CHAPTER - III

PETROGRAPHIC DESCRIPTIONS

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The Bundelkhand granitoids are composed of quartz, plagioclase, K-feldspars and biotite; pyroxene is absent. All the granitoids are one-mica granitoid. Hornblende is present only in the two older varieties i.e. hornblende granitoid and as traces in biotite granitoid. Apatite, zircon, sphene and magnetite are common accessories. The alteration is very limited; the secondary minerals are represented by chlorite, epidote and sericite. Alteration of plagioclase has often been preferential along certain twin lamellae possibly having greater penetrability, whereas other twin lamellae do not suffer any alteration at all. Petrographic evidence indicate early crystallization of hornblende and biotite.

Petrographic studies of the different types of granitoid and mafic magmatic enclaves were carried out in detail. Fiftyfour thin sections representing different types of granitoid were studied to determine modal composition of the granitoids. The thin sections were staind for K-feldspars to differentiate them from untwinned plagioclase. The uncovered thin sections were etched by hydrofluoric acid vapour and then dipped into freshly prepared saturated solution of sodium cobaltinitrite. Consequently, K-feldspars stained yellow making it easy to distinguish them from untwinned plagioclase. Point count method of Chayes (1956) was employed to estimate modal composition of the granitoids. The number of points counted for modal analysis varied from 1200 to 1500 depending on the texture of the rock.

The different types of granitoid generally have similar mineralogy; however, the difference in relative proportion of various phases

is observed The modal composition of the granitoids are presented in Table 2 The older hornblende granitoid and biotite granitoid have higher modal proportion of ferromagnesian minerals and plagioclase In younger leucogranitoid, ferromagnesian constitutents are negligible, hornblende is totally absent, whereas biotite is rare or occurs as traces The content of K-feldspar and quartz concomitantly increases in leucogranitoid Magnetite, when present, occurs generally in association with hornblende and biotite.

Modal Analysis

The modal values of quartz (Q), alkali feldspar (A) and plagioclase (P) of the granitoids were plotted on the IUGS (modal) classification scheme (Fig 18) of Le Maitre et al. (1989). The granitoids cover a large compositional spectrum from quartz diorite through quartz monzodiorite, granodiorite, monzogranite, syenogranite to alkali-feldspar granite. The hornblende granitoids are restricted to quartz diorite and quartz monzodiorite fields, whereas biotite granitoids are concentrated within tonalite and monzogranite fields, the leucogranitoids are clustered within monzogranite and syenogranite fields The granitoids define a calc-alkaline granodiorite (medium-K) trend (Lameyre and Bowden, 1982) on QAP diagram

Hornblende Granitoid

It is a dark coloured medium grained rock having a hypidiomorphic granular texture The rock contains on the average 15% modal hornblende which is often associated with biotite and magnetite Well developed euhedral hornblendes are often partly or fully enclosed within biotite suggesting an earlier crystallization of

Table - 2. Modal Compositions of Bundelkhand granitoids

	Hornblende Granitoids (12 samples)		Biotite Granitoids (21 samples)		Leucogranitoids (21 samples)	
Mineral (mode %)	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**
Quartz	6-19	12	20-38	33	36-49	41
Plagioclase	42-75	66	29-41	37	20-31	28
K-feldspar	3-11	6	19-32	22	31-50	39
Biotite	4-10	7	7-15	12	0.01-0.06	0.04
Hornblende	16-19	15	0.94-3	2	nil	nil
Sphene	0.4-0.8	0.7	0.5-07	0.5	0.003-0.004	0.002
Apatite	0.2-0.7	0.5	0.1-0.4	0.2	0.001-0.003	0.002
Magnetite	0.8-2	0.9	0.3-0.9	0.9	0.01-0.02	0.02
Zircon	0.00-0.68	0.32	0.00-0.53	0.47	0.00-0.49	0.43
Chlorite	0.01-0.5	0.2	0.7-0.8	0.03	0.01-0.08	0.05
Epidote	0.01-0.2	0.001	0.5-0.7	0.2	0.5-0.6	0.5

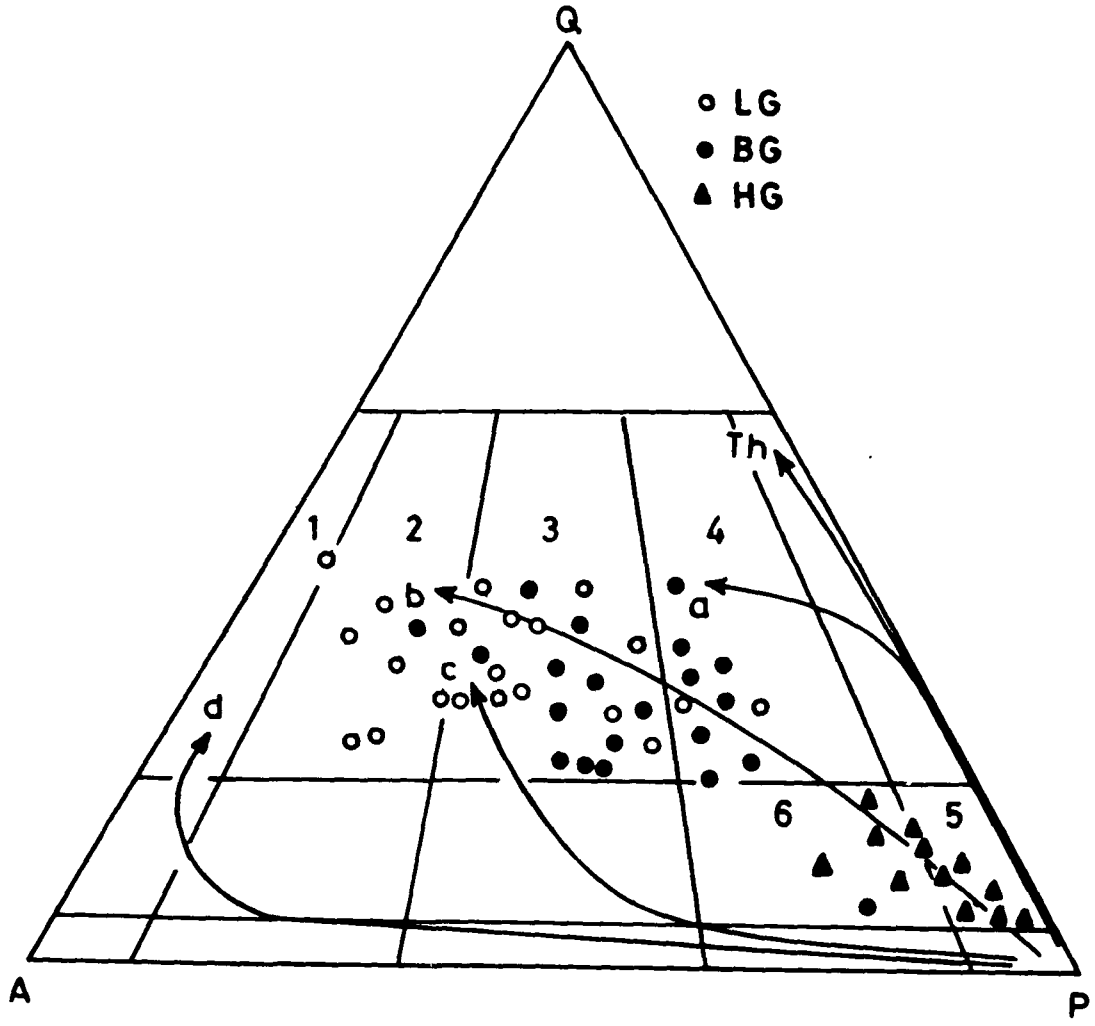

Fig. 18 : The IUGS (modal) classification scheme (Le Maitre et al., 1989) of Bundelkhand granitoids. Fields : 1 alkali feldspar granite, 2 syenogranite, 3 monzogranite, 4 granodiorite, 5 quartz diorite, 6 quartz monzodiorite. Trends : a calc-alkaline trondhjemite (low-K), b clac-alkaline granodiorite (medium-K), c calc-alkaline monzonite (high-K), d alkaline, Th tholeiite (Lameyre and Bowden, 1982). Symbols : HG hornblende granitoids, BG biotite granitoids, LG leucogranitoids.

hornblende than biotite. The hornblende crystals are distributed regularly and evenly within HG. These features indicate that hornblende is a primary phase.

Plagioclase (An_{10} to An_{17}), subhedral to euhedral in shape, is the dominant phase constituting about 66% of the rock. The plagioclase crystals are commonly zoned; the calcic core is altered to sericite in varying degrees, the secondary epidote is sometimes observed in the core. The altered core is mantled by unaltered sodic plagioclase. Sometimes sericitization is present only along certain twin lamellae(Fig. 19) indicating selected alteration.

Quartz makes up only 12% of the rock on average. It occurs both as discrete and as interstitial grains. A large number of quartz show undulose extinction. Intergrowth of quartz with K-feldspar is also observed (Fig. 20). Biotite is subhedral and generally occurs in association with hornblende. Biotite constitutes about 7% of the rock by volume. Chlorite occurs as a common alteration product of biotite. Euhedral sphene (Fig. 21) and magnetite are enclosed within K-feldspar minerals indicating the precipitation of these minerals before K-feldspar from the melt.

Biotite Granitoid

The biotite granitoid rocks are commonly medium granined and porphyritic having large phenocrysts of K-feldspar ranging in size from 1.2 to 4.00 mm in length. K-feldspar generally perthitic (Fig. 22), constitutes about 22% of the rock. The intergrowth pattern of perthite indicates an exsolution origin of the perthites. This, in turn, may suggest hypersolvous crystallization of the K-feldspars.

Fig. 19 : Photomicrograph to show limited alternation (→) of plagioclase. Crossed nicols. Enlargement 42 x.

Fig. 20 : Photomicrograph of intergrowth of quartz (Q) and K-feldspar (K). Crossed micols. Enlargement 70 x.

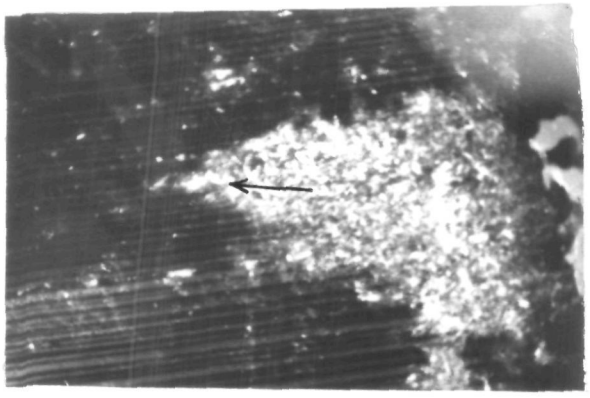

Fig. 19

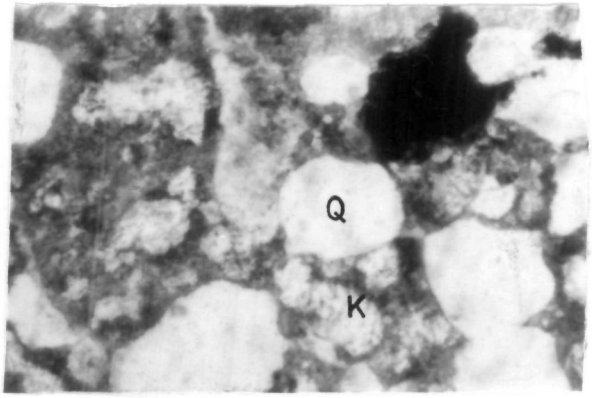

Fig. 20

Biotite is pleochroic from dark brown to very pale brown. It constitutes about 12% of the rock by volume. Apatite and zircon occur as euhedral to subhedral inclusions in biotite indicating an earlier crystallization of these accessory phases from the melt. Biotite shows occasional bending which may have resulted as a consequence of post-crystallization deformation. Zircon mainly occurs as inclusion in biotite and forms pleochroic haloes (Fig. 23).

The average modal concentration of plagioclase is 37%; the An-content varies from An_8 to An_{15}. It occurs in various forms, as inclusions in K-feldspars, as stringers in perthite and as individual grains. The plagioclase lamellae are occasionally bent or broken (Fig. 24) indicating post-crystallization deformation of the grain. The microcline crystals are highly perthitic with abundant stringers of albite. The perthites were formed as a result of exsolution. The strongly perthitic nature of K-feldspar may indicate the emplacement of these plutons at medium crustal level of 10-12 km (Poli and Tommasini, 1991).

Quartz constitutes 21 to 31% of the rock by volume. It occurs as inclusion in K-feldspars and also as interstitial grains. Undulose extinction is common in quartz.

Leucogranitoid

The grain size of the leucogranitoids varies from fine to coarse; as such the leucogranitoids can coveniently be subdivided into fine and coarse subgroups based on textural variation. The leucogranitoids comprise dominantly of K-feldspars which constitute about 39% of the rock. K-feldspars are mostly perthitic which appear to be of exsolution

Fig. 21: Photomicrograph of euhedral sphene (S). Crossed nicols. Enlargement 70 x.

Fig.22 : Photomicrograph of twinned perthite (P). Crossed nicols. Enlargement 42 x.

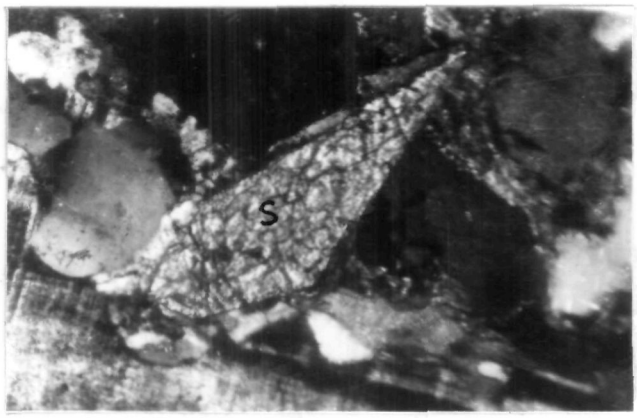

Fig. 21

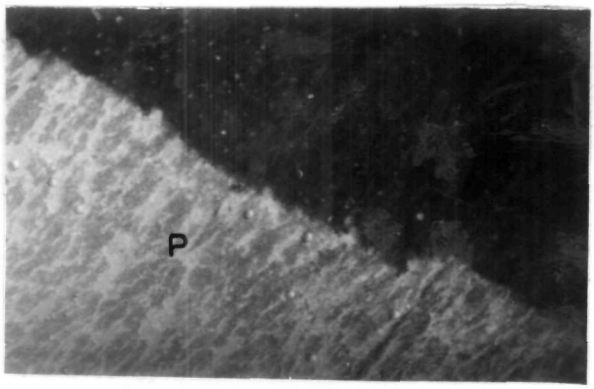

Fig. 22

origin. The fine grained variety is porphyritic; the phenocrysts of K-feldspars vary from 1.3 to 3.5 mm in length.

Plagioclase constitutes 20 to 31% by mode; they occur mainly as subhedral to anhedral crystals and exhibit variable degrees of alteration. The calcic core is normally altered to sericite and occasionally to epidote. Myrmekite is a minor phase occurring within plagioclase (Fig. 25). In porphyritic variety, plagioclase phenocrysts are up to 4.00 mm in length and have inclusions of quartz. Plagioclase crystals in fine grained leucogranitoid are relatively fresh and more sodic (average composition is An_{12}) than those in the older type of granitoids. Postcrystallization deformation of plagioclase is evident from the microfracture filled with quartz which has displaced the plagioclase lamellae (Fig. 26) at a number of places.

Quartz constitutes about 41% of the rock and occurs as individual anhedral crystals and also as graphic intergrowth with K-feldspar indicating simultaneous crystallization of the two minerals. It also occurs as interstitial grains.

Mafic Magmatic Enclaves (MME)

The mafic magmatic enclaves are invariably finer grained than the host granitoids. MME are composed of pyroxene, hornblende, plagioclase, biotite and magnetite. K-feldspars are encountered rarely. The proportions of different minerals in the enclaves vary from one enclave to another.

The rocks display subophitic texture; they have higher content of ferromagnesian phases and plagioclase, and lower content of quartz and K-feldspars than do the host granitoids. Hornblende crystals are

Fig. 23 : Photomicrograph of euhedral zircon (Z) within biotite. Crossed nicols . Enlargement 42 x.

Fig. 24 : Photomicrograph to show bending of plagioclase lamellae (P). Cossed nicols. Enlargement 70 x.

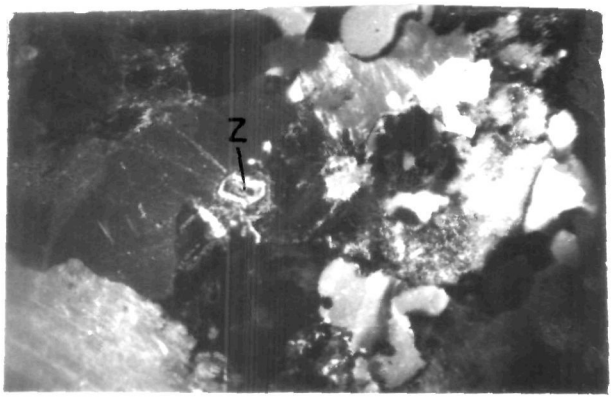

Fig. 23

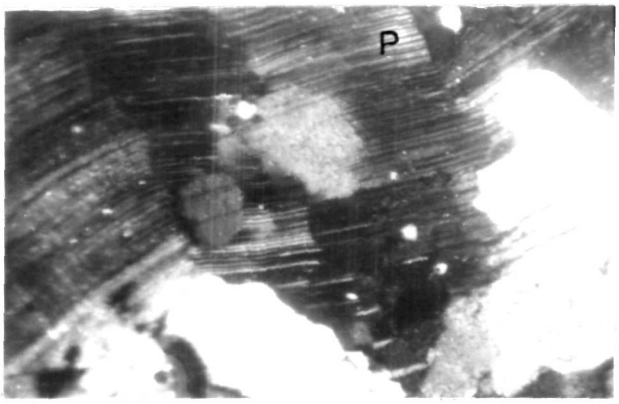

Fig. 24

generally subhedral to anhedral. Apatite, in general acicular, is present as accessory. Hornblende, biotite and magnetite occur together almost invariably both in enclaves as well as in the host granitoids.

Plagioclases are typically zoned; a dusty calcic plagioclase core is surrounded by a rim of sodic plagioclase. The crystal habit of sphene in enclaves is similar to that in host granitoids, whereas apatite is acicular in enclaves and stubby in granitoids. Presence of acicular apatite in the enclaves may indicate undercooling (Reid et al., 1983; Vernon, 1983). This feature, alongwith fine grained nature of the enclaves favours a melt derived origin of the enclaves formed by chilling of blobs of mafic magma in cooler granitic magma (Didier, 1973).

No restite has been observed in the enclaves. The plagioclase which is the best mineral to be preserved as restite (White and Chappell, 1977) shows no evidence of its being a restite. A restite plagioclase is irregularly and patchilly zoned with corroded cores. Chappell et al. (1987) suggested that restite plagioclases may also tend to be unzoned because of slow prograde metamorphism of source rocks. The presence of zoned plagioclase coupled with quench like texture of the enclaves is inconsistent with restite model.

Basic Dykes

Microscopic examinations reveal that the basic dykes are petrographically uniform in composition, commonly showing ophitic textures. Opaques are common. Biotite, a rare phase, is found at some places to be associated with opaques. Plagioclases are commonly altered to sericite.

Fig. 25 : Photomicrograph to show myrmekite (M). Crossed nicols. Enlargement 42 x.

Fig. 26 : Photomicrograph to show displacement of plagioclase lamellae by quartz vein (→). Crossed nicols. Enlargement 70 x.

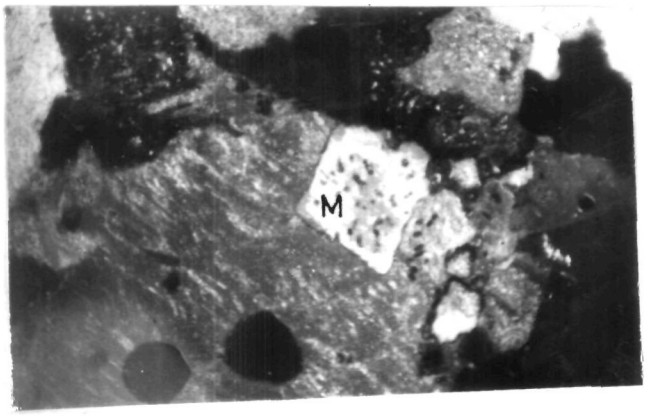

Fig. 25

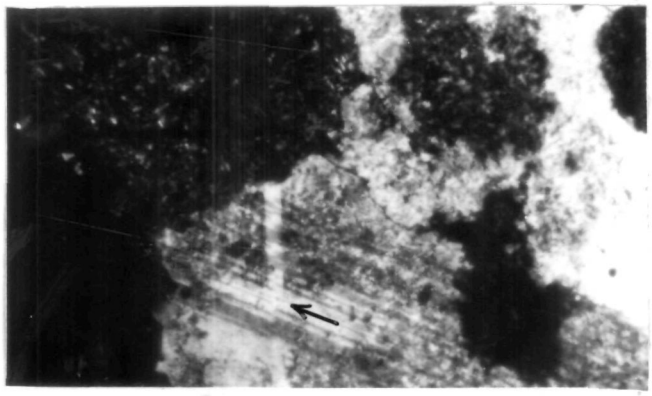

Fig. 26