A NOTE ON PETROGRAPHY AND CHEMISTRY OF MICROGRANULAR ENCLAVES AND GRANITOIDS AROUND TALBAHAT, LALITPUR DISTRICT, UTTAR PRADESH

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In the Bundelkhand terrain of Uttar Pradesh (U.P.) grey and pink granites are the dominant rock types and their petrography and chemistry have been earlier studied by others (Mishra and Sharma, 1974; Sharma, 1982; Basu, 1986; Rahman and Zainuddin, 1993; Sarkar and Miller, 1996; Pati and Mamgain, 1996). These granites intrude gneisses, migmatites, banded iron formation and metasediments. Based on cross cutting relationships and xenoliths in younger granites, Rahman and Zainuddin (1993) recognized five types of granites. Geochemistry of granites revealed subduction related magmatism (Mondal and Zainuddin, 1997).This note presents field, petrographic and chemical characters as well as genetic aspects of the mafic, felsic enclaves and their host granites in the southwestern parts of the Bundelkhand massif around Talbahat, Lalitpur District, U.P.

Geology

The area around Talbahat consists of pink porphyritic medium to coarse-grained granite and it is surrounded by grey porphyritic granite The grey granite is foliated due to preferred orientation of quartz, feldspar and biotite Pegmatites are less and mafic enclaves are common in this granite The pink granite is medium to coarse grained and porphyritic Pegmatite is common and the pink granite contains felsic enclaves It shows cross cutting relationship with grey granite The contact of pink and grey granite is generally sharp and at places diffused and appears that the pink granite intrudes grey granite The granites are criss-crossed by the N-S, NE-SW and NNW-SSE trending quartz veins and mafic and felsic dykes of different dimensions are also common The locations of the samples are given in Fig 1

Mafic microgranular enclaves (MME) in the grey granites are fine grained, dark and composed of mostly biotite They range in size from 25 cm to 1 m in length and subrounded, lobate to elongate in shape The contact of MME with the grey granite is sharp and diffusive at places with serrated and wispy boundaries The enclaves trend parallel to the host granite foliation, N-S, ENE-WSW and are encountered all over the study area (Fig 2a) Millimeter size clots of ferro-magnesium minerals are the constant feature in the MME Felsic microgranular enclaves (FME) in the pink granites are medium to coarse grained, angular in shape and vary in size (up to 10 cm) and lined by fine-grained biotite The contact of FME with the pink granite is generally sharp and at places, chilled margins are also observed Both the enclaves show transitions into their surrounding granite up to few cm in width and appear to be

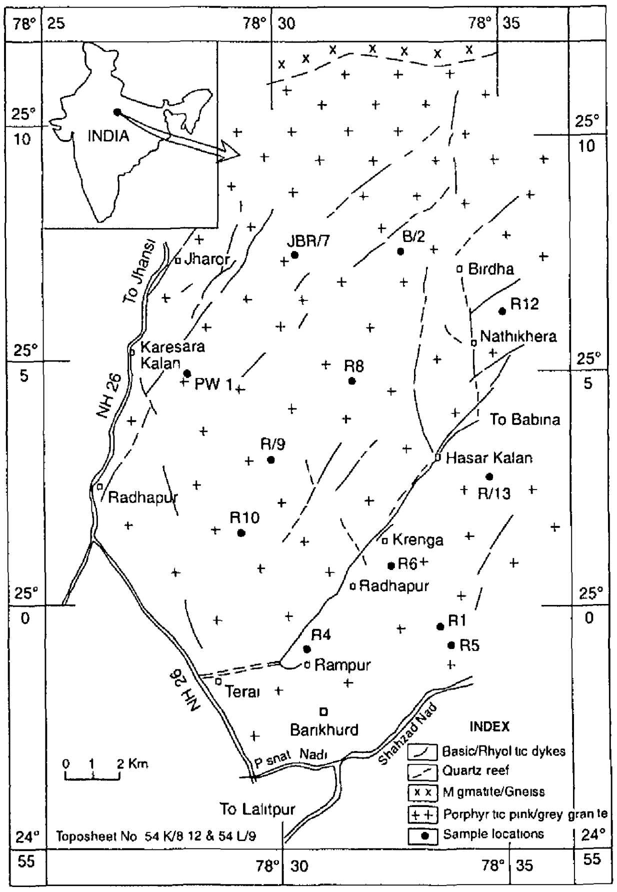

Fig.1. Geological map of the area around Talbahat, Lalitpur and Jhansi districts U P

modifications of the enclaves Metasediments occur as rafts in the granites but these have no relationship with MME and FME

Five representative samples each of grey and pink granite and five samples each of MME and FME are studied for petrology The major elements are analysed by wet chemical method and the selective trace elements are analysed by the Atomic absorption spectroscopy The REE, Y, Sc, Th, Zr, Sr, are determined by the ICPMS The analytical precisions calculated form the replicate analysis of standard is <5% for major elements and 10% for trace elements and the data are summarized in Table 1

Petrography and Chemistry of the Granites and Enclaves

Under the microscope, MME in grey granite vary in size (0 3 mm to 1 2 mm) in shape and are subangular to rounded (Fig 2b) They are finer than the matrix and contain core and a rim The core consists of fine-grained biotite with a rim of quartzo-feldspathic matter Some enclaves occur as detached bodies over granitic matter and some are traversed by it The host grey granites are composed of K-feldspar, plagioclase, quartz and biotite with zircon, apatite and ilmenite These are peraluminous with normative corundum of 2 to 4% and A/CNK ratio of 1 2 In QAP diagram, the

Table 1 Major and trace elements analyses of granites and enclaves from Talbahat area

Sample No	R4	R9	R10	B2	JBR7	PW1	R1	R5	R6	R8	R12	R13
Serial No	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	74 5	72 7	72 1	65 8	65 8	64 6	66 8	71 4	70 0	69 8	68 9	72 6
TiO_2	0 1	0 1	0 2	0 1	0 3	0 2	0 3	0 2	0 2	0 1	0 2	0 1
Al_2O_3	13 7	13 8	14 3	18 3	15 3	18 1	13 8	11 2	14 1	13 8	13 9	13 8
Fe_2O_3	1 4	1 6	1 5	1 7	4 1	2 0	3 2	2 6	1 4	1 7	1 8	0 8
Feo	0 6	1 2	1 2	1 0	1 7	1 0	1 5	1 9	<0 1	0 4	0 8	0 1
CaO	0 5	0 4	0 4	0 4	1 1	0 4	0 8	1 1	0 6	0 8	0 3	0 4
MgO	0 3	0 5	0 4	1 1	0 7	0 7	1 2	0 3	0 2	0 6	0 3	0 1
MnO	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1	<0 1
Na_2O	2 2	2 1	2 2	4 4	1 8	3 4	3 5	3 2	0 1	1 9	0 1	1 9
K_2O	6 0	6 4	7 0	5 9	7 2	8 4	7 0	7 1	12 2	8 3	12 5	9 5
P_2O_5	0 1	<0 1	<0 1	<0 1	0 2	0 1	0 2	0 2	0 4	1 4	<0 1	<0 1
LOI	0 7	1 0	0 7	1 4	1 5	1 4	1 5	0 7	0 8	1 1	0 6	0 6
A/CNK	1 2	1 2	1 2	1 27	1 2	1 1	0 93	0 93	0 97	0 97	0 97	0 97
Ni	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Co	25	35	25	20	25	20	25	55	30	30	30	35
Cu	<10	<10	20	10	35	10	13	10	25	<10	<10	20
V	38	20	10	25	30	15	30	25	20	25	15	30
Rb	120	100	95	145	140	230	80	100	150	130	170	140
Ba	25	100	345	225	840	290	980	490	380	340	300	290
Sr	32	57	79	56	221	64	166	24	22	28	19	14
Nb	7	3	8	17	19	14	13	17	11	18	10	15
La	17	27	32	44	84	52	77	55	80	58	20	84
Ce	38	53	46	83	136	106	110	74	124	85	30	125
Nd	11	18	19	34	63	48	50	36	52	35	11	54
Sm	4	4	4 8	8	12	13	10	6	12	15	9	10
Eu	1	1	1	1	1 3	1	1 2	1	1	1	1	1 5
Tb	<1	<1	<1	<1	<1	1 6	<1	<1	<1	<1	<1	<1
Yb	1 9	2 1	2 2	3 3	3 9	4 2	3 7	2 3	2 4	2 5	2 1	2 4
Lu	1	1	1	1	1 2	1	1	1	1	1	1	1
Y	5 2	6 1	3 3	11	11 1	14 6	12 8	3 2	6 7	6 1	3 8	5 6
K/Rb	414	531	611	337	426	303	726	589	674	529	610	551
Rb/Sr	3 7	1 7	1 1	2 5	0 63	3 5	0 48	4	6 7	4 52	8 8	9 5

S No 1 to 5 are grey biotite granites with ilmenite and zircon, S No 6 is mafic enclave containing fine grained biotite and quartzo feldspathic material S No 7 to 11 are pink coloured potash feldspar granites with apatite and xenotime S No 12 is felsic enclave containing potash feldspar and fine-grained biotite

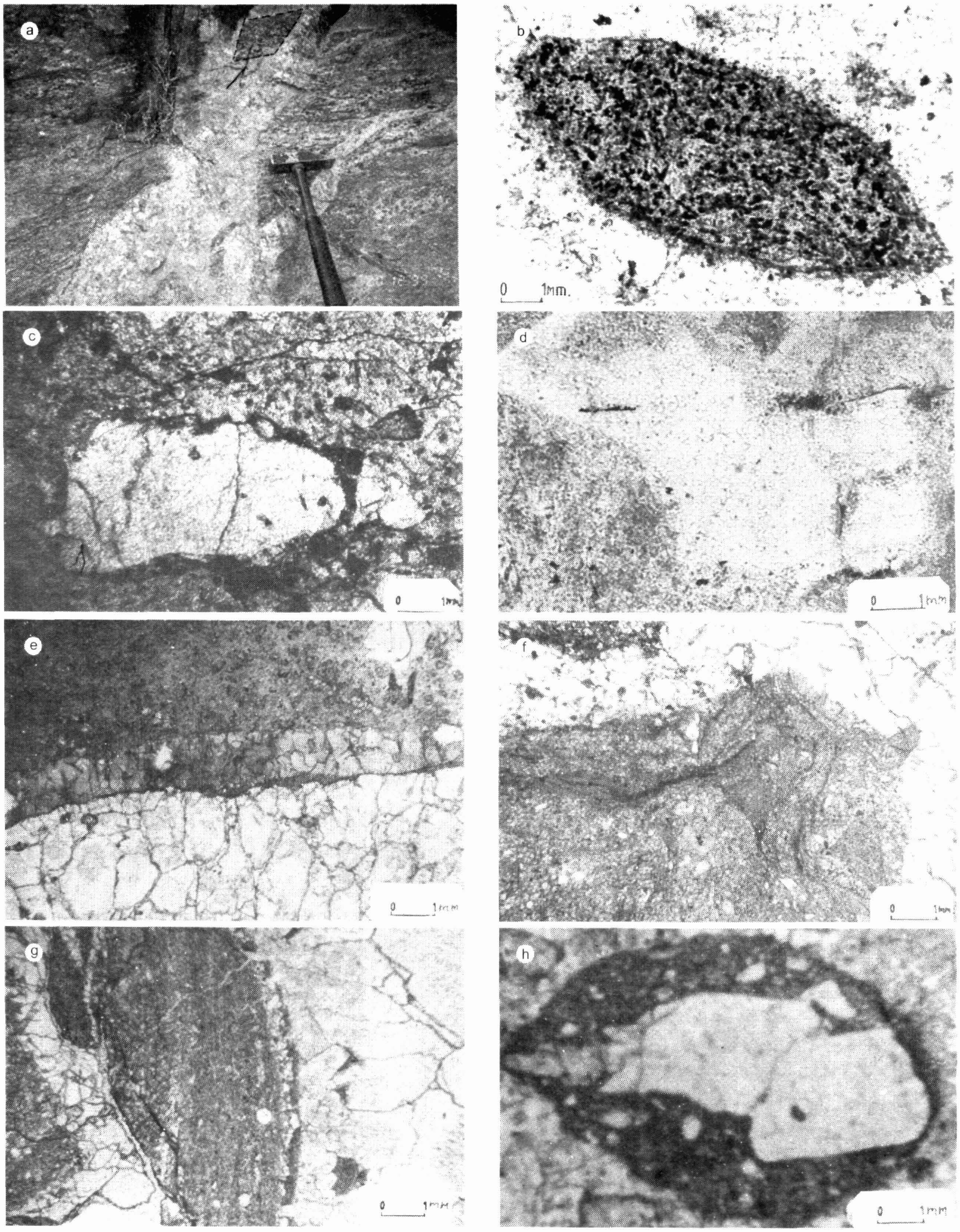

Fig.2. **(a)** MME in grey granitoid around Talbahat. Biotite shows flow structure. **(b)** Mafic granular enclave in grey granite. **(c)** Felsic microgranular enclave in pink granite. **(d)** Resorbed quartz phenocryst in felsic enclave. **(e)** Juxtaposition of fine grained mafic matter and coarse grained felsic matter – first stage. **(f)** Development of K-feldspar kernel in the mafic matter – second stage. **(g)** Development of K-feldspar kernel into phenocrysts – third stage. **(h)** Well developed K-feldspar phenocrysts with biotite rim – fourth stage. Under PPL.

grey granites plot in the granite field (Fig 3) The MME are chemically similar to the grey granites (Table 1)

FME in pink granite vary in size (0 1 mm to 1 7 mm) and are angular in shape (Fig 2c) They consist of quartz and K-feldspar phenocrysts, which occur in the core surrounded by fine-grained biotite as rim Moreover, reaction rims and resorbed phenocrysts (Fig 2d) are also observed The host granite is composed of K-feldspar, plagioclase, quartz along with xenotime and apatite These are metaluminous with 0 25 to 5% normative diopside and A/CNK ratio of 0 93 to 0 97 In QAP diagram the pink granites plot in the alkali feldspar granite field (Fig 3) The FME are chemically similar to pink granites

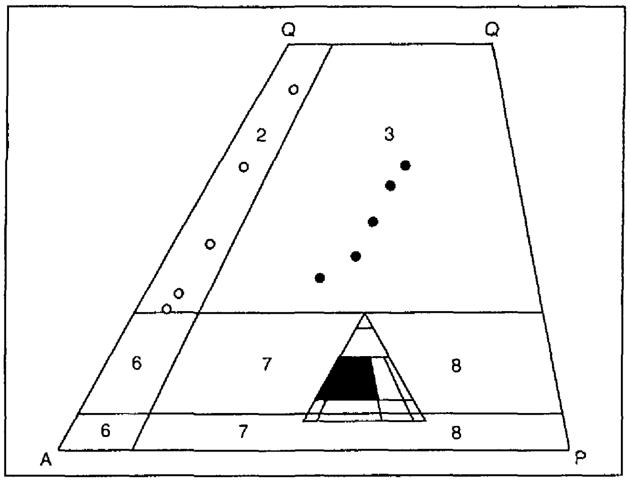

Fig.3. QAP diagram

Stages of Development of Enclaves

Magmatic textures (porphyritic and perthitic), graphic and myrmekitic intergrowths are observed in both the granites From the petrography, four stages of development of enclaves are deciphered In the first stage, juxtaposition of fine grained mafic and feslic matter is noticed with marked boundaries (Fig 2e) In the second stage, the grain size of both mafic and felsic end members have become uniform (fine grained) and kernels of K-feldspar are developed amidst the mafic matter (Fig 2f) In the third stage, the K-feldspar kernels are developed into phenocrysts and at the end the felsic matter has mingled with the mafic matter (Fig 2g) The well-developed enclaves (K-feldspar phenocrysts with mafic borders) mark the fourth stage (Fig 2h) *It is noticed that during this process, fine-grained* nature of the mafic matter is never lost and it is the felsic matter that changed its grain size

Discussion

The enclaves and granites are developed under magmatic conditions as evidenced by preferred orientation of the minerals, magmatic textures, K- feldspar, quartz phenocrysts with rims of biotite, change in the grain size of felsic matter as depicted (Figs 2e-h), and high K/Rb ratios The core and the rim of the felsic enclaves can be explained as during the crystallization of magma biotite crystalizes first, followed by plagioclase, quartz and K feldspar The growing K-feldspar pushes aside or incorporates the small crystals of biotite, plagioclase and quartz The K-feldspar phenocrysts in the enclaves indicate that growth of alkali feldspar rapidly reaches a maximum and then declines due to drop in temperature (Swason, 1977)

The origin of the MME in the intrusive granitoids has been debated and five different models were proposed (Barbarin, 1991) These are (1) Restites (2) Xenoliths, (3) Fragments of the early formed mafic margins of the pluton itself, (4) Mafic segregations of the early crystallizing phases and (5) Pillows of mantle derived mafic magmas mingled or partially mixed with felsic crustal magmas

The textures and compositions of the restites are totally distinct form those of MME, and there are no indications of transformation of restites into MME wherein restites occur besides MME These observations excludes first two models MME are not fragments of early formed mafic margins of the pluton itself (third model) because reversely zoned plutons that have felsic fine grained margins instead of mafic margins, also contain MME The fourth model (autoliths) is consistent with the mineralogical similarity of enclaves and granites, are however, incompatible with grain size and the fine grained margin of the MME The microstructural evidence in support of fifth model is that quartz and K-feldspar megacrysts that indicate grains of these minerals enter the more mafic magma from partially crystallized granitic melt in a zone of mixing, (probably before entrainment of globules of the resulting mixed magma) as enclaves The spatial association of basic and acidic dykes within Bundelkhand granites points towards this possibility The chemical similarity and homogeneous mineralogy of these enclaves and granites indicate cogenetic nature The fine grained texture, chilled margins of the MME and their elongation parallel to the host granites suggests that MME was crystallized from mafic magma that was coeval with the felsic magma

Conclusion

The MME within the grey granite and FME within pink granite belong to two distinct episodes of granitic magmatism in the Bundelkhand area The field, petrographic and chemical aspects of the enclaves and granites indicate mingling or mixing of basic matter with the granitic magma

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