ภาควิชาธรณีวิทยา
คณะวิทยาศาสตร์
จุฬาลงกรณ์มหาวิทยาลัย

วิชา 2307551
Geotectonics
แบบฝึกหัดที่ 15 & 16

ชื่อนิสิต... รหัส.......................................

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แผนผังแยกแยะการแปรสัณฐาน

(Tectonic Discrimination Diagram)

ตาราง - 1. Granites & tectonic discrimination diagram

(Eastern, Centeral, Westeres, - Punya's Data

- 2. Tectonic discrimination diagram

(Cenozoic, Lampang) - Punya's Data

- 3. Basalts & tectonic sefling

(Cenozoic, Lopburi) - Punya's Data

- 4. Dike (Minor Intrusion) & tectonics

(Triassic, Nam Duk - Petchabun)

- Phajuy et al. (2005)'s Data

- 5. Basalt

(Cenozoic, Nam Cho Sop Prap-Ko Kha, Lampang)

ดูรายละเอียดในรูปที่แนบมาในบทนี้

<u>หมายเหตุ</u>

1. การบ้านมี 4 ข้อ ไม่มีเลือกทำทุกข้อ
2. ให้นิสิต แบ่งเป็น 4 กลุ่ม ตามที่กำหนด
3. ตาราง 1 ไม่ต้องทำทุกข้อ (มีเลือกทำได้)
4. ตาราง 1 ตัวอย่างหมายเลข V ไม่ทำครับ
5. เลือกทำ granite - 2 grapl 1 สามเหลี่ยม (triangnlar diagram)

   Basalt - ทำรูป 5.3 ทุกคน และเลือกทำ grapl อื่นๆ อีก 2 กราฟ

   Dyhe - ทำในกราฟ 5.2 และ 5.7
6. บอกด้วยว่า granite & basalt ของคุณอยู่ใน tectonic seething แบบใด เพราะอะไร

+Tectonic Settings and Igneous Rocks(1)

- Volcanics (mainly Basalts)
  (1) TIZ diagram (Pearce& Cann,1973)

+ Ti - Zr - Y diagram (Fig.5.1)

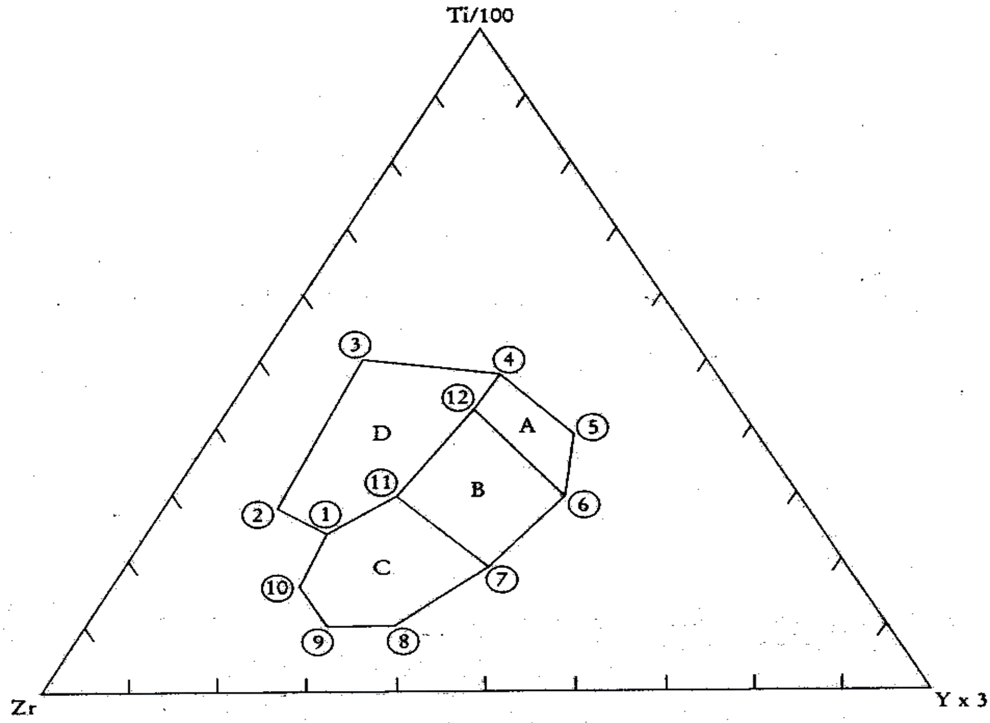

Figure 5.1 The Ti–Zr–Y discrimination diagram for basalts (after Pearce and Cann, 1973). A is the field of island-arc tholeiites, C the field of calc–alkali basalts, D is the field of within-plate basalts and B is the field of MORB, island-arc tholeiites and calc–alkali basalts. Rocks which plot in field B give an ambiguous result but can be separated by plotting on a Ti–Zr diagram (Figure 5.2) or if unaltered on a Ti–Zr–Sr diagram (Figure 5.3). The plotting coordinates, extracted from Pearce and Cann (1973 — Figure 3) are:

Point	Ti/100	Zr	Y × 3	Point	Ti/100	Zr	Y × 3
1	24	55.5	20.5	7	19	40	41
2	28	59	13	8	10	55	35
3	50	38.5	11.5	9	10	62.5	27.5
4	48	24	28	10	16	63	21
5	39	20.5	40.5	11	29.5	45	25.5
6	30	26	44	12	42.5	30	37.5

+ Ti - Zr – diagram
(Fig.5.2)

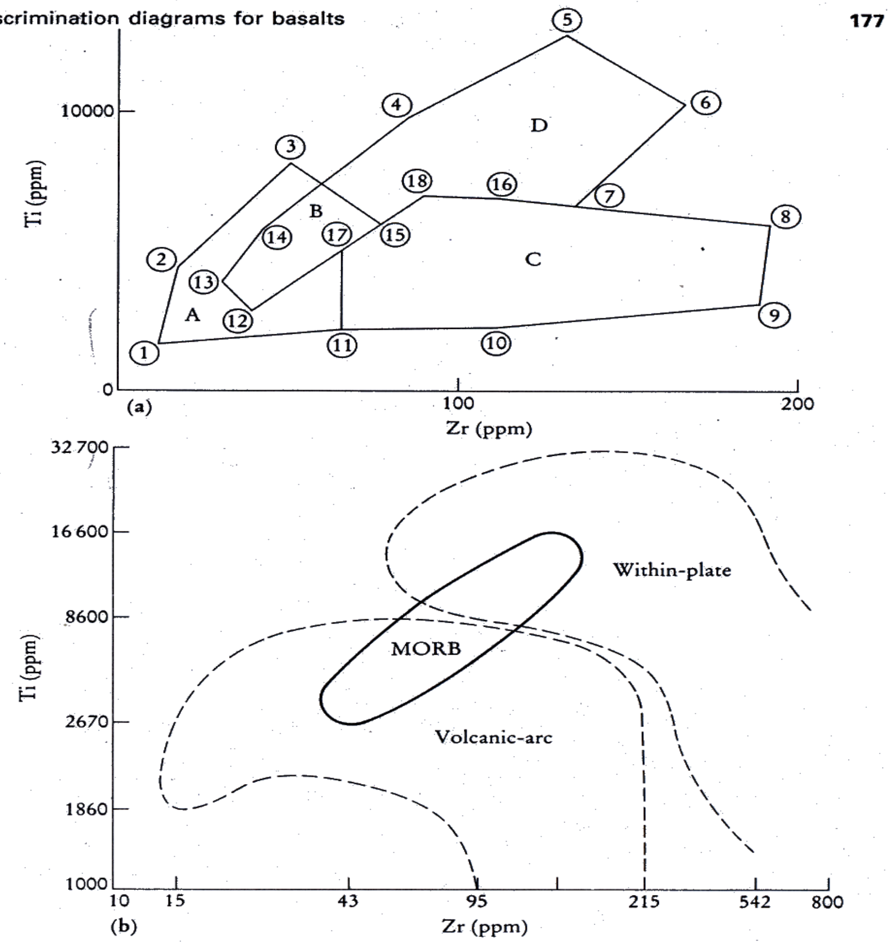

Figure 5.2 Discrimination diagrams for basalts based upon Ti–Zr variations. (a) Linear scale (after Pearce and Cann, 1973); the fields are as follows: A, island-arc tholeiites; B, MORB, calc–alkali basalts and island-arc tholeiites; C, calc–alkali basalt; D, MORB. The plotting coordinates (extracted from Pearce and Cann, 1973 — Figure 2) are as follows:

Point	Zr	Ti	Point	Zr	Ti
1	12	1 700	10	113	2 400
2	18	4 600	11	65	2 400
3	52	8 500	12	39	3 100
4	84	10 400	13	31	4 100
5	131	13 000	14	42	6 000
6	167	10 900	15	78	6 400
7	135	7 100	16	113	7 400
8	192	6 600	17	65	5 400
9	190	3 400	18	89	7 400

(b) Log scale (after Pearce, 1982) showing the fields of volcanic-arc basalts, MORB and within-plate basalts. The values given on the ordinate and abscissa can be used as a guide in drawing the field boundaries (data extracted from Pearce, 1982).

+ Ti - Zr - Sr diagram

(Fig.5.3)

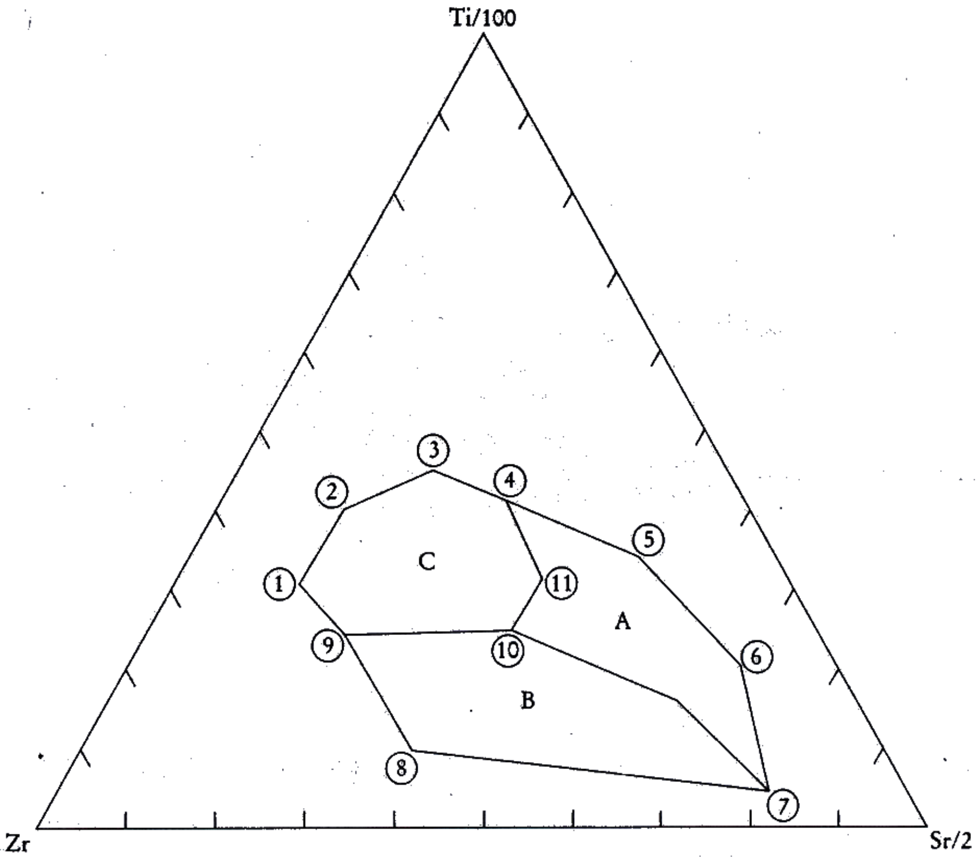

Figure 5.3 The Ti–Zr–Sr discrimination diagram for basalts (after Pearce and Cann, 1973). Island-arc tholeiites plot in field A, calc–alkaline basalts plot in field B and MORB plot in field C. The plotting coordinates for this diagram (extracted from Pearce and Cann, 1973 — Figure 4) are:

Point	Ti/100	Zr	Sr/2	Point	Ti/100	Zr	Sr/2
1	31	55	14	7	5	15	80
2	40	45.5	14.5	8	9.5	53	37.5
3	45	33	22	9	24	53.5	22.5
4	41	27	32	10	24	35	41
5	34	15.5	50.5	11	31	28	41
6	20.5	11	68.5				

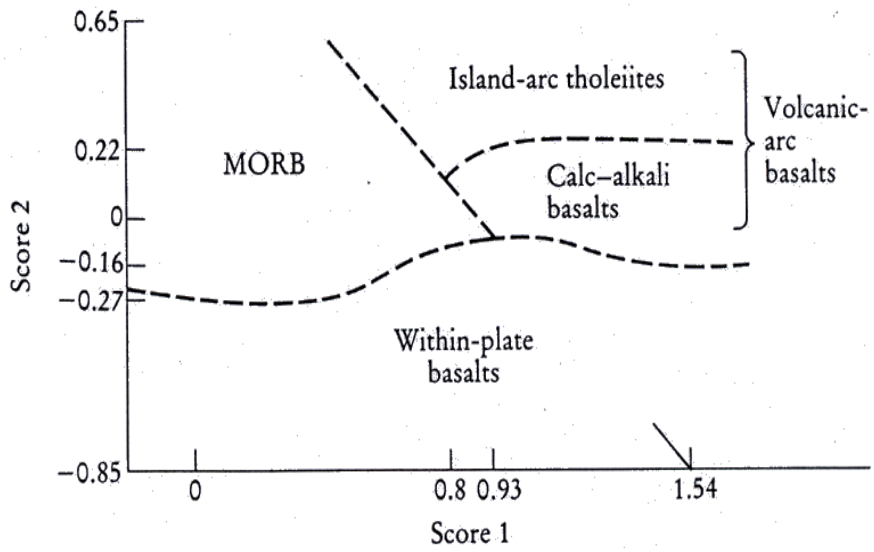

Figure 5.4 Plot of the first principal component score vs the second principal component score for 35 basalt trace element analyses.

$$\text{Score 1} = -0.03707\text{Ti} - 0.0668\text{Zr} - 0.3987\text{Y} + 0.8362\text{Sr}$$
$$\text{Score 2} = -0.3376\text{Ti} - 0.5602\text{Zr} + 0.7397\text{Y} + 0.1582\text{Sr}$$

+ Score 1 - Score 2 diagram - A. Discussion (Fig.5.4)

+Tectonic Settings and Igneous Rocks(2)

-(2) NYTZ diagrams
+ Zr/ Y - Zr diagram (Pearse & Norry, 1979) (Fig.5.5 A & B)

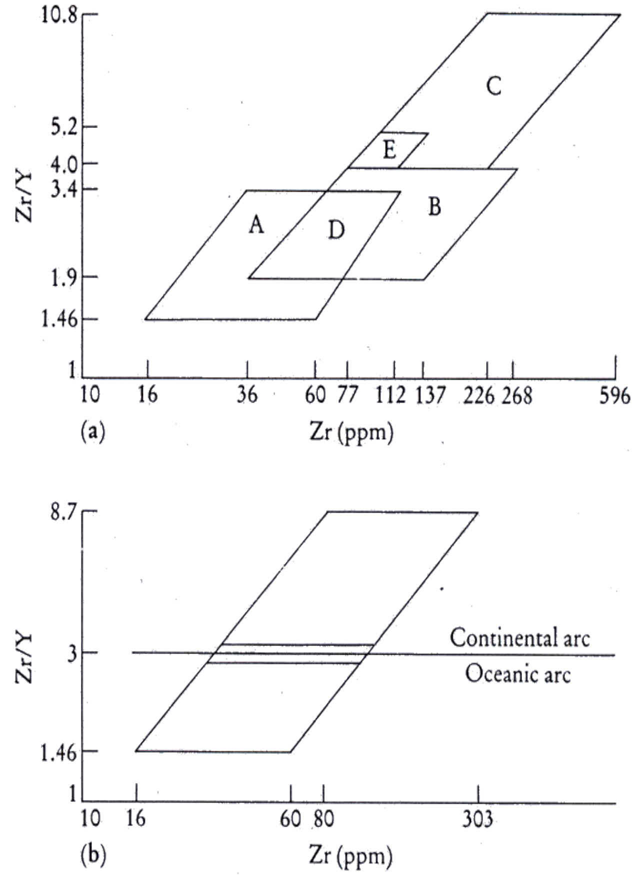

Figure 5.5 Discrimination diagrams for basalts based upon Zr/Y–Zr variations; both diagrams have a logarithmic scale. (a) The fields are A, volcanic-arc basalts; B, MORB; C, within-plate basalts; D, MORB and volcanic-arc basalts; E, MORB and within-plate basalts (after Pearce and Norry, 1979). The values along the ordinate and abscissa are on a logarithmic scale and are given to assist in constructing the field boundaries (data extracted from Pearce and Norry, 1979 — Figure 3). (b) Fields of continental and oceanic-arc basalts separated on the basis of a Zr/Y value of 3. The shaded area is the field of overlap between the two basalt types (after Pearce, 1983).

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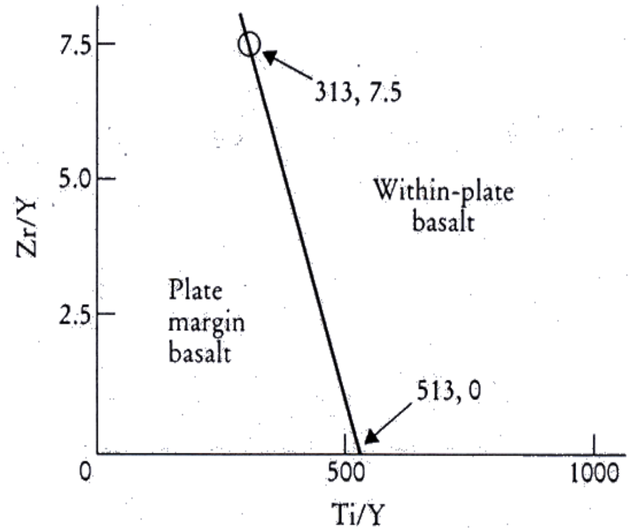

Figure 5.6 The Zr/Y–Ti/Y discrimination diagram for basalts showing the fields of within-plate basalts and plate margin basalts (i.e. all other basalt types). Coordinates are given for the bounding line between the two fields (after Pearce and Gale, 1977).

+ Ti / Y - Nb / Y diagram (Pearse , 1982) (Fig.5.6)

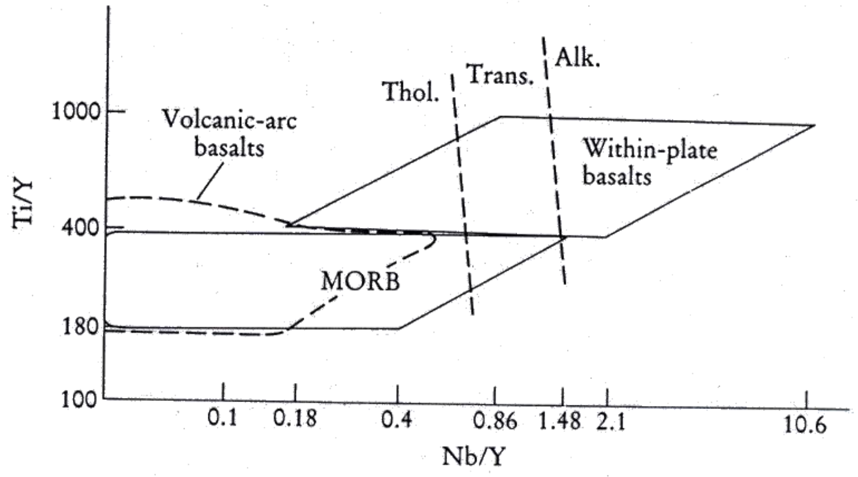

Figure 5.7 The Ti/Y–Nb/Y discrimination diagram for basalts showing the fields of within-plate basalts, MORB and volcanic-arc basalts (dashed line). The within-plate basalts may be divided into tholeiitic (Thol.), transitional (Trans.) and alkali (Alk.) basalt types (after Pearce, 1982). The values given along the ordinate and abscissa are to allow the construction of the field boundaries and are extracted from Pearce (1982 — Figure 9a).

+ Zr / Y - Ti / Y diagram (Pearse & Gale,1970) (Fig.5.7)

+ Zr - Nb - Y diagram (Meschede,1986) (Fig.5.8)

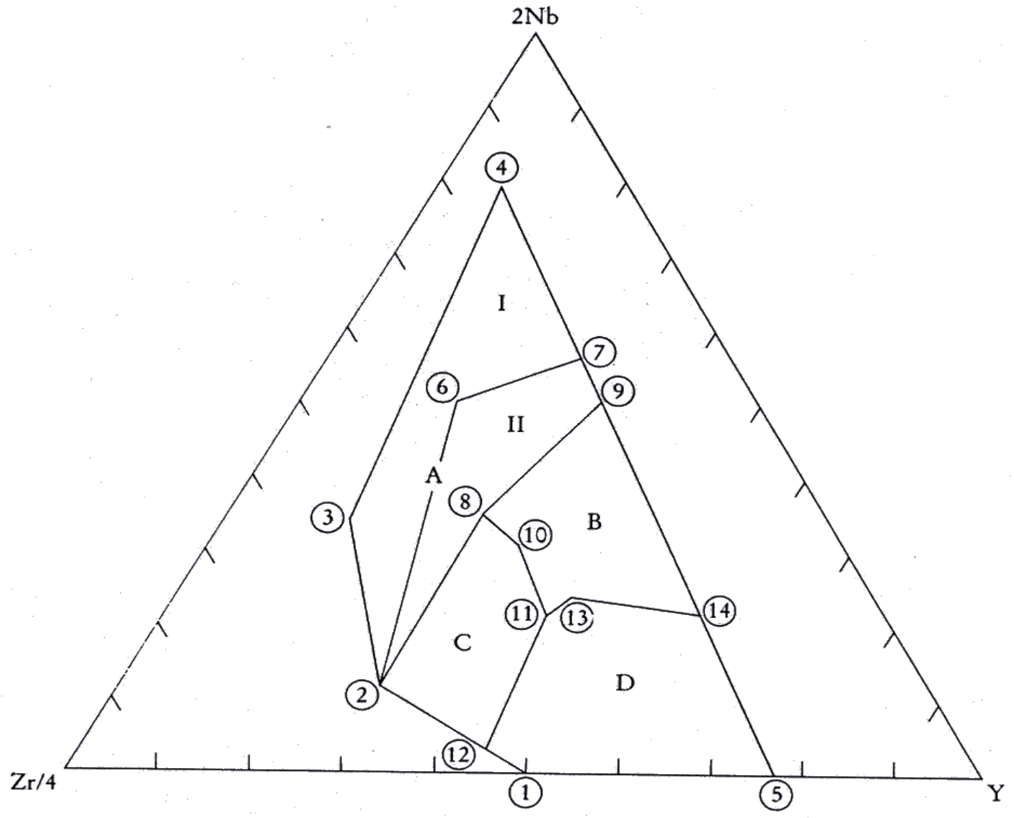

Figure 5.8 The Zr–Nb–Y discrimination diagram for basalts (after Meschede, 1986). The fields are defined as follows: AI, within-plate alkali basalts; AII, within-plate alkali basalts and within-plate tholeiites; B, E-type MORB; C, within-plate tholeiites and volcanic-arc basalts; D, N-type MORB and volcanic-arc basalts. The plotting coordinates for the boundary lines given by Meschede (1986) are:

Point	2Nb	Zr/4	Y	Point	2Nb	Zr/4	Y
1	0	50	50	8	35	37.5	27.5
2	12	60	28	9	50	17	33
3	34	52.5	13.5	10	31	36	33
4	79	14	7	11	22	37	41
5	0	23	77	12	3	53	44
6	50	33	17	13	24	33.5	42.5
7	56.5	16.5	27	14	22	21	57

+Tectonic Settings and Igneous Rocks(3)

-(3) THAT diagram (Wood, 1980)

+ Ta - Th - Hf diagram (immobile elements) all by NAA (Fig.5.9)

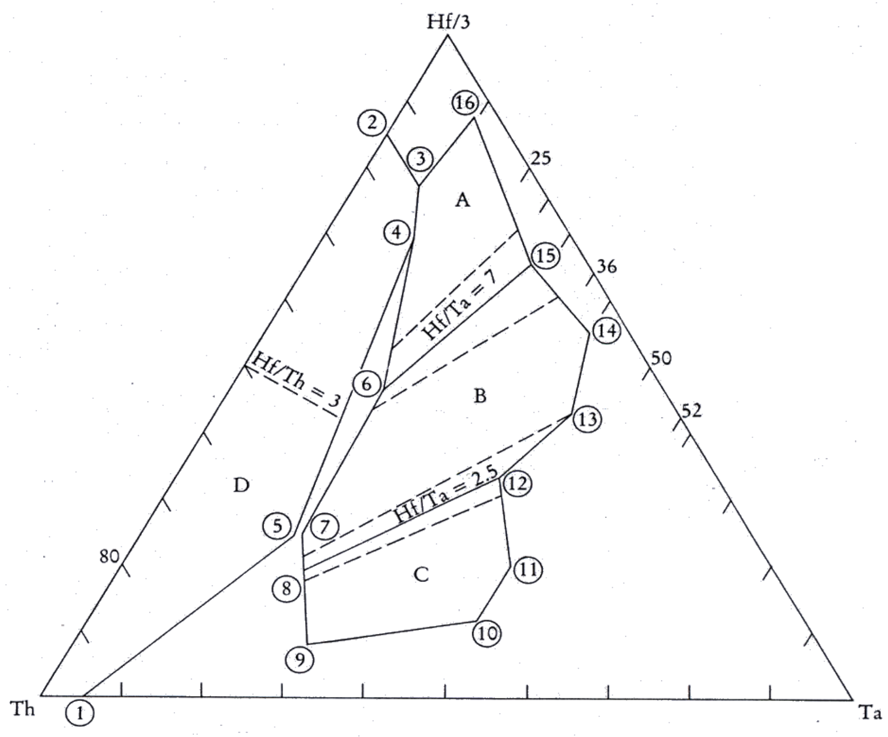

Figure 5.9 The Th–Hf–Ta discrimination diagram for basalts (after Wood, 1980). The fields are: A, N-type MORB; B, E-type MORB and within-plate tholeiites; C, alkaline within-plate basalts; D, volcanic-arc basalts. Island-arc tholeiites plot in field D where Hf/Th > 3.0 and calc–alkaline basalts where Hf/Th < 3.0. The broken lines indicate transitional zones between basalt types. The plotting coordinates for the boundary lines (extracted from Wood, 1980 — Figure 1) are:

Point	Th	Hf/3	Ta	Point	Th	Hf/3	Ta
1	95	0	5	9	63	8	29
2	15	85	0	10	40	12	48
3	15	77	8	11	32	20	48
4	20	69	11	12	27	33	40
5	56.5	24.5	19	13	13.5	42.5	44
6	35	46	19	14	5	55	40
7	55.5	24.5	20	15	7	65	28
8	57	20	23	16	3	87.5	9.5

-(4) TIV Transition - series diagram (Shervais,1982)
MORB Ti / V =20-50, (Fig.5.10)
Ocean-island &alkali basalt
Ti / V = 50 - 100,
island arc tholeiite Ti / V = 10 - 20,
and calc - alkali lava Ti / V = 15 - 50

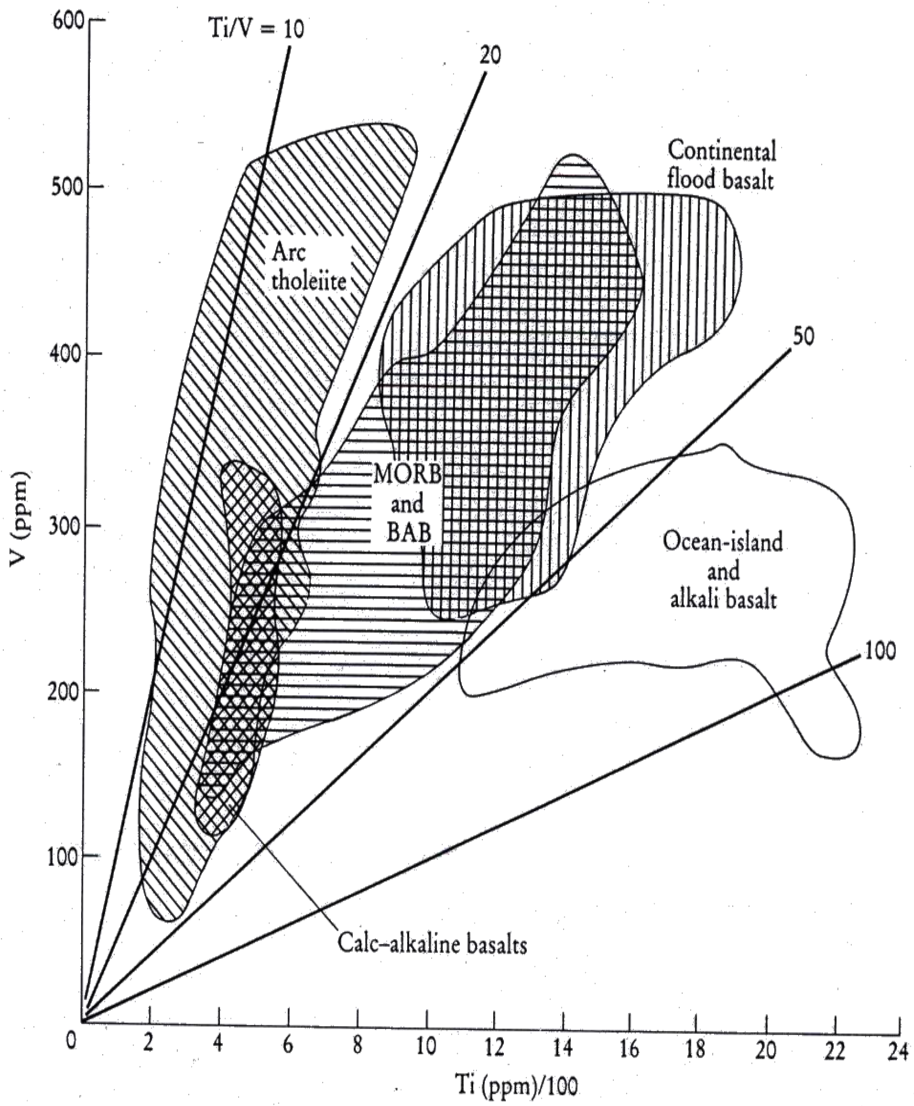

Figure 5.10 The Ti–V discrimination diagram for basalts (compiled from Shervais, 1982). The fields of arc tholeiite (diagonal hatching), MORB and back-arc basin basalts (BAB) (horizontal hatching), continental flood basalts (vertical hatching) and ocean-island and alkali basalt (unshaded) are recognized by their Ti/V ratio as shown. Calc–alkaline basalts (shaded) plot with low Ti concentrations with a wide range of Ti/V ratios.

+Tectonic Settings and Igneous Rocks(4)

-(5) LIN diagram (Cabanis & Lecolle,1989) (Fig.5.11)

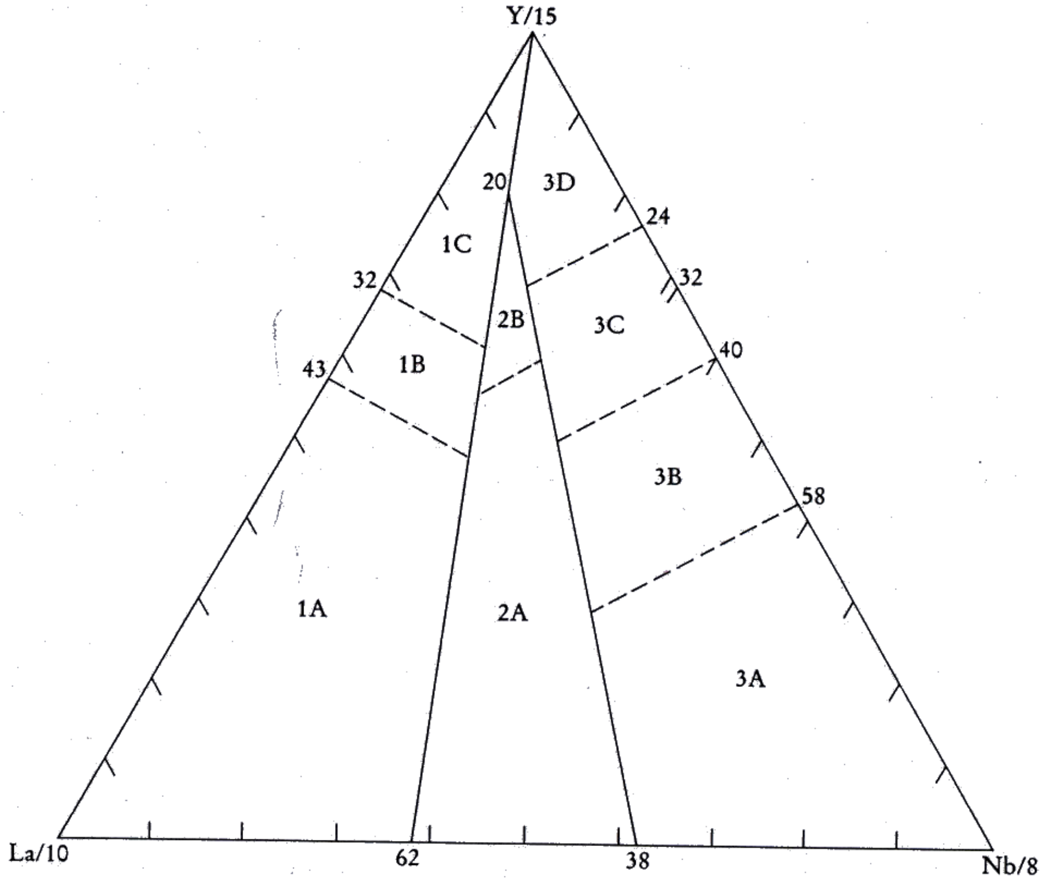

Figure 5.11 The La/10–Y/15–Nb/8 discrimination diagram for basalts (after Cabanis and Lecolle, 1989). The plotting coordinates are shown around the margin of the diagram; the broken lines are drawn normal to the sides of the triangular diagram. Field 1 contains volcanic-arc basalts, field 2 continental basalts and field 3 oceanic basalts. The subdivisions of the fields are as follows: 1A, calc–alkali basalts; 1C, volcanic-arc tholeiites; 1B is an area of overlap between 1A and 1C; 2A, continental basalts; 2B, back-arc basin basalts (although this is less well defined); 3A, alkali basalts from intercontinental rift; 3B, 3C, E-type MORB (3B enriched, 3C weakly enriched), 3D, N-type MORB.

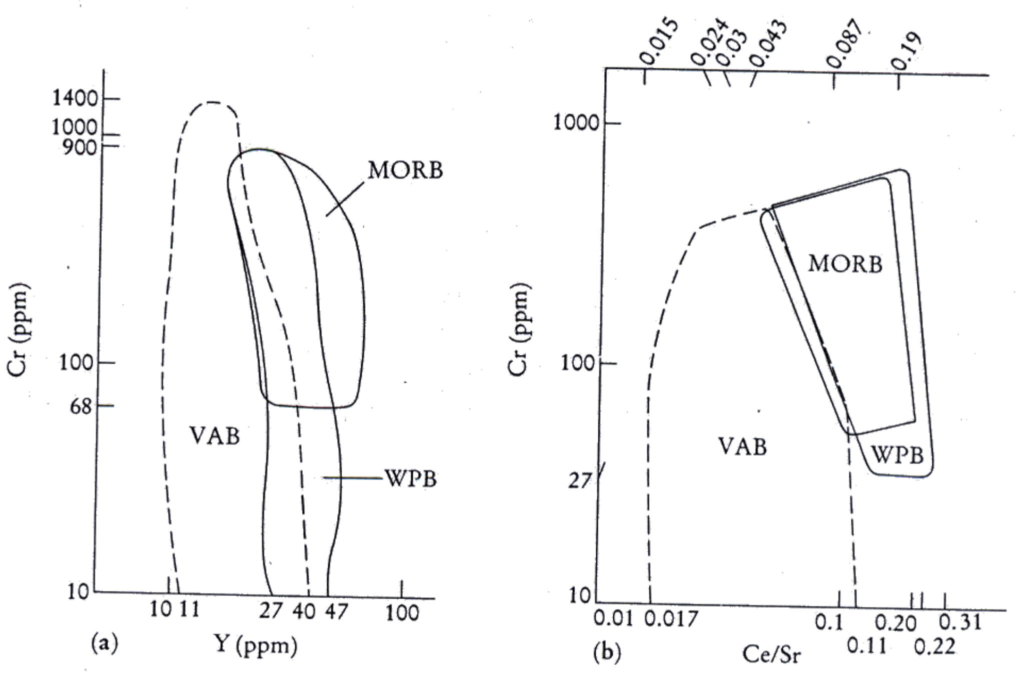

Figure 5.12 (a) The Cr–Y discrimination diagram for basalts (after Pearce, 1982), showing the fields for MORB, volcanic-arc basalts (VAB) and within-plate basalts (WPB). The plotting coordinates useful in constructing the diagram are extracted from Pearce (1982 — Figure 2). (b) The Cr–Ce/Sr discrimination diagram for basalts (after Pearce, 1982), showing the fields for MORB, volcanic-arc basalts (VAB) and within-plate basalts (WPB). The plotting coordinates useful in constructing the diagram are extracted from Pearce (1982 — Figure 5).

-(6) CYC diagram

6.1 Cr - Y diagram (Fig.5.12 a - Pearce,1982)

6.2 Cr - Ce / Sr diagram (Fig.5.12 b -

+Tectonic Settings and Igneous Rocks(5)

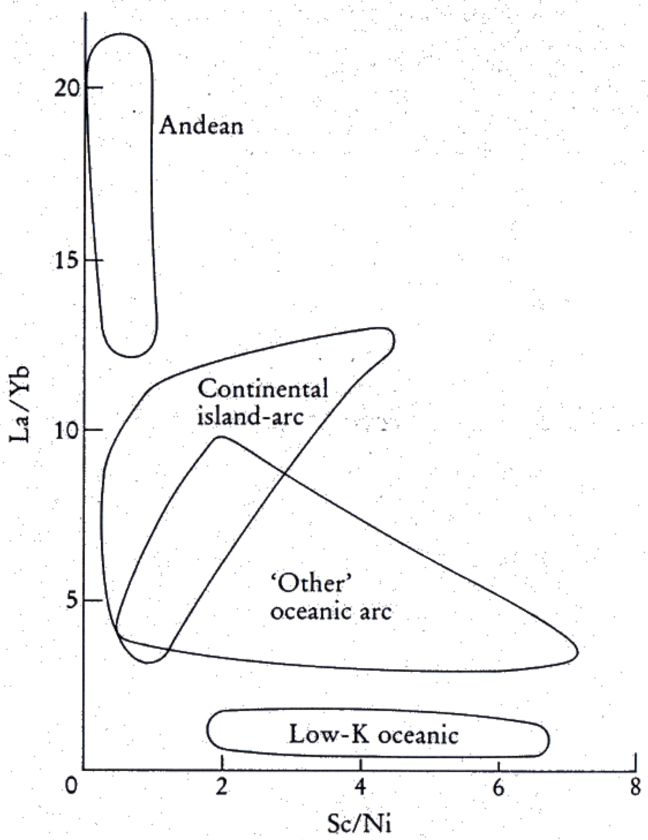

Figure 5.14 The La/Yb–Sc/Ni discrimination diagram for andesites (after Bailey, 1981) showing the fields of Andean-type (active continental margin), continental island-arc, low-K oceanic island-arc and 'other' oceanic island-arc andesites.

-(7) LYBSNI diagram of Andesite

+ La / Yb - Sc / Ni diagram (Bailey,1981) (Fig.5.14)

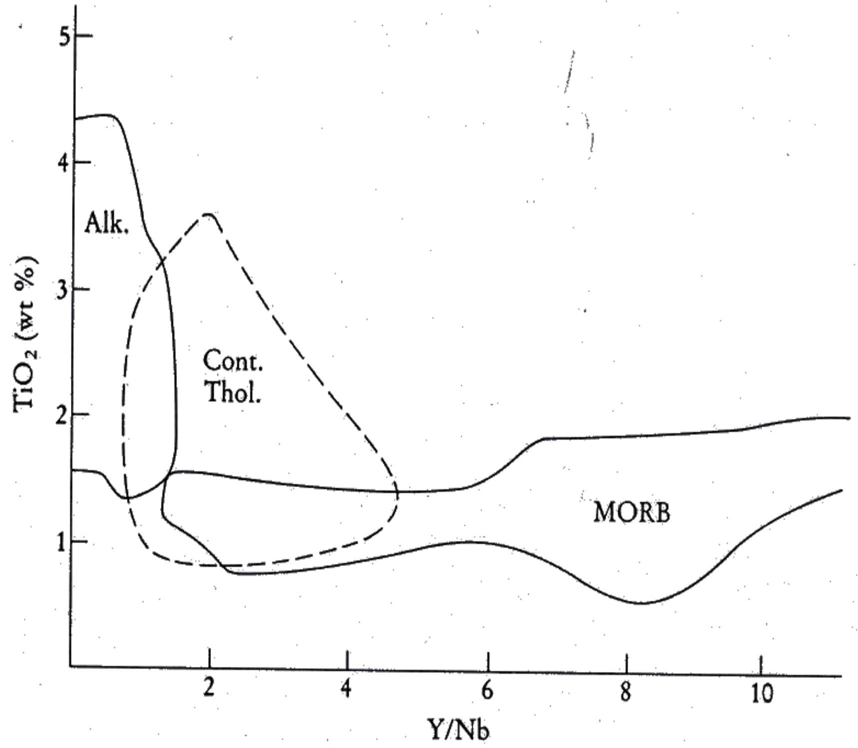

Figure 5.15 The TiO_2–Y/Nb discrimination diagram for basalts (adapted from Floyd and Winchester, 1975), showing the fields of alkali basalts (Alk.), continental tholeiites (Cont. thol.) and MORB.

-(8) TYN diagram of basalts (Floyd and Winchester,1975)
+ TiO_2 - Y / Nb diagram (Fig.5.15)

+Tectonic Settings and Igneous Rocks(6)

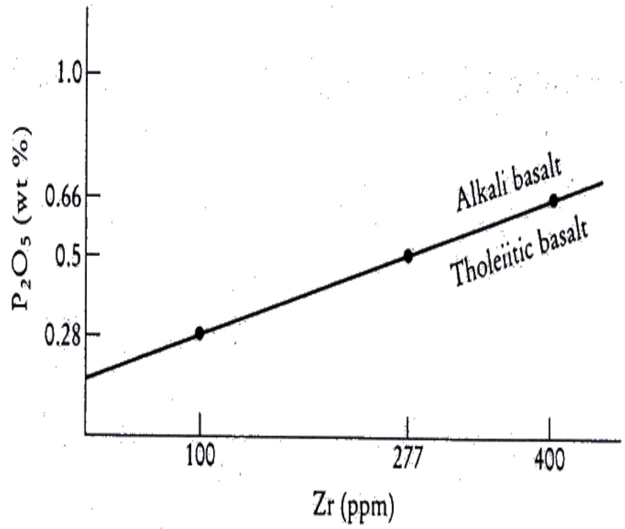

Figure 5.16 The P_2O_5–Zr discrimination diagram for basalts (after Winchester and Floyd, 1976) showing the fields of alkali basalts and tholeiitic basalts. The plotting coordinates of the boundary line are extracted from Winchester and Floyd (1976 — Figure 6).

-(9) POZ diagram of basalts (Floyd and Winchester,1975)
+ P_2O_5 - Zr diagram (Fig.5.16)

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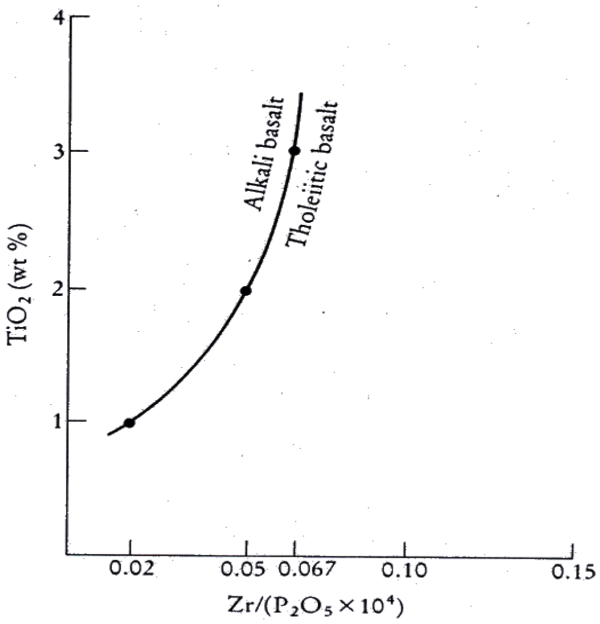


Figure 5.17 The TiO_2–$Zr/(P_2O_5 \times 10\,000)$ discrimination diagram for basalts (after Winchester and Floyd, 1976) showing the fields of alkali basalt and tholeiitic basalt. The plotting coordinates are:

TiO_2	$Zr/(P_2O_5 \times 10\,000)$
1.00	0.020
2.00	0.054
3.00	0.067

(extracted from Winchester and Floyd, 1976 — Figure 2).

+ TiO_2 - Zr / (P_2O_5 x 10,000) diagram (Fig.5.17)

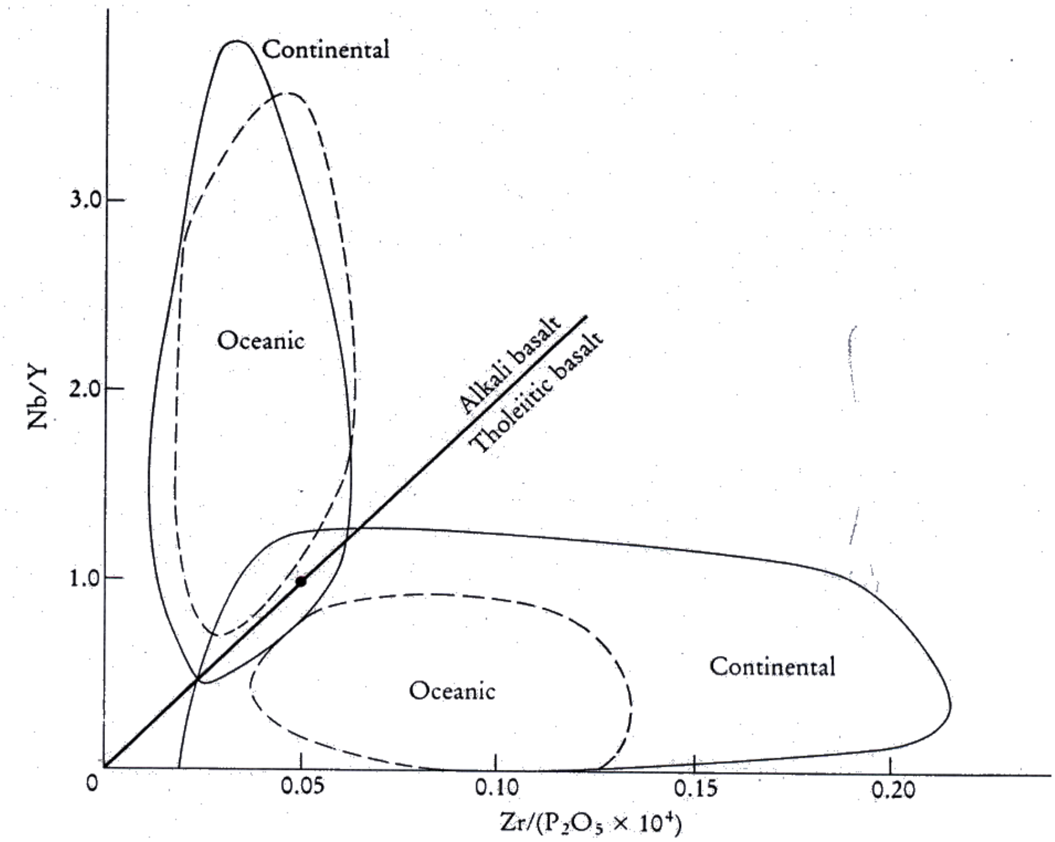


Figure 5.18 The $Nb/Y–Zr/(P_2O_5 \times 10\,000)$ discrimination diagram for basalts (adapted from Floyd and Winchester, 1975), showing the fields of continental and oceanic alkali basalts and tholeiitic basalts. The boundary line and plotting coordinates are taken from Winchester and Floyd (1976 — Figure 11).

+ Nb / Y - Zr / P_2O_5 diagram (Fig.5.18)
+ discussion by Morrison (1978) and Smith (1976)

+Tectonic Settings and Igneous Rocks(7)

-(10) Discrimination diagram of major oxides (Pearce,1976)
+ Discrimination function 1 & 2 (Fig.5.19 a)

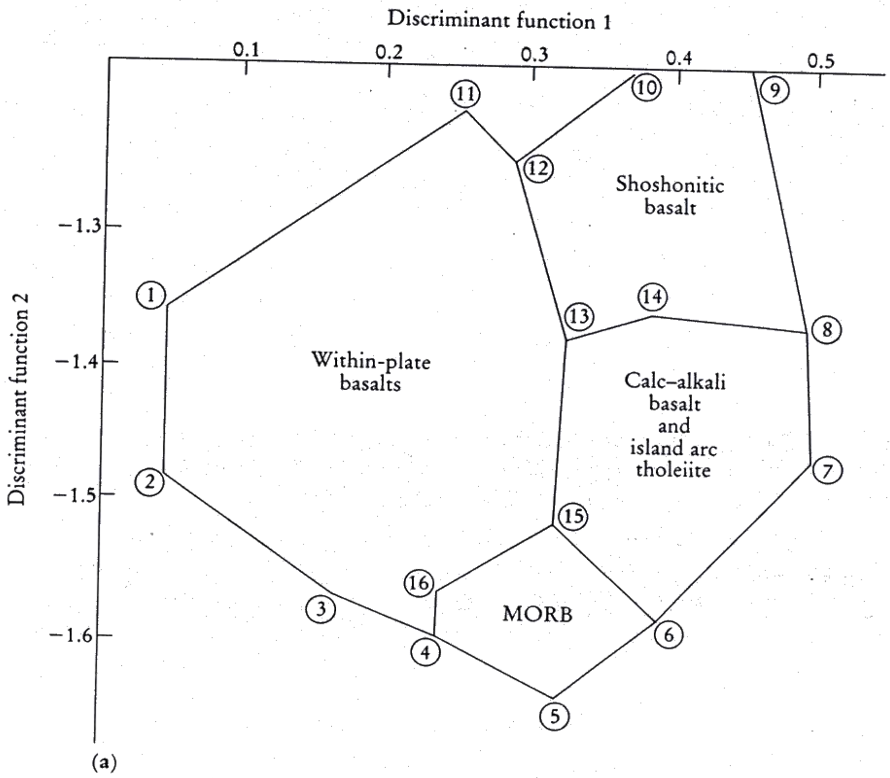


Figure 5.19 (a) Major element discrimination diagrams for basalts (after Pearce, 1976), showing the fields of within-plate basalts, MORB, calc–alkali basalts, island-arc tholeiites and shoshonitic basalts. The functions F1, F2 and F3 are defined in the text in terms of eight major element oxides. Discrimination diagram based upon functions F1 and F2; the plotting coordinates (extracted from Pearce, 1976 — Figure 1) are:

Point	Function 1	Function 2	Point	Function 1	Function 2
1	0.05	−1.36	9	0.455	−1.2
2	0.05	−1.49	10	0.37	−1.2
3	0.16	−1.58	11	0.255	−1.23
4	0.235	−1.61	12	0.29	−1.265
5	0.32	−1.655	13	0.325	−1.395
6	0.39	−1.6	14	0.38	−1.38
7	0.5	−1.485	15	0.32	−1.53
8	0.5	−1.385	16	0.24	−1.58

+ Discrimination function 2 & 3 (Fig.5.19 b) When Fe O / $Fe_2 O_3$ < 0.5 %
CaO + MgO ~ 12 - 20 %

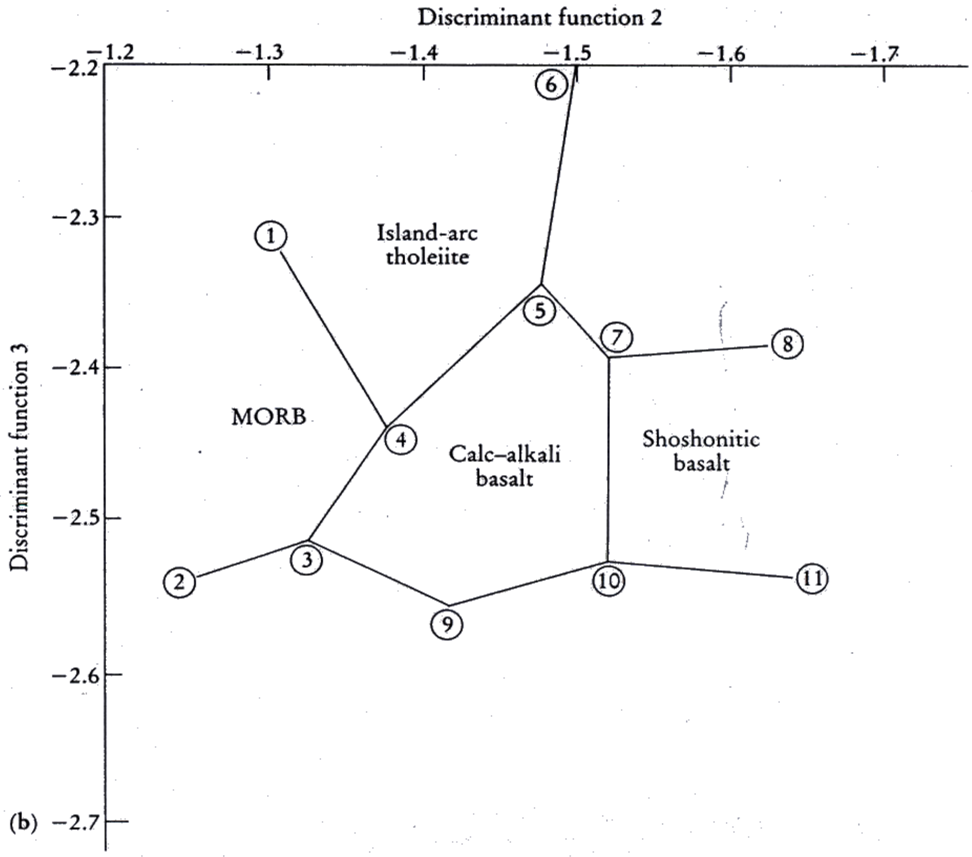


Figure 5.19 (b) Discrimination diagram based upon functions F2 and F3; the plotting coordinates (extracted from Pearce, 1976 — Figure 2) are:

Point	Function 2	Function 3	Point	Function 1	Function 2
1	−1.3	−2.3	7	−1.52	−2.39
2	−1.26	−2.53	8	−1.63	−2.38
3	−1.33	−2.51	9	−1.42	−2.55
4	−1.38	−2.44	10	−1.52	−2.52
5	−1.48	−2.34	11	−1.63	−2.53
6	−1.5	−2.2			

-(11) FAM Diagram (Pearce , 1977)
+ Fe O - $Al_2 O_3$ -Mg O diagram
(Fig.5.20) When SiO_2 ~ 51 - 56 %

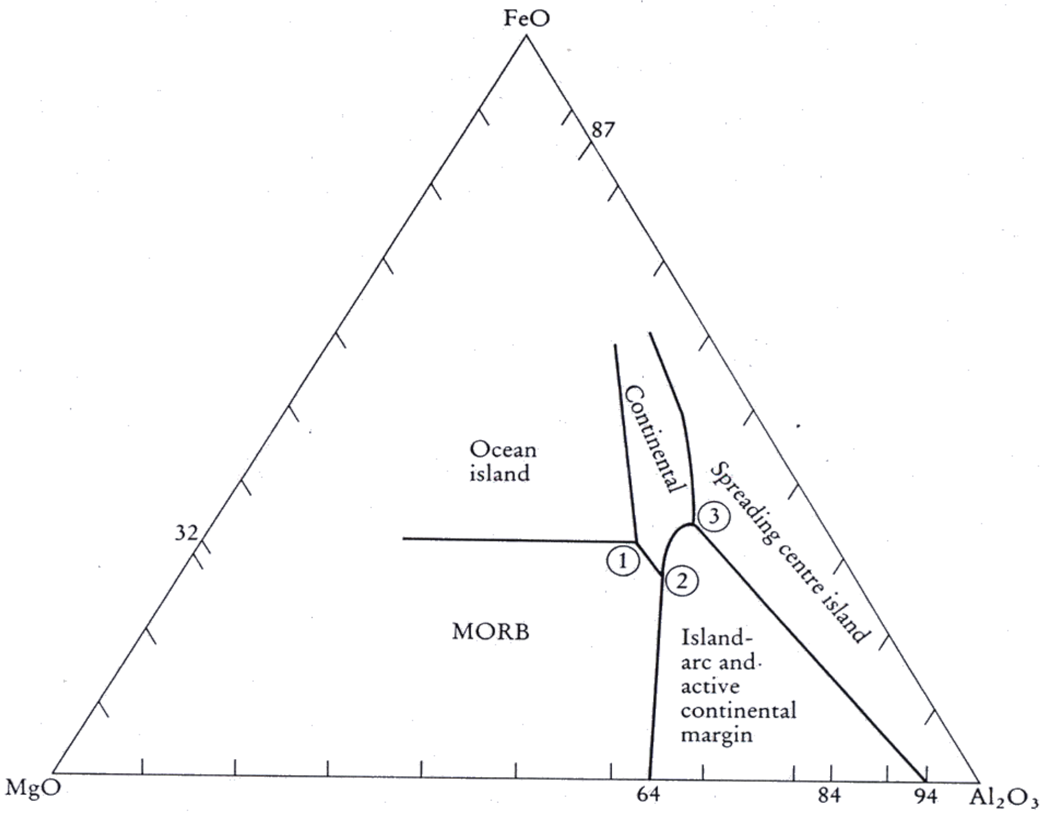


Figure 5.20 The $MgO–FeO_{(tot)}–Al_2O_3$ diagram (after Pearce *et al.*, 1977) showing the discriminant boundaries for a range of tectonic settings based upon the compositional range of recent volcanic rocks. The diagram can only be used with subalkaline rocks in the silica range SiO_2 = 51–56 wt % (calculated dry). The positions of the triple points are those given by Pearce *et al.* (1977). They are:

Point	MgO	FeO	Al_2O_3
1	21.5	32.0	46.5
2	21.0	27.5	51.5
3	14.0	34.5	51.5

-(12) P_2O_5 diagram (Pearce et al.,1975)
+ TiO_2 - K_2O - P_2O_5 diagram for basalts (Fig.5.21)

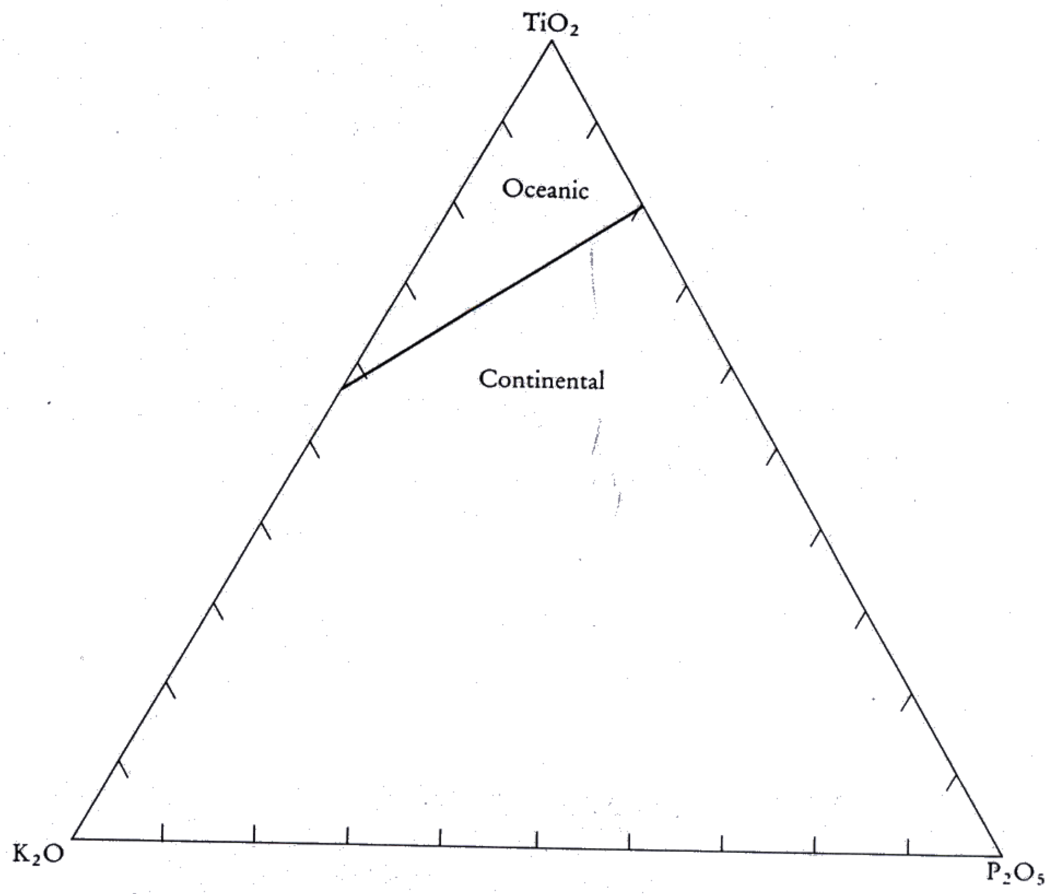


Figure 5.21 The TiO_2–K_2O–P_2O_5 discrimination diagram for basalts (after Pearce *et al.*, 1975). This diagram is not suitable for fractionated and alkaline basalts. Oceanic basalts (MORB and ocean-island basalts) plot near the TiO_2 apex; non-oceanic basalts plot below the boundary line. The coordinates (given by the authors) of the boundary line separating oceanic and continental basalts are K_2O 45.5 %, TiO_2 54.5 %, P_2O_5 0 % and K_2O 0 %, TiO_2 79.6 %, P_2O_5 20.4 %.

+ MnO - TiO_2 – P_2O_5 diagram for basalt/andesite (45 - 54% SiO_2) (Mullen,1983) (Fig.5.22)

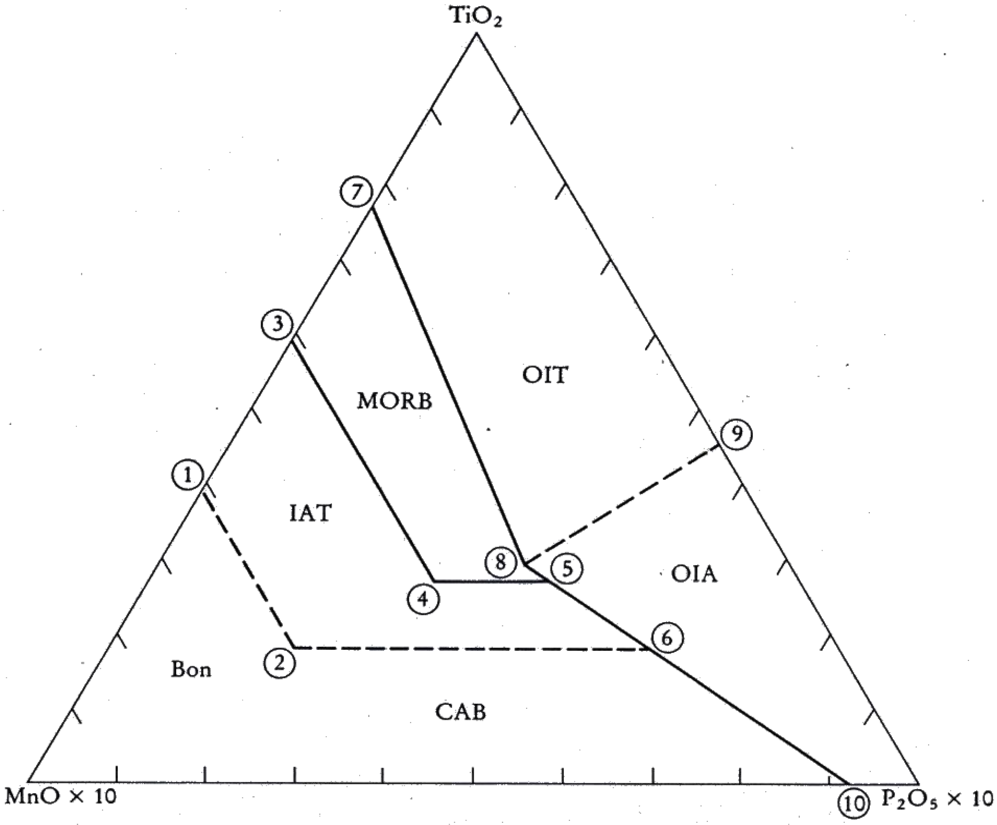


Figure 5.22 The MnO–TiO_2–P_2O_5 discrimination diagram for basalts and basaltic andesites (45–54 wt % SiO_2) (after Mullen, 1983). The fields are MORB; OIT — ocean-island tholeiite or seamount tholeiite; OIA — ocean-island alkali basalt or seamount alkali basalt; CAB — island-arc calc–alkaline basalt; IAT — island-arc tholeiite; Bon — boninite. The boninite field occupies the MnO-rich sector of the CAB field. The plotting coordinates (extracted from Figure 1 of Mullen, 1983) for constructing the boundary lines on the triangular diagram are as follows:

Point	MnO × 10	TiO_2	P_2O_5 × 10	Point	MnO × 10	TiO_2	P_2O_5 × 10
1	61	39	0	6	21	18	61
2	61	18	21	7	23	77	0
3	41	59	0	8	30	29	41
4	41	27	32	9	0	45	55
5	28	27	45	10	8	0	92

+ K_2O – H_2O diagram (Muenow et al., 1990) (Fig.5.23)

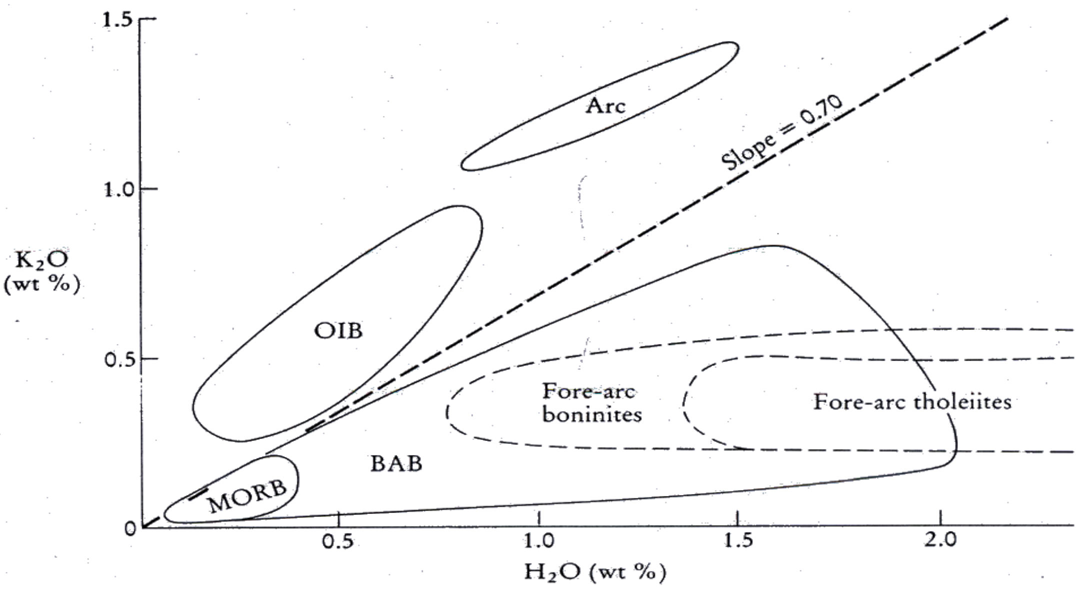


Figure 5.23 The K_2O–H_2O discrimination diagram for basalts (after Muenow *et al.*, 1990). The fields of MORB, OIB (ocean-island basalt), BAB (back-arc basin basalt) and Arc (volcanic-arc basalts) are from Muenow *et al.* (1990). The fields of fore-arc boninites and fore-arc tholeiites are taken from Bloomer and Stern (1990).

back-arc basin field is much more extensive than that of MORB. Water analyses were determined on fresh volcanic glasses by high-temperature mass spectrometry and represent water released above 600 °C and in many samples above 750 °C.

The small degree of overlap between MORB and back-arc basalts means that the diagram (Figure 5.23) can usefully separate the two. There is, however, extensive overlap between back-arc and fore-arc basalts (Bloomer and Stern, 1990).

+Tectonic Settings and Igneous Rocks(8)

+ Granites

(1) Nb - Y and Ta - Yb discrimination diagram (Pearce et al., 1984 (Fig.5.25)

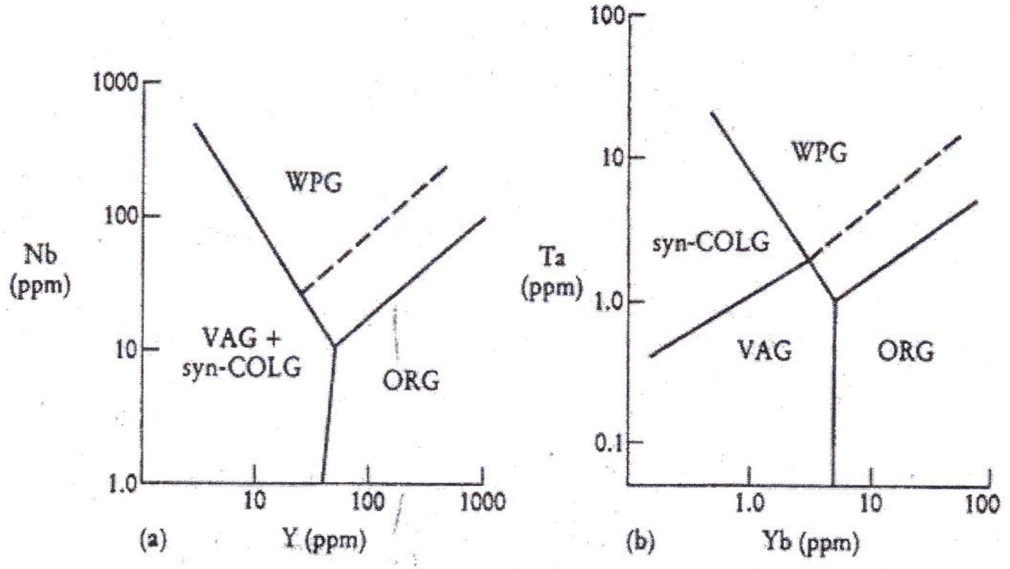


Figure 5.25 (a) The Nb–Y discrimination diagram for granites (after Pearce *et al.*, 1984), showing the fields of volcanic-arc granites (VAG), syn-collisional granites (syn-COLG), within-plate granites (WPG) and ocean-ridge granites (ORG). The broken line is the field boundary for ORG from anomalous ridges. The plotting coordinates (Y,Nb) are as follows (after Pearce *et al.*, 1984) 1,2000 to 50,10; 40,1 to 50,10; 50,10 to 1000,100; 25,25 to 1000,400; (b) The Ta–Yb discrimination diagram for granites (after Pearce *et al.*, 1984), showing the fields of volcanic-arc granites (VAG), syn-collisional granites (syn-COLG), within-plate granites (WPG) and ocean-ridge granites (ORG). The broken line is the field boundary for ORG from anomalous ridges. The plotting coordinates (Yb, Ta) are as follows (after Pearce *et al.*, 1984): 0.55,20 to 3,2; 0.1,0.35 to 3,2; 3,2 to 5,1; 5,0.5 to 5,1; 5,0.05 to 100,7; 3,2 to 100,20.

(2) Rb - Y - Nb discrimination diagram (Pearce et al., 1984) (Fig.5.26)

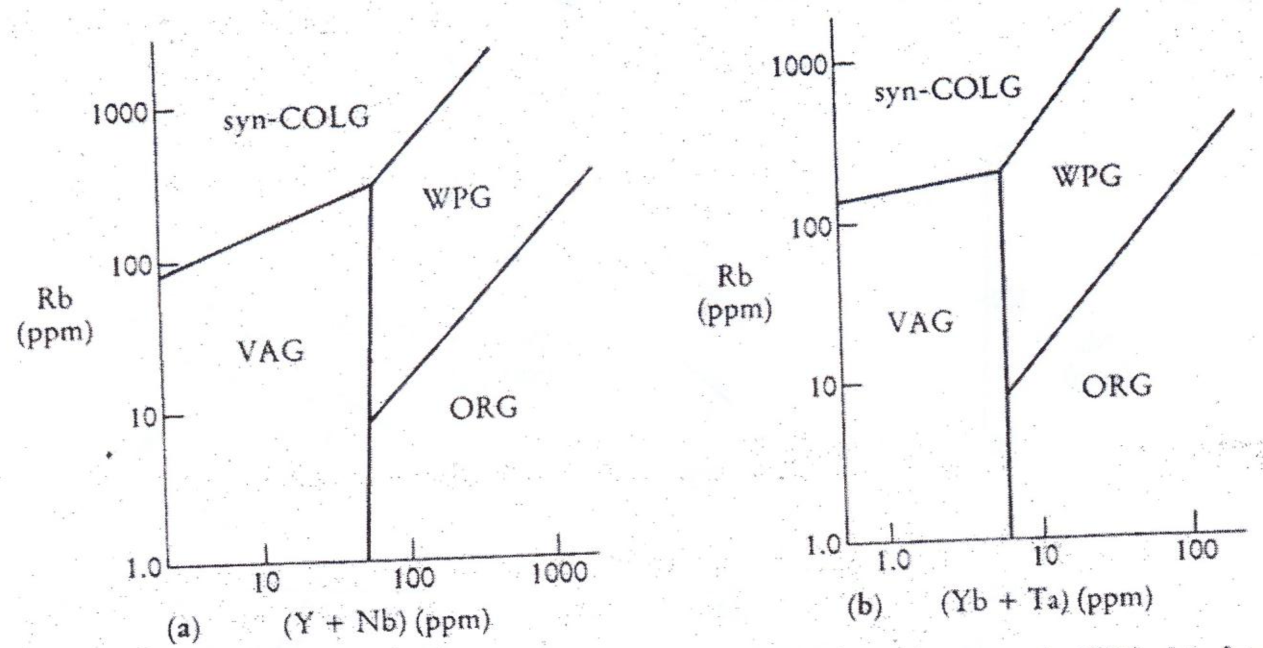
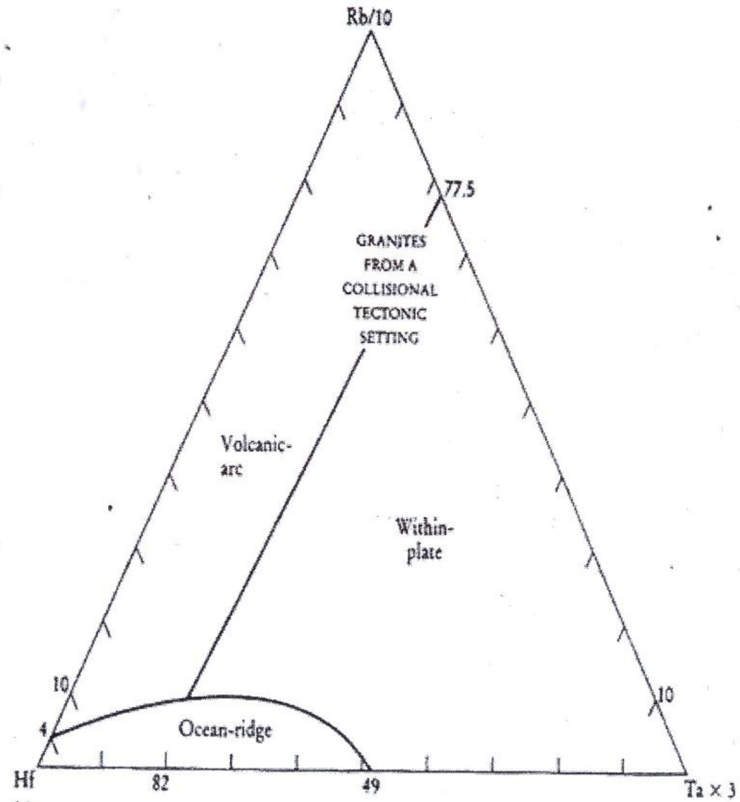


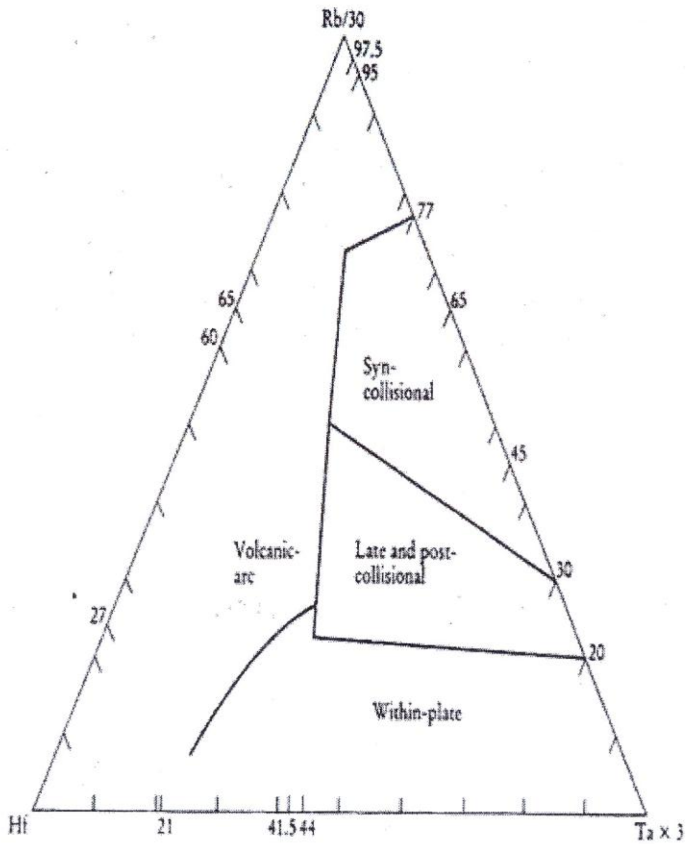
Figure 5.26 (a) The Rb–(Y + Nb) discrimination diagram for granites (after Pearce *et al.*, 1984) showing the fields of syn-collisional granites (syn-COLG), within-plate granites (WPG), volcanic-arc granites (VAG) and ocean-ridge granites (ORG). The plotting coordinates [(Y + Nb), Rb] for the field boundaries (taken from Pearce *et al.*, 1984) are: 2,80 to 55,300; 55,300 to 400,2000; 55,300 to 51.5,8; 51.5,8 to 50,1; 51.5,8 to 2000, 400. (b) The Rb–(Yb + Ta) discrimination diagram for granites (after Pearce *et al.*, 1984), showing the fields of syn-collisional granites (syn-COLG), within-plate granites (WPG), volcanic-arc granites (VAG) and ocean-ridge granites (ORG). The plotting coordinates [(Yb + Ta), Rb] for the field boundaries (taken from Pearce *et al.*, 1984) are: 0.5,140 to 6,200; 6,200 to 50,200; 6,200 to 6,8; 6,8 to 6,1; 6.8 to 200,400.

(3) Rb - Hf – Ta discrimination triangular diagram (Harris et al., 1986) (Figs.5.27 a & b)



(a)

Figure 5.27 (a) The Hf–Rb/10–Ta × 3 discrimination diagram for granites (after Harris *et al.*, 1986), showing the fields for volcanic-arc granites, within-plate granites and ocean-ridge granites. Granites from a collisional tectonic setting plot across the field boundary between volcanic-arc and within-plate granites. The plotting coordinates are extracted from Harris *et al.* (1986 – Figure 1).



(b)

Figure 5.27 (b) The Hf–Rb/30–Ta × 3 discrimination diagram for granites (after Harris *et al.*, 1986), showing the fields for volcanic-arc granites, within-plate granites, syn-collisional granites and late to post-collisional granites. The plotting coordinates are extracted from Harris *et al.* (1986 – Figure 6).

+Tectonics of sandstones & shales(1)

(1) Discrimination Function Diagram Bathia, 1983 (Fig.5.28)

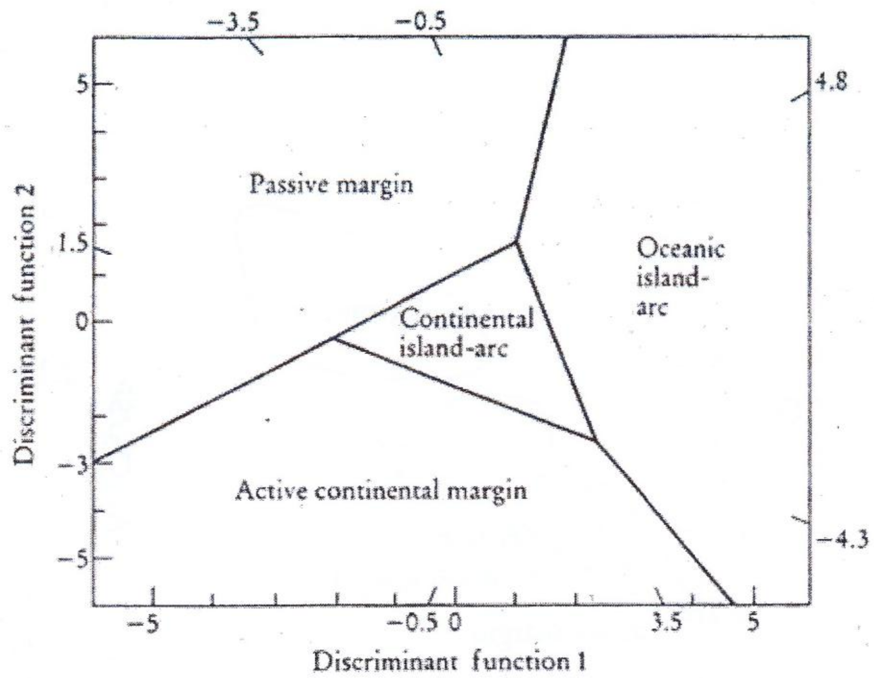


Figure 5.28 The discriminant function diagram for sandstones (after Bhatia, 1983), showing fields for sandstones from passive continental margins, oceanic island-arcs, continental island-arcs and active continental margins. The discriminant functions are as follows:

$$\text{Discriminant function 1} = -0.0447\ SiO_2 - 0.972\ TiO_2 + 0.008\ Al_2O_3 - 0.267\ Fe_2O_3 + 0.208\ FeO - 3.082\ MnO + 0.140\ MgO + 0.195\ CaO + 0.719\ Na_2O - 0.032\ K_2O + 7.510\ P_2O_5 + 0.303$$

$$\text{Discriminant function 2} = -0.421\ SiO_2 + 1.988\ TiO_2 - 0.526\ Al_2O_3 - 0.551\ Fe_2O_3 - 1.610\ FeO + 2.720\ MnO + 0.881\ MgO - 0.907\ CaO - 0.177\ Na_2O - 1.840\ K_2O + 7.244\ P_2O_5 + 43.57$$

(from Bhatia, 1983 — Table 3). The plotting coordinates are extracted from Bhatia (1983 — Figure 7).

(2) Discrimination diagram of sandstone(Bhatia,1983) TiO_2 vs (Fe_2O_3 + MgO) and (Fig.5.29) Al_2O_3 / SiO_2 vs (Fe_2O_3 + MgO)

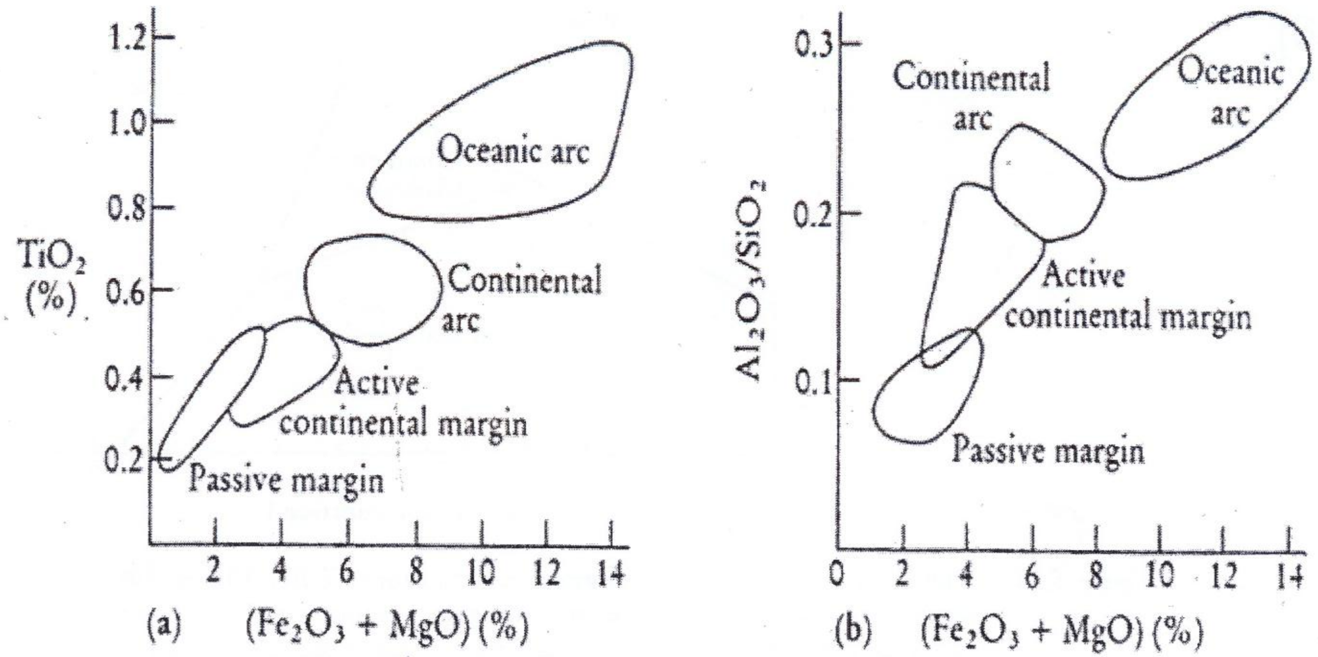


Figure 5.29 Discrimination diagrams for sandstones (after Bhatia, 1983), based upon (a) a bivariate plot of TiO_2 vs ($Fe_2O_{3(tot)}$ + MgO) and (b) a bivariate plot of Al_2O_3/SiO_2 vs ($Fe_2O_{3(tot)}$ + MgO). The fields are oceanic island-arc, continental island-arc, active continental margin and passive margin.

(3) Log K_2O / Na_2 O vs SiO_2 diagram (Roser & Korsch,1986) Sand - mud (Fig.5.30)

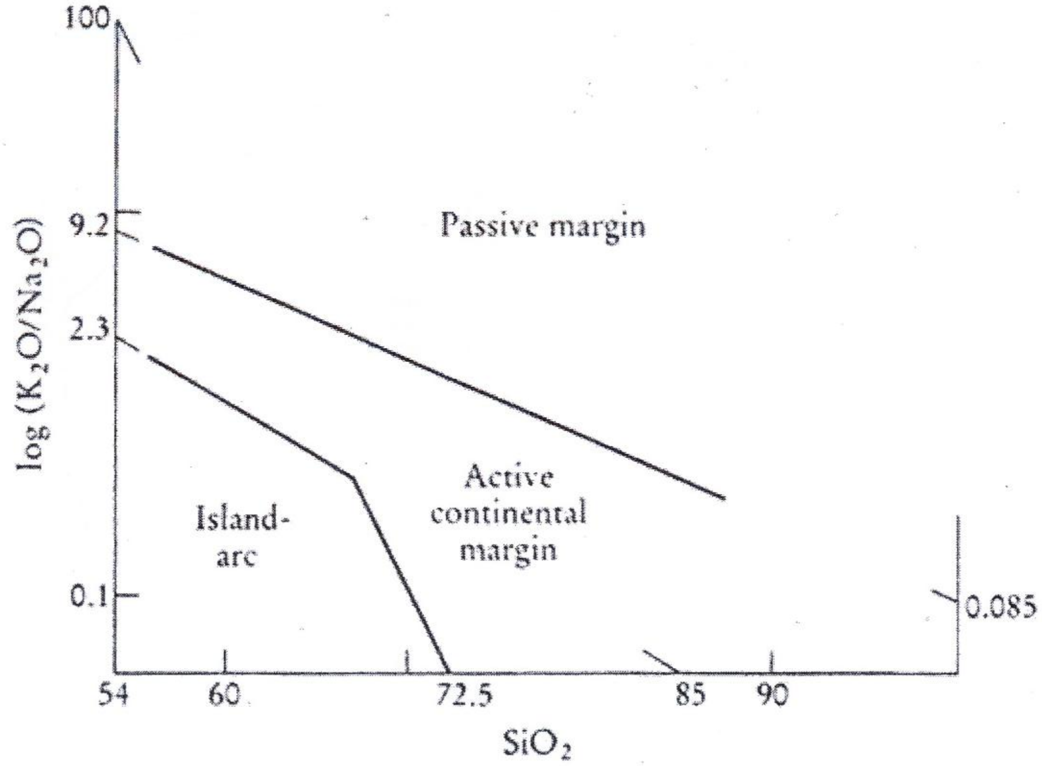


Figure 5.30 The log (K_2O/Na_2O) vs SiO_2 discrimination diagram of Roser and Korsch (1986) for sandstone–mudstone suites and showing the fields for a passive continental margin, an active continental margin and an island-arc. The plotting coordinates for the field boundaries have been extracted from Roser and Korsch (1986 — Figure 2).

+Tectonics of sandstones & shales(2)

(4) Discrimination Function Diagram (rocks) (Roser & Korsch,1988) (Fig.5.31)

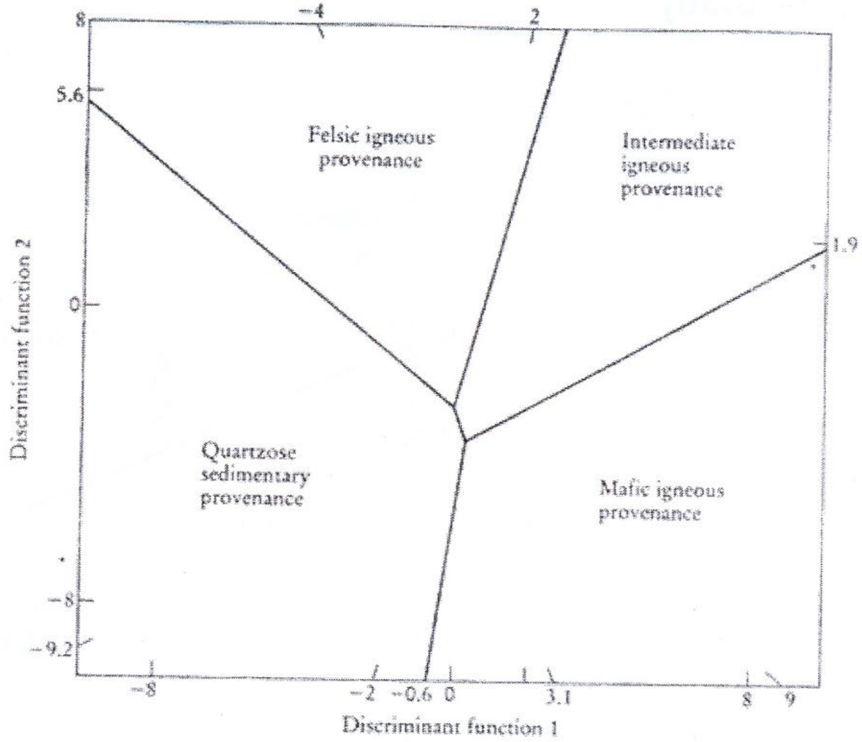


Figure 5.31 Discriminant function diagram for the provenance signatures of sandstone–mudstone suites using major elements (after Roser and Korsch, 1988). Fields for dominantly mafic, intermediate and felsic igneous provenances are shown with the field for a quartzose sedimentary provenance. The discriminant functions are

$$\text{discriminant function } 1 = -1.773TiO_2 + 0.607Al_2O_3 + 0.76Fe_2O_{3(total)} - 1.5MgO + 0.616CaO + 0.509Na_2O - 1.224K_2O - 9.09$$

$$\text{discriminant function } 2 = 0.445TiO_2 + 0.07Al_2O_3 - 0.25Fe_2O_{3(total)} - 1.142MgO + 0.438CaO + 1.475Na_2O + 1.426K_2O - 6.861$$

(Data from Roser and Korsch, 1988 — Table II; plotting coordinates extracted from Roser and Korsch, 1988 — Figure 4.)

(5) Discrimination Function Diagram (Provenance) (Fig.5.32) sand - mud (Roser & Korsch,1988)

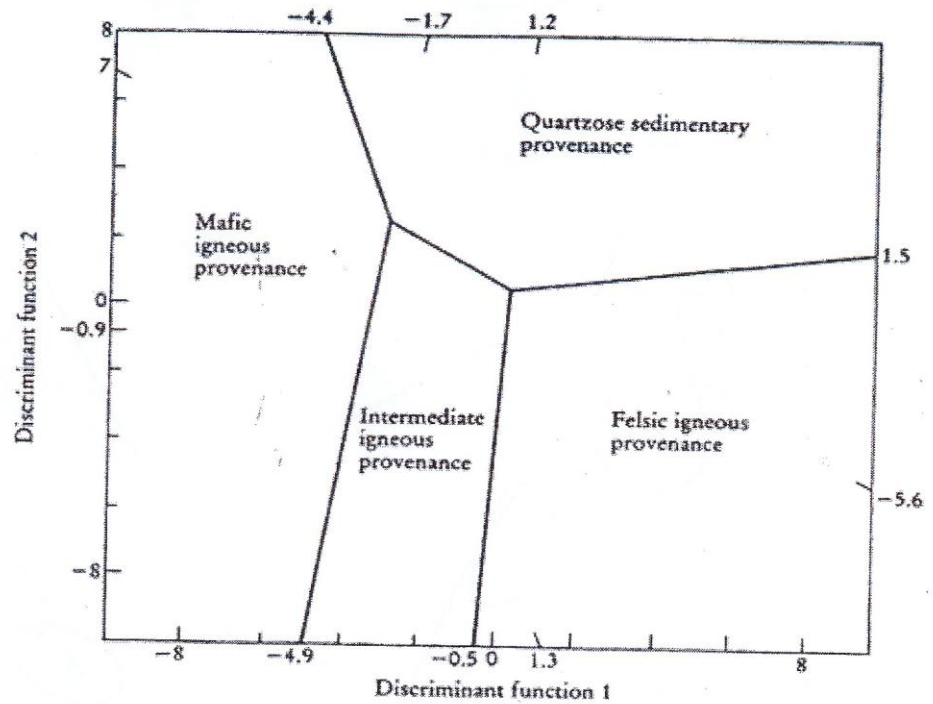


Figure 5.32 Discriminant function diagram for the provenance signatures of sandstone–mudstone suites using major element ratios (after Roser and Korsch, 1988). Fields for dominantly mafic, intermediate and felsic igneous provenances are shown with the field for a quartzose sedimentary provenance. The discriminant functions are

$$\text{discriminant function } 1 = 30.638TiO_2/Al_2O_3 - 12.541Fe_2O_{3(total)}/Al_2O_3 + 7.329MgO/Al_2O_3 + 12.031Na_2O/Al_2O_3 + 35.402K_2O/Al_2O_3 - 6.382$$

$$\text{discriminant function } 2 = 56.500TiO_2/Al_2O_3 - 10.879Fe_2O_{3(total)}/Al_2O_3 + 30.875MgO/Al_2O_3 - 5.404Na_2O/Al_2O_3 + 11.112K_2O/Al_2O_3 - 3.89$$

(Data from Roser and Korsch (1988 — Table IV), plotting coordinates extracted from Roser and Korsch, 1988 — Figure 9).

(6) La - Th - Sc discrimination diagram (Bhatia & Crock,1986 (Fig.5.33)

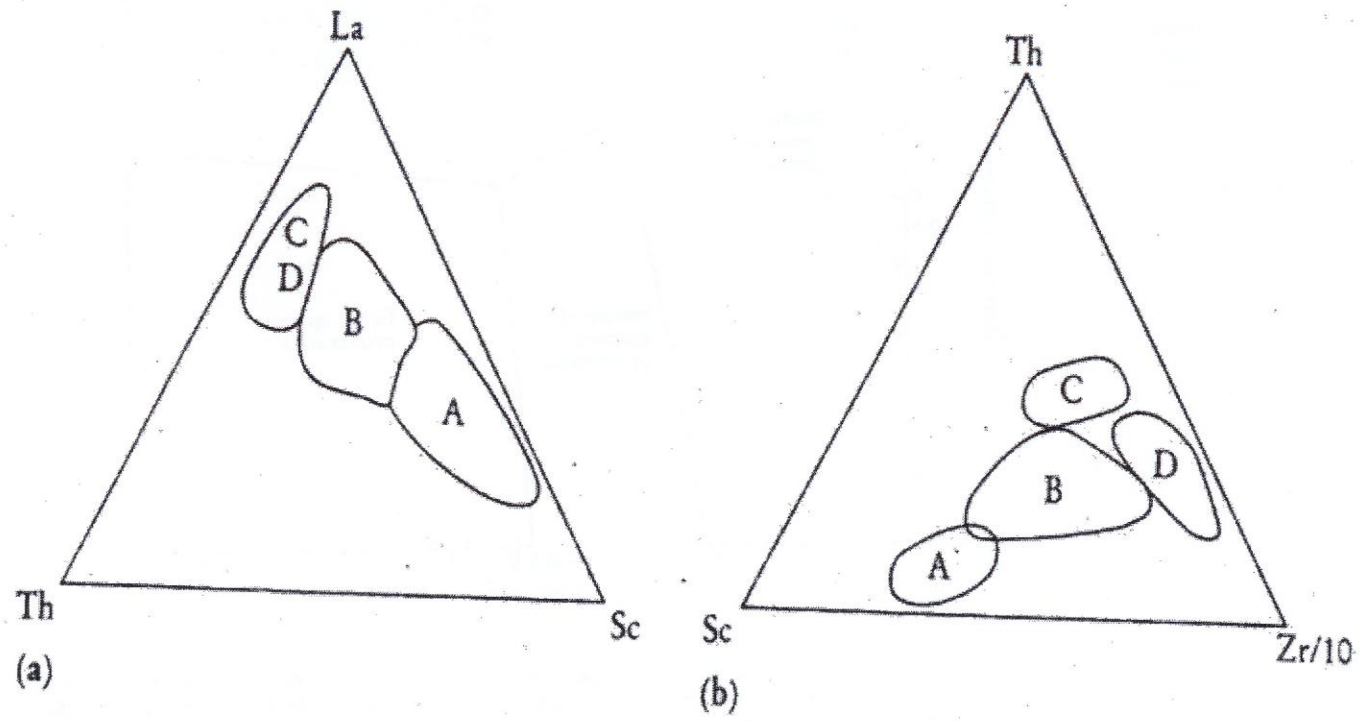


Figure 5.33 (a) La–Th–Sc discrimination diagram for greywackes; (b) Th–Sc–Zr/10 discrimination diagram for greywackes (after Bhatia and Crook, 1986). The fields are: A, oceanic island-arc; B, continental island-arc; C, active continental margin; D, passive margin.

Lab 1 granite

Table1. Major and Trace element analysi of Granites of Thailand (Charusin et al 2006)

SAMPLE	Si02	Ti02	A1203	Fe203	Mn0	Mg0	Ca0	K20	P205	Na20	L.O.I.	Nb	Zr	Y	Sr	Rb	Ba	Ga	Pb	As	Zn	Cu	Ni	Co	Cr	V
TC-1-1	69.57	0.37	14.81	2.48	0.06	1.94	1.91	4.74	0.17	2.8	1.19	15	164	34	169	292	633	22	69	54	57	5	36	6	12	41
TC-1-3	68.02	0.27	16.7	1.83	0.05	1.48	1.5	5.27	0.12	2.5	1.3	12	144	35	107	285	538	19	76	50	48	5	19	5	5	30
TC-10	60.95	0.55	18.91	4.99	0.1	2.42	3.33	2.98	0.39	3.27	2.09	18	253	35	589	262	633	22	15	1	71	5	11	7	5	69
TC-11	67.58	0.51	15.44	3.19	0.05	2.67	1.92	4.82	0.2	1.94	1.8	15	223	37	152	264	724	18	41	8	53	5	34	10	398	51
TC-2	70.87	0.21	14.89	1.44	0.03	0.97	1.65	5.24	0.04	2.93	0.7	6	156	15	307	203	964	20	31	1	31	5	8	5	5	23
TC-4	72	0.27	14.22	2.05	0.03	0.98	1.29	6.09	0.13	2.19	0.5	16	158	73	72	397	304	21	64	1	44	5	21	5	5	22
TC-5-1	68.82	0.22	16.02	2.6	0.11	1.23	4.06	2.88	0.11	2.95	1.39	8	113	17	1036	104	1910	15	21	1	37	5	5	5	5	31
TC-5-2	69.07	0.39	14.99	3.06	0.05	1.34	2.34	4.84	0.12	3	0.8	11	200	43	131	242	253	2	37	1	51	6	18	5	5	27
TC-6	71.04	0.16	15	1.11	0.03	1.08	0.57	5.52	0.23	2.97	2.6	19	96	28	33	389	220	23	39	1	39	5	17	5	5	12
TC-7-3	72.52	0.27	12.95	2.34	0.14	1.23	1.37	6.03	0.07	1.3	2.2	11	192	33	51	187	836	14	6	1	5	5	9	5	5	25
TC-7-4-1	70.08	0.5	13.96	3.04	0.05	1.32	1.22	4.98	0.13	2.33	1.7	18	212	51	75	337	659	19	28	1	38	5	17	5	5	41
TC-7-4-2	70.49	0.31	14.94	1.71	0.03	1.32	0.81	5.74	0.16	2.56	2.4	22	185	40	50	432	260	24	25	1	25	5	23	5	5	20
TC-8-1	52.87	1.45	18.12	7.9	0.13	3.18	5.56	3.57	0.6	3.25	2.3	19	302	29	509	155	1472	22	31	2	81	8	11	16	5	149
TC-9	62.19	0.45	19.7	2.76	0.07	1.52	2.95	4	0.18	4.03	1.4	14	305	27	452	145	1523	21	53	3	40	5	11	6	5	37
TE-1-1-W	63.42	0.56	16.43	4.76	0.09	2.29	4.22	2.83	0.24	3.13	1.99	8	160	18	503	81	638	19	7	2	48	5	11	10	5	82
TE-1-1-W	64.24	0.55	16.34	4.58	0.08	2.28	4.28	2.72	0.18	3.08	1	8	145	21	477	80	388	20	8	1	49	8	10	11	5	89
TE-1-2-1	66.67	0.58	16.62	1.79	0.05	1.99	4.39	1.11	0.2	4.89	1.7	8	148	19	665	48	298	18	5	1	15	5	7	5	5	83
TE-1-3-1	74.2	0.12	14.22	1.07	0.02	0.77	1.1	4.53	0.08	2.9	1	7	77	11	156	146	285	13	12	1	9	5	5	5	5	17
TE-1-3-2	74.16	0.13	14.23	1.07	0.02	0.63	0.87	4.9	0.06	2.59	0.5	8	84	13	111	152	243	16	10	1	12	5	5	5	5	16
TE-1-4-1	72.94	0.17	15.09	1.16	0.03	1.01	1.41	4.46	0.05	2.62	1.09	5	81	10	205	118	386	13	14	1	13	5	5	5	5	19
TE-1-4-2	73.96	0.1	14.29	0.76	0.02	0.71	0.8	4.94	0.03	2.88	1.5	6	58	13	108	149	282	13	13	1	6	5	5	5	5	11
TE-1-4-3	75.02	0.16	14.36	1.13	0.02	0.72	1.18	4.52	0.06	2.53	0.4	9	88	14	162	133	331	13	12	1	10	5	5	5	5	17
TE-1-5-1	72.81	0.19	15.22	1.44	0.02	0.9	1.8	4.01	0.04	2.81	0.1	11	90	24	252	102	407	14	11	1	8	5	7	5	5	21
TE-2-1	75.94	0.08	13.28	1.1	0.03	0.63	0.38	4.57	0.05	3.56	0.1	16	154	67	15	108	251	19	9	1	27	5	9	5	5	6
TE-2-2	74.9	0.08	13.45	1	0.02	0.58	0.79	4.44	0	3.16	1	28	170	86	17	116	125	21	8	1	33	5	11	5	5	6
TE-3-1	61.17	1.1	18.1	5.48	0.11	2.31	3.82	2.63	0.39	4.44	0.9	13	265	33	466	40	659	20	15	1	55	5	5	8	5	105
TE-3-2	69.43	0.47	17.02	1.66	0.02	1.05	0.29	4.53	0.11	3.31	1.9	19	338	30	159	70	707	18	7	2	22	5	6	5	5	31

Table 1. (com.)

SAMPLE	Si02	Ti02	A1203	Fe203	Mn0	Mg0	Ca0	K20	P205	Na20	L.O.I.	Nb	Zr	Y	Sr	Rb	Ba	Ga	Pb	As	Zn	Cu	Ni	Co	Cr	V
TE-3-3	59.84	1.08	18.3	5.36	0.11	2.33	3.96	2.49	0.36	4.28	1.5	12	245	29	464	40	604	19	8	1	62	5	5	14	5	105
TE-4	67.89	0.44	16.03	2.75	0.05	1.92	1.34	5.27	0.17	1.94	1.4	17	197	34	93	325	640	20	43	10	47	5	29	9	14	43
TE-5	65.88	0.57	16.38	4.33	0.07	1.29	2.56	3.97	0.13	3.47	1.3	8	236	49	134	220	224	22	28	21	59	5	11	8	5	38
TE-5-1	65.68	0.67	16.08	5.08	0.09	1.34	2.79	3.68	0.16	3.2	0.7	9	253	53	151	200	328	22	25	57	64	5	16	13	5	43
TE-5-2	67.25	0.47	17.01	3.9	0.07	1.11	2.58	3.54	0.1	3.7	0.2	8	213	49	137	197	203	24	29	4	57	5	11	9	5	32
TE-5-3	67	0.57	16.15	4.52	0.08	1.54	2.71	3.46	0.13	3.7	0.2	9	247	56	140	199	209	23	25	13	66	11	11	8	5	44
TE-5-4	71.56	0.19	16.48	1.61	0.04	0.82	1.57	4.36	0.07	3.01	0.2	5	126	24	94	213	114	19	27	18	26	5	6	5	5	15
TE-6	71.68	0.29	14.86	1.72	0.03	1.31	1.1	5.01	0.2	1.98	1.1	16	183	53	56	288	172	19	38	4	23	5	17	5	5	24
TW-1	70.29	0.23	15.05	1.6	0.04	1.03	1.95	5.9	0.1	2.62	0.6	15	181	16	402	332	794	20	47	1	32	5	16	5	5	24
TW-2-1	68.67	0.54	14.8	3.07	0.06	1.36	2.01	4.91	0.19	2.43	1.1	28	227	30	132	354	346	25	56	2	66	5	20	7	5	33
TW-3	65.93	0.38	16.06	3.21	0.08	1.4	3.4	5.57	0.17	2.73	0.3	17	210	41	470	358	516	20	34	1	54	5	18	6	5	47
TW-4	71.89	0.39	14.12	2.83	0.06	1.17	1.86	3.96	0.17	3.01	0.6	25	235	38	76	380	126	27	54	1	63	5	14	5	5	25
TW-5	67.1	0.57	16.78	3	0.05	1.57	2.01	5.71	0.25	2.69	0.3	24	239	44	187	345	561	21	30	1	41	5	18	7	5	52
TW-6	68.66	0.31	17.48	1.95	0.04	1.4	1.43	4.91	0.16	2.52	1.1	17	141	37	80	333	322	21	52	5	36	5	20	5	5	26
V-1-1	43.37	1.8	17.28	19.25	0.23	5.47	8.77	0.19	0.12	2.86	0.7	2	38	13	155	5	19	20	3	1	125	247	5	76	5	678
V-1-2	47.01	1.89	16.96	10.96	0.18	5.07	8.41	1.7	0.84	2.79	4.37	10	204	42	425	63	439	21	8	1	101	5	5	26	5	266
V-1-3	47.44	0.5	16.04	7.59	0.13	10.24	12.69	0.66	0.14	1.26	2.8	3	89	17	358	27	175	13	5	1	53	15	56	46	285	128
V-2-1	69.42	0.18	15.01	1.98	0.05	0.86	1.65	5.48	0.04	2.55	3.38	11	212	39	85	186	480	17	18	1	36	5	10	5	5	12
V-2-2	68.88	0.21	16.53	2.42	0.06	0.98	0.36	5.06	0.11	3.22	2.1	11	253	34	79	167	529	19	25	1	38	5	9	5	5	12
V-2-3	73.55	0.08	14.31	1.01	0.03	0.89	0.65	5.32	0.04	2.79	1.39	11	134	47	33	190	83	19	31	1	25	5	13	5	5	9
V-2-4	70.64	0.21	15.77	1.6	0.04	1.04	0	5.8	0.06	2.68	0.9	10	203	31	133	160	536	17	22	1	33	5	9	5	5	14
V-2-5	68.97	0.29	14.96	2.4	0.05	1.15	1.59	4.77	0.1	2.83	2.9	13	331	35	110	156	654	19	24	1	47	5	7	5	5	18
V-2-8	70.03	0.25	15.06	2.27	0.05	1.03	1.21	5.54	0.06	2.57	1.4	13	272	38	121	178	671	20	30	1	52	5	9	5	5	14

*** TC = Central Granite Belts of Thailand, TE = Eastern Granite Belts of Thailand, TW = Western Granite Belts of Thailand, and V = Vietnam samples.**

Lab 2 Basalt (Ceno joicy Lampang)

Table 2 Major element analyses (in Persent) of 65 basalt samples for the Nam Cho and the Sop Prap-Ko basalts.

SAMPLE	SiO_2	Al_2O_3	Fe_2O_3	FcO	CaO	MgO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	H_2O	LOI	TOTAL	Mg''
S-2	49.22	16.53	5.90	3.05	7.77	5.99	2.88	1.36	1.93	0.12	0.70	0.78	2.38	95.45	77.78
S-4	48.22	17.39	6.07	1.96	7.63	4.90	2.25	1.98	2.01	0.13	0.85	0.61	5.11	93.39	81.67
S-8	49.00	17.78	4.92	3.19	7.48	4.22	2.79	2.71	2.12	0.13	0.86	0.74	2.95	95.20	70.22
S-11	49.48	17.80	5.32	2.78	7.36	4.54	3.26	1.37	2.14	0.12	0.88	0.66	3.53	95.05	74.43
S-13	49.32	17.69	4.72	3.26	7.27	4.63	3.50	1.24	2.11	0.12	0.85	0.48	3.45	95.01	71.68
S1-1	49.24	17.03	3.95	4.67	7.67	5.42	2.57	2.98	2.05	0.21	0.74	0.45	1.92	96.53	67.41
S1-7	48.63	16.45	6.76	3.36	8.41	5.11	2.12	2.48	1.99	0.18	0.62	0.35	2.40	96.11	73.05
S1-10	47.15	16.07	3.83	5.32	9.23	6.87	1.97	2.19	2.01	0.15	0.64	0.52	2.98	95.43	69.71
S1-13-2	46.18	16.08	3.33	6.31	8.48	7.76	2.40	1.83	2.06	0.17	0.70	0.56	2.88	95.30	68.67
S1-14	46.37	15.93	6.00	4.35	8.97	6.19	2.19	1.44	2.08	0.14	0.70	1.22	3.29	94.36	71.72
S7-2	48.25	17.60	4.78	3.64	7.85	4.32	2.49	1.91	2.11	0.13	0.83	0.80	4.25	93.91	67.9
S7-3-1	47.62	16.59	5.77	3.00	8.67	4.94	1.69	2.56	2.05	0.14	0.71	0.82	4.50	93.74	74.59
S7-5	46.08	15.82	3.51	5.52	9.61	6.85	1.58	2.10	1.94	0.14	0.61	0.61	4.44	93.76	69.27
S8-2	48.23	16.59	5.75	4.18	8.38	5.80	2.68	1.44	2.10	0.14	0.71	0.58	2.42	96.00	71.21
S8-5	46.89	15.99	6.34	3.73	8.75	5.54	2.49	0.62	2.14	0.17	0.78	1.32	3.95	93.44	72.58
S 18-2-1	49.17	18.13	5.88	2.44	7.34	4.52	3.09	1.53	2.11	0.12	0.91	1.08	3.31	95.24	76.75
S 18-3	48.72	17.83	5.79	2.54	7.47	5.01	2.06	3.35	2.11	0.12	0.85	0.67	2.91	95.85	77.85
S 18-5-2	47.75	17.44	3.08	4.58	8.17	5.75	2.10	3.66	2.01	0.12	0.85	0.46	3.55	95.51	69.11
S 18-7	47.85	16.70	4.96	4.41	8.69	5.73	2.39	2.80	2.00	0.14	0.67	0.55	2.31	96.34	69.84
S 18-11	47.62	16.60	2.92	6.25	8.14	7.20	2.38	2.30	1.95	0.15	0.69	0.72	2.47	96.2	67.25
S 19-1	48.40	17.45	5.00	3.24	7.66	5.16	1.74	2.90	2.00	0.13	0.80	0.96	4.12	94.48	73.95
S 19-3	49.46	17.95	4.88	3.25	7.39	4.65	3.22	1.94	2.00	0.12	0.87	0.92	2.82	95.73	71.83
S 19-5	47.44	16.90	4.80	3.47	8.55	5.98	2.20	2.02	1.96	0.13	0.77	1.05	3.98	94.22	75.44
S 19-7	48.64	16.76	5.55	3.96	8.27	5.70	1.85	2.73	1.94	0.14	0.67	0.88	2.26	96.21	71.95
S 19-9	47.14	16.09	2.86	6.42	8.47	7.08	1.72	2.83	1.93	0.15	0.63	0.57	3.72	9532	66.28

Table 3. Major and trace element concentrations of Cenozoic volcanic rocks from the Lop Buri area.

Sample	Si02	Ti02	Al203	Fe203	Fe0	Mn0	Mg0	Ca0	Na20	K20	P205	H20+	H20-	Mg#
NK-1	71.2	0.64	13.3	1.13	3.67	0.07	0.5	0.38	2.55	5.63	0.13	0.49	0.26	
NK-4	77.7	0.13	11.4	0.67	2.17	0.05	0.03	0.26	2.06	4.91	0.05	0.43	0.13	
BP-6/1	72.6	0.27	12.6	0.33	1.09	0.04	0.04	0.66	2.81	5.15	0.03	4.15	0.18	
BP-7	73.2	0.45	13.3	0.7	2.26	0.03	0.04	0.45	3.58	5.11	0.07	0.55	0.27	
BP-8	68.2	0.37	15.1	0.41	1.34	0.04	0.15	1.09	2.75	6.21	0.07	4.01	0.18	
PJI-16	77.2	0.14	12.5	0.17	0.57	0.03	0.02	0.25	3.37	4.72	0.07	0.87	0.02	
PJI-16/1														
PJI-21	72.3	0.29	14	0.42	1.38	0.05	0.13	0.37	4.29	4.79	0.05	1.32	0.06	
CB-2	69.6	0.26	13.5	0.37	1.19	0.03	0.28	1.5	3.2	3.36	0.06	5.87	0.32	
CB-7	77.2	0.14	11.8	0.43	1.38	0.02	0.16	0.32	3.33	4.29	0.04	0.78	0.07	
CB-10	77	0.33	12	0.42	1.38	0.03	0.04	0.37	2.9	4.54	0.04	0.79	0.08	
CB-11/1	73.1	0.43	13.3	0.64	2.09	0.03	0.02	0.59	5.19	3.76	0.05	0.55	0.1	
CB-15	77.5	0.16	11.8	0.37	1.21	0.02	0.02	0.19	3.23	4.96	0.03	0.29	0.21	
CB-15/1	74.5	0.21	11.7	0.22	0.7	0.05	0.01	0.34	3.65	4.51	0.04	3.37	0.15	
MJI-3	69.1	0.58	15.1	0.87	2.85	0.04	0.12	1.13	5.43	3.88	0.09	0.28	0.2	
MJI-4	67.9	0.56	15	0.66	2.13	0.06	0.38	1.57	3.04	5.2	0.13	2.74	0.48	
MJI-5	68.4	0.59	15	0.17	2.31	0.05	0.02	1.42	2.73	4.51	0.05	3.74	0.53	
ST-1	69.2	0.62	16.2	0.48	1.56	0.03	0.11	0.67	4.37	4.91	0.08	1.46	0.2	
BP-2/1	63.4	0.81	15.4	1.38	4.47	0.08	2.42	3.95	2.98	2.47	0.21	2.23	0.15	
MJI-8	61.2	1.12	16.3	1.55	5.06	0.09	1.69	4.77	4.12	2.45	0.43	1.16	0.15	
MJI-10	60.5	1.2	16.8	1.69	5.48	0.12	1	5.01	4.03	2.3	0.41	1.01	0.67	
MJI-11	63.2	0.84	15.8	1.16	3.77	0.08	1.75	4.1	3.35	3.22	0.32	2.09	0.32	43
MJI-13	61.8	1.14	16.5	1.61	5.25	0.06	0.49	3.82	4.01	2.4	0.38	1.65	0.91	13
MJI-14	63	0.77	15.7	1.2	3.89	0.08	1.67	4.27	2.82	3.47	0.25	2.35	0.66	41
PJI-17	59.8	0.98	15.2	1.83	5.97	0.13	2.65	4.54	3.26	3.66	0.31	1.53	0.43	42
PJI-22	59.8	1.01	16.3	1.94	6.33	0.12	2.57	4.48	2.8	3.48	0.28	0.45	0.41	40
SI-3	56.5	1.2	18.5	1.79	5.84	0.13	1.83	6.55	3.33	1.54	0.4	1.65	0.68	33
PN-1	48.8	2.18	17.2	3.21	10.5	0.19	4.58	6.76	3.88	1.33	0.4	0.01	0.33	41
MJI-12	48.2	1.61	16.2	2.66	8.67	0.17	7.42	10.2	2.83	0.82	0.33	0.81	0.42	58
BP-1	48.5	1.82	15.3	2.6	8.45	0.16	7.88	8.49	2.49	1.61	0.56	1.95	0.16	60
PJI-18	47.9	1.55	17	2.62	8.55	0.17	7.51	9.86	2.38	0.37	0.21	1.74	0.34	58
CJI-1	49.2	1.8	17.5	2.53	8.22	0.15	5.63	8.08	3.36	1.52	0.32	1.4	0.38	52
CB-5	48.5	2.14	16.9	2.82	9.23	0.17	5.77	8.72	2.63	0.9	0.35	1.89	0.13	50
CB-9/1	51.7	1.54	18.1	2.06	6.69	0.15	4.71	7.74	3.12	1.75	0.64	1.51	0.08	52
CB-13	47.1	1.45	16.5	3.01	9.96	0.22	9.74	8.78	1.73	0.19	0.15	1.6	0.08	61
CB-14	50.2	1.79	18.4	2.53	8.24	0.1	2.97	8.95	3.36	1.22	0.52	1.59	0.19	37
SI-2	50.8	1.23	18	1.67	5.42	0.15	3.78	9.04	4.1	1.77	0.5	2.55	0.96	53
WJI-25	47.5	2.01	15.4	2.6	8.46	0.14	9.6	8.07	2.48	2.38	0.42	0.65	0.43	64
NJI-26	46.9	1.51	17	2.49	8.1	0.16	6.95	10.5	3.38	0.65	0.56	1.59	0.39	58

Table.3 Major and trace element concentrations of volcanic rocks from the Lop Buri area. (CON)

Li	sc	V	Cr	Ni	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Tl	Pb	Th	U	Y/Nb	Zr/Nb	Zr/Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yr	Lu
28	9.1	32	216		181	85	31	242	8.8	6.1	496	6.4	0.59	1.03	20	16	4.7				29	66	7.8	30	6	1.22	6.1	0.94	5.7	1.18	3.5	0.54	3.46	0.56
		12			251	109	25		5.7	11	580		0.55	0.74	13.7	21	3.7				30	56	6.4	23	4.2	0.42	3.8	0.57	3.9	0.78	2.39	0.37	2.84	0.46
		26	10		142	69	28	179	43		483				22																			
20	4	19	101		95	113	34	237	20	0.72	675	6.7	1.8	0.48	15.6	18	4.8				67	125	12.9	42	7.4	1.13	7.7	1.08	6.6	1.29	3.9	0.63	4.3	0.63
		15			139	130	24		23	2.87	494		1.5	0.68	16.4	17	4.3				36	67	6.8	23	4.3	0.66	3.5	0.55	3.9	0.79	2.48	0.4	2.73	0.4
		4			102		22		26	1.93	154		2.5	0.54	28	20	4.9																	
																					27	54	5	16.7	3.3	0.28	3.4	0.52	3.9	0.82	2.61	0.41	3.11	0.48
24	3.2	10	24		109	47	33	337	35	0.72	352	8.2	2.4	0.46	11.6	16	5				42	80	8.5	28	5.4	0.86	5.3	0.86	5.6	1.18	3.8	0.63	4.6	0.69
		13	11		217	524	30	174	14	22.9	993		1.2	1.2	10.6	14.2	4.7				27	50	5.3	20	4.1	0.71	4.6	0.67	4.9	0.97	3.2	0.48	3.31	0.49
			19		195	16	33	148	59		20				20																			
14		3.7	12		152	22	26	119	32	3.13	81		3.1	0.58	14	24	5.6				27	49	5	15	3.1	0.23	3	0.52	3.9	0.85	2.72	0.46	3.53	0.53
		37	13		69	88	26	64	47		623				18																			
21		3.7	17		92	8	20	103	34	1.23	27		2.5	0.46	11.5	19	4.5				25	41	3.5	9.4	1.4	0.09	1.3	0.28	2.27	0.55	2.1	0.37	3.11	0.49
					83	202	60	294	41		616				14																			
8.5		22	83		75	190	57	349	25	1.82	493		4	0.39	16.6	12.3	4				37	70	7.7	28	5.4	1.1	5.2	0.75	5.4	1.11	3.5	0.34	3.92	0.61
1.3	4.6	20	64		79	193	30	332	27	2.01	503	8.1	1.8	0.37	15.1	13.5	4.2				41	72	9	32	6.2	1.39	6.4	0.98	5.9	1.22	3.6	0.56	3.95	0.59
		61	15		107	232	67	481	46		985				17																			
		142	149	109	29	359	21	322	6		682				25																			
10		99	77	42	37	517	33	272	18	0.48	594		1.01	0.14	6.2	6.7	1.8				34	66	7.5	29	5.7	1.4	5.6	0.77	5.2	1	3.1	0.45	2.76	0.39
																					41	75	9.1	35	6.7	1.67	6.4	0.86	5.9	1.16	3.4	0.49	3.3	0.49
		74	13	21	80	353	88	213	13	1.33	677		0.86	0.64	24	8.1	2.1				45	86	13.8	64	12.5	3.4	14	1.87	12.8	2.6	7.9	1.09	6.9	1.02
		200	67	28	48	409	24	250	6		643				12																			

Li	sc	V	Cr	Ni	Rb	Sr	Y	Zr	Nb	Cs	Ba	Hf	Ta	Tl	Pb	Th	U	Y/Nb	Zr/Nb	Zr/Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yr	Lu
	10	81	203	26	120	475	24	245	15	1.82	636	5.9	0.89	0.26	13.1	8.5	2.2				35	67	7.5	27	5.1	1.32	5.8	0.73	4.5	0.93	2.79	0.42	2.68	0.41
		164	465	291	59	348	20	307	6		552				11																			
		100	112	47	58	360	21	246	15	0.98	500		1.12	0.28	9.5	6.5	1.5				32	64	7	26	5	1.12	4.9	0.63	4.3	0.28	2.15	0.3	1.94	0.23
		234	133	21	44	786	29	249	37		588				9																			
9.7	19.9	182	220	68	12.6	637	29	283	23	0.55	541	5.6	1.3	0.1	8.8	4.5	1	1.26	12.3	9.76	33	69	7.9	31	6.5	2.27	7.2	1.04	6	1.19	3.3	0.49	3	0.45
15		219	356	137	7	550	26		14	0.18	290		1.7		0.74	1.2	0.2	1.86	8.79	4.73	23	46	5.2	21	4.7	1.26	4	0.6	4.2	0.86	2.44	0.34	2.07	0.28
34		162	443	248	12.8	584	32		36	0.58	171		5.4	0.09	4.1	2.2	0.8	0.89	5.31	5.97	19	40	4.9	20	4.4	1.45	4.7	0.67	4.7	0.92	2.68	0.39	2.62	0.37
31		208	253	122	3.1	563	40		8.9	0.18	110		0.06	0.03	1.34	1.2	0.7	4.49	15.1	3.35	8.1	20	2.7	13	3.6	1.28	4.5	0.69	5.2	1.12	3.4	0.53	3.33	0.51
27		183	253	122	17	818	32		32	1.07	315		18	0.19	6.2	2.8	0.9	1	6.03	6.03	27	52	6.1	25	5.1	1.49	5.1	0.71	4.8	0.94	2.83	0.4	2.65	0.4
13		246	162	48	9.2	489	37		22	2.12	162		1.4		6.3	2.3	0.8	1.68	7.73	4.59	19	40	5	22	5.1	1.65	5.1	0.77	5.5	1.13	3.2	0.46	3.21	0.47
		245	145	43	20	510	20	208	31		475				6			0.64	6.71	10.4														
		254	467	220	20	306	21	97	9		172				7			2.33	10.8	4.62														
		298	123	46	33	846	25	174	18		456				7			1.39	9.67	6.96														
		215	171	61	34	881	18	190	39		392				7			0.46	4.87	10.6														
12		173	465	321	21	653	28	154	48	0.21	290		2.7	0.04	6.8	3.4	1.2	0.58	3.21	5.5	23	46	5.2	21	4.7	1.49	4.5	0.64	4.1	0.81	2.23	0.34	1.98	0.31
16		158	453	283	5.3	1064	29	173	12	0.07	294		0.96	0.03	9.5	2.08	0.9	2.42	14.4	5.96	27	59	7.1	29	5.4	1.64	5.1	0.71	5.1	0.99	3	0.44	2.77	0.42

Table 4.Whole-rock analyses of the studied mafic dike samples.(Nam Duk) Phajuy et al.(2005)

[Proceedings Geo Indo, Khon Khaen, p386 - 962]

Sample n	ND4/5	ND4/6	ND5/2	ND5/6	ND7/1	ND8/1
Major oxides(wt%)						
SiO_2	51.62	51.14	49.58	53.3	64.33	59.48
TiO_2	1.22	0.90	1.17	1.04	0.41	0.54
Al_2O_3	17.56	15.35	17.13	17.5	16.55	17.24
FeO	11.14	10.28	11.62	9.72	5.77	7.20
MnO	0.06	0.03	0.05	0.03	0.00	0.00
MgO	5.18	8.65	9.53	4.24	2.73	3.29
CaO	8.64	9.24	4.51	6.22	5.82	4.12
Na_2O	3.34	2.79	4.69	4.46	3.65	6.69
K_2O	1.07	1.37	0.26	2.26	0.96	0.29
P_2O_5	0.19	0.19	0.19	0.20	0.13	0.14
LOI	5.03	3.48	5.93	3.88	4.59	2.40
Trace elements (ppm)						
Y	28	17	24	27	16	17
Rb	23	32	7	59	23	6
Ni	2	74	41	0	9	5
Th	2	2	3	24	5	5
Zn	99	84	99	94	64	59
Cu	26	83	64	21	11	13
Nb	2	2	4	2	1	2
Zr	98	85	107	121	106	99
Sr	651	936	0	0	586	969
Cr	30	240	153	14	30	2
Ba	207	274	982	418	355	153
Pb	5	5	6	4	10	4
Ga	21	16	19	18	13	18
Rare earth elements (ppm)						
La	-	11.4	11.6	11.6	-	-
Ce	-	25.4	25.8	25.8	-	-
Pr	-	3.49	3.65	3.68	-	-
Nd	-	15.2	16.1	16.5	-	-
Sm	-	3.67	3.98	4.04	-	-
Eu	-	1.16	1.25	1.28	-	-
Gd	-	3.35	4.02	4.31	-	-
Tb	-	0.55	0.64	0.73	-	-
Dy	-	3.16	3.7	4.51	-	-
Ho	-	0.65	0.77	0.97	-	-
Er	-	1.84	2.17	2.82	-	-
Yb	-	1.61	2.01	2.73	-	-
Lu	-	0.24	0.29	0.41	-	-

Table 5 Trace element analyses (in ppm) of 25 basalt samples for the Nam Cho and the Sop Prap-Ko Kha basalts, Lampang

SAMPLE	Ba	Ce	Co	Cr	Nb	Ni	Pb	Rb	Sr	V	Y	Zn	Zr
S-2	682	37	51	153	47	161	26	66	984	324	24	50	218
S-4	826	28	50	103	56	106	23	99	1902	347	22	51	260
S-8	878	47	42	91	61	107	35	82	1024	354	13	74	254
S-11	832	43	41	91	57	107	30	93	1303	370	10	68	266
S-13	838	46	65	89	58	99	29	90	986	345	24	43	219
S1-1	766	32	48	140	43	122	28	95	1327	350	82	43	187
S1-7	778	36	47	150	30	131	38	38	1243	351	31	80	198
S1-10	676	28	56	132	33	122	36	28	1862	343	17	69	197
S1-13-2	766	36	53	118	37	148	44	35	943	363	25	66	218
S1-14	903	44	48	149	41	140	23	40	1122	365	22	74	239
S7-2	804	27	46	86	50	95	40	73	1407	359	12	60	253
S7-3-1	681	25	39	156	38	113	10	95	2726	351	76	65	196
S7-5	617	22	44	130	39	114	11	114	1107	326	114	42	116
S8-2	698	30	48	151	42	117	46	37	910	371	28	76	202
S8-5	823	39	46	141	35	163	52	50	1113	369	21	71	243
S18-2-1	966	48	50	84	61	75	5	79	1248	342	33	10	270
S18-3	977	36	56	98	58	86	5	56	1072	337	41	67	249
S18-5-2	905	36	54	83	52	90	5	79	1101	328	31	29	254
S18-7	778	20	57	94	36	123	5	89	1639	338	37	17	221
S18-11	731	20	59	104	40	97	5	72	848	335	21	63	218
S19-1	782	28	60	78	58	95	5	76	1396	391	44	67	258
S19-3	843	31	64	69	58	78	5	109	2171	390	26	52	275
S19-5	695	24	47	100	44	87	48	373	2305	372	416	75	220
S19-7	667	22	58	101	39	102	5	336	1352	382	513	28	178
S19-9	666	41	52	115	33	100	5	52	852	371	32	61	187