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Distribution of major and some trace elements of some granites from Bangka, Indonesia.

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Abstract: Concentration ranges and arithmetic means of major and four trace elements of the Menumbing, Pelangas and Tempilang granites in Bangka are discussed. The whole rock chemistry of these three granites do not show any great differences, except for Ca^{2+} which, in the Pelangas granite will correspond to the high-Ca^{2+} granite.

Trace elements of Ba and Sr are greater in the Pelangas granite than in the Menumbing and Tempilang granites.

The Na^{+}/K^{+} and $Al^{3+}/Na^{+}+K^{+}+{}^{1}/_{2}Ca^{2+}$ ratios indicate that the granites have similarities to the S-type granites of White *et al.* (1977) which may have a sedimentary origin. The Ca-Sr, K-Rb, Ba-Sr, Rb-Sr and Fe-Mg ratios compared with previous average granite data show that the granites in the study area are highly differentiated rocks. The relationship of Sn content with the concentration of Rb and Rb/Sr ratio are positive but is inverse to the K/Rb ratio.

INTRODUCTION

The old geological map of the tin-provinces in Indonesia shows at least 15 intrusive bodies of granitic rocks in the Island of Bangka. Hosking (1977) placed the Island of Bangka in the West-belt of the tin-belts of Southeast Asia.

This paper is a preliminary study made primarily to describe the distribution of major and certain trace elements in the whole rock of the granites in the Menumbing, Pelangas and Tempilang areas of Bangka Island (Figure 1). A total of 30, 11 and 11 samples from the Menumbing, Pelangas and Tempilang granites respectively were analysed for some major elements, Rb, Sn, Ba, Sr, W, Zr, Nb, and Fe. Only the results for major elements and Rb, Sn, Ba and Sr are discussed here.

All the granitic rocks discussed fall within the range in composition of intrusive acid igneous rocks often termed as granites. The Pelangas granites falls within the high calcium category of Turekian and Wedephol (1961) while the Menumbing and Tempilang granites are low calcium granites. Based on the Na^{+}/K^{+} and $Al^{+}/Na^{+}+K^{+}+{}^{1}/_{2}\ Ca^{2+}$ ratios, the granites in the study area are similar to the S-type granites of Chappell and White (1974) which may have a sedimentary origin.

The ratios of Ca/Sr, K/Rb, Ba/Sr, Rb/Sr and Fe/Mg for the samples analysed when compared with previous average data for granites show that the granites of the present study area are highly differentiated rocks. The data also indicates that the relationship of Sn content, the Rb content and the Rb/Sr ratio is positive while the relationship to the K/Rb ratio is inverse.

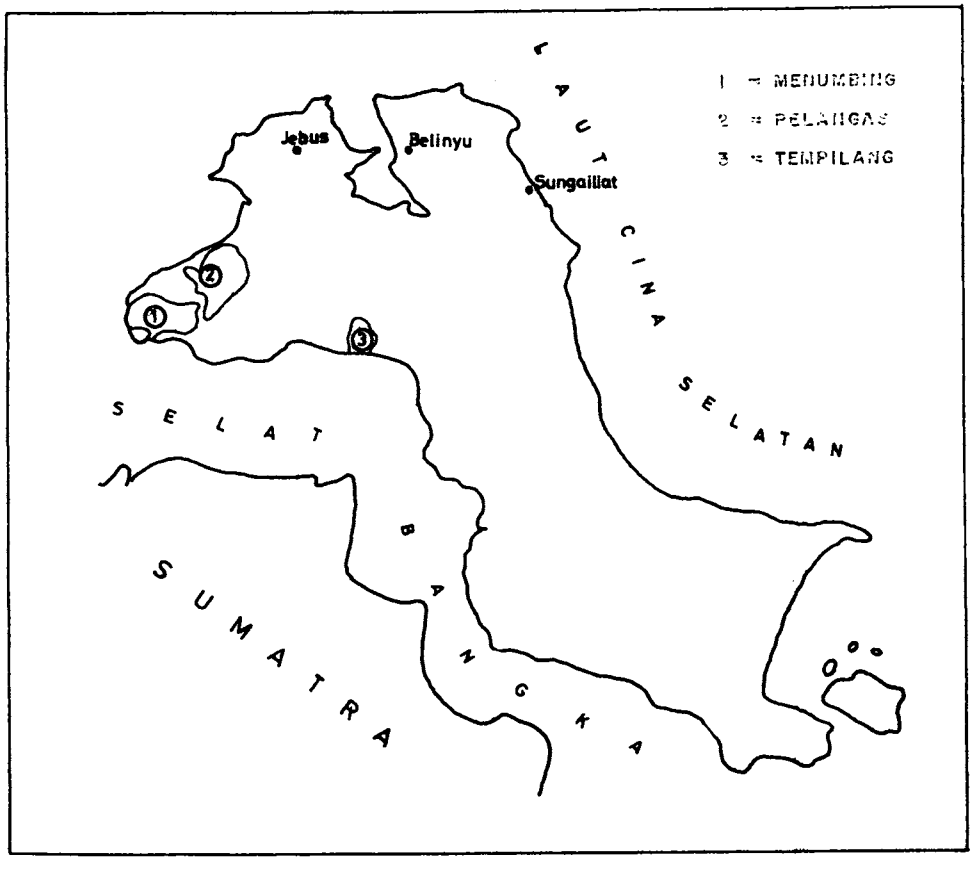

Fig. 1 Island of Bangka, scale 1:1,000,000

WHOLE ROCK CHEMISTRY

The concentration ranges and arithmetic means for the three intrusive bodies of granitic rocks from the Bangka Island is given in Table 1. The elements are listed in order of increasing ionic radius. Major elements are expressed as weight per cent while the trace elements as parts per million. The major elements are expressed as oxides for comparative purposes only and in addition a few element ratios are also listed. A large number of the samples analysed have a SiO_2 content within the 72 to 75 per cent range. The SiO_2 concentration is high and relatively uniform among the samples. The average SiO_2 content is 72.98 per cent.

A plot of the Al_2O_3, femic, K_2O, Na_2O and CaO content against the SiO_2 content (Figure 2) shows that the Pelangas granite has a relatively higher CaO content compared to the other two. Thus, using the classification of Turekian and Wedephol (1961), the Pelangas granites corresponds well to the high-Ca granitic rocks whereas the Menumbing and the Tempilang granites correspond to the low-Ca granitic rocks. There appears to be no significant difference in the contents of Al_2O_3, femic oxides, K_2O and Na_2O. Generally the plots of the oxides except for CaO are dispersed and remain almost constant with the increase in SiO_2

TABLE 1.

CONCENTRATION RANGES AND ARITHMETIC MEANS FOR THE MENUMBING, PELANGAS AND TEMPILANG GRANITES.

	Menumbing			Pelangas			Tempilang		
	Range		Ar. mean	Range		Ar. mean	Range		Ar. mean
Element									
% Si	33.06	– 34.95	33.88	32.40	– 33.63	33.10	33.29	– 34.28	33.72
% Al	6.36	– 8.85	7.95	7.47	– 8.6	97.94	7.35	– 8.78	8.08
% Mg	0.07	– 0.76	0.24	0.16	– 0.58	0.37	0.06	– 0.17	0.12
% Ti	0.08	– 0.27	0.18	0.14	– 0.33	0.25	0.05	– 0.22	0.14
Sn	6	– 90	24	10	– 24	15	8	– 38	19
% Fe	0.58	– 3.07	2.01	2.14	– 3.23	2.55	0.81	– 2.24	1.63
Mn	23	– 1001	372	23	– 300	82	400	– 1100	518
% Na	1.21	– 1.57	1.33	1.18	– 1.40	1.27	1.18	– 1.61	1.38
% Ca	0.52	– 1.35	0.96	1.44	– 2.06	1.81	0.79	– 1.28	0.98
Sr	11	– 75	45	95	– 140	140	12	– 80	41
% K	2.07	– 3.40	2.82	2.28	– 3.19	2.83	2.61	– 3.19	2.85
Ba	15	– 300	182	300	– 700	476	10	– 380	139
Rb	410	– 900	564	280	– 360	315	350	– 400	378
Oxides									
SiO_2	71.53	– 76.38	73.66	70.45	– 73.12	71.97	72.38	– 74.53	73.32
Al_2O_3	12	– 16.75	15.02	14.10	– 16.40	14.99	13.87	– 16.57	15.26
FeO (t)	0.10	– 2.99	1.34	0.34	– 2.83	1.70	0.10	– 2.68	1.07
MgO	0.15	– 1.27	0.40	0.27	– 0.97	0.61	0.10	– 0.29	0.20
CaO	0.73	– 1.90	1.36	2.03	– 2.90	2.55	1.11	– 1.74	1.39
Na_2O	1.64	– 2.13	1.80	1.63	– 1.90	1.71	1.69	– 2.18	1.83
K_2O	2.50	– 4.10	3.40	2.75	– 3.85	3.42	3.15	– 3.85	3.44
TiO_2	0.14	– 0.45	0.29	0.24	– 0.55	0.42	0.09	– 0.36	0.23
Ratios									
Ca/Sr	137	– 655	213	125	– 206	150	127	– 700	239
K/Rb	32	– 66	50	77	– 106	90	65	– 84	76
Ba/Sr	1.36	– 6.0	4.04	3.0	– 5.0	3.96	1.66	– 4.75	3.39
Rb/Sr	6	– 67	13	2.28	– 3.78	2.6	4.62	– 33.33	9.2
Fe/Mg	2.23	– 28.44	8.37	4.01	– 17.06	6.89	7.36	– 29.50	13.58

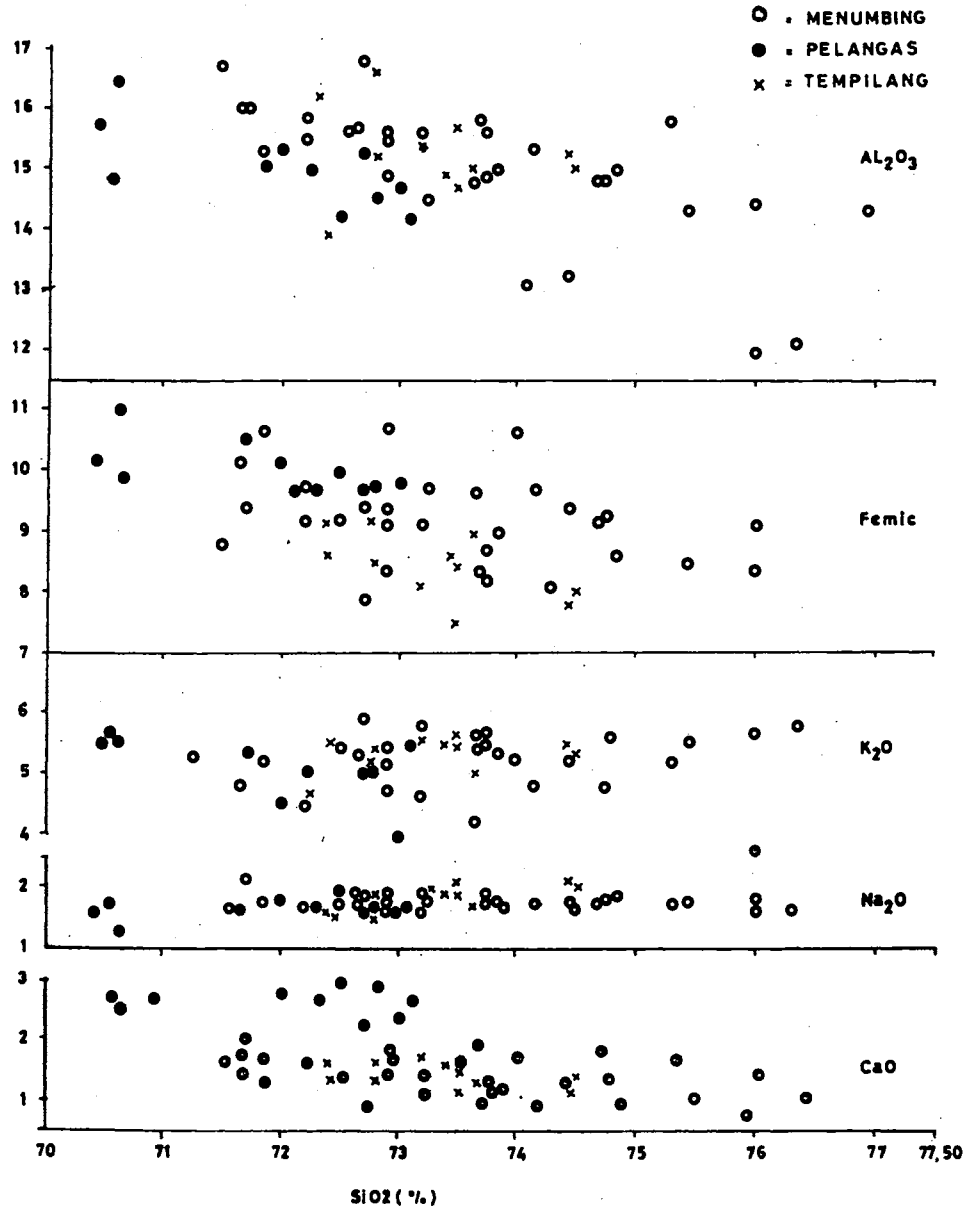

Fig. 2 Variation of major oxides against SiO_2

content. The K_2O content is always higher than that for Na_2O but both showing a similar trend. The concentrations of Al_2O_3, Na_2O and K_2O in the three granitic rocks are very similar with an average of 15 per cent for Al_2O_3; 3.40 per cent for K_2O and 1.83 per cent for Na_2O.

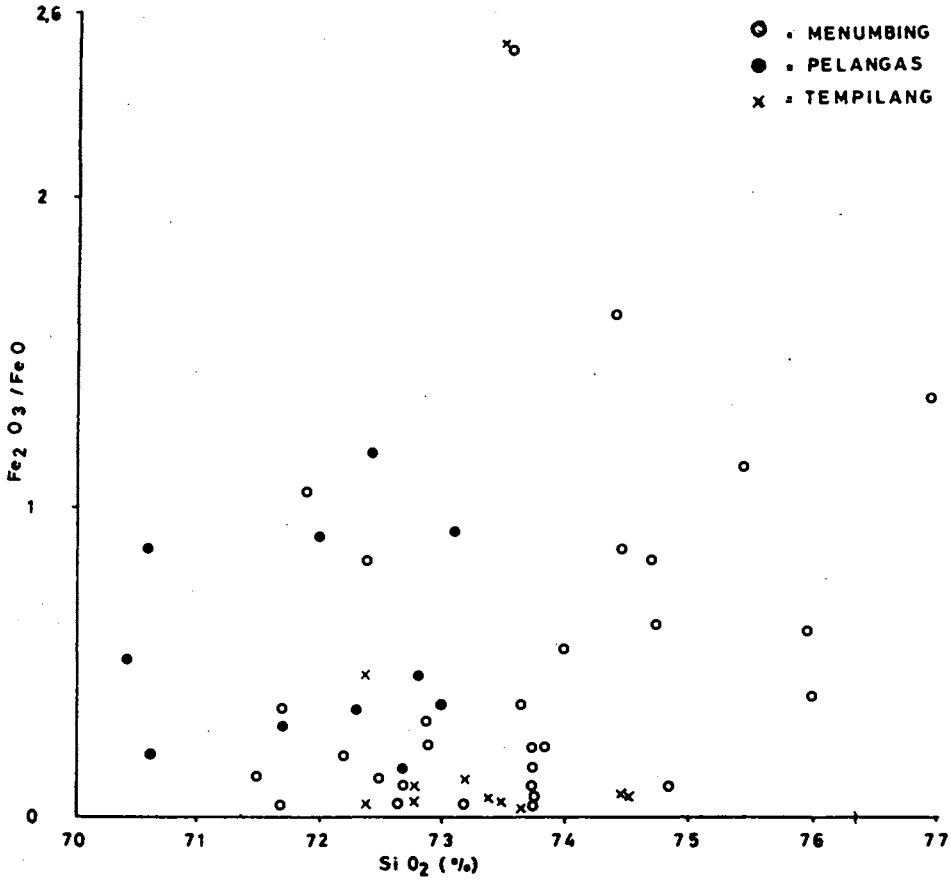

Fig. 3 Variation of ferric/ferrous against SiO_2

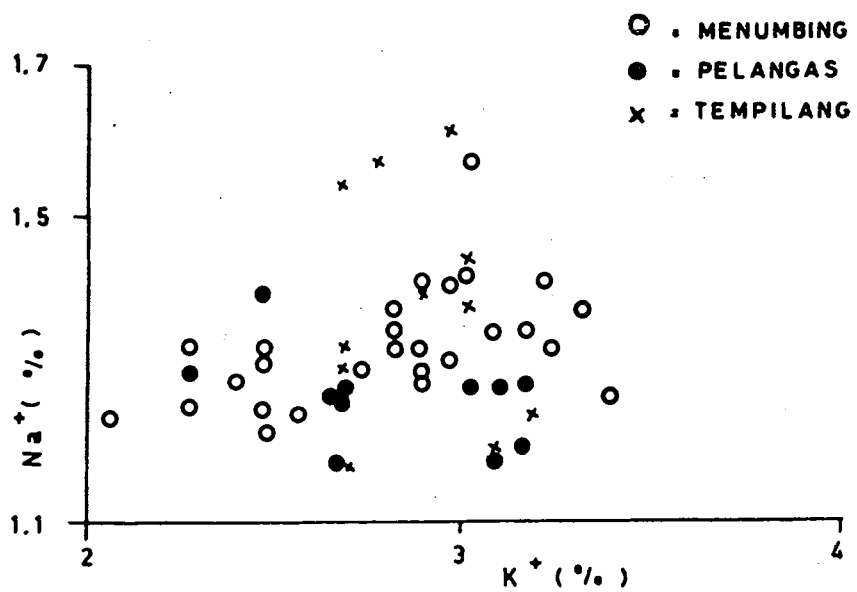

Fig. 4 Relationship of $Na^+ - K^+$

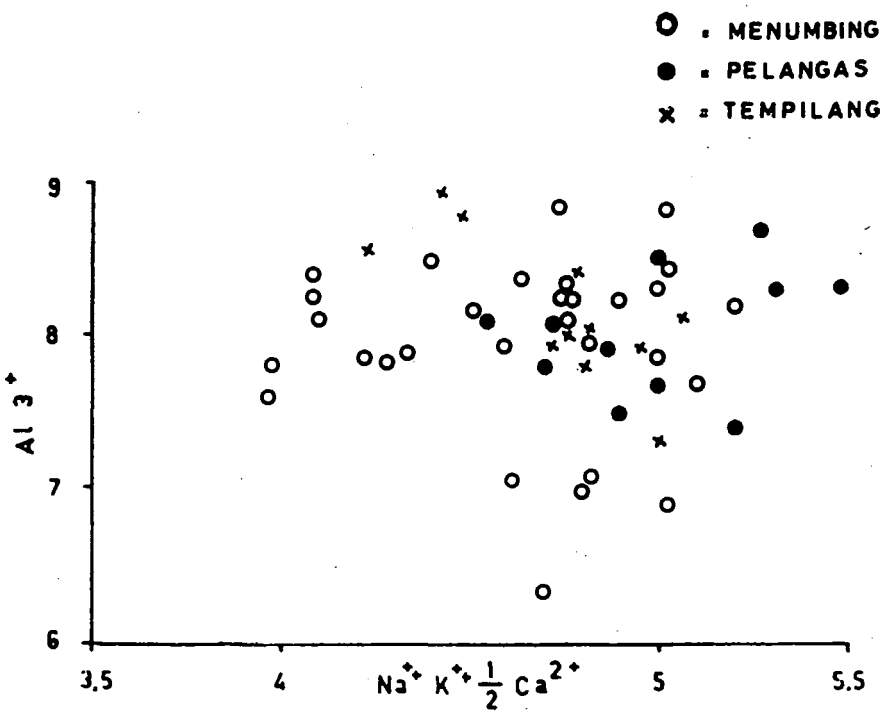

Fig. 5 Relationship of $Al^{3+} - Na^{+} + K^{+} + {}^{1}/_{2}\,Ca^{2+}$

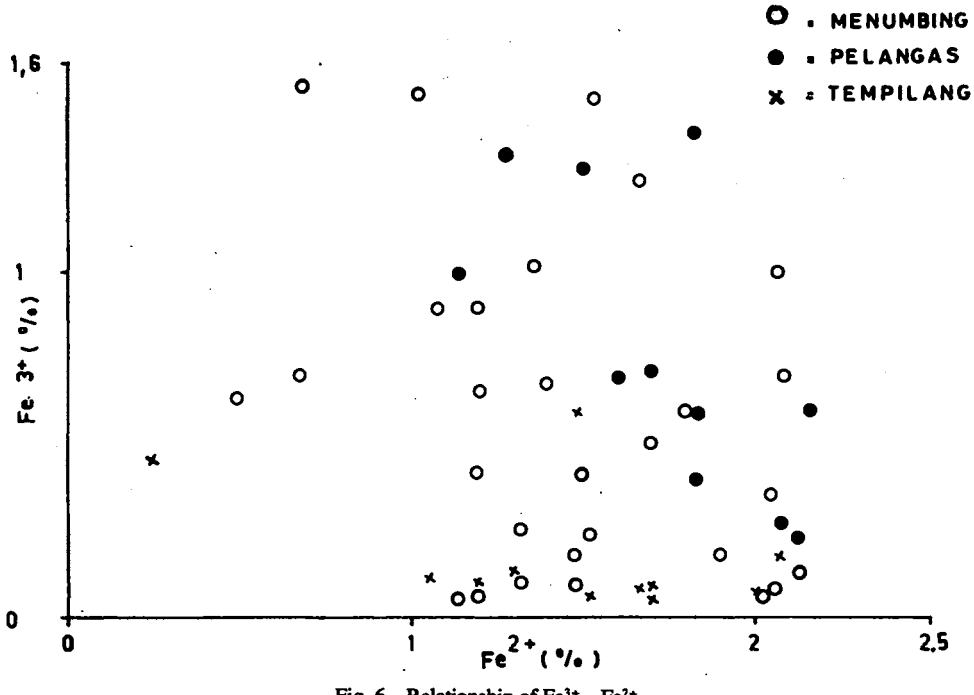

Fig. 6 Relationship of $Fe^{3+} - Fe^{2+}$

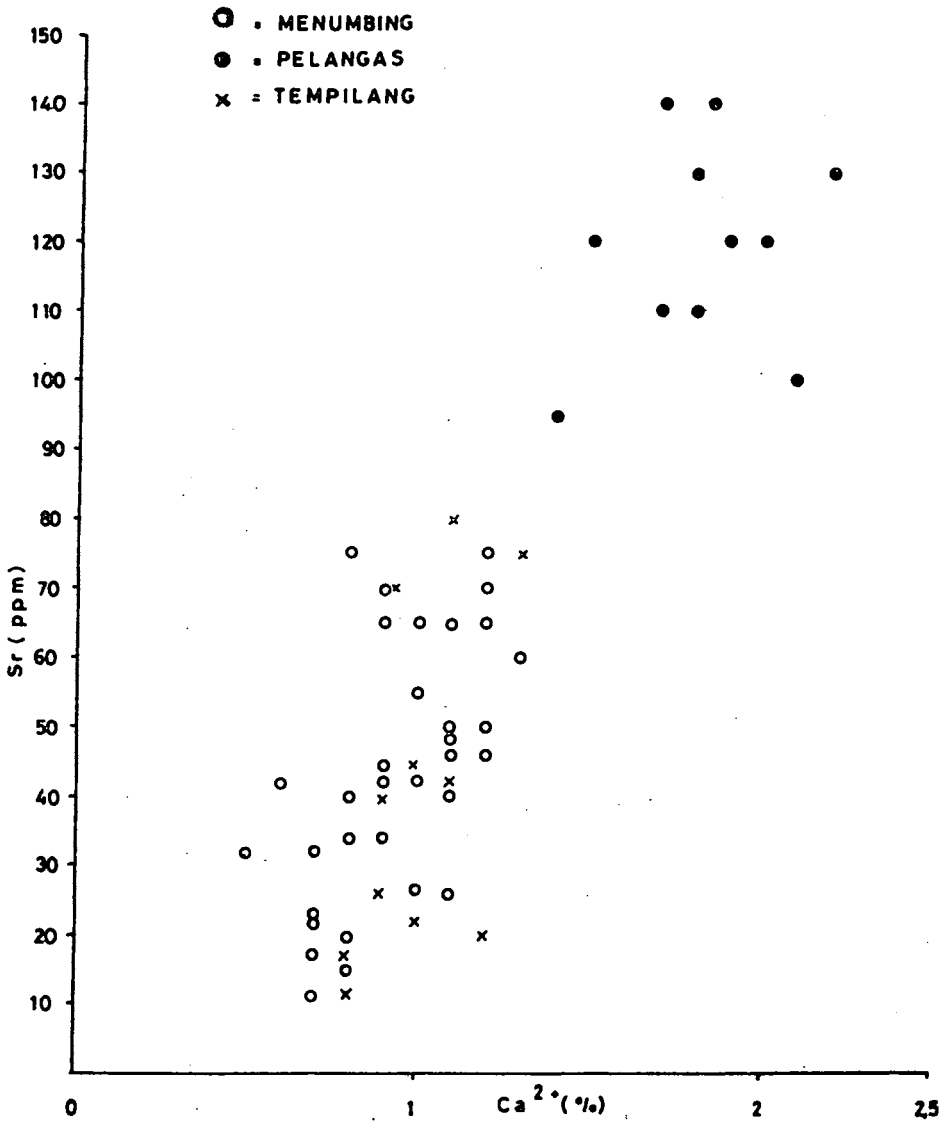

Fig. 7 Relationship of Ca – Sr

The variation of the ferric to ferrous oxide ratio with respect to SiO_2 per cent is shown in Figure 3. The Fe_2O_3/FeO ratio is relatively lower in the Tempilang granite when compared to the other two granites.

The plots of Na^+ against K^+, Al^{3+} against $Na^+ + K^+ + {}^1/2Ca^{2+}$ and the plot of Fe^{3+} against Fe^{2+} are shown in Figures 4, 5 and 6 respectively. Some ratios of selected major elements is given in Table 2. These plots do not indicate any distinctive differences between the granites.

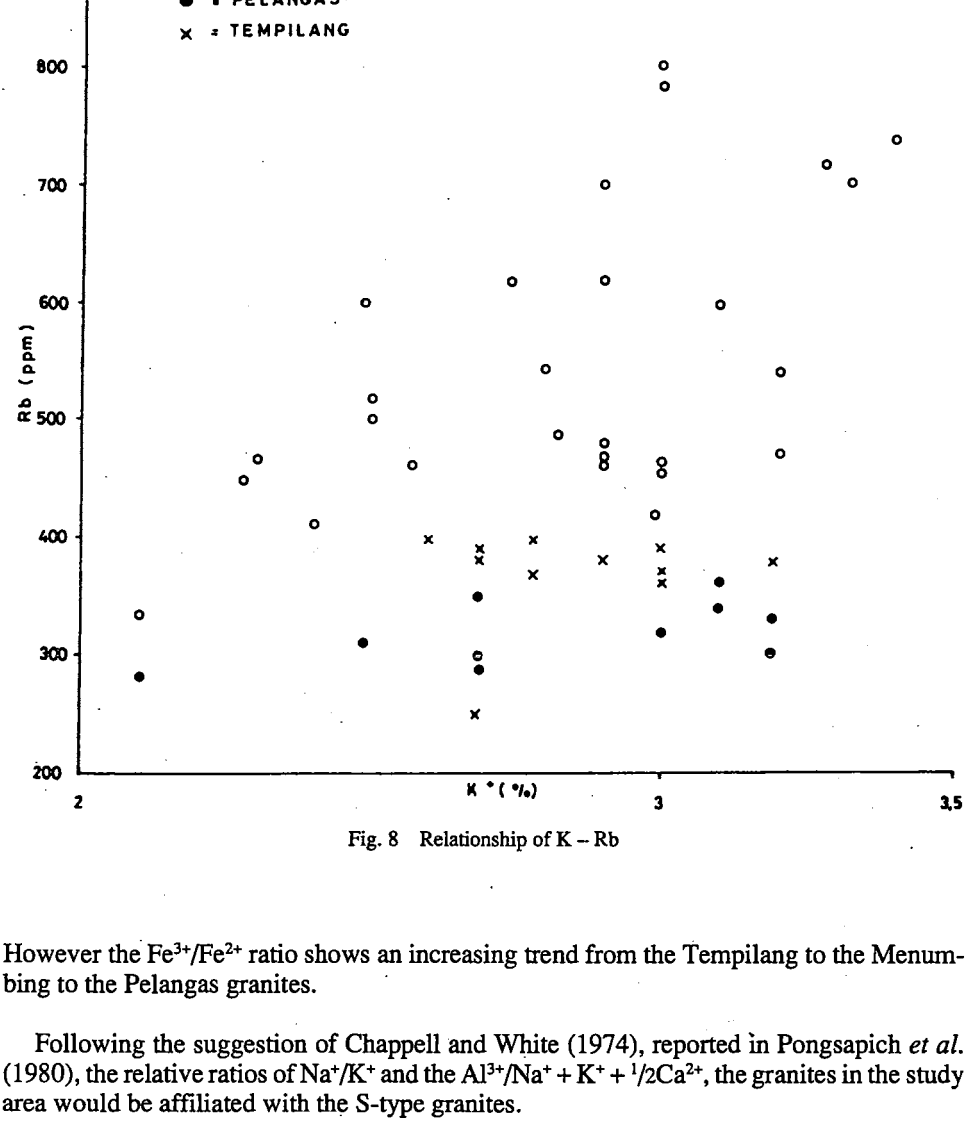

Fig. 8 Relationship of K – Rb

However the Fe^{3+}/Fe^{2+} ratio shows an increasing trend from the Tempilang to the Menumbing to the Pelangas granites.

Following the suggestion of Chappell and White (1974), reported in Pongsapich *et al.* (1980), the relative ratios of Na^+/K^+ and the $Al^{3+}/Na^+ + K^+ + {}^1/2Ca^{2+}$, the granites in the study area would be affiliated with the S-type granites.

ELEMENT RATIO

Some major and trace element ratios were used to trace the geological differentiation processes of the granitic rocks. A plot of S^+ against Ca^{2+} (Figure 7) shows that the concentration of Sr in the Pelangas granites is higher than that of the Menumbing and the Tempilang granites. The data also shows a definite enrichment of Sr relative to Ca^{2+}. This is in agreement with the findings of Turekian and Kulp (1956). The Ca/Sr ratios for the rocks

TABLE 2
SOME RATIOS OF MAJOR ELEMENTS.

	Menumbing	Pelangas	Tempilang
1. Na^+/K^+	0.37 - 0.60	0.38 - 0.62	0.37 - 0.58
	av. 0.47 (<0.857)	av. 0.46 (< 0.857)	av. 0.50 (<0.857)
2. $Al^{3+}/Na^+ + K^+ + {}^1/_2\, Ca^{2+}$	0.03 - 5.20	1.41 - 1.78	1.47 - 2.02
	av. 1.72 (> 1.1)	av.1.60 (> 1.1)	av. 1.71 (>1.1)
3. Fe^{3+}/Fe^{2+}	0.03 - 2.26	0.11 - 0.98	0.03 - 2.24
	av. 0.48	av 0.50	av. 0.29

TABLE 3
ELEMENTS AND ELEMENTS RATIOS

Elements/ ratios	Menumbing	Tempilang	Pelangas
Sn	24	19	15
Rb	564	378	315
Sr	45	41	120
K/Rb	50	70	90
Rb/Sr	13	9	3
Ca/Sr	213	239	150

average 213, 150 and 239 in the Menumbing, Pelangas and Tempilang granites respectively (Table 1).

A plot of Rb against K^+ for the rocks is shown in Figure 8. This shows that the Rb content is scattered. The K/Rb ratios average 90, 76 and 50 in the Pelangas, Tempilang and Menumbing granites respectively.

A plot of Sr against Ba in Figure 9 indicates that Sr contents increase as the Ba content increases. The Ba/Sr ratios average 4.04, 3.96 and 3.36 in the Menumbing, Pelangas and Tempilang granites respectively. The average Ba content in the Pelangas granites is 474 parts per million which is much greater which average 182 and 139 parts per million respectively.

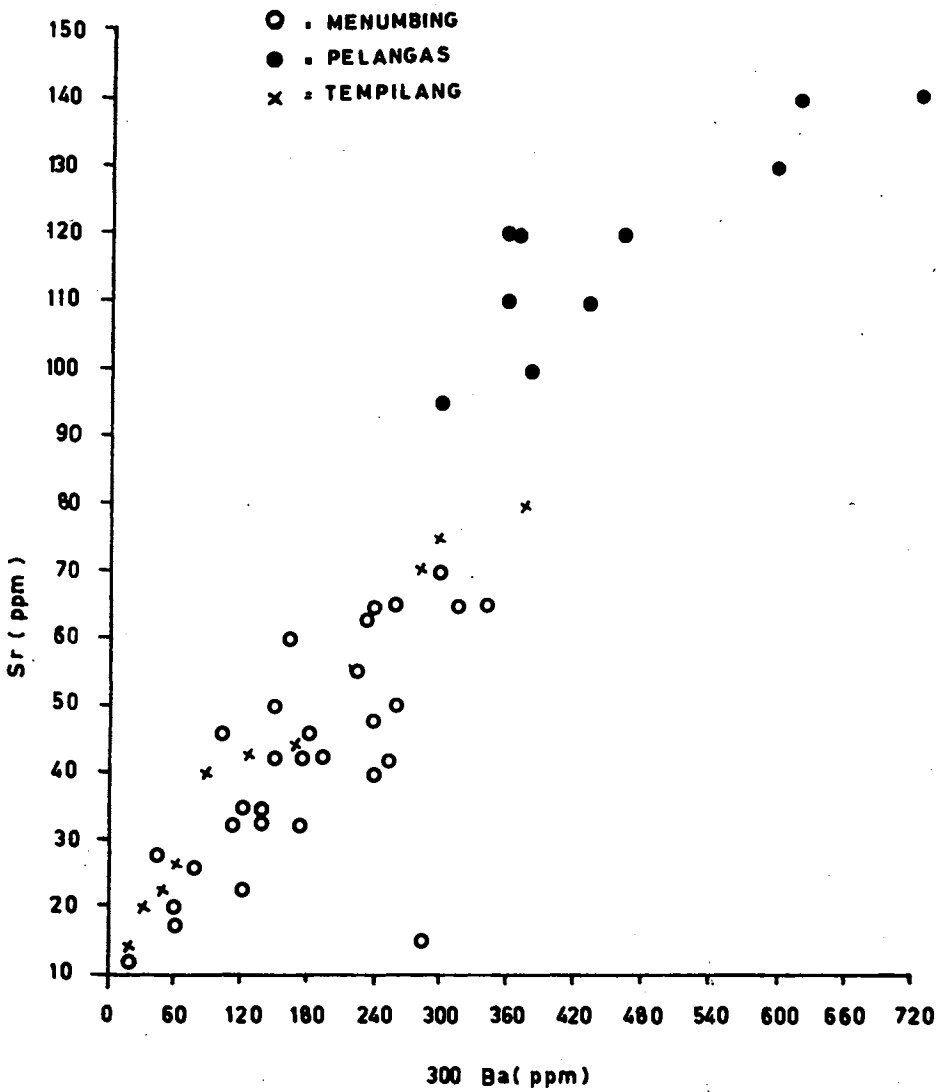

Fig. 9 Relationship Ba – Sr

The Sr content in the rocks decrease with increasing Rb content (Figure 10). The Sr content in the Pelangas granite average 120 parts per million which is nearly three times the content of 45 and 41 parts per million respectively in the Menumbing and Tempilang granites. The Rb/Sr ratio averages 2.6 in the Pelangas granite and increase to 9.2 in the Tempilang granites and 13.0 in the Menumbing granite.

The concentrations of Rb, Sr and the Rb/Sr ratios plotted against a parameter which reflects the degree of differentiation is given in Figure 11. This plot shows that the Sr

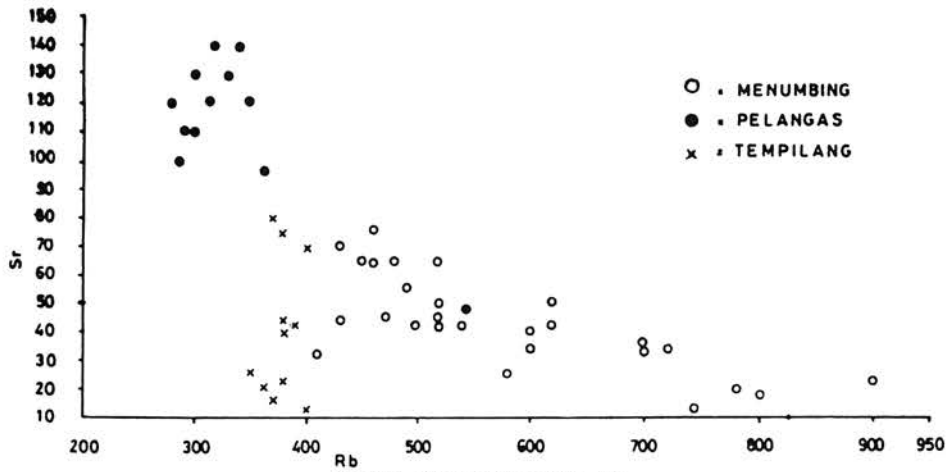

Fig. 10 Relationship of Rb – Sr

concentration decreases as the $^1/_3Si + K - (Ca + Mg)$ increases while the Rb content shows an opposite trend. The Rb/Sr ratio initially remains constant at a value around 3 but subsequently increases to a value over 10.

A plot of the ferromagnesian elements (Fe and Mg) in Figure 12 do not indicate any particular trend. The Mg/Fe ratios are not distinctive but the average of the Fe/Mg ratios increased slightly from an average of 6.9 in the Pelangas granite to 8.4 and 13.6 in the Menumbing and Tempilang granites respectively.

By comparing the elemental ratios of Ca/Sr, K/Rb, Ba/Sr, Rb/Sr and Fe/Mg of the samples in the study area with those of known differentiated granitic rocks such as the Blue-Tier Batholith (Groves 1972), Main Range Granite, Malaysia (Hutchison, 1977), Cape Granite, South Africa and Snowy Mountains, Australia (Kolbe and Taylor, 1966), Southern California Batholith (Nockolds and Allen, 1953) and larger pegmatites (Taylor and Heier, 1960) it can be concluded that the granites in the study area are highly differentiated rocks.

The tin content of the rocks varies widely ranging from a low of 6 parts per million to a maximum of 90. The average values for the three granites is 24, 19 and 15 parts per million in the Menumbing, Tempilang and Pelangas granites respectively. This content is at least 2-3 times higher than the values for the tin content in the granites of Peninsular Malaysia (Yeap, 1974; Sitanggang, 1979). From Table 3 it is observed that the tin content in the Pelangas granite is lower than that in the Menumbing and Tempilang granites. The concentration of Rb tends to increase with the higher tin content. With an increase in the Rb/Sr ratio, the tin content also shows an increase but this is inversely proportional to the K/Rb ratio. The concentrations of Sr and the Ca/Sr ratios do show any relationship to the tin content.

CONCLUSION

The preliminary study of the Menumbing, Pelangas and Tempilang granites on Bangka Island indicates several features. Firstly, based on the Ca^{2+} content, the Pelangas granite is

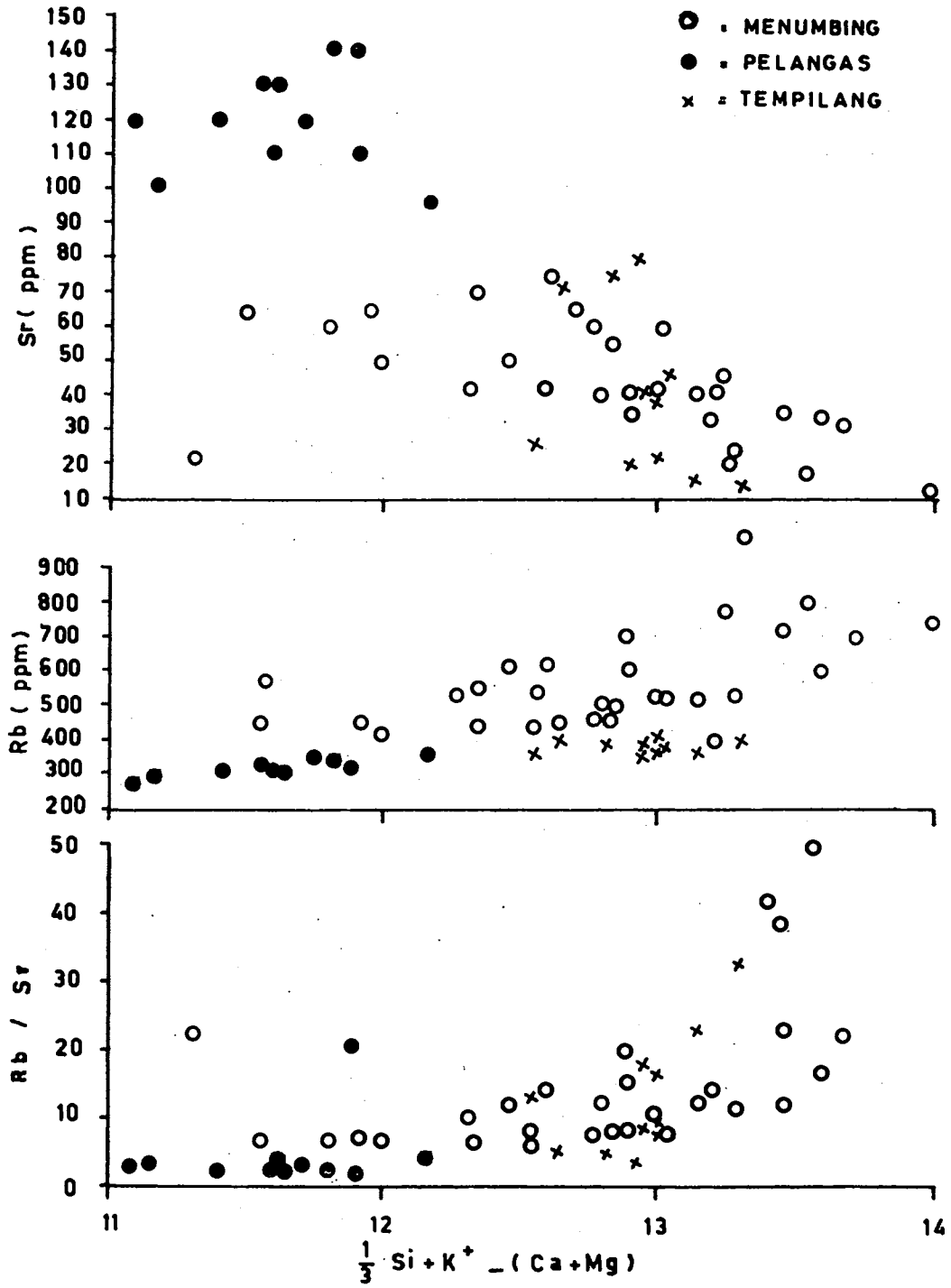

Fig. 11 Relationship of Sr, Rb and Rb/Sr against ($^1/_3$ Si + K) + (Ca + Mg)

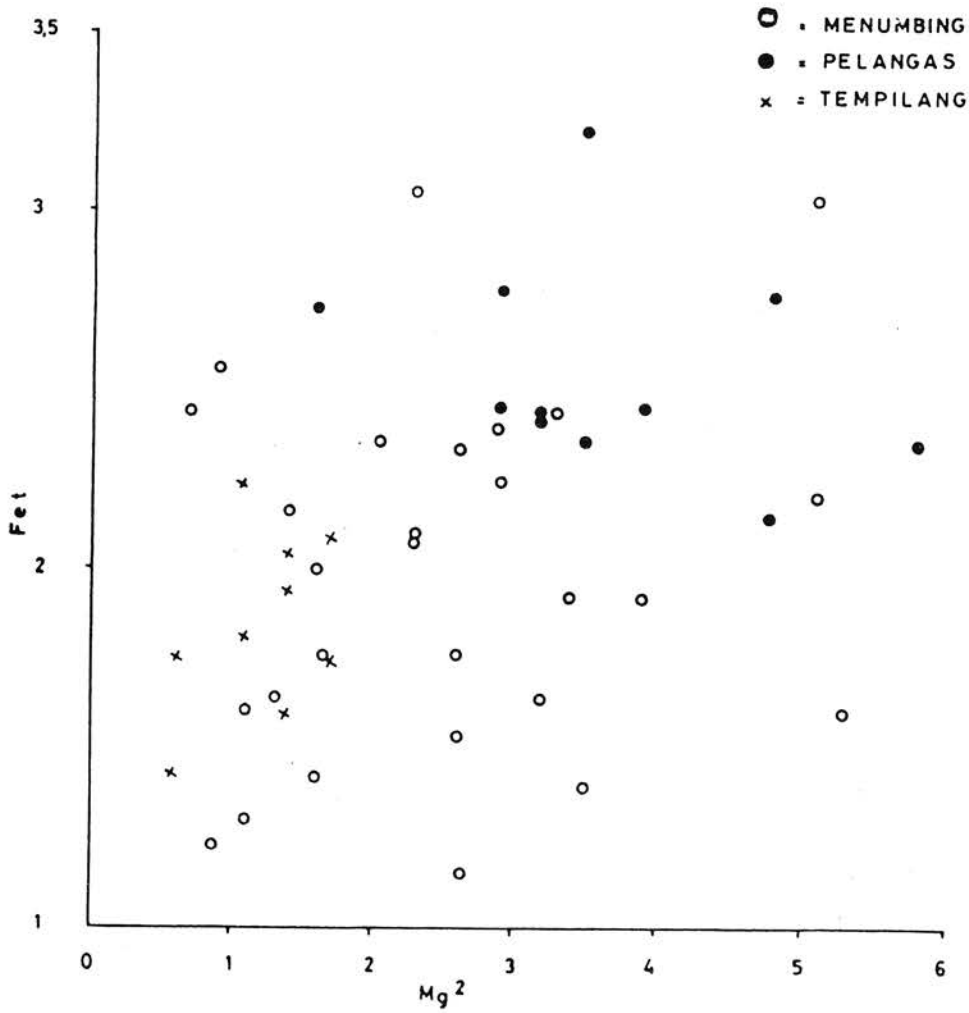

Fig. 12 Relationship of Fe(total) – Mg

a high-Ca granite while the Menumbing and Tempilang granites are low-Ca granites. The Rb and Sr content of the granites reflect the degree of differentiation of the granite. Rb content increases while the Sr content decreases with differentiation. Finally it appears that an increase in the tin content is reflected by a decrease of the K/Rb ratio and an increase in the Rb/Sr ratio in these granites.

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Development Laboratories (AMDEL) using XRF techniques. However any error presented in this paper is the sole responsibility of the author.

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