Petrographic Characterization of the rock types in the parts of Kallakurichi – Thiruvannamalai District, Southern Granulite Terrain, Tamil Nadu, India

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Abstract

The present study area covers the Kallakurichi and Tiruvannamalai districts which form the northeastern part of the Southern Granulitic terrain of peninsular India. It is represented by charnockites and Granitic gneisses. Petrographic study of these present rock types aims to understand the textural and mineralogical variations present through the traverse covering the Madurai block, Palghat-Cauvery shear zone and Madras block. It also represents the lithological characters present in the study area. Based on the present petrological study, it consists of dominant Charnockite as compared to Granitic gneisses. Charnockites are fresh and unaltered and not comparable with the gneisses which exhibit foliated features and deformation. Granitic gneisses are more felsic as compared to the charnockites, as they are dominant in quartz and feldspar. The present study suggests that the petrographic characters of Charnockite and Granitic gneisses deduce the igneous and metamorphic activities and represent distinctive textural characters of geologic processes.

Key Words: Charnockites; Gneisses; Southern Granulite Terrain (SGT); Kallakurichi; Tiruvannamalai

1. Introduction

The petrographic study of the rocks helps to identify the optical significance of lithology, which predominantly provides information about mineral assemblages, mineralogical characteristics, and textural characteristics of the rocks (Cady et al., 1986). Mineral assemblages and their distinguishing characteristics reveal the aggregate composition of the rock from where it was the origin. In addition, the petrographical studies give a summation of the rock's origin as a preliminary assessment. Understanding the textures of the rocks in the terrain is so essential that it even outlines the evolution of the rock and the stages of its formation (Folk, 1959). The study area is situated in the northern part of the Southern Granulite Terrain (SGT) in Tamil Nadu. Many authors have described the petrography primarily focusing on SGT. Earlier workers (Howie, 1955; Rama Rao, 1945) reported various petrographic descriptions of SGT. Detailed petrography and mineral chemistry of SGT were also performed on the metapelites and granulitic rocks (Raith et al., 1983; Santosh, 1996). Very few studies were carried out on geochemistry in the areas of Tiruvannamalai as well as in and around Kallakurichi but no work describing the petrographical understanding and further classification of the region's rock types were conducted. Thus, the present study was to highlight the important petrographic characteristics of the rock types in and around Kallakurichi and Tiruvannamalai district, Tamil Nadu.

A detailed petrographic study in Kallakurichi and Tiruvannamalai, part of Southern Granulite Terrain in Tamil Nadu was performed for the rock types present in the study area (Fig. 1). Approximately 20 locations were examined in which 16 thin sections were prepared

and observed. Through this study, an attempt was made to analyze the different textures and mineral assemblages present in the rock. The detailed petrographical examination of each rock type reveals that Charnockite and gneissic rock comprise most of the study area. The remaining lithology of the region is comprised of charnockite, hornblende biotite gneiss, amphibolite, granitic gneiss, migmatite, polymetallic and ultramafic rocks. Charnockite and Granitic gneiss are considered and investigated for the igneous and metamorphic textural study.

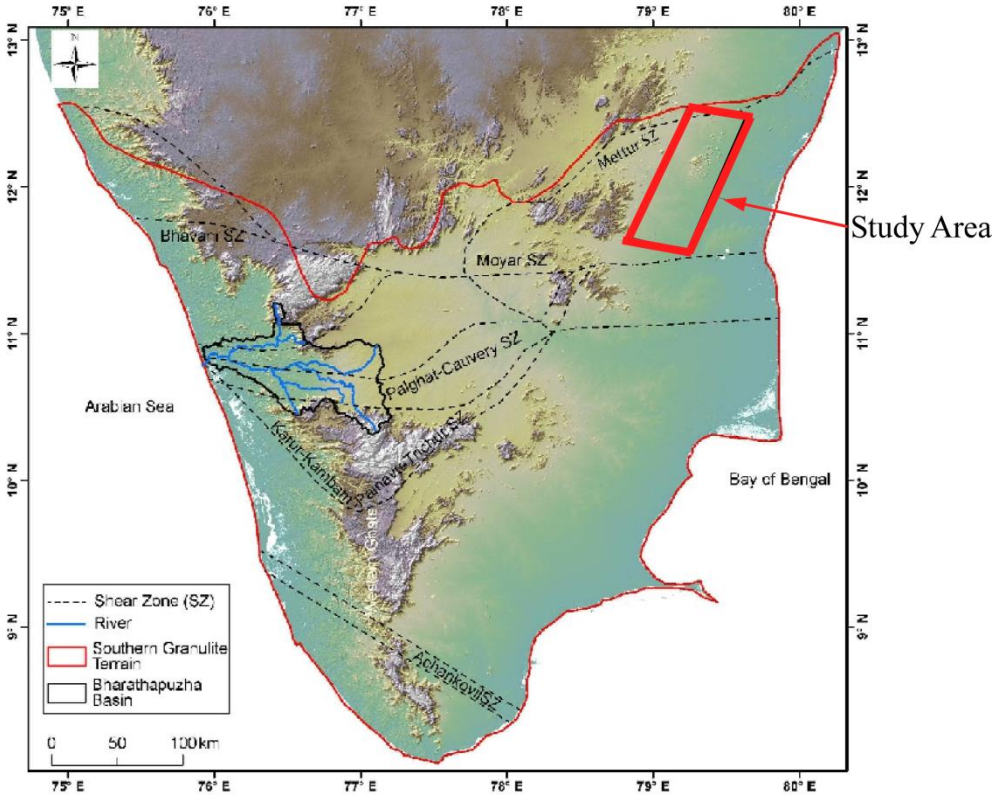


Fig.1: Map showing the structural features of the Southern Granulite Terrain SGT along with the study area.

Modified after *(Reddy et al., 2021)*

2. Geological Setting

In terms of lithological distributions, the southern peninsula of India is vast and diverse. It is broadly divisible into the Dharwar Craton in the north and the Southern Granulite Terrain (SGT) in the south, as defined by the dominance of greenstone belts and

juvenile granitic intrusions in the western and eastern parts of the terrain, respectively (Chadwick et al., 2000). Each crustal block possesses unique petrological and geochronological characteristics. They belong to Archean to Proterozoic formations with distinct structural and mineralogical characteristics. The Archaean Dharwar Craton contains numerous schist belts, and the Neoarchaean-Neoproterozoic Southern Granulite Terrain (SGT) contains high-grade rock formations (Harris et al., 1994) along with the Proterozoic Cuddapah Basin and Tertiary sediments (Antony & Castro, 2021). The Fermor line divides the Dharwar craton and the SGT based on the degree of metamorphism (Fermor, 1936) as a transitional boundary between the high-grade and low-grade terranes. It distinguished the Archaean and Proterozoic terrains as charnockite provinces and non-charnockite provinces and considered the charnockite provinces to be deeply buried, highly metamorphosed terrain.

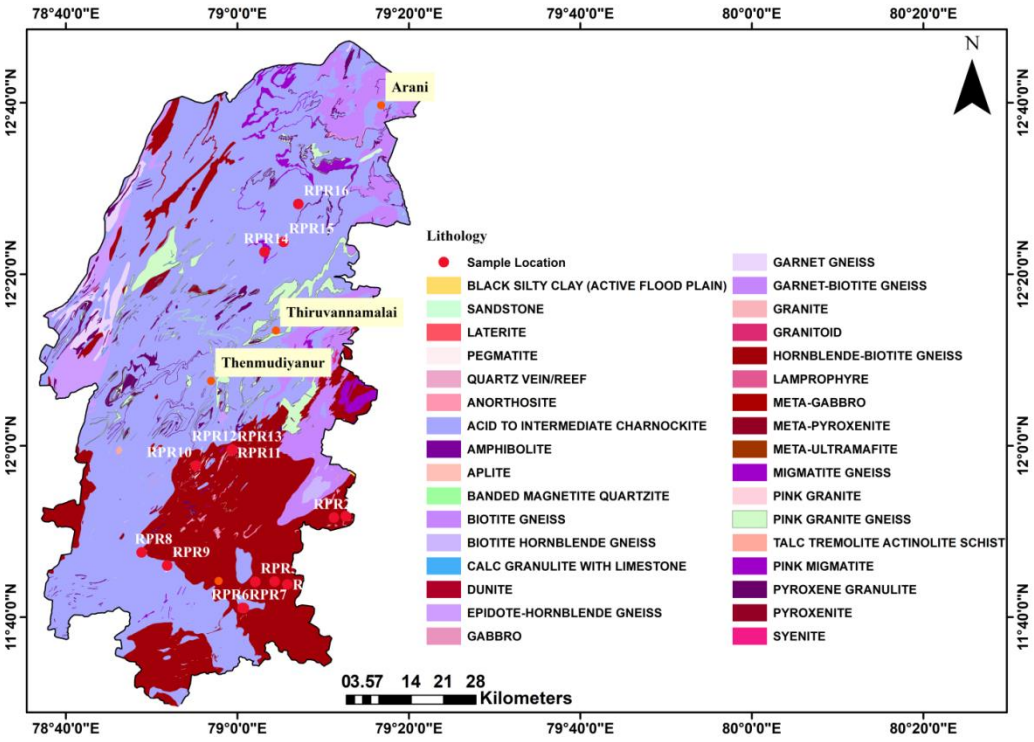


Fig. 2: Geological map with sample locations from Kallakurichi and Tiruvannamalai districts covering the northeastern part of Southern Granulite Terrain

The present study area is bounded by (Lat-12°46'N to11°29'N; Long- 78°37'E to 79°16'E) Jawadhu Hills and Kalvarayan Hills in the west, Villupuram district in the east, Perambur district in the south and Vellore district in the north (Fig. 2). The selected region possesses distinct lithological characteristics, and its in-depth study suggests the geological evolution of the terrain. The lithology covers the rock types of Hornblende-biotite gneiss, biotite gneiss, charnockite, amphibolite, pyroxenite, granite, schist, banded iron formation, banded magnetite quartzite and pegmatite. Therefore, we focused on the Charnockite and Granitic gneisses from Kallakurichi and Tiruvannamalai districts, Tamil Nadu which covers the eastern part of the Southern Granulite Terrain following the traverse of Madurai block, Palghat-Cauvery Suture Zone (PCSZ) and Madras block.

The study area is situated in the southeastern part of the Deccan Plateau, characterised by undulating terrain and rocky outcrops. This region is also a part of the Eastern Ghats, a mountain range that runs parallel to the eastern coast of India. The study area has a diverse landscape, ranging from hills (which are undulated landforms) and plateaus to plains. The study area's elevation ranges from 52m to 255m, clearly shown in Fig. 3. The contour map was also prepared for the study area with an interval of 50m. The study area's topology is depicted graphically, with adjacent contour lines appearing as connected nodes (Fig. 4) and Fig. 5 showing the linkages between the districts of the study area.

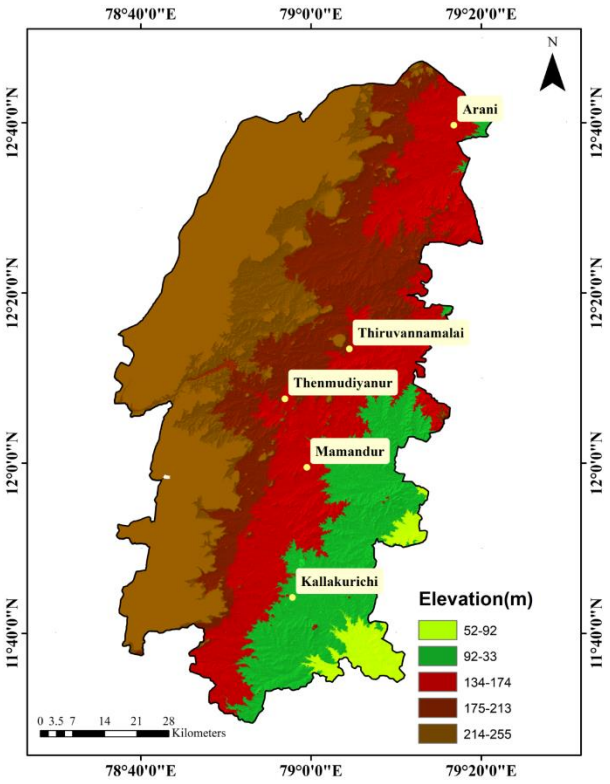


Fig. 3: Elevation map of the study area representing Kallakurichi, Tiruvannamalai districts, Tamil Nadu.

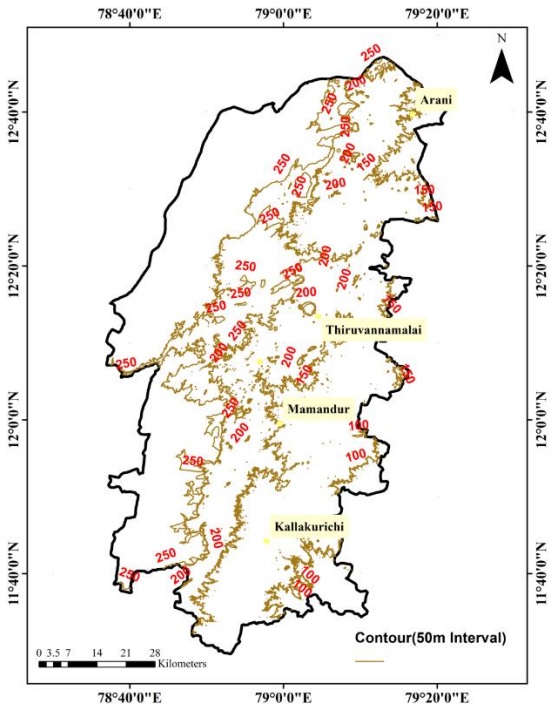


Fig. 4: Contour map of the study area representing Kallakurichi and Tiruvannamalai districts, Tamil Nadu.

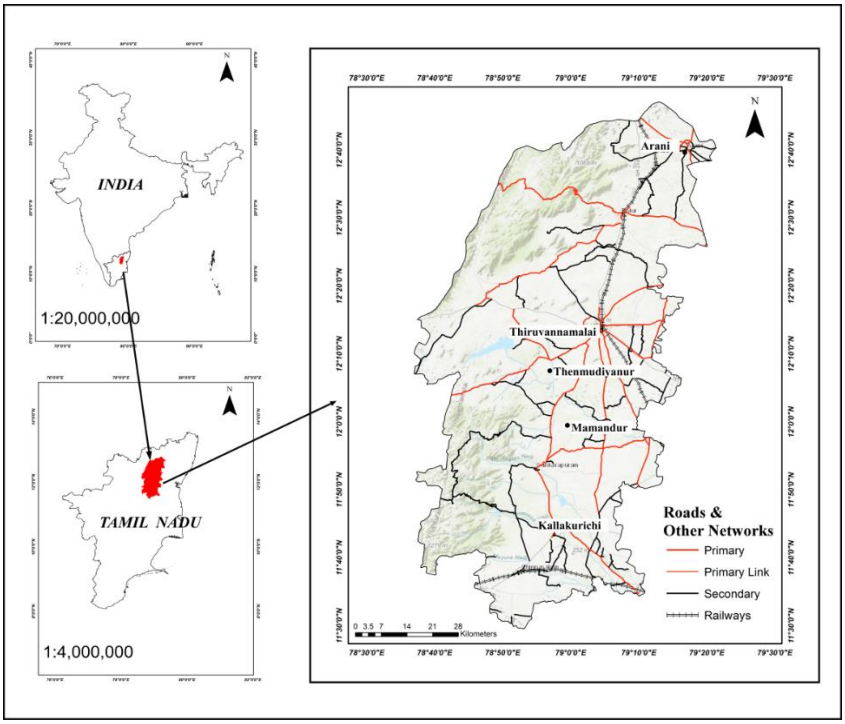


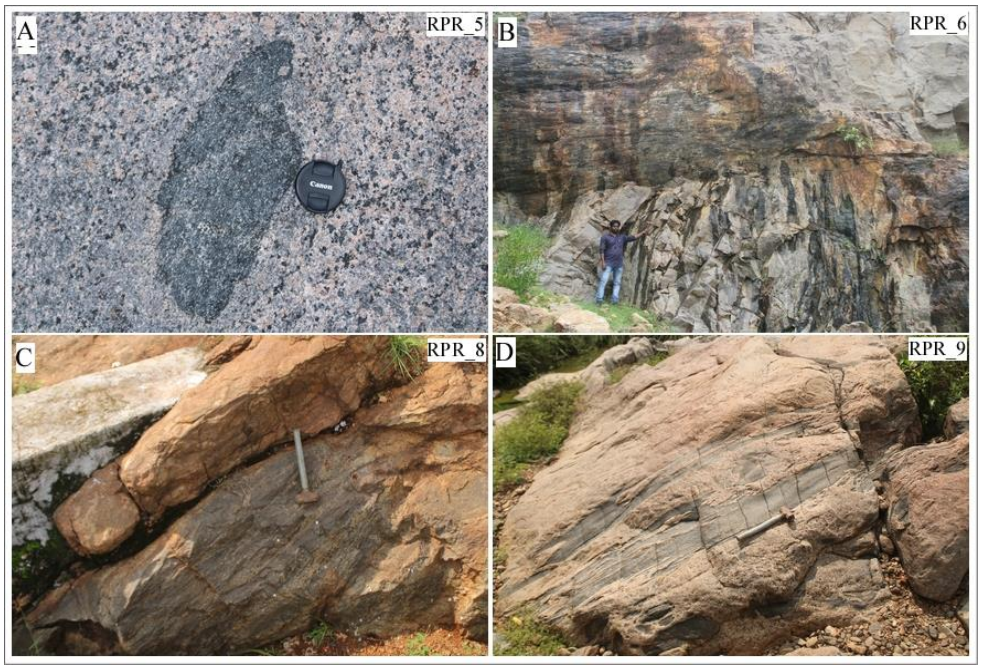
Fig. 5. Location map of the study area showing linkages between the districts of Kallakurichi and Tiruvannamalai district, Tamil Nadu

3. Sample collection

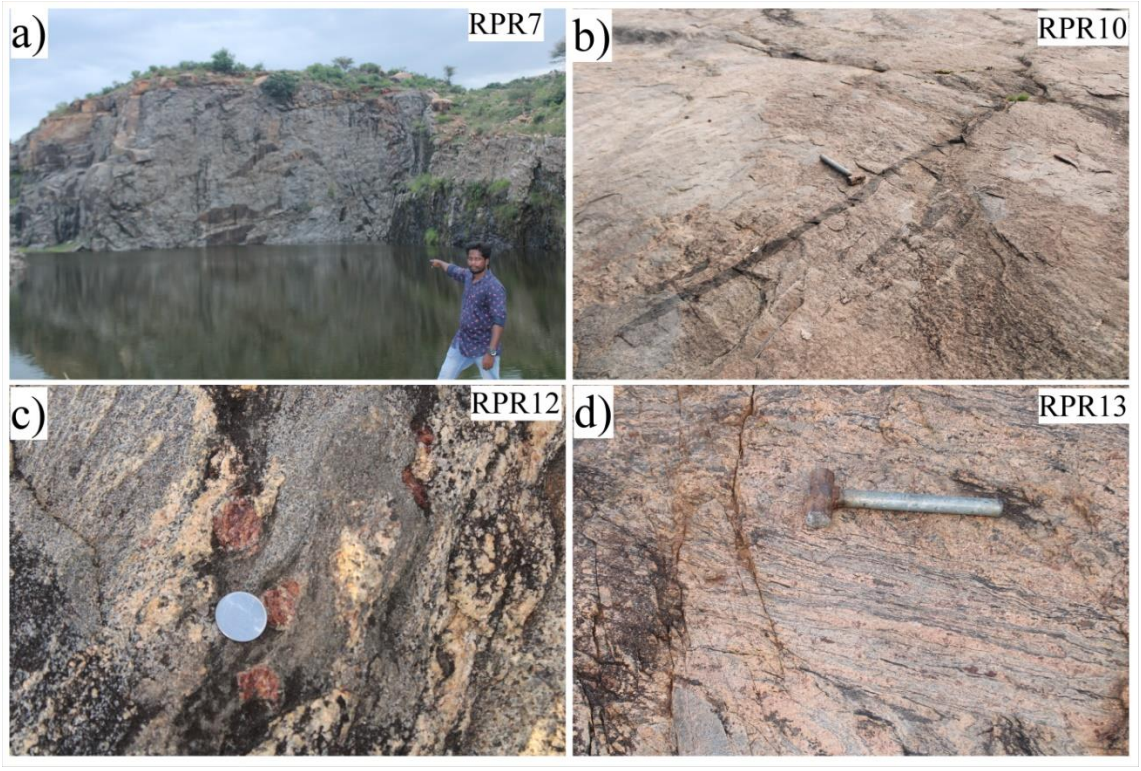
Fresh and unaltered samples were collected covering the Kallakurichi and Tiruvannamalai areas ((Lat-12°46'N to11°29'N; Long- 78°37'E to 79°16'E) covering the part of SGT, Tamil Nadu. The present samples cover almost all the rock types including Charnockite and Granitic gneiss exposures. Massive, hard, coarse, and fine-grained, melanocratic (light to dark pink) consisting of orthopyroxene as its character-defining ferromagnetic mineral along with quartz and feldspar (Fig. 6). The collected samples of Charnockite and Granitic gneiss were processed for preparing thin sections and undergone for mineral identification and petrographic study. Systematic methods and different instruments were used for cutting and grinding the rock samples and heating the samples which were

undergone after cutting followed by mounting the glass slide. Thin jawless diamond cutting vessels were used for cutting.

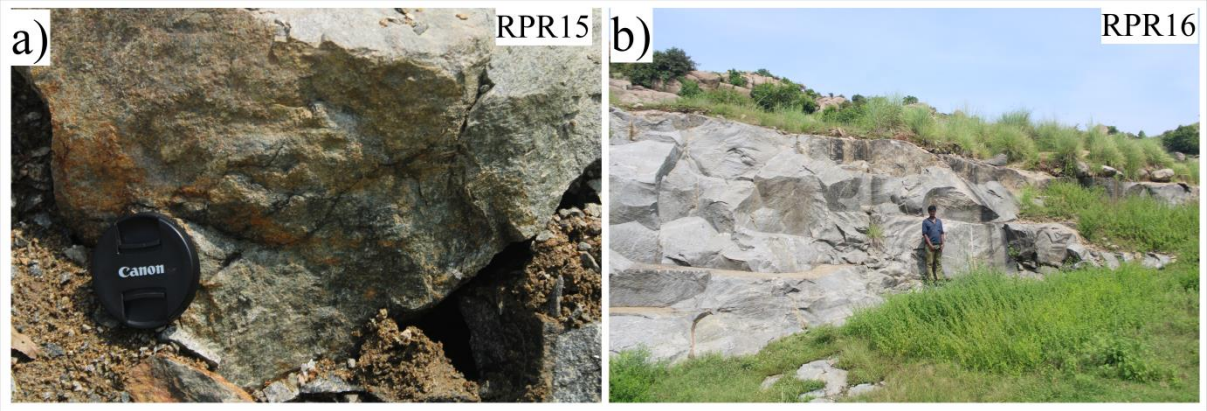
A) Charnockite rock from Elavanasur area; B) Granitic Gneiss from Memalur area; C) Charnockite rock from Alur area; D) Charnockite rock from Thiyagaduragam area



A) Granitic Gneiss from Thiyagaduragam area; B) Charnockite rock from Malaikottalam area; C) Charnockite rock from Gomuki Dam viewpoint; D) Charnockite rock from Vadakanandhal area



a) Charnockite from Malaikottalam area; b) Granitic Gneiss from Pudhupettai area; c) Granitic Gneiss from Vada Mamandur d) Charnockite from Vada Mamandur area

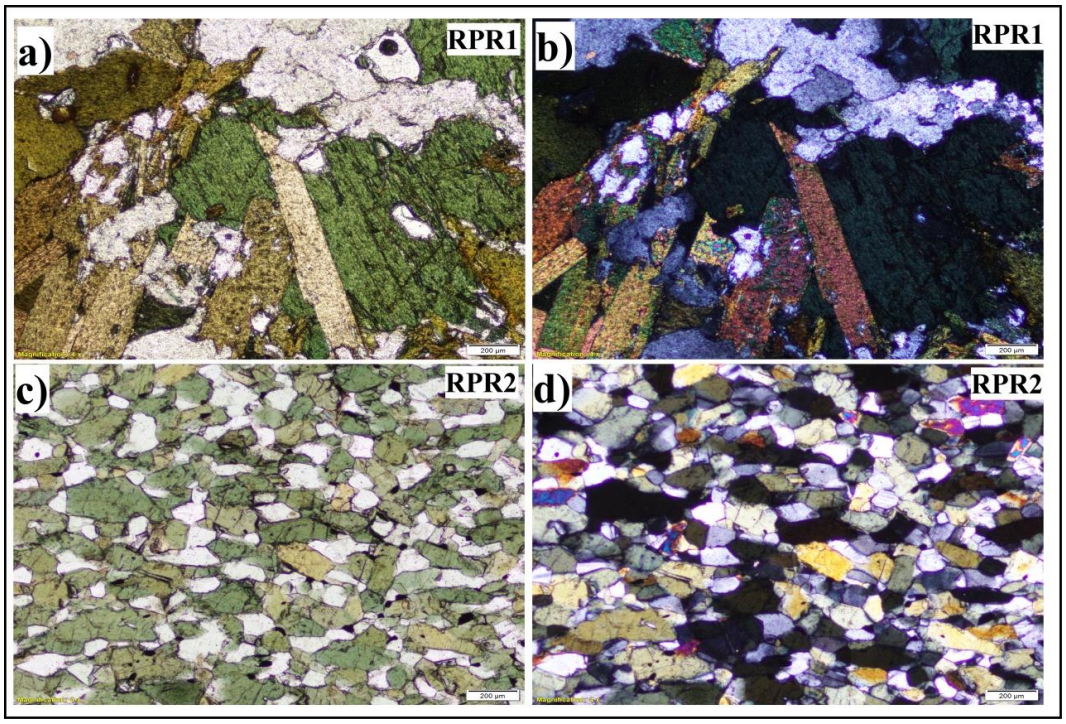


a) Granitic Gneiss from Andapattu area; b) Charnockite from Kadasarapakkam area.

Fig. 6. Field photographs of Charnockites and Granitic gneiss from Kallakurichi and Tiruvannamalai districts, a part of Southern Granulite Terrain (SGT), Tamil Nadu, India.

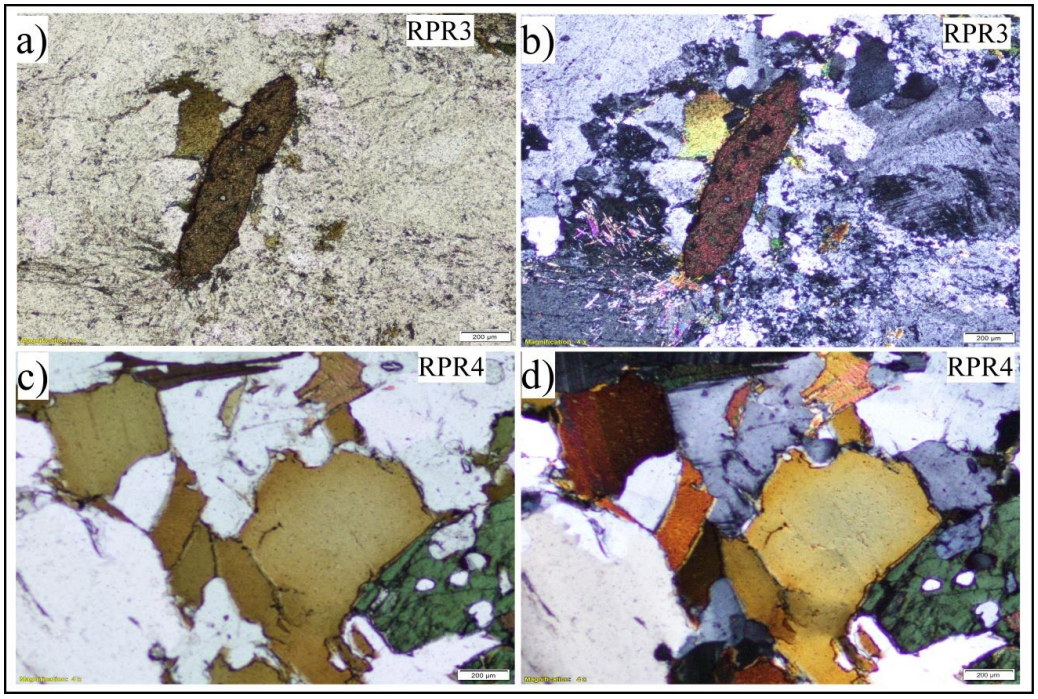
4. Petrography

The minerals obtained in charnockite are amphibole, biotite, feldspar, hornblende, micas, muscovite or illite, olivine, plagioclase, pyroxene, and quartz. Some rocks are brownish green as well. Charnockite rock consists of orthopyroxene along with quartz, feldspar, and titanium. Having a dark colour and clouding of feldspars are typical features. Gneiss shows foliation and poor schistosity and cleavage. It shows banding typically light- and dark-coloured layers; light-coloured layers are usually composed of feldspars and quartz and dark-coloured layers are usually composed of hornblende and biotite. Detailed petrographic characterization is given in Table.1. The present study of Charnockites and Granitic gneiss in plane-polarized and crossed-polarized photographs (Fig. 7).



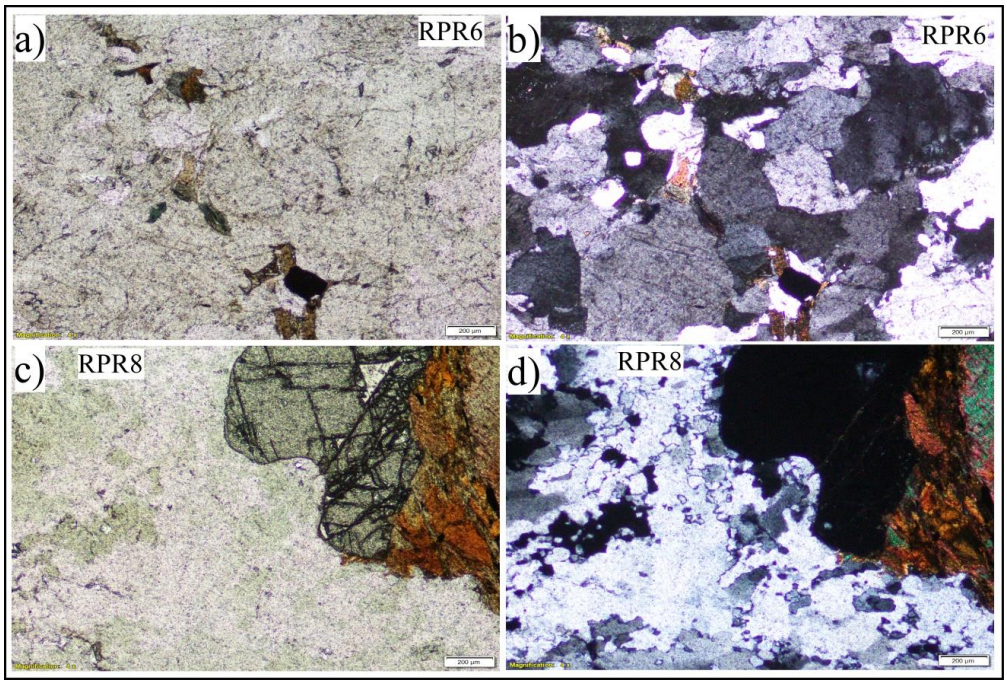
Charnockite rock from Elavanasur a) in plane-polarized light, b) in crossed-polarized light.

Granitic Gneiss from Memalur c) in plane-polarized light, d) in crossed-polarized light

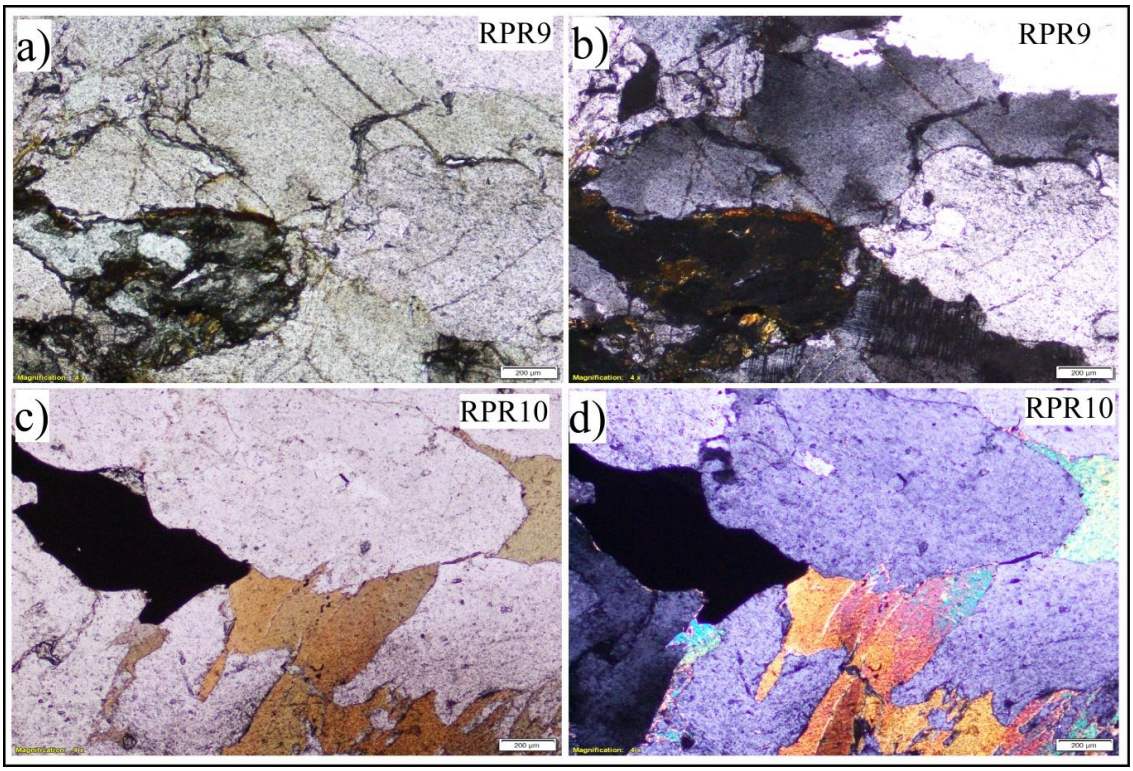


Charnockite rock from Alur area a) in plane-polarized light, b) in crossed-polarized light.

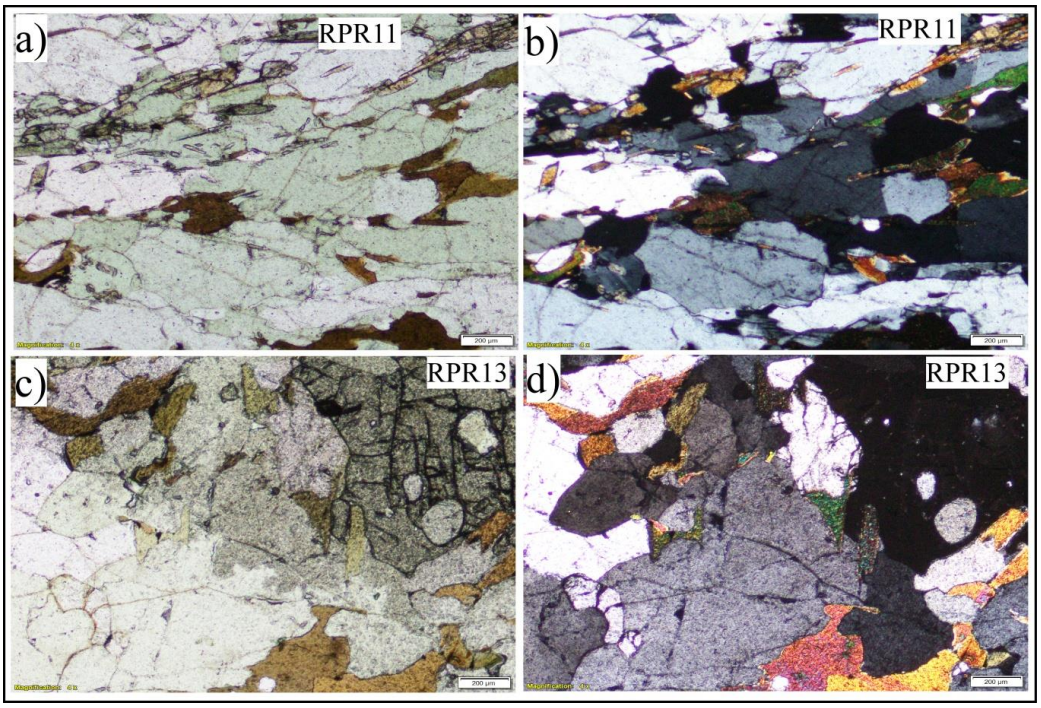
Charnockite rock from Thiyagaduragam area c) in plane-polarized light, d) in crossed-polarized light



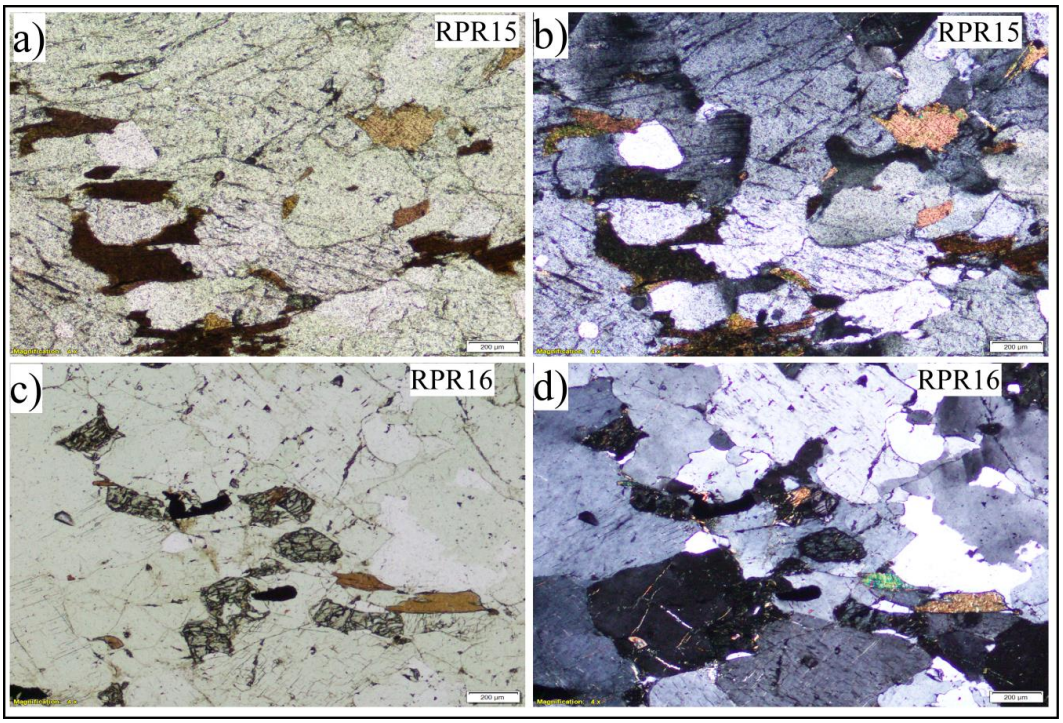
Charnockite rock from Malaikottalam area a) in plane-polarized light, b) in crossed polarized light; Charnockite rock from Gomuki Dam viewpoint c) in plane-polarized light, d) in crossed polarized light



Granitic Gneiss from Pudhupettai area a) in plane-polarized light, b) in crossed polarized light; Granitic Gneiss from Vadakanandhal c) in plane-polarized light, d) in crossed polarized light



Charnockite Vada Mamandur a) & c) in plane-polarized light, b) & d) in crossed-polarized light



Granitic Gneiss from Andapattu area a) in plane-polarized light, b) in crossed-polarized light; Charnockite from Kadasarapakkam area a) in plane-polarized light, b) in crossed-polarized light

Fig. 5. Photomicrographs showing the Charnockites and Granitic Gneisses from Kallakurichi and Tiruvannamalai districts, Tamil Nadu.

Table 1. Petrographic characters for charnockites and Granitic gneiss for Kallakurichi and Tiruvannamalai district, Tamil Nadu

S. No	Samples	Petrographic characters
1.	RPR-1	Melanocratic, massive mainly composed of feldspar and quartz. Orthopyroxene mainly is subhedral showing green colour altering to biotite and hornblende and iron oxides are released which occupy the margins of pyroxene. Olivine is altering to opaque oxides. **Mineral constituents: Orthopyroxene, Quartz, Feldspar** **Rock Name: Charnockite**
2.	RPR-2	Melanocratic, massive mainly composed of feldspar and quartz. Orthopyroxenes are euhedral which are moderately pleochroic from pale green to pink and corroded along the margin and left with cleavage traces. Subhedral Clinopyroxene shows pleochroic in shades of green. Secondary alteration and inclusions of hornblende within Clinopyroxene occur. Sometimes dark colour clouding of feldspar in k-feldspar. Idiomorphic crystals of garnet show the sieve texture. Myrmekitic texture between plagioclase and quartz is also seen. Opaque oxides, rare zircon, apatite, and epidote are also present. Amphibole and olivine are also present. **Mineral constituents: Quartz, K-feldspar, Biotite** **Rock Name: Granitic Gneiss**
3.	RPR-3	Melanocratic, massive mainly composed of feldspar and quartz. Untwined plagioclases are also present dominantly. Clinopyroxene is surrounded and corroded along the margins of the Orthopyroxene grains. Amphibole which is altered to biotite grains. Large idiomorphic garnets are present with the amphiboles. Sometimes zircon and opaque oxides are also present. **Mineral constituents: Orthopyroxene, Quartz, Feldspar**

Rock Name: Charnockite

4. RPR-4 Melanocratic, massive mainly composed of K-feldspar and quartz. Euhedral orthopyroxene, mainly hypersthene is moderately pleochroic showing reddish brown. Inclusions of zircon and apatite are observed in the garnet and orthopyroxene grains. Few amphibole grains are present along with the garnet. Garnet is intruded in the K-feldspar grains.

Mineral constituents: Orthopyroxene, Hypersthene, Quartz, Feldspar

Rock Name: Charnockite

5. RPR-5 Melanocratic, massive mainly composed of K-feldspar and quartz. Untwined plagioclase can be observed. The margins of the garnet are surrounded by pyroxene.

Mineral constituents: Quartz, K-feldspar, Garnet

Rock Name: Granitic Gneiss

6. RPR-6 Melanocratic, massive mainly composed of K-feldspar and quartz. Orthopyroxene is intruded in the amphiboles. Orthopyroxene is altering into biotite which is evidenced by the presence of opaque oxides along the margins. Untwined plagioclase is also present. Small idiomorphic garnets are present and intruded in the feldspar. Rare Zircons and epidotes also can be observed.

Mineral constituents: Orthopyroxene, K-feldspar, Quartz, Biotite

Rock Name: Charnockite

7. RPR-8 Melanocratic, massive mainly composed of K-feldspar and quartz. Apatite, zircons, and epidotes are observed abundantly. Amphibole grains altering to the biotite/ apatite. Opaque oxides are surrounded along the margins of the hypersthene.

Mineral constituents: K-feldspar, Quartz, Hypersthene

Rock Name: Charnockite

8. RPR-9 Melanocratic, massive mainly composed of dominantly amphibole and feldspar and quartz. The margins of the pyroxene are undeformed, and the grains are surrounded and altered by biotite and opaque oxides. Hypersthene is dominantly present in this thin section. Garnet is surrounded by pyroxenes.

Mineral constituents: Amphibole, Feldspar, Quartz, Hypersthene

Rock Name: Charnockite

9. RPR-10 Feldspar and quartz are dominantly present showing poikilitic texture. Apatite and zircon are present in the groundmass and show strong deformation.

Mineral constituents: Feldspar, Quartz, Zircon

Rock Name: Granitic Gneiss

10. RPR-11 Feldspar and quartz are dominantly present showing poikilitic texture. Hypersthene is dominantly present in this thin section. Garnet is surrounded by pyroxenes.

Mineral constituents: Feldspar, Quartz, Hypersthene

Rock Name: Charnockite

11. RPR-13 Melanocratic, massive mainly composed of dominantly amphibole and feldspar and quartz. The margins of the pyroxene are undeformed, and the grains are surrounded and altered by biotite and opaque oxides. Hypersthene is dominantly present in this thin section. Garnet is surrounded by pyroxenes.

Mineral constituents: Amphibole, Feldspar, Quartz, Hypersthene

Rock Name: Charnockite

12. RPR-15 Melanocratic, massive mainly composed of K-feldspar and quartz. Untwined plagioclase can be observed. Orthopyroxenes are euhedral which are moderately pleochroic from pale green to pink and corroded along the margin.

		Mineral constituents: Quartz, K-feldspar **Rock Name: Granitic Gneiss**
13.	RPR-16	Melanocratic, massive mainly composed of dominantly amphibole and feldspar and quartz. The margins of the pyroxene are undeformed, and the grains are surrounded and altered by biotite and opaque oxides. Hypersthene is dominantly present in this thin section. Garnet is surrounded by pyroxenes. **Mineral constituents: Amphibole, Feldspar, Quartz, Hypersthene** **Rock Name: Charnockite**

5. Discussion and Conclusion

The detailed petrographic study was carried out in the Kallakurichi and Tiruvannamalai districts.

covering the traverse of Madurai Block, Palghat Cauvery Shear Zone, and Madras Block. Textural and mineralogical compositions were identified for the present Charnockite and Granitic gneisses in the study area. Distinct mineralogy and textural characteristics throughout the traverse indicate the various metamorphic stages and variations in the level of deformation activity. The present study area consists dominantly of Charnockite which are undeformed and unaltered rocks consisting of orthopyroxene, quartz, feldspar, hypersthene, amphiboles and accessory minerals like biotite, zircon, and apatite. Whereas Gneiss is deformed and altered as compared to Charnockite rocks and few samples show foliation and consist of K-feldspar, quartz, biotite, sillimanite, and garnet. Future studies of geochemistry on these rock types may expose the distinguished features in genesis, tectonic setting, and evolution of magma.

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