CHAPTER X
GNEISSES AND GRANITES
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INTRODUCTION:

The gneisses and granites are also common associates of charnockites like meta-sediments. Different opinions have been expressed regarding their relationship to charnockites. Advocates of metamorphic origin believe that one is the modification of the other. Some consider charnockites to be modifications of gneisses and granites (Stillwell, 1918, Vredenberg, 1918, Groves, 1935, Ramberg, 1952 and Quensel, 1951), while others adduce evidences in favour of the formation of gneisses by modification of charnockites under middle or low amphibolite facies conditions (Sutton and Watson, 1951, Cowan, 1962).

In the Sivasamudram area gneisses and granites are the most abundant rock types. Observations made indicate that they are of the same age. They neither exhibit intrusive relationship between them nor with the charnockites. They have been largely formed by the breakdown and conversion of charnockites by migmatization and granitization under middle or low amphibolite facies conditions.
FIELD DISTRIBUTION:

(a) *Gneisses*: Between gneisses and granites, gneisses are the most extensively developed quartzofeldspathic rocks and occupy a total area of about 130 sq. kms. Good exposures are found in the Anthravallli hill \(^{2329}\), round about Agasanapura, around Gaudagere, north of Dabbahalli and west of Appagondanballi. These exposures resemble those of banded acid and intermediate charnockites.

(b) *Granites*: The only large exposure of granite is in the southern portion of the area where it occupies whole of the hill \(^{3131}\) (Kundur Betta). It also occurs as small ovoidal patches (not of mappable size) in gneisses of the central and northern region. The area covered by granites is about 5 sq. kms. Good exposures are found only in Kundur Betta \(^{3131}\).

Field Characters and Relationship

The gneisses are mostly fine to medium grained and well banded due to the presence of dark components in alternate layers. There the quartzofeldspathic veins, running parallel to banding occur in large number; the banding looks much accentuated. There is generally linear parallelism of minerals along the banding.
The granites are medium to coarse grained. The most common are massive, coarse to medium grained, and do not exhibit structures like banding, foliation and lineation.

The gneisses of the area are mainly biotite- and hornblende-bearing types which are migmatitic and show a rapid but gradational variation in colour, texture and mineral assemblage. The colour varies from white to grey and the texture from fine to coarse, often showing augens of felspar. The different varieties of gneisses are found often in intimate association with one another as parallel bands. They are always traversed by number of quartzofelspathic veins, which range in composition from pegmatite to granite and less commonly to an aplite. Generally these veins run parallel to the foliation but at places they transgress it. They are 5 to 6 cm in width and traceable along the strike for not more than 3 or 5 metres.

The granites of the area are mainly non-porphyritic and medium to coarse grained. The quartzofelspathic veins, which are very common in gneisses, are less frequent in granites; their colour varies from white to pink and they show a discordant relationship with the rude foliation of the granites.

Relation between Gneisses and Granites:

Except for the big outcrop of granite in the southern portion of the area, the other outcrops are very small.
and occur as patches and ovoidal outcrops in the gneisses. The contact between gneisses and granites is always gradational. At the contacts, the granites progressively lose their massive nature and becomes more or less gneissic and finally merge with the gneisses. This progressive variation can be seen in .2329'. Besides occurring as patches in gneisses, they also occur as thin veins a few centimetres thick, running parallel to the gneissosity. These features are well exposed in the Agasamapura quarry and along the Mullhalla river course (north of Dabbahalli).

PETROGRAPHY:

Gneisses and granites of the Sivasamudram area show considerable variation in the field and petrological characters. Though such variations are observed at many places, in a few localities, they are well seen, such exposures have been described in this account as types named after the localities.

1. Veined gneisses of the type occurring in the northern most part of the north eastern region, well exposed around Anthravalli hill — Anthravalli Type.

2. The strongly foliated and distinctly banded hornblende- and biotite-gneisses, well exposed in the
northern most part of the north western region, around Agasanapura and Gaudageeri villages — Agasanapura — Gaudageeri type.

3. The gneisses of the southern charnockite region, typically seen north of Dabhalli, Bevni and Manchanapura villages — Dabhalli—Bevni—Manchanapura type.

**ANHARVALLI TYPE**

The quarries located around Anharvalli in the northern region of the area provide the best exposures of veined gneiss. It is a medium grained grey gneiss traversed by numerous quartzofelspathic and granitic veins parallel to foliation. In thin section it shows xenomorphic granular texture and mainly consists of quartz, felspar, plagioclase and biotite, with accessory magnetite, apatite and zircon. Hornblende occasionally occurs. K-felspar is essentially microcline. It is perthitic; the blebs predominantly being of a string type. Quite often it carries inclusions of other minerals. It occurs as anhedral grains and commonly shows characteristic cross hatched twinning. Quartz sometimes forms shapeless grains as big as felspars but usually small anhedral grains occupying the interstices of felspar and blebs within it. It invariably shows undulose extinction and carries grey or dark brown dusty inclusions. Plagioclase
(An, 24-31%), abundance varies considerably, sometimes it is present almost to the exclusion of K-felspar and in others it is subordinate to it. It occurs as anhedral grains which are both twinned and untwinned and often antiperthitic. Reddish brown pleochroic variety of biotites occur as laths aligned parallel to banding. Green variety of hornblende occasionally occurs as prisms in intimate association with biotite. Garnet is a pink variety and occurs as anhedral grains. Granular magnetite, ilmenite and pyrite are mostly confined to the biotite rich portions. Apatite occurs as needles and slender prisms generally among felspars. Zircon is seen as rounded grains. A number of fracture planes are sometimes seen traversing the sections and in such cases there is development of secondary minerals like sericite, saussurite and calcite at the expense of felspar and chlorite from biotite all along the fracture planes.

2) AGASAHAPURA GAUDAGERE TYPE

This gneiss is migmatitic, very well banded and foliated, medium grained and white to greasy grey in colour.

In this section it shows xenomorphic granular texture and consists mainly of quartz, plagioclase, K-felspar, hornblende and biotite with accessory magnetite, apatite and zircon, and looks more similar to the veined gneisses,
described earlier, excepting that hornblende is more common and abundant than in the former. In texture it however, resembles the acid charnockites (diaphoretic) containing hornblende and biotite. Quartz occurs as either anhedral interstitial patches or grains or as blebs within the felspar, hornblende and biotite. The interstitial quartz often carries dusty and occasionally randomly arranged hair-like inclusions and shows distinct undulose extinction. The K-felspar is microcline showing typical cross-hatching and is perthitic. Plagioclase is often antiperthitic and has an anorthite content 24-27%. It is both twinned and untwinned. The twinning is faint, patchy, and sometimes distorted and is mostly after the albite and albite-ala laws. Plagioclase felspar occasionally contains oriented inclusions and shows replacement relationship with Myrmekite development at the borders of K-felspar, especially when it is in contact with plagioclase, (as mentioned previously). Green variety of hornblende occurs as prisms and patches. Biotite either forms edgings to hornblende or independent patches and flakes. Magnetite, apatite and zircon are present exhibiting the usual characters.

3) Dabbhalli-Hebbi-Manchanapura type

This type has less conspicuous banding and foliation than the previously described Agasanapura-Caudagere type.
It is coarse grained light greasy grey rock sometimes traversed by thin ramified veins of mylonites. In thin section it resembles the diaphanoretic acid charnockite in texture and freshness and differs from it only in the absence of hypersthene. A characteristic mineralogical feature of this type is the general predominance of plagioclase over K-felspar. The gneiss is essentially composed of quartz, plagioclase felspar, biotite, K-felspar and hornblende. Accessory magnetite, apatite and zircon are also present. Anhedral (occurs occasionally quartz as big patches but commonly as small grains occupying the interstices of other minerals. It shows undulose extinction and is characterised by dusty and less commonly by hair-like inclusions. Plagioclase (22-27%) is commonly twinned but the twin lamellae are faint and distorted. K-felspar is usually microcline-perthite and shows typical grating structure and occurs in small grains within the interstices of plagioclase, showing a replacement relationship with it. Myrmekite development, especially at the K-felspar borders, is rare. Biotite occurs in scales and tattered patches. It is usually more common than hornblende. If present hornblende is seen in elongated prisms associated with biotite. Magnetite associated with ilmenite, is usually seen as irregular granules. Apatite occurs as needles associated with felspars. Pale brown to colourless zircon occurs generally
in well rounded and more or less ovoid grains. Very subordinate amounts of pyroxene are also met with.

The modal analyses of all the three types are given in table XXV.

GRANITIC

The granite comprising the Kundur hill is the only large exposure of the area. It is massive, nonporphyritic, medium to coarse grained, pink or brown variety. The pink or brown colour is due only to the presence of abundant felspar of that colour. The section shows granitic texture (Plate XVIII, Fig. A) and chiefly consists of microcline quartz and plagioclase. Biotite occurs in subordinate amounts. Accessory magnetite and apatite also occur. Microcline forms large anhedral plates, showing invariably though sometimes uneven, cross-hatched twinning and carries inclusions of quartz and other minerals. It is usually perthitic with the blebs predominantly of the film type. Plagioclase (An. 28%), though subordinate to the k-felspar, is generally present in variable amounts. It is more altered than k-felspar and occurs in comparatively small plates, often replacing the former. The felspars are always clouded with brownish ferruginous dust, which is responsible for its brown colour. Quartz forms anhedral grains occupying the interstices. It carries brownish dusty inclusions. Myrmekite is observed at the
<table>
<thead>
<tr>
<th>Minerals</th>
<th>S.285</th>
<th>S.353</th>
<th>S.255</th>
<th>S.325</th>
<th>S.40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarts</td>
<td>17.63</td>
<td>27.60</td>
<td>30.98</td>
<td>15.20</td>
<td>30.14</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>30.77</td>
<td>60.00</td>
<td>52.58</td>
<td>33.53</td>
<td>46.90</td>
</tr>
<tr>
<td>K-felspar</td>
<td>20.00</td>
<td>-</td>
<td>3.00</td>
<td>20.00</td>
<td>12.67</td>
</tr>
<tr>
<td>Hornblende</td>
<td>6.00</td>
<td>-</td>
<td>-</td>
<td>8.43</td>
<td>8.00</td>
</tr>
<tr>
<td>Biotite</td>
<td>20.11</td>
<td>8.80</td>
<td>13.02</td>
<td>14.46</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>2.50</td>
<td>2.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iron ore</td>
<td>2.00</td>
<td>2.00</td>
<td>0.80</td>
<td>6.43</td>
<td>1.99</td>
</tr>
<tr>
<td>Apatite</td>
<td>1.00</td>
<td>0.80</td>
<td>0.70</td>
<td>1.50</td>
<td>0.90</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.80</td>
<td>-</td>
<td>0.50</td>
<td>0.20</td>
</tr>
<tr>
<td>Sp. Gr.</td>
<td>2.79</td>
<td>2.80</td>
<td>2.76</td>
<td>2.86</td>
<td>2.87</td>
</tr>
</tbody>
</table>

S.285 - Anthravalli type from Anthravalli
S.353 | Dabbahalli-Hebbni-Manchanpura type
S.255 |
S.325 | Agasampura-gudagere type
S.40  |
borders of K-felspar, especially where K-felspar is in contact with the plagioclase. Brown biotite forms thin scales and patches. Granular magnetite occurs as discrete or composite grains with ilmenite in intimate association with biotite. Apatite forms needles and granules. The modal composition of the granite is given in Table XXVI. The granite occurring as inclusions in gneisses possess the same mineralogical and petrological character as of the one described above.

MINERALOGY

The essential minerals of gneisses and granites are quartz, K-felspar, plagioclase, hornblende and biotite. Accessory minerals are magnetite, zircon, apatite and secondary minerals are chlorite and calcite. Garnet occurs locally. In the following account the characters of these minerals are described.

Quartz:

Next to felspars, quartz is the most abundant constituent of the gneisses and granites. It is colourless, yellowish white or grey in hand specimen. In thin section it is always fresh and colourless. It usually occurs in two forms, as anhedral patches of variable size and shape occupying the interstices of felspars and as rounded blebs in felspars and other minerals. The former type always shows marked undulose extinction (Plate XVIII, Fig. B)
Table XXVI

MODES OF GRANITE

<table>
<thead>
<tr>
<th>Minerals</th>
<th>S.240</th>
<th>S.241</th>
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</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>30.59</td>
<td>31.03</td>
</tr>
<tr>
<td>Quartz</td>
<td>19.75</td>
<td>24.10</td>
</tr>
<tr>
<td>Biotite</td>
<td>6.65</td>
<td>6.83</td>
</tr>
<tr>
<td>Potashfelspar</td>
<td>39.14</td>
<td>38.05</td>
</tr>
<tr>
<td>Iron ore</td>
<td>2.93</td>
<td>-</td>
</tr>
</tbody>
</table>

S.240 - From Kundur hill
S.241 - 3131', 1.5 kms. west of Dasandoddi.
and carries fine dusty inclusions and tiny inclusions of all associated minerals. In gneisses the quartz is elongated parallel to banding and foliation and undulose extinction is most prominent. Myrmekitic intergrowth of quartz and felspar is quite common, its development being characteristically restricted to the contacts between the grains of k-felspar and plagioclase and usually myrmekite bodies project from the plagioclase into k-felspar. As opined by many investigators, here also myrmekite is regarded as of replacement origin and as the result of replacement of one felspar by another.

Potash felspar

The K-felspar, though variable in abundance is always less frequent than the plagioclase in gneisses. In the gneisses of the chamockite region K-felspar is present in very subordinate amounts, not exceeding 2% of the mode, but in those of Anthravalli and Agasanapura-Gaudagere type it is almost as abundant as quartz and sometimes even more. In hand specimen it is impossible to distinguish K-felspar from plagioclase. It is white, pale yellowish white or of grey colour. In thin-section it is colourless, fresh, clear and occurs in anhedral plates of variable size; the size increasing with its abundance. When present as plates, it is sieved with quartz and other minerals. The K-felspar commonly shows cross-hatched twinning but untwinned ones are also not uncommon; the
the twinning being sometimes patchy and uneven. Another common feature is the perthitic nature of K-felspar. This is always seen whether or not the felspar shows cross-hatching. The development of perthitic texture is often patchy and uneven but the blebs are never seen cutting the boundaries. The perthitic bodies are mostly strings and stringlets and are commonly oriented parallel to (100) and (010) of the host.

In order to know the nature of untwinned and faintly twinned K-felspar grains, optic axial angles were determined on the 4-axes Universal stage. 35 grains of K-felspar from 15 sections of gneisses were studied to know the nature of the K-felspar which is untwinned and faintly twinned. All the grains had 2V values between 80° and 88° from which it is inferred that it is microcline.

In granites K-felspar is the abundant constituent. It occurs in the form of anhedral patches of pinkish to brown colour. In thin section it is colourless, but carries small inclusions of all the associated minerals and commonly quartz.

Most K-felspar grains of granites show cross-hatched twinning the 2V\_x being 78° to 86°. Untwinned grains are rare. Besides the K-felspars are commonly perthitic. As in the case of gneisses, in these rocks also the perthitic
development is patchy and uneven. The perthitic bodies are mostly stringlet and string type, oriented parallel to (100) and (010) plane of the host felspar. The abundant occurrence of microcline in the granites from various parts of Mysore State has also been reported by investigators like Suryanarayana (1957), D'orua (1959), Venugopal (1961) and Narasimhamurthy (1961).

**Plagioclase Felspar**

In gneisses plagioclase (24-31% An) is generally more abundant than potash felspar. In the gneisses of the charnockite region in particular it is sometimes present almost to the exclusion of K-felspar. In handspecimen it cannot be distinguished from associated K-felspar. Like the latter it shows whitish, yellowish white or light grey colour.

In thin section the plagioclase of gneiss looks very much like that of the intimately associated acid charnockite. It is usually fresh and clear but sometimes contains thin brown rod- and hair-like inclusions, probably ferriferrous, which are arranged in a regular manner. It is untwinned or shows faint, patchy and distorted twinning mostly according to the albite and albite ala laws (Table XXVII).

In the granites plagioclase is always a subordinate felspar. Like the associated K-felspar it shows pink,
### Table XXVII

**Anorthite Content, Twin Laws of Plagioclase Felspar of Gneisses and Granites**

<table>
<thead>
<tr>
<th>Varieties</th>
<th>An%</th>
<th>Albite Manebach</th>
<th>Manmbach-</th>
<th>Albite-Ala</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gneiss</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dabbehalli-Hebni-Manchanapura type:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite gneiss</td>
<td>24%-28%</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>26%-31%</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Biotite-garnet-gneiss</td>
<td>24%-26%</td>
<td>2</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Asagansapura-Gaudacere type:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornblende-gneiss</td>
<td>25%-28%</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Amthavalli type:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornblende-biotite-gneiss</td>
<td>24%-27%</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Granite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kundur type:</td>
<td>20%-24%</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Quartz-plagio-class-biotite-K-felspar</td>
<td>25%-26%</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>20%-31%</td>
<td>18</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>
white or grey colour. In thin section it occurs as anhedral plates of smaller size. It is quite fresh but sometimes shows saussuritisation. It is untwinned or twinned, showing faint and irregular twin lamellae. The anorthite content ranges from 20 to 26%. The twinning is mostly on the albite and albite-ala laws (Table XXVII).

Hornblende:
Hornblende is an important ferromagnesian mineral of the Anthravalli and Agasamapura-Gaudagere gneisses but is less common than biotite. In hand specimen it has black to dark green colour. In thin section it is fresh and shows dominant green colour and pleochroic with 

\[ X = \text{pale green}, \quad Y = \text{Yellowish green} \quad \text{and} \quad Z = \text{dark green}. \]

It has \( 2V_x = 64^\circ \), \( (\gamma - \alpha) = 0.025 \), \( (\gamma - \beta) = 0.008 \), \( (\beta - \alpha) = 0.017 \) and \( c \wedge z = 14^\circ \). It is completely absent in granites.

Biotite:
This is the most common ferromagnesian mineral in gneisses and granites. It is the concentration of biotite in separate thin layers that is mainly responsible for the banding and foliation of the gneisses. It is fresh, less chloritised and reddish brown variety with a strong pleochroism, \( X = \text{pale brownish yellow} \) and \( Y = Z \text{ reddish brown}. \) Biotite of granite is also reddish brown but often chloritised.
Irregular black opaque granules of magnetite of variable size are seen at times as composite grains with ilmenite and pyrite in all the gneisses and granite varieties.

Zircon:

Pale brown to colourless zircon is a scarce minor constituent. It occurs in thin section as small rounded ovoidal grains.

Apatite:

Apatite is rarely absent in gneisses and granites. It occurs usually as long colourless microscopic needles and as subhedral grains among felspar.

Secondary Minerals:

Blue green fibrous chlorite and patches of colourless calcite occur by the side of biotite having been formed from it.

Garnet is restricted to the Agasanapure, Dabhalili-Hebbni and Manchanapura types of gneisses. It occurs in small discrete anhedral grains which are dark pink in colour. It shows irregular cracks and alteration into chlorite along them.
PETROCHEMISTRY:

Chemical analyses of the main gneisses (nos. 5.325, S. 40, S. 265, S. 255) and granite (nos. S.240, S.241) varieties of the area along with C.I.P.W. norm, Niggli values and Niggli bases are presented in Tables XXVIII and XXIX respectively. A perusal of the tables reveals the close similarity between gneiss and acid charnockite (nos. S.255 and S.40) analyses. Pichamuthu (1965) interpreted this factor as evidence of an isochronal transformation of gneiss into charnockite, but as has already been mentioned, the observations of the present investigation have proved that it in the other way. The granites contain less of silica but more of iron and lime and are more close to the granodiorite in composition than granite proper. The two analyses are, however, closely comparable with those of the identical granite varieties of the Closepet area.
The origin of granitic rocks is rather controversial and extensively discussed. Many well known geologists have strived hard to find an acceptable solution ever since the granite problem was posed about 180 years ago. The work and literature on granites is piling up so quickly that it has become rather difficult to keep pace with it. Important contributions on different aspects of granites have been made by Sederholm (1923), Bramwell and Harwood (1932), Fabst (1928), Eskola (1933), Balk (1937), Backlund (1946), Macgregor and Wilson (1939), Rastall (1945), Reynolds (1946 and 1947), Read (1946, 1949), Bowen (1947), Buddington (1948, 1957), Perrin and Roubault (1949) and a host of other investigators. Excellent summaries of the views that have been expressed on the origin of granites are given by Read (1943, 1944 and 1957), Holmes (1945), Barth (1948) and Turner and Verhoogen (1960). Since the literature on the granite problem is very well known the author has not attempted to review it. However, as the granites and gneisses of the present area under investigation constitute an integral part of the gneisses and granites of Mysore State the author considers it pertinent to briefly review the views that have been expressed on the origin of granites and gneisses of
Mysore State in general. This will enable to see how far the views of author of this thesis tally with those of other investigators.

Review of the Views on the origin of gneisses and granites of Mysore:

The officers of State Geological Survey namely Smeeth (1916), Sampat Iyengar (1920), Jayaram (1912) and others differentiated the crystalline complex of Mysore as constituting four epochs of igneous intrusion; the oldest being 'Champion gneiss' and the next being the 'Peninsular gneiss', the third being 'Charnockites' and the youngest being 'Closepet granite'. This view was accepted for many years. Thus according to them the granites and gneisses of Sivasamudram area, constituted an integral part of the second and the final major epoch of granitic intrusions of Mysore.

Rama Rao has studied for several years the gneissic and granitic formations of Mysore and has published numerous research papers. In one of his recent papers (1964) he distinguishes only three epochs of granitic intrusion. The oldest among them, the Champion gneiss, has intruded the crystalline schists as laccoliths, within the period covered by the Dharwar system itself, and the other two, the Peninsular gneiss and Closepet granite, long after the formation of Dharwar and with pronounced
irruptive unconformity. According to him, the Peninsular gneiss "consists of a composite series of granitised rocks and intrusive granites of different types," and the Closepet granite, which also consists of several types "is believed to have intruded as a batholith though there are indications of granitization of some other rocks at certain places." Further he considered the charnockites "as of metamorphic origin resulting from reconstruction of earlier rocks of diverse composition and as such cannot represent any particular epoch of intrusion."

Radhakrishna (1956), who made a detailed investigation of the Closepet granite, concluded that it does not represent a separate igneous(Closepet) intrusion but that it is a replaced and modified portion of the older gneisses by metasomatic transformation through influx of alkali rich solutions along a regional belt of weakness.

Suryanarayana (1960) has given several field evidences to show that the Closepet granites have originated by the injection metamorphism of granitic liquids along the original stratification or schistose planes of the country rock, hornblende schists and the gneisses.

Babu (1960) has shown that the Chamundi granites are related to the Closepet granites. They are metamorphic in origin and the field evidences shows that they grade on to the Peninsular gneisses.
Research workers of the Karnataka University, namely D'cruz, Venugopal and Narasimha Murthy, working on some of the granitic areas of Mysore (a good summary of these investigations is given by Sadashivaiah, 1962) have opined that the gneisses and granites were formed by injection metamorphism and granitization of Dharwar metamorphites. "The early metamorphites granitized at higher energy levels under a deep burial gave rise to coarse grained and porphyritic granites.... Similar to eruptive granites." While those granitized at shallower depths and at lower energy levels got converted into gneissic granites, gneisses, migmatites and the associated rocks (Peninsular gneiss) and Sadashivaiah (op. cit.) based on the above investigation, considers that the porphyritic grey and pink granites of Mysore termed generally as "Closepet granites" may be called as the "Closepet granite facies" of the peninsular gneissic complex.

From the above it is very clear that almost all recent investigators have differed in their views from the earlier officers of the Mysore State geological survey and have adduced evidences in favour of a metamorphic and metamorphic origin of gneisses and granites and there is very often a tendency not to distinguish the Closepet granite as a separate granitic intrusion but to consider it as either a phase or as a modified product of the Peninsular gneiss.
Origin of the Sivagumudram Gneisses and Granites:

(a) Gneisses:

The following field, petrological, mineralogical and chemical characters must be taken into consideration before offering and interpretation on the genesis of these rocks.

1. Absence of intrusive characters and transgressive relationship and a general concordance between the regional trend of gneisses and the associated charnockites, granites and metasediments.

2. Intimate association and gradation into charnockites. It is important to know that even in the portions which are covered with gneiss there are thin clots, patches, lenses and pods of acid charnockites in various stages of their conversion into the surrounding gneiss.

3. Occurrence of thin, generally concordant, calcareous, ferruginous and siliceous metasedimentary intercalations similar to those found in charnockites.

4. Common occurrence of basic inclusions, with or without hypersthene, stretched parallel to the banding and foliation of gneisses, the contacts being sharp with a narrow transition zone. In this respect the gneisses again closely resemble the acid charnockites of the area.
5. The banded and foliated character of the gneisses.

6. There are the following progressive variations in the field characters of gneisses when traced from the southern charnockitic region to the northern granitic region of the area.

   a) Increase in the abundance of gneisses and decrease in the size and frequency of the charnockite patches.

   b) Increase in the degree of banding and foliation near the granite patches the banding becomes irregular and discontinuous.

   c) Increasing mobilisation and plastic deformation of xenoliths.

   d) Increasing proportion of granite material.

   e) Decrease in the proportion of basic charnockite inclusions and increase in the proportion of basic inclusions devoid of hypersthene.

7) Variation in the grain size and mineral assemblages along and across the banding of gneisses.

8) General freshness of the rocks in both hand specimen and in sections.
9) Occurrence of one mineral as an inclusion in the other.

10) Undulatory extinction of quartz and its occurrence in two generations.

11) The untwinned or patchy and faint twinned nature of plagioclase according to the albite and albite-albite laws.

12) The unzoned nature and frequent antiperthitic character of plagioclase.

13) Presence of myrmekite, especially at the borders of K-felspar.

14) Occurrence of well rounded and ovoidal zircon grains and absence of sphene.

15) Besides the above, the gneisses show the following progressive variation in petrological characters when they are traced from the southern charnockite region to the northern granitic region of the area.

   a) The gneisses, which resemble the disphthoretic acid charnockites in the southern region, get increasingly modified into light coloured typical biotite and hornblende gneisses when traced towards the northern portion of the area.
b) Increase in the quantity of K-felspar. The felspar of gneisses of the southern region is dominantly antiperthitic plagioclase like those of the associated disphathoretic acid charnockites, while the felspar of gneisses of the northern region is dominantly K-felspar.

c) The pyroxenes which are scarcely met within the gneisses of southern charnockitic region, disappear as the gneisses are traced towards the north and in the northern region they are restricted to thin clots and patches of charnockites, which are in the various stages of their conversion into the enclosing gneisses.

16) The close similarity in the chemical composition between the gneisses and the acid charnockites.

17) The younger age of the gneisses when compared to the charnockites of the area.

From the above mentioned field and petrological characters and radiometric age data, the following generalisations can be made on the genesis of the gneisses of the Sivasamudram area,

The gneisses are metamorphic and metasomatic rocks having been formed by the modification of the older charnockites by migmatization and granitization under low or middle amphibolite facies conditions.
The occasional occurrence of acid charnockite patches as inclusions in gneisses showing imperceptible gradation into the gneisses and close similarity or progressive variation in the field characters and petrology between the two amply favour the above conclusion.

The occurrence of hydroxyl minerals, like biotite and hornblende, in the gneisses indicate that water was widely prevalent in addition to lower temperature and pressure during their transformation by migmatization and granitization of charnockites.

The progressive increase in the degree of modification of charnockites and in the abundance of granitic components from south to north of the area suggests that migmatization and granitization has progressively advanced from north to south of the area.

From the above evidences, it is clear that the gneisses are metamorphic and metasomatic in origin formed by the granitization and migmatization of mostly charnockites. The charnockites were once far more extensively and widely distributed than they are at present. Some metasediments occurring in the gneisses not show evidences of transformation and remained as resistors due to their physical inconsistency and chemical impermeability.
A gneise-charnockite relation, similar to what the author of this thesis has noted in the Sivasamudram area, has been reported by Sutton and Watson (1951) from Secourie, Scotland and by Cooray (1962) from Ceylon and Devaraju (1967) from the Satnur-Halaguru area.

(b) **Granites:**

1) Absence of intrusive and transgressive relationship with associated rocks.

2) Occurrence as patches of variable size in the gneisses.

3) Gradual passage into the enclosing gneisses.

4) The rarity or absence of basic inclusions in the massive non-foliated granites.

5) The absence of metasedimentary inclusions.

6) The rarity or absence of acid charnockite inclusions.

7) Variation in the texture and mineral composition within the limits of a small portion of the outcrop.

8) The potash felspar present is the low temperature form namely, microcline. There are no evidences of its formation by the inversion of pre-existing orthoclase.
and this according to Warmo (1958) is characteristic feature of synkinematic or late-kinematic pre cambrian granites.

9) The occurrence of quartz in two generations.

10) The occurrence of unzoned plagioclase which is either untwinned or twinned showing faint or irregular twin lamellae chiefly according to albite and albite-ala laws.

11) The occurrence of plagioclase felspar showing the same anorthite content and twin laws as those found in the gneisses.

12) Presence of myrmekite at the border of felspar.

13) Frequent occurrence of well rounded and ovoidal grains of zircon.

14) The similarity of its chemical composition with those varieties of the type area namely, Closepet.

15) The same age of granites as that of gneiss of the area.

The above mentioned field and petrological evidences suggest that the granites must be regarded as metamorphic and metasomatic in origin, having been formed by the metasomatic transformation of the country rocks through the influx of granitising fluids.
The author believes that at no stage the granitic rocks of the area existed as a melt. Instead, they are products of granitization of pre-existing rocks, which have been felspathised to the extent of availability of the granitising fluids, in the form of emanations coming from below. These have brought about a series of replacements (Potash metasomatism and albitionisation) in the charnockites before converting them into rocks of granitic character. The various types of gneisses and granites of the area may be regarded as representing a succession of events which occurred in their formation. The types at present, have been arrested in their respective stages of relative development by the decline in the energy level of granitizing agents. The origin of gneisses and granites of the Sivasamudram area represent a chain of events and the gneisses are believed to have been formed a little earlier when the energy level of the granitizing fluids was slightly low and the granites a little later when the energy level of granitizing fluids was high.

The preservation of rude foliation and the occurrence of granite as numerous veins, penetrating the associated gneisses parallel to the foliation and banding indicate that the influx of the granitic liquids was not at a stretch a large scale event, and in a violent and forceful manner but took place along the foliation planes of the country rocks coverted them slowly under metasomatic
conditions into rocks of granitic character and ultimately leading to the formation of granites. This marked the last episode of the Archaean history of the Sivasamudram area and it was not responsible for the formation of charnockites as opined by Vredenberg (op. cit.) and Rama Rao (op. cit.).