



## Field Geological and Petrographic Study of Granitic Rocks around Devadurga, Eastern Dharwar Craton, Southern India

P. R. C. Phani<sup>1</sup>, K. Sreenu<sup>2</sup>, N. Ningam<sup>2</sup>

<sup>1</sup>Cyient Ltd., Uppal, Hyderabad <sup>2</sup>Geology Department, Osmania University, Hyderabad

### ABSTRACT

Field geological and petrographic characteristics of granitic rocks and their variants exposed at Devadurga town, Raichur district, Karnataka are described. The granitic rocks of Devadurga are part of younger 'Closepet granite' within a country of Peninsular Gneissic Complex (PGC) of Archaean age. Based on field and petrographic observations of this investigation, the younger granitic rocks of 'Closepet granite' within the study area can be sub-divided into leucogranite, grey porphyritic granite, pink granite, pink biotite granite, grey biotite granite, pink porphyritic granite. All these granitic variants possess more or less similar mineralogical assemblages and petrographic features such as myrmekitic, perthitic signifying their magmatic origin.

**Keywords:** *granitoid, younger granite, granite gneiss, field geology, petrography, modal mineral abundance, Devadurga, EDC.*

### I. INTRODUCTION

The mineralogical, petrographic and geochemical differences of granitic rocks of peninsular India have attracted petrologists to carry out continued research to comprehensively decipher their origin and evolution. The geological, geodynamic and tectonic framework of the Dharwar craton is well documented in some recent publications (e.g. Chadwick et al., 2000; Chardon et al., 2008, 2011; Jayananda et al., 2000, 2008, 2013; Ramakrishnan and Vaidyanadhan, 2010). Even though several workers have published enormous data on Dharwarian granitoids, still there exists a vacuum in understanding their geology and evolution. The present study encircles around field geological and petrographic characteristics of granites exposed near

Devadurga area (16°24'24.62"N 76°55'42.24"E), Raichur district of Karnataka state.

The area has undulated topography with vast peneplain comprising occasional tors and clusters of granitic residual hillocks. The main hillocks are situated around Devadurga, southern part of Devadurga (Lingusugur Reserved Forest) and Jalihalli. The maximum elevation in the area is 575 m.s.l. at Lingasugur Reserved Forest at S of Kottadoddi. The area is drained by NE flowing Krishna River. Many tributaries are present forming dendritic drainage pattern indicating homogeneity in the country rock lithology. The general country rock of the study area is younger PGC (2.5-2.7 Ga) that has been identified to be younger or nearly equivalent in age (to the Closepet Granite) and occurs as enclaves within the granite. These PGC rocks are mainly composed of the banded granite gneiss with well-developed to poorly-developed gneissosity and the stratified migmatite gneiss.

Detailed field traverses have been conducted in the study area confining to granitoid bodies with limited field checks on Peninsular Gneisses (PGC). The structural attitude was recorded using Brunton compass and GPS. Fresh rock from outcrops were selected which possess different variations in granitic rocks, from quarries, vertical cliffs and surface exposures for petrographic study. About 15 samples have been collected for preparing thin-sections which were examined under research microscope at the Petrology Laboratory, Department of Geology, Osmania University, Hyderabad. The field and petrographic study aided to distinguish the various litho units of younger granitoids and their relationship

with each other pertaining to their texture, mineralogy and mode of occurrence.

## II. GEOLOGICAL SETTING

The Dharwar craton consists primarily of greenstone-granite gneiss terrain, and has been subdivided into two parts, namely the western Dharwar craton (WDC) and the eastern Dharwar craton (EDC) based on the characteristics of greenstone belts, degree of metamorphism, age and nature of the gneissic rocks (e.g., Swami Nath and Ramakrishnan 1981; Radhakrishna and Vaidyanathan 1997; Chadwick *et al* 2000; Jayananda *et al* 2000; Ramakrishnan and Vaidyanathan 2010). (Fig.1) The two blocks are separated by a network of vertical shear zones, thought to represent a terrane boundary along which the Closepet granite has been emplaced (e.g. Moyen, 2001). The TTG gneisses form the complex, polyphase, mid-Archaean (3.3–2.7Ga) basement of the craton known as the ‘Peninsular Gneiss Complex’ (PGC). Two groups of volcano-sedimentary greenstone belts viz., the older one, the Sargurs (3.3–3.0Ga) which occur as mappable enclaves within PGC, and the younger Dharwar Super group (3.0–2.7 Ga) which occur as large N-S trending greenstone belts. These granite greenstone belts and the PGC have been intruded by the late Archaean (2.6-2.5 Ga) K-rich granites viz., Closepet granite, Chitradurga, Arsikere and Banawar in the West and Torangal, Bellary and Raichur in the east (Friend and Nutman, 1991; Nut man *et al.*, 1996) (Fig. 1).

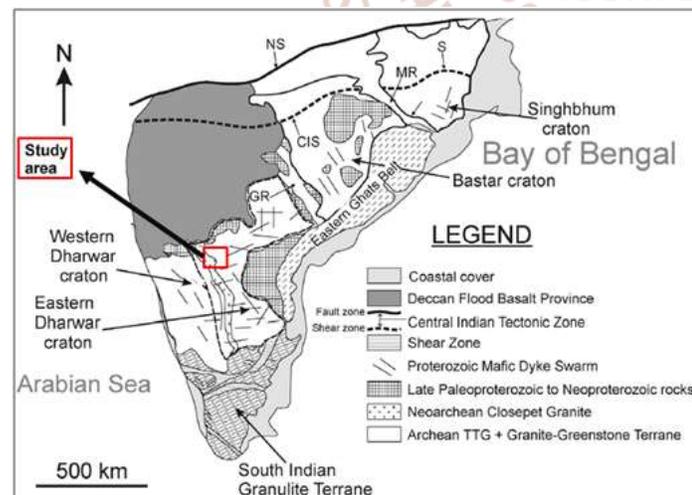


Figure 1. Regional geological map of peninsular India (modified after French *et al.*, 2008)

The area under investigation is a part of the Eastern Dharwar Craton and exposed parts of Raichur-Devadurga Schist belt and Hutti-Muski Schist belt within the Dharwar Super group, which are the oldest

in the study area (Fig.2). These linear NE-SW trending schist belts are predominantly composed of metabasalt and pillowed metabasalt with acid volcanics and few amphibolite enclaves. The major part of the study area comprises different variants of granite that belong to the Closepet granite batholith. The granitic belt maintains an average width of 20km and extends for nearly 500km. Zircon dating of these granites in southern part revealed their geochronological age between 2.51 and 2.53 Ga old (Friend and Nutman, 1991; Jayananda *et al.*, 1995), and in the northern part, it is calculated to be 2.56 Ga old (Nutman *et al.*, 1996). The study area exposes rocks from Archaean to Paleoproterozoic in age

The area is covered mainly by the younger granitoids that are coeval to Closepet granite. Based on field geological relations, the Closepet granites have been divided into (a) root zone where magma is generated, interacts with basement and evolves, transfer zone where the magma rises upwards and the intrusion zone where the feeder dykes are emplaced (Moyen *et al.*, 2002). Due to the upheaval of deeper part of the crust towards the southern part, degree of metamorphism, as evidenced by the presence of typical textures, increases from north to south. The granite gneisses and the migmatites occurring as enclaves within the younger granite belong to the younger PGC units (younger in age to Hutti- Muski Group). Seven varieties of granite based on the field characteristics were identified viz., leucogranite, grey granite, grey biotite granite, grey porphyritic granite, pink granite, pink porphyritic granite and pink biotite granite. These rocks have been intruded by younger basic intrusives i.e. dolerite and gabbro dykes and acidic intrusives i.e. quartz and pegmatite veins of Paleoproterozoic age.

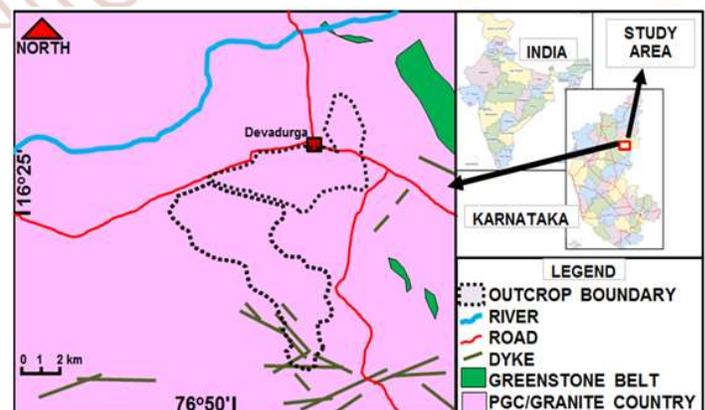


Figure 2. Geological map of the study area showing younger granite outcrop boundaries (modified after GSI, 2003).

### III. COUNTRY ROCK CHARACTERISTICS

The country rock granite gneisses exposed in the study area belong to the Peninsular Gneissic Complex (2.5-2.7Ga), composed of two litho-variants viz., the migmatites and the granite gneiss. The migmatites are observed 1km NE of Mandaragi and along road section 6km east of Nawalagudda (towards Devadurga). In field, the migmatites were identified by the presence melanosome, mesosome and leucosome layers occurring in an irregular fashion. The granite gneiss possesses well-developed gneissic banding composed of felsic and mafic mineral phases. The presence of several S-type asymmetric folds indicates possible shearing (deformation) that the rock has undergone. The NW-SE trending foliation was well developed with steep dip due NE. Both the country rocks, viz., granite gneiss and the migmatite gneiss showed sharp contact with the granitoids that surround these rocks. The sharp contact between granitoids and country rock gneisses and migmatites does not support the anatectic origin of the younger granitoids in this area (Moyen et. al., 2001). Limited thin-sections were prepared for granite gneisses of the study area and studied under the microscope to understand the general mineralogy and textures. Under the microscope, the granite gneiss is coarse-grained with recrystallized grain boundaries indicating metamorphic origin. The gneissosity observed in hand-specimens is not so conspicuous in the thin-sections. The gneisses comprise minerals like quartz, sericitised plagioclase, microcline, biotite and epidote. The accessory mineral phases comprise zoned zircon and sphene. The presence of sub-grain development in big quartz grains and small pockets of brecciation etc. indicate deformation to post-emplacment. Presumably these granite gneisses are younger intrusions than the PGC of gneisses Dharwar Craton in general. Sheared phenomena are common within the granite gneiss (Fig.3a). Ptygmatic folds within silicic veins were observed at many places denoting ductile deformation (Fig.3b). At the contact between granite and granite gneiss, well-developed porphyritic texture represented by large laths (2-4 cm) of feldspar are noticed (Fig.3c). Medium to coarse-grained textured felsic pegmatite veins displaying slight deformation are common (Fig.3d).

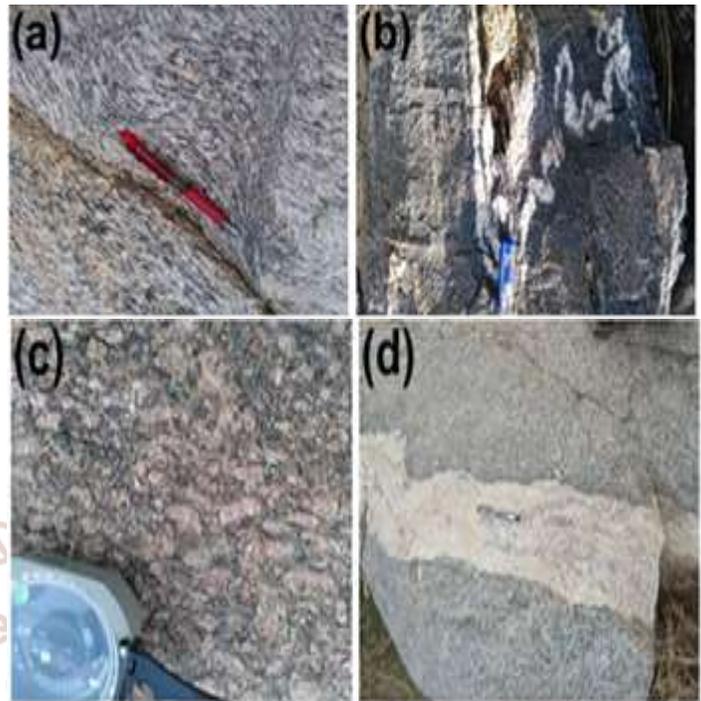


Figure 3. Field characteristics of granite gneisses of the study area. (a) Shearing in granite gneiss (b) ptygmatic folding of silicic veins (c) porphyritic texture in pink granite at contact of gneissic rocks and (d) felsic pegmatite vein in granite gneiss

### IV. FIELD AND PETROGRAPHIC CHARACTERISTICS OF YOUNGER GRANITES

The variants of younger granites viz., leucogranite, porphyritic grey granite, biotite pink granite, porphyritic pink granite and biotite grey granite of the study area are described below. The biotite pink granite shows predominant and well-developed laths of pink feldspar (Fig.4a). The mafic enclaves occur as augen shaped entities within the granite (Fig.4c). Felsic pegmatite veins are common and cut across the granitic bodies in more than three trends i.e., NS-EW, ENE-WSW, NW-SE, NNE-SSW etc. At the peripheries of these felsic veins, intense shearing is observed whereas at the central portion the shearing effect is little (Fig.4c). The pink granite shows porphyritic texture with large grains of K-feldspar (Fig.4d). As a result of metasomatic action, intense epidotisation in granite is noticed especially at the contact of granite and migmatites and (Fig.4e). The leucogranite outcrop shows a massive and uniform equigranular texture (Fig.4f).

#### A. Leucogranite:

This litho unit is well exposed at about 1km SW and 2km SE of Suladaguda, occurring as elongated elliptical outcrops trending N-S to NNW-SSE.

Leucogranite occurs as small mappable patches or enclaves within the pink biotite granite in the form of low lying hills in the study area. It is medium to coarse grained, white coloured, composed mainly of light coloured feldspars, colourless quartz and completely devoid of mafic mineral grains. This litho unit is presumed to be the oldest of all granites occurring within the younger pink biotite granite.

### B. Porphyritic Grey Granite:

The grey porphyritic granite occurs as small enclaves near Hosura Siddapur (16°20'58.31"N 76°45'10.69"E). The alignment of biotite and K-feldspar laths give rise to foliation. The rock predominantly is composed of medium to coarse-grained (3-5cm) quartz, K-feldspar, plagioclase and biotite. At some places the presence of mafic enclaves, ranging from 7- 14 cm in length, are observed. The mafic enclaves occur in elliptical shape and also possess reaction rims at the enclave boundary. The enclaves are both mafic and felsic indicating a heterogeneous source region comprising both types of magmas. Under the microscope, the biotite grey granite displays triple junctions and recrystallised grain boundaries to support that it has undergone metamorphism (Fig.5a)

### C. Pink Granite:

The pink granite rock, the second predominant lithology, is mainly exposed near Gudadda Irabageri and few km South of Wengalapur and occurs as steep granite hills, tors and knolls that had bouldery outcrop patterns with steep hill slopes. The rock is massive, medium to coarse grained, predominantly comprises quartz, plagioclase and pink K-feldspar, completely lacks the presence of biotite or any mafic mineral but rarely biotite as accessory mineral. At places, biotite is present as accessory giving rise to biotite pink granite. A transitional contact between the biotite pink granite and the pink granite was observed along a traverse taken from Wengalapur to Gudadda Irabageri wherein the amount of biotite and possibly hornblende reduce gradationally towards Gudadda Irabageri. Even though few quartz/felsic pegmatite veins are observed, they found to bear no mineralization. Perthitic intergrowth is more in pink granites when compared to grey granites. Microcline occurs as euhedral to subhedral plates and also as interstitial grains between quartz and plagioclase grains. Feldspars show various intergrowth textures. Inclusions of zircons are noticed and alteration of

biotite to chlorite along the grain boundaries is seen at places.

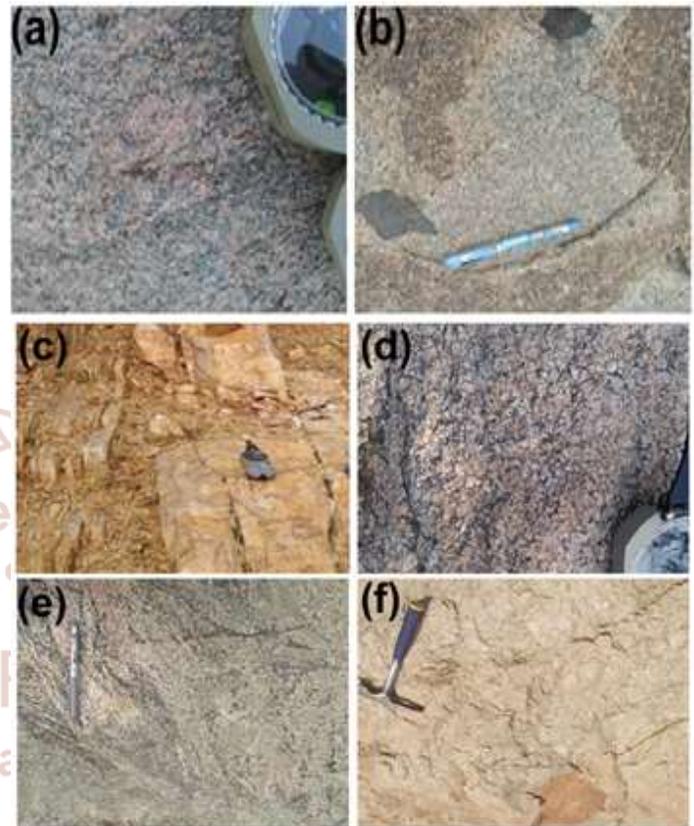


Figure 4. Field photographs of different types of features in younger granites of Devadurga. (a) biotite pink granite (b) augen shaped mafic enclave in grey granite (c) felsic pegmatite vein. Note sheared peripheries of the vein (d) pink granite with porphyritic texture (e) intense epidotisation in granite and (f) leucogranite outcrop surface.

### D. Biotite-Pink Granite:

The massive biotite-pink granite occupies the major portions of the given study area, in the form of bouldery outcrops forming tors. At places, this rock type is feebly foliated either due to primary magmatic process or secondary deformation. The trend of both the primary and the secondary foliations were NNW-SSE. In general, the rock is medium to coarse-grained and at places shows the agglomeration of large K-feldspar crystals. The rock comprises quartz, pink K-feldspar, plagioclase, biotite as the major mineral constituents. Megascopically it was observed that grains of K-feldspar were surrounded by biotite flakes. Greenish brown coloured flakes of biotite are common ferromagnesian mineral found in these pink granites. Based on field studies, it is presumed that the biotite pink granite occupies major area of the present study and is youngest of all younger granites.

Enclaves of leucogranite making sharp contact are not so uncommon in this litho unit.

### E. Porphyritic Pink Granite:

The porphyritic pink granite, occurring mainly at Hosur Siddapur, predominantly contains pink K-feldspar as phenocrysts (2-5 cm) within the fine-grained groundmass composed of plagioclase, quartz, biotite and hornblende (Fig.5b). At places in the outcrops, it is observed that phenocrysts are agglomerated giving rise to agglomerate-porphyritic texture. The contact between the porphyritic pink granite and the biotite pink granite appears to be transitional as it could not be established during field studies due to lack of proper outcrops to demarcate the contact. The porphyritic granite variety might have developed in the core of the magma chamber thus allowing feldspar grains to crystallise in the form of megacrysts. The rock under thin section is inequigranular with anhedral to subhedral grains, coarse grained rock with quartz, microcline, plagioclase, biotite and hornblende as the essential minerals. Under the microscope, the rock shows myrmekitic texture indicating deformation or metasomatism (Fig.5c). Zircon, apatite, sphene and monazite are the accessory minerals identified (Fig.5d). The myrmekite could be classified as rim myrmekite as the quartz blebs were found only on the rims of the plagioclase grains. Perthitic texture is also observed which is an exsolution texture (Fig.5e).

### F. Biotite Grey Granite:

Small enclaves within the biotite pink granite were observed to the south of Alur near Suladaguda. A hillock composed of biotite grey granite was also observed along west of the road between Mandaragi and Mundalaguda. The biotite grey granite was differentiated from the biotite pink granite by the color of the K-feldspar grains. The rock is massive, medium to coarse grained and is composed of quartz, plagioclase, grey K-feldspar and biotite clots. At hand-scale, some garnets within the biotite clots along with tourmaline crystals were also identified. In the litho unit is exposed at Yereguda in the western part of the study area, at places, the development of magmatic primary foliation trending nearly NNW-SSE ( $343^\circ$ ) is observed. The rock occurs as a major lithology on the Jalihalli-Raichur road. The biotite grey granite hosts the pegmatite veins near Yereguda, ranging from 1m to 10m in length, were observed but the extension of the pegmatite veins is obscured by alluvial cover. However, these pegmatite dykes

deserve further geological and geochemical studies to locate any mineralisation. Under the microscope, the biotite grey granite displays triple junctions and recrystallised grain boundaries to support that it has undergone metamorphism similar to grey granite gneiss. Even though the rock shows slight gneissosity at hand-scale, under the thin-section, it is absent. The major minerals present in the rock are quartz, sericitized plagioclase, microcline, biotite and epidote. Indications of deformation after emplacement supported by features like sub-grain formation in quartz and small pockets of brecciation, etc. Magmatic zoned zircon, sphene are the accessory minerals (Fig.5f).

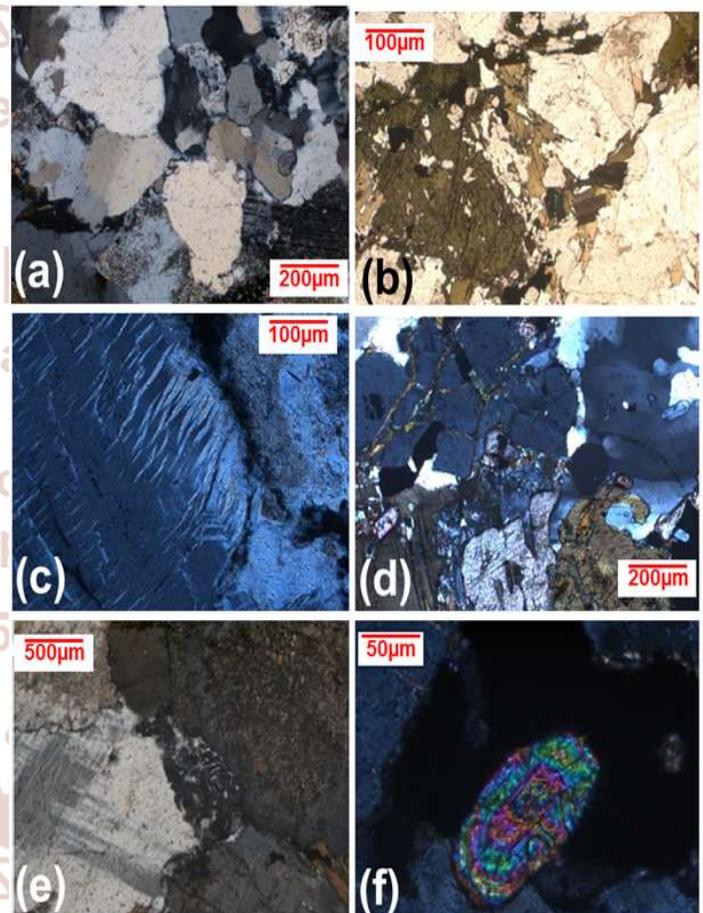


Figure 5. Micro photographs showing textures and mineralogy of younger granites of the study area. (a) tri-junction between mineral grains within granite gneiss (b) hornblende and biotite in porphyritic pink granite (c) perthitic texture in porphyritic pink granite (d) apatite, monazite, sphene and zircon grains in porphyritic pink granite (e) myrmekitic and perthitic texture in porphyritic pink granite (f) zoned zircon crystal within ilmenite supporting magmatic crystallization.

## V. MODAL MINERAL ANALYSIS

Modal analysis was performed by using swift automatic point counter. The instrument was set-up to give a grid width of 0.01 mm on E-W and 0.33 mm N-S. At least 2000 points were counted for coarse grains, but where the grain size is less than 1 mm the number of point counted are reduced. Representative sections of the granites are selected for modal analysis and the data is presented in Fig.6. A predominance of quartz, K-feldspar, plagioclase with minor amounts of biotite and other accessory minerals is clearly evident.

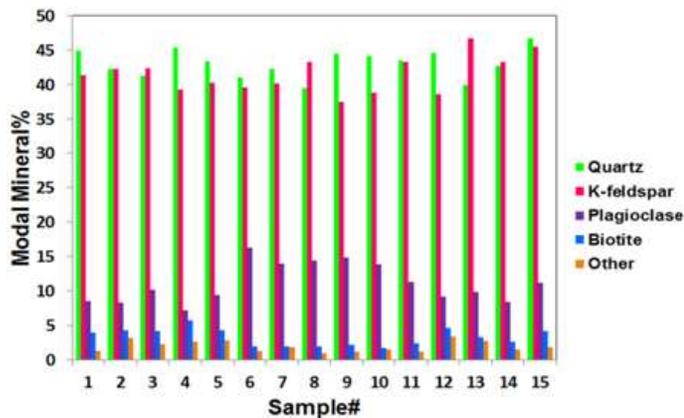


Figure 6. Histogram showing modal mineral abundances in younger granites of the study area.

## VI. CONCLUSIONS

A study of field and petrographic characteristics of younger granites occurring within the younger PGC of the EDC, exposed at Devadurga, Raichur district of Karnataka reveal various types of granites viz., Leucogranite, Porphyritic grey Granite, Biotite pink Granite, Porphyritic pink Granite and Biotite grey Granite. The younger granites are hosted by younger PGC granite gneisses. The outcrops occur as residual hills, tors and knolls of different magnitudes in the study area. Petrographically, the younger granites are composed of minerals like quartz, microcline, pink K-feldspar, plagioclase, biotite and hornblende. The important accessory minerals include zircon, sphene, garnet and tourmaline in biotite clots. The pink and grey granites are traversed by considerably voluminous veins of felsic pegmatite. Although no visible mineralisation could be observed, these pegmatites may deserve further investigations. Owing to the presence of incipiently or partly recrystallised grain boundaries, the grey and pink granites appear to have undergone some amount of metamorphism. The overall field relations and micro-textures of this study suggest that these younger granitic rocks are originated from magmatic activity coeval to other

younger granites of Archaean age of the Dharwar craton and elsewhere.

## ACKNOWLEDGEMENTS

The authors thank Prof. Mādabhooshi Srinivas, Head of the Department, and Dr. G. Prabhakar (Head, UCSS), Chairman, Board of Studies, Department of Geology, Osmania University, Hyderabad for permitting them to use petrological research microscope facility at Saifabad campus.

## REFERENCES

1. Chadwick, B., Vasudev, V. N., Hegde, G. V., (2000). The Dharwar craton, southern India, interpreted as the result of late Archaean oblique convergence. *Precambrian Res.*, Vol.99, pp. 91-111.
2. Chardon, D., Jayananda, M., Chetty, T. R. K., Peucat, J. -J., (2008). Precambrian continental strain and shear zone patterns: the South Indian case. *J. Geophys. Res.*, Vol. 113, B08402, <http://dx.doi.org/10.1029/2007JB005299>.
3. Chardon, D., Jayananda, M., Peucat, J.-J., (2011). Lateral constrictional flow of heterogenic crust: insights from the NeoArchaean of South India, geological and geophysical implications for orogenic plateau. *Geochem.Geophys.Geosys.*12, Q02005, <http://dx.doi.org/10.1029/2010GC003398>.
4. French, J. E., Heaman, L. M., Chacko, T., Srivastava, R. K., (2008). 189-1883 Ma Southern Bastar-Cuddapah mafic igneous events, India: a newly recognized Large Igneous Province. *Precambrian Res.*, Vol. 160, pp.308-322.
5. Friend, C. R. L. and Nutman, A. P. (1991). SHRIMP U-Pb geochronology of the Closepet granite and Peninsular Gneiss, Karnataka, South India. *J. Geol. Soc. India*, Vol. 38, pp.357-368.
6. GSI (2003). "Metallogenic map of India", Scale 1: 2.5 million, Geological Survey of India, Second Edition, 2003.
7. Jayananda, M., Kano, T., Peucat, J. J., Channabasappa, S., (2008). 3.35 Ga komatiite volcanism in the western Dharwar craton, southern India: constraints from Nd isotopes and whole rock geochemistry. *Precambrian Res.*, Vol. 162, pp.160-179

8. Jayananda, M., Martin, H., Peucat, J-J., Mahabaleswar, B. (1995). Late Archaean crust–mantle interactions: geochemistry of LREE-enriched mantle derived magmas- Example of the Closepet batholith, southern India. *Contrib. Mineral. Petrol.*, Vol. 199, pp. 314–329.
9. Jayananda, M., Moyen, J.-F., Martin, H., Peucat, J. -J., Auvray, B., Mahabaleswar, B. (2000). Late Archaean (2550-2520 Ma) juvenile magmatism in the eastern Dharwar craton, southern India: constraints from geochronology, Nd–Sr isotopes and whole rock geochemistry. *Precambrian Res.*, Vol. 99, pp.225–254.
10. Jayananda, M., Peucat, J. J., Chardon, D., Krishna Rao, B., Corfu, F., 2013. NeoArchaean greenstone volcanism, Dharwar craton, Southern India: constraints from SIMS zircon geochronology and Nd isotopes. *Precambrian Res.*, Vol. 227, pp. 55-76.
11. Moyen, J-F., Martin, H., Jayananda, M. (2001). Multi-element geochemical modelling of crust–mantle interactions during late-Archaean crustal growth: the Closepet granite (South India). *Precambrian Research*, Vol. 112, pp.87-105.
12. Moyen J-F, Jayananda, M. Nedelec, A., Martin, H., Mahabaleswar, B. and Auvray, B. (2002). From the Roots to the Roof of a Granite: the Closepet Granite of South India. . *J. Geol. Soc. India* Vol. 62(6).
13. Nutman, A. P., Chadwick, B., Krishna Rao, B. and Vasudev, V. N. (1996). SHRIMP U–Pb zircon ages of acid volcanic rocks in the Chitradurga and Sandur Groups and granites adjacent to Sandur schist belt. *J. Geol. Soc. India*, Vol.47, pp. 153–161.
14. Radhakrishna, B. P. and Vaidyanathan (1997). *Geology of Karnataka*. Geol. Soc. Ind., 353p.
15. Ramakrishnan, M., Vaidyanadhan, R., (2010). *Geology of India*. Geological Society of India, Bangalore, pp. 994.
16. Swami Nath, J. and Ramakrishnan, M. (eds) (1981). Early Precambrian supracrustals of southern Karnataka. *Geol. Surv. India Memoir*, Vol.112, 352 p.