathur.P.O., Kodanad-679 534	247/08-09/6653/M3/08,dt.16.07.08	Granite	222/P	Pallur	Thalappilly	2.0234 Hectare	22-Jul-08	21-Jul-18
24	M/S.Canon Granites (Pvt) Ltd., Ottappilavu, Perumbilavu, Kunnamkulam, Thrissur	416/08-09/8165/M3/08 dt.15.10.08	Granite	60, 62/P	Perumbilavu	Thalappilly	3 Acre 10.75 Cents	22-Oct-08	21-Oct-18
25	M/S.Canon Granites (Pvt) Ltd., Ottappilavu, Perumbilavu, Kunnamkulam, Thrissur	417/08-09/8166/M3/08 dt.15.10.08	Granite	55/P, 56/P, 57/P, 58/P, 630/P	Perumbilavu	Thalappilly	9 Acre 36.25 Cents	22-Oct-08	21-Oct-18
26	M/S.Best Granites, Kothachira, Kadangode, Thippilassery.P.O.,Thrissur	382/08-09/8559/M3/08 dt.26.09.08	Granite	1238	Kadangode	Thalappilly	6 Acre	31-Oct-08	30-Oct-18
27	M/S.Canon Granites (Pvt) Ltd., Ottappilavu, Perumbilavu, Kunnamkulam, Thrissur	109/08-09/4063/M3/08 dt.10.05.08	Granite	52,53,54	Perumbilavu	Thalappilly	4.5650 Hectare	6-Nov-08	5-Nov-18
28	M/s.Popular Granites, Althara .P.O., Perumbilavu, Thrissur	383/2009-10/6897/M3/2009 dt.02.11.09	Granite	873/P, 874/P,875/P	Karikkad	Thalappilly	2.0235 Hectare	25-Nov-09	24-Nov-19

29	Managing Director M/s.Jams Granites (Pvt) Ltd., Malavattom, Thiruvillwamala. Thrissur	458/09-10/7430/M3/10 dt.07.12.09	Granite	180/2, 180/3, 184/1	Pampady	Thalappilly	1.6530 Hectare	28-Dec-09	27-Dec-19
30	M/s.Best Granites Thippilassery.P.O. Kadangode.P.O. Thrissur	202/10-11/3617/M3/2010 dt.28.06.10	Granite	1323/4 1323/5 1324/1 1324/5 1324/6 1324/7	Kadangode	Thalappilly	2.4300 Hectare	23-Jul-10	22-Jul-20
31	Mathew.M.Pathrose, Esskay Industries, Thayoor, Velur.P.O., Thrissur District	446/10-11/5891/M3/10 dt.19.10.2010	Granite	1049/2-1	Velur	Thalappilly	0.9510 Hectare	19-Nov-10	18-Nov-20
32	M/s.ABA Industries, Kadangode, Thippilassery.P.O., Thrissur	77/2012-13/1926/M3/2012 dated, 27.04.12	Granite	1251/2,3,11, 1250/3/2,3, 1233/3, 1255/1,2,3, 4	Kadangode	Thalappilly	4.9421 H	21-05-2012	20-05-2022
33	St.Basil Granites Poovanchira.P.O. Thrissur district	635/04-05/8349/M3/04 dt.04.01.05	Granite	313/6, 1, 7, 16,17, 18	Pananchery	Thrissur	1.1005 Hectare	10-Jan-05	9-Jan-17

34	St.Basil Granites Poovanchira.P.O. Thrissur district	636/04-05/8350/M3/04 dt.04.01.05	Granite	1374/4/40, 4/44, 4/48, 4/61, 4/62 , 4/34, 4/5, 4/42, 4/51, 1/36, 1/7, 4/2, 4/4, 4/33	Peechi	Thrissur	1.7257 Hectare	10-Jan-05	9-Jan-17
35	Anappara Karinkallu Thozhilali Sahaya co-op Society, R.V.Puram.P.O., Thrissur District	64/05-06/3462/M3/05 dt.05.05.05	Granite	878/4, 883/1	Vilvattom	Thrissur	0.4700 Hectare	23-May-05	22-May-17
36	M/S.Thomson Granites, Punneliparambil House, P.O.Thazhekkad, Thrissur	308/05-06/7080/M3/05 dt.01.09.05	Granite	1069/1,2 1069/1,4 1088/1,2 1089/3 1087/2 1089/2 147/15,3	Ollukkara	Thrissur	4.8054 Hectare	3-Sep-05	2-Sep-17
37	M/S.K.J.Vasudevan Nair Granites, Killannur, Kuttikkad, M.G.Kavu.P.O., Thrissur	689/05-06/1728/M3/06 dt.01.03.06	Granite	1362/2	Killannur	Thrissur	1.1800 Hectares	8-Mar-06	7-Mar-18
38	M/S.K.J.Vasudevan Nair Granites, Killannur, Kuttikkad, M.G.Kavu.P.O., Thrissur	716/06-07/415/M3.07 dt.4.02.07	Granite	1364/2, 1364/3	Killannur	Thrissur	0.8097 Hectare	21-Feb-07	20-Feb-17

39	M/S.K.J.Vasudevan Nair Granites, Killannur, Kuttikkad, M.G.Kavu.P.O., Thrissur	717/06-07/416/M3/07 dt.4.2.07	Granite	1360/1, 1360/5, 1360/2Pt	Killannur	Thrissur	1.1874 Hect are	21-Feb-07	20-Feb-17
40	M/S.Victory Granites Metals Mannampetta , Varakara.p.o., Thrissur District	13/07-08/3047/M3/2007 dt.11.04.07	Granite	1426/1Pt, 1426/2 Pt, 1427/1Pt	Amballur	Thrissur	0.8879 Hect are	26-Apr-07	25-Apr-17
41	M/S.Thrissur Sands & Gravels (Pvt) Ltd, Pandiparambu, P.O.Vellanikkara	118/08-09/4892/M3/08 dt.22.05.08	Granite	1476/1,2,4,5	Madakkathara	Thrissur	1.3739 Hect are	31-May-08	30-May-18
42	M/S.Thrissur Sands & Gravels (Pvt) Ltd, Pandiparambu, P.O.Vellanikkara	119/08-09/4893/M3/2008 dt.22.05.08	Granite	1465/3, 1465/4	Madakkathara	Thrissur	0.6350 Hect are	31-May-08	30-May-18
43	M/S.Thrissur Sands & Gravels (Pvt) Ltd, Pandiparambu, P.O.Vellanikkara	120/08-09/4894/M3/08 dt.22.05.08	Granite	1466/1	Madakkathara	Thrissur	0.5850 Hect are	31-May-08	30-May-18
44	M/S.Thrissur Sands & Gravels (Pvt) Ltd, Pandiparambu, P.O.Vellanikkara	121/08-09/4898/M3/08 dt.22.05.08	Granite	1464/2, 1464/3, 1464/4, 1464/7	Madakkathara	Thrissur	1.0864 Hect are	31-May-08	30-May-18
45	The Managing Director, M/S.Thrissur Sand and Gravel (P)Ltd., Pandiparambu, P.O.Vellanikkara	289/08-09/7417/M3/08 dt.07.08.08	Granite	1463/5	Madakkathara	Thrissur	1.0603 Hect are	18-Aug-08	17-Aug-18

46	Johnson.P.T., Mg.Partner, M/S.Thomson Granites (Pvt) Ltd., Mullakkara, Mannuthy.P.O., Thrissur	425/08-09/9162/M3/08 dt.17.10.08	Granite	147/4/1/1P, 147/1070/1P 147/1070/3P	Ollukkara	Thrissur	1.8919 Hectare	28-Oct-08	27-Oct-18
47	M/S.G.M& Sons Granites, Ponganamkad.P.O., P.O.Kurichikkara	424/08-09/9161/M3/2008 dt.17.10.08	Granite	1043 & 54 P	Killannur	Thrissur	0.8903 H	31-Oct-08	30-Oct-18
48	Managing Partner, M/s.K.J.Vasudevan Nair Granites, M.G.Kavu,Thrissur	403/09-10/7725/M3/2009 dt.11.11.09	Granite	1361/1	Killannur	Thrissur	0.372 Hectare	17-Dec-09	16-Dec-19
49	Managing Partner, M/s.K.J.Vasudevan Nair Granites, M.G.Kavu,Thrissur	402/09-10/7727/M3/09 dt.11.11.09	Granite	1364/6, 1364/7	Killannur	Thrissur	0.4920 Hectare	17-Dec-09	16-Dec-19
50	Managing Partner, M/s.K.J.Vasudevan Nair Granites, M.G.Kavu,Thrissur	587/09-10/437/M3/2010 dt.16.02.10	Granite	66/1364/4p, 66/1364/5p, 66/1364/8p, 66/1364/7p	Killannur	Thrissur	1.2671 Hectare	6-Mar-10	5-Mar-20
51	Managing Partner, M/s.K.J.Vasudevan Nair Granites, M.G.Kavu,Thrissur	545/09-10/439/M3/10 dt.22.01.10	Granite	1361/2	Killannur	Thrissur	2 Hectare	6-Mar-10	5-Mar-20
52	Managing Partner, M/s.K.J.Vasudevan Nair Granites, M.G.Kavu,Thrissur	546/09-10/438/M3/2010 dt.23.01.10	Granite	1362/5P	Killannur	Thrissur	0.5040 Hectare	6-Mar-10	5-Mar-20

53	Aniyan Mathew, Managing Director, Four Star Granites Pvt Ltd, Ollukkara Village, Koottala.P.O. Thrissur District	481/10-11/5966/M3/10 dt.06.11.2011	Granite	1255/P (old sy Nos.147/190/3, 6, 8,9 & 15)	Ollukkara	Thrissur	0.3762 Hectare	10-Jan-11	9-Jan-21
54	P.Aravindakshan, Pottanattu House, Ayyappankavu.P.O.	692/10-11/3791/M3/2010 Dt. 14.01.11	Granite	147/187/1P (1252/1) 147/184/4 (1249/2)	Ollukkara	Thrissur	0.5241 Hectare	19-Jan-11	18-Jan-21
55	P.Aravindakshan, Pottanattu House, Ayyappankavu.P.O.	94/10-11/3792/M3/2010 Dt. 11.05.10 10/11-12/3792/M3/2010 dated, 08.04.11 (re execution)	Granite	147/122 P (1187/p)	Ollukkara	Thrissur	0.3683 Hectare	25-May-11	24-May-21
56	St.Joseph Granites, Achenkunnu, Valakkavu, Thrissur	694/11-12/7231/M3/2011 Dated 12.01.12	Granite	1317/1 Part, 1317/2 Pt	Peechi	Thrissur	3.5688 Hectre	18-Jan-12	17-Jan-21
57	M/s.Mridhul Granites and Cursher (P)Ltd., Kothara, Madakkathara.P.O.,	78/2012-13/9355/M3/2011 dated, 02.05.2012	Granite	1461/1, 1462/1,2, 1463/1,2	Madakkathara	Thrissur	2.8964 H	8-May-12	7-May-22
58	M/s.Mridhul Granites and Cursher (P)Ltd., Kothara, Madakkathara.P.O.,	79/2012-13/9356/M3/2011 dated, 02.05.12	Granite	1457/1	Madakkathara	Thrissur	0.7182 H	8-May-12	7-May-22
59	M/s.St.Basil Granites, Poovanchira.P.O.,Thrissur	900/2013-14/2475/M3/2014 Dated, 22.03.14	Granite	331/4, 331/6p, 340/3,340/3p	Pananchery	Thrissur	2.107 H	16-Apr-14	15-Apr-26

60	M/S.B.P.Associates Cherukode.P.O., Vallapuzha, Pattambi , Palakkad District	306/2014-15/9173/M3/2014 dated 13.08.14	Granite	685, 688, 690/p, 687, 689, 690, 700/p	Desamangalam	Thalappilly	4.7024 H	28-Aug-14	27-Aug-26
61	T.Mathew Abraham, Proprietor, Southern Rock & Aggregate Mining Company, Vallamkulam.P.O., Thiruvalla, Pathnamthitta	830/2014-15/1494/M3/2015 dated 17.03.15	Granite	1019/3,4,5,6,7 10/21/6,8,9 1027/p, 1028/p, 1029/p, 1030/p	Painkulam	Thalappilly	7.8000 H	19-Mar-15	18-Mar-27
62	M/s.Best Granites, Thippilassery.P.O., Kadangode, Thrissur	30/2015-16/2040/M3/2015 dated 18.04.15	Granite	1323/1,2,7, 8,9,10,11, 1253/4, 1322/1,2,3, 4,7, 1256/1,2, 1225/1, 1228/3	Kadangode	Thalappilly	7.2399 H	15-May-15	14-May-20
63	M/s.Edathadan Granites, Mattathur.P.O., Ombathungal, Kodakara, Thrissur	91/2015-16/4663/M3/2015 dated 07.05.15	Granite	1270/4,5,7,8 1271/2,3,4 1273/1,2 1272/1	Kodassery	Chalakudy	4.7065 H	20-May-15	19-May-27

Table 2b: List of Quarrying Permit granted under CRPS for Granite Building Stone *(valid as on 31.10.2016)*

Sl. No.	Concession no.	Date of grant	Name & address of permit holder	Sy. Nos	Village	Taluk	Area (hectares)	Panchayat	Valid up to	Consolidated Royalty (Rs.)
1	39/15-16/CRPS/GS/1154/C2/TDO/15	02.11.15	ഹനീഫ.വി.എം. വട്ടംപറമ്പിൽ വീട് എരുമപ്പെട്ടി, തൃശ്ശൂർ	771/2	കരിയന്നൂർ	തലപ്പിള്ളി	0.2230H	എരുമപ്പെട്ടി	01.11.2016	3,00,000
2	40/15-16/CRPS/GS/1090/C2/TDO/15	02.11.15	ബോബി.സി. ചാത്തയിൽ വീട് ആനകര.പി.ഒ. പാലക്കാട്	1269/2	കടങ്ങോട്	തലപ്പിള്ളി	0.4047	കടങ്ങോട്	01.11.2016	7,00,000
3	41/15-16/CRPS/GS/843/C2/TDO/15	06.11.15	ജോവി.സി.വി. ജയം സാന്റ് & ഗ്രാവൽസ് (പ്രൈ) ലിമിറ്റഡ്, കടമ്പോട് പി.ഒ. പാടി, തൃശ്ശൂർ	1294/2	കോടശ്ശേരി	ചാലക്കുടി	0.4047	കോടശ്ശേരി	14.6.2016	7,00,000
4	42/15-16/CRPS/GS/936/C2/TDO/15	11.11.15	കെ.എം.അബ്ദുൾ മജീദ് കുളമ്പിൽ പടിഞ്ഞാക്കര വീട്, ചെറുതുരുത്തി. പി.ഒ.	1006/P	പൈങ്കുളം	തലപ്പിള്ളി	0.0971	പാഞ്ഞാൾ	10.11.2016	75,000

5	43/15-16/CRPS/GS/2021/C2/TDO/15	11.11.15	ഇ.കൃഷ്ണകുമാർ, ഇരിക്കാലിൽ വീട്, മലേശ്വമംഗലം.പി.ഒ., തൃശ്ശൂർ	191	തിരുവിലാമല	തലപ്പിള്ളി	0.2023	തിരുവിലാമല	10.11.2016	3,00,000
6	44/15-16/CRPS/GS/1185/C2/TDO/15	11.11.15	കെ.എം.അബ്ദുൾ ഖാദർ കൂട്ടപുരയ്ക്കൽ വീട് കുമ്പളക്കോട്. പി.ഒ. തൃശ്ശൂർ	1800	പഴയന്നൂർ	തലപ്പിള്ളി	0.3885	പഴയന്നൂർ	10.11.2016	5,00,000
7	45/15-16/CRPS/GS/1936/C2/TDO/15	16.11.15	പി.ടി.വിൻസെന്റ് പൊറത്തൂർ വീട്, പി.ഒ.മൂർ തൃശ്ശൂർ	1102/2	ചിറ്റ	തലപ്പിള്ളി	0.1943	എരുമപ്പെട്ടി	15.11.2016	1,50,000
8	46/15-16/CRPS/GS/1029/C2/TDO/15	23.11.15	ശാന്താ അനിയൻ പെരിഞ്ചേരിൽ വീട്, വെങ്ങാനെല്ലൂർ.പി.ഒ. ചേലക്കര, തൃശ്ശൂർ	324/3	വെങ്ങാനെല്ലൂർ	തലപ്പിള്ളി	0.1377	വെങ്ങാനെല്ലൂർ	22.11.2016	1,50,000
9	47/15-16/CRPS/GS/1378/C2/TDO/15	25.11.15	ജോസ്.കെ. ഫ്രാൻസീസ് മാനേജിംഗ് പാർട്ട്ണർ മെസേഴ്സ് സെന്റ് ജോസഫ് ഗ്രാനൈറ്റ്സ്, പി.ഒ.മുളയം, തൃശ്ശൂർ	324/3	പീച്ചി	തൃശ്ശൂർ	0.1495	പാണഞ്ചേരി	24.11.2016	1,50,000

10	48/15-16/CRPS/GS/914/C2/TDO/15	25.11.15	ഷൈജി യോഹന്നാൻ കോയിക്കര വീട് ചുവന്നമണ്ണ്.പി.ഒ. തൃശ്ശൂർ	80/339/5	പാണഞ്ചേരി	തൃശ്ശൂർ	0.0971	പാണഞ്ചേരി	24.11.2016	75,000
11	49/15-16/CRPS/GS/932/C2/TDO/15	02.12.15	എം.വി.അശോകൻ മനക്കാട്ടുപ്പടി വീട്, അടിച്ചിലി, പി.ഒ.കുന്നപ്പിള്ളി, തൃശ്ശൂർ	1116	മേലൂർ	ചാലക്കുടി	0.1417	മേലൂർ	01.12.2016	1,50,000
12	50/15-16/CRPS/GS/930/C2/TDO/15	02.12.15	എം.കെ.എം.മുത്തു മാറാംപുറത്ത് വീട് എരുമപ്പെട്ടി.പി.ഒ. തൃശ്ശൂർ	765/1, 766/1	കരിയന്നൂർ	തലപ്പിള്ളി	0.4047	എരുമപ്പെട്ടി	01.12.2016	7,00,000
13	50/15-16/CRPS/GS/1075/C2/TDO/15	04.12.15	ജോയ് ജേക്കബ് ഇഞ്ചക്കുഴിപാറയിൽ വീട് കുുകാട്.പി.ഒ., തൃശ്ശൂർ	736/p	മാടക്കത്തറ	തൃശ്ശൂർ	0.3399	മാടക്കത്തറ	03.12.2016	5,00,000
14	51/15-16/CRPS/GS/962/C2/TDO/15	04.12.15	അൽഫോൺസ ജെയിംസ്, കുുപറമ്പിൽ വീട് അളഗപ്പനഗർ.പി.ഒ., തൃശ്ശൂർ	859/3	വരന്തരപ്പിള്ളി	ചാലക്കുടി	0.1214	വരന്തരപ്പിള്ളി	03.12.2016	1,50,000
15	52/15-16/CRPS/GS/2784/C2/TDO/15	04.12.15	ഡേവിസ് ജോൺ പൈനാട്ട് വീട് ചാലക്കുടി.പി.ഒ., തൃശ്ശൂർ	1281/1	കോടശ്ശേരി	ചാലക്കുടി	0.1512	മറ്റത്തൂർ	03.12.2016	1,50,000

16	53/15-16/CRPS/GS/1664/C2/TDO/15	20.01.16	പൗലോസ് ബെന്നി മുള്ളപൊട്ടക്കൽ വീട് കുറിച്ചിക്കര.പി.ഒ. തൃശ്ശൂർ	1387/3	കിള്ളന്നൂർ	തൃശ്ശൂർ	0.0972	മുളങ്കുന്നത്തുകാവ്	06.12.16	75,000
17	54/15-16/CRPS/GS/1474/C2/TDO/15	23.01.16	പി.എൻ.പവിത്രൻ പരീഷാപ്പിൽ വീട്, വേലൂപ്പാടം.പി.ഒ., തൃശ്ശൂർ	1166	ആമ്പല്ലൂർ	മുകുന്ദപുരം	0.1440h	അളഗപ്പനഗർ	06.12.16	1,50,000
18	55/15-16/CRPS/GS/1031/C2/TDO/15	23.01.16	ജോസ് തോമസ് കുട്ടിയാനിയിൽ വീട് വെങ്ങാനെല്ലൂർ.പി.ഒ. ചേലക്കര	50/3 p	വെങ്ങാനെല്ലൂർ	തലപ്പിള്ളി	0.0951	ചേലക്കര	06.12.16	75,000
19	56/15-16/CRPS/GS/2022/C2/TDO/15	01.02.16	ഇ.കൃഷ്ണകുമാർ ഇരിക്കാലിൽ വീട്, പി.ഒ.മലേശമംഗലം, തൃശ്ശൂർ	195/1, 195 2/2	തിരുവിലാമല	തലപ്പിള്ളി	0.2023	തിരുവിലാമല	06.12.16	3,00,000
20	57/15-16/CRPS/GS/1032/C2/TDO/15	03.02.16	വത്സ സെബാസറ്റ്യൻ വിലങ്ങപ്പാറ വീട് പി.ഒ.ചേലക്കര, തൃശ്ശൂർ	324/6	വെങ്ങാനെല്ലൂർ	തലപ്പിള്ളി	0.1416	ചേലക്കര	06.12.16	1,50,000
21	58/15-16/CRPS/GS/1030/C2/TDO/15	08.02.16	ജോൺ ജോർജ്, പാരകളം വീട്, വെങ്ങാനെല്ലൂർ. പി.ഒ. തൃശ്ശൂർ	323	വെങ്ങാനെല്ലൂർ	തലപ്പിള്ളി	0.0971	ചേലക്കര	06.12.16	75,000

22	59/15-16/CRPS/GS/1156/C2/TDO/15	08.02.16	ടി.സി.സന്തോഷ് തെക്കൂട്ട് വീട്, കൂട്ടഞ്ചേരി.പി.ഒ., തൃശ്ശൂർ	734/B/8,9	നെല്ലുവായ്	തലപ്പിള്ളി	0.2023	എരുമപ്പെട്ടി	06.12.16	3,00,000
23	60/15-16/CRPS/GS/1050/C2/TDO/15	10.02.16	കെ.എം.രാമചന്ദ്രൻ കൊല്ലാറ വീട് പി.ഒ.കുറിച്ചിക്കര, തൃശ്ശൂർ	1135/2	കിള്ളന്നൂർ	തൃശ്ശൂർ	0.3237	മുളങ്കുന്നത്തുകാവ്	06.12.16	5,00,000
24	61/15-16/CRPS/GS/1075/C2/TDO/15	15.02.16	വി.പി.ഗോവിന്ദൻകുട്ടി വടക്കേപറമ്പിൽ വീട് കൊാഴി. പി.ഒ. തൃശ്ശൂർ	434/4	വടക്കേത്തറ	തലപ്പിള്ളി	0.1295	പഴയന്നൂർ	06.12.16	1,50,000
25	62/15-16/CRPS/GS/1166/C2/TDO/15	24.02.16	ആദം.എ.എച്ച്., ആഞ്ജിലിക ടവത്ത് വീട്, പി.ഒ.കരുമാത്ര	66/1378/1P	കിള്ളന്നൂർ	തൃശ്ശൂർ	0.1215	മുളങ്കുന്നത്തുകാവ്	06.12.16	1,50,000
26	63/15-16/CRPS/GS/1176/C2/TDO/15	09.03.16	വി.പി.ഗോവിനദൻകുട്ടി വടക്കേപറമ്പേൽ കൊാഴി.പി.ഒ	596/1	കൊാഴി	തലപ്പിള്ളി	0.0809	കൊാഴി	06.12.16	75,000
27	64/15-16/CRPS/GS/459/C2/TDO/16	08.03.16	ഫിറോസ് ബാബു ചിറക്കാട്ടിൽ വീട് പി.ഒ.അനമനങ്ങാട്, മലപ്പുറം	215	തിരുവിലാമല	തലപ്പിള്ളി	0.5000.	തിരുവിലാമല	06.12.16	7,00,000

28	65/15-16/CRPS/GS/1602/C2/TDO/15	30.03.16	അബ്ദുൾ സലാം മൂലയിൽ വീട് മുള്ളൂർക്കര തൃശ്ശൂർ	364/1 P	മുള്ളൂർക്കര	തലപ്പിള്ളി	0.2027	മുള്ളൂർക്കര	06.12.16	3,00,000
29	1/16-17/CRPS/GS/2945/C2/TDO/16	11.04.16	പി.വി.ജേക്കബ് പുത്തൂർ വീട് തയ്യൂർ.പി.ഒ. തൃശ്ശൂർ	837/4	തയ്യൂർ	തലപ്പിള്ളി	0.3319	വേലൂർ	06.12.16	5,00,000
30	2/16-17/CRPS/GS/1301/C2/TDO/16	20.04.16	ഷിബു.പി.ജോൺ പൈനാടത്ത് വീട് കറുകുറ്റി. പി.ഒ. എറണാകുളം	2054/2	കുറ്റിച്ചിറ	ചാലക്കുടി	0.2995	കോടശ്ശേരി	06.12.16	3,00,000
31	3/16-17/CRPS/GS/2700/C2/TDO/16	09.05.16	ഷൈജി യോഹന്നാൻ കോയിക്കര വീട് ചുവന്നമണ്ണ്, തൃശ്ശൂർ	339/8	പാണഞ്ചേരി	തൃശ്ശൂർ	0.0972	പാണഞ്ചേരി	06.12.16	75,000
32	4/16-17/CRPS/GS/1680/C2/TDO/16	09.05.16	പി.ഭാസി മാനേജിംഗ് ഡയറക്ടർ മെസേഴ്സ്.ത്രീ സ്റ്റാർ ഗ്രാനൈറ്റ്സ് (പ്രൈ) ലിമിറ്റഡ്, പി.ഒ.തയ്യൂർ	834/2, 834/3, 834/4, 834/7	തയ്യൂർ	തലപ്പിള്ളി	0.4047	വേലൂർ	06.12.16	7,00,000

33	5/16-17/CRPS/GS/460/C2/TDO/16	09.05.16	സി.എം.ജോസഫ് മാനേജിംഗ് പാർട്ട്ണർ മെസേഴ്സ് യൂണിവേഴ്സൽ അസോസിയേറ്റ്സ് കൂട്ടാല	147/191/1	ഒല്ലൂക്കര	തൃശ്ശൂർ	0.0972	തൃശ്ശൂർ കോർപ്പറേഷൻ	06.12.16	75,000
34	6/16-17/CRPS/GS/290/C2/TDO/16	13.05.16	ഡേവിസ് ജോൺ, പൈനാടത്ത് വീട് ചാലക്കുടി.പി.ഒ., തൃശ്ശൂർ	1282/2	കോടശ്ശേരി	ചാലക്കുടി	0.099	മറ്റത്തൂർ	03.12.16	75,000
35	7/16-17/CRPS/GS/1571/C2/TDO/16	20.05.16	പി.വി.മത്തായി, പൊക്കൽ വീട്, മുളയം.പി.ഒ. വലക്കാവ്	884/10/2	കല്ലൂർ	മുകുന്ദപുരം	0.4047	തൃക്കൂർ	06.12.16	7,00,000
36	8/16-17/CRPS/GS/478/C2/TDO/16	06.06.16	സി.എം.ജോസഫ് മാനേജിംഗ് പാർട്ട്ണർ മെസേഴ്സ് യൂണിവേഴ്സൽ അസോസിയേറ്റ്സ് കൂട്ടാല	147/200/1 (1273/1)	ഒല്ലൂക്കര	തൃശ്ശൂർ	0.0971	തൃശ്ശൂർ കോർപ്പറേഷൻ	06.12.16	75,000
37	9/16-17/CRPS/GS/1139/C2/TDO/16	10.06.16	ടി.എൽ.പിയൂസ് തലക്കോട്ടൂർ വീട് കൂനംമൂച്ചി.പി.ഒ.	11/p	ചൂൽ	തലപ്പിള്ളി	0.1305	ചൂൽ	06.12.16	1,50,000

38	10/16-17/CRPS/GS/913/C2/TDO/16	15.06.16	പി.പി.പോൾ, പൊന്മാണിശ്ശേരി വീട് പി.ഒ. ചെങ്ങാലൂർ	843/1	വരന്തര പ്പിള്ളി	ചാലക്കുടി	0.1538	വരന്തര പ്പിള്ളി	06.12.16	1,50,000
39	11/16-17/CRPS/GS/2300/C2/TDO/16	20.06.16	കെ.ആർ.വിശ്വനാഥൻ മാനേജിംഗ് പാർട്ട്ണർ മെസേഴ്സ് ചേലക്കര ഗ്രാനൈറ്റ്സ്, കിള്ളിമംഗലം	847	കിള്ളിമംഗലം	തലപ്പിള്ളി	0.4100H	കിള്ളിമംഗലം	06.12.16	7,00,000
40	12/16-17/CRPS/GS/1174/C2/TDO/15	24.06.16	ടി.കെ.മോഹനൻ, കൃഷ്ണ നിവാസ് പി.ഒ.പഴയന്നൂർ, തൃശ്ശൂർ	434/1	വടക്കേത്തറ	തലപ്പിള്ളി	0.0971	പഴയന്നൂർ	06.12.16	75,000
41	13/16-17/CRPS/GBS/2153/C2/TDO/16	12.08.16	പി.വി.മത്തായി, പൊക്കൽ വീട്, മുളയം.പി.ഒ	1069	ചെങ്ങാലൂർ	മുകുന്ദപുരം	0.4047	പുതുക്കാട്	06.12.16	7,00,000
42	14/16-17/CRPS/GBS/2718/C2/TDO/16	12.08.16	ഒ.എ.ജോസ് മാണി കംപാറ ഗ്രാനൈറ്റ്സ് (പ്രൈ) ലിമിറ്റഡ്, തെക്കുംകര	1538/12	തെക്കുംകര	തലപ്പിള്ളി	0.1862	തെക്കുംകര	06.12.16	1,50,000
43	15/16-17/CRPS/GBS/1250/C2/TDO/16	12.08.16	കെ.ജെ.ബൈജു കീഴേടത്ത് വീട് പി.ഒ.അത്താണി, തൃശ്ശൂർ	1115/2	തെക്കുംകര	തലപ്പിള്ളി	0.3000H	തെക്കുംകര	06.12.16	3,00,000
44	16/16-17/CRPS/GBS/1294/C2/TDO/15	03.09.16	കെ.എ.അഗസ്തി, കളപുരയ്ക്കൽ വീട് പി.ഒ.ഇഞ്ചക്കു	322/1, 286, 323/1	മുപ്ലിയം	ചാലക്കുടി	0.4000h	വരന്തര പ്പിള്ളി	06.12.16	5,00,000

45	17/16-17/CRPS/GBS/1678/C2/TDO/16	23.09.16	ബി.എ.തമ്പി, ബ്രഹ്മക്കുളം തെക്കേതിൽ വീട് പി.ഒ.ചേലക്കര, തൃശ്ശൂർ	1693	തിരുവിലാമല	തലപ്പിള്ളി	0.2914h	തിരുവിലാമല	06.12.16	3,00,000
46	18/16-17/CRPS/GBS/2968/C2/TDO/16	26.10.16	ബൈജു.ഇ.എസ്., ഇമ്മാനിയേൽ വീട് പി.ഒ.വെട്ടുകാട് തൃശ്ശൂർ	127	തൃക്കൂർ	മുകുന്ദപുരം	0.2023	തൃക്കൂർ	06.12.16	3,00,000
47	19/16-17/CRPS/GBS/2717/C2/TDO/16	28.10.16	പി.എസ്.മണി പുല്ലാനിപറമ്പത്ത് വീട് പറക്കാട്, എളവള്ളി	563/25	പാർളിക്കാട്	തലപ്പിള്ളി	0.0972	വടക്കാഞ്ചേരി മുനിസിപ്പാലിറ്റി	06.12.16	75,000
48	20/16-17/CRPS/GBS/1015/C2/TDO/16	14.11.16	മുഹമ്മദ് സലീം, കോട്ടിലിൽ വീട്, കൂറ്റനാട്.പി.ഒ., പാലക്കാട് ജില്ല	7/p	കടങ്ങോട്	തലപ്പിള്ളി	0.0972	കടങ്ങോട്	06.12.16	75,000

Table 2e: List of Quarrying Permit granted under CRPS for Laterite Building Stone *(valid as on 31.10.2016)*

Sl. No.	Concession no.	Date of grant	Name & address of permit holder	Sy.Nos	Village	Taluk	Area (hectares)	Panchayat	Valid up to	Consolidated Royalty (Rs.)	No. of passes issued so far
1	25/15-16/CRPS/LS/2415/C2/TDO/15	06.11.15	സുനി, പുല്ലാനിപറമ്പത്ത് വീട് നമ്പഴിക്കോട്.പി.ഒ.	60/1,2	എളവള്ളി	ചാവക്കാട്	0.0977	എളവള്ളി	05.11.2016	75,000	750
2	26/15-16/CRPS/LS/2565/C2/TDO/15	16.11.15	ഏലിയാസ്, തച്ചേത്തുകുടി വീട്, പുളിങ്കര, പി.ഒ.കുറ്റിച്ചിറ, തൃശ്ശൂർ	90	കോടശ്ശേരി	ചാലക്കുടി	0.0971	കോടശ്ശേരി	15.11.2016	75,000	750
3	27/15-16/CRPS/LS/2641/C2/TDO/15	18.11.15	പീനറ്റ്.സി.ഡി. ചീരമ്പൻ വീട് പി.ഒ.വേലൂർ തൃശ്ശൂർ	1466	വേലൂർ	തലപ്പിള്ളി	0.0971	വേലൂർ	17.11.2016	75,000	750

4	28/15-16/CRPS/LS/2785/C2/TDO/15	25.11.15	മണി.പി.എസ്. പുല്ലാനിപറമ്പത്ത് വീട് എളവള്ളി.പി.ഒ., തൃശ്ശൂർ	1590/1,2, 1591/2	വടക്കാഞ്ചേരി	തല പ്പിള്ളി	0.0747	വടക്കാഞ്ചേരി	24.11.2016	75,000	750
5	29/15-16/CRPS/LS/2688/C2/TDO/15	25.11.15	സുരേഷ്കുമാർ.കെ. കെ. താഴത്തു വീട്ടിൽ വീട് പി.ഒ.മടത്തുംപടി, തൃശ്ശൂർ	410/3	കാക്കുളിശ്ശേരി	ചാല ക്കുടി	0.0711	കുഴൂർ	24.11.16	75,000	750
6	30/15-16/CRPS/LS/2073/C2/TDO/15	25.11.15	സാവദ്, തറയിൽ വീട് പിലാക്കാട്.പി.ഒ., തൃശ്ശൂർ	169/1	പിലാക്കാട്	തല പ്പിള്ളി	0.1944	വരവൂർ	24.11.16	1,50,000	1500
7	31/15-16/CRPS/LS/2669/C2/TDO/15	02.12.15	സലീം.പി.എം. പാലയ്ക്കപറമ്പിൽ വീട് തളി. പി.ഒ. തൃശ്ശൂർ	107/2	തിച്ചൂർ	തല പ്പിള്ളി	0.0971	വരവൂർ	01.12.16	75,000	750
8	32/15-16/CRPS/LS/2464/C2/TDO/15	04.12.15	പി.എ.ജോസഫ് പൂങ്കുടിയിൽ വീട്, പി.ഒ. പിലാക്കാട്, തൃശ്ശൂർ	60/3 ു	പിലാക്കാട്	തല പ്പിള്ളി	0.1940 ഒ	വരവൂർ	03.12.16	1,50,000	1500
9	33/15-16/CRPS/LS/2696/C2/TDO/15	04.12.15	ലെവി.എ.ഒ. ആളൂർ വീട് പി.ഒ.കുട്ടൻഞ്ചേരി, തൃശ്ശൂർ	227/4	പിലാക്കാട്	തല പ്പിള്ളി	0.0969	വരവൂർ	03.12.16	75,000	750
10	34/15-16/CRPS/LS/1721/C2/TDO/15	04.12.15	സുജയൻ.കെ. കിഴക്കേകര വീട് കളടത്തൂർ, കുമരനെല്ലൂർ പാലക്കാട്	188/1	തിച്ചൂർ	തല പ്പിള്ളി	0.0971	വരവൂർ	03.12.16	75,000	750

11	35/15-16/CRPS/LS/2852/C2/TDO/15	9.12.15	സുധീർ, പട്ടരുപറമ്പിൽ ചാവക്കാട്. പി.ഒ., തൃശ്ശൂർ	170/1	പിലാക്കാട്	തലപ്പിള്ളി	0.1942	വരവൂർ	08.12.16	1,50,000	1500
12	36/15-16/CRPS/LS/2088/C2/TDO/15	9.12.15	കെ.ടി.ദിനേഷ് കിഴക്കേതറയിൽ വീട്, പി.ഒ.തിരുമിറ്റക്കോട്, തൃശ്ശൂർ	170/1	പിലാക്കാട്	തലപ്പിള്ളി	0.1943	വരവൂർ	08.12.16	1,50,000	1500
13	37/15-16/CRPS/LS/2917/C2/TDO/15	18.12.15	നൂറുദ്ദീൻ.കെ.എം. കൈയ്ക്കുളങ്ങര വീട് വെള്ളറക്കാട്.പി.ഒ. തൃശ്ശൂർ	1279/2, 3	പെരുമ്പിലാവ്	തലപ്പിള്ളി	0.0972	കടവല്ലൂർ	17.12.2016	75,000	750
14	38/15-16/CRPS/LS/2536/C2/TDO/15	11.01.16	ജയൻ.പി.എസ്., പുതുക്കുളങ്ങര വീട് പി.ഒ.കുറ്റൂർ	181/1	തങ്ങാലൂർ	തൃശ്ശൂർ	0.0971	അവണൂർ	10.01.2017	75,000	750
15	39/15-16/CRP/LS/3202/C2/TDO/15	29.02.16	പി.വി.സിനീഷ്, പത്തായിവട്ടവളപ്പിൽ, പന്നിശ്ശേരി	134	ആളൂർ	തലപ്പിള്ളി	0.0809	കാണശ്ശേരി	28.02.17	75,000	750
16	40/15-16/CRP/LS/3137/C2/TDO/15	29.02.16	വേണു.കെ.കെ. കുട്ടംകുളങ്ങര വീട്, അകതിയൂർ.പി.ഒ. കുന്നംകുളം	218/4	ചൊവ്വന്നൂർ	തലപ്പിള്ളി	0.0971	പോർക്കുളം	28.02.17	75,000	750
17	41/15-16/CRP/LS/319/C2/TDO/16	02.03.16	വിശ്വംഭരൻ മേൽവീട്ടിൽ വീട് പി.ഒ.കുന്നംകുളം	309	കടങ്ങോട്	തലപ്പിള്ളി	0.0971	കടങ്ങോട്	01.03.2017	75,000	750

18	42/15-16/CRP/LS/339/C2/TDO/16	02.03.16	്വിശ്വംഭരൻ മേൽവീട്ടിൽ വീട് പി.ഒ.കുന്നംകുളം	511	വെള്ളറക്കാട്	തലപ്പിള്ളി	0.0971	വെള്ളറക്കാട്	01.03.2017	75,000	750
19	43/15-16/CRP/LS/955/C2/TDO/16	23.03.16	തോമസ്.സി.ഡി. ചുങ്കത്ത് വീട അടാട്ട്	674/ു	തയ്യൂർ	തലപ്പിള്ളി	0.0956	വേലൂർ	22.03.2017	75,000	750
20	1/16-17/CRPS/LS/19/C2/TDO/16	06.04.16	ജോസഫ്.പി.എ. പൂംകുടിയിൽ വീട് പിലാക്കാട്, തൃശ്ശൂർ	169/42	വരവൂർ	തലപ്പിള്ളി	0.1943	വരവൂർ	05.04.2017	1,50,000	1500
21	2/16-17/CRPS/LS/1252/C2/TDO/16	28.04.16	എ.കെ.സഹദേവൻ അത്താണിക്കൽ വീട് കുറുമാൽ.പി.ഒ. വേലൂർ	854	വേലൂർ	തലപ്പിള്ളി	0.0971	വേലൂർ	27.04.2017	75,000	750
22	3/16-17/CRPS/LS/1257/C2/TDO/16	28.04.16	കെ.ജി.ബാഹുലേയൻ കരണംകോട്ട് വീട് പോന്നോർ. പി.ഒ.	122/3	തോളൂർ	തൃശ്ശൂർ	0.0971	തോളൂർ	27.04.2017	75,000	750
23	4/16-17/CRPS/LS/1517/C2/TDO/16	09.05.16	തോമസ്.വി.വി. വാഴപ്പിള്ളി വീട്, മുർ.പി.ഒ. തൃശ്ശൂർ	328/2	തങ്ങാലൂർ	തൃശ്ശൂർ	0.0972	.അവണൂർ	08.05.17	75,000	750
24	5/16-17/CRPS/LS/1275/C2/TDO/16	13.05.16	ഉണ്ണികൃഷ്ണൻ.കെ. എം. കരുതുപറമ്പിൽ വീട് പേരാമ്പ്ര.പി.ഒ.	1447/4, 1448/1	മറ്റത്തൂർ	ചാലക്കുടി	0.0931	മറ്റത്തൂർ	12.05.2017	75,000	750

25	6/16-17/CRPS/LS/1276/C2/TDO/16	03.06.16	തങ്കച്ചൻ വിതയത്തിൽവീട് പി.ഒ.കൊരട്ടി തൃശ്ശൂർ	297/8	കിഴക്കുമുറി	തൃശ്ശൂർ	0.0904	കൊരട്ടി	02.06.17	75,000	750
26	8/16-17/CRPS/LS/1250/C2/TDO/16	8.08.16	ടി.എ.സാവദ് തറയിൽ വീട്, പിലാക്കാട്.പി.ഒ	169/1	പിലാക്കാട്	തലപ്പിള്ളി	0.1942	വരവൂർ	07.08.17	1,50,000	1500
27	9/16-17/CRPS/LS/2263/C2/TDO/16	10.08.16	സുനിൽ പുലിക്കുന്നത്ത് വീട്, പി.ഒ. പുതുരുത്തി	173/2,3	പിലാക്കാട്	തലപ്പിള്ളി	0.0970ഒ	വരവൂർ	09.08.17	75,000	750
28	10/16-17/CRPS/LS/2264/C2/TDO/16	10.08.16	ഉൻസാബ് ഉമ്മർ കൊടക്കാട്ടിൽ വീട് പിലാക്കാട്.പി.ഒ., തൃശ്ശൂർ	163	പിലാക്കാട്	തലപ്പിള്ളി	0.0971ഒ	വരവൂർ	09.08.17	75,000	750
29	11/16-17/CRPS/LS/2774/C2/TDO/16	22.08.16	ജോസ്.സി.ഒ. ചെമ്മാഞ്ചേരി വീട്, പൊയ്യ.പി.ഒ.	321/1	പൊയ്യ	കൊടുങ്ങല്ലൂർ	0.0971ഒ	പൊയ്യ	21.08.17	75,000	750
30	12/16-17/CRPS/LS/3188/C2/TDO/16	22.08.16	പീനറ്റ്.സി.ഡി. ചീരമ്പൻ വീട് പി.ഒ.വേലൂർ	1468	വേലൂർ	തലപ്പിള്ളി	0.0972ഒ	വേലൂർ	21.08.17	75,000	750
31	13/16-17/CRPS/LS/1713/C2/TDO/16	29.08.16	ഷൈനി പയ്യപ്പിള്ളി വീട് പൂപ്പത്തി. പി.ഒ., പൊയ്യ	253/1	പൊയ്യ	കൊടുങ്ങല്ലൂർ	0.0971ഒ	പൊയ്യ	28.08.17	75,000	750
32	16/16-17/CRPS/LS/3377/C2/TDO/16	06.09.16	എം.കെ.വിശ്വംഭരൻ മേൽവീട്ടിൽ വീട് പി.ഒ.കുന്നംകുളം	354	കടങ്ങോട്	തലപ്പിള്ളി	0.0971	കടങ്ങോട്	05.09.17	75,000	750

33	17/16-17/CRPS/LS/3120/C2/TDO/16	09.09.16	അബ്ദുൾ സലാമു.സി വി. ചങ്ങരത്തുവളപ്പിൽ വീട് തളി.പി.ഒ. വരവൂർ	149	പല്ലൂർ	തലപ്പിള്ളി	0.0972	ദേശമംഗലം	08.09.17	75,000	750
34	18/16-17/CRPS/LS/3249/C2/TDO/16	09.09.16	അശോകൻ.കെ.കെ. കല്ലിങ്ങൽ വീട് പി.ഒ.ചൂൽ, തൃശ്ശൂർ	511/1	വെള്ളറക്കാട്	തലപ്പിള്ളി	0.0971	കടങ്ങോട്	07.08.17	75,000	750
35	19/16-17/CRPS/LS/1918/C2/TDO/16	09.09.16	സരിഷ്.ഇ.പി., എരുവീട്ടിൽ വീട്, ചായ്പ്പൻകുഴി.പി.ഒ., തൃശ്ശൂർ	1516/2	കുറ്റിച്ചിറ	ചാലക്കുടി	0.0970ഒ	കോടശ്ശേരി	08.09.17	75,000	750
36	20/16-17/CRPS/LS/3319/C2/TDO/16	23.09.16	ഹരിദാസ്.സി.ആർ ചക്കാലപറമ്പിൽ, പി.ഒ.അവണൂർ	158/4	തങ്ങാലൂർ	തൃശ്ശൂർ	0.1942ഒ	അവണൂർ	22.09.17	1,50,000	1500
37	21/16-17/CRPS/LS/1585/C2/TDO/16	14.10.16	സൈനുദ്ദീൻ കുറുമാച്ചാമയിൽ വീട്, പി.ഒ.പിലാക്കാട്, തൃശ്ശൂർ	162/3	പിലാക്കാട്	തലപ്പിള്ളി	0.0971	വരവൂർ	13.10.2017	75,000	750
38	22/16-17/CRPS/LS/3456/C2/TDO/16	26.10.16	ടി.ആർ.പോൾസൺ തയ്യാലയ്ക്കൽ വീട് പി.ഒ.അളഗപ്പനഗർ, തൃശ്ശൂർ	146/1	ചെങ്ങാലൂർ	മുകുന്ദപുരം	0.0648	പുതുക്കാട്	25.10.2017	75,000	750
39	23/16-17/CRPS/LS/3617/C2/TDO/16	02.11.16	ജിംഷാദ്.ടി.എ. തളത്തിൽ വീട്, പി.ഒ.തിച്ചൂർ	188/2	തിച്ചൂർ	തലപ്പിള്ള	0.0972	വരവൂർ	01.11.17	75,000	750
40	24/16-17/CRPS/LS/3435/C2/TDO/16	16.11.16	വാസുദേവൻ മൂരിപ്പാറ വീട്, പി.ഒ.പിലാക്കാട് തൃശ്ശൂർ	174/6	പിലാക്കാട്	തലപ്പിള്ളി	0.0971	വരവൂർ	15.11.17	75,000	750

41	25/16-17/CRPS/LS/3831/C2/TDO/16	18.11.16	ഷൈജൻ.ടി.വി. തറയിൽ വീട്, പി.ഒ.ഇയ്യാൽ, തൃശ്ശൂർ	294/5	ചിറമനങ്ങാട്	തലപ്പിള്ളി	0.0971	കടങ്ങോട്	17.11.17	75,000	750

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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 orginate 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 paranthesis) 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
	Mio-Pliocene(N 12) (TertiaryTt)	Laterite Warkalli Formation (Sandstone and clay with ligniteintercalations) 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	Charnockites(younger) (550Ma)	Massive charnockite, incipient charnockite, Cordierite charnockite
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	Garnet-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
A	Charnockite(older) (Ac) 2600Ma	Mafic granulite, pyroxene granulite, Banded magnetite quartzite and gneissic charnockite
R		
C	Khondalite Group (Ak)	Quartzite, mafic granulite, calc-granulite garnet-biotite-sillimanite-cordierite gneiss, garnet-biotite-gneiss, leptynite
H	Peninsular Gneissic Complex (PGC I) (Ap) (3000Ma)	Foliated granite, hornblende 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, migmatisation 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 consists of quartz-mica schist with kyanite, quartz-sericite schists, quartzites, magnetite quartzite, fuchsite quartzite and meta-ultramafites. Their contact with the surrounding gneisses is 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- ultabasic 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 serpentinised 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. Char nockite 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 migmatisation 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 $\pm$ 50 Ma (Soman,1997).

Also charnockite has been subjected to retrogression and migmatisation.

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°49‘30": 75 °34'00") to Vengad (11°53‘30":75 °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 migmatisation, 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-assemblage. 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 migmatisation 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^{o}06'20", 76^{o}05'56") Velli (11^{o}04'00":76^{o}07'45"), Kalpetta (11^{o}04'12":76^{o}05'32). An extensive basic diorite has been mapped over an area of 25 sq km at Panavalli (11^{o}53'30", 76 ^{o} 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 (An_{58-72}) 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 agmatised 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 Warrier and Venkataraman, 1986). The pyroxenes are uralitised 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 Warrier 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 charcteristics.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 microperthitic 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 was 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$\pm$ 30 Ma, Nair, *et al*,1985) is lower than Rb-Sr age (595 $\pm$ 20 m.a Santhosh *et al*, 1986), but is higher than that of U-Pb-age(505$\pm$20ma, 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 contains 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 Trikkaippetta ($11^0$35'04":$76^0$08"41":), Manikkunnu ($11^0$35"41":76^0 07'09"), Kuttamangalam ($11^0$30'08":$76^0$07'11":) (Anilkumar *et al,* 1993).

Fine biotite-granite is a fine grained massive rock exposed around Muttilmala ($76^0$06'38":$11^0$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. K_2O content always exceeds that of Na_2O. The high SiO_2, 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 K_2O content with respect to SiO_2 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 ($11^0$01'52":$76^0$42'00") and Vachchapathi ($11^0$04'15":$76^0$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. SiO_2 varies from 58.76 to 73%, Al_2O_3 14% to 17%, Na_2O 1.8% to 2.4% and K_2O 0.8 to 1.5%. The distribution of SiO_2 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 Kumbla 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 ($9^0$15'45":$76^0$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 80^0. The dolerite dykes of Kuttuparamba ($11^0$49'30":$75^0$34'00") in Kannur District shows cross cutting relationship with all the formations. The basic dykes of Vamanapuram ($8^0$43'00":$76^0$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 ± Ma and 476 ± 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°28'30": 76°57'20") to Kasaragod (12°30'00": 74°59'00") between coastal and midland regions with intervening promontories of the crystalline rocks. The Quilon Formation is mainly seen at Paravur (08°48'00": 76°40'00") Padappakkara (08°58'30": 76°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°45'20";76°42'00") and Varkala (8°44'00": 76°43'00") and Cherthala (9°41'00":76°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'), Puliyur (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 lateratisation. Further, the erosional features on the top part of the bauxite horizon corroborate 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 demonstrates 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 Andoorkonam (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 indicates 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 (F_1) 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 F_2 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 (F_3) which deform F_1 and F_2 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 iden tified 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 be 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 a 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 Thiruvanathapuram area, the temperature at the peak of metamorphism indicated by the mineral assemblages of the calc-silicate rocks is about 830ºC 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 800ºC. 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 indicates varying metamorphic conditions and uplift history. It is also summerised that there is a progressive decline in the uplift of different segments from north to south (Soman, 1997).


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS