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Geochemistry of biotite from Kuala Lumpur granite

Azman A. Ghani

Department of Geology, Faculty of Science, University of Malaya, 50603, Kuala Lumpur, Malaysia

ABSTRACT This work presents a new biotite analyses of Kuala Lumpur granite. The biotites have been analysed from three different samples namely equigranular normal biotite-muscovite granite (NBMG), deformed muscovite granite (DBMG) and porphyritic biotite-muscovite granite (PBMG). Geochemistry of the biotite is similar to the biotite crystallised from peraluminious melt, characterised by high Al_2O_3. The compositions of the biotite under study were defined by FO_2 near to that of the SiO_2-Fe_2SiO_4- Fe_3O_4 buffer

ABSTRAK Kerja ini membentangkan analisa biotit dari granit Kuala Lumpur yang terkini. Biotit telah dianalisa dari tiga sample iaitu biotit muskovit granit samabutiran, muskovit granit terdeformasi dan biotit muskovit granit porfiritik. Geokimia biotit-biotit tersebut adalah sama dengan biotit yang menghablur dari magma peraluminous, yang dicirikan oleh Al_2O_3 yang tinggi. Komposisi biotit yang dikaji juga boleh didefinasikan berdekatan dengan buffer SiO_2-Fe_2SiO_4- Fe_3O_4.

(geochemistry, biotite, granite)

INTRODUCTION

Kuala Lumpur (KL) granite located on the west side of the Main Range batholith (Figure 1). It was emplaced into metasedimentary schist, phyllites and limestones of Silurian and Devonian age. The granite consists of two lobes that are a smaller lobe to the west of Kuala Lumpur city and the main body to the east of the city. It consists of fine to coarse grained muscovite to biotite granite. Ng [1] distinguished the Kuala Lumpur granite into four different units that is megacrystic biotite granite (unit 1), megacrystic muscovite-biotite granite (unit 2), equigranular tourmaline-muscovite granite (unit 3) and unit 4 consists of pegmatite, aplite and microgranite. In the granite, biotite is the most important mafic phase and crystallized in wide range of rock types ranging from pegmatite and microgranite to biotite granite. This study will examine the composition of the biotite from different facies of the Kuala Lumpur granite. Biotites were analyzed from three different samples, namely (1) Equigranular biotite-muscovite granite (NBMG) (2) Deformed biotite muscovite granite (DBMG) collected within the Kuala Lumpur fault zone and (3) porphyritic biotite-muscovite granite (PBMG) located within the contact zone (<10 m) with pelitic rocks. The aims of this paper are to highlight some of the geochemical characteristics of the biotite that crystallized from peraluminous magma as well as to differentiate geochemical differences between the three samples.

PETROGRAPHY

All three samples have a similar mineral content that is alkali feldspar, plagioclase, biotite, muscovite, quartz, Fe-Ti oxide and tourmaline. Summary of petrographic features of the three samples is shown in Table 1. Biotite occurs as subhedral to anhedral plates up to 4 mm across. Majority of the biotites are brown in colour except those from the porphyritic biotite-muscovite granite where most of the biotites are reddish in colour. Slight bending and kinking of the plates sometimes occur, especially the biotite from the deformed muscovite granite. Pleochroism scheme range from Y = light brown yellow to pale brown and X = dark brown to foxy red. Incipient replacement by chlorite, along with the secondary epidote and magnetite, is common along crystals margins and cleavages.

WHOLEROCK GEOCHEMISTRY

Before discussing the chemistry of biotite from the Kuala Lumpur granite, it is necessary to briefly discuss the whole rock geochemistry geochemistry of the Kuala Lumpur granites. The major and trace elements data for the Kuala Lumpur granite are taken from previous work [2]. The Kuala Lumpur granite is very felsic with $SiO_2 > 71\%$. The rocks are peraluminous with average ACNK value is 1.11. They are also corundum normative (average C = 1.5). The geochemistry of the granites indicate that they are evolved which is evident from Rb/Sr ratio [2].

BIOTITE GEOCHEMISTRY

Representative biotite analyses of the KL granite are given in Table 2. Structural formulae have been calculated on a basis of 22 oxygen. Average of the biotite composition form all samples are (1) Equigranular biotite-muscovite granite: SiO_2 - 0.15; TiO_2-0.1; Al_2O_3-0.15; P_2O_5-43.51; FeO(total)-0.34; MgO-0.15; CaO-55.60; Na_2O - 0.28; K_2O-0.09 and BaO-0.1. (2) Deformed biotite muscovite granite: SiO_2, 0.15; TiO_2, 0.1; Al_2O_3, 0.15; P_2O_5, 43.51; FeO (total), 0.34 ; MgO, 0.15; CaO, 55.60; Na_2O, 0.28; K_2O, 0.09 and BaO, 0.1.and (3) porphyritic biotite-muscovite granite: SiO_2, 0.15; TiO_2, 0.1; Al_2O_3, 0.15; P_2O_5, 43.51; FeO(total), 0.34; MgO, 0.15; CaO, 55.60; Na_2O, 0.28; K_2O, 0.09 and BaO, 0.1. For classification purposes all the biotite from the Kuala Lumpur granite are plotted in the Mg vs. $Al^{vi}+Fe^{3+}+Ti$ vs. $Fe^{2+}+Mn$ diagrams (Figure 2). In general the biotite is all Fe biotite and siderophyllite & lepidomelane in composition [3]. The biotite from deformed biotite muscovite granite plot near to the siderophyllie & lepidomelane whereas the biotite from Equigranular biotite-muscovite granite and porphyritic biotite-muscovite granite plot nearer to the Fe biotite. On a XMg vs Si (Figure 3), the biotite from Kuala Lumpur granites plot in the annite and siderophyllite field. The biotite from deformed biotite muscovite granite has low XMg and majority of the samples are plots in the annite field.

The biotite composition have a slight deficiency in the Y site (5.38-5.71 based on the 22 p.f.u.) compared to the ideal value (6) in the end members of trioctahedral members. Biotites from the contact facies have low Al^{iv} (0.34 to 0.68 based on the 22 p.f.u) and those from the deformed biotite muscovite granite have high Al^{vi} (0.94-1.09, 22 p.f.u), Fe^{3+}(0.36-0.38 22 p.f.u) and Fe^{2+} (2.87-3.11 22 p.f.u) compared to biotites from the other facies. The X site for the all three facies are also varies; porphyritic biotite-muscovite granite (1.34 - 2.001 22 p.f.u), Equigranular biotite-muscovite granite (1.86 - 2.01 22 p.f.u) and deformed biotite muscovite granite (1.89 - 1.94 22 p.f.u). Variation within crystal also occurs, thus biotite from the deformed biotite muscovite granite, from core to rim TiO_2, Al_2O_3 and Feo decrease whereas MgO increase. Those from the PBMG show an increase of MgO, FeO and BaO from core to rim.

Biotite composition also depends largely upon the nature of the magma (calc-alkaline, peraluminous or alkaline). Abdel Rahman (1994) [4] showed that using several discriminant diagram (e.g. FeO* vs MgO-Al_2O_3, FeO* vs MgO , Al_2O_3 vs MgO) where FeO* = [FeO+(Fe_2O_3x0.89981), biotite crystallized from different magma i.e. calc-alkaline, alkaline and peraluminous suite, can be distinguished. Those crystallized from calc alkaline magma is enriched in MgO whereas biotite crystallized from peraluminous magma has high Al_2O_3 content. Whole rocks geochemical data of the Kuala Lumpur granites [2] [5] show that majority of the data plot in peraluminous field in ACNK vs SiO_2 diagram. The biotite from the Kuala Lumpur granites also plot in the peraluminous field on MgO - Al_2O_3 diagram [4]. Average trend exhibit a negative MgO - Al_2O_3 correlation (Figure 4). The trend suggests that the 3Mg ---- 2Al substitution is effective in producing Al-rich biotite crystallizing from peraluminous melts [4]. The plot also show that the biotites from the deformed biotite muscovite granite sample have lowest MgO (3.41-3.81%) content compared to those from Equigranular biotite-muscovite granite (5.53-5.64%) and porphyritic biotite-muscovite granite (5.88-6.19%) samples. Furthermore the biotites from deformed biotite muscovite granite also have low TiO_2, Cr_2O_3 and high FeO content (1.68-2.25%, 0-0.04% and 24.44-26.71% respectively)

ESTIMATED OXYGEN FUGACITY ON BIOTITE COMPOSITION

Wones and Eugster [6] carried out the main investigation of the stability of biotite. They discussed the variations in composition of biotite along the phlogopite-annite join with changing temperature, oxygen fugacity (fO_2) and pressure. The oxygen fugacities were defined by a number of oxygen buffers which included the Fe_2O_3-Fe_3O_4 (HM), Ni-NiO (NNO) and SiO_2-Fe_2SiO_4-Fe_3O_4 (QFM) buffers. The estimated position of the biotite solid solutions for each of these buffers is shown in Figure X together with the composition of the biotite from the Kuala Lumpur granite. As the Fe^{3+} contents were not determined separately, the Fe^{3+} in the biotites were recalculated so that $Fe^{3+}/(Fe^{2+} + Fe^{3+}) = 0.11$ [7]. The general trend shown by the biotite from the Kuala Lumpur granite is parallel to the estimated composition of biotite solid solution for individual buffers. This trend suggests that consanguineous granitoid were buffered during crystallisation, fO_2 increasing with decreasing temperature. The plot shows that the compositions of the biotites under study were defined by fO_2 near to that of the SiO_2-Fe_2SiO_4-Fe_3O_4 buffer (Figure 5).

CONCLUDING REMARKS

In general, chemistry of the biotite from Kuala Lumpur is similar to the biotite crystallized from peraluminous melt [8],[9],[10],[11]. They are characterized by high Al_2O_3 (wt%). The peraluminous nature of the biotite is also an evident from Fe/Fe+Mg vs Al^{iv} diagram, where all the biotite from Kuala Lumpur granite plots in peraluminous field. This may suggests that the chemistry of the biotite in the Kuala Lumpur granitic rocks depends largely upon the nature of the magma i.e. peraluminous [2]. However the biotite also show some intersamples variation. Biotite from Deform facies have low TiO_2, Cr_2O_3 and BaO and high FeO content compared to those from the normal and contact facies and biotite from the contact facies have low Al_2O_3, low Al^{vi} and high Al^{iv} and MgO.

Biotites from Caledonian granites (British Isles) and Cordilleran granites (North American) have been plotted in Mg vs Al^{vi}+Fe^{3+}+Ti vs Fe^{2+}+Mn for comparison with the biotites from the Kuala Lumpur granites. In general, biotites from the Kuala Lumpur granite have low Mg and high Fe compared to those from Cordilleran and Caledonian granites. Compared to other trioctahedral mica [12] the biotite from Kuala Lumpur granite has high FeO and slightly low K_2O contents.

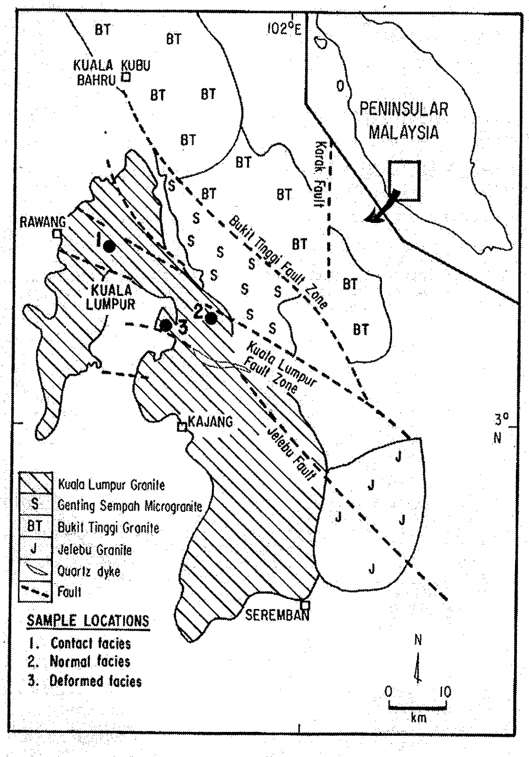


Figure 1.

Regional geology of the Kuala Lumpur and its surrounding area.

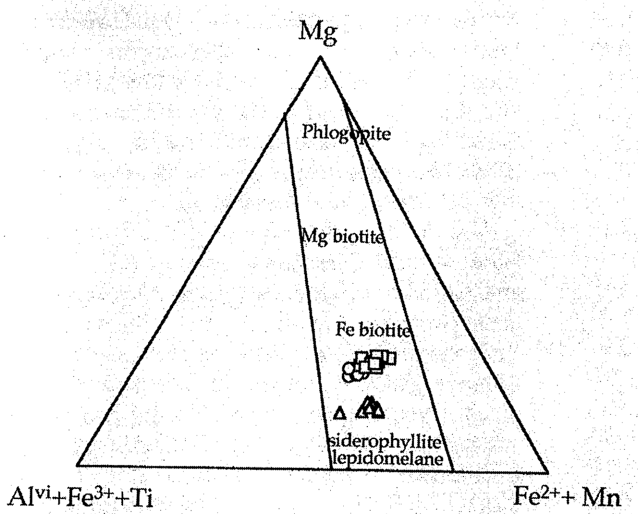


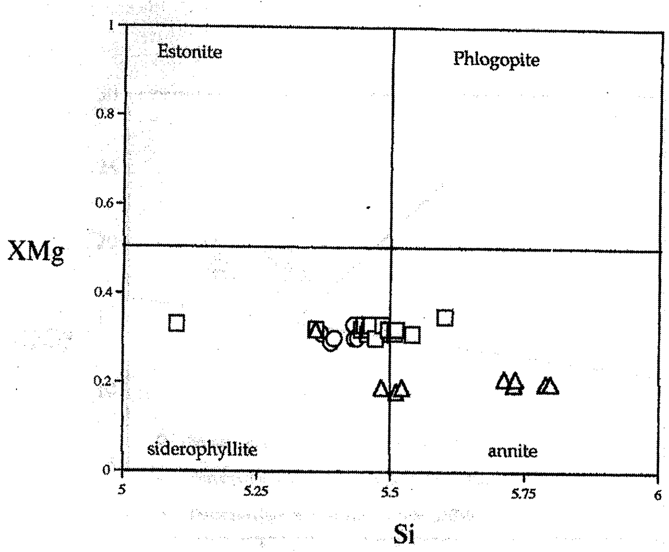
Figure 2.

Mg vs Al^{vi}+Fe^{3+}+Ti vs Fe^{2+}+Mn diagram (Foster 1960) for biotite from the Kuala Lumpur granite.

Figure 3.

XMg vs Si diagram for biotite from the Kuala Lumpur granite

○ Equigranular biotite muscovite granite (NBMG)
Porphyritic biotite muscovite granite (PBMG)
□ Deformed biotite muscovite granite



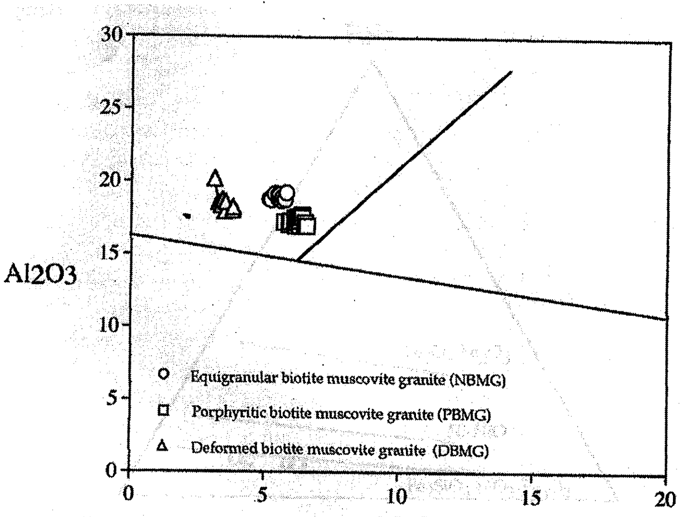


Figure 4.

Al_2O_3 vs MgO diagram (after Abdel Rahman 1994) for biotite from the Kuala lumpur granite.

Figure 5.

The relationship between Fe^{3+}-Fe^{2+}- Mg contents of biotite from the Kuala Lumpur granite (Fe^{3+}: calculated values). The estimated position of biotite defining the HM, NNO and QFM oxygen buffer are shown in heavy lines (Wones and Eugster 1965)

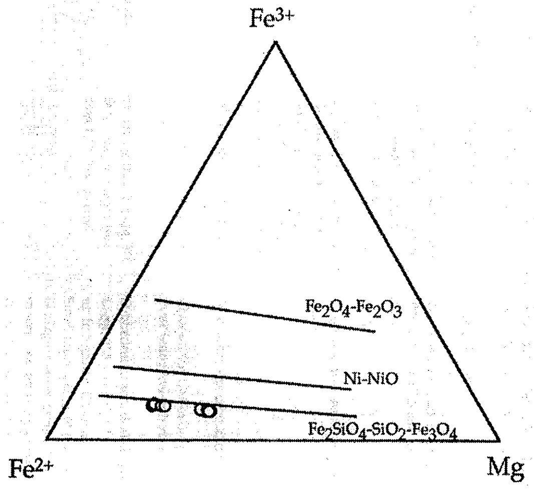


Table 1: Mineralogical and petrological characteristics of the three samples where the biotite occurs.

	PBMG (CONTACT)	NBMG (NORMAL)	DSMG (DEFORMED)
Mineralogy	Kf, Plag, Qtz, Bio, Musc, Tour Tour, Zir, Opaque, Apa.	Kf, Plag, Qtz, Bio, Musc, Tour, Zir, Opaque, Apa.	Kf, Plag, Qtz, Bio, Musc, Tour, Zir, Opaque, Apa.
General Texture	Porphyritic	Equigranular	Equigranular, deformed
Biotite	X= black brown, Y= foxy red brown. Small crystal (<1.5 mm). Chloritised, Pleochroic haloes	X= olive, Y = dark brown, 0.5 to 2 mm. Chloritised	X= olive, Y = dark brown, 0.5 to 3 mm in size. Highly chloritised)pale green)
Plagioclase	2 phase, small euhedral as inclusion in Kf (<0.5 mm) and large euhedral to subhedral (up to 6mm) Zoning - well developed.	Subhedral to anhedral (up to 4 mm)	Small subhedral to anhedral (<2 mm).
K-feldspar	Microcline - microperthite	Microcline - microperthite	Microcline microperthite
Accessory Mineral	Opaque, Zir (inc in Bio), Apa	Opaque, Zir (inc in Bio), Tour (euhedral-anhedral).	Opaque, Zir (inc in Bio), Tour (anhedral).
Muscovite	Skeletal grains in plag/Kf. Small inc. in plag is less common (Secondary)	Subhedral to anhedral shape, Large (0.5 – 3 mm), Clot up to 5 grains (primary). Small musc grains (0.1 mm) in plagioclase or as an alteration product along grain boundary (Secondary).	Secondary skeletal, replace plagioclase and main component of the foliation.

Kf: K-feldspar; **Plag:** Plagioclase; **Qtz:** Quartz; **Bio:** Biotite; **Musc:** Muscovite; **Zir:** Zircon; **Apa:** Apatite; **Tour:** Tourmaline, **Opaque:** Opaque phases

Table 2. Representative composition of the biotite from the Kuala Lumpur granites.

Sample Loc	PBMG Core Contact	PBMG Rim Contact	PBMG Core Contact	PBMG Rim Contact	NBMG Core Normal	NBMG Rim Normal	NBMG Core Normal	NBMG Rim Normal	DBMG Core Deform	DBMG Rim Deform	DBMG Core Deform	DBMG Rim Deform
SiO_2	34.9	32.28	35.07	34.9	34.57	34.57	35.53	35.66	35.03	35.22	36.77	36.3
TiO_2	3.17	7.54	3.25	2.6	3.52	3.01	2.77	3.08	2.25	2.08	1.69	1.68
Al_2O_3	17.3	17.6	17.06	17.18	18.68	18.76	19.06	18.89	18.72	18.6	18.23	18.02
Cr_2O_3	0.08	0.06	0.13	0.14	0.2	0.07	0	0.11	0.02	0.04	0	0
FeO	23.98	22.97	23.06	23.06	22.74	22.95	21.63	21.39	26.71	26.25	25.25	24.44
MgO	6.09	6.19	5.88	6.18	5.6	5.53	5.55	5.64	3.41	3.52	3.81	3.79
CaO	0	0.2	0	0	0	0.06	0	0.03	0	0.012	0	0.1
Na_2O	0.41	0.32	0.4	0.2	0.41	0.19	0.27	0.35	0.32	0.45	0.22	0.33
K_2O	9.13	6.03	9.33	9.43	9.24	8.88	9.28	9.55	9.27	8.91	9.2	8.81
BaO	0.03	0.43	0.15	0.14	0.31	0.35	0.55	0.25	0	0	0	0.17
Total	**95.19**	**93.45**	**94.55**	**94.45**	**95.28**	**94.32**	**94.64**	**94.94**	**95.73**	**95.19**	**95.41**	**93.63**
Structural formulae based on 22 oxygen												
Si	5.46	5.08	5.51	5.5	5.37	5.39	5.48	5.51	5.48	5.52	5.71	5.73
Al^{iv}	2.54	2.92	2.49	2.5	2.63	2.61	2.52	2.49	2.52	2.48	2.29	2.27
Z site	8	8	8	8	8	8	8	8	8	8	8	8
Al^{iv}	0.65	0.34	0.67	0.68	0.79	0.85	0.98	0.95	0.94	0.96	1.05	1.09
Cr	0.01	0.01	0.02	0.02	0.03	0.01	0	0.01	0	0.01	0	0
Fe^{3+}	0.35	0.33	0.34	0.34	0.33	0.33	0.31	0.3	0.38	0.38	0.36	0.36
Fe^{2+}	2.79	2.69	2.7	2.76	2.63	2.67	2.5	2.46	3.11	3.07	2.95	2.87
Mg	1.42	1.45	1.38	1.45	1.3	1.29	1.29	1.3	0.8	0.82	0.88	0.89
Ti	0.37	0.89	0.38	0.31	0.41	0.35	0.32	0.36	0.27	0.25	0.2	0.2
Y site	5.58	5.71	5.47	5.56	5.49	5.5	5.4	5.38	5.5	5.47	5.44	5.41
Ca	0	0	0	0	0	0.1	0	0	0	0.02	0	0.02
Na	0.12	0.1	0.12	0.06	0.12	0.06	0.08	0.11	0.08	0.14	0.07	0.1
K	1.82	1.21	1.87	1.89	1.83	1.77	1.84	1.88	1.85	1.78	1.82	1.78
Ba	0	0.03	0.01	0.01	0.02	0.02	0.03	0.02	0	0	0	0.01
X site	1.95	1.34	2.001	1.95	1.86	1.86	1.96	2.01	1.93	1.94	1.89	1.9

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