Chapter IV

STRUCTURAL SETTING OF THE STUDY AREA
CHAPTER IV
STRUCTURAL STUDY OF THE STUDY AREA

4.1 INTRODUCTION:

This chapter deals on the detailed structural studies carried out by the author in the study area. Attur Valley is a physiographic expression of a major deep seated lineament, hence the name "Attur Valley Lineament"; named after a small town located in the eastern part of the lineament. This is considered as important lineament as it forms a part of the complex shear system which practically divides in Tamil Nadu into northern and southern blocks an observation based on physiography. Srinivasan (1974) considered the Attur Valley as a rift zone between Shevroy-Chitteri-Kalrayan and Kollaimalai-Pachamalai hill massifs. Drury and Holt (1980) interpreted Attur Valley lineament as a branch of their complex curvilinear shear system, which incorporates Moyar-Bhavani, Palghat-Cauvery and several other northerly trending lineaments.

Though the importance of Attur Valley lineament is widely known in Tamil Nadu Geology, no detailed work on how this lineament has affected the earlier lithologies, structure and associated features is
available. The earlier analyses were based on Landsat imagery and aerial photo-interpretations without any ground control (Grady, 1971; Srinivasan, 1974; Katz, 1978; and Drury and Holt, 1980). Seshanchavadi area preserves most of the earlier structures like folds, faults, shears and older minor features inspite of metamorphism and deformation, whereas the older structures in the Seshanchavadi area are largely modified, masked and even obliterated, possibly because of extensive igneous activity and attendant metasomatism.

The broad structural grain of the area of investigation is reflected by the alignment of ridges, hillocks and elongated mounds. This is the results of rheological properties of constituent lithotypes and differential weathering. Most of the pyroxene granulites and interbanded magnetite quartzites exhibit linear to arcuate arrangement reflecting the dominance of E-W trending fold episodes. Abrupt changes in alignment and division of certain ridges and mounds indicates faulting and dislocation.
FIG. 13.

Figure 11

(After S. Narayana swami, 1975)
4.2 EARLY WORK ON STRUCTURE:

The study of structural tectonism and metamorphism of the granulite terrain of South India has been undertaken by several geologists. To large extent our present knowledge of the petrology, tectonic setting, distribution of these rocks of Peninsular India is due to the work of the early pioneers. Among them may be mentioned Bruce Foote, King, Middlemiss, Walker, Vredenberg, Holland and others of the Geological Survey of India and Smith, Sampath Iyengar and Jayaram of Mysore Geological Department. Fermor, Krishnan, Rama Rao, Narayanaswami and Pichamuthu are the other geologist who have presented interpretations on the complex geological problems of his region.

NARAYANASWAMI (1975):

Narayanaswami (1975) modified the earlier views and opines that the charnockite and khondalite of the southern granulite terrain and Eastern Ghats represents the oldest stratigraphic units (Fig.11).
4.3 AERIAL PHOTO INTERPRETATION :

4.3.1 SUGAVANAM et al (1976 and 1978) :

The Geological Survey of India Officers did a commendable job, in organising a group discussion on granulite facies terrain during the year 1976. They presented two papers on,

1. "Geology and whole rock chemistry of granulites and

2. "Structure, tectonism, metamorphism, metasomatic activity and metallogeny in parts of northern Tamil Nadu".

Sugavanam et al (1978) have presented the various stages of structure, tectonics, metamorphism, magmatic activity and metallogeny in parts of northern in Tamil Nadu comprising North Arcot District. This paper introduces five periods of folding (Refer Table 1).

F<sub>1</sub> Folds

These are regional, longitudinal folds with their axial traces in NNE-SSW direction and are essentially isoclinal, asymmetrical in nature with steep westerly dipping axial planes and are composed of broad synforms with narrow tightly pressed antiforms.
Figure 12: Diagrams showing the sequence of evolution of folds in the Jutogh klippe.

(After Srikantia & Bhargava, 1984)
F₂ Folds:
Parallel to ENE-WSW low plunge in the direction of ENE. F₂ folds are generally kinks on the limbs of the longitudinal F₁ folds.

F₃ Folds:
Parallel to the direction of N-S with low plunge to south and very much restricted in their development and areal extent. Highly brecciated and mylonitic rocks constitute shear zones closely connected with F₃ deformation.

F₄ Folds:
It is parallel to WNW-ESE direction, it's impact on regional picture is more significant where its interference with earlier folds have resulted in the formation of structural basins and domes.

Similar structures have been explained by Srikantia and Bhargava (1984) where F₁ is a minor fold and reclined due to tectonic transport and F₂ and F₃ having formed after the emplacement of the thrust sheet. F₂ is the most pervasive structure and F₃ is the large cross-fold resulting in culminations and depressions of F₂ folds (Fig.12).
F₅ Folds

Parallel to NNE-SSW, i.e. co-axial with earlier F₁ Folds. F₅ folds are the youngest formation showing open shear folds of cataclastic nature. They are well developed over large areas forming prominent dextral enechelon folds on the limbs of earlier folds. Due to folded folds, magnetite quartzite and pyroxene granulite, are repeated as several parallel bands at Bagmarpettai (Sugavanam et al, 1978).

Sugavanam noted pyrite and pyrrhotite in several detached bands and lenses of pyroxene granulite which are closely associated with rocks of metasedimentary affinites, namely, magnetite-quartzites, sillimanite schist and graphite schist.

4.3.2 SRINIVASAN (1974)

Srinivasan (1974) attempted to unravel the geological structures in Attur Valley, Tamil Nadu based on aerial photographs, (Refer Fig.2). The inference from the azimuthal frequency diagram shows that E-W structural trends is more in Attur Valley in the areas north and south of Attur Valley. The two major E-W faults coincide with Vellar and Swetha nadi respectively.
Srinivasan concludes that:

1) The northern and southern hill masses of (Shevaroy-Chitteri-Kalrayan) and (Kollimalai, Pachaimalai) hills respectively have suffered upward movement. He believes that the preservation of metasediments in basin structures (Kanjamalai and Palaniyapuri basin etc.). In Attur and the major structure of steps found on the fault planes and the northerly overturned synclinal structure of Godumalai that rests on fault-slip and groove lineations present on the fault planes suggest an upward thrust movement.

The Attur Valley has suffered a minor eastward shift as suggested by the off-sets of dolerite and faults along these two faults. The E-W and NE-SW faults are perhaps responsible for the eastern Ghats developing into isolated hills unlike the continuous hill mass of the western Ghats. The NE-SW trends observed in the western Ghats are parallel to the oldest faults and dykes trending in NW-SE directions of this area indicating circumstantial relation. The chronological order of the fault systems are,

1. NW-SE
2. NE-SW and
3. E-W.
MAJOR LINEAMENTS AND THE INTRUSIVE COMPLEXES

(After V Srinivasan, 1977)
Figure 4. General tectonic map of the Precambrian of South India, Sri Lanka showing craton-mobile belt relations. In the craton the greenstone belts (dark) and the Closepet granite (crosses) are at high angles to the mobile belt boundaries. Younger rocks are shown in a stippled pattern. Scale 1: 12,000,000 (after Swami Nath and Karasuka Circle, 1974).

(Source M. B. Katz, 1978)
Legend

--- Lineaments

--- Charnockite massifs

--- Granite

--- State boundary

Figure 1E

INTERPRETATIVE TECTONIC MAP OF THE MOBILE BELT OF SOUTH INDIA BASED ON LANDSAT-1 IMAGERY. Scale 1:2,500,000.

(After M.B. Katz, 1978)
Srinivasan (1977) attempted the lineament map of Tamil Nadu and their relation of the intrusive complexes (Fig. 13). He observed that in the E-W fault zones, dunites are associated with pyroxenites and the pyroxenites are garnetiferous variety. This type of garnetiferous pyroxenite is not found in the ultrabasic complexes in the NW-SE and NE-SW fault zones.

4.4 REMOTE SENSING TECHNIQUES FOR STRUCTURAL STUDY:

4.4.1 Katz (1978)

The explanation for the regional tectonics of the Precambrian shield of South India by Katz (1978) is very interesting. Quartzites, garnet-sillimanite gneisses, marbles, diopside, scapolite, calciphyres with subsidiary iron-formation representing metasediments along with quartzo-feldspathic gneisses, amphibolites and hypersthene "charnockitic" gneisses of dubious origin comprised the Archaean granulite facies belt. In these ensialic linear belts lithologies can be traced for hundreds of kilometres along the strike and the belts appear to be bounded by major tectonic lineaments (Fig. 14). As these belts are fault-bounded, ensialic linear zones within an older migmatitic basement they may represent intercratonic, aulacogenes (Fig. 15). The structural, metamorphic and igneous events indicated for these belts also point to tectonic controls that consists of atleast two phases.
Figure 16: Diapiric-domal structural style of the oolitic ironstones.


(Source M.B. Katz, 1978)
Figure 17 Schematic evolution of high grade mobile belts from A) fundamental fracturing to B) tensional tectonic stage and the development of aulacogens to finally C) transform tectonic stage with internal secondary rifting and external large-scale rifting and spreading in the craton. Strain ellipses define structures in the mobile belt as a result of dextral simple shear. (after Katz, 1976c).

(Source M.B. Katz, 1978)
Figure 1B. Progressive dextral simple shear showing relationship of strain ellipse to the structural elements. A) Reference circle undergoing dextral simple shear on a vertical shear couple acting as mobile belt boundaries. B) Resulting strain ellipse with XZ horizontal and XY the vertical plane of flattening. Compressional structures are formed parallel to X, tensinal structures parallel to Z. Riedel (R) and conjugate Riedel (R') shears are also developed. C) En echelon structures are characteristic of simple shear deformation. (After Wilcox, Harding & Seely, 1973 and Eicher and Watterson, 1974). Note, drawings are not in perspective.

(Source M.B. Katz, 1978)
Figure 19. Aulacogens of South India – Sri Lanka. The northeast trending Highland belts, Madurai and Salem aulacogens and the northwest Kerala aulacogen and their boundary lineaments (Mh-Mahavelli River lineament, YG-Yanam lineament, Bound-Boundry lineament, Att-Attur lineament, Ko-Kolapatti fault, Bh-Dhavani lineament, Kb-Kabhani lineament). Dextral transform movement along these bounding lineaments converted the aulacogens into mobile belts. Charnockite formation was localized along en echelon lineaments and lineament intersections. Major transform movement in the mobile belt caused tensio nal conditions in the Dharwar cratonic causing rifting, spreading and emplacement of oceanic crust, the precursors of the greenstones. Tensional thermal axes (TTA) in the mobile belts coincide with pre-ore belts (Nuggihalli-NU, Kolar) or granites (Chinnagutta granite-CG) in the craton and granites within the mobile belt (Sankari granite-SG). Intersection of the TTA with the Dhavani lineament (Bh) are loci of carbonatites. Tectonic compilation based on Landsat-1 imagery. Scale 1:4,000,000 (after Katz, 1976c).

(Source: M.B. Katz, 1978)
1. Tensional tectonic stage (≥ 3000 m.y.) which led to the aulacogenes. The early structures were probably gravity influenced diapirs (Fig.16) and nappes with quasi-horizontal structural elements and,

2. Transform tectonic stage (≥ 2800 m.y.) which converted the aulacogenes into mobile belts (Fig.17).

In Fig.18, the progressive dextral simple shear with reference to a reference circle is shown. Enechelon structures are formed on the boundaries of the belt.

In South India, Katz recognised three sub belts on the basis of the positions of the original aulacogenes viz. Salem, Madurai and Kerala sub belts (Fig.19). In Sri Lanka the high land series sub belt is recognised, while the southwest group is considered as the southern extension of the Kerala sub-belt into Sri Lanka.

The sense of movement along the bounding lineament is dextral in regard to the NE trending Salem, Madurai (of India) and high land series of (Cylon) sub belts, and sinistral in regard to the Kerala sub-belts, as many of the structures within these belts are compatible with respectively clockwise and anticlockwise rotations. The overall folding style of most of South India shows a marked dextral vergence (Narayanaswami, 1959). However, in some cases, the high strain has rotated
Figure 20: Tectonic analysis of Landsat-1 imagery of the Nilgiris (NJ), Biligirirangan Hills (BG) and the Shevaroys (SH) of Tamil Nadu. Dextral movement on the bounding lineaments, the Kabbani (KB) and the Ilavani (IH) has developed a regional northeasterly foliation (fine lines) and fracture patterns (dark lines) which can be fitted into approximately oriented strain ellipses. The Moyar (MM) and the Attur Valley fault (AV) are considered as Riedel (R) shears developed from the Kabbani (KB) - Ilavani (IH) shear couple. (SG) Sankari granite. Scale 1:1,000,000.

Figure 21: Structural elements in the Attur Valley fault zone (AV, Fig. 20) en echelon fold axes, NNW dikes, NNW synclinal faults and resultant strain ellipse (inset) after Srinivasan (1974).

(After M.B. Katz, 1978)
the structural elements sub-parallel to the borders and the sense shearing is difficult to ascertain.

The tectonic analysis of Landsat Imagery of Salem sub-belt is given in the Fig.20. The northern Kabbani lineament (Kb) is enechelon to the penetrative Bhavani lineament (Bh) and between them lies the large charnockitic massif of the Nilgiri (NL) and Biligirirangan hills (BG). Dextral movement along these lineaments would cause a zone of tension in the intervening region with further crustal thinning and accompanying thermal highs and hot spots, leading to local high temperature resulting in charnockite metamorphism. A similar locale, between the Bhavani (Bh) and Shevaroys (SH) is occupied by charnockitic massifs. This dextral type shear deformation is apparent in the internal structure (Refer Fig.17). A major WNW Riedel shear along the Moyar river (Mo) developed from Kabbani lineament (KB), separates the Nilgiri from Biligirirangan hills and is compatible with a strain ellipse. With X oriented about 60° azimuth. This orientation is conformable the regional foliation (XY trace) and fits tensional direction (Z) of prominent NNW fractures found in the Nilgiris. A similar strain analysis for the Biligirirangan (BG) and the Shevaroys (SH) results in a strain ellipse
DEEP MAIN FAULTS IN TAMIL NADU
(After Grady, 1971.)

SCALE

0 10 20 30 40 km.
oriented with X at about $45^\circ$ azimuth, which fits the trend of the regional foliation and also accounts for a conjugate fracture system NNW and EW.

The Attur Valley fault zone (AV) (Not Attur lineament - Att) is another Riedel-type fault at low angles and in synthetic relationship to the penetrative Bhavani lineament (Bh), (Fig. 21). This fault zone separates the Shevaroys from the Kollaimalai, Pachaimalai in the South (Srinivasan, 1974). Structural elements within this zone are compatible with overall dextral simple shear.

4.4.2 **GRADY (1971):**

John C. Grady, a U.N. Photogeologist in the project for mineral development in India has identified "Deep main faults in South India using aerial photographs". He recognised several structural regions in South India for the first time as shown in Fig.22. A clear distinction between the Southern tectonic plateau and eastern Ghats, Nilgiris and Tamil Nadu hills were presented. His observations generated extensive work on the tectonics of South India.
Figure 23: Lineaments across Shevaroy-Chitteri-Kalmyan-Kollaimalai & Pachaimalai Hills (based on Landsat imagery interpretation)

(After K.S. Subramanian et al., 1979)
Figure 24: Vectors map of South India. Bold dot-dash line indicates the western limit of a positive Bouguer gravity anomaly (Kaila and Bhatia 1981). The mid-Proterozoic Cuddapah and Kaladgi basins are indicated by CB and KB; late-Proterozoic zones of high strain are: N.V. Nallamalai-Vellikonda; M.O. Mysur-Bharavani; M. Attur; P.Ca. Palghat-Cauvery; A. Achemov; lower case letters a-g are granulite masses referred to in the text: a—Coorg; b—Dilliranganan (D-R); c—Shervani; d—Nilvili; e—Kollimalai; f—Anaimalai; g—Palmi. The inset shows the main Archaean blocks in South India: EG—Eastern Ghats; NB—northern block; WSB—western sub-block; ESB—eastern sub-block; SB—southern block.

(After S.A. Drury et al, 1984)
Figure 2.5 sketch crustal section from north to south illustrating a model for late-Archaean crustal shortening and thickening in South India before the development of major transcurrent shear belts. The bold pecked line represents the depth of presently exposed rocks after crustal thickening, and indicates the large vertical displacements associated with the Moyar-Bhavani (M-B) and Palghat-Cauvery (P-C) shear zones. Stippled units are Archaean supracrustal rocks, black units represent possible tectonized relics of marginal basin crust and now eroded "ophiolites," crosses indicate the possible distribution of granulites. The sigmoidal crustal underthrusts associated with crustal thickening are based on Shackleton (1981) and Coward (1983). Abbreviations: SHIM—Shimoga; HPUR—Holenarsipur; MYS—Mysore; NIL—Nilgiri; AN—Anaimalais; KOD—Kodaikanal; AND—Andipatti (figs. 1, 2, and 3). Vertical and horizontal scale bars are 30 km.

(After S.A. Drury et al., 1984)
4.4.3 **SUBRAMANIAM et al (1979):**

Based on land form profile, lineaments and unsheared nature of the ultramafic emplacements (Chalk Hills in Salem District) traced within the gneisses-charnockite region the mega, minor and intermediate lineaments. It can be noticed that there is a paucity of lineaments in Salem-Attur Valley zone (Fig. 23).

4.4.4 **DRURY et al (1980, 1984):**

Landsat imagery interpretation work carried out by Drury et al (1984) is highly useful for getting an over view on granulite-gneissic terrain of South India (Fig. 24). The major Moyar lineament (M) is identified upto 20 km wide, 200 km long and appears to be major complex shear zone with an overall dextral movement. Fig. 25 shows a sketch of the crustal thickening in South India before the development of major shear belts according to Drury et al.

4.4.5 **JAYAKUMAR et al (1983):**

Using induced geomagnetic variation study, and correlating it with remote sensing data, Jayakumar et al (1983) presented a correlation between Precambrian tectonics and mineralization of Southern Peninsular
**Figure 26:** SKETCH OF SOUTHERN PENINSULA OF INDIA - SRILANKA BASED ON REMOTE SENSING TECHNIQUES

Autocogenes of Salem, Madurai, Kerala & Highland series & their boundary lineaments are shown.

**LEGEND**

- Permanent observatories
- Magnetometer array stations
- Induction vectors
- Graphite occurrences
- Suggested electric current directions

*(After D. JAYAKUMAR et al., 1983)*
Figure 2.7 BOUGUER ANOMALY MAP OF HIGH GRADE TERRAIN OF SOUTH INDIA

(Bouguer Anomaly Profile A A')

(After D.C. Mishra, 1988)
Figure 28 A simplified geological map of Tamilnadu - Kerala region.

(After Reddi A.G.B. et al., 1988)
India. Fig. 26 shows the permanent geomagnetic observation stations, magnetometer array station, induction vector, suggested electric current direction and graphite mineralisation. The anomalous geomagnetic variation has been attributed to tectonism and mineralization during the Precambrian period (Nityananda and Jayakumar, 1981).

4.4.6 MISHRA (1988):

Bouguer anomaly map presented in Fig. 27 of high-grade terrain of South India prepared by NGRI (1978) coincides for a considerable part with exposed charnockite. The northern gradient of Bouguer high coincides with Bhavani fault almost parallel to Palaghat-Trichy line which suggest its extension to a considerable depth.

4.4.7 REDDI et al (1988):

Aeromagnetic evidence of crustal structure in granulitic terrain of Tamil Nadu and Kerala show the Palghat-Tiruchirapalli region is down faulted suggesting a junction of profound structural dislocation between the granulite terrain and the Karnataka craton (Reddi et al., 1988). Fig. 28 shows a total intensity
magnetic map suggesting a deeper schematic layer and therefore the "Moho" by implications. The area seems to be composed of a mosaic of independent crustal block involved in a relative vertical movements.

4.4.8 GOPALAKRISHNAN et al (1990):

Pristine (very early) sutures in granulite-gneiss terrain of Tamil Nadu was demarcated by Gopalakrishnan et al (1990). They consider that the Tamil Nadu granulite-gneiss terrain consists of four petro-tectonic blocks or microplates namely,

1. Gudiyatham-Arakonam plate in the north,
2. Yercaud-Madras and
3. Dimbam-Krishnagiri microplates in the middle and
4. Trichy-Madurai microplate in the south.

Between Yercaud-Madras microplate, Gudiyatham-Bhavani suture zone is demarcated (Refer Fig.8). Similarly between Trichy-Madurai microplates and the DTK-YM plate in the north exists, Mettupalayam, Perambalur suture zone. Though they opines that supportive evidence for the suture zone are present in the form of
1. Remnants of oceanic crust with tectonic slices of probable ophiolite sequences.

2. Thrust slices and incorporation of marginal sequences of micro continents.

3. Shear zones with mylonitization

4. Collision or compressive mechanism manifested by high temperature, high pressure mineral assemblages, and

5. Later emplacement of alkaline and alkali carbonatite complexes along suture zones, more work needs to be done before accepting this hypothesis.

4.5 STRUCTURAL PATTERN OBSERVED IN THE STUDY AREA:

The various structural elements studied at Seshanchavadi area are brought out on the scale 1:50,000 in separate map of the above area (Fig. 29). During the course of the work, emphasis was mainly on recording the facts faithfully by tracing the details of fold patterns, faults and shear zones, trends of foliation etc.
FIG. 19 STRUCTURAL MAP OF THE STUDY AREA

LEGEND

- Strike and Dip of foliation
- Axial traces of major folds with plunge direction
- Axial traces of other folds
- Axial traces of minor folds
- Shear zones with dislocation
- Other shear zones
- Pyroxene granulite bands
- Banded magnetite quartzite
- Basia dykes

Scale 1:2
The various structural elements recognised in the study area and studied in detail by the author includes both penetrative linear and planar features like foliation, lineation, folds, faults, shear zones. Folds have played a dominant role in the evolution of the present structural set-up, hence maximum attention is given to bring out different episodes of folding their inter-relationship styles and interferences. Metamorphic and igneous and metasomatic activities associated with each deformational episode are recognised and account of the some are given separately. Despite multiple episodes of deformation metamorphism and igneous, metasomatic activities, several older lithologies and structures though modified are rather well preserved in the Seshanchavadi area.

4.5.1 **FOLIATION**:

Foliation in general is defined by either compositional layering or preferred orientation of phyllosilicate or prismatic and platy mineral grains.

Banded magnetite quartzites serve as the best example of compositional layering. They are made up of alternate bands of magnetite and quartz + garnet +
other mafics. Thickness of individual bands vary from less than a cm to more than 4 cm. Though these bandings are primarily sedimentary in nature the reconstitution and readjustment of different layers during metamorphism justify their being considered as foliation. The foliation in sillimanite quartzites and gneisses is due to preferred orientation of prismatic sillimanite and/or garnets and their alternation with quartz or quartz-feldspar association. Two pyroxene granulites of this area are generally well foliated as a result of linear arrangement of platy and lenticular minerals, alternating with granular mineral aggregates.

Charnockites and various types of older and younger gneisses show well developed foliations as a result of both compositional variation and preferred orientation of platy/planear minerals and their alternation. Though charnockites do not readily show foliation in a fresh surface, the same become pronounced on weathered surfaces. The foliation in gneisses is commonly marked by compositional banding and colour variation pegmatoidal granites and gneissic granites show distinct grain size variation and the occasional flakes of biotite/muscovite exhibit preferred orientation.
Foliation in general trends ENE-WSW to E-W with moderate to steep dips on either one of the sides throughout the study area. The reversal of dips often indicate folding of rock formations into series of antiforms and synforms. The general trends locally swerve of change abruptly due to folding / faulting. Striking changes from northeast of Seshanchavadi. Crudely developed secondary foliations (sometimes parallel to primary foliation) are noticed in the core region of the major synform, south of Seshanchavadi.

4.5.2 LINEATION:

Well developed groove lineations are recorded from a few places in Seshanchavadi area. They are found only in the hinge regions of major folds, commonly represented as closely spaced grooves rich in quartz often with a coat of muscovite flakes. Prominent axial plane groove lineations are found at the hinge region of broad folds within the garnet bearing quartzites around hill 4600.

4.5.3 FOLDS:

The detailed mapping of pyroxene granulite bands and associated banded magnetite quartzites, which are
utilized as marker horizons in Seshanchavadi area forms the basis for delineation of fold episodes. Based on detailed field studies of major and minor folds, interpretation of structural trends, fold geometry, orientation of fold axes and disposition of marker horizons, three different episodes of folding are delineated. A fourth episode was inferred on the basis of swerving of fold limbs and northeasterly stretching, but closer examination revealed that the stretching and dislocation conforms to the regional NE-SW trending shear zones, and therefore only three episodes of folding could be established. They are described as Fl, F2 and F3 episodes as follows.

4.5.3.1 Fl FOLDS:

The earliest folds in the area of investigation are represented by a set of tight isoclinal folds, showing highly varying trends. Major Fl fold axes are noticed only at a few places amidst complexly folded and interbanded pyroxene granulite and magnetite quartzites lithologies (such association of pyroxene granulite and magnetite quartzites is common to granulite terrain in Tamil Nadu). However minor Fl folds are common in almost all the rock types and show a reasonably good preservation.
Among the major and megascopic Fl folds, the simplest and easy to recognise folds are found in magnetite quartzite bands exposed along the ridge 2km west, and in the bands constituting the low mounds 3km north of Ponnarampatti. A discrete tight Fl folds along the ridge south of hill 4600 shows a inflated/extended hinge region.

The most important major Fl fold axis delineated is based on the convergence of a set of tightly folded pyroxene granulite bands traversing the western half of Seshanchavadi area. The original E-W trending Fl fold axis of the pyroxene granulite bands is rotated in different directions due to refolding.

A set of tightly folded, thin magnetite quartzites, interbanded with pyroxene granulites and refolded along ENE-WSW axes are located around the hill peak 4600, west of Ponnarampatti. Inter-relationship of these bands has been ambiguous due to extreme shearing and stretching at an angle to their trends. The other set of complexly folded close-knit magnetite quartzite bands enveloped in a major pyroxene granulite body occupying the mound 438 (NE of Seshanchavadi)
PLATE - VIII

Fig. 1 A gneissic charnockite showing F1 fold exposed near Ponnarampatti.

Fig. 2 Hornblende-biotite gneiss showing F2 folds west of Vellalakundam.
PLATE VIII

FIG-1

FIG-2
seems to have developed as a result of intensive lateral compression at varying angles during Fl fold episode. The gradual shallowing of dips of these quartzite bands towards the central part and their ultimate convergence could be the result of such a process. The same set of bands extends eastwards with a swerve to occupy a ridge north of Muttampatti. These bands have simpler inter-relationships.

Minor Fl folds are found at several localities in a variety of rock types. However, they are most common in magnetite quartzites. A majority of these banded magnetite quartzites show various pattern of tight isoclinal and open upright folds with greatly varying axial trends due to imposition of later folds. Minor tight folds in charnockites and pyroxene granulites become pronounced due to differential weathering, whereas these folds are distinct in gneisses, even in fresh surfaces due to compositional banding. Some well developed and excellently preserved Fl folds in charnockite could be seen in west of Seshanchavadi. (Plate VIII Fig.1)
4.5.3.2 F2 FOLD EPISODE:

In the Seshanchavadi area, F2 folds have almost E-W axial trends, thus they are almost co-axial with the earlier F1 folds.

F2 folds are well represented by the folded pyroxene granulite bands and associated magnetite quartzite bands, occupying the arcuate ridge south of Seshanchavadi and a set of four thin folded pyroxene granulite bands. Generally F2 folds are tight asymmetric folds south of Seshanchavadi show highly varying dips along their limbs and thus poses difficulty in designating them either as true synforms or antiforms. However the northern most E-W trending tight fold consisting of thin sub-parallel limbs and thickened hinge region clearly exhibits a synformal closure. Whereas its complimentary folds further southwards show highly varying steep dips in the hinge region and the pyroxene granulite bands in the limb region show frequent opposing dips. These aberrations could either be the result of interference of F1 with the co-axial F2 folds or the variation in dips could be attributed to later deformations.

The hinges of F2 antiformal and complimentary synformal folds in western sector show the development
of axial plane lineation with moderate easterly plunges, whereas the hinges of major F2 folds in the eastern parts are marked by intense shearing and brecciation which could be the result of late F2 shearing (Plate VIII Fig.2).

A look at the geological and structural maps of Seshanchavadi area shows that all the major F2 folds have varying degree of thickening and thinning, more as a result of intense shearing both along and across (E-W, NE-SW respectively) the general trends, rather than simple folding of rock formations. The extreme stretching of pyroxene granulite bodies, north and east of Vellalakundam and northeast of Seshanchavadi is due to shearing along different angles. The highly digitated, complex, thick body of pyroxene granulite full of enclave, east of Mudiyanur may also be related to F2 episode.

4.5.3.3 F3 FOLDS

F3 episode is the last phase of folding in the area. It is represented by broad open folds with NNW-SSE to NW-SE axes. They are very obvious along the E-W trending lithologies as broad cross folds.
In Seshanchavadi area these broad F3 folds could be seen as gentle warping of the major and minor pyroxene granulite bands, banded magnetite quartzite and sillimanite quartzite bands, and even the E-W to NE-SW trending dolerite dykes show warping along north westerly axes. The northwesterly trending F3 warps being cross folds on the dominant E-W trending earlier folds, they have affected almost all the lithologies, including charnockites.

The intensity of F3 folding could be estimated from the development of prominent axial plane groove lineations and a fracture pattern parallel to their axial trend well developed groove lineations are noticed along axial region of a broadly warped magnetite/ferruginous quartzite band in the northeastern Foot hill of mound 438 (NE of Seshanchavadi). The lineations trend N 40°W and plunge 40°. Similar lineation with NNW moderate plunge are noticed at the axial region of many broad warps in pyroxene granulite bodies. A few of the north-northwesterly trending major fractures are utilized for the emplacement of coarse grained dolerite dykes with sheared / chilled contacts. The large number of minor NNW-SSE fractures which the sites
Isoclinal assymmetrical F1 fold, kinks of limbs of F1 fold (F2 fold) is noticed in northern slope of Vellalakundam Reserve Forest.
PLATE IX

FIG. 1
retrogression of charnockite to biotite gneiss are also related to F3 deformation (Plate IX Fig. 1). The fractures served as channels for the fluids bringing about retrogression.

4.6 SHEAR ZONES / FAULTS:

Attur Valley has long been known as a zone of intense shearing and dislocations. It is traversed by several wide shear belts with its synthetic and antithetic fracture cutting across the whole rock formations in the area. Throughout the Seshanchavadi area, wide spread shearing and mylonitisation with attendant dislocations are noticed. The prominent shear zones are in E-W, NE-SW and NNW-SSE directions, among which are E-W and NE-SW are of intense nature, regional scale and possibly related shear zones, whereas the NNW-SSE set, though widely distributed are smallscale minor fractures.

The major shear zones / faults encountered in the study area investigated are given local names for easy recognition and convenience of description, and are described as follows :-

1. Mudiyanur shear zone
2. Singipuram shear zone
4.6.1 MUDIYANUR SHEAR ZONE:

A 5 km long zone of intense shearing and mylonitisation extending from northwest of Mudiyanur to hill 582 and further eastwards in a E-W direction is termed as Mudiyanur shear zone (after the name of nearby villages). The eastern end of this shear zone coalesce with NE-SW trending shear zone along Singipuram river, whereas its western end leads into the major Kammalapatti valley in the adjacent area. This shear zone could be traced along the strike of a prominent intimately interbanded sequence of sillimanite quartzite and banded magnetite quartzite and further eastwards into charnockitic country. These interbands of sillimanite quartzite are so thoroughly mixed up that one can get the gradation from magnetite quartzite to sillimanite quartzite as a result of intense shearing. A dolerite dyke is emplaced parallel to this shear zone from a point north of Mudiyanur, where feeder dyke cuts across the zone.
4.6.2 **SINGIPURAM SHEAR ZONE**:

This is a NE-SW trending narrow linear shear zone, the trend of which is followed by Singipuram Ar (river). It forms the southeastern boundary of Seshanchavadi area. It extends from south of Singipuram towards, SW for a distance of about 6 km. The north-easterly stretching of pyroxene granulite bands and other associated rocks in the vicinity of this shear zone is attributed to strong northeasterly movements.