Field Relation and Petrographic Implication of Kadavur Complex, Southern Granulite Terrane, Tamil Nadu, India

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Abstract: *The Precambrian (~810Ma) gabbro-anorthosite Kadavur complex (10˚35′N:78˚11′E), Karur district, Tamil Nadu occurs as intrusive within the country rocks comprising quartzite, granitic gneiss and migmatites belonging to the Southern Granulite Terrain (SGT). The detailed field investigations reveal that Kadavur complex consists of three well defined types: i) earlier deformation-controlled schistose (remnant) gabbro-anorthosite, ii) well defined layered gabbro-anorthosite and iii) lensoid pegmatoidal gabbro-anorthosite. Petrography of the layered gabbro-anorthosite type (as per IUGS classification) indicates several petrographic variants namely gabbro-norite, noritic-gabbro, gabbro, anorthositic norite, anorthosite, norite and anorthoitic gabbro, leucogabbro and rarely melagabbro and pyroxene hornblende gabbro norite.*

Keywords: *SGT, Gabbro-anorthosite, Kadavur complex, Intrusive rock*

1. Introduction:

The terrestrial anorthosite bodies do not have voluminous and widespread distribution over the world. Their restricted occurrences include Lac-Saint Jean complex, Quebec (Buddinton 1939), Fiskenaesset, Greenland and Grenville of eastern Canadian Shield (Ashwal, 2000, 2010; Ashwal and Myers, 1994), layered Bushveld Complex or Stillwater Complex (Cawthorn, 1996) and Superior Province of Canada (Polat et al. 2018). Terrestrial anorthosite occurrences may be divided into the following five types [Ashwal (1993)] which are: a) Archean anorthosite plutons b) Proterozoic “massif-type” anorthosite plutons c) centimeter to 100m thick layers in layered mafic intrusions d) thin cumulate layers in ophiolites / oceanic crust and e) anorthosite xenoliths occuring in other rock types. So far as the Indian context is concerned, Southern Granulite Terrain (SGT) and Eastern Ghats Granulite Belts (EGB) are classical terrains of anorthosite occurrences of Precambrian time (Naqvi and Rogers, 1987; Radhakrishna, 1990, 1993). The common country rocks in the SGT accommodating the anorthosite represent high grade rocks (Ramakrishnan et al. 1978; Santosh et al.1992). In a recent review paper of the Southern Granulite Terrane, Santosh (2020) emphasized the important role of gabbro-anorthosite bodies in the sense that these bodies probably represent

supra-subduction setting (Ram Mohan et al. 2013).The country rocks of SGT commonly include charnockites, khondalites, mafic granulites, migmatitic gneisses and schists (Nambiar,1987; Nambiar et al. 1989,1992; Santosh 1986; Roy and Purohit, 2018; Nair et al. 1985).The present research furnishes the detailed field relations and petrographic analysis on the Kadavur gabbro-anorthosite complex in an attempt to understand its petrogenetic aspects.

2. Geological Setting:

The gabbro-anorthosite intrusive complex of Kadavur (10°35´N: 78°11´E) was initially reported by Subhramaniam (1956) from the Southern Granulite Terrane (SGT) of the Indian shield (Fig.1a). However, during that time, occurrence of this intrusion was reported to be located at the Eastern Ghat Belts since the term SGT was first coined by Subhramanyam and Verma (1986) based on geophysical consideration. The main ideas of Subhramaniam (1956) regarding the petrogenesis of Kadavur complex were i) the intusion represented a funnel-shaped concordant body and ii) the Kadavur complex was related to Adirondack type intrusion. However sometimes after, Windley and Selvan (1975) opined that the Kadavur intrusive complex was not comparable to Adirondack type massif and commented that this anorthosite to be of early Archean layered gabbro anorthosite type. Sarkar and Bose (1978, 1987) based on comprehensive studies suggested a composite nature of the Kadavur complex and according to those authors the complex was possibly related to multiple magmatism. In fact Sarkar and Bose (1978, 1987) indicated that this complex is divisible into three mappable units each having distinct petrological attributes. The variation in these attributes according to the authors reflects tectonic and physio-chemical environments which effectively controlled the crystallization-differentiation patterns represented by the units. Moreover, the Kadavur complex was thought to be a manifestation of unique association of anorthosite rocks having different class affinities (layered and massif). Kumar et al. (2013) presented a brief petrography and geochemical account of the Kadavur complex and broadly speculated a tholeiitic trend of igneous members. During the recent years, Kooijman et al. (2011) provided U-Pb geochronological data on the quartzite country rocks surrounding the main gabbro-anorthosite intrusions of Kadavur. Based on the geochronological data (presented by

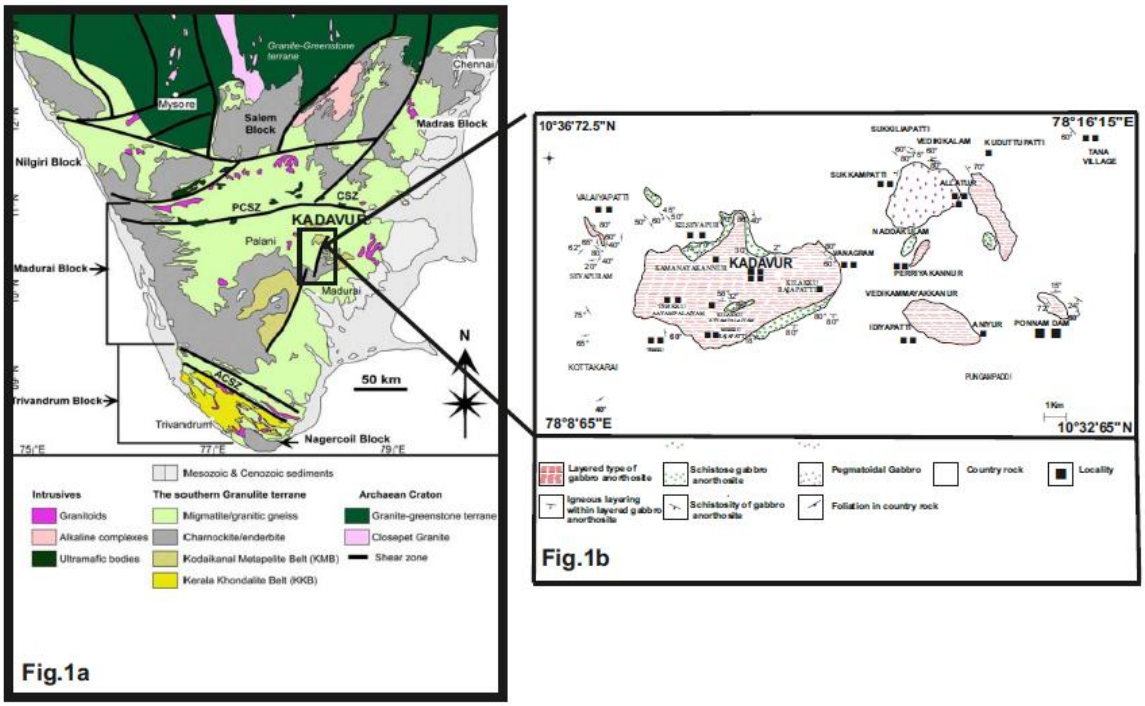

Fig.1a. Location of the investigated area (Kadavur Complex) within the regional tectonic-frame of the Southern Granulite Terrane (Santosh and Sajeev 2006). 1b. Geological map of the investigated area, Kadavur complex (Sarkar et al.2022). Country rocks comprise mostly, quartzite, granitic gneiss and migmatites.

Kooijman et al. 2011) an indirect age of the anorthosite intrusion after early Neoproterozoic metamorphism has been inferred (~ 810Ma). The disposition of the Kadavur Complex (Fig. 1a) shows it characteristically falls in Palani block of the Southern Granulite Terrane (SGT). Moreover this Kadavur Complex is found to lie on the NNE-SSW trending Cauvery Shear Zone (CSZ) (Fig 1a). Therefore it appears that CSZ has good influence on emplacement of the Kadavur anorthosite - gabbro mass. In fact the Kodaikanal – Palani massif is an important component of India's Southern Granulite Terrane (SGT); understanding the tectonic history of its rocks gives considerable insight into its role within South India (Catlos et al. 2011). However, up to date petrological detailing of the Kadavur complex is yet lacking. The shear zone controlled nature of Kadavur complex is a very pertinent matter because in many other parts of shield areas such shear zone controlled gabbroic mass is related to parent magma chamber.

3. Present Study:

Based on our recent field investigation and attribute petrography can be done. Our present finding which are detailed below:-

3 (a) Field Geology:

Detailed field mapping by the present authors have been carried out on the Kadavur complex (10°35´N: 78°11´E) and a geological map has been presented in Fig.1b. This map (Fig.1b) suggests a revision of the earlier field relation given by the previous author (Subhramaniam 1956).The important rock types as documented in the present study are given below: a) highly schistose gabbro-anorthosite b) layered gabbro-anorthosite c) pegmatoidal gabbro-anorthosite. The members of the Kadavur intrusive complex are accommodated by the surrounding country rocks which include hornblende schists, amphibolites, granitic gneiss, quartzite and migmatite. The country rocks in the most of the cases are foliated. Fig.2a shows foliation pattern of the country rocks with development of down-dip lineation. The field-photographs of leucosome and melanosome (part of migmatite recorded in the field area) have been shown in Fig.2 (b- d). Foliation pattern in well developed quartz-biotite-gneiss or granite gneiss is presented in Fig.2e and Fig.2f. Field photographs of layered gabbro with presence of saussuritized plagioclase have been given in Fig.3a and Fig.3b respectively. Layered disposition in gabbroic rocks is very conspicuous (Fig.3c). Well developed exposure of anorthosite has been shown in Fig.3d. Field photographs showing schistose gabbro anorthosite have been presented in Fig.4a and Fig.4b. Extensive planar structure and development of elongated minerals indicate effects of deformation in this region. Coarse grained pegmatoidal gabbro is occasionally present in the study area (Fig.4c and Fig.4d).

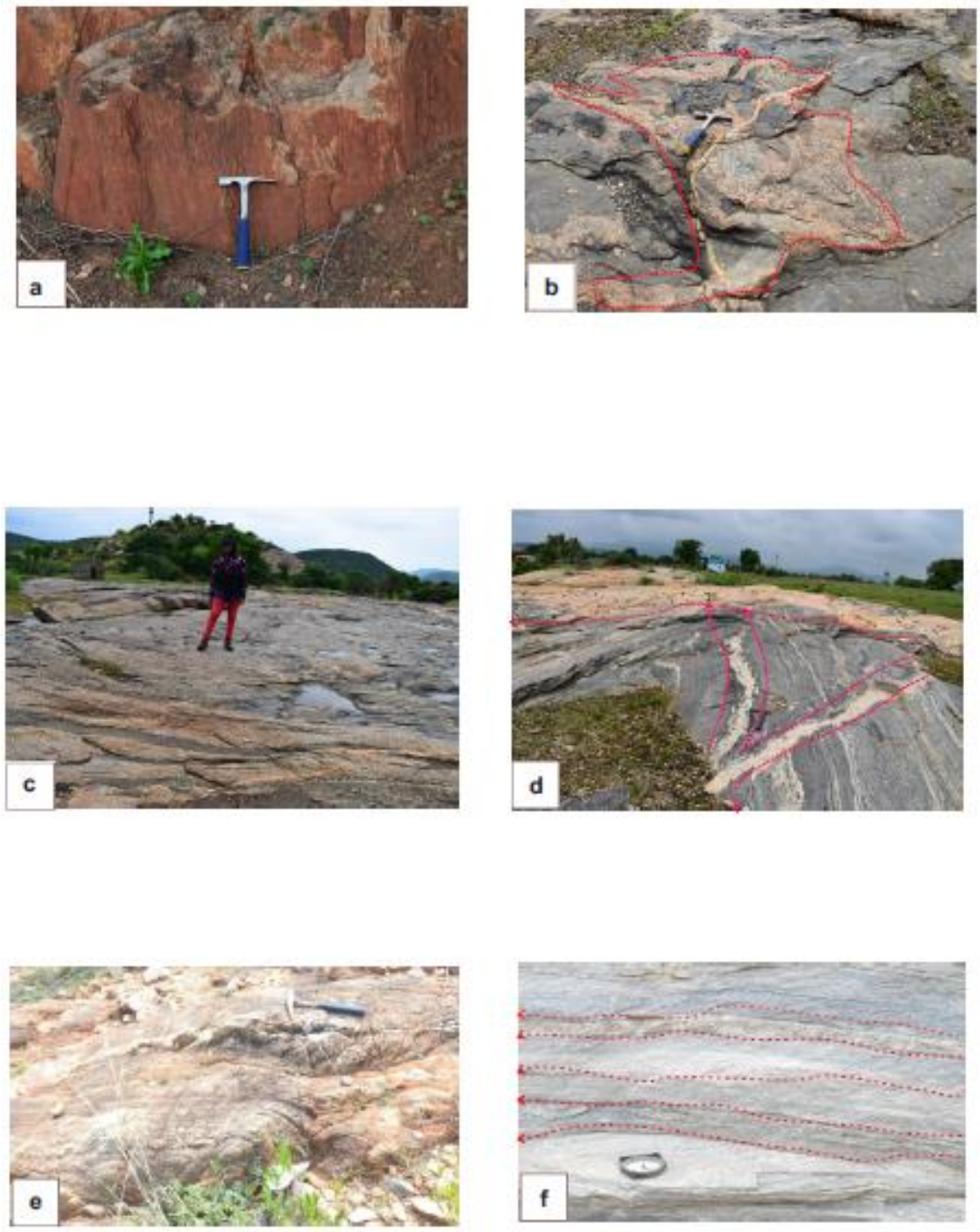

Fig.2 Field photographs of country rocks: a) Development of schistossity plane along with down dip lineation. b) Presence of leucosome and melanosome in migmatite c) Plan view showing vast occurrence of migmatite d) Migmatite with well developed gneissic banding. e) Gneissic banding in quartz biotite gneiss. f) Well developed gneissosity plane in granite gneiss.

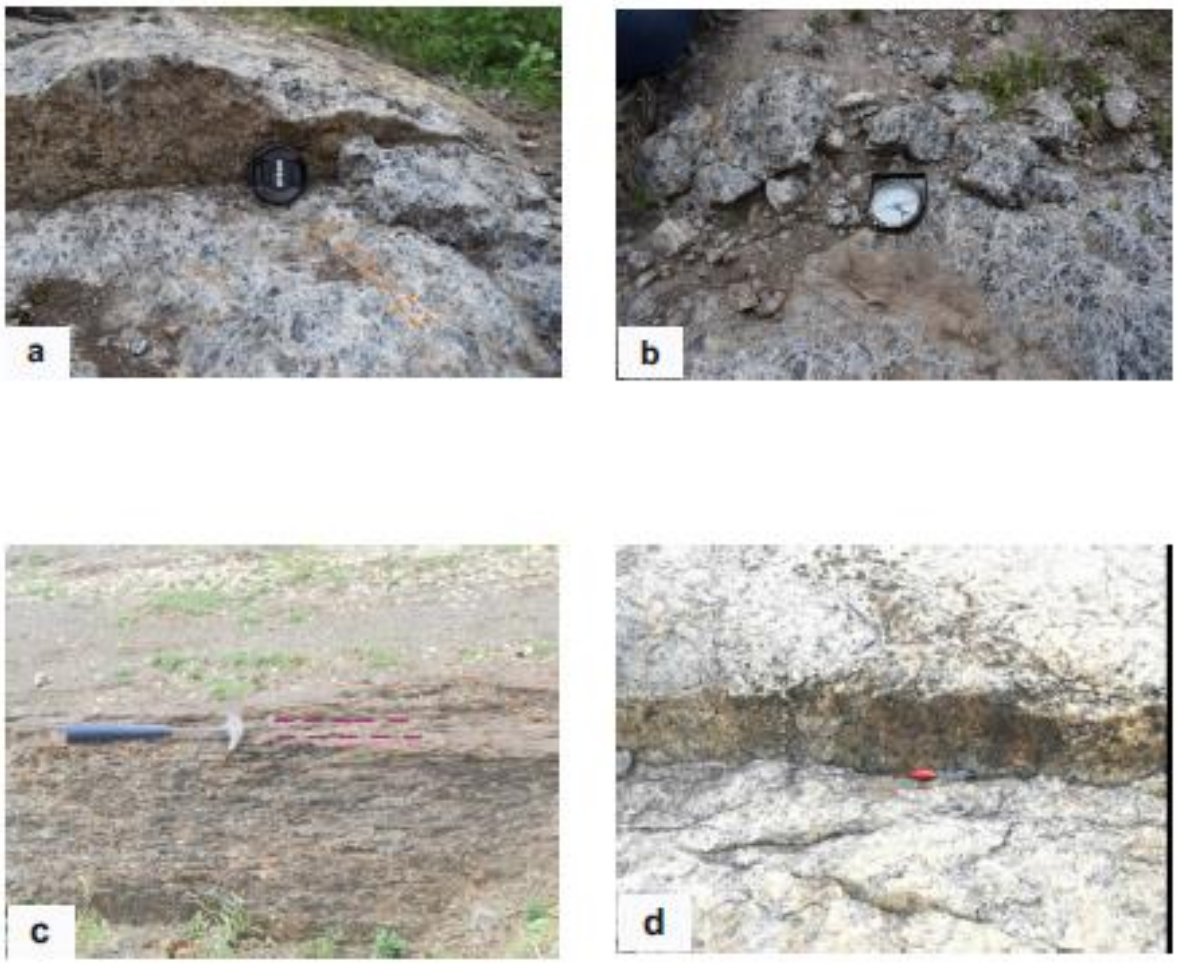

Fig.3 Field photographs of layered gabbro-anorthosite: a) Layered gabbro with development of igneous layering. b) Layered gabbro showing presence of altered plagioclase. c) Plan view of intrusive layered gabbro. d) Exposure of massive anorthosite near Kadavur village. For Figs. 3a and 3c, attitude of igneous layering has been marked.

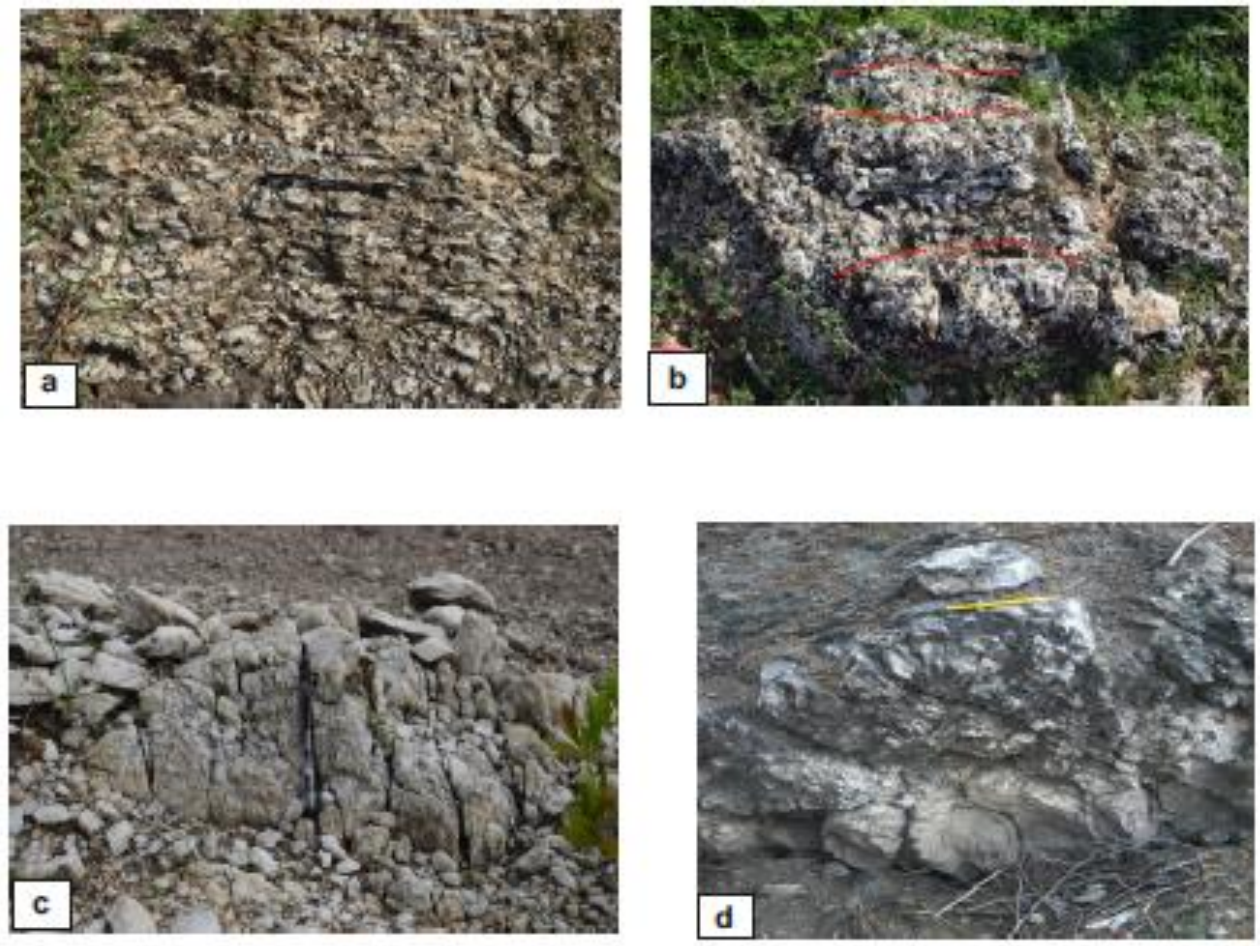

Fig.4 Field photographs of: a) schistose gabbro; b) highly schistose anorthosite; c) and d) coarse grained pegmatoidal gabbro.

3 (b) Petrography:

As mentioned earlier, the intrusive members of the Kadavur complex are divisible into three broad types which are (i) early deformed schistose gabbro-anorthosite type (ii) well defined layered gabbro anorthosite type and (iii) lensoid pegmatoidal gabbro anorthosite type. Out of these three types, type (ii) is spatially the most dominant type while type (iii) is exposed only at few localities (Fig.1b). Fig.5 gives some representative hand-specimen photographs and photomicrographs of three types of gabbro-anorthosites. Fig.5.a1 is a hand-specimen of anorthosites while photomicrograph of anorthosite (Fig.5.a2) shows evidence of typical protoclastic granulation. Hand-specimen photographs and photomicrographs of anorthositic gabbro have been presented in Fig.5.b1 and Fig.6.b2 respectively while Fig.5.c1 and Fig.5.c2 represent hand-specimen photographs and photomicrographs of norite. Fig.5d shows a coarse grained pegmatoidal gabbro while photomicrograph of schistose anorthosite is depicted in Fig.5e. The photomicrograph of anorthosite shows the evidence of deformation where constituent mineral grains are aligned parallel to schistossity plane. The hand specimens and photomicrographs of different types of country rocks (hornblende schist, amphibolites, granitic gneiss and alkali feldspar granite) are represented in Fig.6 (a-d). The systematic classification those modal data were referred to IUGS recommended plagioclase-pyroxene-hornblende diagram (Fig.7a) and plagioclase-orthopyroxene-clinopyroxene diagram (Fig.7b) (Streckeisen, 1976). Introspection into these diagrams, reveal following petrographic variants namely anorthosite, gabbro anorthosite, norite, anorthositic gabbro, anothositic norite, gabbro norite, noritic gabbro, gabbro, leucogabbro and rarely melagabbro and pyroxene hornblende gabbro norite.

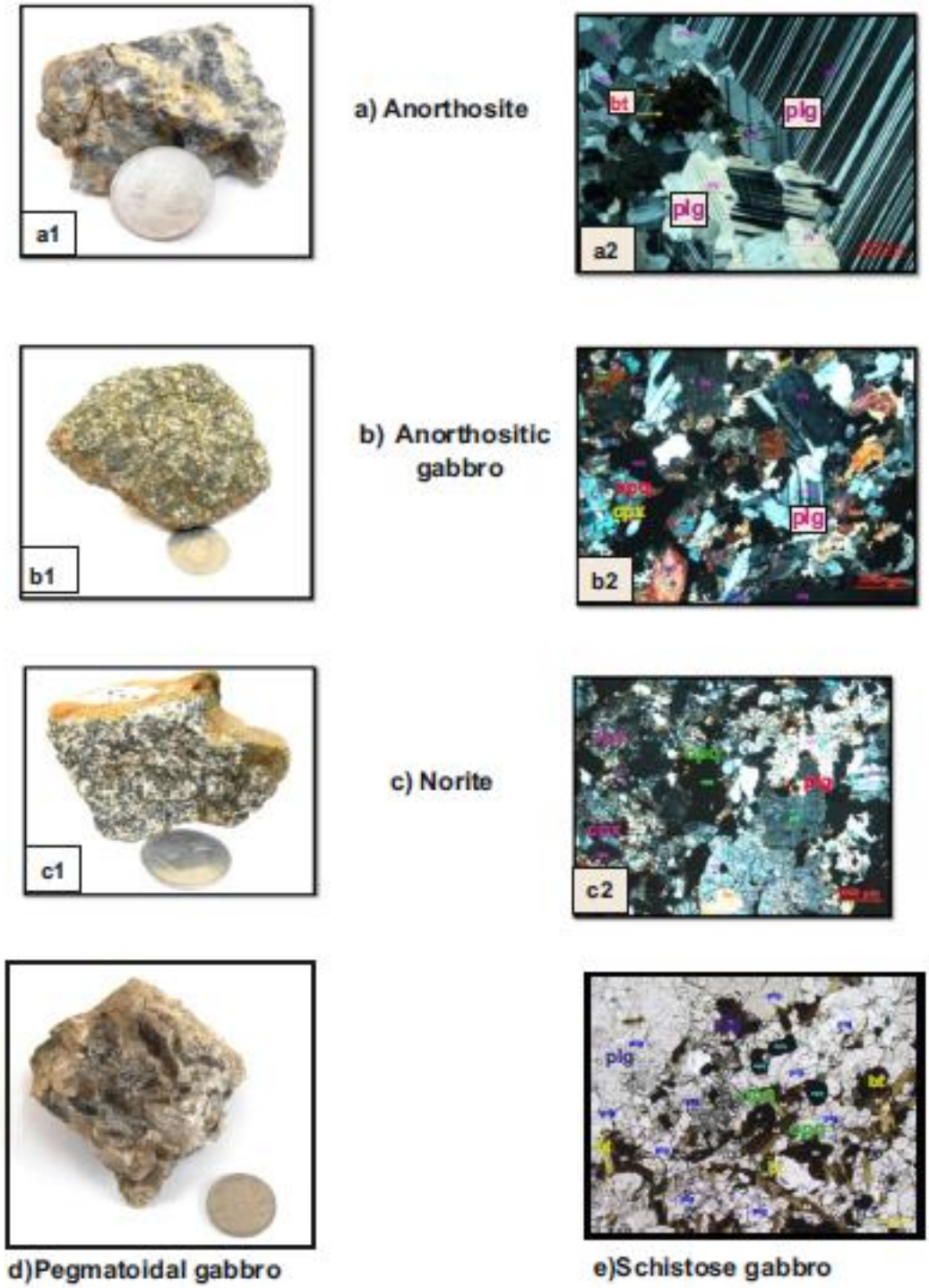

Fig. 5 Hand specimen photograph (left) and photomicrographs (right) of three types of layered gabbro-anorthosites

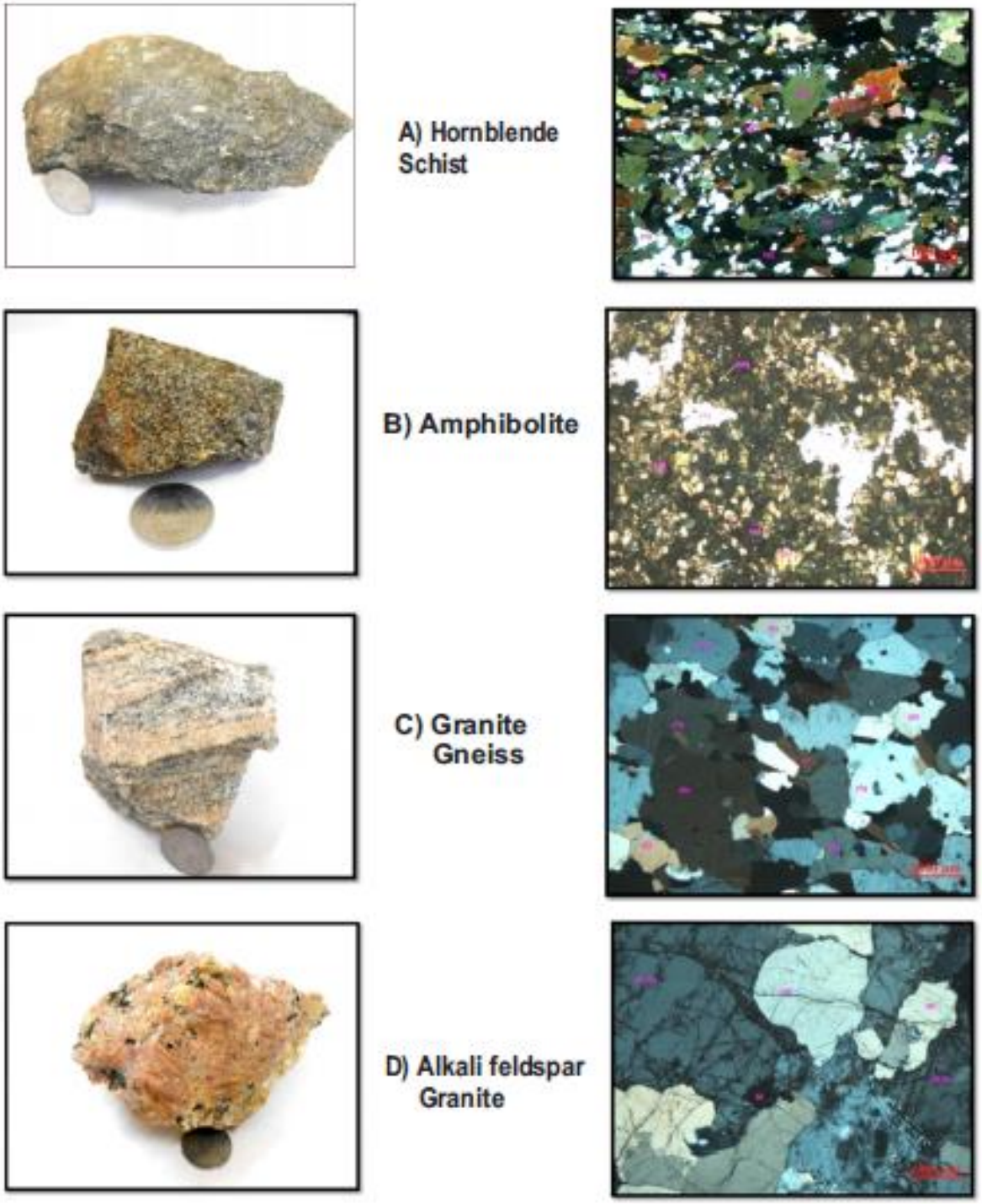

Fig.6 Handspemicen photographs (left hand panel) and photomicrographs (right hand panel) of country rocks.

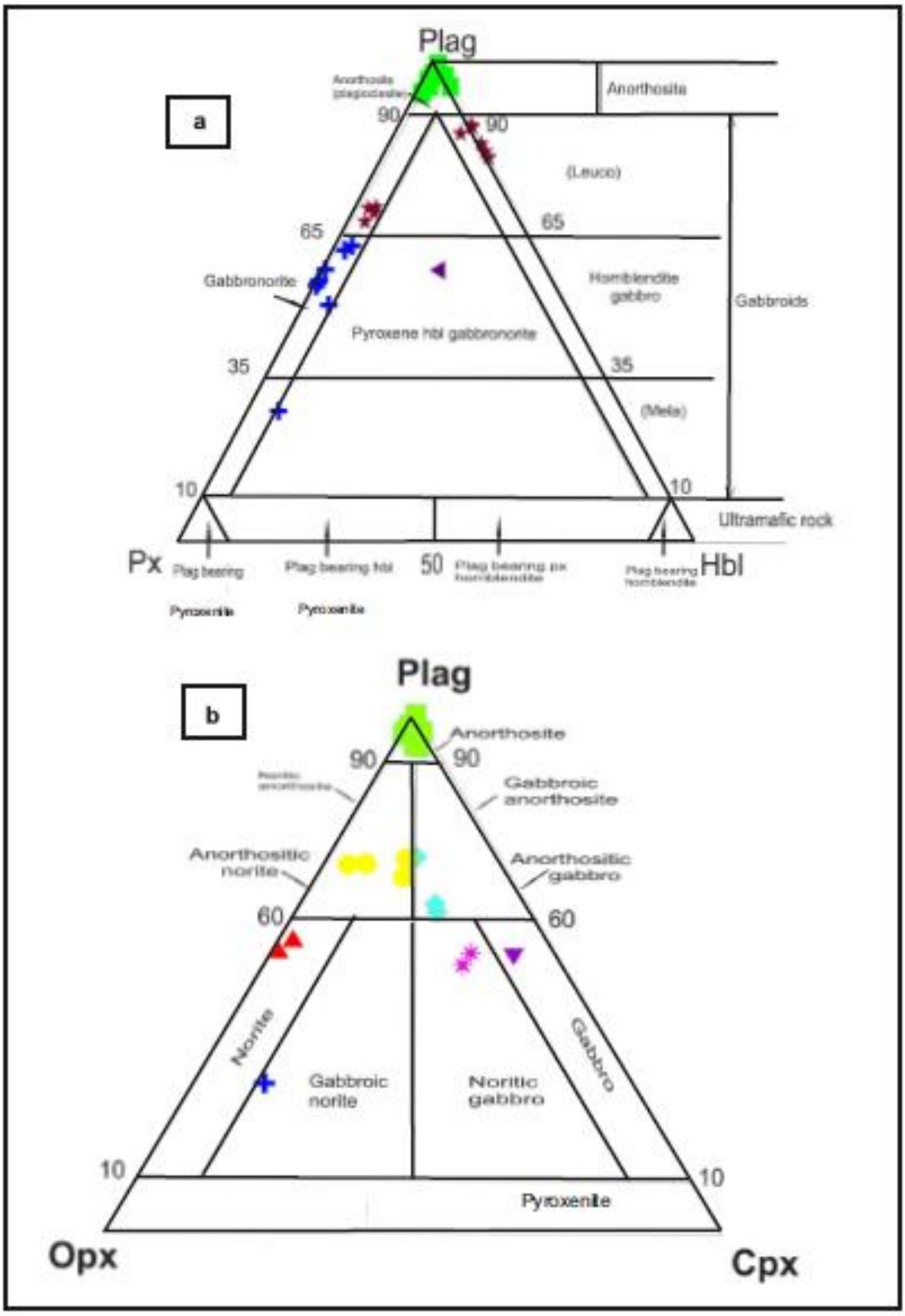

Fig.7a Plagioclase- pyroxene- hornblende triangular diagram (Streckeisen 1976)

7b Plagioclase- orthopyroxene-clinopyroxene triangular diagram (Streckeisen 1976)

4. Discussion:

The Southern Granulite Terrane (SGT) belongs to high grade granulite terrane of several crustal blocks and collisional shear zones in the Peninsular India. The country rock types in our study area are amphibolites, granite gneiss, hornblende schist, migmatites, and alkali feldspar granite mainly. As stated earlier with different three major rocks corresponded to different geological environment. The schistose gabbro-anorthosite variety appears to be the earlier phase of intrusion and suffered at least one set of deformation coeval to that of enclosing high grade country rock. The major dominant intrusive rock unit is layered gabbro-anorthosite with a number of petrographic variant corresponding to different conditions in magma chamber. The pegmatoidal gabbro-anorthosite represents the latest phase of inclusion corresponding to volatile enrichment condition. Based on the clear cut field character and petrography evidence of distinguishable types corresponds to early emplacements (schistose gabbro-anorthosite) while layered and pegmatoidal gabbro-anorthosite type marks a relatively quiet deformation free magmatic intrusion. It has been suggested that geological evolution of parental magma subsequently suffered early schistose variety of gabbro-anorthosite and high grade metamorphic country rocks and later or daughter magma products are deformation free layered and pegmatoidal varieties of gabbro-anorthosite rocks.

5. Conclusion:

Based on detailed petrography analysis and field relation studies following important conclusions can be drawn-

a) The Kadavur complex (10°35´N: 78°11´E) consists of three principal rock types which are i) early Schistose (deformed) gabbro-anorthosite ii) well-defined layered gabbro-anorthosite and iii) lensoid pegmatoidal gabbro-anorthosite.

b) The layered type has varied petrographic variants which are gabbro-norite, noritic-gabbro, gabbro, anorthositic norite, anorthosite, norite and anorthoitic gabbro, leucogabbro and rarely melagabbro and pyroxene hornblende gabbro norite.

c) The layered gabbro-anorthosite complex based on petrographic and field-relation maintained a magmatic regime throughout being controlled by appearance and disappearance of several constituent minerals and hydration ambience from core of complex to the margin**.**

The investigated area of SGT has been attempted to identify the litho-units of intrusive and country rocks. However, the geological relation between these rock types is not well

understood. So, it is important to establish mineralogy, tectonic-setting and age determination of various litho-types. The future studies are required to determine the above aspects to demonstrate the geological evolution of plate-tectonics.

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