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# Chemical characteristics of some of the granitic bodies from Terengganu area, Peninsular Malaysia

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**Abstract:** The present study involves some of the granitic rocks from the Eastern granitic belt which is located in the Terengganu area. Four granitic bodies will be considered : they are Maras Jong pluton, Jerong batholith, Perhentian granite pluton, and Kapal batholith. The range of $SiO_2$ in each granitic body is : Maras Jong (65.67-76.34%), Jerong (66.7-76.9%), Perhentian (70.9-75.4%) and Kapal (63.03-76%). All granites are high K calc alkali. They also have high total alkali content where ($Na_2O$ + K2O : 5.9 to 9.8) and are mildly metaluminous to peraluminous (ACNK values : Maras Jong = 1.01 - 1.27; Jerong = 0.98 - 1.05; Perhentian = 0.92 - 1.03 and Kapal = 0.89 - 1.07). LIL elements and $TiO_2$ vs Zr plots of all the granites indicate that K-feldspar, biotite plagioclase, zircon, biotite, hornblende and sphene play an important role in determining the variation during fractionation process. The geochemistry of the granites show that each granitic body has a specific character and probably is made up of individual batches of melt.

## INTRODUCTION

The Peninsular Malaysia granites are distributed in three parallel belts which have been grouped into 2 granite provinces (Cobbing *et al*., 1986); the Main Range province with an age range of 200 to 230 Ma and the Eastern province with a range of 200 to 264 Ma. The eastern granitoid province, which consists of the Central belt and the Eastern Belt comprises an extended compositional spectrum from gabbro to monzogranite, forming small batholiths and small plutons which are generally smaller than those of the Main Range. The present study involves the granitic rocks from the northern part of Eastern Belt granite belt which located is in the Terengganu area (Figure 1).

Four granitic bodies from the Eastern Belt of Terengganu area are considered: they are Maras Jong pluton, Jerong batholith, Perhentian granite pluton, and Kapal batholith (Figure 1). Detailed description of these granitic bodies has been given by previous workers (Mac Donald, 1967; Chand, 1978; Cobbing *et al*., 1986, 1992; Azman, 1992) and only a short synopsis is given here to facilitate relation of the different granites to their geochemical relationship.

## GRANITE DESCRIPTION

### Maras Jong pluton

The Maras Jong granite is the most easterly granitic pluton in the Eastern Belt of mainland Terengganu. The rock is coarse grained and consists of plagioclase, K-feldspar, quartz, biotite, apatite, tourmaline, opaque phases, muscovite, sericite, chlorite and epidote. Small dykes of microgranite and quartz porphyry are fairly common (Rajah *et al*., 1977). The granite is characterised by tourmaline clots bordered by felsic material. The size of the clots usually is less than 15 cm across. Age of this granite is about 260 Ma obtained by K-Ar method (Bignell & Snelling, 1977). The granites carry about 1% of xenoliths which may be of metasedimentary origin.

### Jerong batholith

The Jerong batholith is located immediately to the south of the Maras Jong granite. The batholith is a rather small but complex body having a compositional range from gabbro to granite. It consists of several plutons such as the Tanggol, Wakaf, Kenanga granites and the Mempelas gabbro (Cobbing *et al*., 1992). The most basic

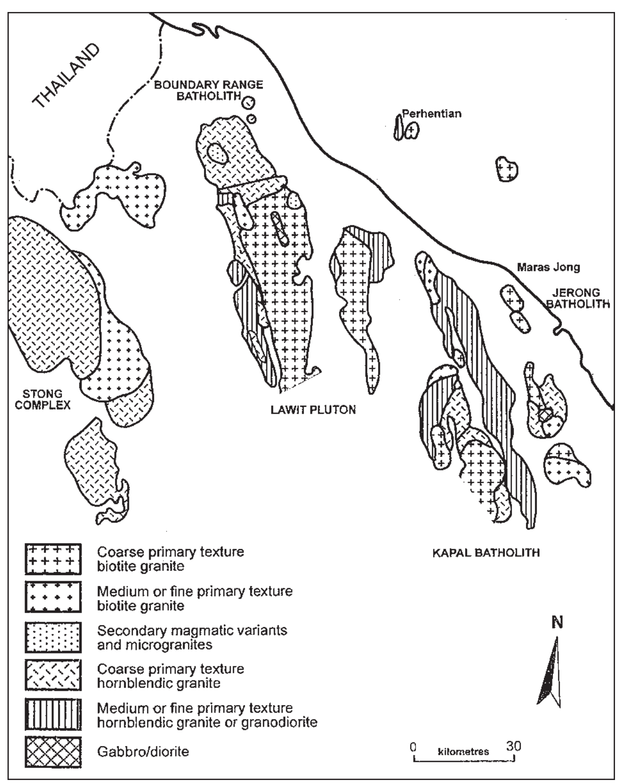


**Figure 1.** Simplified geological map of Terengganu and the northern part of Peninsular Malaysia showing all four granites mentioned in the text.

component is the ilmenite-bearing Mempelas gabbro which occurs at the centre of the batholith. Both olivine and pyroxene gabbros are present. The granite phases are generally medium to coarse grained biotite to hornblende biotite granite. They consist of plagioclase, K-feldspar, quartz, hornblende, biotite, pyroxene, olivine, apatite, opaque phases and sphene.

## Perhentian granite

The Perhentian granite is located off Terengganu in the Perhentian Island. The granite is similar to the Maras Jong granite, both in grain size and mineralogy. It forms the whole of Pulau Perhentian Besar and Pulau Rawa and part of Pulau Perhentian Kecil (Figure 1). The granite is inequigranular to megacrystic with grey-white megacrysts. The main body contains biotite only but marginal phases also carry traces of hornblende. The main granite type is syenogranite and monzogranite.

## Kapal Batholith

Kapal batholith, one of the largest granitic bodies in the Eastern Belt, extends from the Setiu River in the north to Gunong Irong in the south (Rajah *et al*., 1977). The batholith also consists of several smaller granitic plutons such as Saok Granodiorite, Chengal Granite and Kesing Granite. The batholith is a composite body ranging from diorite to monzogranite in composition and dominated by granodiorite. Contact relationships in the northern part of the body are variable but towards the south the trend is more conformable (Rajah *et al*., 1977). Roof pendants and faulted contacts along with quartz veins and mafic dykes are common.

## CHEMICAL VARIATION

This section will emphasize the chemical variation within and between the granite bodies. The geochemical data are taken from Cobbing *et al.* (1992), Liew (1983) and Azman (unpublished data). Selected Harker diagrams for the major elements are given in Figure 2. The range of $SiO_2$ for each of the granite bodies is: Maras Jong (65.67-76.34%), Jerong (66.7-76.9%), Perhentian (70.9-75.4%) and Kapal (63.03-76%). The data show that the range of $SiO_2$ values from each granitic body, especially the Maras Jong, Jerong and Kapal, overlap. In general, the plots show clear trends of decreasing $Al_2O_3$, $TiO_2$, Fe(tot), MgO, CaO, $P_2O_5$ and MnO and $K_2O$ increase with increasing $SiO_2$. Two samples from the Kapal batholith show exceptionally high MgO, CaO and low $Na_2O$. This probably suggests that this sample may represent a separate pulse from the rest of the Kapal granite samples. The difference between the four granites probably is best illustrated on a $P_2O_5$ vs $SiO_2$ diagram. Thus, two trends can be differentiated in this diagram; Maras Jong samples form a separate trend to those of other three granites. This results from a higher $P_2O_5$ content of the Maras Jong granite compared to the other three granites at a given $SiO_2$ concentration. For example the sample with 65% $SiO_2$ from the Maras Jong has 0.24% $P_2O_5$ compared to the Kapal granite which only has 0.16% $P_2O_5$ at the same $SiO_2$ content. On the other hand the Maras Jong granite, and to a lesser extent those from Perhentian granite, have low CaO content compared to Jerong and Kapal granites.

The majority of the samples fall in the field of high-K calc-alkaline magma as defined by Peccerilo and Taylor (1976) (Figure 3). The calc alkali nature of the granite is also shown in the figure 4. A combined plot of CaO vs SiO2 and $Na_2O + K_2O$ vs $SiO_2$ shows that all granites are to be calc alkali (Peacock, 1931).

In Figure 5, the ratio of mol $Al_2O_3/(CaO + Na_2O + K_2O)$ (ACNK) is plotted against $SiO_2$. Compositions above the

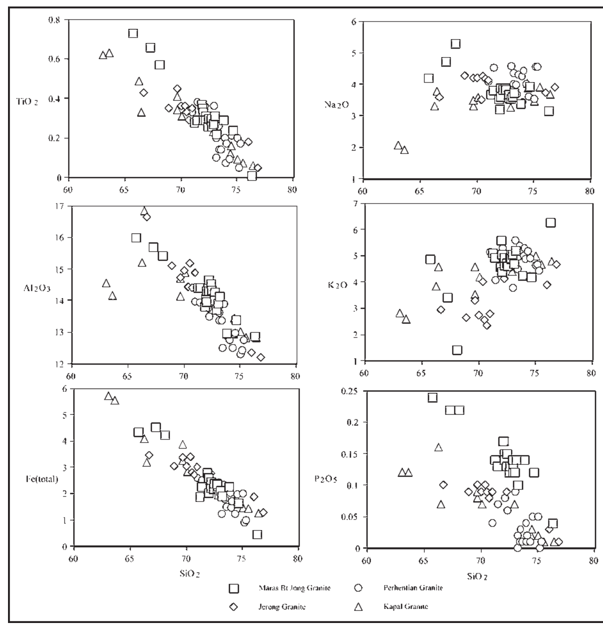


**Figure 2.** Major element Harker diagrams of the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area. All values in percentage.

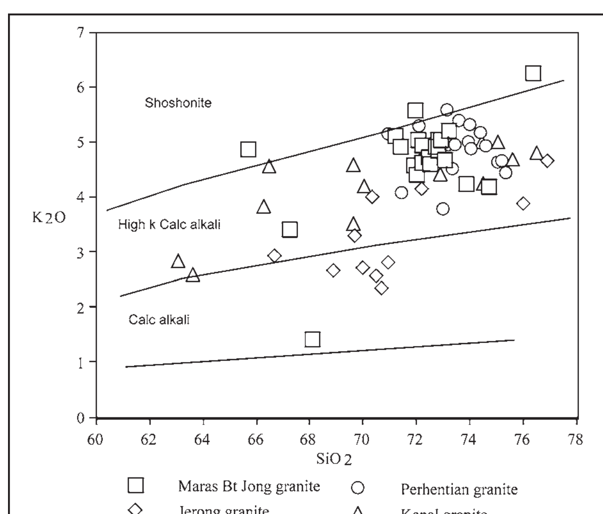


**Figure 3.** $K_2O$ vs. SiO2 diagram of the granitic rocks from the Terengganu area. Note the different trends shown by both rocks. Compositional fields after Peccerillo and Taylor (1976). All values in percentage.

line ACNK = 1 are peraluminous. Samples with ACNK > 1.1 are S type according to the definition of Chappell and White (1974). The range of ACNK in each granite is: Maras Jong = 1.01 - 1.27; Jerong = 0.98 - 1.05; Perhentian = 0.92 - 1.03 and Kapal = 0.89 - 1.07. The data show that the granites are mildly metaluminous to peraluminous (Shand, 1943). In general three trends have been produced by the granites. They are (1) decrease with increasing $SiO_2$ (Maras Jong and Perhentian granites), (2) flat trend with increasing $SiO_2$ (Jerong granite) and (3) increase with increasing $SiO_2$ (Kapal granite). Only four samples from the Maras Jong granite fall in the 'S' type field.

Harker diagrams of trace elements are shown in Figure 6. In general, Sr, V, Zr, and to lesser extent Zn and Ba decrease with increasing $SiO_2$. Trends of Rb, Ce, La, and Pb are much more scattered. Th and Y produce a 'J' shaped trend with increasing $SiO_2$. Both Ce and La in Kapal and Jerong granites plot in two trends respectively, one decreases and the other increases with $SiO_2$. This may indicate that these granites consist of several separate granitic pulses. The Kapal granite also shows significantly low Nb compared to other three granites whereas the Maras Jong granite has low Ce, Y and La. The Y vs $SiO_2$ plot also distinguishs the Perhentian and Kapal granites from the other two granites. Y content in both Perhentian and Kapal granites show a 'J' type trend compared to Maras Jong and Jerong granites which show a flat trend with increasing $SiO_2$. The Maras Jong granite has the lowest Ba and Sr and considerably high Rb compared to other three granites.

On a log Sr vs log Ba plot (Figure 7), the general trend of all granites seems to be controlled by fractionation of K-feldspar, biotite and plagioclase. Detail examination shows the Perhentian and Maras Jong trends are slightly different from the Jerong and Kapal granites. The former two granites show a trend compatible with liquid evolution by extraction of K-feldspar or K-feldspar + biotite or K-feldspar + plagioclase or all these three minerals. The rocks from the Kapal granite produce a much scattered plot. On a log Rb vs log Sr plot (Figure 7), the general trend for all granites is consistent with extraction of hornblende and biotite at the early stage and K-feldspar dominating the later stage. This trend relates to high Rb content at low Sr. However, compared to the modal data, hornblende may not play an important role in determining the variation in both Maras Jong and Perhentian granites (modes lack hornblende).

The $TiO_2$ vs Zr plot (Figure 8) is important in constraining the role of zircon, magnetite and sphene as well as hornblende and biotite during crystallization. The general trend shown by all granites seems to be controlled by zircon, biotite, hornblende and sphene. The best individual trend probably is shown by the Perhentian granite. Thus the crystallisation options for Perhentian granite are zircon+sphene, zircon+hornblende, zircon+ magnetite, zircon+biotite+hornblende and biotite+ hornblende+sphene or some combination of these minerals.

The spider diagrams of the trace elements (+ K, P and Ti) for each of the granites are shown in Figure 9. Profiles for Kapal, Perhentian and Jerong granites show a family likeness with marked depletion in Ba, Nb, P and Ti which is probably related to fractionation of feldspars, apatite and iron titanium minerals. The negative Nb anomaly, which is often taken to characterised subduction-related magmas (e.g. McCulloch & Gamble, 1991), is also present in all granite profiles, and is therefore probably inherited from the source region (e.g. Muir *et al*., 1996). The Maras Jong granite shows slightly different profiles compared to the other three granites. The former profile is depleted in Ba, Th, Nb, Sr and Ti which is probably related to fractionation of feldspars and iron titanium mineral.

One of the most distinctive differences between the Maras Jong granite and the other three is in the La and Ce contents, the Maras Jong granite having much the lowest value. These differences are well displayed on La vs Ce diagram (Fig. 10) where the fields for the Maras Jong

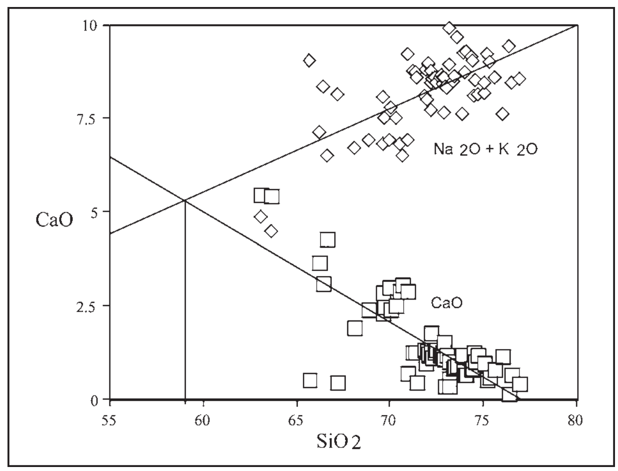


**Figure 4.** Combined plot $Na_2O + K_2O$ and CaO vs $SiO_2$ for the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area. All values in percentage.

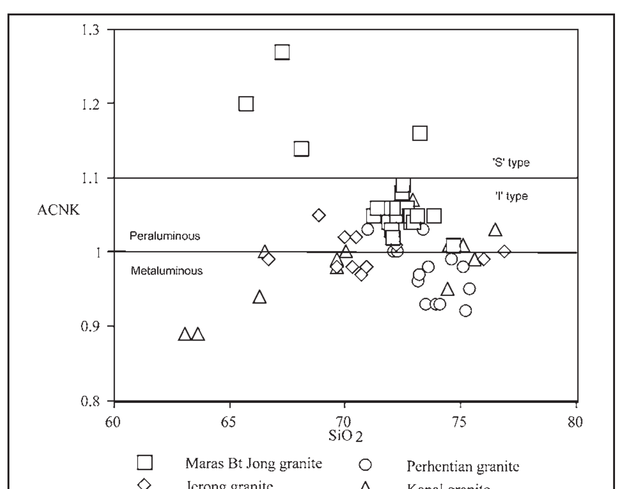


**Figure 5.** ACNK vs SiO2 (%) plot of the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area. Line at ACNK = 1 divides peraluminous and metaluminous field and line at ACNK = 1.1 divides 'I' and 'S' type granite fields. Note the different trends shown by both rocks.

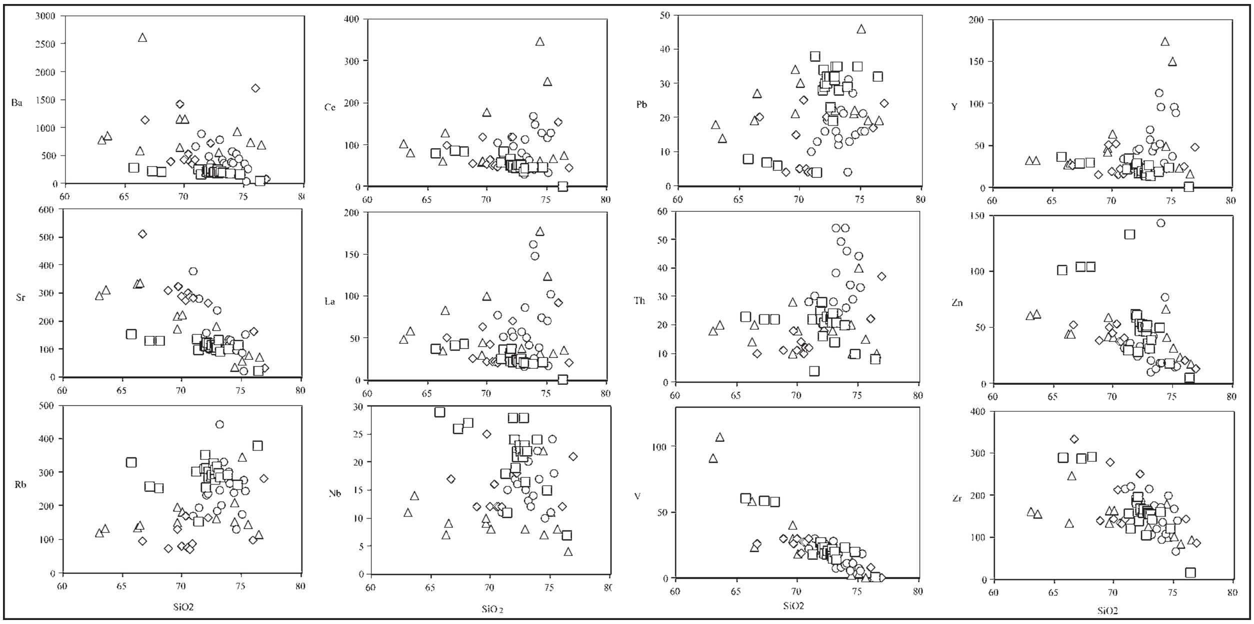


**Figure 6.** Trace element Harker diagrams of the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area. Trace elements in ppm and $SiO_2$ in percentage.

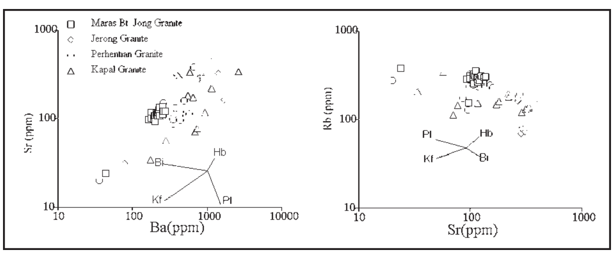


**Figure 7.** LIL element modeling for the granites from the Terengganu area. Mineral vector indicates the net change in composition of the initial liquid after 20% fractionation. Pl = plagioclase; Kf = K-feldspar, Hb = hornblende ; Bi = biotite.

granite are distinct and lower than those of the other three granites. Notably also the same trend is shown by all granites which probably related to fractionation of accessory phases ($Kd^{La}_{allanite}$ = 2594; $Kd^{Ce}_{allanite}$ = 2278). The Perhentian samples plot near the La:Ce = 1:1 line whereas the other three granites have trends further from the line.

## CONCLUDING REMARKS

The trends shown by all granites on major element plots are similar to other calc alkaline granitic rocks elsewhere (e.g. Atherton & Sanderson, 1987). More specifically the granites belong to the high-K calc alkaline series of Peccerillo & Taylor (1976). The granites also have high total alkali contents where Na2O + K2O range between 5.9 to 9.8. Recent Circum Pacific Volcanic display the same K-enrichment where the magmas have passed through thick continental crust. LIL elements and $TiO_2$ vs Zr plots of all the granites indicate that K-feldspar, biotite plagioclase, zircon, biotite, hornblende and sphene play an important role in determining the variation during fractionation process. The geochemistry of the granites shows that each granitic body has a specific character and probably is made up of individual batches of melt. The bulk of the evidence presented here also indicates that although fractional crystallisation was an important mechanism in controlling the evolution of the plutons, a simple fractionation model cannot explain many of the incompatible element variation.

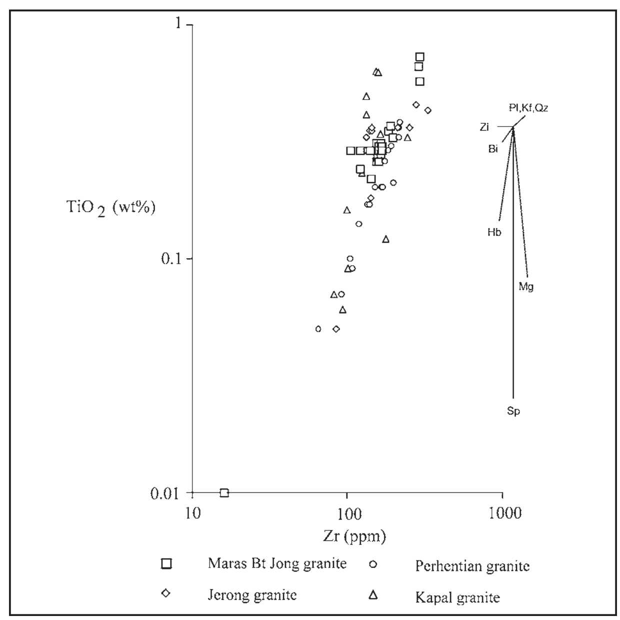


**Figure 8.** $TiO_2$ vs. Zr plot of the syenitic and granitic rocks from the Perhentian area. Mineral vectors indicate path evolved liquids for 15% of a mineral precipating: Pl = plagioclase; Kf = K-feldspar, Qz = quartz; Mt = magnetite, Sp = sphene; Hb = hornblende; Bi = biotite; Zi = zircon.

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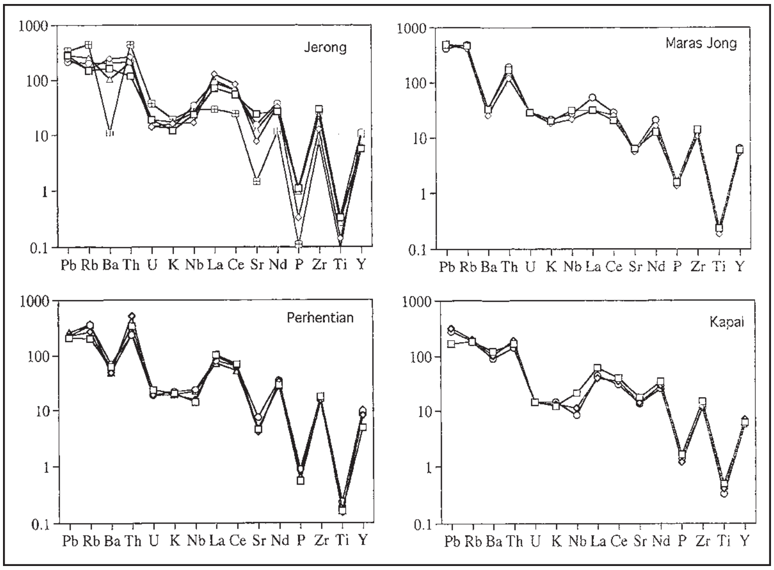


**Figure 9.** Primodial mantle normalized diagram for the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area.

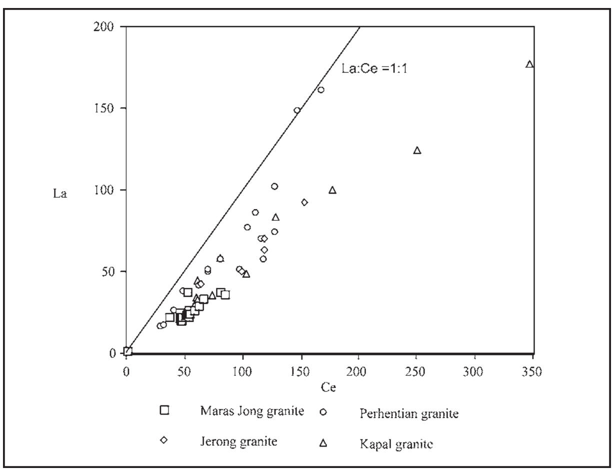


**Figure 10.** La vs Ce (in ppm) plot of the Maras Jong, Jerong, Perhentian and Kapal granite from the Terengganu area.

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