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Age determination on the Kuantan granite and dolerite dykes

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Abstract: The results of Rb/Sr age determination work on 6 whole rock samples of the granite in the Kuantan area together with K-Ar data on biotite separates are reported. The whole rock data plotted on an isochron 292 ± 12 m.y. with an initial $^{87}Sr/^{86}Sr$ ratio of 0.704. K-Ar data from the biotites gave discordant ages.

K-Ar dating of whole rock samples from 6 dolerite dykes intrusive into the granite gave ages of about 100 m.y. except one sample which gave an age of 131 m.y.

INTRODUCTION AND GEOLOGICAL SETTING

A general account of the geology of this area can be found in Fitch (1952) and in Hanif (1975).

The country rock in the Kuantan area, (Fig. 1) consists of a sequence of conglomerate, sandstone and subordinate shale interbedded with rhyolitic and ash-flow tuffs in the southwest, and a sequence of quartzite, grit, conglomerate and black shale in the north. Fossil evidence on the age of these sediments is poor, but they are considered to be late Palaeozoic on structural and lithological grounds.

Granitic rocks form a prominent north-northwest trending ridge from Tanjong Tembeling to Bukit Kechil and also form the circular hills of Bukit Galing and Bukit Ubi in the south and Bukit Pengorak in the north. The granite is typically white to grey in colour, medium to coarse-grained and variably porphyritic. It consists of K-feldspar, plagioclase, quartz and biotite. Plagioclase is usually sericitized and saussauritized. Biotite is partially or completely altered to chlorite.

Intruding the granite is a series of dolerite dykes ranging in thickness from a few centimetres to a few metres. A thickness of 4.5 metres for one dyke was reported by Hanif (1975). The dykes are usually undifferentiated and show only grain size and textural variations from the chilled contact inwards. The rock is grey to black in colour, holocrystalline except at the chilled margins and variably porphyritic with feldspar phenocrysts. The groundmass consists of plagioclase, pyroxene, alteration products and opaque iron oxides. Fitch (1952) states that titanaugite dolerite and olivine dolerite are equally abundant.

Basalt extends over the low-lying areas and surrounds the granite hills.

PREVIOUS WORK

As with so many other places in Peninsular Malaysia, reconnaissance age

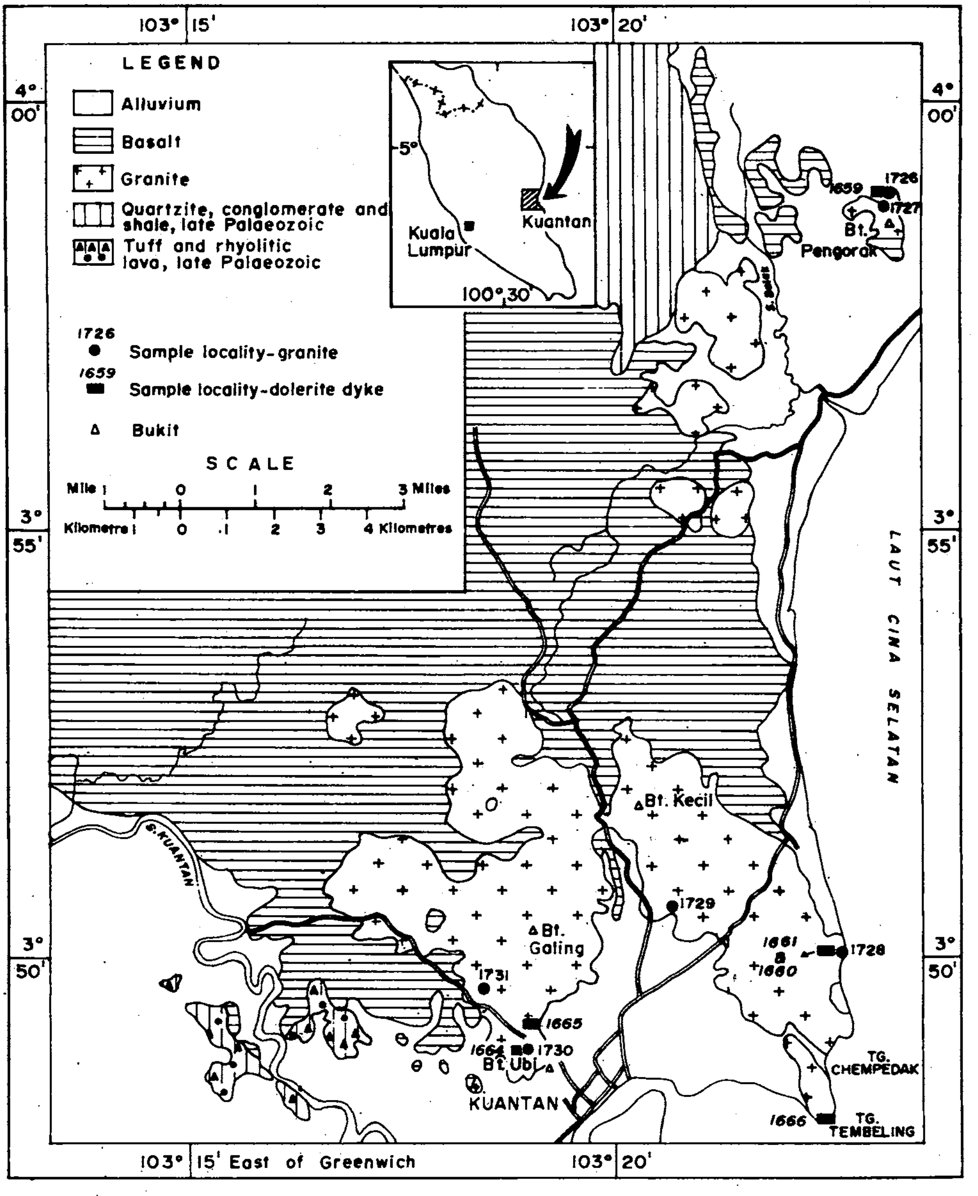

Fig. 1. Map showing location of samples dated. Geology after Fitch (1952).

determination work in Kuantan has been done by Bignell and Snelling (1977a, 1977b). Out of 5 whole rock samples analysed from Bukit Ubi 3 samples fitted an isochron of 261 ± 9 m.y. with initial $^{87}Sr/^{86}Sr$ ratio 0.7085 ± 0.0034 (Bignell & Snelling 1977a). Biotite separated from one of the samples gave a K-Ar age of 221 ± 8 m.y.

A dolerite whole rock sample from Tanjong Tembeling gave a K-Ar age of 114 ± 4 m.y. (Bignell and Snelling 1977b).

Haile *et al.* (1983) reported the results of K-Ar dating of several dyke samples from Kuantan.

PRESENT WORK

The present work was carried out to date the Kuantan granite by analysing a larger number of samples, and also to date more of the dolerite dykes. The work was done within the framework of Swiss technical assistance to the Geological Survey of Malaysia. P. Stille and E. Frank from the University of Berne assisted in the sample collection. Mineral separation and isotopic analysis were done by the author at the Dept. of Isotope Geology, University of Berne during the course of a 2-year fellowship from the Swiss Technical Cooperation.

The standard procedures for mineral separation, chemistry and mass spectrometry used at Berne were followed. Rb-Sr procedures are described in Jaeger (1962) and Rb and Sr isotopic ratios were measured on an AVCO mass spectrometer.

The K-Ar procedures are described in Purdy and Jaeger (1976). Argon isotopic ratios were measured on a Varian GD 150 mass spectrometer and potassium concentrations measured in duplicate with a Beckman flame photometer.

The decay constant recommended by Steiger and Jaeger (1977) was used.

ANALYTICAL RESULTS AND DISCUSSION

R-Sr results:

Rb-Sr measurements by the whole rock were made on six samples from the Kuantan granite. Sample locations are shown in Fig. 1 and details can be found in the appendix. The analytical data are listed in Table 1 and are presented in the isochron diagram in Fig. 2.

TABLE 1

RB-SR WHOLE ROCK DATA FOR THE KUANTAN GRANITE

No.	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
KAW 1726	112.0	67.8	6.514	0.7311
KAW 1727	115.1	70.9	6.405	0.7305
KAW 1728	144.3	98.4	5.785	0.7286
KAW 1729	106.5	68.1	6.166	0.7292
KAW 1730	218.9	35.8	24.139	0.8037
KAW 1731	205.5	57.8	14.029	0.7637

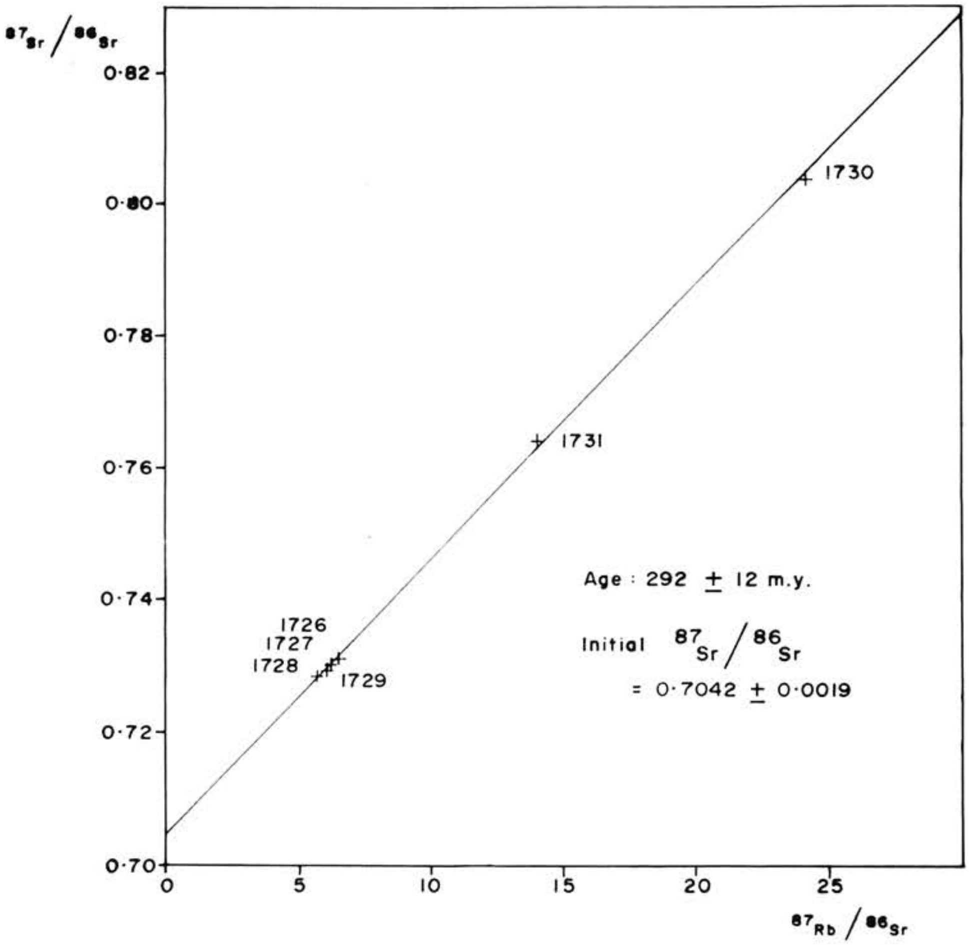

Fig. 2. Rb-Sr whole-rock isochron for the Kuantan granite.

Examination of Fig. 2 shows that all the data points are essentially collinear. The calculation of the isochron data was after Brooks and Compston (1965). This calculation yields:

$$\text{Age} = 292 \pm 12 \text{ m.y.}$$
$$\text{Initial } ^{87}Sr/^{86}Sr = 0.704 \pm 0.002$$

The whole rock isochron age is older than the 261 m.y. reported by Bignell and Snelling (1977a) from three samples from the Bt. Ubi quarry. However the authors stated that two other samples analysed plotted above the 261 m.y. line and were not used in the data calculation. As more samples have been analysed in the present work and there is a better sample distribution, it is considered that 292 ± 12 m.y. is a better Rb-Sr estimate of the age of the Kuantan granite.

The initial $^{87}Sr/^{86}Sr$ ratio of 0.704 ± .002 is also lower than that reported in the earlier work (0.7085 ± 0.0034). This value of 0.704 indicates that the magma giving rise to the granite could have originated by partial melting of upper-mantle material or by differentiation of primary basalt magma.

Subsequent to the present work, Liew (1983) has undertaken a study of the petrogenesis of Peninsular Malaysia granitoid batholiths which included U-Pb zircon dating of some of the plutons. Three zircon size fractions separated from a sample collected from Bt. Ubi plotted on a reverse discordia with lower intersection at 263 m.y. and upper intersection at 1350 m.y. This pattern has been interpreted as arising from a mixed zircon population with the age of the upper intersection representing an old component of inherited zircon and the lower intersection the young or magmatic zircon.

With this interpretation, two important assumptions have to be made: there exists are ideal mixing relationship between the two zircon populations and that there has been no post emplacement Pb loss.

If the zircon age is accepted, then the 292 m.y. Rb-Sr isochron will have to be explained as an inherited isochron, i.e. the anomalous old age has been produced by assimilation of wall rocks with highly radiogenic strontium.

K-Ar results:

K-Ar measurement on the biotite concentrates separated from the six whole-rock samples are listed in Table 2. There is a marked discordance in the apparent ages of the biotites compared to the whole rock isochron age.

TABLE 2

K-Ar DATA FOR THE KUANTAN GRANITE

No	Sample	% K	$^{40}Ar_{rad} \times 10^{-6}$ cm^3 STP/g	% rad	Calculated age (m.y.)
KAW 1726	Biotite/Chlorite	3.31	34.241	95.8	247 ± 8
KAW 1727	Biotite/Chlorite	3.84	39.410	95.8	246 ± 8
KAW 1728	Biotite	5.47	55.296	96.3	242 ± 8
KAW 1729	Biotite/Chlorite	3.19	27.006	93.9	205 ± 7
KAW 1730	Biotite	6.68	57.118	97.3	207 ± 6
KAW 1731	Biotite	5.46	53.779	97.8	236 ± 7

The biotites have been extensively chloritized and this is reflected in the low K value of some of the samples. However the loss of K is not correlatable to the loss of radiogenic argon as sample KAW 1730 with the highest K value of 6.68 % gives one of the lowest apparent ages 207 m.y.

It is probable that a combination of the effects of alteration and subsequent tectonic events possibly related to the intrusion of the dolerite dykes have acted to various degrees to give rise to the variable loss of radiogenic argon from the biotite.

K-Ar measurements on whole-rock samples from 6 dolerite dykes are listed in Table 3. Repeat argon determinations for 3 of the samples are also listed. Details of sample locations are given in the appendix.

TABLE 3

K-Ar WHOLE-ROCK DATA FOR DOLERITE DYKES IN THE KUANTAN AREA

No.	Locality	% K	$^{40}Ar_{rad} \times 10^{-6}$ cm³ STP/g	% rad	Calculated age (m.y.)
KAW 1659	Bukit Pengorak	0.41	1.573	74.9	95.5 ± 3.8
KAW 1660	Tanjong Pelindong	0.82	3.250	68.1	98.6 ± 4.3
			3.235	72.8	98.2 ± 4.0
KAW 1661	Tanjong Pelindong	1.21	4.781	84.3	98.3 ± 3.5
KAW 1666	Tanjong Tembeling	1.17	4.744	81.5	101 ± 4
KAW 1664	Bukit Ubi	0.98	4.215	80.0	107 ± 4
			4.226	81.2	107 ± 4
KAW 1665	Bukit Galing	0.95	5.137	88.7	133 ± 5
			5.049	90.0	131 ± 4

Four of the samples are in good agreement and give a mean age of 98 m.y. Two other dykes apparently are older, one giving 107 m.y. and the other 131 m.y.

Bignell and Snelling (1977b) reported an age of 114 ± 4 m.y. for a dyke from Tanjong Tembeling.

CONCLUSIONS

The Kuantan granite which is intrusive into a late Palaeozoic sequence of sediments has been dated by the Rb-Sr whole-rock isochron method at 292 ± 12 m.y. (Carboniferous/Permian boundary). However subsequent U-Pb zircon dating by Liew (1983) has given a date of 263 m.y. which depending upon the reliability of the zircon data raises the possibility that the Rb-Sr isochron could be anomalously old having resulted from the magma assimilating wallrock with highly radiogenic strontium.

There is a marked discordance in the apparent K-Ar ages of the biotite which range from 247 m.y. to 205 m.y.

K-Ar dates from the dolerite dykes indicate that their emplacement took place over an extended period of time, beginning in the early Cretaceous and probably culminating 98 m.y. ago during the mid-Cretaceous.

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APPENDIX

SAMPLE LOCALITIES

KAW 1726	Malaysian Rock Products Quarry, Bt. Pengorak	Lat. 03°59′10″N Long. 103°24′10″E
KAW 1659	Malaysian Rock Products Quarry, Bt. Pengorak	Lat. 03°59′10″N Long. 103°24′10″E
KAW 1727	Citra Quarry, Bt.Pengorak	Lat. 03°58′55″N Long. 103°24′05″E
KAW 1728	Tanjong Pelindong	Lat. 03°50′00″N Long. 103°22′45″E
KAW 1660	Tanjong Pelindong	Lat. 03°50′00″N Long. 103°22′45″E
KAW 1661	Tanjong Pelindong	Lat. 03°50′00″N Long. 103°22′45″E
KAW 1729	Bukit Beserah	Lat. 03°50′30″N Long. 103°21′00″E
KAW 1730	JKR Quarry, Bt. Ubi	Lat. 03°49′00″N Long. 103°18′55″E
KAW 1664	JKR Quarry, Bt. Ubi	Lat. 03°49′00″N Long. 103°18′55″E
KAW 1731	Chan Foong Koon Quarry, Bt. Galing	Lat. 03°49′20″N Long. 103°18′45″E
KAW 1665	Lee Quarry, Bt. Galing	Lat. 03°49′15″N Long. 103°18′45″E
KAW 1666	Tanjung Tembeling	Lat. 03°48′15″N Long. 103°22′30″E