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K-Ar dating of micas from granitoids in the Kuala Lumpur-Seremban area

KWAN TAI SEONG

Geological Survey of Malaysia
Alor Setar

Abstract : The granitoids in the area represent the southern component of the N-S trending Main Range Batholith, with the Kuala Lumpur pluton predominating in the western half of the area. This pluton consists mainly of a medium to coarse-grained megacrystic muscovite-biotite granite. It is an important source of tin deposits in the vicinity of Kuala Lumpur and Seremban, and is commonly genetically related to pegmatites. Cobbing and Mallick (1987) divided the other granitoids present based on their textural and mineralogical characteristics. These granitoids include the Tampin, Chembong, Jelebu, Kuala Kelawang, Genting Sempah, Bukit Tinggi and Manchis plutons. Besides these, small satellite ultrabasic intrusives occur in the northeast. They are believed to predate the granitoids.

Metasedimentary rocks, Silurian to Carboniferous in age, are the dominant country rocks. The presence of Permian to Triassic sequences is restricted to the northeast.

The major faults in the area strike SE and show left-lateral displacements. They are commonly filled with vein quartz to form occasional topographically prominent features such as the Klang Gates ridge. Gobbett and Tjia (1973) and Hutchison (1986) suggested a post-early Cretaceous age for these faults.

K-Ar dates of biotites from the granitoids varied between 82 ± 3 Ma and 214 ± 6 Ma. Muscovites from the Kuala Lumpur pluton gave apparent ages ranging from 160 ± 5 Ma to 212 ± 6 Ma while those from their associated pegmatites yielded values varying between 164 ± 5 Ma and 218 ± 7 Ma. The older mica dates for the Kuala Lumpur pluton are considered to represent its emplacement age. The U-Pb zircon ages of 211^{+5}_{-8} Ma and 215^{+2}_{-4} Ma established by T.C. Liew (1983) support this. Resetting of K-Ar ages is evident in the rest of the micas and their patterns of distribution indicated relatively higher retentivity of radiogenic argon for samples in the northwestern part of this pluton. Muscovites from the pegmatites displayed a somewhat similar pattern that is interpreted to be a result of a superimposed thermal effect on their cooling trend.

The U-Pb age of 219^{+5}_{-9} Ma for the Genting Sempah pluton (T.C. Liew, 1983) is concordant with a K-Ar biotite age of Bignell and Snelling (1977) and their Rb-Sr isochron age for the Jelebu pluton, thus suggesting the probability that these granitoids were emplaced during a single episode. However, their K-Ar biotite ages indicated a greater influence of the Cretaceous event known further southeast.

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INTRODUCTION

The area investigated is situated at the southwestern part of Peninsular Malaysia and bounded approximately by latitudes 2° 36'N to 3° 29'N and longitudes 101° 30'E to 102° 10'E (Figure 1).

The granitoids form the southern component of the North-South trending Main Range and are important sources of alluvial tin particularly in the western part in the vicinity of Kuala Lumpur and Seremban.

This paper presents the results of K-Ar age determinations of micas mainly from the Kuala Lumpur pluton and its associated pegmatites and attempts to consolidate the results of previous geochronological work by other researchers to provide a better understanding of the emplacement history of the granitoids in this part of the Main Range Batholith.

GEOLOGY

The Granitoids

The Kuala Lumpur pluton constitutes about half of the area occupied by granitoids in this region. It is predominantly made up of a medium to coarse-grained variably megacrystic muscovite-biotite granite (Semenyih unit) and a subordinate coarse-grained megacrystic biotite granite (Lanjan unit) which is restricted in occurrence to the northwestern part. This pluton is believed to be genetically related to tin mineralisation in the Kuala Lumpur tin field. Pegmatites, in the form of dykes 1 to 2 metres thick and irregular stringers 1 to 2 cm across were commonly seen to cut the Semenyih unit. They carried mainly quartz, feldspar, tourmaline, muscovite and occasionally cassiterite.

The subdivision of the other granitoids adopted here is a consequence of a granite study jointly conducted by the British Geological Survey and its Malaysian counterpart from 1981 to 1982 (Cobbing & Mallick, 1987). Based on mineralogical and textural characteristics, four plutons have been recognised in the southeastern part adjacent to the Kuala Lumpur pluton. They are the Kuala Kelawang pluton (G^{KK}), the Jelebu pluton (G^{JL}), the Chembong pluton (G^{CB}) and the Tampin pluton (G^{TP}). No known tin mineralisation is associated with these plutons.

The Tampin pluton forms the southern extremity of the Main Range Batholith. It consists mainly of a coarse-grained megacrystic biotite granite. Large areas of this pluton have been observed to be affected by intense cataclastic deformation which resulted in the presence of foliated varieties.

The Chembong pluton is less strongly foliated than the Tampin pluton and is described as a predominantly coarse-grained sparsely megacrystic biotite granite. No field contacts have been observed between the Tampin and Chembong plutons.

The Jelebu pluton is made up of a fine to medium-grained, equigranular megacrystic biotite granite. There are certain varieties of the Chembong pluton which resemble the Jelebu pluton lithologically. No field relationship has been established between the Jelebu and the Kuala Lumpur plutons. However, the Jelebu pluton was seen to cut the Tampin pluton at Kg. Terang, adjacent to the Sg. Muar.

The Kuala Kelawang pluton consists mainly of a medium to coarse-grained megacrystic biotite granite and occupies a relatively small area in the neighbourhood of Kuala Kelawang. It appears to be cut by small plutons which have been assigned to the Kuala Lumpur suite. Textural similarities exist between the Jelebu and Kuala Kelawang plutons, thus indicating that they are related.

It is probable that the Chembong, Jelebu and Kuala Kelawang plutons are physically continuous to form a north-south trending belt in the central part of the Main Range Batholith.

The age relationships between these plutons observed in the field so far appear to indicate that the Tampin pluton is the oldest unit and these four plutons were emplaced earlier than the Kuala Lumpur pluton.

Towards the northeastern part three other granitoids have been observed, viz. the Genting Sempah pluton (G^{GS}), the Bukit Tinggi pluton which is predominantly made up of the Gap granite unit (G^{GP}) and the Ulu Kali granite (G^{UK}), and the Manchis (G^{MC})Pluton.

The Genting Sempah pluton has been described as consisting essentially of a fine to medium-grained, equigranular microgranite with small megacrysts of quartz, feldspar and biotite. This pluton is located principally between two major faults. Shu (1968) noted that this pluton was invaded along joints by aplite and pegmatite veins associated with the Kuala Lumpur pluton. He also observed that the marginal phases of the Genting Sempah pluton could become tuffaceous or rhyolitic in appearance. The available evidence indeed suggests that these rocks in the marginal regions of the pluton had penetrated a very high level of emplacement.

Besides the Gap and Ulu Kali granite suites, other rock types have been recognised in the Bukit Tinggi pluton, viz. the Sg. Senaling granite unit and the Sg. Rodah microgranite. Mapping of the various units of this pluton has been hindered by the variation in their textural characteristics and the effects of cataclastic deformation. The Gap granite which is a coarse-grained megacrystic biotite granite is presumably the oldest unit. This outcrops as a marginal band with the Ulu Kali granite occupying the core. The Ulu Kali unit is made up of a medium to coarse-grained megacrystic biotite granite. Exposure of the Sg. Senaling granite unit which is a medium-grained, equigranular sparsely megacrystic biotite granite has been described as poor and restricted to the less accessible region in the upper stream courses to the west of Telemong. The Sg. Rodah microgranite, on the other hand, is widespread and generally forms dykes and sills besides also occurring as stocks or small bodies. This predominantly fine to medium-grained biotite granite with megacrysts of K-feldspar, plagioclase and quartz which represent xenocrysts derived from earlier phases such as the Gap and Ulu Kali units, had been affected by major cataclastic deformation. Alluvial tin is known to be associated particularly with the microgranitic varieties in the western part of this pluton.

The Manchis pluton occurs east of the Bukit Tinggi pluton. This body of essentially coarse-grained megacrystic biotite granite bears a close resemblance to the Teris pluton further towards the northeast. Its association with tin mineralisation on the western flank has been noted.

Other Intrusives

Besides these granitoids, small bodies of ultrabasic intrusives which had been commonly altered to serpentinite, are present in the northeastern part of the area. The age of these are not precisely known, but are believed to be older than the granitoids in the area (Hutchison, 1973).

The Country Rocks

The following description of the country rocks is made with reference to the 8th Edition of the Geological Map of Peninsular Malaysia (1985) compiled by the Geological Survey of Malaysia on a scale of 1:500 000.

Fringing the granitoids in the northwestern portion of the area are rocks of Silurian age consisting mainly of schists, phyllites and slates with localised occurrences of limestones; and Devonian rocks mostly sandstones with minor phyllites, schists and slates.

Carboniferous phyllites, slates, shales and sandstones predominate in the Kuala Lumpur area. The argillaceous units of these rocks are commonly carbonaceous. Silurian rocks are subordinate here. These include limestones in the Batu Caves area besides schists, phyllites, slates and minor sandstones.

Rocks of Devonian age are predominant in the area southwest of the granitoids from Kajang to the southern extremity of the Main Range near Malacca. These are made up of phyllites, schists and slates with the restricted presence of sandstones, shales, mudstones and siltstones which may be thermally metamorphosed near the intrusive contacts.

A screen of Silurian rocks occur in the central part of the granitoids which is bounded by the major NW-SE trending faults.

Bordering the granitoids in the eastern part are rocks of Silurian to Devonian age. A sequence of Permian rocks consisting of phyllites, slates and shales with subordinate sandstones and schists outcrop further east. This sequence is succeeded by a Triassic series of interbedded sandstones/siltstones and shales with the limited occurrence of conglomerate and chert.

The complex fault pattern in the area has been recognised by Shu (1969). SE striking faults are dominant. These are represented by the Bukit Tinggi Fault zone, the western end of the Kuala Lumpur-Endau Fault zone and other subparallel faults. They exhibit left-lateral displacements and are commonly filled with vein quartz, the largest of which is the Klang Gates ridge. The other sets of fractures in the area include those striking NE (extension joints), NS and ESE which are considered to be second order shear joints.

Gobbett and Tjia (1973) noted that the offsets of the Lower Paleozoic rocks brought about by the major faults are of the same order as those of the granitoids present here and the Early Cretaceous Tebak Formation in East Johore. This suggests that movement along these faults is predominantly if not entirely post-Early Cretaceous. Hutchison (1986) substantiated this by stating that the two known Late Cretaceous granite localities of Gunung Ledang and Gunung Pulai further towards the southeast lie on this fault trend. In addition, the location of these fault traces is shown by numerous Tertiary basins and the thick Older Alluvium of South Johore and Singapore.

PREVIOUS GEOCHRONOLOGICAL WORK

Bignell and Snelling (1977) undertook both Rb-Sr and K-Ar dating of these granitoids. The results of their work are shown in Tables la, lb, and Figures 2 to 4. All ages shown have been recalculated using the constants recommended by Steiger and Jaeger (1977).

Eleven samples of micas from nine localities (Figure 1) were used for K-Ar age determinations. The apparent ages obtained range from 94 ± 3 Ma to 213 ± 4 Ma. The oldest age is for a biotite-bearing rhyolite (Sample 149) collected from the marginal zone of the Genting Sempah pluton. Most of these micas were considered to have suffered argon loss as a result of subsequent plutonic and/or volcanic activity, faulting and mineralisation.

In Figure 2, two isochrons were suggested by Bignell and Snelling (1977), viz. 283 ± 7 Ma, R_1 = 0.7106 ± 0.0010 and 225 ± 3 Ma, R_1 = 0.7095 ± 0.0005. The older isochron was constructed with 8 samples and has a MSUM (ratio of 'sum of squared residuals' to 'degrees of freedom') of 5.5. Five of these samples were collected from this area of which 4 (Samples 174, 175, 176 and 179) are from the Semenyih unit of the Kuala Lumpur pluton and the other (Sample 169) is from the Kuala Kelawang pluton. The rest of the samples were gathered east and southeast of the area. The high MSUM was attributed to an open system behaviour or the effect of grouping rocks of different ages or initial $^{87}Sr/^{86}Sr$ ratios, thus invalidating the accuracy of this isochron age.

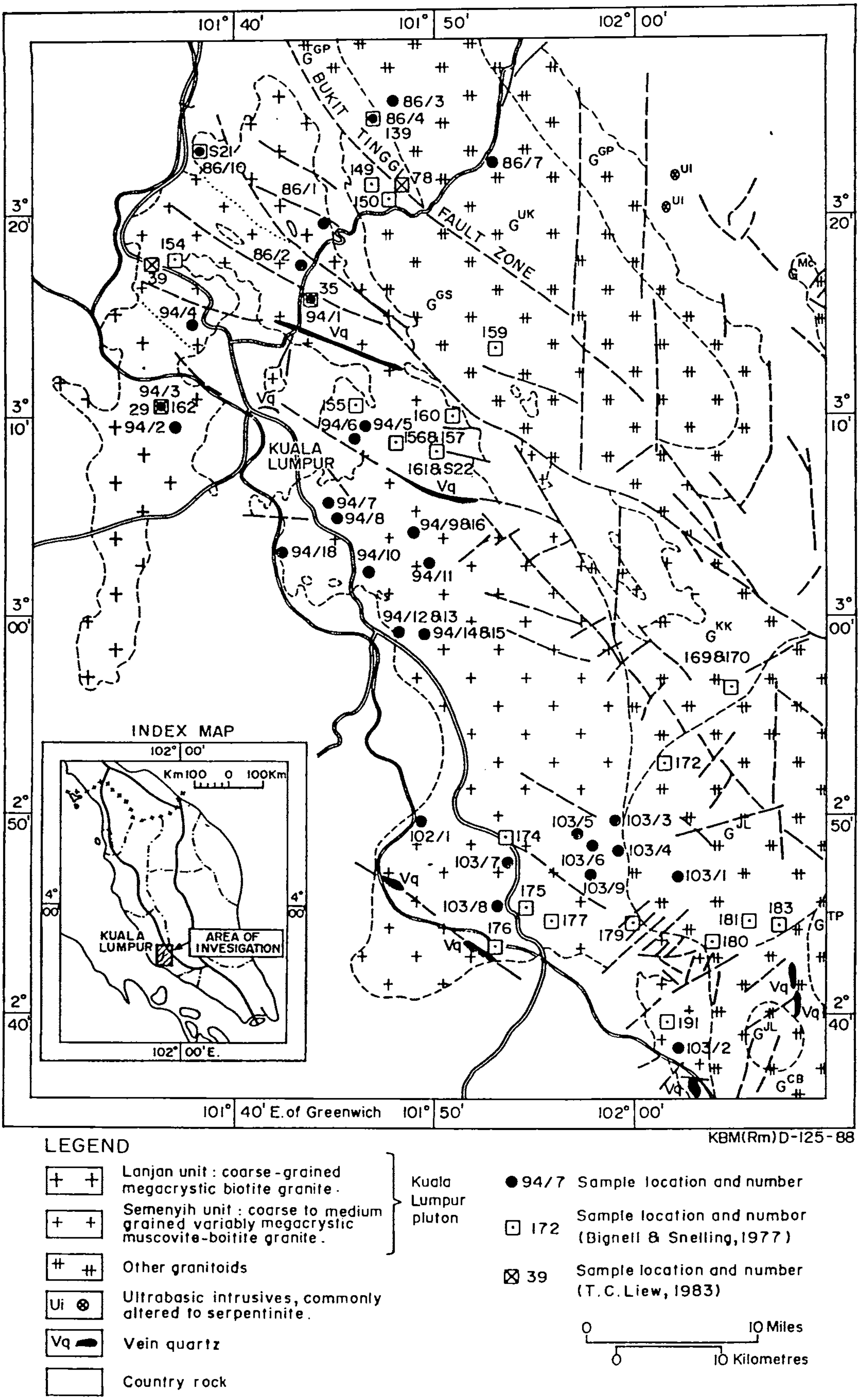

Figure 1 : Geology and sample locations.

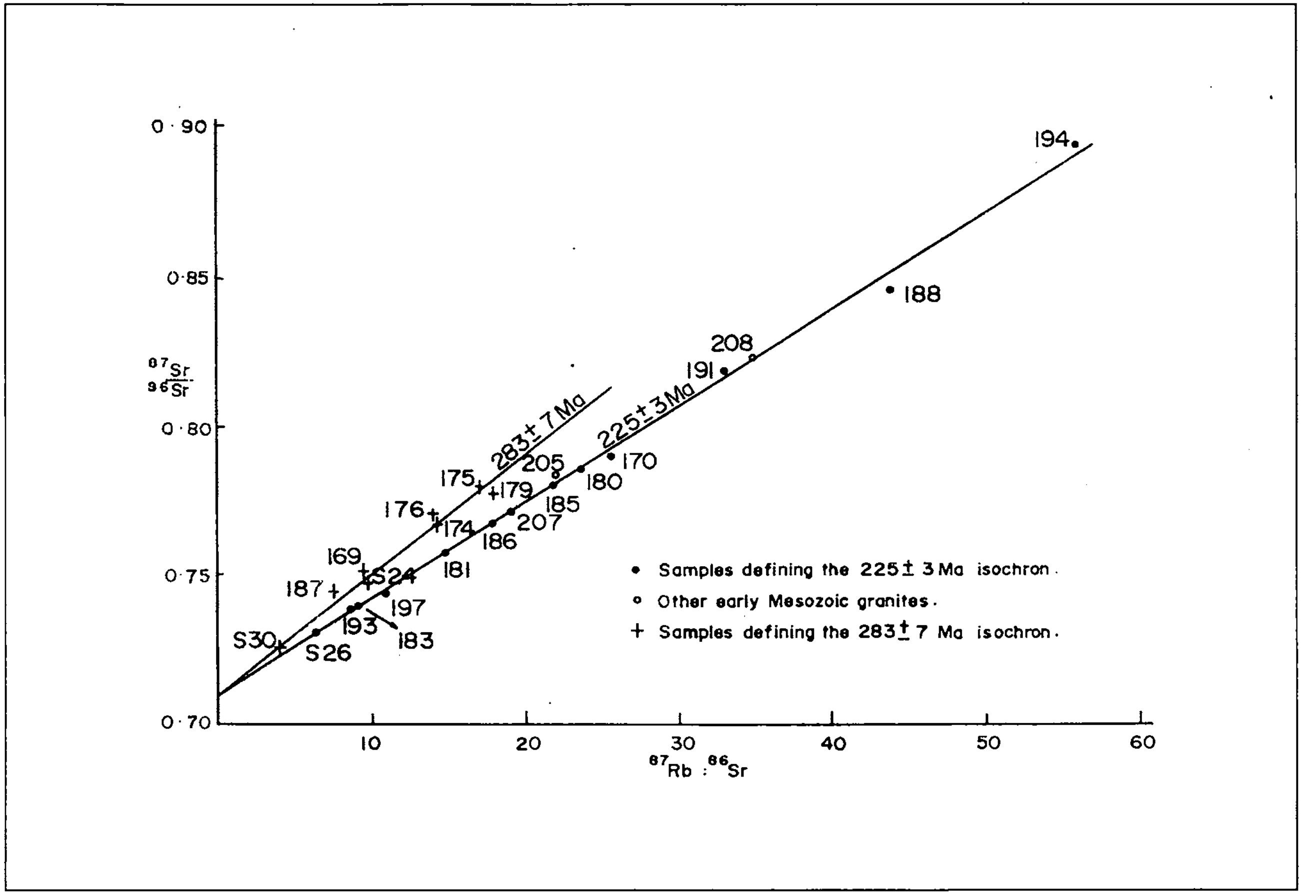

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Figure 2 : Isochron diagram for late Paleozoic and Early Mesozoic granites from the Main Range batholith and adjacent plutons in Negeri Sembilan, Malacca and parts of Johore (Bignell & Snelling, 1977).

Table 1a : K-Ar age determinations of granites from the Kuala Lumpur-Seremban area (Bignell & Snelling, 1877)

Sample No.	%K	Vol.$^{40}Ar_{rad}$/g (x10^{-6} ccm STP)	Age in Ma
139 Bi	6.59	24.82	94 ± 3
149 Bi	5.65	49.03	213 ± 4
156 Bi	6.20	33.51	134 ± 3
156 Mu	8.85	61.75	172 ± 4
157 Mu	8.28	52.73	157 ± 4
161 Hu	8.75	63.26	178 ± 7
162 Bi	4.41	54.07	205 ± 5
172 Bi	5.39	27.29	126 ± 3
175 Bi	7.19	49.25	169 ± 5
177 Mu	8.26	56.59	169 ± 5
S21 Bi	5.65	43.20	187 ± 5
S22 Bi	5.45	29.31	133 ± 6
S22 Mu	8.97	69.76	189 ± 8

Table 1b : Whole-rock Rb-Sr data for granites from the Kuala Lumpur-Seremban area (Bignell & Snelling, 1977)

Sample No.	ppm Rb	ppm Sr	$^{87}Rb:^{86}Sr$	$^{87}Sr:^{86}Sr$
139	345	73.00	13.70	0.7484
150	245	150	4.74	0.7397
154	602	17.80	97.88	1.0113
155	725	6.69	314.0	1.5885
156	643	18.10	102.8	1.0149
159	257	169	4.40	0.7369
160	438	74.80	17.06	0.7750
162	477	40.20	34.32	0.8368
169	375	113	9.64	0.7505
170	498	56.5	25.51	0.7896
174	443	89.9	14.35	0.7679
175	418	70.2	17.24	0.7805
176	380	78.2	14.14	0.7708
179	453	73.4	19.99	0.7779
180	541	66.7	23.64	0.7852
181	377	74.1	14.81	0.7572
183	358	116	9.01	0.7391
191	589	52.1	33.04	0.8180
S21	345	68.80	14.56	0.7532

The younger isochron of 225 ± 3 Ma was assigned to samples that were collected mainly from localities east and southeast of the area. However, 5 samples, viz. 3 from the Jelebu pluton (Samples 180, 181 and 183) and 1 each from the Kuala Kelawang pluton (Sample 170) and the Semenyih unit of the Kuala Lumpur pluton (Sample 191) were included in this isochron diagram. The MSUM for this 12-point plot is 1.1 which was considered to be attributable to experimental error alone. However, taking into consideration only samples of the Jelebu pluton (Samples 180, 181, 183, 185 and 186), an isochron of 221 ± 6 Ma, R_1 = 0.7108 ± 0.0017 was obtained. This isochron has a MSUM value of 0.007.

Figure 3 shows the isochron diagram of Bignell and Snelling (1977) for samples exclusively from the Kuala Kubu Bharu-Gap Road. A 206 ± 2 Ma isochron age was ascribed to this presumably Bukit Tinggi suite with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7110 ± 0.0010. The MSUM for this isochron is 3. With the inclusion of samples from this area, viz. Samples 138 and 139 from the Bukit Tinggi pluton; Samples 154, 155 and 156 from the Semenyih unit and Sample S21 from the Lanjan unit of the Kuala Lumpur pluton, no change in the isochron age was effected. However, a lower initial Sr ratio of 0.7106 ± 0.007 was obtained together with a slightly higher MSUM value of 3.3. The MSUM value in both cases is near the specified limit of acceptance. However, this age appears to be supported by U-Pb ages of T.C. Liew (1983) to be discussed later.

Figure 4 is a composite isochron diagram from Bignell and Snelling (1977) for samples from the Kuala Lumpur/Fraser's Hill region. Two samples from the Kuala Lumpur pluton, viz. Sample 160 (Semenyih unit) and Sample 162 (Lanjan unit) have been assigned to the 245 5 Ma, R_1 = 0.7136 ± 0.0019 isochron. The other 4 samples defining this isochron did not possess any unique and unifying petrographic feature and were collected from geographically scattered localities. As such, the authors had chosen not to refer to this array of apparently colinear points as a geologically meaningful isochron. Two samples of the Genting Sempah pluton, viz. Samples 150 and 159 plotted above the 290 ± 10 Ma isochron shown in the diagram. Together with another lithologically similar sample from the Kuala Kubu Bharu-Gap Road (Sample 90), they defined an 'isochron' of 447 ± 113 Ma, R_1 = 0.7079 ± 0.0077. The MSUM value for this 'isochron' is 0.28. Bignell and Snelling (1977) had considered this .isochron' to be unreliable on account of its large error and small MSUM which reflected the close bunching of points.

T.C. Liew (1983) did U-Pb dating of zircons from granitoids collected from 4 localities in the area (Figure 1). They included 3 samples from the Kuala Lumpur pluton (Samples 29, 35 and 39) and a sample from the Genting Sempah pluton (Sample 78). Besides these, 3 other samples (Samples 38, 41 and 45) from granitoids occurring north of the area were also examined. Sample 38 was collected from the JKR quarry in Bentong while the other 2 samples were gathered from the Kuala Kubu Bharu-Gap Road.

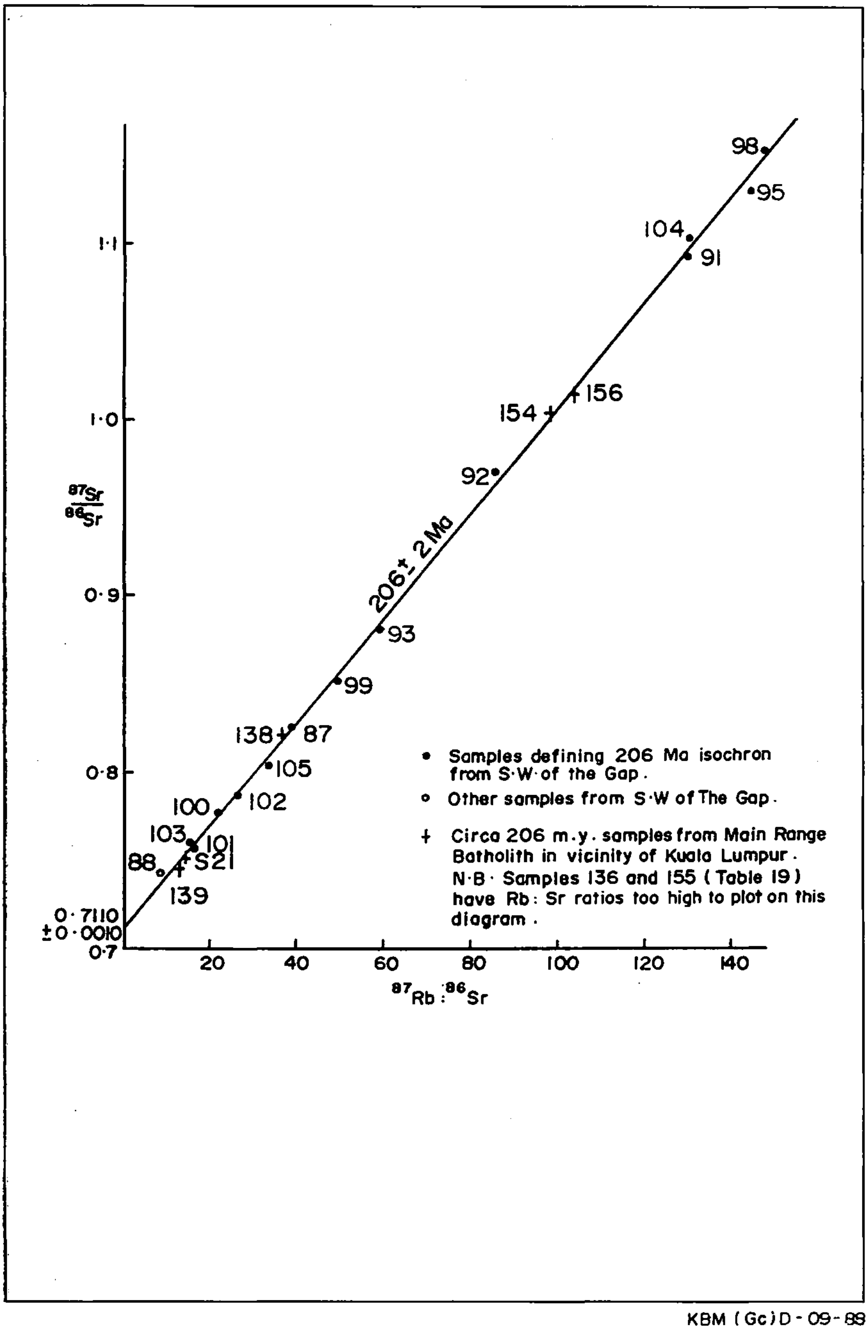

Figure 3 : Isochron diagram for samples from the Gap Road defining a 206 ± 2 Ma line (Bignell & Snelling, 1977).

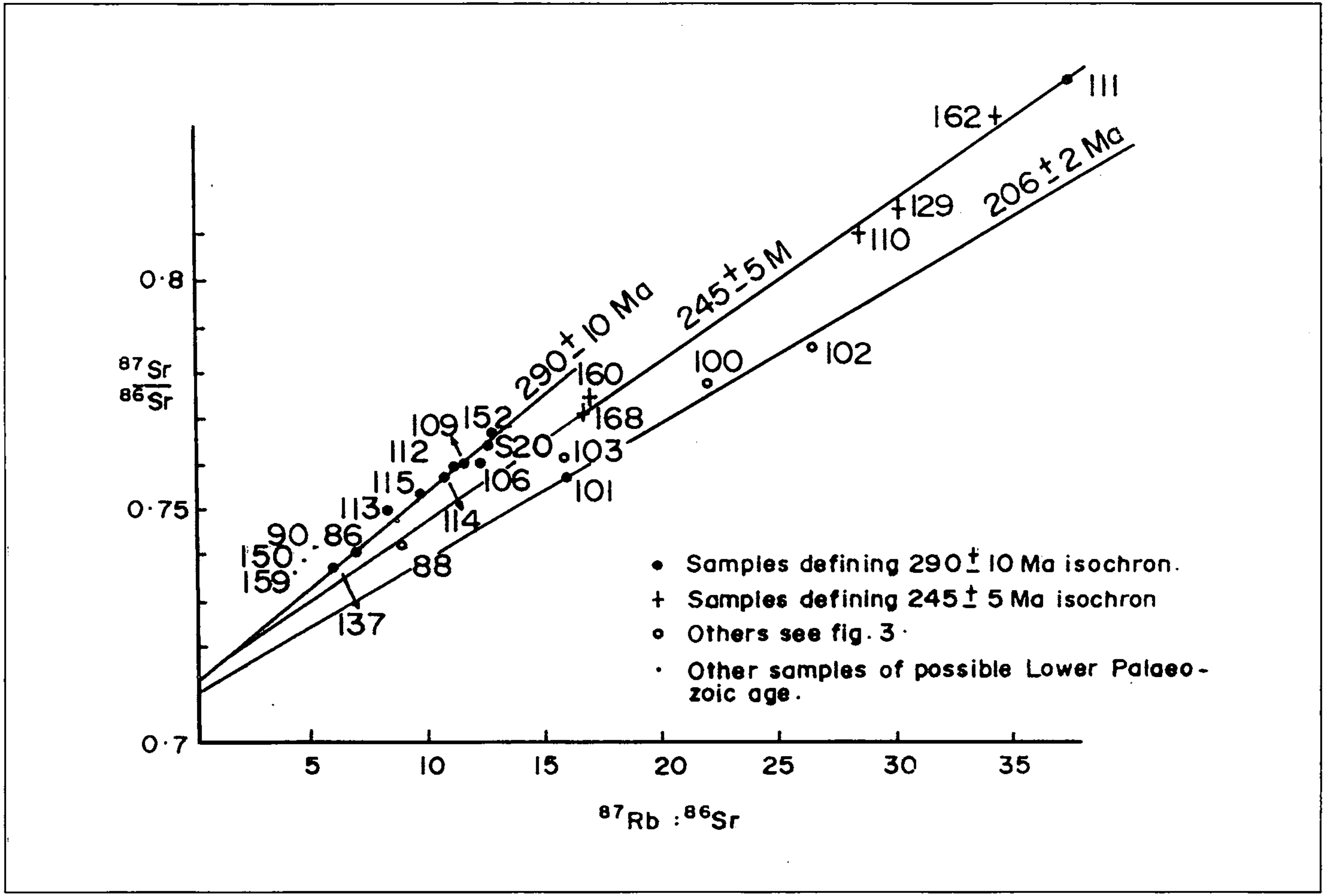

Figure 4 : Isochron diagram for samples from the Kuala/Fraser's Hill region (Bignell & Snelling, 1977)

Samples 29, 35 and 39 yielded reverse discordia paterns and lower intersections with concordia of 215^{+2}_{-4} Ma , 211^{+5}_{-8} Ma and 215^{+2}_{-4} Ma respectively. Sample 78 from the Genting Sempah pluton also showed a similar pattern that gave a lower intersection with concordia of 219^{+5}_{-9} Ma.

Some fractions of the samples collected north of the area, however, plotted concordantly. Three fractions each from Samples 38 and 41 gave mean $^{206}Pb/^{238}U$ ages of 198 ± 2 Ma and 206 ± 2 Ma respectively while 2 other fractions of Sample 45 (Tranum granodiorite) yielded an age of 208 ± 2 Ma. Samples 38 and 41 belong to the Ulu Kali suite of the Bukit Tinggi pluton. The difference in their U-Pb ages has been attributed to either an extended intrusive history or the possibility of a different and younger suite of rocks in that area. Nevertheless, the U-Pb age of 206 ± 2 Ma for Sample 41 appears to be concordant with the Rb-Sr isochron age established by Bignell and Snelling (1977) for granitoids in this region.

Yap and Kwan (1985) presented the results of K-Ar age determination on some of the muscovites in pegmatites from the northern part of the area. Ages ranging from 187 ± 6 Ma to 215 ± 7 Ma were obtained. The older K-Ar dates are concordant with the U-Pb zircon ages of T.C. Liew (1983), thus indicating that they represent the emplacement age of the pegmatites.

PRESENT WORK

For this study, the granitoids and/or muscovites in pegmatites from 30 localities were collected (Figure 1). At each pegmatite locality, usually more than 1 sample were collected. The muscovites were hand-picked in the field and then processed in the laboratory by grinding under alcohol, sieving and separating with magnetic separators as well as shaking tables. Sampling of the granitoids involved the collection of 30 kg each of the rocks. These samples were subjected to the conventional methods of mineral separation to obtain the mica concentrates. The 60 to 80 ASTM mesh size fractions were normally selected for K-Ar age determination.

The measurement of potassium was accomplished with the use of an Instrumentation Laboratory Model IL443 flame photometer with a lithium internal standard. The equipment has a quoted precision of 0.61% relative standard deviation. Argon isotopic compositions were determined by the isotope dilution method (Flisch, 1982) with a VG 1200 MM mass spectrometer. The constants recommended by Steiger and Jaeger (1977) were used for the K-Ar age computations. The estimated error for these ages is less than 4% at the 95% confidence level.

RESULTS AND DISCUSSION

The analytical K-Ar results for the micas are appended (Appendix 1). Apparent ages ranging from 82 ± 3 Ma to 214 ± 6 Ma were recorded for biotites from the granitoids, while the muscovites of these rocks, wherever present, yielded dates that varied between 160 ± 5 Ma and 212 ± 6 Ma. The range of K-Ar ages for muscovites from the pegmatites is from 164 ± 5 Ma to 218 ± 7 Ma. The older mica dates are concordant with the U-Pb zircon ages of these granitoids established previously by T.C. Liew (1983). Argon loss as a consequence of thermal disturbance is considered to be responsible for the pattern of distribution of the other K-Ar mica dates.

Figure 5 shows a plot of %K against the radiogenic argon content for micas from the granitoids (after Harper, 1970). A reference line is drawn from the oldest mica date (Sample 94/3) to the origin. Assuming that this date approximates the age of emplacement of the granitoids, all points that plot below this line would indicate amples that have suffered argon loss to varying degrees; the further the deviation, the greater the extent of argon loss. The biotites in the area appear to have a wider range of argon loss than the muscovites. This greater retentivity of radiogenic argon in muscovites is also observed in individual samples.

Within the Kuala Lumpur pluton, the biotites from the northern part, particularly the western lobe (Samples 94/2 and 94/3) suffered less argon loss than those of the southern portion. The greatest thermal disturbance had apparently affected the biotites from the other granitoids, notably Samples 86/3, 86/4 and 86/7 from the Bukit Tinggi, and Sample 103/1 from the Jelebu pluton. The biotite dates for these samples range from 82 ± 3 Ma to 97 ± 3 Ma, thus suggesting the known Cretaceous event further southeast as a possible source of this thermal effect. The muscovites from the Semenyih unit of the Kuala Lumpur pluton seem to show a similar trend as the biotites in these rocks.

A plot similar to Figure 5 was made for muscovites from the pegmatites in the area (Figure 6). A general southeasterly trend of decrease in ages is again apparent. These pegmatites are known to be related to tin mineralisation, and considering the distribution of tin deposits in the area, this resultant trend of decreasing ages is probably a relict pattern of their cooling ages which now bears the effect of a later thermal disturbance.

CONCLUSION

The older K-Ar mica dates are concordant with the U-Pb emplacement ages of 211^{+5}_{-8} Ma to 215^{+2}_{-4} Ma established by T.C. Liew (1983) for the Kuala Lumpur pluton.

The U-Pb age of 219^{+5}_{-9} Ma of T.C. Liew (1983) for the Genting Sempah pluton and the K-Ar age of 213 ± 4 Ma for a biotite-bearing rhyolite at the marginal zone of this pluton (Bignell and Snelling, 1977) do not indicate any significant difference in the emplacement ages for the other granitoids. This is substantiated by the Rb-Sr isochron age of 221 ± 6 Ma for a suite of rocks from

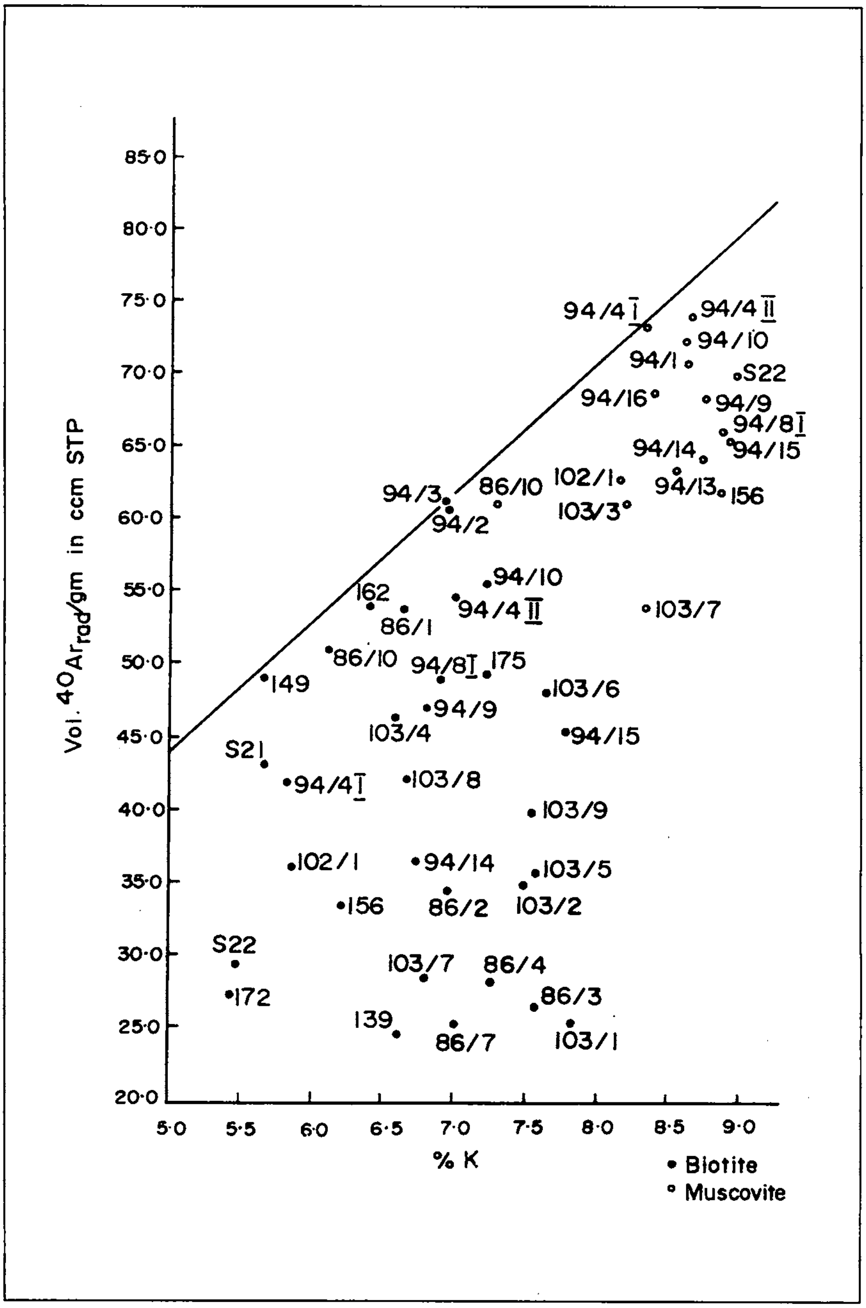

Figure 5 : Plot of % K against Vol. $^{40}Ar_{rad}$/gm for micas from granitoids in the Kuala Lumpur-Seremban area.

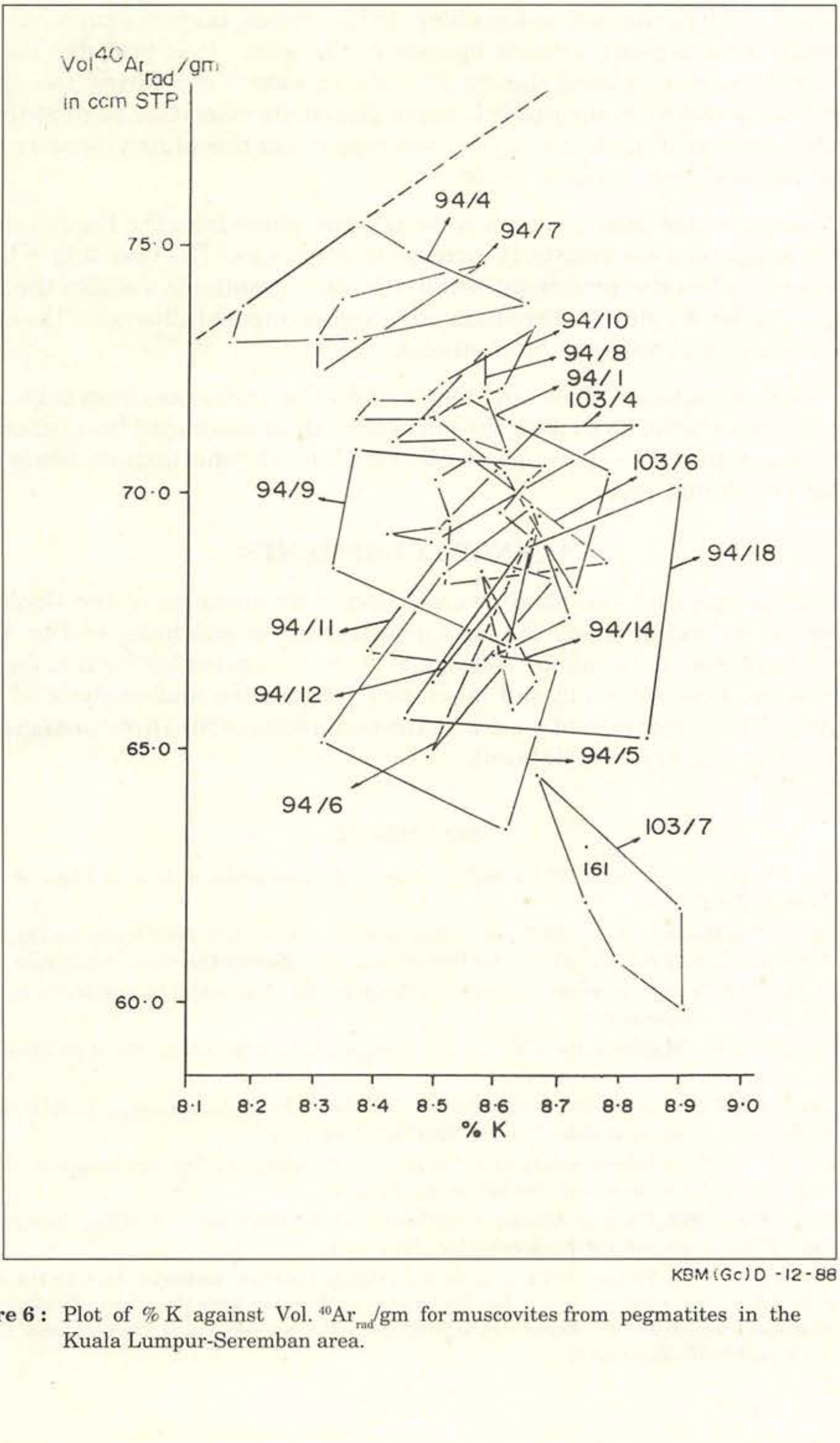

Figure 6 : Plot of % K against Vol. $^{40}Ar_{rad}$/gm for muscovites from pegmatites in the Kuala Lumpur-Seremban area.

the Jelebu pluton (Bignell and Snelling, 1977). Hence, there is a present lack of evidence for a pre-late Triassic episode in the area. It is probable that the granitoids were emplaced during a single episode. Considering the spatial relationships between the Kuala Lumpur pluton, its associated pegmatites and the distribution of tin deposits, it is conceivable that this pluton represents the latest phase of this intrusive event.

The pattern of distribution of K-Ar dates for micas from the Kuala Lumpur pluton suggests a southeasterly increase in argon loss. The resetting of biotite ages seem to be most prominent within the other granitoids, notably the Bukit Tinggi and Jelebu plutons, thus indicating a more intense influence of the known Cretaceous event towards the southeast.

The distribution of K-Ar apparent ages for the muscovites from pegmatites is somewhat similar to that for the micas from their associated host rocks, and appears to reflect the superimposed effect of a later thermal disturbance on their pattern of cooling ages.

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APPENDIX 1

K-Ar analytical data for micas from granitoids and their associated pegmatites in the Kuala Lumpur-Seremban Area

Sample No.	%K	Vol. $^{40}Ar_{rad}$/g ($x10^{-6}$ ccm STP)	% $^{40}Ar_{rad}$	Age in Ma
86/1 Bi	6.63	53.71	98.8	197 ± 6
86/2 Bi	6.95	34.57	97.6	124 ± 4
86/3 Bi	7.56	26.31	57.9	87 ± 4
86/4 Bi	7.25	28.15	98.7	97 ± 3
86/7 Bi	7.00	25.16	96.7	90 ± 3
86/10 Bi	6.10	50.89	98.1	203 ± 6
86/10 MU	7.30	60.98	98.0	203 ± 6
94/1 A	8.62	71.51	93.4	202 ± 6
94/1 B	8.55	72.08	97.6	205 ± 6
94/1 C	8.50	71.36	98.1	205 ± 6
94/1 D	8.79	70.56	98.0	196 ± 6
94/1 E	8.73	68.18	97.8	191 ± 6
94/1 Mu	8.62	70.50	99.3	199 ± 6
94/2 Bi	6.95	60.80	100.0	212 ± 6
94/3 Bi	6.93	61.22	99.8	214 ± 6
94/4 A	8.16	72.99	97.4	217 ± 7
94/4 B	8.18	73.79	98.9	218 ± 7
94/4 C	8.45	74.83	95.2	215 ± 7
94/4 D	8.37	75.42	94.2	218 ± 7
94/4 E	7.20	55.07	97.3	187 ± 6
94/4 I Bi	5.80	41.98	99.8	177 ± 5
94/4 I Mu	8.36	73.16	99.6	212 ± 6
94/4 II Bi	7.00	54.57	99.1	190 ± 6
94/4 II Mu	8.65	73.94	98.9	208 ± 6
94/5 A	7.41	56.88	98.8	187 ± 6
94/5 B	8.62	63.49	97.8	180 ± 6
94/5 C	8.32	65.14	98.5	191 ± 6
94/5 D	8.60	66.87	87.0	190 ± 6
94/5 E	8.70	66.75	98.8	187 ± 6
94/5 F	8.72	67.69	99.0	189 ± 6
94/5 G	8.66	69.77	98.4	196 ± 6
94/5 H	8.52	68.43	99.1	196 ± 6
94/6 A	8.49	64.91	96.7	187 ± 6
94/6 B	8.67	69.70	93.6	196 ± 6
94/6 C	8.62	66.81	98.1	189 ± 6
94/6 D	7.69	61.74	98.4	196 ± 6

Note : The suffixes 'Bi' and 'Mu' denote samples from the granitoids, while sample numbers with a single capitalised alphabet at the end indicate muscovites from the associated pegmatites.

Appendix 1 Continued

Sample No.		%K	Vol.$^{40}Ar_{rad}$/g (x10^{-6} ccm STP)	% $^{40}Ar_{rad}$	Age in Ma
94/7 A		8.57	74.74	99.0	211 ± 6
94/7 B		8.30	73.05	97.3	213 ± 7
94/7 C		8.34	73.91	96.8	215 ± 7
94/7 D		8.42	85.38	81.4	217 ± 8
94/7 E		8.30	72.66	98.8	212 ± 8
94/8 A		8.62	70.92	96.8	200 ± 6
94/8 B		8.53	73.02	96.1	207 ± 6
94/8 C		8.43	71.04	97.7	205 ± 6
94/8 D		8.53	72.12	97.2	204 ± 6
94/8 E		8.56	71.15	94.8	202 ± 6
94/8 F		8.47	71.46	90.7	205 ± 7
94/8 I	Bi	6.90	48.95	96.9	174 ± 5
94/8 I	Mu	8.88	66.01	96.6	182 ± 6
94/9 A		8.68	70.48	91.1	198 ± 7
94/9 B		8.37	70.91	95.7	206 ± 6
94/9 C		8.63	67.03	98.7	190 ± 6
94/9 D		8.33	68.56	98.7	200 ± 6
94/9 E		8.65	70.28	99.2	198 ± 6
94/9 F		8.66	69.40	99.4	195 ± 6
94/9 G		8.61	69.74	99.1	197 ± 6
94/9	Bi	6.80	46.98	98.8	170 ± 5
94/9	Mu	8.75	68.38	94.8	191 ± 6
94/10A		8.66	73.50	98.5	206 ± 6
94/10B		8.40	71.91	97.1	208 ± 6
94/10C		8.48	71.83	99.3	206 ± 6
94/10D		8.48	71.60	96.7	205 ± 6
94/10E		8.37	71.41	96.8	207 ± 6
94/10F		8.51	72.20	98.8	206 ± 6
94/10	Bi	7.20	55.57	98.9	188 ± 6
94/10	Mu	8.61	72.20	98.0	204 ± 6
94/11A		8.58	66.74	94.1	190 ± 6
94/11B		8.70	68.45	95.6	192 ± 6
94/11C		8.52	69.04	99.0	197 ± 6
94/11D		8.39	66.93	90.8	194 ± 6
94/12A		8.62	68.22	96.3	193 ± 6
94/12B		8.50	66.38	95.7	190 ± 6
94/13	Mu	8.55	63.33	99.2	181 ± 5
94/14A		8.67	66.31	97.3	187 ± 6
94/14B		8.58	68.55	99.1	195 ± 6
94/14C		8.63	65.84	98.5	186 ± 6
94/14	Bi	6.71	36.27	98.8	134 ± 4
94/14	Mu	8.73	60.41	97.1	170 ± 5

Appendix 1 Continued

Sample No.		%K	Vol.$^{40}Ar_{rad}$/g (x10^{-6} ccm STP)	% $^{40}Ar_{rad}$	Age in Ma
94/15	Bi	7.787	45.43	99.2	144 ± 4
94/15	Mu	8.93	65.61	98.5	180 ± 5
94/16	Mu	8.40	68.54	90.8	199 ± 7
94/18A		8.85	65.31	92.7	181 ± 6
94/18B		8.45	65.69	89.5	190 ± 6
94/18D		8.65	69.04	98.9	194 ± 6
94/18E		8.90	70.386	97.7	193 ±66
102/1	Bi	5.85	36.16	97.2	152 ± 5
102/1	Mu	8.15	62.77	98.1	188 ± 6
103/1	Bi	7.80	25.36	97.4	82 ± 3
103/2	Bi	7.48	34.87	98.7	116 ± 4
103/3	Mu	8.20	61.21	97.9	182 ± 6
103/4A		8.67	71.44	98.6	200 ± 6
103/4B		8.52	69.43	97.4	198 ± 6
103/4C		8.83	71.54	98.3	197 ± 6
103/4D		8.43	69.26	99.0	200 ± 6
103/4E		8.50	69.10	98.5	198 ± 6
103/4	Bi	6.58	46.38	97.2	173 ± 5
103/5	Bi	7.55	35.83	95.6	116 ± 4
103/6A		8.78	68.78	99.3	191 ± 6
103/6B		8.56	70.74	98.7	201 ± 6
103/6C		8.53	69.56	97.7	198 ± 6
103/6D		8.50	70.37	98.8	201 ± 6
103/6E		8.52	68.28	99.4	195 ± 6
103/6	Bi	7.63	47.94	98.1	155 ± 5
103/7A		8.80	60.98	98.5	170 ± 5
103/7B		8.89	62.04	99.8	171 ± 5
103/7C		8.75	62.14	99.3	174 ± 5
103/7D		8.91	60.000	98.4	165 ± 5
103/7E		8.67	64.59	98.2	182 ± 5
103/7	Bi	6.79	28.36	98.0	104 ± 3
103/7	Mu	8.33	54.08	98.3	160 ± 5
103/8	Bi	6.65	42.24	98.9	156 ± 5
103/9A		8.28	55.11	98.7	164 ± 5
103/9	Bi	7.53	39.91	97.8	131 ± 4

Note : The suffixes 'Bi' and 'Mu' denote samples from the granitoids, while sample numbers with a single capitalised alphabet at the end indicate muscovites from the associated pegmatites.