CHAPTER III
PETROGRAPHY OF THE GRANITOIDS
3.1 INTRODUCTION

The present Chapter deals with the petrographic studies of the granitoid rocks of the study area. In this Chapter the optical studies of the rock forming minerals of granitoids and their related intergrowths have been discussed. Also the granitoid rocks of the area have been classified using various parameters.

3.2 CLASSIFICATION OF GRANITOID ROCKS OF LADAKH BATHOLITH

While classifying the granitic rocks, care has been taken to avoid the confusion and controversies that have crept into nomenclature of rocks as a result of rapid development in the descriptive petrography. The existing literature on the classification of igneous rocks (Johnsen, 1957; Streckeisen, 1967, 1974, 1976; Debon and Le Fort, 1983) has been consulted and the most commonly used classification of Streckeisen (1976) has been adopted using the recalculated percentage of quartz, potash feldspar and plagioclase in QAP triangular diagram.

The modal analyses of various members of the Ladakh batholith recognised in the study area are given in Table 2,3 and 4. The plotting of modal data in QAP diagram (Fig.5) suggest that the granitoid from the study area falls into the following types:

1. Quartz monzodiorite;
2. Granodiorite; and
3. Granite

Field studies and intrusive relationships of various phases of granites suggest that the granitic rocks of different ages fall in the same petrographic groups. This is evident from the fact that biotite porphyritic granite which is Permo-Triassic in age falls in the same fields of QAP diagram as the biotite granite and hornblende granite of Tertiary age. Therefore, in the forthcoming Chapters Streckeisen's classification given above has not been followed strictly and the granitic rocks of the study area have been grouped as
Type I, II and III based on their mineral composition, texture, field relationships and abundance.

Type I, hornblende rich granitic rocks developed as a small pluton near Chumathang lie along the extreme southern margin of the Ladakh batholith and has a faulted contact with grey red and green shales of Indus Flysch. The rock is dark in colour massive medium to coarse grained and non prophyritic in texture. It varies in composition from quartz monzodiorite to granodiorite.

Type II, biotite bearing rocks of granitic composition extensively developed between Trido to Gaik and further north of Chumathang. The apophysis and tongues of this granite intrude the porphyritic granite and hornblende granite, at Gaik and Chumathang respectively. The Type II granite is frequently traversed by aplitic and pegmatitic veins. Therefore, aplite and pegmatites associated with this biotite bearing granite have also been included in Type II granite.

Type III, biotite bearing porphyritic granite exposed near Gaik village and further continued towards west of Gaik. Porphyritic granite is also found as relict along the higher levels. This granite is massive in nature and porphyritic in characters. Biotite bearing granite (Type II) and their differentiates (aplitic and pegmatites) are intruded in this granite.

Table 2 - Modal Analysis of different types of granite
Type I (Hornblende bearing granitic rock)

<table>
<thead>
<tr>
<th></th>
<th>LKG 18</th>
<th>VKL 74</th>
<th>VKL 102</th>
<th>VKL 85</th>
<th>VKL 49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>18.96</td>
<td>4.09</td>
<td>11.43</td>
<td>4.09</td>
<td>18.50</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>49.76</td>
<td>52.85</td>
<td>60.79</td>
<td>45.51</td>
<td>42.50</td>
</tr>
<tr>
<td>Potash feldspar</td>
<td>21.14</td>
<td>12.30</td>
<td>10.98</td>
<td>5.36</td>
<td>20.70</td>
</tr>
<tr>
<td>Biotite</td>
<td>4.40</td>
<td>12.20</td>
<td>3.50</td>
<td>10.01</td>
<td>8.52</td>
</tr>
<tr>
<td>Hornblende</td>
<td>-</td>
<td>11.13</td>
<td>4.83</td>
<td>24.44</td>
<td>7.78</td>
</tr>
<tr>
<td>Clino-Pyroxene</td>
<td>-</td>
<td>3.31</td>
<td>1.10</td>
<td>5.82</td>
<td>-</td>
</tr>
<tr>
<td>Epidote</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.73</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>4.14</td>
<td>-</td>
<td>4.40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rest</td>
<td>1.60</td>
<td>4.03</td>
<td>2.97</td>
<td>3.04</td>
<td>2.00</td>
</tr>
</tbody>
</table>
Table 3: Modal analysis of biotite granite and aplite (Type II)

<table>
<thead>
<tr>
<th></th>
<th>VLK 48</th>
<th>VLK 14</th>
<th>VLK 86</th>
<th>VLK 63</th>
<th>VLK 0</th>
<th>VLK 67</th>
<th>VLK 8</th>
<th>VLK 50</th>
<th>LKG 44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>20.64</td>
<td>19.34</td>
<td>20.94</td>
<td>25.10</td>
<td>28.84</td>
<td>26.13</td>
<td>27.68</td>
<td>30.43</td>
<td>33.10</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>42.53</td>
<td>48.82</td>
<td>43.55</td>
<td>44.74</td>
<td>35.41</td>
<td>36.64</td>
<td>36.55</td>
<td>38.89</td>
<td>37.40</td>
</tr>
<tr>
<td>Potash Feldspar</td>
<td>25.99</td>
<td>25.54</td>
<td>13.02</td>
<td>12.13</td>
<td>23.63</td>
<td>25.91</td>
<td>29.69</td>
<td>25.97</td>
<td>23.82</td>
</tr>
<tr>
<td>Biotite</td>
<td>4.27</td>
<td>1.70</td>
<td>15.62</td>
<td>-</td>
<td>6.80</td>
<td>5.79</td>
<td>-</td>
<td>3.12</td>
<td>4.08</td>
</tr>
<tr>
<td>Hornblende</td>
<td>-</td>
<td>-</td>
<td>3.78</td>
<td>-</td>
<td>-</td>
<td>2.82</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>3.02</td>
<td>3.08</td>
<td>1.09</td>
<td>2.02</td>
<td>-</td>
<td>1.00</td>
<td>5.64</td>
<td>1.09</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.01</td>
<td>4.24</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rest</td>
<td>0.45</td>
<td>1.51</td>
<td>2.00</td>
<td>-</td>
<td>1.08</td>
<td>1.70</td>
<td>0.54</td>
<td>0.50</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Table 4: Modal analysis of biotite porphyritic granite (Type III)

<table>
<thead>
<tr>
<th></th>
<th>VLK 28</th>
<th>LKG 37</th>
<th>LKG 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>25.21</td>
<td>27.20</td>
<td>25.30</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>35.13</td>
<td>25.13</td>
<td>46.96</td>
</tr>
<tr>
<td>Potash Feldspar</td>
<td>29.64</td>
<td>37.81</td>
<td>20.91</td>
</tr>
<tr>
<td>Biotite</td>
<td>7.52</td>
<td>9.59</td>
<td>5.81</td>
</tr>
<tr>
<td>Hornblende</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rest</td>
<td>2.50</td>
<td>2.27</td>
<td>1.02</td>
</tr>
</tbody>
</table>
Fig. 5
Q-A-P Plots Of Ladakh Granitoids
(After Strekeisen, 1976)

3-Granite; 4-Granodiorite; 9-Quartz Monzodiorite
3.3 OPTICAL STUDIES OF GRANITOID ROCKS

A systematic examination of important characteristics of the rock forming minerals, common to all the members, has been carried out and the results are discussed below.

3.3.1 Quartz

Quartz is an important constituent of the Type I, II and III granites. The Type II and Type III granites have high content of quartz. In Type I quartz commonly occurs as colourless xenomorphic grains and shows first order polarization colours and wavy extinction (Pl.2d). In Type II and III granite, quartz occurs in association with potash feldspar and plagioclase. In general the grain size varies from 1.5 mm x 0.70 mm to 0.1 x 0.7 mm.

The stress undergone by different granitic rocks is registered by the quartz grains in the form of undulose and linear banded extinction. Quartz crystals shows sutured outline and at places has recrystallized in the interstices between grains of other minerals (Pl.2e). Under high magnification quartz shows inclusions of dusty opaque minerals, however no definite pattern of these inclusions in observed.

Three generations of quartz have been recognised; their distribution and morphological characters are given in Table 5.

a. Interstitial quartz (xenomorphic and poikilitic)

b. Recrystallized quartz and

c. Worm like blebs of quartz

The wide variation in the nature and mode of occurrence of quartz in the three types of granite is indicative of a long period of crystallization.

The occurrence of automorphic crystals with occasionally corroded margins or rounded blebs of quartz occuring as inclusion in large crystals of plagioclase (Pl.2f) indicate early crystallization at high temperature above 573°C (Mehner, 1968).
The interstitial quartz (xenomorphic) is mostly present in Type II and Type III granites. The textural relationship between this form and adjoining minerals (feldspar, etc.) indicates that this generation of quartz might have formed more or less simultaneous with crystallization of other mineral constituents.

The vermicular (worm-like) quartz closely associated with albite and orthoclase forms myrmekitic texture; such vermicular quartz indicates a late-low temperature crystallisation between preaqueous and post-aqueous phase (Hibbard, 1979). This type of quartz does not show sutured boundaries nor any effect of stress which further suggests that during crystallisation of quartz the whole material was in semiliquid or inliquid stage.

It may be concluded therefore from the above data that the three generations i.e. interstitial, recrystallized and worm like blebs of quartz have formed with falling temperature.

Table 5 Mode of occurrence of quartz in various types of granite

<table>
<thead>
<tr>
<th>Type I granite</th>
<th>Type II granite</th>
<th>Type III granite</th>
</tr>
</thead>
<tbody>
<tr>
<td>l. Xenomorphic quartz interstitially replacing the plagioclase and biotite. Extinction uniform.</td>
<td>i. Xenomorphic and poikilitic show wavy extinction sutured margin and replacing character.</td>
<td>i. Xenomorphic and poikilitic quartz irregular show deformation and undulose extinction.</td>
</tr>
<tr>
<td>ii. Recrystallised quartz found as clear grains without strain effect, show undulose extinction.</td>
<td>ii. Recrystallized quartz is less as compared to Type II and show banded extinction.</td>
<td></td>
</tr>
<tr>
<td>iii. Worm like blebs of quartz commonly associated with plagioclase and potash feldspar.</td>
<td>iii. Worm like blebs of quartz generally associated with albite.</td>
<td></td>
</tr>
</tbody>
</table>
3.2.2 Plagioclase

Plagioclase is the most common constituent widely distributed from Type I to Type III granite of Ladakh batholith. In composition it varies from albite to andesine. Commonly the crystals are subhedral to euhedral and they vary in size from 4.0 mm x 1.3 mm to 1.0 mm x 0.4 mm. Where the plagioclase is in contact with orthoclase or quartz it usually has its own crystal boundaries, since it crystallised before them, but where it lies against the ferromagnesiam minerals, the latter have better developed faces.

Plagioclase in Type I (granodiorite, quartz-monzodiorite) is dominant amongst the other constituents. The crystals are euhedral to subhedral in shape and they vary in size from 1.9 mm x 0.5 mm to 0.5 x 0.30 mm. Plagioclase laths show complex twinning and occasionally these twins are deformed and show microfractures (Pl.3a). The anorthosite content vary from An25 to An40. The crystal boundaries are sharp, rarely corroded and generally does not show albitic intergrowth. Few crystals of plagioclase are zoned with high An content in core. Some of the plagioclase laths at times show clouding due to dusty opaque inclusions. Besides, epidote, hornblende and rutile crystals have also been observed within plagioclase as inclusions.

Three generations of plagioclase have been recognised in the Type II granite (biotite granite-aplite). Those of the first generation are clouded and generally found as skeletal and rarely euhedral with corroded boundaries. It occurs as inclusions in the alkali feldspar and perthite. First generation plagioclase are very much altered i.e. sericitised, saussuritised with released calcite along cleavage and fractures (Pl.3b). The second generation plagioclase occur as euhedral phenocrysts. They are not much altered (Pl.3c); and show deformation of twin lamellalae. Orthoclase is found frequently as relict in crystals of oligoclase and vice-versa which indicates a more or less simultaneous crystallisation of alkali feldspar and plagioclase from the melt. Second generation plagioclase is also involved in myrmekitic intergrowth and in various types of perthite development.
The third generation plagioclase commonly occur as stringy, blebs and veins in association with earlier formed plagioclase and some times with alkali feldspar phenocrysts. This generation of plagioclase are albitic (An6–An9) in composition.

The plagioclase in Type III granite (Porphyritic granite) are bigger in size (about 7.5 mm x 5.5 to 5.00 mm x 3.50) and euhedral. They vary in composition from An12 to An28. Some of the plagioclase crystals are highly sericitised and saussuritised along the weak planes and occasionally rimmed by albitic intergrowth. The smaller crystals are colourless whereas the larger phenocrysts, at times, are characterised by inclusions of sericite, hornblende, biotite and apatite. Albitic twinning is common.

Thus it may be concluded from above study that the plagioclase in Type I, II and Type III granites of Ladakh batholith gradually changes in composition from Andesine (An40) to albite (An6), i.e. An 25-40 in Type I, An 10-30 in Type II, and An 12-28 in Type III. The change in the composition of the plagioclase within each type of granite is in the range of 15-20% An content.

**Twining in Plagioclase**

While the plagioclase in Type II (Biotite granite) show variety of twins such as polyscalepolysynthetic, albite, simple and complex or mechanical twins the Type I and Type III granite plagioclase show polysynthetic twins only, and that too rarely. The various twins noted in the plagioclase from the granititic rocks of Ladakh are shown in Fig.6.

The mechanical twining in plagioclase has a characteristic feature Fig.6b. The lamellae tend to curve and taper to a point. They form cluster and tend to be thicker and more numerous at grain boundaries. Such type of glide twins suggest a high stress during the origin (Vance, 1962). Other complex twins (Fig.6 e,c) matched with the Goari's (1951) proposed C twin which are connected with crystallisation of plagioclase from melt.
Camera Lucida Diagrams Of Twins In Plagioclase From
The Different Type Of Granite

Fig. 6
Clouding of Plagioclase

Plagioclase of Type I and Type II granite are more clouded in comparison to Type III granite. In clouded plagioclase, the following observations are made.

1. The calcic plagioclase are more cloudy;

2. The boundary between clouded and unclouded plagioclases do not show a change in An content;

3. In most of the cases the particles responsible for clouding are very minute and they could not be identified by optical microscope even at high magnification. A few particles which were identified are the minute grains of magnetite, ilmenite, sericite, biotite and hornblende;

4. The distribution of clouds vary from grain to grain; and

5. Clouding is also caused partially by the alteration of plagioclase (Pl.3d).

Several theories have been suggested by various workers for the genesis of plagioclase clouding (Groves, 1935; Shand 1945; Gilkey, 1954).

It is generally believed that the clouding is due to the presence of numerous minute dark particles distributed throughout the crystals such as magnetite, ilmenite, biotite rutile and hornblende and their alteration products.

Myrmekites in different types of granites

Myrmekitic intergrowth has been observed in most of the thin sections of the granitoids and an attempt has been made to correlate the myrmekitic intergrowth with the crystallisation and cooling of the granites of various types.

The myrmekite associated with Type II granite of the batholith
exhibit a plug like or a petal-shaped shape (Pl. 3e) and are seen either towards the marginal part of the megacrysts of perthite or around the crystal boundaries where they form a see-saw tooth pattern. The myrmekitic quartz is in the form of short cylinder, slightly curving vermicules, oriented tonon-oriented (Pl. 3f). The myrmekitic in Type III granite is different because the vermicules of quartz in this type show a definite pattern of growth behaviour. They either show a dendritic form, usually tree-like with a common trunk (Pl. 3e) or a multiple channel like form. The individual channel being long cylinder and uniformly traversing across the myrmekitic plagioclase.

Following observation on myrmekites have been made irrespective of different type of granite.

1. Generally the myrmekites are developed at the border to plagioclase and orthoclase crystals.

2. Myrmekitic overgrowth is more in biotite granite (Type II) and porphyritic granite (Type III) comparative to granodiorite, quartz-monozo-diorite (Type I).

3. Some of the crystals having myrmekitic growth are bounded by albitic (An6) rim.

4. Where the myrmekitic plagioclase is at the contact of K-feldspar the worm like quartz are seen projected into the K-feldspar.

5. The plagioclase involved with myrmekites vary in composition from An 15-25.

6. At places myrmekitic development is noted at the interface of perthite and plagioclase, with the convexity of myrmekitic pointing towards the perthite.

7. Myrmekite is totally enclosed in perthite without any connection with adjoining plagioclase and quartz.
In most of the cases cited above, the potash feldspar is invariably in association with the myrmekite except in some cases. Myrmekite enclosed in potash feldspar derives its two component i.e. plagioclase and quartz from the feldspar. The plagioclase involved in the myrmekitic intergrowth is acidic (An 15-25) and the composition of plagioclase blebs of perthite is almost the same as that of the coarse myrmekite.

An attempt has been made to examine these observations in the light of earlier works. Since the term myrmekite was first described by Sederholm (1916), two school of thoughts exists. The first school, replacement origin with two different views, one is replacement of potash feldspar by plagioclase Sederholm, 1916; Binns, 1966) and the other is the replacement of plagioclase by potash feldspar (Drescher-Kaden, 1948; Osterwald, 1955) for the release of quartz during the intergrowth formation. While the second school (Schwankte, 1909; Spencer, 1945; Ashworth, 1972) believes that the exsolution derive both the component of myrmekite, (plagioclase and quartz) which are held in solid solution in the form of albite and K-feldspar. The similar views has been supported by experimental work of Carman and Tuttle (1963).

Recently, Hibbard (1979) suggested a model for myrmekite development which is based on the textural relationship for the porphyritic granodiorites of Naveda. According to him the myrmekite results from micro pressure quenching during the separation of an aqueous phase crystallisation progress.

The occurrence of myrmekite as lobate units on plagioclase, extending into K-feldspar, results from precipitation of oligoclase as local continuations of plagioclase growth from a melt that simultaneously expels an aqueous-rich fluids enriched in K-feldspar component. Late K-feldspar crystallises from the aqueous rich fluids filling in around the myrmekite. Quartz in myrmekite represents the inability of silica to diffuse from the quenched melt and occurs as vermiculizers. Microscopic examination of the different types of development of myrmekite and their textural relation with other minerals indicate that the myrmekite in granites from the present area has been developed in the hydrothermal environment.
3.3.3 Alkali Feldspar

Alkali feldspar (perthite, orthoclase and microcline) are the important constituents of different types of granite. Alkali feldspar crystals occur as hypidiomorphic, xenomorphic and idiomorphic, and are of two generation: (a) early crystallised phenocrysts and (b) interstitial xenomorphic grains.

The early crystallised phenocrysts are mostly present in Type III granite. They are mostly orthoclase and perthite. Occasionally the small patches of microcline are also observed. The early phenocrysts show marked alteration, clouding and contain inclusion of plagioclase.

The second generation of potash feldspars occur as interstitial xenomorphic grains and are represented by orthoclase, microcline and perthite. This generation of alkali feldspar is mostly associated with Type II granite while the Type I granite is very poor in potash feldspar.

Microcline found only in few sections show rarely euhedral laths which show cross hatched twinning and some times perthitic texture. The intensity of cross-hatched twinning in poor and varies some times within a single grain (Pl.4a and 4b).

The orthoclase is colourless and sometimes show development of imperfect cleavage. Extinction angle varies from 5° to 10°. The orthoclase present in Type I granite is altered and clouded. Commonly, the alkali feldspar crystals of Type II and Type III granite show carlsbad twinning (Pl.4c). The twinning has been studied in detail by several workers and divergent views have been put forward regarding its origin (Boggild, 1911; Reinhard and Bachlin, 1936; Laves, 1950, 1954; Smith, 1974). While supporting the views of Laves, Barth (1969) suggested that most of the twinned microcline grains in granites, gneisses and crystalline schists are due to the inversion from orthoclase. It is stable at a relatively lower temperature than orthoclase. Therefore occurrence of microcline in biotite granite, aplite and pegmatite (Type II) and porphyritic granite (Type III) indicates comparatively lower temperature of crystallisation of the rocks in comparison to the hornblende.
granite (Type I) which is devoid of microcline.

Potash feldspars in Type II and Type III granites are characterised by perthite intergrowth. This type of intergrowth is dominant in orthoclase whereas, the perthite associated with microcline was observed rarely. Perthites have been classified using the textural properties (Andersen, 1928; Barth, 1969) such as hair perthite, film perthite, stringe perthite and bleb perthite.

Two generations of perthitic intergrowths have been clearly recognised in some of the alkali feldspar phenocrysts (Pl.4d,e). The first generation albite laths occur as hairs, and stringe type and follow the cleavages and other weak planes while the second generation perthites in the form of blebs are superimposed on first generation with acute angle (Pl.4d,e). The second generation albite laths vary in composition from An 15-20 whereas, the composition of first generation albic lamellae and the overgrown rims around oligoclase in An 6-9. The compositional similarity in the latter indicates that the two might have originated from the same solution simultaneously.

Perthites are considered to be the result of exsolution of sodic phase from the homogenous soda-potash feldspar (Spencer, 1937, 1938; Barth, 1969; Smith, 1974; Yund and Ackerman, 1979; Yund et al., 1980). On the other hand, replacement origin for perthite has also been proposed by several workers (Anderson, 1928; Rosenquist, 1950; Robertson, 1959).

Perthites in the rocks of present area show uniformity in their shape and size within an individual grain. The lamellae show definite orientation and do not extend from margins to the centres of the grains. These characters of the perthites point to their origin by exsolution of sodic component originally present in solid solution in potash feldspar.

3.3.4 Hornblende

Hornblende is the most common mineral in the Type I granite (hornblende granite) although occasionally it is observed in Type II granite also.
Hornblende crystals vary from 2.00 mm to .55 in length and 0.1 mm to 0.05 mm in width and show green, grey to bluish green colour, high refractive index and two sets of amphibolite (prismatic) cleavages (Pl.4c). The mineral is strongly pleochroic from pale green to green or bluish green and shows 12-20° extinction angle. Sometimes it shows alterations to green biotite with structural continuity. The presence of plagioclase and quartz inclusions in the hornblende forms a sieve structure.

3.3.5 Muscovite

Muscovite is a subordinate constituent of Type II granite (Biotite granite, aplite and pegmatite). It has at times formed by the alteration of biotite while muscovite associated with pegmatite has developed due to late hydrothermal fluids. Besides the large flakes small flakes are also observed. Muscovite as inclusion and along cleavage planes is also found in plagioclase. Some of the muscovite flakes are bent which suggest deformation of the rock.

3.3.6 Biotite

Biotite is a common mineral in all the three types granites, though it is absent in a few individual varieties, i.e. aplite, etc. Biotite in Type III granite shows greenish brown to light brown pleochroism whereas in Type I and Type II it is brownish grey to light green. The above difference in the colour of the biotite is attributed to differences in the ratios of ferrous to ferric iron and titanium (Hall, 1941; Hayama, 1959; Marini, 1971). The brownish colour in biotite is suggested to be due to the presence of ferrous iron (Harker, 1932). Barth (1936) suggested the increase of FeO causes the reddish colour in biotite. However, Hall (1941) suggested that the red colour in biotite is due to the excess of MgO in presence of TiO2.

Alteration of biotite into clear muscovite and bluish green chlorite is quite common (Pl.4f). The observed alteration of biotite in later formed bodies (Type II granite and pegmatite) may be due to hydrothermal solutions at moderate temperature and pressure (Schwartz, 1958).
In various thin sections the flakes of biotite, and muscovite are bent which also suggests the effect of deformation (Pl.5a). Seived structures are also observed. Inclusion of various minerals such as zircon, apatite, sphene, magnetite are commonly seen in biotite.

3.3.7 Accessory Minerals

Zircon, apatite, sphene and magnetite are the main accessory Minerals in Type I, II and Type III granites of the Ladakh batholith. Beside, chlorite and epidote are the common secondary minerals in Type II, III and Type I granite respectively.

Zircon occur as euhedral zoned crystal with well developed faces and is characterised by high relief and strong birefringence, straight extinction under polarised light. It mostly occur as inclusion in biotite and hornblende.

Apatite shows well developed faces in euhedral form and is commonly embedded in biotite laths. It is easily distinguished by high relief, straight extinction in prismatic sections and grey interference colour. Small grains of apatite occur as inclusions in biotite.

Sphene occurs as euhedral crystal and presents acute rhombic cross sections. It is observed in abundance in Type I granite in comparison to Type II and Type III (Pl.5b).

Calcite, rutile, ilmenite are some of the minor constituents present in studied granitoid rocks.

To sum up from the above, the quartz present in different types of rocks is underformed to deformed. The feldspar indicates a high temperature for the formation of these rocks. The zoning and twinning in feldspar of Type I granite clearly suggest that the rock formed from a melt during its rise in an orogenic belt where pressure and temperature fluctuations were common. Also, the presence of hornblende indicates a hydrous nature of magma during crystallisation.