

# Geology, Field relationships and Petrography characteristics of Melur Granite / Leptynite, Madurai Block, Southern India.

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**Abstract** - The Melur region in southern Tamil Nadu features a significant 15 km long belt of garnetiferous leptynite, formed by crustal anatexis and intense migmatization of metasedimentary protoliths under granulitic facies conditions. Characterized by a mineral assemblage of quartz, feldspar, and garnet with a granoblastic texture, the leptynite's formation involved slow cooling and partial melting at high temperatures and moderate to high pressure. Textural features like perthite, polysynthetic twinning in plagioclase, and equilibrium garnet growth further support slow cooling and dynamic metamorphism. The presence of equilibrium garnet, biotite, and quartz reinforces the evidence for partial melting and high-grade metamorphism in the area. Studying the Melur leptynite is crucial for deciphering the region's metamorphic history and tectonic evolution, offering insights into the high-temperature and pressure conditions associated with regional tectonic processes and crustal thickening.

**Key Words:** Field characters, Petrography, Leptynite/ granite, Melur, South India.

## 1 INTRODUCTION

The Southern Granulite Terrain (SGT) of India, south of the Dharwar Craton, is a collage of crustal blocks including the Coorg, Nilgiri, Salem, Madras, Madurai, Trivandrum and Nagercoil Blocks, the basement rocks of which range in age from Mesoarchean to Neoproterozoic (Santosh et al., 2003, 2006, 2009; Collins et al., 2007a, 2007b; Clark et al., 2009; Santosh et al., 2009, 2015, 2016; Clark et al., 2009; Collins et al., 2014; Plavsa et al., 2014; Praveen et al., 2014; Shaji et al., 2014; Samuel et al., 2014; Yang et al., 2015; Amaldev et al., 2016). The Madurai Block (MB), bounded between PCSZ in the north and Achankovil Suture Zone (AKSZ) in the south, is mainly composed of Neoproterozoic to Meso-Neoproterozoic charnockite-granite-migmatite gneisses intercalated with metasedimentary rocks (Plavsa et al., 2012, 2014). The Madurai Block (MB) is the largest among the various crustal blocks in the SGT and has been the focus of various investigations relating to crustal evolution, including the various magmatic records and ultrahigh-temperature metamorphism (Harris et al., 1994; Brown and Raith, 1996; Sajeew et al., 2004; Tateishi et al., 2004; Santosh et al., 2009; Tsunogae and Santosh, 2011; Plavsa et al., 2012, 2014). The Palghat–Cauvery Shear Zone System (PCSS) of southern India has long been recognised as a prominent tectonic feature separating much of the states of Kerala and Tamil Nadu from the rest of India (Chetty, 1996; Chetty and Bhaskar Rao, 2006a,b; Drury et al., 1984). It is only in the last decade or so, however, that this zone has been suggested to be a cryptic suture of one of the strands of the Mozambique Ocean that closed as Gondwana amalgamated (Clark et al., 2009; Collins et al., 2007a; Sajeew et al., 2009; Santosh et al., 2009; Sato et al., 2011). The Madurai Block (Bartlett et al., 1998) lies directly south of the PCSS, its northern part overlying a south-dipping electrical feature (Naganjaneyulu and Santosh, 2010, 2011) recently interpreted as the relics of a subduction system (Santosh et al., 2009). However, a difficulty with this Ediacaran–Cambrian suture model of Collins et al. (2007a) and Santosh et al. (2009) has been the lack of evidence of Neoproterozoic magmatism in the Madurai Block – the location of a volcanic arc in the model of Santosh et al. (2009). Cryogenian magmatism has been identified in adjacent Gondwanan terranes. For example, in central Madagascar, voluminous mafic and felsic arc-related magmatism intrudes throughout the basement of the island (Handke et al., 1999; Kroner et al., 2000). To the east, in Sri Lanka, similar-aged magmatism has also been reported (Kröner et al., 2003).

The investigated area around Melur granite/leptynite rock contains the high-grade regionally metamorphosed metapelites (Fig.1). This area forms a part of the peninsular gneiss, the most widely spread group of rocks in many parts of Tamil Nadu. The rock formation is popularly known as multi colour granite (leptynite) essentially made up of a supra crustal assemblages of quartz and feldspar as major constituents ( $\pm$  silimanite  $\pm$  graphite  $\pm$  garnet  $\pm$  magnetite), closely inter banded with calc- silicate rocks and

dolomite, as well as garnetiferous gneiss or schist, occurring within a vast area of biotite gneiss ( $\pm$  garnet). The rock around Melur can be broadly classified into the khondalite and charnockite groups. Khondalite group in this area is essentially made up of calc granulite/ crystalline limestone and garnetiferous sillimanite gneiss, with minor bands of quartzite. Charnockite group, on the other hand, includes the acid to intermediate charnockite with minor bands of two pyroxene granulite. Both groups of rocks were later migmatized and reconstituted, giving rise to grey coloured migmatite comprising hornblende biotite gneiss, as well as garnet biotite gneiss and garnetiferous quartzo-feldspathic granulite. The intrusions of younger pink granite and pink pegmatoidal granite had converted part of the grey migmatite into pink migmatitic gneiss and pink augen gneiss. The white granite garnetiferous quartzo-feldspathic granulite occurring east of Melur is considered to be reconstituted garnetiferous sillimanite gneiss, while the pink augen gneiss well developed near Tiruchunai is due to the blastic growth of pink potash feldspar augen within the grey biotite gneiss. Several minor pegmatite and quartz veins represent the area's last stage of intrusive activity.

### GEOLOGY OF THE STUDY AREA

The Madurai Block (Fig. 1) is split into two by a NE–SW trending feature known as the Karur–Kamban–Painavu–Trichur (KKPT) lineament (Ghosh et al., 2004). This lineament marks an isotopic boundary with Archaean crust lying to the northwest and Proterozoic crust preserved to the south and east (Bhaskar Rao et al., 2003; Ghosh et al., 2004; Plavsa et al., submitted for publication; Tomson et al., 2006). The KKPT also marks the surface expression of a series of south-dipping reflectors prominent in the region's deep reflection seismic survey (Rajendra Prasad et al., 2007). The Proterozoic metasedimentary rocks in the Madurai Block commonly yield zircons with ages from 2.6 to 1.8 Ga (Collins et al., 2007b; Sato et al., 2011), although occasional older Mesoarchaeoan and Mesoproterozoic zircons have also been reported (Collins et al., 2007b; Sato et al., 2011). Collins et al. (2007b) suggested that these might correlate with the Itremo Group of central Madagascar and that the Madurai Block might form a southern continuation of the intra-East African Orogen continent Azania (Collins et al., in press; Collins and Pisarevsky, 2005). Others have disputed this and instead interpret the metasedimentary rocks of the Madurai Block as a metamorphosed passive margin to the Dharwar craton of India (Bhaskar Rao et al., 2003; Ghosh et al., 2004).

The Melur area has witnessed major crustal anatexis leading to the generation of a large volume of garnetiferous quartz-feldspathic rock (leptynite) which occurs as a 15km long ENE-WSW/ E-W (Fig.1) trending linear belt between Kilaiyur in the west and Keelavalavu- Purakuttu Malai in the east within the gneiss/ meta sedimentary sequence. Quartzite occurs as discontinuous bands and lenses within this rock. The white rock contains K-feldspar, Plagioclase and quartz with minor biotite. Pink colored garnet is ubiquitously developed in this rock. Presence of enclaves/schlieren of garnet-biotite gneiss suggests that the quartzo-feldspathic rock could be the anatectic product of the metasedimentary protoliths during intense migmatization. The garnet-bearing quartz-feldspathic rock is being extensively quarried for dimension stone because of its pure white colour with pink dots of garnet. The area exhibits rocks of granulitic facies represented by the khondalite and charnockite belonging to the Eastern Ghat Super group. The Khondalite Group of rocks comprise siliceous, aluminous and calcareous metasediments and garnetiferous granulite. The rock units comprise mainly garnetiferous sillimanite gneiss, calc granulite, garnetiferous granulite, biotite gneiss, pink granite and pegmatoidal granite. The calc granulite generally occurs in wide bands in a migmatitic country or as thin bands in the pegmatoidal granites. Several thin bands of calc granulite, ranging in size from 25 m to 2 km with a width of about a few centimetres to 20-30 m, are seen east and west of Karungalakkudi. Around Malampatti, the calc granulite forms wider bands. The increase in thickness of these bands in the area may be due to repeated folding. Garnetiferous sillimanite gneiss (metapelites) occurs as lenses in garnetiferous granulite of the Kilaiyur/ Keelavalavu area. Sulphide mineralization is also noticed in metapelites. Metapelite is a disadvantage factor in getting dimensional stone.

Quartzite occurs across fractures west of Melur. Diopside-bearing quartzite is noticed around Salahanippatti, Kil Nattarmangalam and north of Nagappanpatti. Green coloured, coarse, hard, compact charnockite is observed in the southeastern part of the mapped area around Vellalur, Odaipatti Malai and Pulimalaipatti Malai. ENE trending garnetiferous granite is traced for a strike length of 18 km from Terkutteru-Kilatyur- Keelavalavu and up to E. Melampatti. Fine to medium-grained grey granite associated with puckered hornblende biotite gneiss is observed around Tiruchchunai, Sekkadipatti and west of Pulipatti. The mapped area's western, central and northeastern part is dominated by migmatite, puckered hornblende gneiss, biotite gneiss, augen gneiss and pink migmatite. The granites of the Melur area occurring as NE-SW trending, linear bodies are emplaced within a relatively more stable Tiruchirappalli-Madurai-Palayamkottai (TMP) tectonic block of southern Tamil Nadu, lying south of the major E-W trending. Noyil-Cauvery lineament.

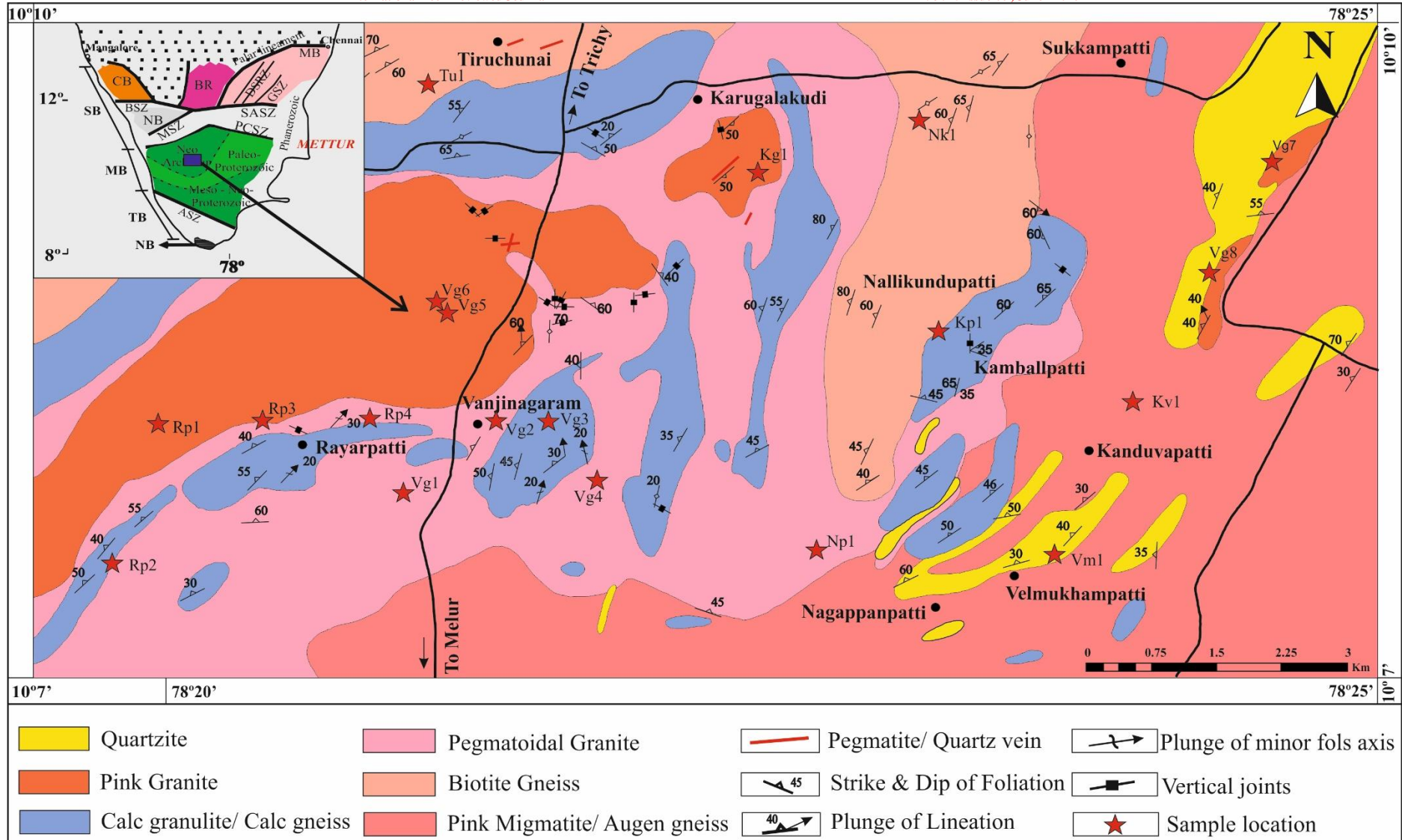


Figure 1: Geology and structural map of the study area (after Krishnan, 1989).

## METHODS AND FIELD RELATIONSHIPS

The geological field equipment utilized in the field investigations included toposheets, a hand-held GPS, a Brunton compass, a digital camera, a hummer, sample bags, a notebook, and a pen. The field investigating procedure in the present research work around the vicinity of Melur comprises mainly of field work to study, in detail, the various geological signatures exhibited by the various litho units and the collection of representative rock samples for detailed petrographic studies. The Melur granite/leptynite area comprises a variety of lithologies, including charnockites, khondalites, leptynites, pyroxene granulites, quartzites, and calc-granulites (Fig.2). The leptynites comprise garnetiferous granites and gneisses, while khondalites comprise garnet-sillimanite-graphite gneisses. Pyroxene granulites occur as sills and dykes, whereas leptynites are widely distributed, forming low-lying mounds and hillocks around the Madurai region. Based on texture, structure, and mineral assemblage, leptynites are classified into grey, leucocratic, and pink. All three types are products of granulite-facies metamorphism of sediments of appropriate compositions. Grey leptynites are garnet-biotite-sillimanite-cordierite-sapphirine-bearing gneisses and exhibit migmatitic structures such as banding and layering. Leucocratic leptynites are whitish, medium-grained, primarily consisting of quartz, potash feldspar, and garnet, often showing granulitic textures. Pink leptynites, on the other hand, are pinkish, coarse-grained, and composed of stretched grains of quartz, feldspars, and pink garnets. Leptynites commonly occur as minor plutons and sheets intruding charnockitic rocks. Field investigations included sampling alkali granites from two localities: Melur and Keelavalavu. At Melur, a large working quarry exposes greasy, green, medium- to coarse-grained charnockite with feeble foliation, containing mafic magmatic enclaves of melanocratic gabbroic rocks. These charnockites and gabbros are intruded by sheets of pink granite and coarse-grained K-feldspar-bearing pegmatite, with retrogressed "bleached" zones surrounding the intrusions. The alkali granite here is medium-grained, rich in K-feldspar, slightly foliated, and contains greenish hornblende and brown biotite. At Keelavalavu, the exposure consists of medium-grained, slightly foliated pink granites, where hornblende and biotite occur along thin compositional bands or as scattered grains in the matrix. Leptynites in the investigated area are rich in garnet, giving the rocks a pinkish colour and they exhibit schistose features with well-developed foliation and occasional banding. The banding is primarily observed between garnet-biotite-rich layers and quartz-feldspar-rich layers.

## LEPTYNITE

Leptynite rocks are typically light-colored, appearing in white, grey, or pinkish tones due to the predominance of quartz and feldspar, and they are fine- to medium-grained with a granoblastic texture that indicates equigranular interlocking mineral grains formed under high-grade metamorphism. Essential minerals include quartz, alkali feldspar (microcline/orthoclase), and plagioclase, while accessory minerals such as garnet, biotite, sillimanite, or graphite may also be present, depending on the protolith composition and metamorphic conditions. The texture is generally granoblastic or lepidoblastic, with occasional weak foliation or lineation resulting from directed stress, and faint compositional banding caused by mineral segregation during deformation.



**Figure 2:** Field photographs of (a) Kashmir White deposit is a product of remelting of the pre-existing country rock garnetiferous sillimanite gneiss and pegmatite vein intruded in granite rock at Edayapatti village near Ova Malai, (b-d) pegmatite enclave within granite at Vanjinagaram area, (g) Presence of garnet like allanite produced within pink pegmatoidal granite, (e-f,h) granite rock exposed at Vanjinagaram area, Quartzo - Feldspathic Granite (leptynite) near Vanjinagaram area, Melur Taluk.

Leptynite often forms smooth, rounded outcrops, with surfaces appearing slightly exfoliated or polished due to weathering of quartz-rich layers. These rocks are sometimes associated with banded gneiss, charnockite, or migmatites and may exhibit migmatitic features if partially melted during high-grade metamorphism. Subtle layering or banding is visible in some

exposures, indicating alternating felsic and mafic mineral compositions. Structural measurements, such as strike and dip of foliation planes, can provide critical information about the tectonic setting, and representative samples are essential for petrographic analysis to confirm mineralogy and metamorphic history. Leptynite's presence in granulite terrains suggests high temperature and moderate to high pressure, with deformation occurring under ductile regimes. These rocks are often intercalated with charnockite, garnet-biotite gneiss, or migmatites, and their origin may involve the partial melting of crustal materials, where the felsic melt crystallizes to form quartz and feldspar-rich assemblages. Kashmir White deposit is a product of remelting of the pre-existing country rock garnetiferous sillimanite gneiss and pegmatite vein intruded in granite rock at Edayapatti village near Ova Malai (Fig.2a), (Fig.2 b-d), pegmatite enclave within granite at Vanjinagaram area, (Fig.2g). Presence of garnet-like allanite produced within pink pegmatoidal granite, (Fig.2e-f,h) granite rock exposed at Vanjinagaram area Quartzo - Feldspathic Granite (leptynite) near Vanjinagaram area Mapping leptynite distributions helps delineate high-grade metamorphic zones and tectonic boundaries. At the same time, structural and mineralogical observations aid in reconstructing the metamorphic and deformation history.

## PETROGRAPHY

### Leptynite

The leptynites in the study area display several interesting textural features, including interlocking quartz and feldspar, graphic intergrowths of plagioclase and quartz, perthitic intergrowths between albite and K-feldspar, and intergrowths of garnet and biotite. In addition to these major minerals, minor constituents such as ilmenite and spinel are present, with ilmenite often found as inclusions within garnet. Some leptynite samples contain garnet porphyroblasts enclosing orthopyroxene and sillimanite (Fig.3). The grey granite in the area is composed primarily of K-feldspar (~35%), plagioclase (~30%), quartz (~30%), and biotite (~5%), with accessory phases (<1%) including apatite, zircon, allanite, opaques, muscovite, sericite, epidote, chlorite, calcite, titanite, garnet, and tourmaline. Microscopically, leptynite exhibits an inequigranular, medium - to coarse-grained texture dominated by quartz, plagioclase feldspars (white oligoclase), string-like and stringlet-like perthite, microcline, and minor amounts of rounded to subrounded garnet and biotite mica; accessory minerals include zircon and muscovite mica. Myrmekitic intergrowths of quartz and plagioclase feldspars and alteration of plagioclase feldspars to zoisite/kaolin are observed in places. Generally, an increase in the rock's perthite content and a decrease in plagioclase feldspar content correlate with a brighter whiteness in the Kashmir white material. Conversely, a higher proportion of microcline feldspar relative to plagioclase feldspars is associated with a more common occurrence of pink colouration in the leptynite deposit. The leptynite of Melur shows evidence of garnet rusting, bent twin lamellae in plagioclase feldspar (likely due to later deformation), and alteration of garnet to biotite, which probably contributes to iron staining upon weathering. Host leptynites are characterized by abundant plagioclase and alkali feldspar in roughly equal proportions, and myrmekitic intergrowths of quartz and feldspars are common. Biotite, garnet, and ilmenite are also present, with biotite distributed arbitrarily throughout the rock and small ilmenite inclusions common. Granoblastic texture is a prevalent feature in these leptynites. In some locations, small patches of pelitic assemblages (sillimanite – biotite – garnet – feldspar – quartz + ilmenite) occur as xenoliths within the leptynite (Fig.3).

### MICROSCOPIC DESCRIPTION OF LEPTYNITE

#### (i) Garnet

Garnets occurred as coarse xenoblasts of anhedral structure. They are usually fractured due to high stress within the rocks, which are later filled with iron leaching. They are poikiloblastic, including spinel, biotite, plagioclase, quartz and magnetite. In some sections of leptynite, garnet porphyroblasts are deformed and filled with sillimanite, biotite and orthopyroxene (Fig. 3a-c). Spinel occurs as a rhombic structure and was found as an inclusion in garnet and ilmenite (Fig. 3d). Under plane polarised light, spinel is green in colour, non-pleochroic and has no cleavage, while under cross-nichol, the mineral is black, hence isotropic. Spinel inclusion indicated the prograde metamorphic process (Fig.3e-f).

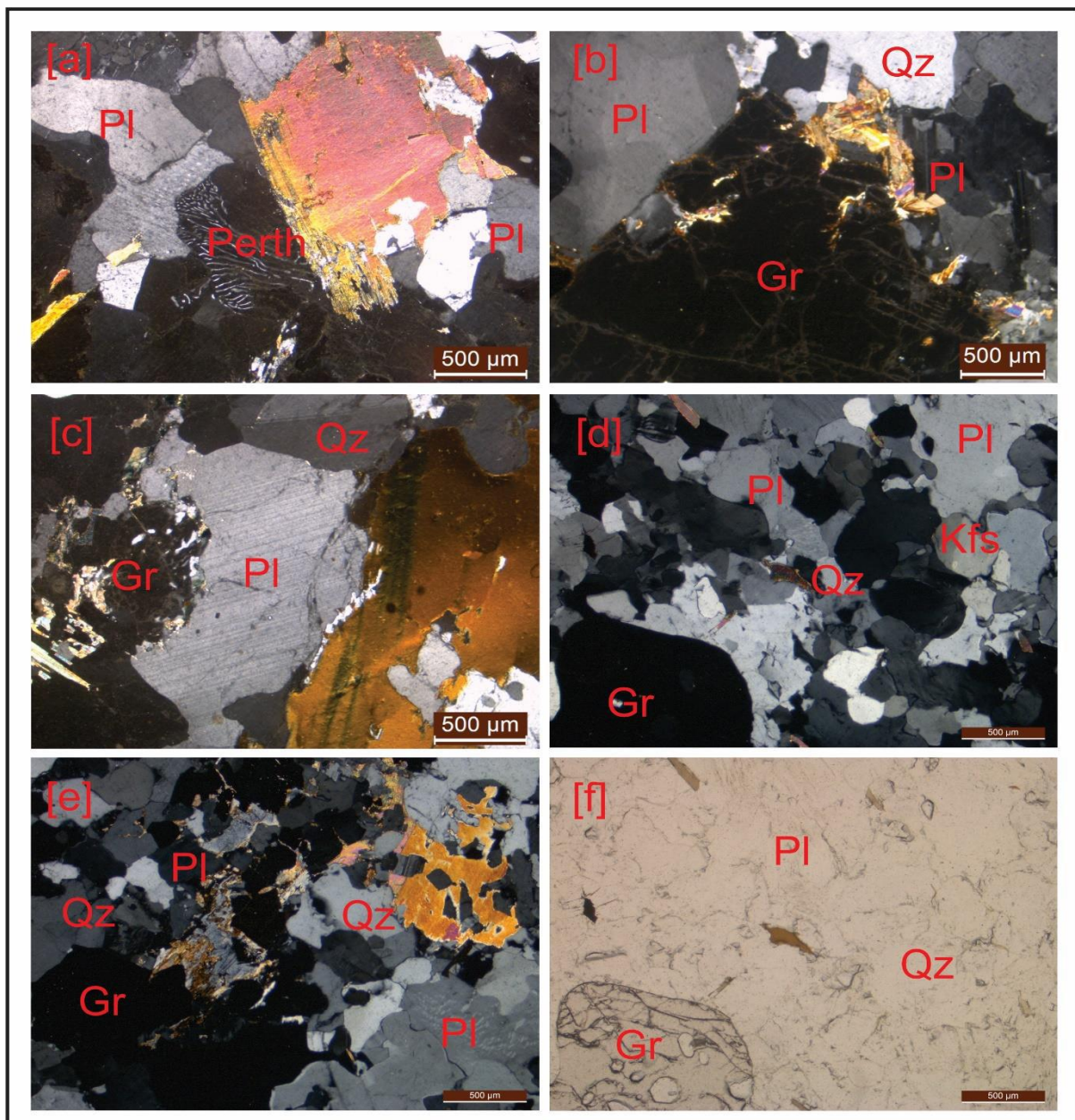
#### (ii) Biotite

Biotites are subhedral with corroded surfaces. They are pleochroic from yellowish brown to dark brown. They are found as inclusions within garnet, and those developed in garnet show no particular cleavage planes. They have formed assemblages with garnet, Plagioclase, K-feldspar and quartz. This textural relation suggested that biotite and quartz react to form garnet and potash feldspar (Fig. 3a). zircon in biotite is widespread. Petrography also indicated the effects of radioactivity on biotite, which are

indicated by dark radioactive halos within the minerals. Biotite was also included within K-feldspar (Fig. 3c). In some sections, biotite and quartz are included in garnet porphyroblast, which is again surrounded by biotite, orthoclase, and quartz (Fig. 3e). The textural relation might suggest the following reaction: (Biotite + quartz = Garnet + K-feldspar).

### (iii) Plagioclase

Plagioclases were medium to coarse, colourless, nonpleochroic minerals with anhedral to subhedral structure. They have shown lamellar twinning, sometimes in two sets perpendicular to one another, and developed perthitic intergrowth (Fig. 3). The Ab-An content in plagioclase of leptynite in the study area varied from Ab21-28 and An2-14. Plagioclases in some sections are altered into clay minerals undergoing sericitization. Sericite is grungy-looking, fine-grained stuff that commonly replaces plagioclase. Their birefringence is irregular and generally low because they comprise tiny crystals.



**Figure 3:** The Photomicrographs showing (a) leptynite with myrmekitic texture intergrowth of plagioclase and quartz; (b) Biotites are subhedral with corroded surfaces. They are pleochroic from yellowish brown to dark brown; (c) They have displayed wavy extinction, which might indicate origin by syntectonic crystallization; (d) The potash-feldspar in the present leptynite is

found as microclines; (e-f) They occurred as anhedral to subhedral minerals. Under plane polarised light, spinel is green in colour, non-pleochroic and has no cleavage, while under cross-nichol, the mineral is black, hence isotropic.

#### **(iv)K-feldspar**

The potash-feldspar in the present leptynite is found as microcline. They occurred as anhedral to subhedral minerals. They have formed assemblages with plagioclase, biotite and quartz surrounding xenoblasts of garnet crystal. They have displayed polysynthetic twinning (Fig. 3d). The perthitic intergrowth of albite and microcline is very common. Sometimes, microcline includes biotite (Fig. 3a).

#### **(v)Quartz**

Quartz occurred in an anhedral form and was colourless under plane polarised light. They commonly occur as inclusions within garnet, K-feldspar and biotite (Fig. 3). They have displayed wavy extinction, which might indicate origin by syntectonic crystallization.

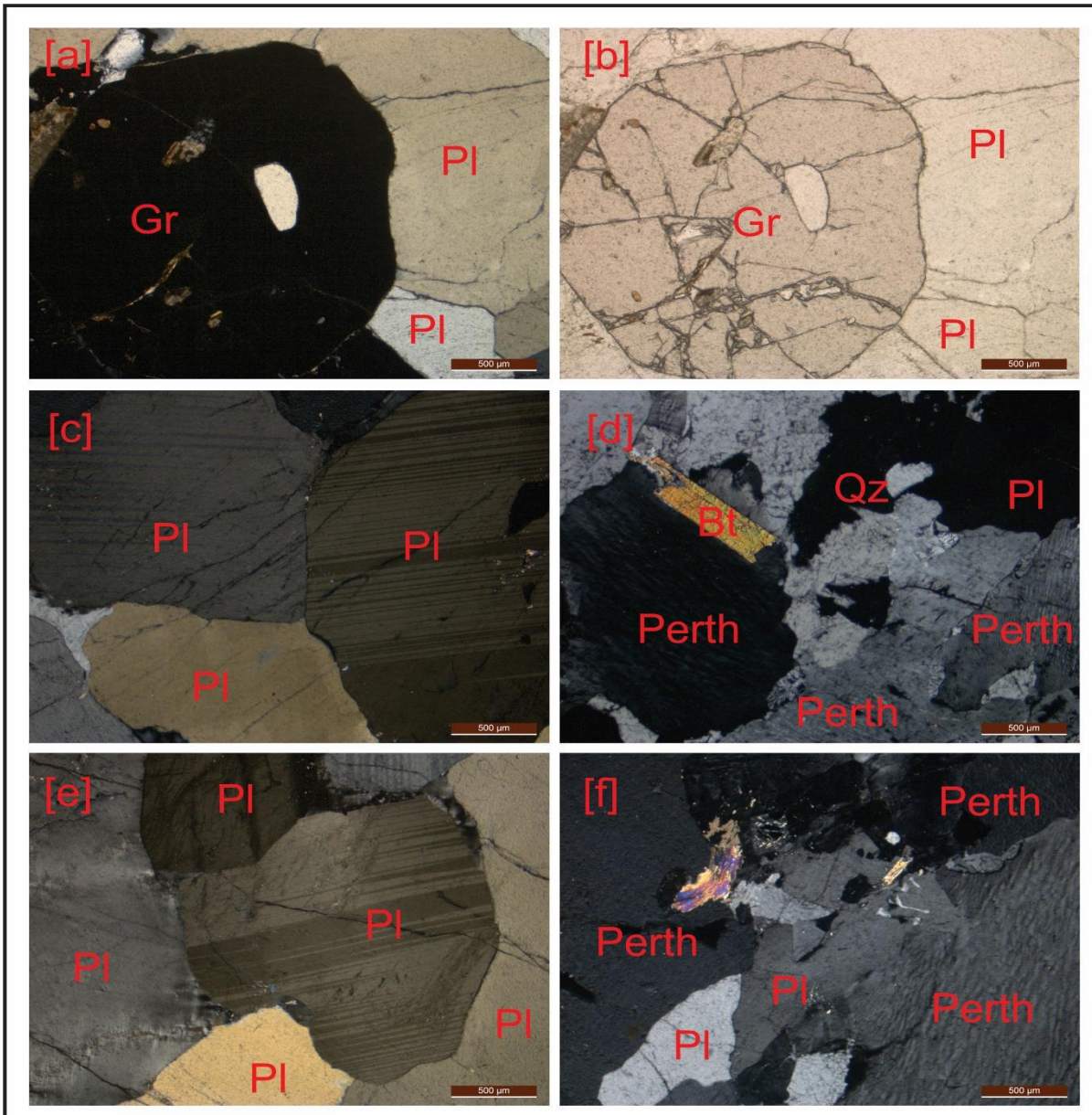
#### **(vi)Sillimanite**

Sillimanites occurred as inclusions in garnet porphyroblasts. They are colourless and found in a needle-shaped form under plane polarised light. They are observed in between the cracks of deformed garnet porphyroblasts. They found small prismatic forms of orthopyroxene within garnet and small biotite flakes (Fig. 3 b & e). The mineral association might indicate the following mineral reaction: (Garnet + K-feldspar +H<sub>2</sub>O = biotite + sillimanite + quartz).

### **Granite**

This granite shows coarse-to-medium-grained hypidiomorphic equigranular to porphyritic texture with euhedral K-feldspar phenocrysts embedded in an eugranitic matrix. Most of the K feldspar phenocrysts have microcline twinning with well-developed linear perthite exsolution lamellae and grade imperceptibly into smaller polygonal grains due to the recrystallization in deformed samples. Myrmekitic colonies are abundant along the grain boundaries of K-feldspar in some samples (Figs 4 & 5). Plagioclase, mostly unzoned and poikilitic, shows sericite and saussurite alteration in a few grains. Quartz often forms an interlocking network with feldspars, and at places is strained with the incipient formation of sub-grains. Aggregates of biotite laths occur interstitially, having inclusions of apatite, zircon, and opaques, and are partially altered to chlorite and epidote at a few places. The secondary muscovite is occasionally intergrown with biotite or occurs as irregular grains in plagioclase. Angular to sub-rounded grains of garnet occur around biotite and contain tiny inclusions of biotite itself. The pink granite consists of approximately. 40% quartz, 55% K-feldspar and Plagioclase, with the former dominating the latter and the remaining primarily comprised of biotite and minor hornblende.

The accessories (<1%) include zircon, titanite, allanite, fluorite, apatite, epidote, sericite, chlorite, rutile and opaques. Most K-feldspar shows simple twinning, and some mantle the plagioclase grains. Exsolution textures like micropertite, occasionally mesopertite and micrographic intergrowth are very common. The abundance of the ferromagnesian mineral is more variable in this granite as compared to others, as some samples of this granite are without any appreciable amount of biotite or hornblende. Such variation in mineral content could be the result of fractional crystallization. The accessories (<1%) include zircon, titanite, allanite, fluorite, apatite, epidote, sericite, chlorite, rutile and opaques. Most K-feldspar shows simple twinning, and some mantle the plagioclase grains. Exsolution textures like micropertite, occasionally mesopertite and micrographic intergrowth are very common. The abundance of the ferromagnesian mineral is more variable in this granite as compared to others, as some samples of this granite are without any appreciable amount of biotite or hornblende. Such variation in mineral content could be the result of fractional crystallization.



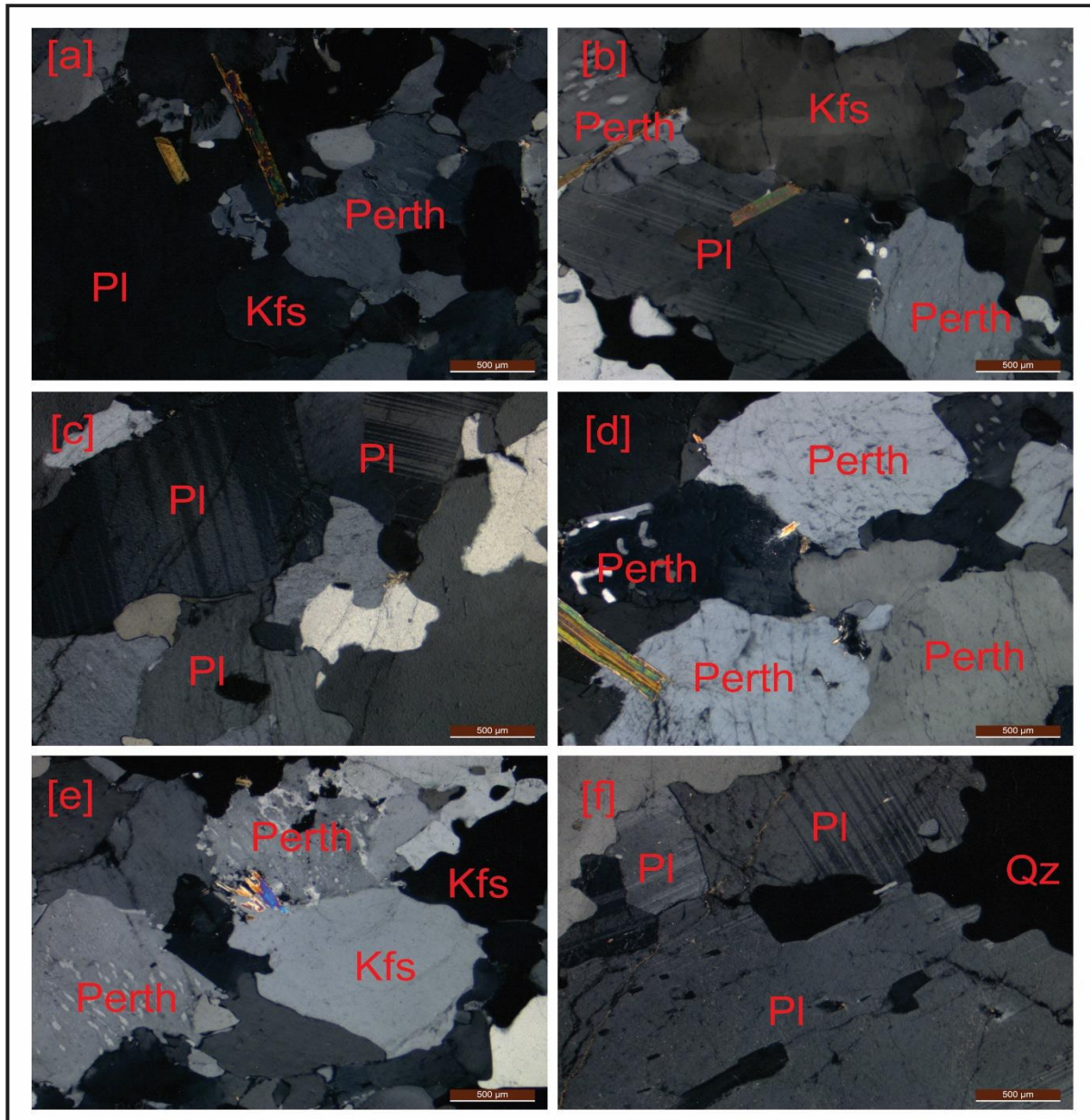
**Figure 4:** The (a-

f) Photomicrographs showing important textural features include interlocking texture between quartz and feldspar, graphic intergrowth of plagioclase and quartz and intergrowth of garnet and biotite; Garnets occurred as coarse xenoblasts of anhedral structure; Biotite also occurred as an inclusion within K-feldspar; They have shown lamellar twinning which are sometimes in two sets perpendicular to one another and they developed perthitic intergrowth.

#### MICROSCOPIC DESCRIPTION OF MINERALS

##### (i) *Microcline*

The microcline perthites show patch- and braided-perthites and are commonly surrounded and traversed by rims and veinlets of microgranulated and recrystallized quartz, respectively. Slight sericitization of the K-feldspars is observed. Some of the patch perthites look very much like replacement perthites.



**Figure 5:** The (a-f) Photomicrographs of the microcline perthites show patch- and braided-perthites and are commonly surrounded and traversed by rims and veinlets of micro granulated and recrystallized quartz; Quartz is also of two generations; the latter replaces plagioclase feldspar and occur in interstitial spaces; Some of the patch perthites look very much like replacement perthite.

#### (ii) Sodic Plagioclase

Sodic plagioclases (Ab-An<sub>12</sub>) occur as large and small discrete grains and exsolved phases in the potassium feldspar. The plagioclases, particularly the larger crystals, show varying degrees of sericitization and saussuritization (Fig.4&5). The reaction involves loss of potassium and calcium by the feldspars and probably accounts for the dominance of sodic plagioclase in samples with high epidote mineral contents; (ii) a lesser amount occurs as discrete grains with no apparent relationship to the alteration of feldspars or any other mineral. Plagioclase, while in contact with microcline, develops an albitic rim and occasional development of myrmekite. The clustered aggregate with its crystallographic arrangement resembles plagioclase, formed early in a crystallizing silicate melt.

#### (iii) K- Feldspar

K-feldspar has an average size ranging between 8 and 12 mm (Fig.4). Large crystals of microcline exhibit characteristic grid (cross-hatched) twinning and sometimes take a significant percentage of the stage. K-feldspar crystals are albite and are elongate, and plagioclase exhibits well-formed polysynthetic twins (Fig.4&5). Orthoclase appears euhedral and exhibits recognizable Carlsbad twinning with well-defined edges.

**(iv) Quartz**

Quartz is primarily interstitial to the feldspars, but some occur in the granulated and recrystallized rims and veinlets around and within the feldspars, while some occur simply as inclusions in the feldspars (Fig.4&5). Quartz grains are subhedral in shape and occur as clear crystals with a white colour. Few tiny quartz grains resembling those crystallized during the stress of ductile shear are observed; such grains exhibit translational fabrics and wavy extinction. Quartz is also of two generations; the latter replaces plagioclase feldspar and occurs in interstitial spaces.

**(v) Epidote**

Epidote minerals are present in almost all sections and vary in amount from accessory to major component, sometimes exceeding the typical ferromagnesian mineral (Fig.4&5).

**(vi) Biotite**

Biotite flakes have been chloritized to different degrees and are seldom found fresh. They have a greenish colour with green and yellow pleochroic colours. Muscovite occurs as discrete flakes (including those formed as by-products of epidotization) and as an alteration product of the feldspars. Biotite occurs as large brown crystals (Fig.4d &5a-b &d). Biotite is a stretched mineral with randomly oriented laths of diagnostic light to dark-brown colour.

**(vii) Hornblende**

Hornblende appears as sub-angular and elongate masses with pleochroism typically pale brown to dark brown, while biotite occurs as large plates and groundmass minerals. Smaller grains of quartz and hornblende form the supporting minerals in an interlocking structure.

**(viii) Opaque minerals**

Iron oxide, sphene, zircon, allanite and apatite are accessory minerals. Garnet occurs in amounts varying between that of the minor and accessory component (Fig.4&5). It is commonly poikiloblastic, including quartz, biotite, and hornblende. It may be fractured and elongated parallel to the direction of gneissosity in the rock.

Table 1. Textural and mineralogical characters of granite and leptynites of the Melur area

Type	Modal Mineralogy		Texture
Granite		Average	Pink and white color in fresh outcrop, fine to medium grained, granoblastic rock. Stringlet perthites are remarkable. Bands and laers are conspicuous with well-defined streakly elongation of garnet and biotites. Reaction zones of silimanite and garnet are recorded between spinel and quartz.
	Quartz	32.1	
	Plagioclase	27.3	
	K-Feldspar	29.2	
	Biotite	5.0	
	Spinel	2.5	
	Zircon	0.7	
	Apatite	0.6	
	Opaques	2.6	
Leptynite	Quartz	28.9	Cream to white in color, mostly medium grained, exhibit spotted appearance due to garnet porphyroblasts in coarse varieties. Patchy perthites and myrmekites are prominent.
	Plagioclase	16.9	
	K-Feldspar	38.4	
	Garnet	10.3	
	Biotite	2.8	
	Zircon	0.7	
	Apatite	0.4	
	Opaques	1.6	

## Summary

The Melur area in southern Tamil Nadu has undergone significant crustal anatexis, forming a large volume of garnetiferous quartzo-feldspathic rock, commonly referred to as leptynite. This rock is a linear belt stretching approximately 15 km, with an ENE-WSW or E-W trend, between Kilaiyur in the west and Kilavalavu-Purakuttu Malai in the east. Leptynite is characterized by its white colour and mineral composition, primarily consisting of K-feldspar, Plagioclase, quartz, and minor biotite, with garnet being a prominent mineral. Quartzite bands and lenses are found intermittently within the leptynite, and the presence of enclaves and schlierens of garnet-biotite gneiss indicates that leptynite may be the anatectic product of metasedimentary protoliths during intense migmatization.

The Melur region is also marked by granulitic facies rocks, such as khondalite and charnockite, which belong to the Eastern Ghat Supergroup. The Khondalite Group comprises various metasedimentary rocks, including siliceous, aluminous, and calcareous metasediments and garnetiferous granulite. Various rock units such as garnetiferous sillimanite gneiss, calc granulite, biotite gneiss, pink granite, and pegmatoidal granite are observed. Calc granulite appears as wide bands or thin layers within migmatitic terrains, and its thickness varies with repeated folding. The area also shows evidence of sulphide mineralization in metapelites, though the presence of metapelites hinders the extraction of dimensional stones. The region's granites, such as the garnetiferous granite and grey granite, occur as linear bodies along NE-SW trends and are part of a stable tectonic block within the Tiruchirappalli-Madurai-Palayamkottai region, south of the Noyil-Cauvery lineament.

Leptynite rocks are typically light-colored, appearing in white, grey, or pinkish tones due to their quartz and feldspar composition. These rocks are fine to medium-grained, with a granoblastic texture indicating high-grade metamorphism. The essential minerals include quartz, alkali feldspar (microcline/orthoclase), and plagioclase, while garnet, biotite, sillimanite, or graphite may appear as accessory minerals, depending on the metamorphic conditions. Leptynite's texture generally shows granoblastic or lepidoblastic features, with weak foliation or lineation that results from directed stress during deformation. These rocks may also exhibit subtle layering or banding, reflecting alternating felsic and mafic mineral compositions. The structural measurements and petrographic analysis of leptynite reveal that it forms under high-temperature and moderate to high-pressure conditions, associated with granulite facies metamorphism and partial melting.

## CONCLUSION

- The leptynite in the Melur area formed through crustal anatexis and intense migmatization of metasedimentary rocks under granulitic facies conditions.
- Its mineral composition (quartz, feldspar, garnet) and granoblastic texture indicate slow cooling and partial melting at high temperatures.
- Textural features like perthitic textures, polysynthetic twinning in plagioclase, and garnet equilibrium growth point to slow cooling and moderate to high-pressure dynamic metamorphism.
- The presence of equilibrium garnet, biotite, and quartz, alongside observed textures, strongly supports the region's partial melting and high-grade metamorphism.
- The study of Melur leptynite is crucial for understanding the region's metamorphic history and tectonic evolution, providing insights into the high-temperature and pressure conditions associated with regional tectonic processes and crustal thickening.

## REFERENCE

- [1] Amaldev, T., Santosh, M., Li, T., Baiju, K.R., Tsunogae, T., Satyanarayanan, M., 2016. Mesoarchean convergent margin processes and crustal evolution: petrologic, geochemical and zircon U–Pb and Lu–Hf data from the Mercara Suture Zone, southern India. *Gondwana Res.* 37, 182–204.
- [2] Bartlett, J.M., Dougherty-Page, J.S., Harris, N.B.W., Hawkesworth, C.J., Santosh, M., 1998. The application of single zircon evaporation and model Nd ages to the interpretation of polymetamorphic terrains: an example from the Proterozoic mobile belt of south India. *Contributions to Mineralogy and Petrology* 131, 181–195.
- [3] Bhaskar Rao, Y.J., Janardhan, A.S., Vijaya Kumar, T., Narayana, B.L., Dayal, A.M., Taylor, P.N., Chetty, T.R.K., 2003. Sm–Nd model ages and Rb–Sr isotope systematics of charnockites and gneisses across the Cauvery Shear Zone, southern India: implications for the Archaean-Neoproterozoic boundary in the southern granulite terrain. In: M. Ramakrishnan (Ed.), *Tectonics of Southern Granulite Terrain*. Geological Society of India Memoir, vol. 50, pp. 297–317.
- [4] Brown, M., Raith, M., 1996. First evidence of ultrahigh-temperature decompression from the granulite province of southern India. *J. Geol. Soc. Lond.* 153, 819–822.
- [5] Chetty, T.R.K., 1996. Proterozoic shear zones in southern granulite terrain, India. In: Santosh, M., Yoshida, M. (Eds.), *Gondwana Research Group Memoir*, vol. 3: The Archaean and Proterozoic Terrains in Southern India within East Gondwana, pp. 77–89.
- [6] Chetty, T.R.K., Bhaskar Rao, Y.J., 2006a. Constrictive deformation in transpressional regime: field evidence from the Cauvery Shear Zone, Southern Granulite Terrain, India. *Journal of Structural Geology* 28, 713–720.

- [7] Chetty, T.R.K., Bhaskar Rao, Y.J., 2006b. Strain pattern and deformational history in the eastern part of the Cauvery shear zone, southern India. *Journal of Asian Earth Sciences* 28, 46–54.
- [8] Clark, C., Collins, A.S., Kinny, P.D., Timms, N.E., Chetty, T.R.K., 2009. SHRIMP U–Pb age constraints on the age of charnockite magmatism and metamorphism in the Salem Block, southern India. *Gondwana Res.* 16, 27–36.
- [9] Clark, C., Collins, A.S., Santosh, M., Taylor, R., Wade, B.P., 2009. The P–T–t architecture of a Gondwanan suture: REE, U–Pb and Ti-in-zircon thermometric constraints from the Palghat Cauvery shear system, South India. *Precambrian Research* 174, 129–144.
- [10] Collins, A.S., Clark, C., Sajeev, K., Santosh, M., Kelsey, D.E., Hand, M., 2007a. Passage through India: the Mozambique Ocean suture, high-pressure granulites and the Palghat–Cauvery shear zone system. *Terra Nova* 19, 141–147.
- [11] Collins, A.S., Santosh, M., Braun, I., Clark, C., 2007b. Age and sedimentary provenance of the Southern Granulites, South India: U–Th–Pb SHRIMP secondary ion mass spectrometry. *Precambrian Res.* 155, 125–138.
- [12] Collins, A.S., Clark, C., Plavsa, D., 2014. Peninsular India in Gondwana: the tectono thermal evolution of the Southern Granulite Terrain and its Gondwanan counterparts. *Gondwana Res.* 25, 190–203.
- [13] Collins, A.S., Pisarevsky, S.A., 2005. Amalgamating eastern Gondwana: the evolution of the Circum-Indian Orogens. *Earth Science Reviews* 71, 229–270.
- [14] Drury, S.A., Harris, N.B.W., Holt, R.W., Reeves-Smith, J., Whiteman, R.T., 1984. Precambrian tectonics and crustal evolution in south India. *Journal of Geology* 92, 3–20.
- [15] Geological Survey of India, 1995. Geological and Mineral Map of Tamil Nadu and Pondicherry, Bangalore.
- [16] Ghosh, J.G., de Wit, M.J., Zartman, R.E., 2004. Age and tectonic evolution of Neoproterozoic ductile shear zones in the Southern Granulite Terrain of India, with implications for Gondwana studies. *Tectonics* 23 (TC3006). doi:10.1029/2002TC001444.
- [17] Handke, M., Tucker, R.D., Ashwal, L.D., 1999. Neoproterozoic continental arc magmatism in west-central Madagascar. *Geology* 27, 351–354.
- [18] Harris, N.B.W., Santosh, M., Taylor, P.N., 1994. Crustal evolution in south India: constraints from Nd isotopes. *J. Geol.* 102, 139–150.
- [19] Kröner, A., Kehelpanna, K.V.W., Hegner, E., 2003. Ca. 750–1100 Ma magmatic events and Grenville-age deformation in Sri Lanka: relevance for Rodinia supercontinent formation and dispersal, and Gondwana amalgamation. *Journal of Asian Earth Sciences* 22, 279–300.
- [20] Naganjaneyulu, K., Santosh, M., 2010. The Cambrian collisional suture of Gondwana in southern India: a geophysical appraisal. *Journal of Geodynamics* 50, 256–267.
- [21] Naganjaneyulu, K., Santosh, M., 2011. Crustal architecture beneath Madurai Block, southern India deduced from magnetotelluric studies: implications for subduction–accretion tectonics associated with Gondwana assembly. *Journal of Asian Earth Sciences* 40, 132–143.
- [22] Plavsa, D., Collins, A.S., Foden, J.F., Kropinski, L., Santosh, M., Chetty, T.R.K., Clark, C., 2012. Delineating crustal domains in Peninsular India: age and chemistry of orthopyroxene-bearing felsic gneisses in the Madurai Block. *Precambrian Res.* 198–199, 77–93.
- [23] Plavsa, D., Collins, A.S., Payne, J.L., Foden, J., Clark, C., Santosh, M., 2014. Detrital zircons in basement metasedimentary protoliths unveil the origins of southern India. *Geol. Soc. Am. Bull.* 126, 791–812.
- [24] Praveen, M.N., Santosh, M., Yang, Q.Y., Zhang, Z.C., Huang, H., Singanajam, S., Sajinkumar, K.S., 2014. Zircon U–Pb geochronology and Hf isotope of felsic volcanics from Attappadi, southern India: implications for Neoproterozoic convergent margin tectonics. *Gondwana Res.* 26, 907–924.
- [25] Rajendra Prasad, B., Kesava Rao, G., Mall, D.M., Koteswara Rao, P., Raju, S., Reddy, M.S., Rao, G.S.P., Sridher, V., Prasad, A.S.S.R.S., 2007. Tectonic implications of seismic reflectivity pattern observed over the Precambrian Southern Granulite Terrain, India. *Precambrian Research* 53, 1–10.
- [26] Sajeev, K., Osanai, Y., Santosh, M., 2004. Ultrahigh-temperature metamorphism followed by two-stage decompression of garnet-orthopyroxene-sillimanite granulites from Ganguvarpatti, Madurai Block, southern India. *Contrib. Mineral. Petrol.* 148, 29–46.
- [27] Sajeev, K., Windley, B.F., Connolly, J.A.D., Kon, Y., 2009. Retrogressed eclogite (20 kbar, 1020 C) from the Neoproterozoic Palghat–Cauvery suture zone, southern India. *Precambrian Research* 171, 23–36.
- [28] Samuel, V.O., Santosh, M., Liu, S.W., Wang, W., Sajeev, K., 2014. Neoproterozoic continent growth through arc magmatism in the Nilgiri Block, southern India. *Precambrian Res.* 245, 146–173.
- [29] Santosh, M., Yokoyama, K., Sekhar, S.B., Rogers, J.J.W., 2003. Multiple tectonothermal events in the granulite block of southern India revealed from EPMA dating: implications on the history of supercontinents. *Gondwana Res.* 6, 29–63.
- [30] Santosh, M., Morimoto, T., Tsutsumi, Y., 2006. Geochronology of the khondalite belt of Trivandrum Block, Southern India: electron probe ages and implications for Gondwana tectonics. *Gondwana Res.* 9, 261–278.
- [31] Santosh, M., Maruyama, S., Sato, K., 2009. Anatomy of a Cambrian suture in Gondwana: Pacific-type orogeny in the southern India? *Gondwana Res.* 16, 321–341.
- [32] Santosh, M., Yang, Q.Y., Shaji, E., Tsunogae, T., Ram Mohan, M., Satyanarayanan, M., 2015. An exotic Mesoarchean micro continent: the Coorg Block, southern India. *Gondwana Res.* 27, 165–195.
- [33] Santosh, M., Yang, Q.Y., Shaji, E., Ram Mohan, M., Tsunogae, T., Satyanarayanan, M., 2016. Oldest rocks from Peninsular India: evidence for Hadean to Neoproterozoic crustal evolution. *Gondwana Res.* 29, 105–135.
- [34] Sato, K., Santosh, M., Tsunogae, T., Chetty, T.R.K., Hirata, T., 2011. Subduction–accretion–collision history along the Gondwana suture in southern India: a laser ablation ICP–MS study of zircon chronology. *Journal of Asian Earth Sciences* 40, 162–171.
- [35] Shaji, E., Santosh, M., He, X.F., Fan, H.R., Dhanil Dev, S.G., Yang, K.F., Thangal, M.K., Pradeepkumar, A.P., 2014. Convergent margin processes during Archean–Proterozoic transition in southern India: geochemistry and zircon U–Pb geochronology of goldbearing amphibolites, associated metagabbros, and TTG gneisses from Nilambur. *Precambrian Res.* 250, 68–96.
- [36] Tateishi, K., Tsunogae, T., Santosh, M., Janardhan, A.S., 2004. First report of sapphirine + quartz assemblage from southern India: implications for ultrahigh temperature metamorphism. *Gondwana Res.* 7, 899–912.
- [37] Tomson, J.K., Bhaskar Rao, Y.J., Vijaya Kumar, T., Mallikharjuna Rao, J., 2006. Charnockite genesis across the Archean–Proterozoic terrane boundary in the South Indian Granulite Terrain: constraints from major-trace element geochemistry and Sr–Nd isotopic systematics. *Gondwana Research* 10, 115–127.
- [38] Tsunogae, T., Santosh, M., 2011. Sapphirine + quartz assemblage from the Southern Granulite Terrain, India: diagnostic evidence for ultrahigh-temperature metamorphism within the Gondwana collisional orogen. *Geol. J.* 46, 183–197.
- [39] Yang, Q.Y., Santosh, M., Pradeepkumar, A.P., Shaji, E., Prasanth, R.S., Dhanil Dev, A.G., 2015. Crustal evolution in the western margin of the Nilgiri Block, southern India: insights from zircon U–Pb and Lu–Hf data on Neoproterozoic magmatic suite. *J. Asian Earth Sci.* 113, 766–777.