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Field Relations and Petrochemistry of the Jeli Igneous Complex, North Kelantan: Preliminary Observations

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Abstract

The Jeli Igenous Complex is located about 1 km north of Jeli town, Kelantan which is part of the Jeli granite. Four main rock types occur in the area namely (in decreasing age) coarse grained foliated biotite granite (CFBG), grey microgranite (GM), medium grained foliated biotite granite (MFBG), and hornblende biotite basaltic dyke (HBBD). The field evidence suggests that both GM and MFBG magmas are synplutonic. The CFBG, MFBG and GM consists of typical granitic (s.l) mineral that is quartz, plagioclase, K-feldspar, biotite, zircon, apatite, sphene, allanite and opaque phase whereas the HBBD contains hornblende, quartz, plagioclase, biotite, apatite, sphene and opaque phases. Petrographic study shows that the rocks in the area have undergone both magmatic and high temperature solid-state deformation.

Hubungan Lapangan dan Petrokimia Kompleks Igneus Jeli, Utara Kelantan: Tinjauan Awal

Abstrak

Batuan igneus komplek Jeli yang merupakan sebahagian daripada granit Jeli, terletak kira-kira 1 km ke utara Pekan Jeli, Kelantan. Terdapat 4 jenis batuan di kawasan ini yang dinamakan (berdasarkan penurunan usia batuan) granit biotit berfoliasi butiran kasar (CFBG), mikrogranit kelabu (GM), granit biotit berfoliasi butiran sederhana (MFBG) dan daik hornblend biotit berbasalt (HBBD). Bukti lapangan mencadangkan bahawa magma GM dan MFBG adalah sinplutonik. CFBG, MFBG dan GM mempunyai komposisi granit yang lazim terdiri daripada mineral kuarza, plagioklas, K-feldspar, biotit, zirkon, apatit, sfen, alanit dan mineral legap manakala HBBD pula mengandungi mineral hornblend, kuarza, plagioklas, biotit, apatit, sfen dan mineral legap. Kajian petrografi menunjukkan bahawa batuan di kawasan ini telah melalui proses magmatik dan canggaan bahan pejal pada suhu tinggi.

INTRODUCTION

A preliminary observation on the field relation, petrography and major element geochemistry of the igneous rock (Jeli Igenous Complex) found at kilometer 1.5 East-West highway is reported in this paper. The outcrop is located about 1 km north of the Jeli town, Kelantan (Fig. 1). The igneous rock is part of the Jeli granite (Singh *et al.*, 1984). The granite is bordered by the Stong Complex to the southwest and the Kemahang granite to the east. General geology of the area has been studied by Husin (1993) and he suggested that the area is underlain by several granitic types include granodiorite and porphyritic granite.

FIELD RELATION

At least four main rock types are found in the study area. They are coarse grained foliated biotite granite (CFBG), medium grained foliated biotite granite (MFBG), grey microgranite (GM) and hornblende biotite basaltic dyke (HBBD). Minor leucogranite and quartz veins occur everywhere intruding all the four rocks types.

CFBG is the oldest rock type and is characterised by coarse grained size (0.2 cm to 2 cm across) and alignment of biotite clots. It is cut by all the three main rock types with sharp contacts. The contact between the CFBG and MFBG is shown in Figure 2. The contact is bordered by a 5 cm thick leucogranite margin. Biotite foliation along with stretched enclave in the MFBG is parallel to the contact. On the other hand, biotite foliation in the CFBG is oblique 45° to the contact (Fig. 2).

The synplutonic nature of the contacts between the GM and MFBG can be seen in the lower part of the outcrop and is shown in Figures 3,4 and 5. The structures vary considerably from cm scale streaky intermingling to discrete 'pillowlike' structure (meter scale). In term of the volume, MFBG is more dominant and the GM tends to form an 'enclave' structure in the MFBG. However at the upper part of the outcrop, both rocks form a 'dykelike' structure in which the GM 'dyke' is cut by the MFBG 'dyke' (Fig 6). Angular to subangular inclusions of CFBG, up to 15 cm across occur in the GM 'dyke'.

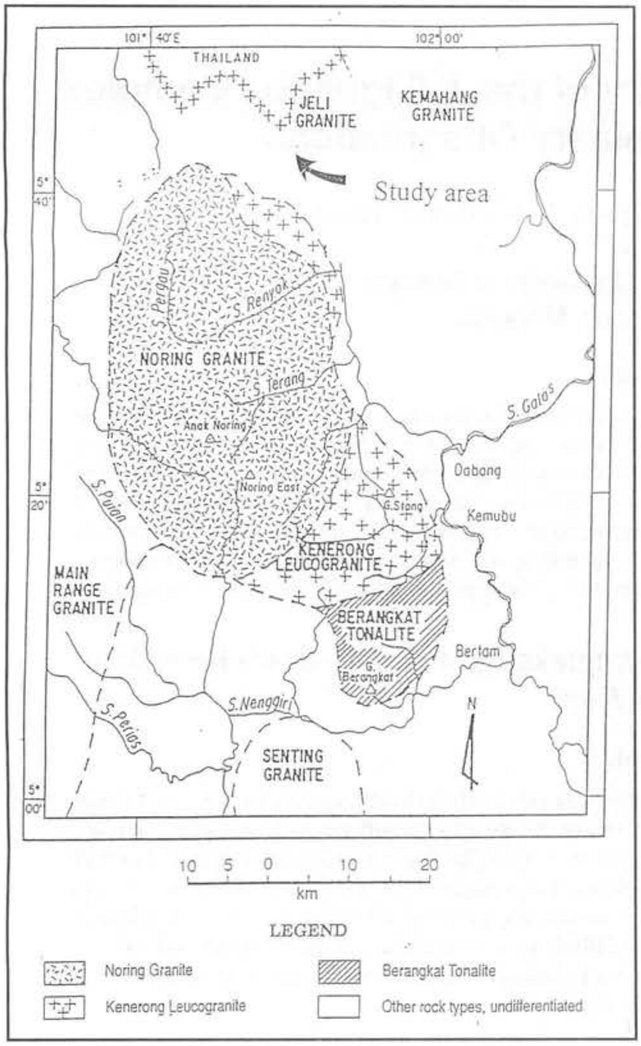

Figure 1: Map showing the location of the Jeli Igneous Complex.

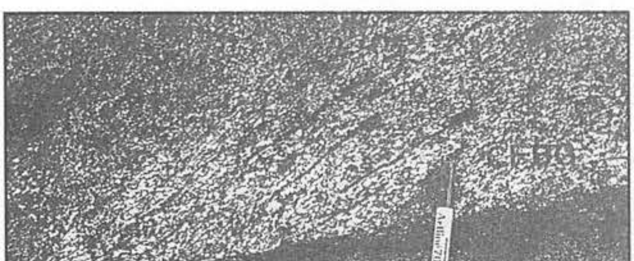

Figure 2: Photograph showing the contact between the coarse grained foliated biotite granite (CFBG) and medium grained foliated biotite granite (MFBG). Note that the biotite foliation in the CFBG is oblique to the contact.

PETROGRAPHY

Mineral composition and textures of all the four rock types is given in Table 1. The CFBG, MFBG and GM consists of typical granitic (s.l.) minerals that is quartz, plagioclase, K-feldspar, biotite, zircon, apatite, sphene, allanite and opaque phases. The proportion of the minerals are different, thus in the CFBG plagioclase, K-feldspar and quartz constitutes about 90% of the modal composition whereas in both MFBG and GM, K-feldspar content is much less (<10%). Total modal of plagioclase + quartz in the latter two rocks is about 80%. The HBBD contains hornblende and biotite as the main mafic phases in contrast to the other three rocks which only contain biotite.

The main difference between the rocks are:

(1) Grain size: CFBG is coarse grained and other three are fine to medium grained size ,

(2) Foliation: Only the GM does not show any foliation, the other three rocks contain prominent foliation, which is homogenously distributed within the rocks, and

(3) Foliation mineral: The foliation in the three rocks is made up of different minerals, that is, CGBG : biotite and fine grained re-crystallised quartz-feldspar, MFBG: fine grained recrystallised quartz and HBBD: thinly stretched biotite.

GEOCHEMISTRY

Analytical procedure

Major element oxides were analysed by X-ray fluoresence (XRF) at the Department Mineral and Geoscience Malaysia, Ipoh. The equipment used was a Phillips PW 1480 X-ray spectrometer. Glass fusion disc were used for the analysis of major elements. The discs were prepared by fusing a mixture of 1 g of rock sample with 6 g of flux (lithium tetraborate + lithium metaborate) at about 1000°C and casting the melt on an aluminium platten.

Represantative geochemical analysis of the rocks is given in Table 2. Average SiO_2 content for the rocks are CGBG (67.11%), GM (65.25%). MFBG (71.22%) and HBBD (51.47%). Elemental variation is shown by Al_2O_3, Fe^{tot}, CaO and MgO. HBBD has the highest Al_2O_3, Fe^{tot} and CaO content (19.27%, 8.15% and 9.72% respectively; see table 2) compared to the other three rocks.

Interestingly large elemental variations are also shown by the three granitic rocks (s.l) (CGBG, GM, MFBG). They are :

(1) SiO_2 content indicate GM is the most basic composition compared to the CFBG and MFBG.

(2) Total alkali content gradually decrease from CFBG to MFBG to GM.

(3) Na_2O + CaO content is higher in both GM, MFBG compared to the CGBG

(4) K_2O content is higher in the CFBG compared to the GM and MFBG.

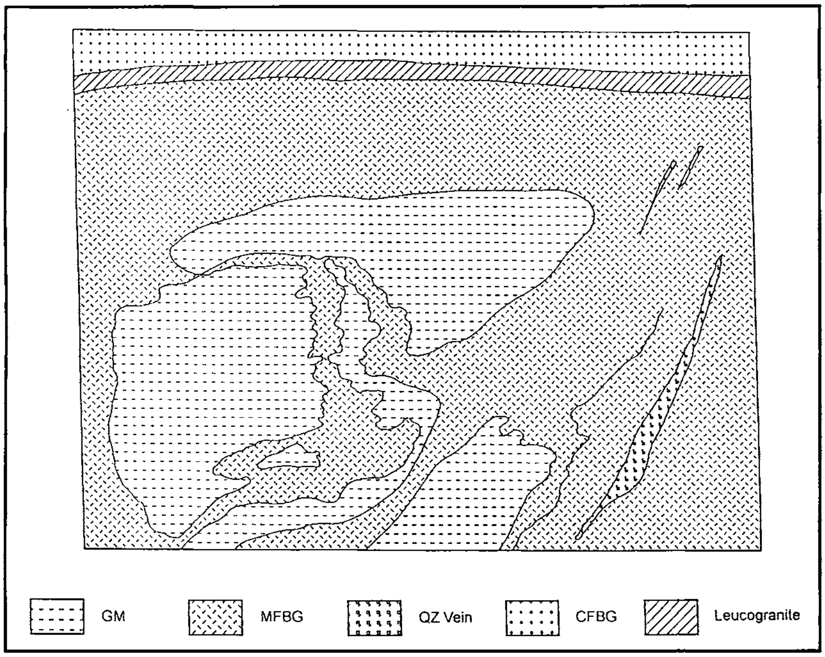

Figure 3: Field sketch of the lower part of Figure 2 showing the nature of the contact between medium grained foliated biotite granite (MFBG) ang grey microgranite (GM). The contact between both rocks is characterized by irregular outline suggesting that the magmas are synplutonic.

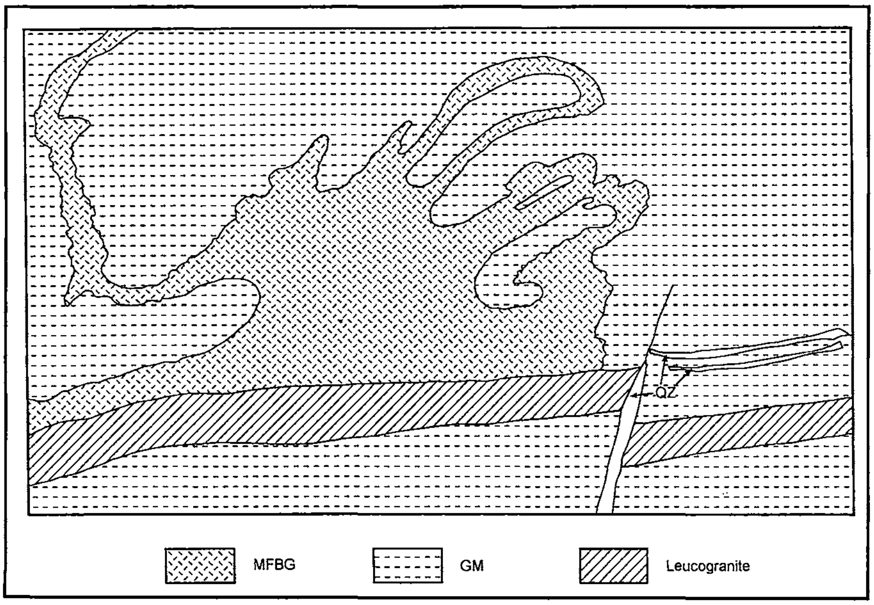

Figure 4: Another view of the nature of the contact between the MFBG and GM.

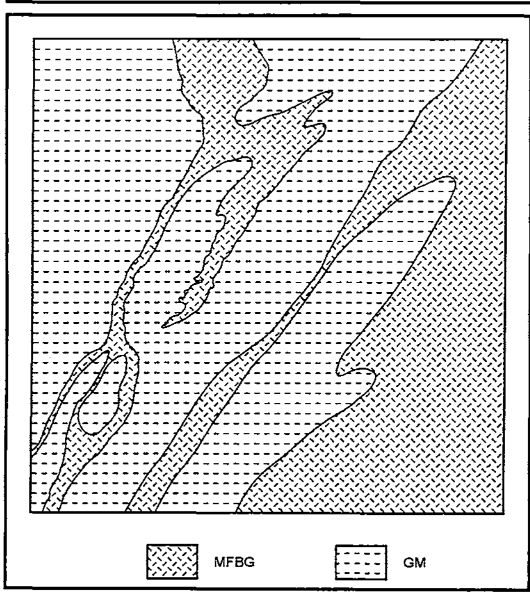

Figure 5: Field sketch showing the contact between the MFBG and GM. Note that the GM sometime engulf the MFBG block.

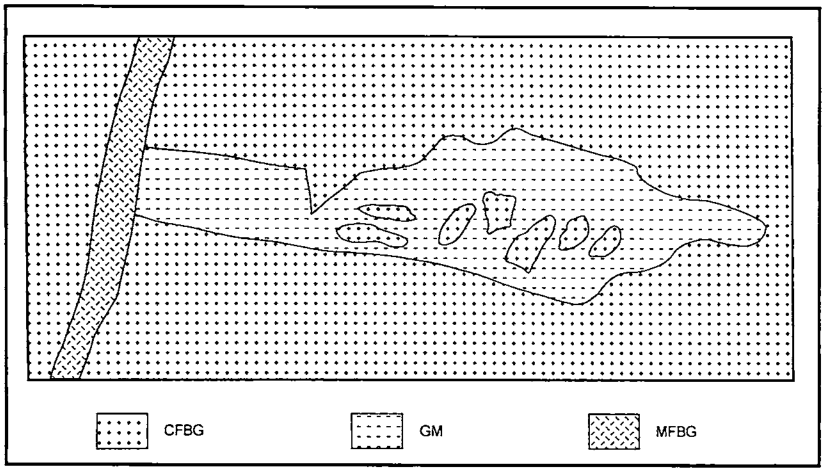

Figure 6: The 'dyke-like' GM rocks with inclusions of CFBG rocks.

Table 1 : Summary of the petrographic characteristics of the four main rock types found in the Jeli Igneous Complex.

Rock Type	Coarse grained foliated biotite granite (MFBG)	Fine grained foliated biotite granite (MFBG)	Grey Microgranite (GM)	Hornblende biotite basaltic dyke (HBBD)
Mineralogy	Quartz, plagioclase, k-feldspar, biotite, zircon, apatite, sphene, opaque	Quartz, plagioclase, biotite, k-feldspar, apatite, zircon	Quartz, plagioclase, biotite, allanite, k-feldspar, apatite	Quartz, plagioclase, biotite, hornblende, apatite, sphene, opaque
Grain size	Coarse (0.2-2cm)	Medium to fine (0.1-0.5cm)	Medium to fine (0.1 -0.3cm)	Fine (less than 0.1mm)
General texture	Foliated (visible in hand specimen)	Weakly foliated (visible only in hand specimen); recrystallised quartz	non foliated and slightly porphyritic in thin section	Foliated (visible only in thin section)
Foliation mineral	Biotite & fine grained recrystallised quartz-feldspar	Fine recrystallised quartz	-	Thin stretch biotite
Plagioclase	Subhedral, wrap by biotite foliation, twinning, irregular outline	Zoning	Zoning & twinning, phenocrystic with black rim	Fine grain & same size with other minerals
Quartz	Clusters of anhedral grains with lobate boundaries	2 types: Anhedral and form interconnected network and & fine grained recrystallised	Anhedral and scattered	Anhedral fine grained
K-feldspar	Coarse grain and rarely perthitic	Small amount	Small amount	
Biotite	2 types: coarse grain foliated and fine grained foliated (recrytallised)	Weakly foliated and anhedral	Anhedral, bladed shape, sometimes very weakly foliated	2 types: subhedral non-foliated and stretch foliated (thin) crystals
Hornblende	-	-	-	Euhedral-anhedral. Usually smaller than non-foliated biotite
Accessory	Zircon, apatite and sphene associated with biotite clot. Opaque associated with scattered and rarely associated with foliation	Zircon, apatite	Apatite and allanite	Apatite, sphene, opaque
Other textures				

Table 2 : Representative major elements composition of the four main rock types found in the Jeli Igneous Complex.

Sample Number	D3	GK1	GS1	MGR2
Rock Type	Hornblend biotite basaltic dyke	Coarse grained folliated biotite granite	Medium grained foliated biotite granite	Grey Microgranite
SiO_2	51.47	67.11	71.22	65.25
Al_2O_3	19.27	14.34	15.03	17.02
Fe(total)	8.15	4.91	2.22	3.85
TiO_2	1.06	0.76	0.37	0.24
CaO	9.72	2.54	3.23	5.34
MgO	5.29	2.80	0.95	1.65
Na_2O	2.23	3.66	3.89	4.26
K_2O	2.30	3.81	2.69	1.86
P_2O_5	0.79	0.37	0.27	0.37
MnO	0.10	0.07	0.04	0.07
Total	100.36	100.37	99.89	100.78

DISCUSSION AND CONCLUSION

Relative Age

The field relations suggest that the relative age of the rocks in decreasing order are: CGBG–GM/MFBG–HBBD.

Magmatic and High-Temperature Solid-State Deformation

The rocks from study area display a variety of magmatic structures. On a large scale, there are numerous examples of sharp contacts between different rock types. Other igneous features include 'stretched' enclaves (Berger and Pitcher, 1970; Marre, 1987), occurrence of leucocratic dykes cutting the CFBG, GM and MFBG (Miller and Paterson 1994) and blocks of CFBG in GM. However in thin section, much of textural features favour high-temperature solid state deformation. Microstructures within the zone of solid state deformation include undulatory extinction of quartz and subgrains development in quartz with lobate boundaries, bending of biotite, fractured plagioclase (Guglielmo Jr, 1993) and occurrence of myrmekite intergrowth parallel to the foliation (in CFBG) (Vernon, 1991). Evidence of magmatic deformation in the thin section is scant. Thus, the rocks in the area have undergone both magmatic and high temperature solid state deformation.

Magma Interaction Between MFMG and GM

Field relations described in the earlier section suggest that MFMG and GM are synplutonic. Both magmas probably intruded the CFBG at about the same time. Interestingly only MFGM show foliation compared to the weakly porphyritic texture in the GM. The different rocks texture indicate that the magmas intruded at different viscosity. Van der Molen & Paterson (1987) showed that a magma mush with less than 70% crystals is incapable of recording solid state deformation. Thus, the GM magma probably contained less than 70% crystals compared to MFGM, which presumeably contained more than 70% crystals when they came into contact with each other. This allowed mingling and mixing between the two magmas. Evidence of the processes have been recorded in both field and in thin section. In the field, mingling of both MFBG and GM is shown in Figures 3, 4 and 5. In the thin sections, magma mixing is evident from corroded plagioclase with thin mantle layers (Table 1).

Geochemical Interpretation

All the four main rock types in the study area have distinct chemical compositions. Higher CaO +Na_2O content in both MFBG (7.12%) and GM (9.60%) compared to the CFBG (6.20%) may be reflected by the higher lower modal proportion of K-feldspar in the MFBG and GM. On the other hand, the CFBG has higher K_2O content (3.81%) compared to the other granitic rocks (MFBG: 2.69% and GM: 1.88%). This may reflect the higher modal K-feldspar content in the rock. Geochemical analysis also confirmed the basaltic nature of the HBBD

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