THE INTERNATIONAL JOURNAL OF
SCIENCE & TECHNOLEDGE

# Field and Petrology of Migmatites in and around Melur Region, Madurai District, Tamil Nadu

**Maharani K.**
Department of Earth Sciences, Annamalai University, Annamalai Nagar, India
**Chidambaram S.**
Department of Earth Sciences, Annamalai University, Annamalai Nagar, India
**Nepolian M.**
Department of Earth Sciences, Annamalai University, Annamalai Nagar, India

***Abstract:***
*A petrological and structural feature of the study area rock units of the Melur region has been resulted due to the environmental variables of pressure, temperature and fluid activity. Polydeformation and polymetamorphism of the rock units has produced orientations in different directions resulting in the formation of heterogeneous silicate rock with igneous and metamorphic textures. Typically, the rock contains alternating lighter layers (leucosomes, comprised of light-colored minerals such as quartz, feldspar, and muscovite) and darker layers (melanosomes, comprised of dark-colored minerals such as amphibole and biotite). This heterogeneous nature of the rock results from partial melting that occurs when a precursor rock is exposed to high pressures and temperatures.*
*The present study area Madurai district falls in the latitude N10°02' and longitude of E78°16'. Strike of the formation is NN34°E and dip is 35°SW. The pegmatoidal gneiss formations are having the minor folds, several mica bandings and joints. The major intrusions of study area having Garnetiferous pegmatites and granitic composition and the augen gneiss. The mineralisations of Garnets and thick Mica banding have originated from the high pressure and high temperature. Thin veins and lenses of granitic composition measuring 2-15 cm have segregated along rock foliation. The vein material is replacive in character as evidenced by sutured margins and interlocking relationships of Quartz and Feldspar grains, total absence of contact metamorphic effects and that of chilled margins adjacent to the granitic veins. There is a general concordance of the veins with the foliation of the rock. They occur as patches. The migmatites exhibit a great variety of structures has the minor and major Quartz veins were also Crystallized during the melt Segregation. The study area is highly the shearing during the crystallization.*

## 1. Introduction

Migmatites are those in which a granitic component and a metamorphic host rock (gneiss) are mixed on a scale sufficiently coarse for the mixed condition of the rock to be megascopically recognizable. There is a general concordance of the veins with the foliation of the rock. They occur as patches. The migmatites exhibit a great variety of structures. The pegmatic structure formed by the angular fragments of paleosome included in veins of homogeneous metasome, are common. Structures are formed where large Quartz and Feldspar crystals are constituting the metasome, are dispersed within the paleosome in the shape of augen. The forms of feldspar are frequently rounded, nevertheless, a tendency towards xenomorphic habit is frequently seen. The Southern Granulite Terrain (SGT), which is the high-grade metamorphic terrain of Tamil Nadu and Kerala in southern India, is traditionally divided into a number of tectonic blocks (figure 1) separated by Proterozoic shear zones (Gopalakrishnan *et al* 1975; Drury and Holt 1980; Harris and Santosh 1993; Harris *et al* 1994; Chetty 1996).

The paleosome consists essentially of K-feldspars with plagioclase (sodic oligoclase), quartz, muscovite, biotite, and tourmaline. There is a marked recrystallization of the minerals of the paleosome and the texture portrays the microfabric of the parent rock.

Petrographically, the rocks are characterised by a progressive coarse grain and simultaneous reduction in the preferred mineral orientation, since all oriented structures of the paleosome are blurred by the growing minerals of the metasome. The feldspars are twinned, sericitized, and have embayed boundaries due to replacement by the metasome. Quartz in the paleosome occurs as medium grained subhedral crystals with curved and cuspate boundaries. Deformation or kink bands having undulose extinction are very frequent. The mineral also occurs as aggregates between feldspar porphyroblasts and is certainly older than the latter. It is characterised by its convex shape against hypidiomorphic feldspar crystals. Large feldspar crystals upto several cm in diameter are characteristic.

**2. Study Area**

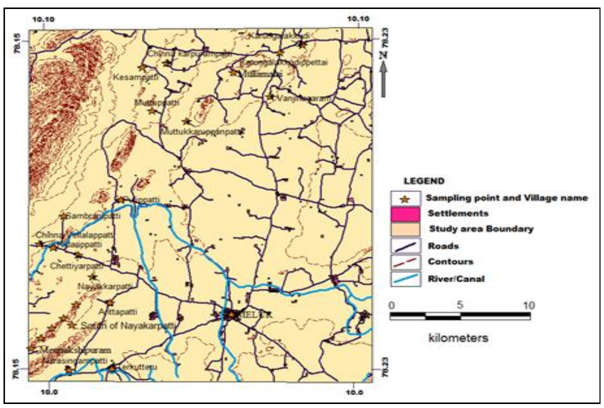
The present study area falls in the Madurai district survey of India Topographic sheet number 58 J/8. It covers the SW part of the Topographical sheet. It is situated Latitude from **10º0' to 10º10'** Longitude **78º15' to 78º23'** (Fig.1). The study area, Therkutheru is one of the village in Melur Taluk in Madurai District in Tamil Nadu State. Therkutheru is located 5.5 km distance from its main taluk town Melur.The samples were collected north of Melur and in each location more than 3 samples are collected from the field. The locations are Nayakarpatti to Meenakshipuram near by Perumal malai, Narasingapuram, Terkutheru is situated in south of perumal malai. The perumal malai is present in the study area west of melur region, the distance between 5.186 km. The study area covers the villages are Karungalakudi, Chinna karpurampatti, Mullamai, muttupatti, muthukarupanpatti, Vanjinagaram, pulipatti, sampirani patti,china vellalapatti, kidaripatti,chettiyarpatti, and arittapatti.

**3. Petrological Characters**

The study area is chiefly composed of metamorphic and igneous. They are older and younger gneissic formation, Granitic intrusions and pegmatitic intrusions are present in the study area some enclaves are also present. For examples of rock types in present study area such as, variety of Granite and gneissic (Hornblende Biotite Gneiss, Quartzo felspathic gneiss), Quartzite (Fig.3). The Quartzite formation is mostly in the Forest region (Azhahar Hill and Perumal malai). Stromatic migmatite present illustrates the three components are the medium-colored mesosome or parent rock, and the quartzo-feldspathic leucosome separated from the mesosome by the thinner ferro-megnesian melanosome. Some of the outcrops are weathered and most of the outcrops are having alternate intrusion of Pegmatite, Granite and younger /older gneiss.

Mica bandings are common at many places with Garnet grains are observed in the contact between Gneiss, Granite and Pegmatite's later pegmatite intrusions during crystallization.

The study area have melanosomes may represent residues after partial melting, the small volume of melanosome (typically only 1–2mm thick) account for the volume of leucosome in the rocks. The contrast in geometry between the patch and stromatic migmatites could result from differences in the timing of leucosome formation (i.e. patch migmatites formed post-kinematically) and/or from local differences in strain during deformation.



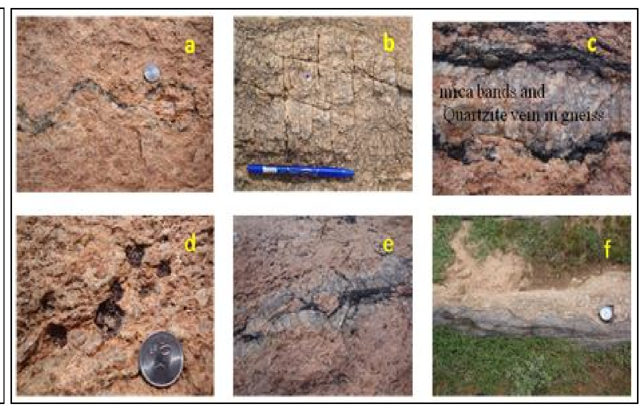




*Figure 1: shows the base map of the study area*

*Figure 2: Field Photograph (a) Mica banding with folding in weathered gneiss. (b) Joints in gneissic rock. (c) Mica banding and quartz vein in gneiss. (d) A big crystals of Garnet grains in older gneiss. (e) Augen Structure is identified in gneiss. (f) The contact between Gneiss and Granite body.*

*3.1. Metamorphism And Migmatization*

The augen-gneisses of the Menderes Massive have been regarded as orthogenesis. This interpretation we cannot accept, for the following reasons :

- The regular banding (foliation) of the gneisses is parallel with the stratification of the schists and intercalated marbles and quartzites, at the contact of the schists and the gneisses.
- There exists stratiform, concordant intercalation of layers of different composition in the gneisses.
- In a typical sample of an augen-gneiss the rounding index of the strongly indicative of a clastic sedimentary origin of the host-rock (Schuiling, 1958).
- In the transition zone between schists and gneisses, a regular alternation of schist- and gneiss bands has often been observed, a situation highly unusual in intrusive contacts.

So the possibility that the gneisses represent a tectonized magmatic granite seems remote. Anatexis of migmatite area the process that during the rise in temperature, leading towards this magmatic stage, hydrothermal and pegmatitic conditions arise, in reversed sequence to the situation well known and generally accepted at the end of a magmatic intrusion.

It has been suggested (Brown and Solar 1998a, 1999; Brown *et al.* 1999) that, melt migration pathways in migmatites relate to rock fabrics, although this may not be the case in all syntectonic vein networks (Handy *et al.* 2001). Some migmatites are depleted in a component equivalent to leucogranite, and these migmatite terrains may represent sources of leucogranite (Sawyer 1998; Milord *et al.* 2001; Solar and Brown 2001a).

Within migmatites, the geometry of leucosomes and smaller-volume granites (less than a few kilometers wide or long) may record the melt flow network through the crust (e.g., Brown and Rushmer, 1997; Sawyer, 1998; Brown and Solar, 1999; Brown et al., 1999), particularly so if the leucosomes do not record solid state strain. Migmatites are in two types that correspond with structural zones. Stromatic migmatites are parallel layered leucosome-melanosome-paleosome and are found in apparent flattening zones. Heterogeneous migmatites do not show this structure and are found between zones of stromatic migmatite.

*3.2. Geological Settings Of Study Area*

The southern granulite terrain (south of Dharwar craton) includes several regional en echelon Neoproterozoic shear zones which dissect the terrain into different Late Archaean and Proterozoic crustal blocks such as the Madras, Northern, Nilgiri, Madurai and Trivandrum blocks (Harris et al 1994)

The present study area having different rock types such as Migmatitic Gneiss, Granite etc are the generally trends NE to SW direction. The Stike of the formation of older pegmatoidal Gneiss is N45°E. the three joints are observed.such as parallel joints, perpendicular, oblique. Dip of the formation is S80°W.

In the field the intrusions of Pegmatite veins and Quartzite veis are also observed, sometimes the minor veins of Quartz is present it may be most disturbed during the tectonic activity. The number of Folds and Faults are Present in the gneissic rock (Fig.2).

The Gneiss formation is generally weathered very coarse to medium grained rocks. The mica bandings are more in the formations. The phenocrysts of Feldspars are present in the outcrop. The Garnets are also fine to big crystals in older gneissic formation. Some were the pegmatite body is intruded few feet. The minor quartz veins are also present in this formation. The weathered gneiss outcrop is nearly 50m.

The Granite body is intrusion within the older gneiss and the earlier formation the commercial product of the pink granite is formed. The intrusion of gray granite is fine grained in nature. The types of granite is intruded in the older gneiss, it is gray and pink granite body. The nature of the formation is very fresh. The formation having sheet joint and some minor quartz veins are also present. The formation is very fine to coarse grained in nature.

The migmatised gneiss (Hornblende Biotite Gneiss) is very fresh in nature and the coarse grained texture.the intrusions are more. The intrusions are two types, such as pegmatite and Granite. These intrusions are having big crystals of Mica and Garnets. The migmatised gneiss is very coarse to medium granied and the intruded granite is very fine to medium grained in nature.

The pegmatite is having very coarse to coarse grained texture. The grains are very less compactness. This formation having patches of garnets and the patches of micas depending upon the temperature during the crystallization.

The presents of Quartzite formation of the study area is Azhagar hill and the Perumal malai.

The big crystals mainly consist of K-feldspars, mica and sometimes garnets that have hypidiomorphic forms with respect to quartz. The shape of the crystals is generally optically uniform in spite of their large size. Plagioclases, mostly albite, in the form of large crystals, are also a common constituent of the metasome and are generally more xenomorphic than the K-feldspars. It appears to have been formed early during the metamorphic evolution and then retrogressed and enveloped by Biotite flakes (Barbey, 1996) they also fill the interstices of other minerals. Plagioclases are generally replaced by K-feldspars and Perthite (Fig.4).

*3.3. Structural Characters Of The Study Area*

The study area tectonically fall on the structural feature within the Neoproterozoic south of palaghat Cauvery shear zone (PCSZ) is a fold belt and that the Dharwar craton continues with the 2.5 old Granulite terrains to the north of PCSZ. The fold belt is constituted of Madurai block (Ramakrishnan, 1993,2003, 2004).

We can consider the Study Area is rotational thrust or reverse fault and this type of shearing is reported for the first time in this part of Southern Granulite Terrain. During fieldwork, we observed Gneiss and granite intrusive and quartzite veins, garnet and Mica mineralisation within the track are structurally controlled and they need to be studied in detail.

Similarly there are different pulses of granite intrusion in this area. The earliest granite intrusive of smaller dimension was stretched and boudinaged and these boudins are aligned along the gneissosity in host charnockite like boudins of basic granulite. The later granite intrusives are larger in dimension and they intruded along the gneissic planes in the host charnockite. These are syntectonic intrusions as the gneissic layering in the granite intrusive is parallel to the gneissosity in the host charnockite (Srinivasan and Rajeshdurai, 2010).

All the formations are trending in the NNE to SSW, the dip of the formation is SE to NW. here the formations are having three sets of joints. Such as 1. Strike joints, 2.dip joints and 3.Oblique joints. These are the varying with degree. They are the older gneissic formation Parellel joint or strike joints are N30°W, dip joint is N120°E and the diagonal joint is N45°E. The pegmatoidal gneiss is having strike is N30°E and the dip of the formation is S70°W.

A number of mica bandings are also noted in the study area. The bandings are also parallel to the formation. The mica bands are also somewhat anticline and syncline in nature. The younger gneiss is having some shearing effect of the study area. The number of sheared structure is measured field itself; this effect is depending upon the plastic, elastic, and rupturing of the formation and also the stress of the formation.

The migmatites can be subdivided into stromatic migmatites with melanosomes and leucosomes and nebulites Brown (2004). Stromatic migmatites represent the lower-grade part of the migmatites, broadly comparable with metatexites as defined and described by Brown (1979). The pre migmatization fabric (e.g. layering and foliation) is well developed within the palaeosome (Fig. 3a) although the granites are white to pinkish, medium- to fine grained garnet- and cordierite-bearing granites with numerous medium- to coarse-grained cordierite- and garnet-bearing xenoliths(Fig.4)

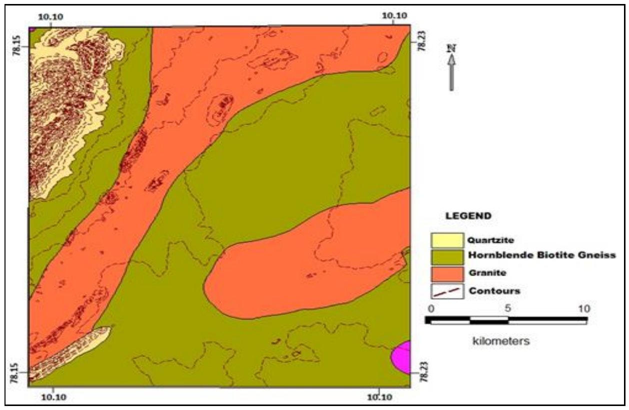



*Figure 3: Geology map of the study area*

From Pb isotopes in lecosome of the migmatite gneiss. The axial traces of superimposed folds, F1 and F2 where the cut across by the AKSZ are. The migmatite outcrop is parallel to the F2 fold indicating migmatisation was Syn-F2 in the pandyan mobile belt. The Achankoil Shear zone is considered 550Ma old Ductile shear zone with left lateral shear sense and occurring parallel to the tenmalai-Gutan shear zone on the south of the belt(Sacks, at al 1997). Oriented inclusions of quartz in large plagioclase crystals are a clear indication of replacement of Quartz by the latter. All porphyroblasts have grown by pushing aside idiomorphic biotite flakes constituting the paleosome, thereby enriching it at their growing edge. This is evident even in hand specimen where the biotite flakes are seen to wrap around the Feldspar porphyroblasts.

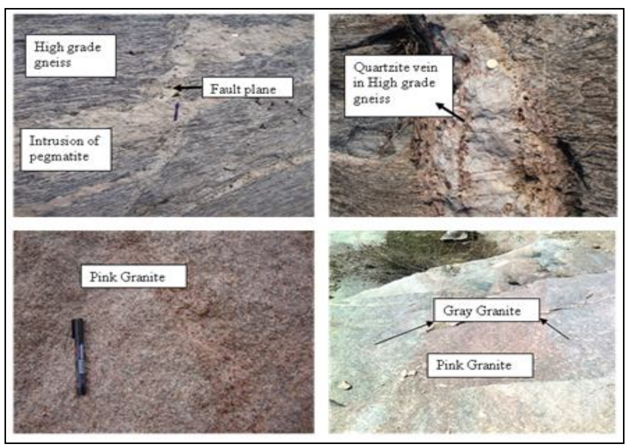



*Figure 4: Shows the field photo for the structural characters*

The different types of gneiss is migmatise depending upon the different mineralization like mica, orthoclase and Quartzite during the increasing the pressure and temperature variation. These rocks are grouped under migmatite complex. The migmatites are generally grey coloured but at many places they are affected by later intrusion of pink feldspar veins caused by potash metasomatism and are converted to pink migmatite. The gneisses in the southern part of Tamil Nadu made up of garnet-biotite gneiss and Garnetiferous quartzofeldspathic gneiss represent the migmatised and retrograded equivalents of Charnockite and Khondalite groups (Narayanaswamy and Purnalakshmi, 1967, Narayanaswamy 1971).

Adequate geochronological data are lacking for the Migmatite Complex which are likely to have components of different ages, as the terrain has experienced multiple deformations and polymetamorphism with concomitant anatexis. The Migmatite Complex has been assigned Archaean age. However, it also includes migmatites of younger ages (Early Proterozoic) such as the gneiss east of Coimbatore (2100 Ma, Crawford 1969) and the Gingee Migmatite (2250 Ma, GSI, 1978, Balasubramanyan et.al., 1979).

The samples are under the thin section study coarse grained hypidiomorphic texture, the quartz grain is unhedral in shape and equigranular, the feldspars, hornblende and biotite are euhedral to subhedral shape, the biotite micas are also big size and crystallized in the linear trending. The hornblende and the mica minerals are having the pleochroism pink to green. Mostly the feldspars are well developed euhedral crystal and some crystals are shows the perthitic in nature. The twinnings are present in the different plagioclase feldspars that they are simple twin, multiple polysynthetic twin, cross-hatched twin in microcline. The myrmekitic intergrowth texture is also observed. Some of the opaque minerals are also present. Some of the minerals are altered by the temperature (Fig.5).

Quartz is seen replacing feldspars along cleavage planes and grain boundaries. The crystal boundaries of replacing quartz are often irregular and curved. In spite of the rather complex shapes, the quartz crystals are optically uniform. Muscovite and Biotite in the metasome occur as aggregates of big crystals having random orientation. In the metasome, myrmekites of cauliflower-like intergrowths of plagioclase in close interpenetration with wormlike quartz are seen near the boundaries of K-feldspar crytallisation.

In situ crustal melting forming migmatites is common in quartzo-feldspathic gneisses, pelitic gneisses and K-feldspar augen gneisses. From field evidence it seems likely that all these lithologies constituted source rocks for granite melts (Searle,2009). Migmatitic gneisses and granite intrusions dominate the CSZ/MB region. Supracrustal rocks are limited to small, highly deformed and migmatised lenses. Sharp contact and cross cutting dikes of charnockite and hypersthene-bearing pegmatoidal rocks in the migmatite–supracrustal units, presence of enclaves and xenoliths, homogeneity on a mesoscopic scale and preservation of igneous textures

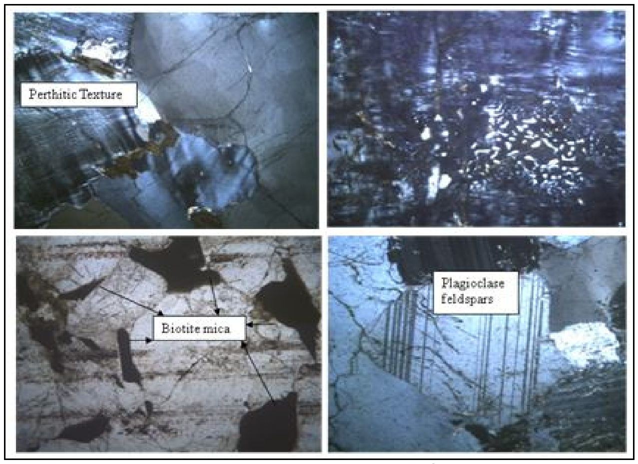



*Figure 5: Shows the Microphotograph for the migmatites*

Hornblende Biotite-gneisses are the dominant rock type. These are medium-grained rocks, dominantly characterized by mineral assemblages poor in K-feldspar. Plagioclase is xenoblastic or less commonly subidioblastic, regularly has idioblastic compositional zoning (Figure 7), and albite twinning. Pericline and Carlsbad twinning are rare.

Plagioclase commonly contains relatively large muscovite grains parallel to cleavage (Carlos, 2008). The composition of plagioclase (45-60%), biotite (15%), with minor content minerals are Quartz (40-60%), K-feldspar (13%), plagioclase An, Al,, (l0-30%), biotite (l0- 25%) The gneisses display volumetric ratio is centimetre- to metre-scale layering with alumina-rich containing minor amounts (15%) of Garnet and Kyanite (f Sillimanite), and K-feldspar-bearing layers composed of quartz **(40%),** K-feldspar (15%), plagioclase (25%), Biotite (15%) and Muscovite (1≤5%).

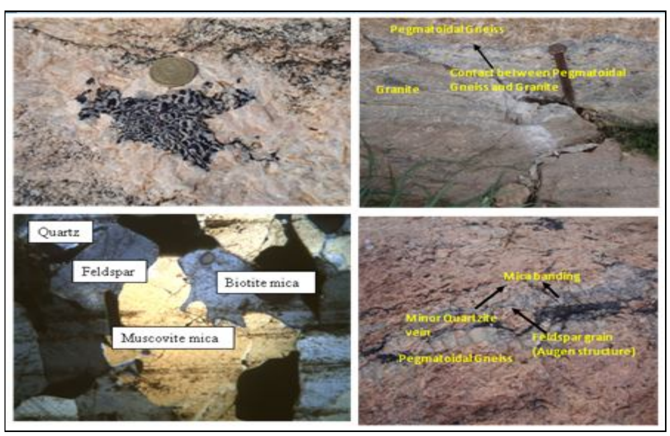



*Figure 6: Shows the Field and Microphotograph for the migmatites*

**4. Conclusion**

The study area more number of tectonically disturbed and sheared in nature. Melts were sourced from fertile muscovite-bearing pelites and quartzo-feldspathic gneisses of the Neo-Proterozoic formation. Surfaces as sinks for melt and as important escape channels.

In a recent reason between orogeny and crustal melting requires a multidisciplinary approach in which field observations, experimental investigations and theory from diverse disciplines petrology, tectonics. This interdisciplinary research in orogenesis and crustal melting is leading to significant advances in understanding. Examples of such advances are:

The improvement in and the progress of the petrophysical basis for the identification of, which have enabled us to infer the presence of melt in the middle crust of active origins and to place limits on the amount of melt present in the crust. The revelation that melt generation and segregation, and magma extraction, ascent and emplacement generally are syntectonic processes involving feedback relations, and that rate and timescales likely are much shorter than once believed.

A better understanding of the feedback relations among the various processes involved particularly the thermal structure and deformation of the partially molten crust, and its role in orogenic collapse. Granite melts breaking up host gneisses into xenoliths of pegmatites and present of big garnets with mica bandings (mica schist) in study area.

**5. References**


1. Brown and Solar (1998a), Petrogenesis of Migmatites in Maine, USA: Possible Source of Peraluminous Leucogranite in Plutons?
2. Brown (1999) The mechanism of ascent and emplacement of granite magma during transpression: a syntectonic granite paradigm.
3. Brown (2004) Analogue modelling of syntectonic leucosomes in migmatitic schists.
4. Balasubramanyan (1978, 1979) GSI, Part VI – Tamil Nadu and Pondicherry miscellaneous publication no. 30, geology and mineral resources of the states of India.
5. Carlos A. Zuluaga C.1 and Harold H. Stowell2 (2008) Multidisciplinary Approach To Study Migmatites: Origin And Tectonic History Of The Nason Ridge Migmatitic Gneiss, Wenatchee Block, Cascades Crystalline Core, Wa, USA. Earth Sci. Res. J. Vol. 12, No. 2, pp. 235-264.
6. Brow, M (2002) Petrograde processes in migmatites and granulites visited, Journal of Metamorphic geology20, 25-40.
7. Brow, M (2004) Melt segregation in migmatites, journal of geophysical research 100, pp.656-679.
8. Barbey, 1996 Granite-migmatite genetic link: the example of the Manaslu granite and Tibetan Slab migmatites in central Nepal.
9. Chetty T R K 1996 Proterozoic shear zones in Southern Granulite Terrain; Memoir Gond. Res. Gr. 3 77–89.
10. Crawford 1969 Part vi–Tamil Nadu and Pondicherry miscellaneous publication no. 30, geology and mineral resources of the states of India.
11. Drury S A and Holt R W (1980) The tectonic framework of the south Indian craton – a reconnaissance involving LANDSAT imagery; Tectonophys. 65 T1-T15.
12. Gopalakrishnan K, Sugavanam E B and Venkata Rao V 1975 Are there rocks older than Dharwars? A reference to rocks in Tamil Nadu; Ind. Mineralogist 16 26–34.
13. Harris N B W, Santosh M and Taylor P N 1994 Crustal evolution in South India: Constraints from Nd isotopes;
14. J. Geol. 102 139–150.
15. Harris N B W and Santosh M 1993 Chronological constraints on granulite formation in southern India and Sri Lanka; Geol. Soc. India Memoir 25 361–379.
16. Handy (2001) Tectonic Faults: Agents of Change on a Dynamic.
17. Narayanaswamy and Purnalakshmi, (1967), GSI, Hyderabad miscellaneous publication no. 30
18. Geology and mineral resources of the states of India.
19. Narayanaswamy (1971), GSI, Hyderabad, Hyderabad miscellaneous publication no. 30
20. Geology and mineral resources of the states of India.
21. Rushmer, 1997, Evolution and Differentiation of the Continental Crust By Michael Brown, Tracy Rushmer.
22. http://facstaff.buffalostate.edu/solargs/Solar/NSF-EAR0510726/project%20description.pdf
23. Ramakrishnan (1993, 2003, 2004) Cratons and Fold Belts of India, By Ram S. Sharma.
24. Rajeshdurai P, Srinivasan V and Swain A K (2008) Metamorphic evolution of granulites around Rajapalayam area, Madurai Block, Southern Granulite Terrain, Tamil Nadu; Geol. Surv. India Spec. Publ. 91 45–60.
25. Sacks (1997) Cratons and fold belt of India, Springer volume.
26. Schuiling (1958), On petrology, age and structure of the Menderes Migmatite complex, Mineralogical - Geological Institute, Utrecht. Holland.
27. Searle, M. P.Cottle, J. M. *, Streule M. J. and Waters, D. J. (2010) Crustal melt granites and migmatites along the Himalaya: melt source, segregation, transport and granite emplacement mechanisms 219–233.
28. Sawyer 1998; Milord et al. 2001; Solar and Brown 2002). Atlas of Migmatites.
29. Srinivasan and Rajadurai (2010) The Suruli shear zone and regional scale folding pattern in
30. Madurai block of Southern Granulite Terrain, south India. J. Earth Syst. Sci. 119, No. 2, pp. 147–160 © Indian Academy of Sciences
31. Tomson, J.K. Bhaskar Rao, Y.J. Vijaya Kumar, T. Mallikharjuna Rao, J. Charnockite genesis across the Archaean–Proterozoic terrane boundary in the South Indian Granulite Terrain: Constraints from major–trace element geochemistry and Sr–Nd isotopic systematics Gondwana Research 10PP. 115–127