17/9/76

THE METAMORPHIC GEOLOGY OF THE WINDMILL ISLANDS AND ADJACENT COASTAL AREAS, ANTARCTICA.

VOLUME 2

by

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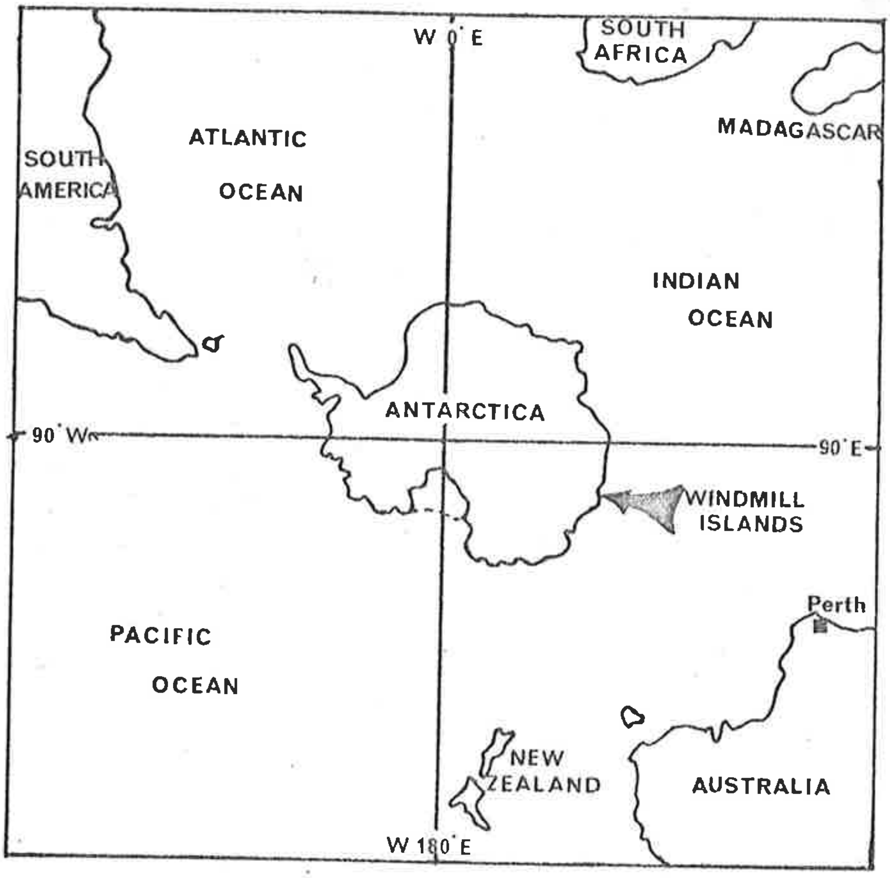
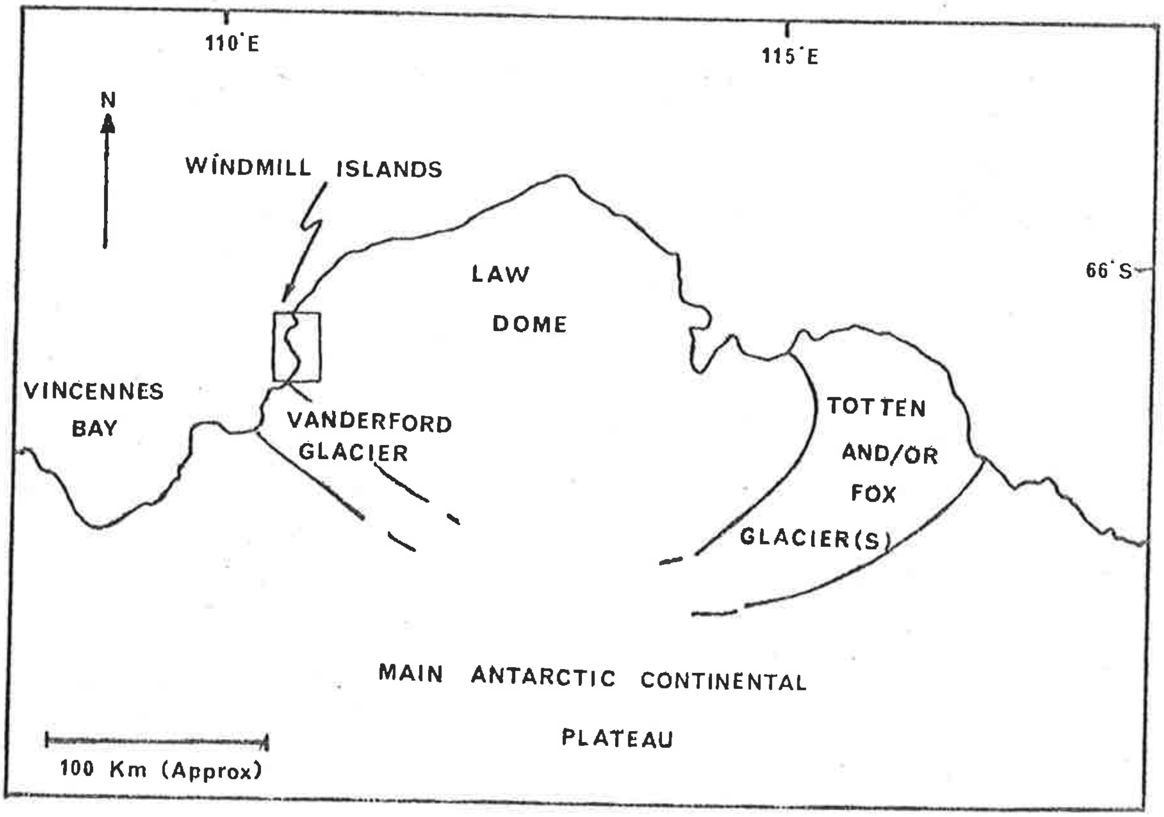
a. Location map of Antarctica

b. Map of the Law Dome.


W 0° E
SOUTH AFRICA
MADAGASCAR
ATLANTIC OCEAN
SOUTH AMERICA
INDIAN OCEAN
ANTARCTICA
90° W
90° E
WINDMILL ISLANDS
Perth
PACIFIC OCEAN
NEW ZEALAND
AUSTRALIA
W 180° E

a


110° E
115° E
N
WINDMILL ISLANDS
LAW DOME
66° S
VINCENNES BAY
VANDERFORD GLACIER
TOTTEN AND/OR FOX GLACIER(S)
MAIN ANTARCTIC CONTINENTAL PLATEAU
100 Km (Approx)

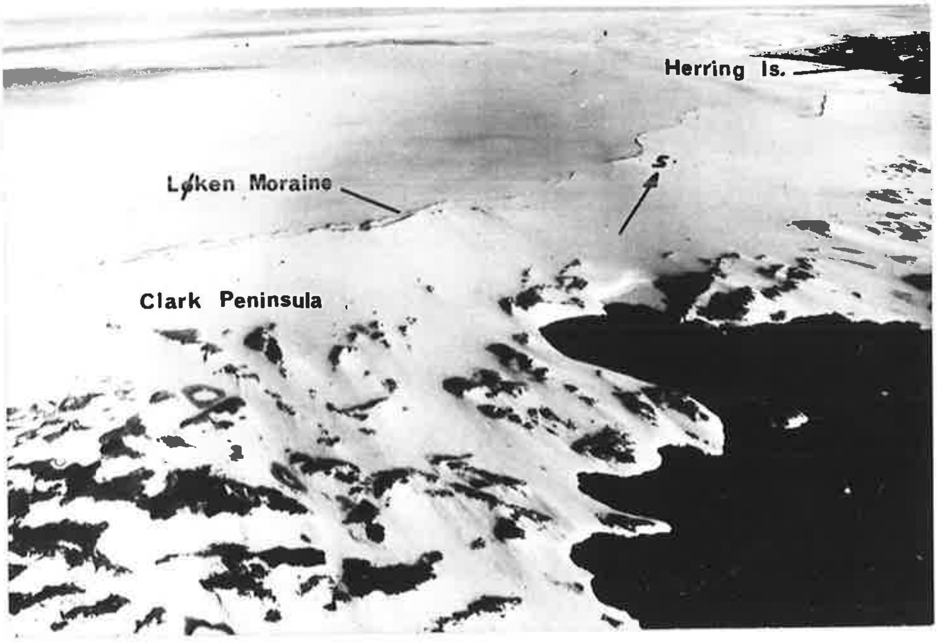
b

Figure 1.2

a. Air photo of the Windmill Islands (looking south from over Clark Peninsula).

b. The Løken Moraine

c. Melt lake and melt streams on Clark Peninsula.



a

b

c

Figure 1.3

Geological map of Antarctica (Modified from Harrington, 1965).

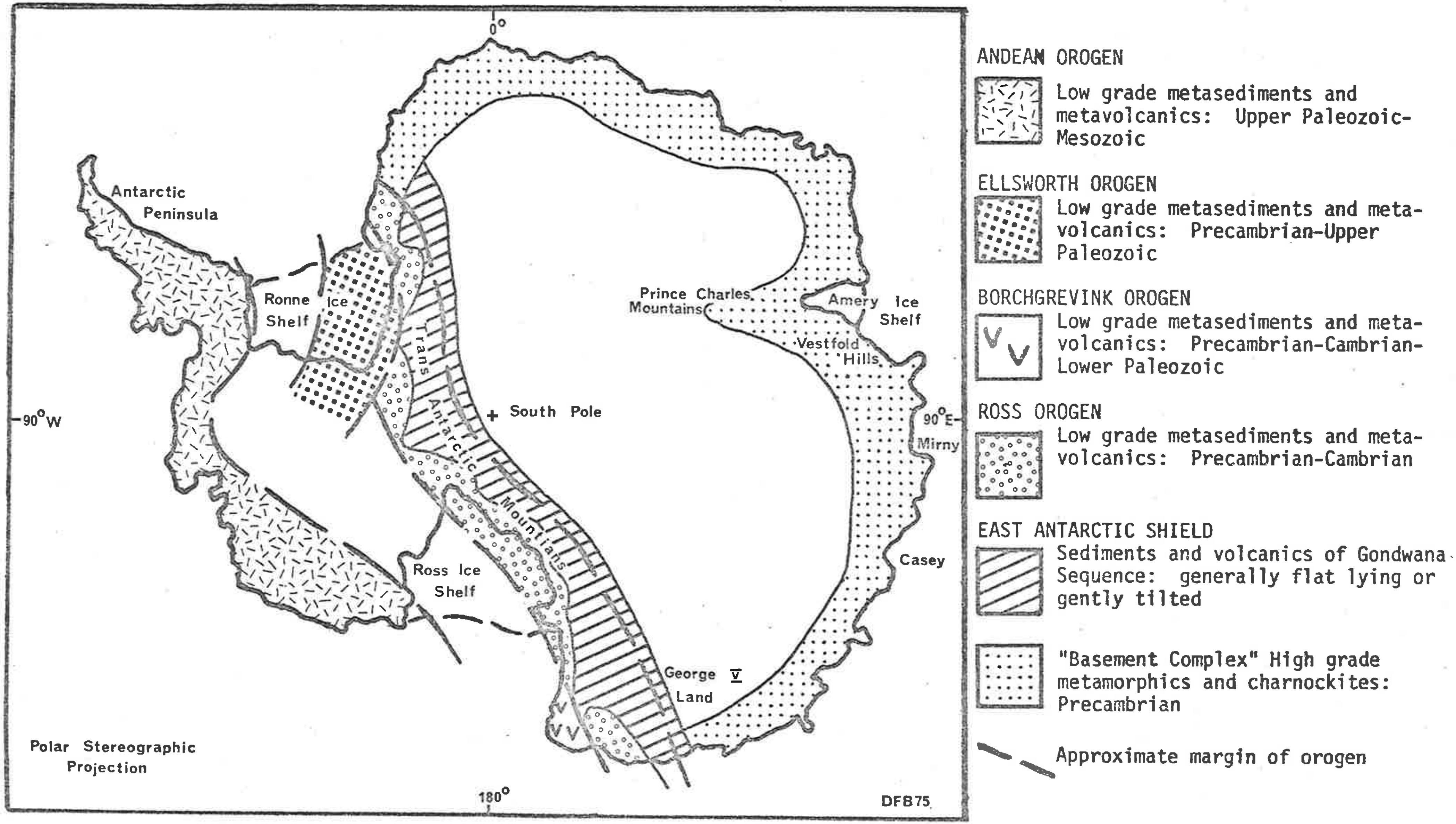

0°
Antarctic Peninsula
Ronne Ice Shelf
Trans Antarctic Mountains
South Pole
Prince Charles Mountains
Amery Ice Shelf
Vestfold Hills
90°E
Mirny
Casey
George V Land
Ross Ice Shelf
90°W
Polar Stereographic Projection
180°
DFB75
ANDEAN OROGEN
Low grade metasediments and metavolcanics: Upper Paleozoic-Mesozoic
ELLSWORTH OROGEN
Low grade metasediments and metavolcanics: Precambrian-Upper Paleozoic
BORCHGREVINK OROGEN
Low grade metasediments and metavolcanics: Precambrian-Cambrian-Lower Paleozoic
ROSS OROGEN
Low grade metasediments and metavolcanics: Precambrian-Cambrian
EAST ANTARCTIC SHIELD
Sediments and volcanics of Gondwana Sequence: generally flat lying or gently tilted
"Basement Complex" High grade metamorphics and charnockites: Precambrian
Approximate margin of orogen

Figure 2.1

Descriptive textural terms (from Moore, 1970 with modifications by Collerson, 1974).

Grain boundary shapes from Spry, (1969).

a. straight

b. curved

c. embayed

d. scalloped

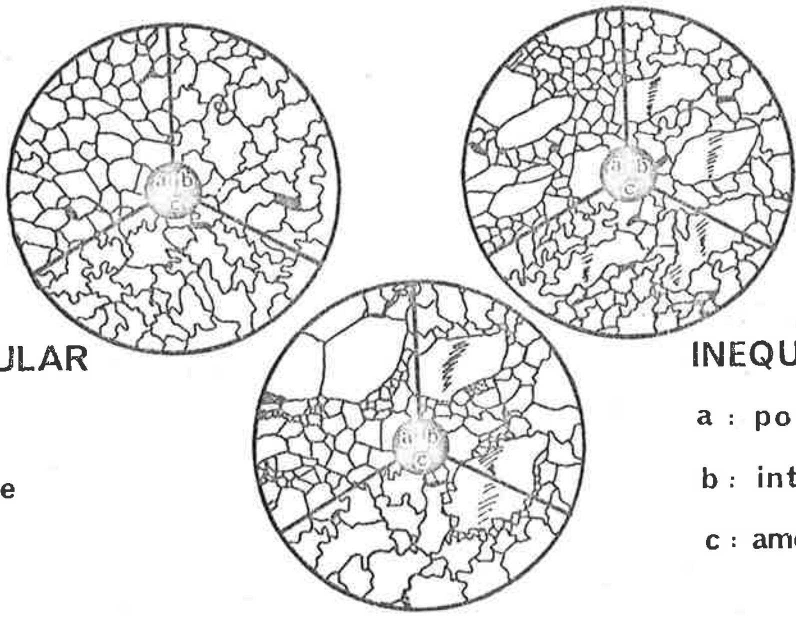
e. 1. sutured (lobate)

 2. sutured (serrated)

f. rational

g. irrational

GRANOBLASTIC



EQUIGRANULAR

a : polygonal

b : interlobate

c : amoeboid

SERIATE

INEQUIGRANULAR

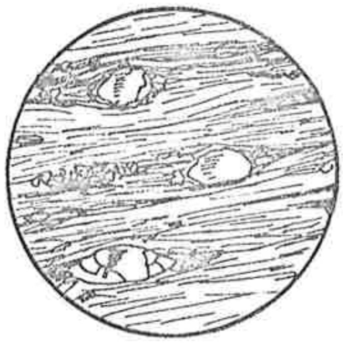
a : polygonal

b : interlobate

c : amoeboid

GRANOBLASTIC ELONGATE

ANASTOMOSING



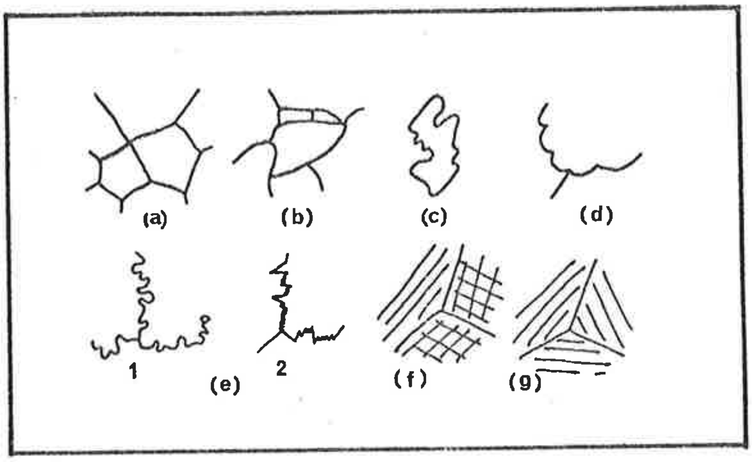


Figure 2.2

Geological map of the Windmill Islands, Antarctica.

(located in pocket in the back of volume 2).

Figure 2.3

Geological map of Ford and Cloyd Islands

(located in pocket in the back of volume 2).

GEOLOGICAL MAP OF FORD AND CLOYD ISLANDS.

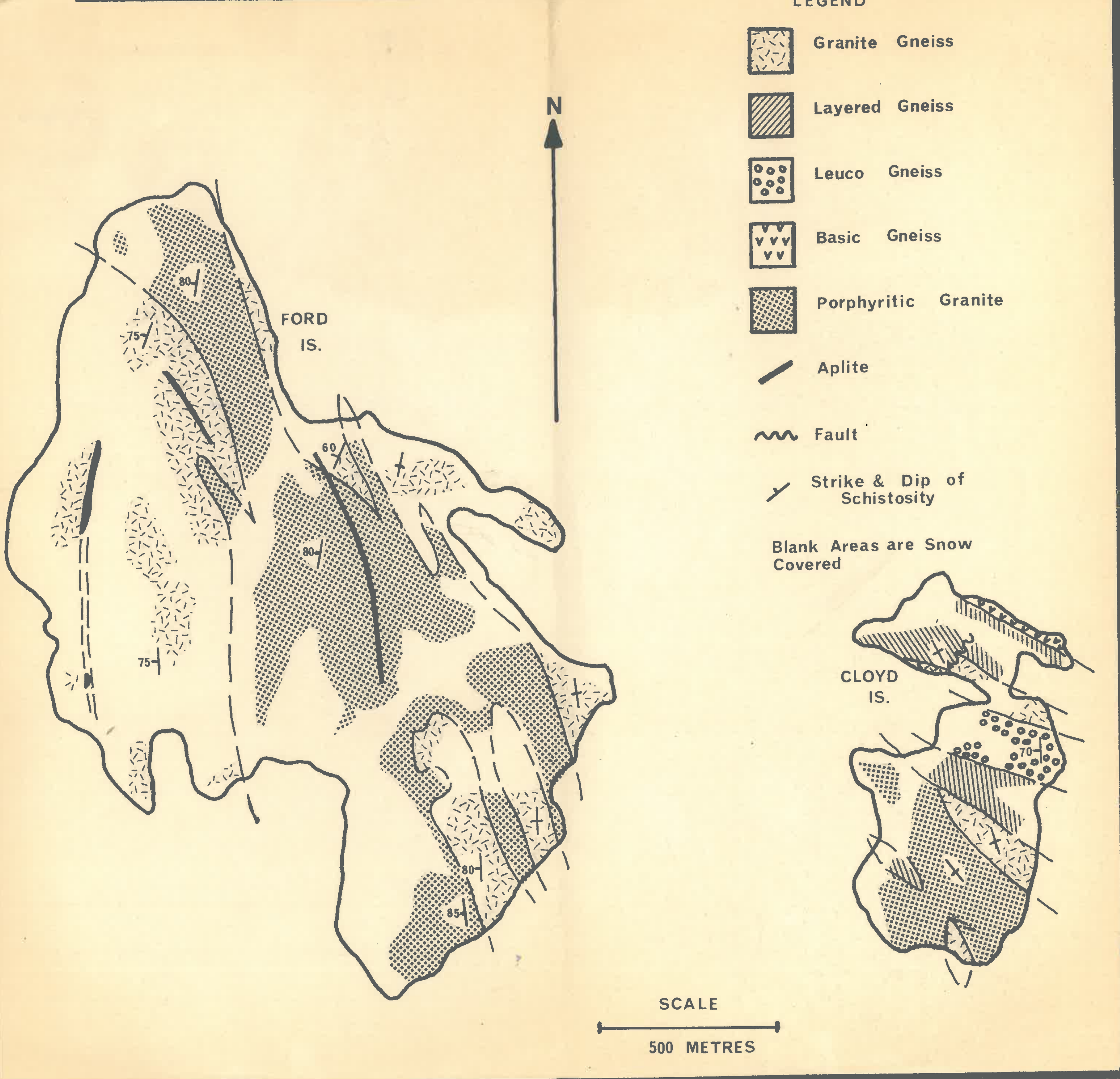


Figure 2.4

Geological map of Herring Island.

(from Oliver, 1970).

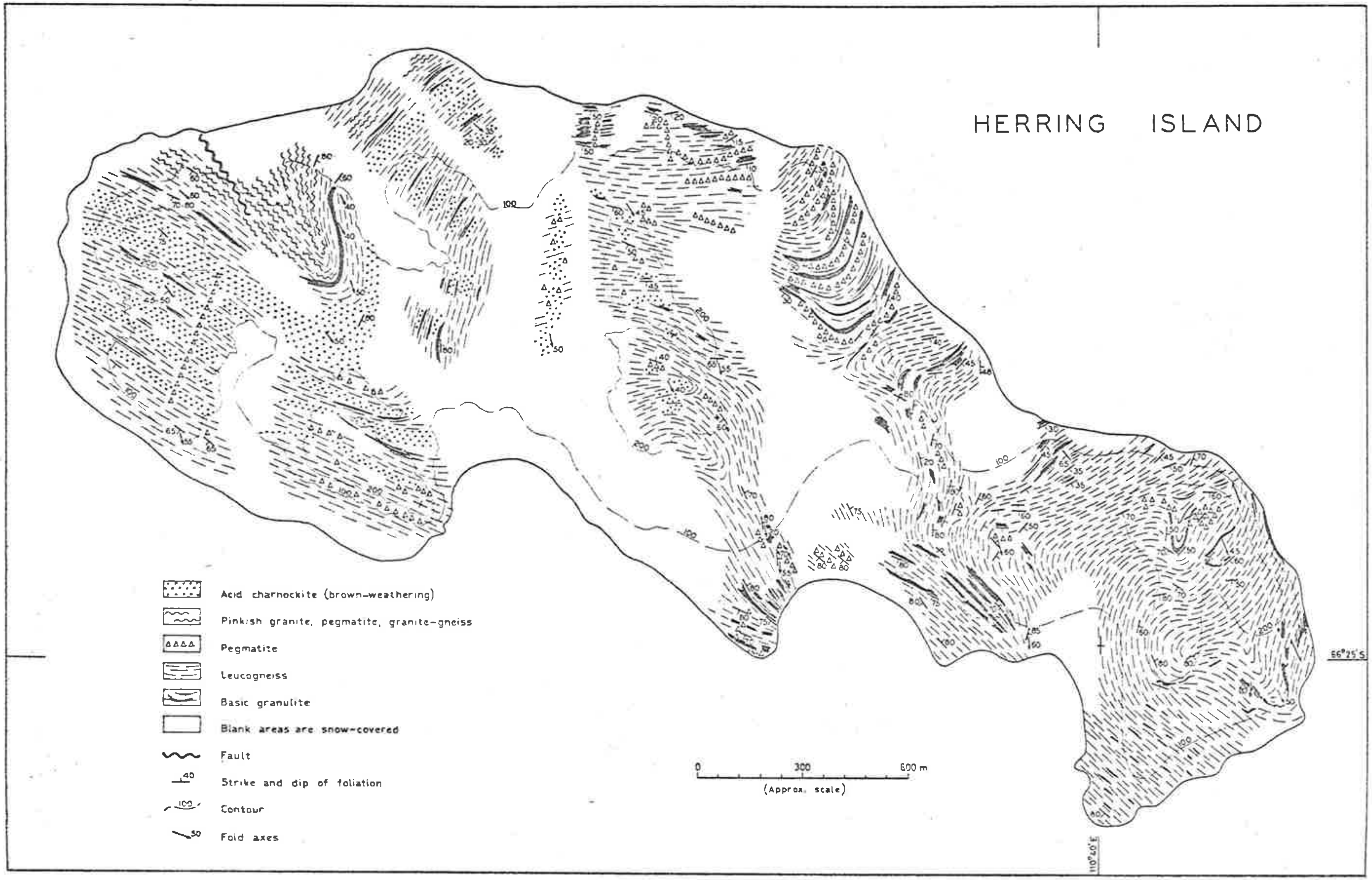
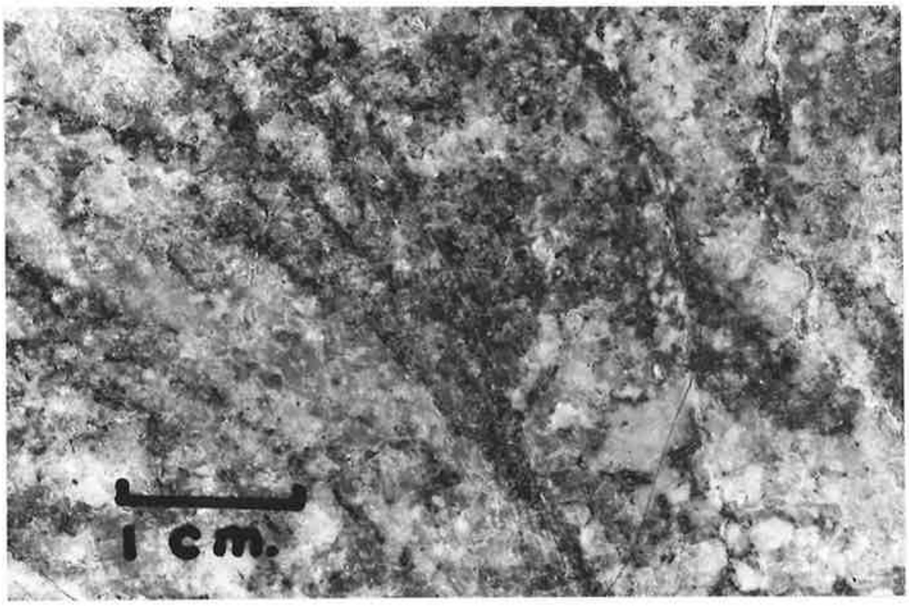

HERRING ISLAND
Acid charnockite (brown-weathering)
Pinkish granite, pegmatite, granite-gneiss
Pegmatite
Leucogneiss
Basic granulite
Blank areas are snow-covered
Fault
Strike and dip of foliation
Contour
Fold axes
0
300
600 m
(Approx. scale)
66°25'S
110°40'E

Figure 2.5

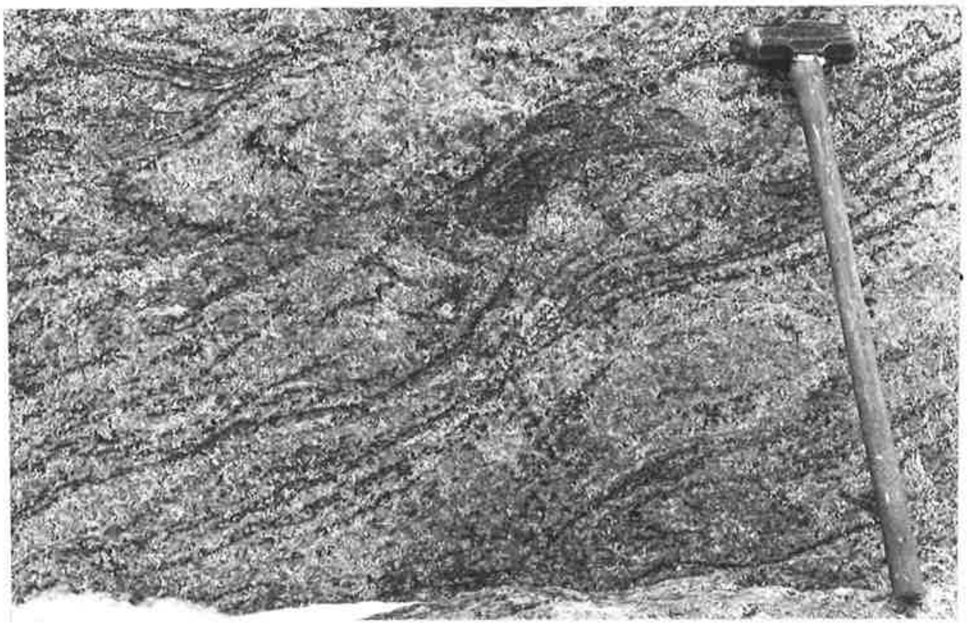
a. Weakly layered gneiss

b. Ribbon gneiss

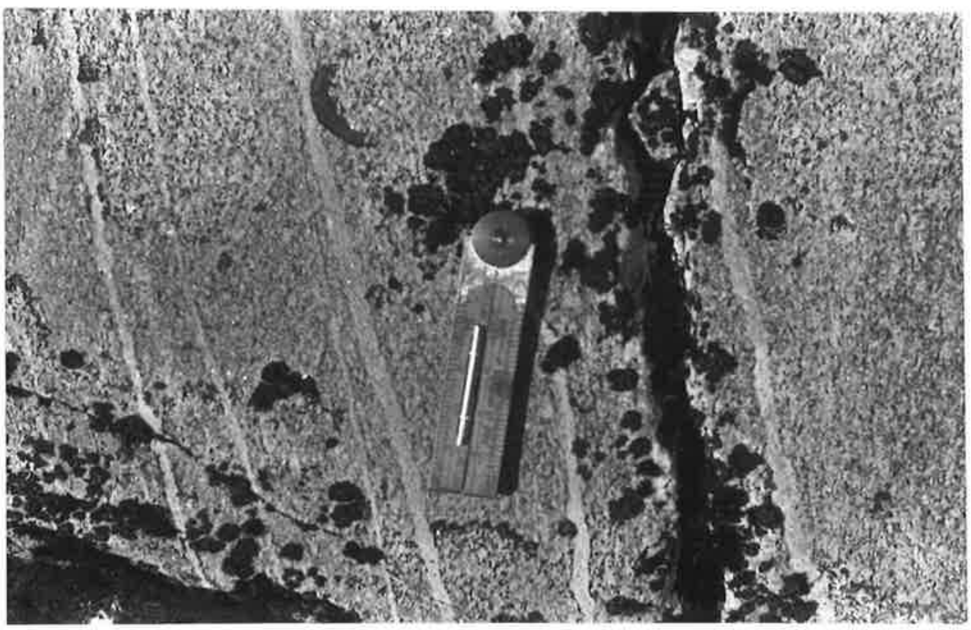
c. Layered granite gneiss near core of major fold on Clark Peninsula. Rule parallel to schistosity (S_3) at an angle to the layering.



a



b



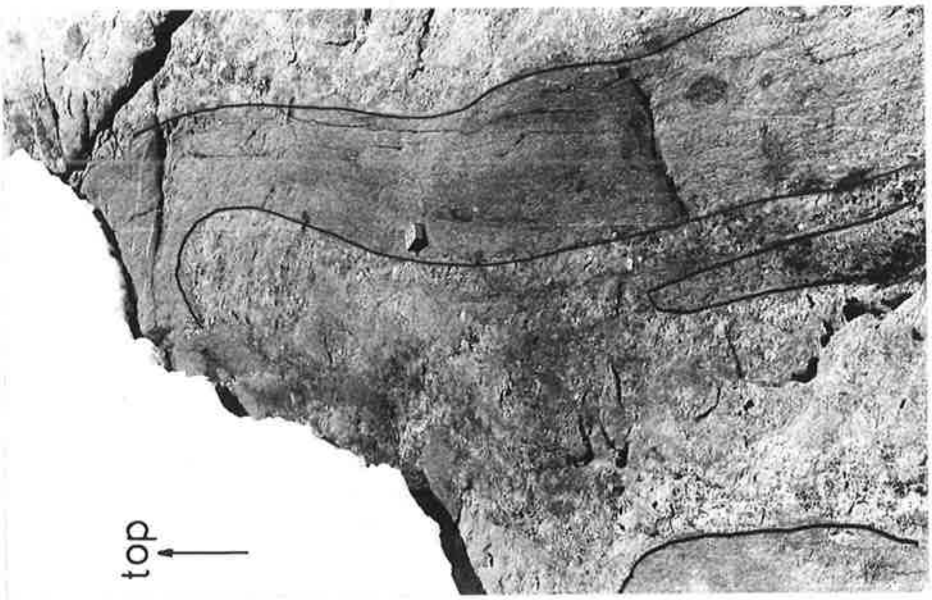
c

Figure 2.6

a. Development of layering in layered granite gneiss from a pegmatite.

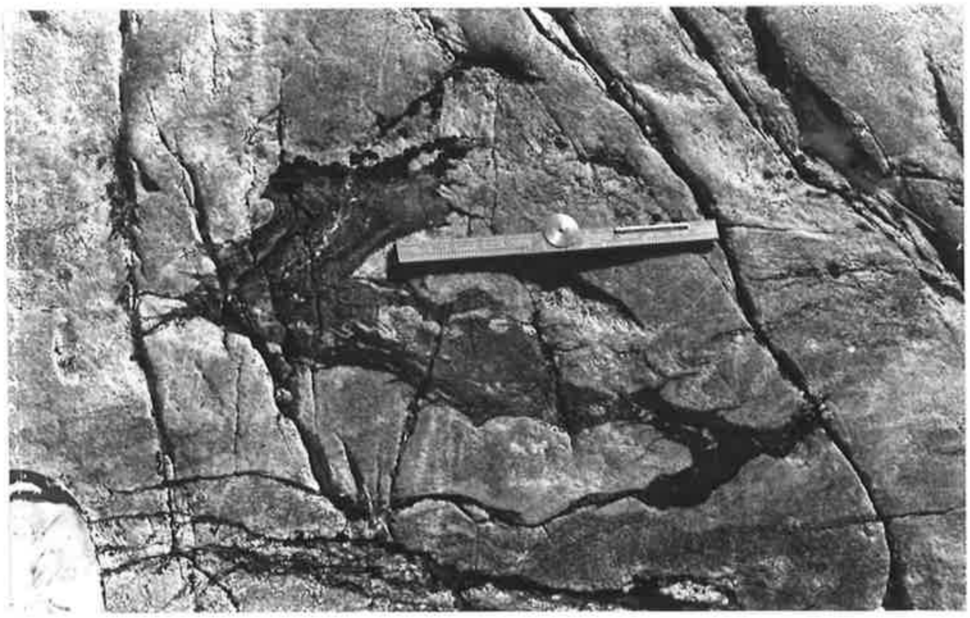
b. Plagioclase rims developing around plagioclase; uncrossed polars. Length of bar 1.0mm.

c. Folded basic pod in leuco gneiss.



a

b



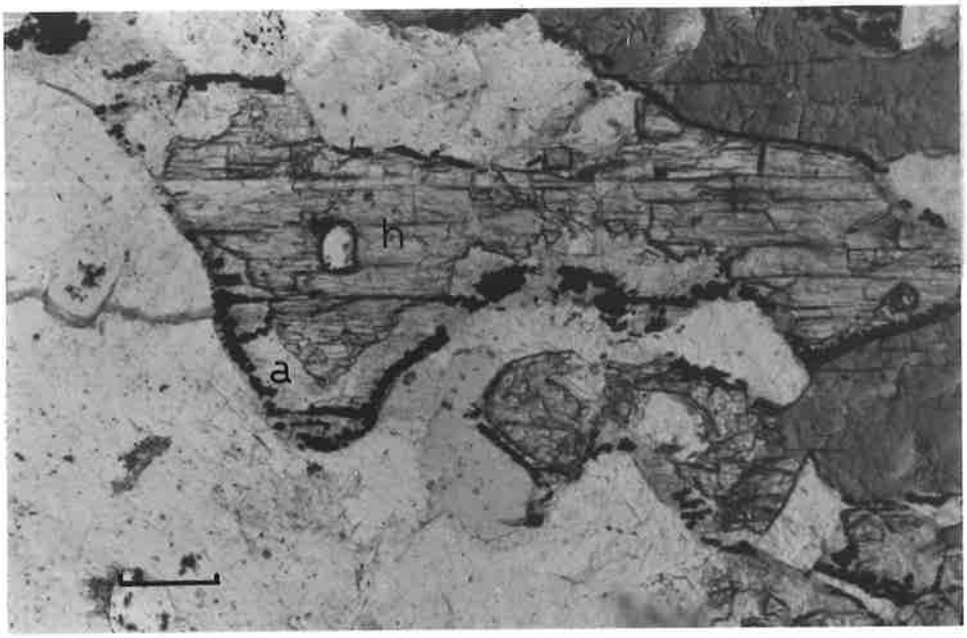
c

Figure 2.7

a. Orthopyroxene (h) altering to anthophyllite (a) and iron oxide; uncrossed polars. Length of bar 0.1mm.

b. Migmatite gneiss from Clark Peninsula.

c. Contact of migmatite gneiss with leuco gneiss (Mitchell Peninsula).



a

b

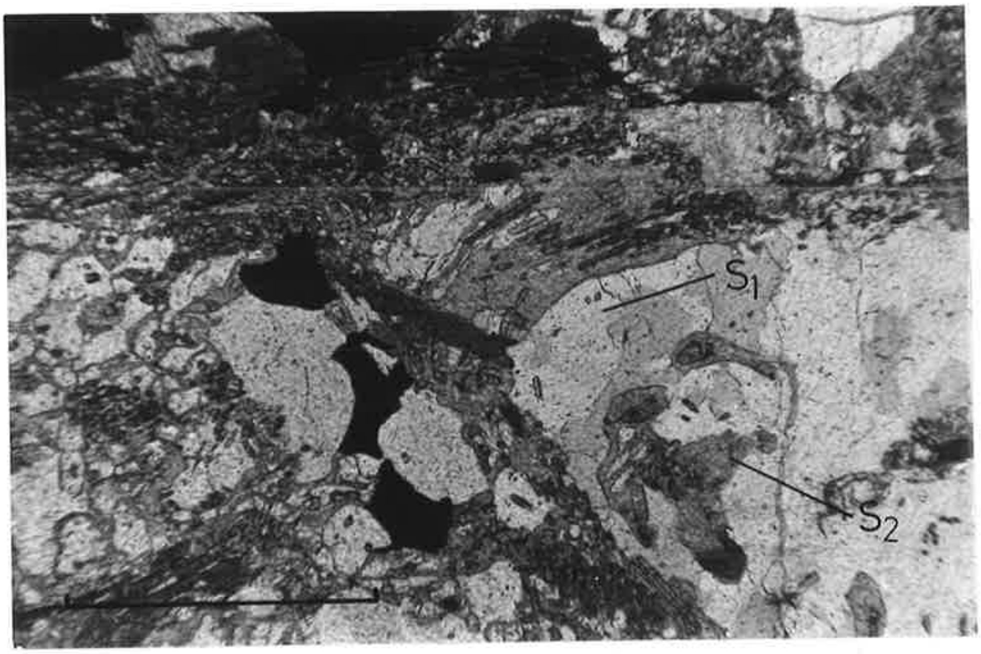
c

Figure 2.8

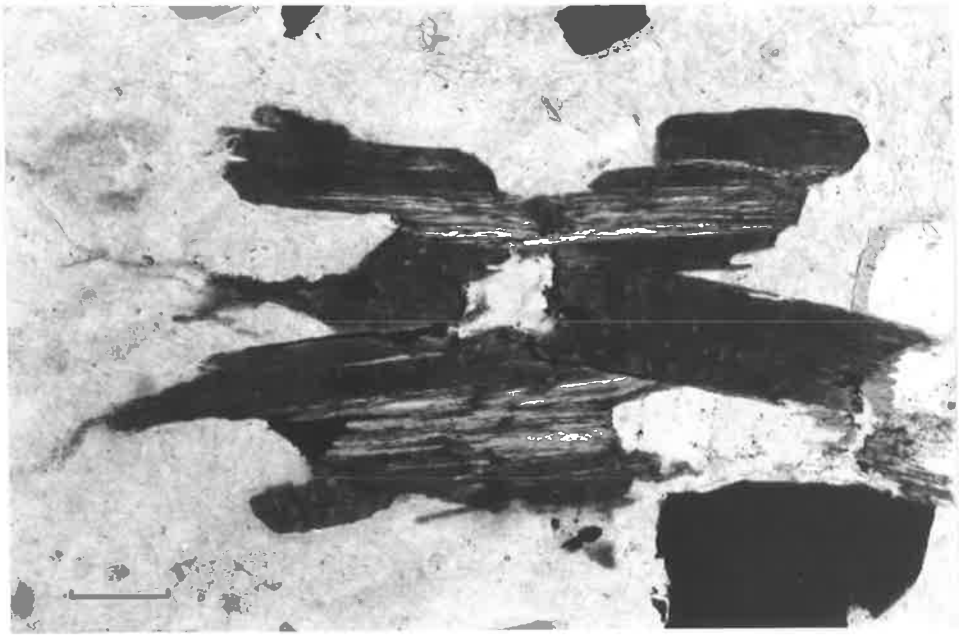
a. Folded sillimanite defining S_1 with axial plane biotite defining S_2; uncrossed polars. Length of bar 1.0mm.

b. Biotite altering to chlorite along (001) cleavage plane; uncrossed polars. Length of bar 0.1mm.

c. Pleochroic halo about zircon included in cordierite; uncrossed polars. Length of bar 0.1mm.



a



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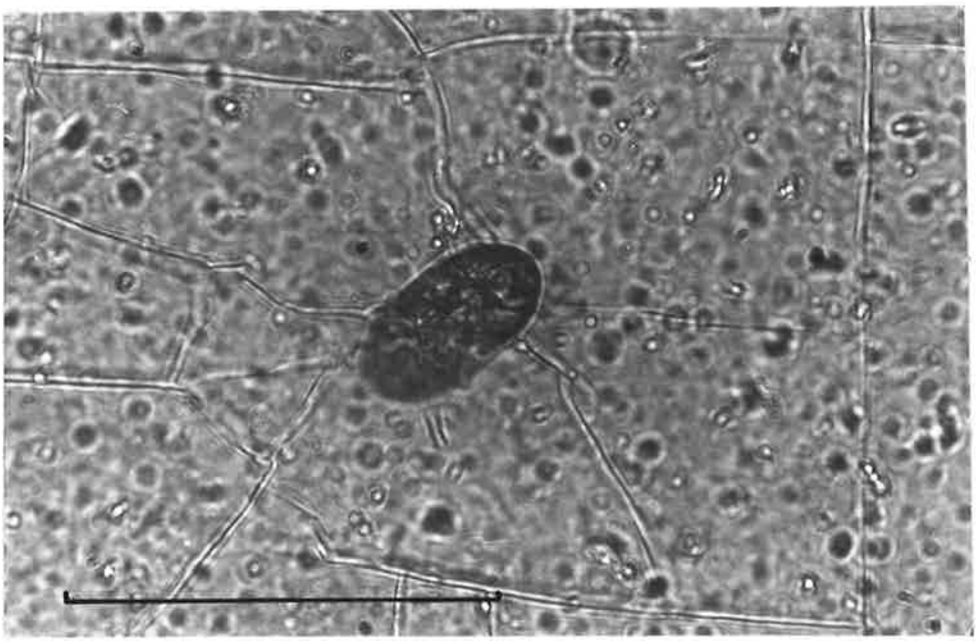


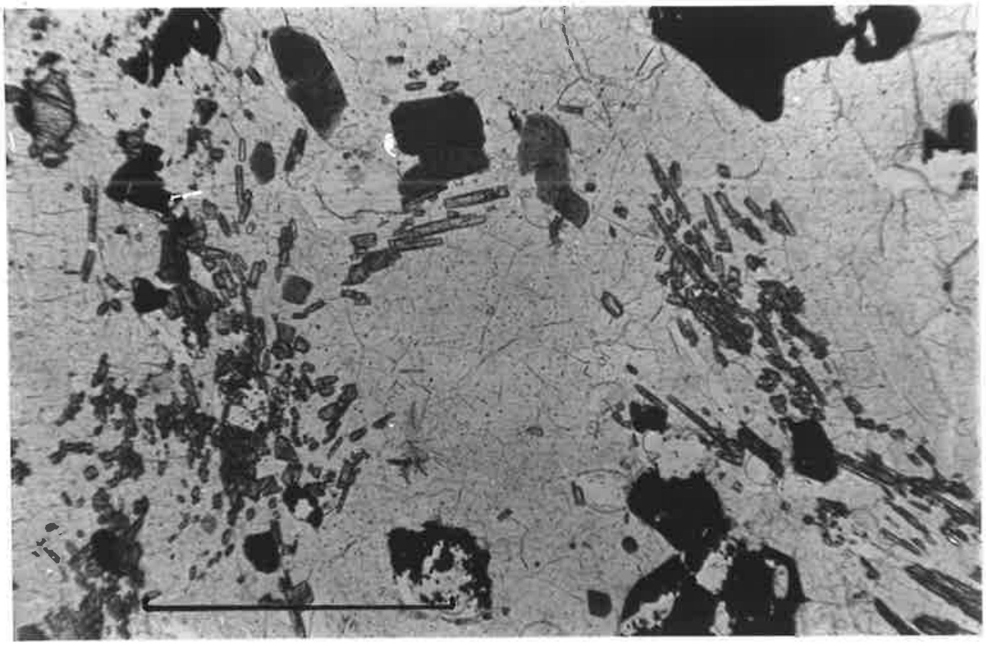
c

Figure 2.9

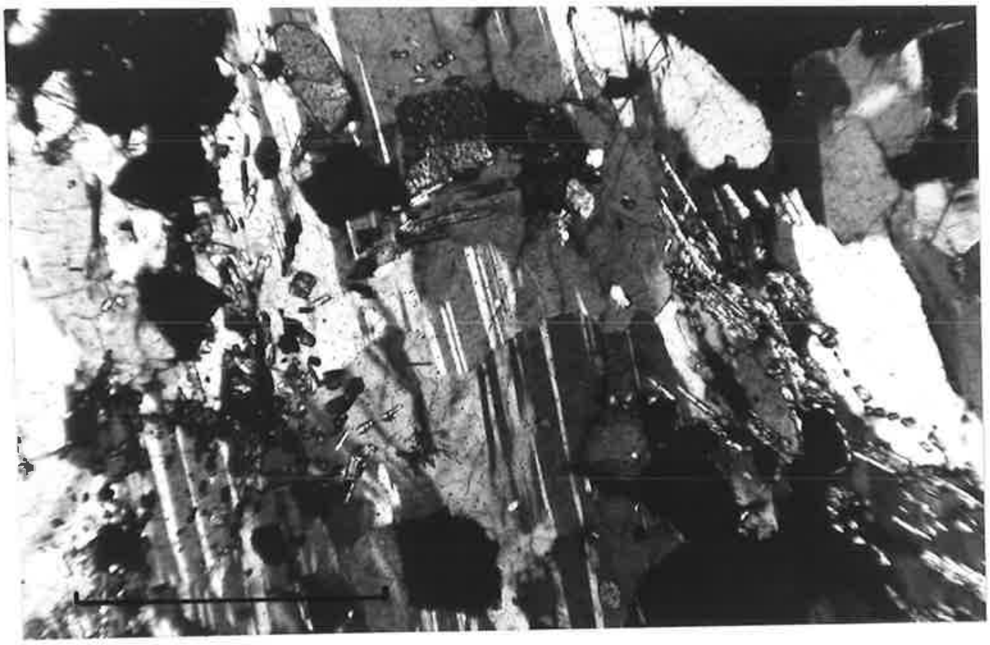
a. Folded sillimanite in cordierite; uncrossed polars. Length of bar 1.0mm.

b. Same as above but with crossed polars, showing multiple twinning in cordierite. Length of bar 1.0mm.

c. Cordierite altering to pininite(?); uncrossed polars. Length of bar 1.0mm.



a



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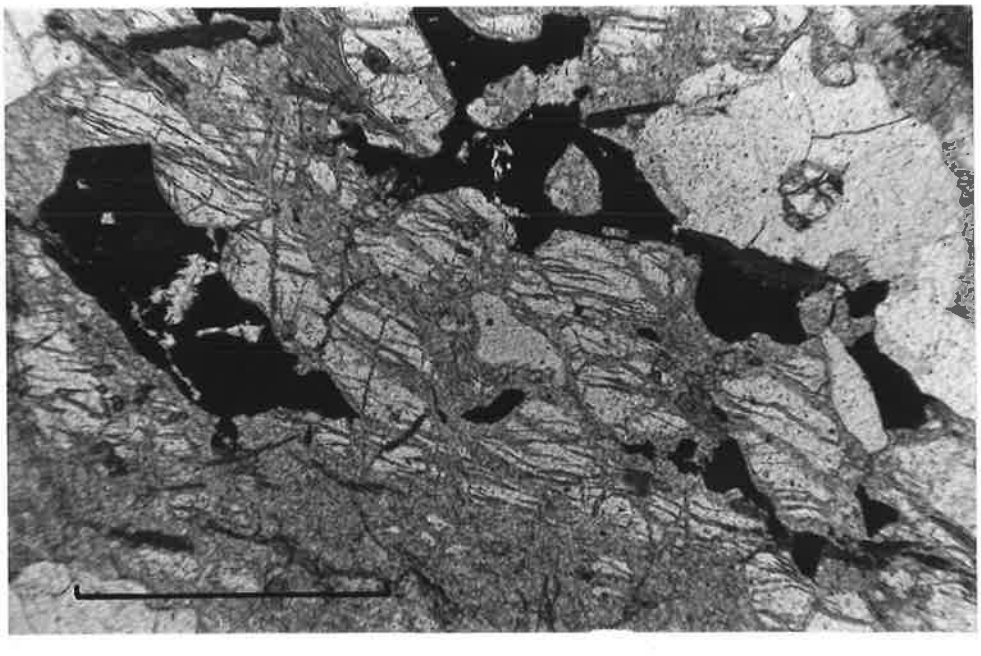


c

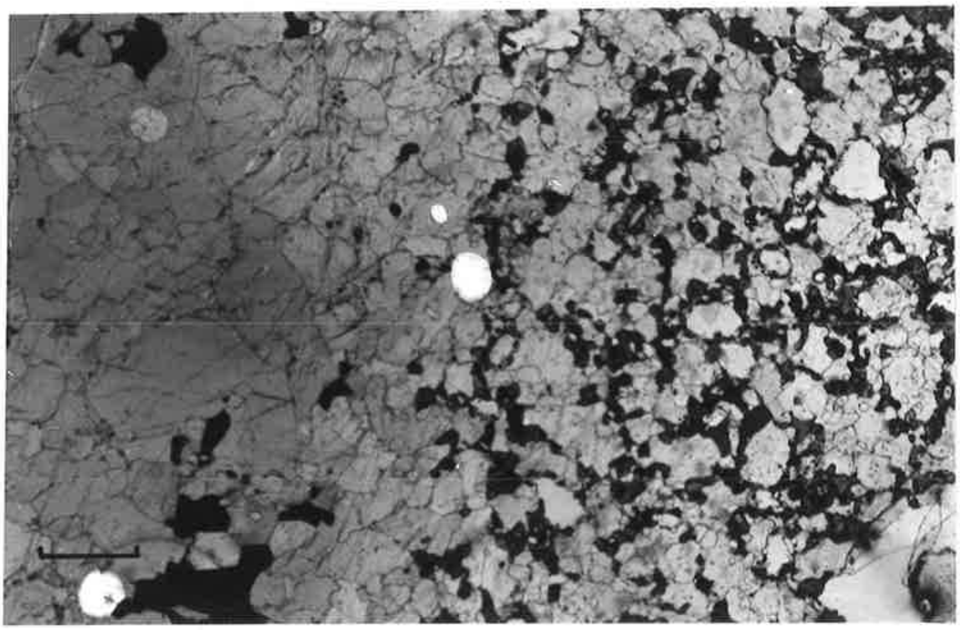
Figure 2.10

a. Layered gneiss from Robinson Ridge.

b. Mineralogical and grain size layering from layered gneiss (Haupt Ntk); uncrossed polars. Length of bar 1.0mm.

c. Quartz vein showing Sm and S_4?; crossed polars. Length of bar 1.0mm.

a



b

c

Figure 2.11

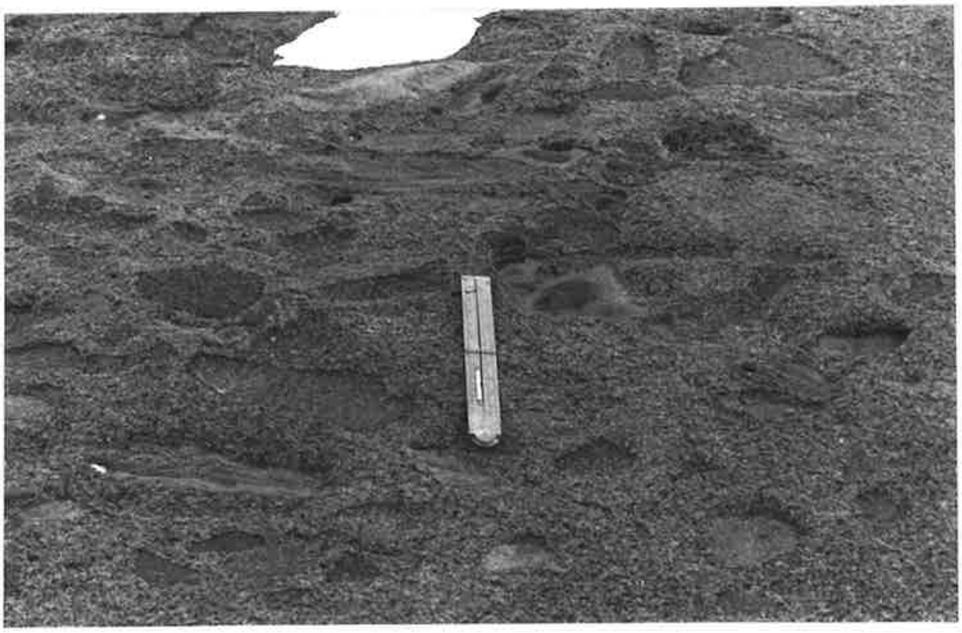
a. Honeycomb weathering of charnockite from Browning Peninsula.

b. Xenoliths of country rock within a xenolith of charnockite in charnockite. (Peterson Island). Note leucocratic reaction rim.

c. Close up of above.

a

b



c

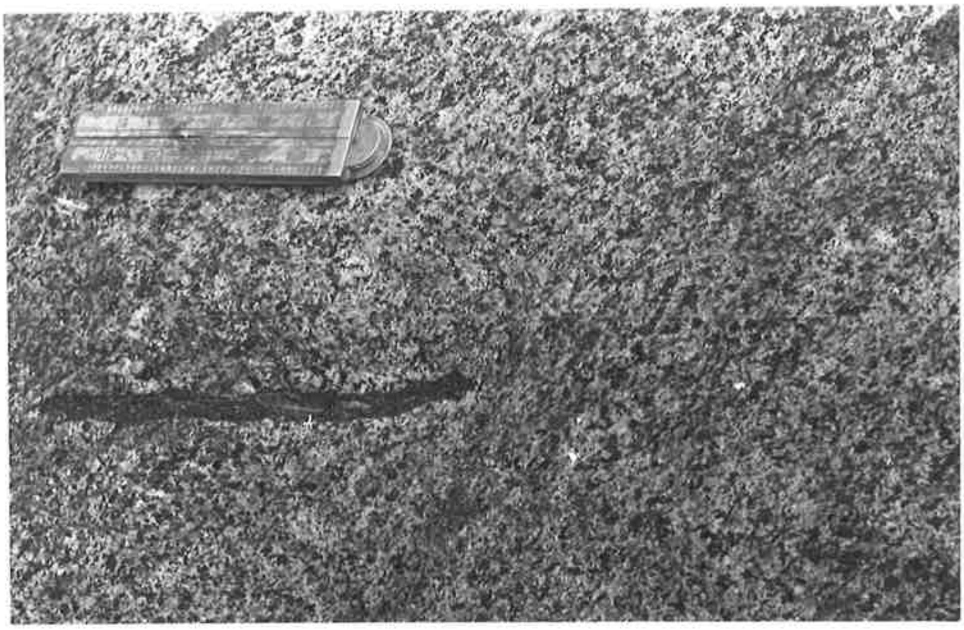
Figure 2.12

a. Contact of charnockite with layered gneiss (Bosner Island).

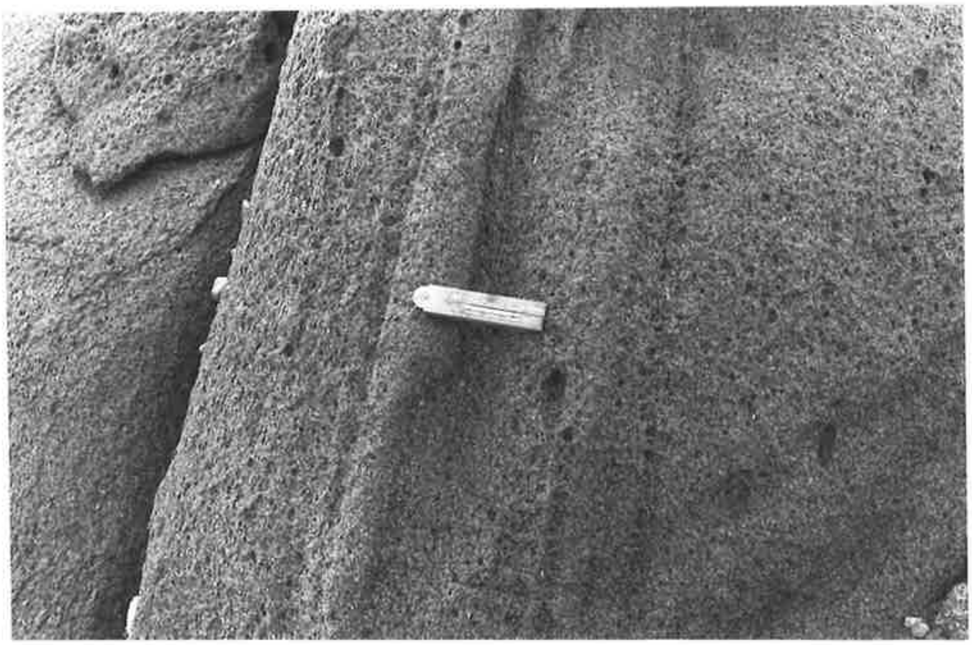
b. Elongate xenoliths in charnockite parallel to schistosity. (Ardery Island).

c. Layering in charnockite (Peterson Island).

a



b

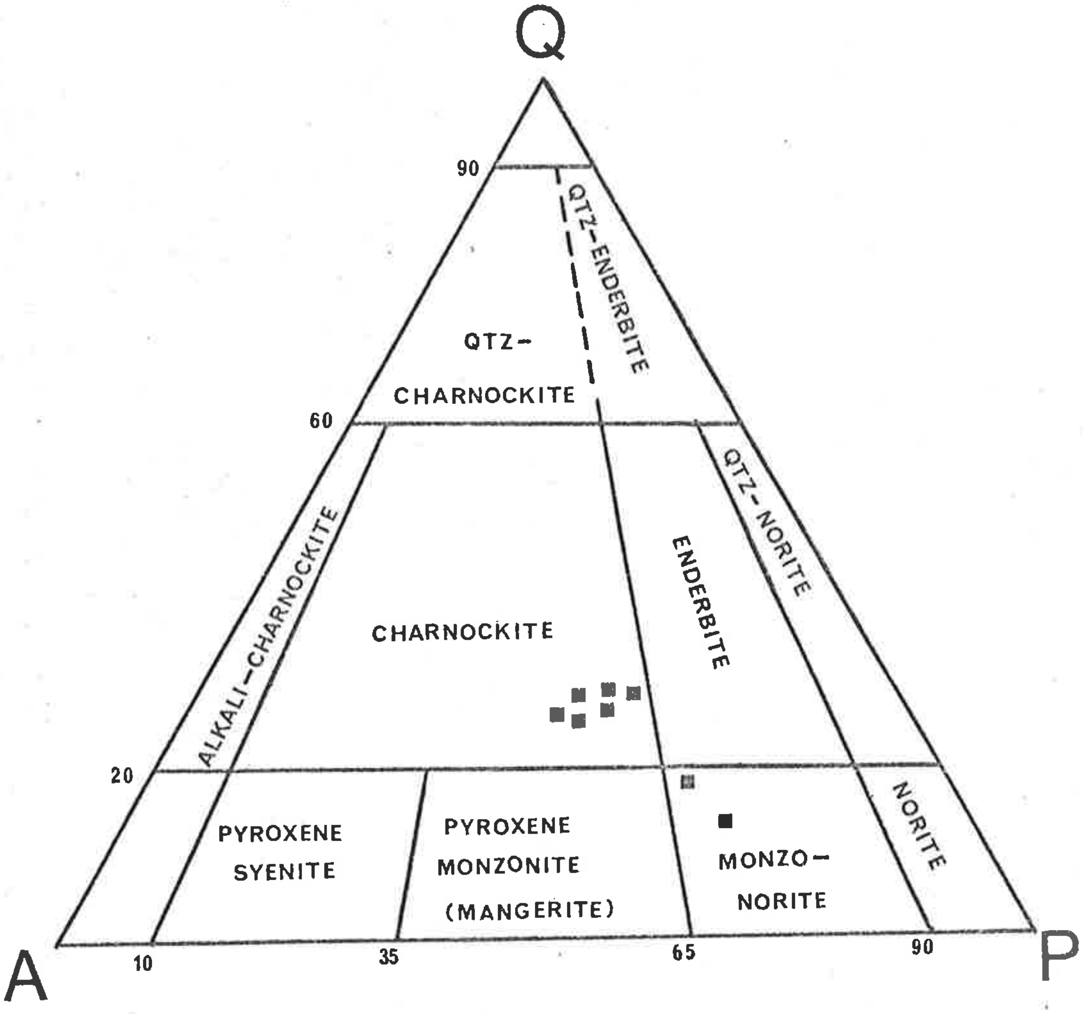


c

Figure 2.13

Modal analyses of charnockites plotted on classification diagram from Tobi, (1971).

CHARNOCKITE ROCK SUITE CLASSIFICATION
AFTER TOBI 1971



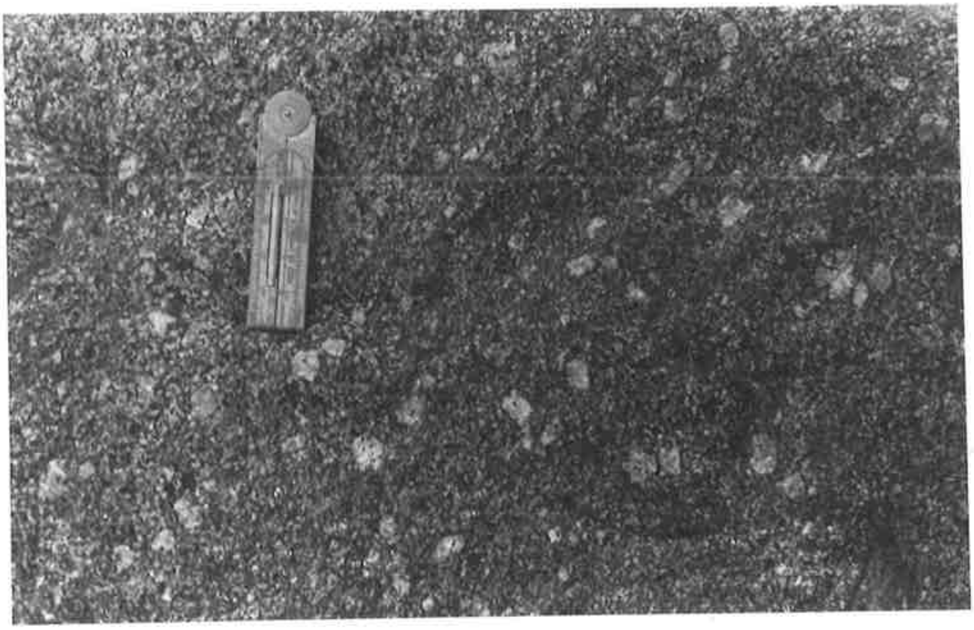
ALL ROCKS CONTAIN ORTHOPYROXENE

Figure 2.14

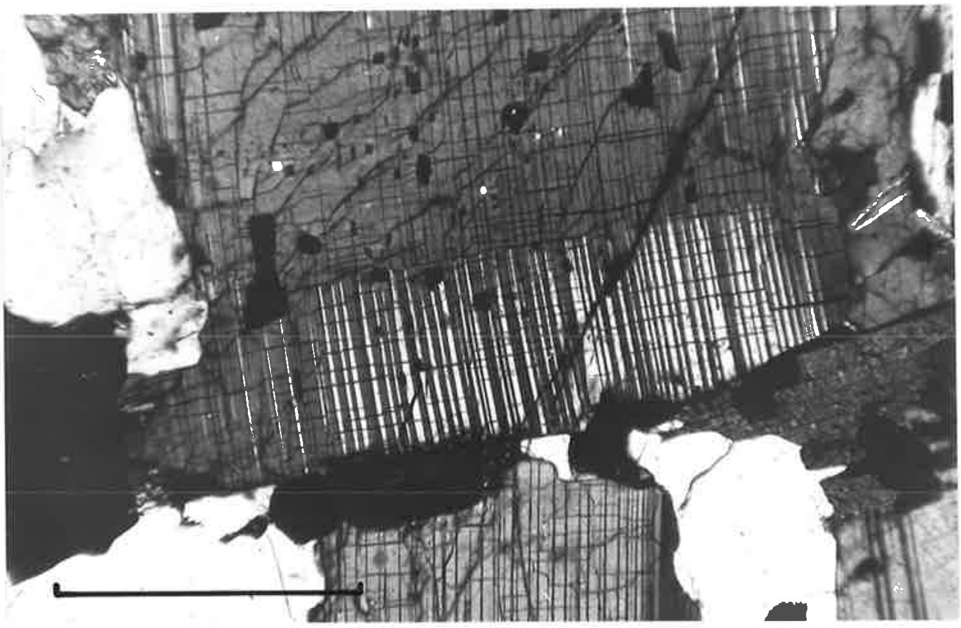
a. Plagioclase porphyroblasts in charnockite (Odbert Island).

b. Kinked plagioclase crystal from charnockite; crossed polars. Length of bar 1.0mm.

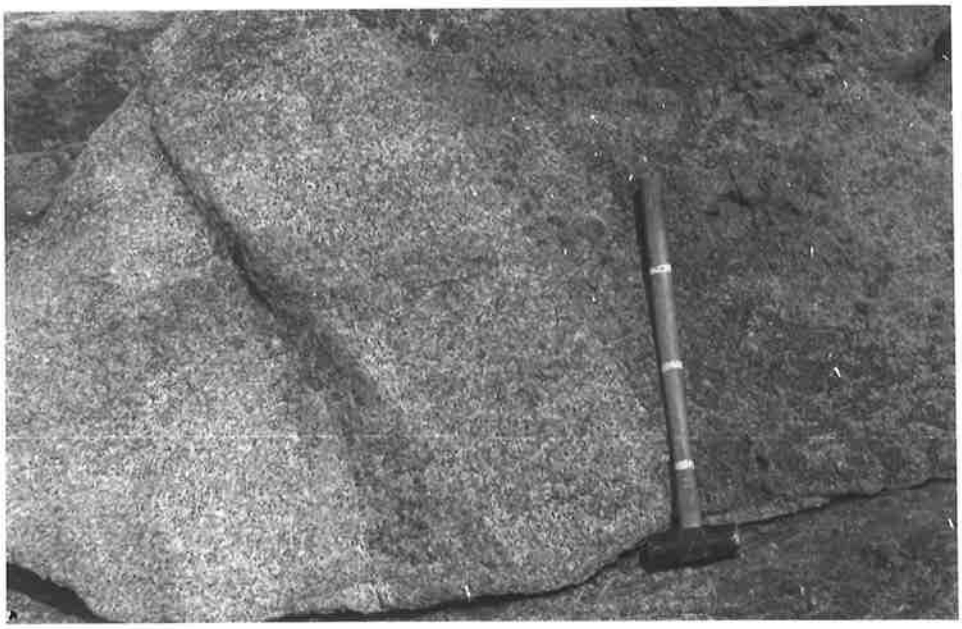
c. Contact of porphyritic granite (on right) with granite gneiss (Ford Island). The schistosity in the granite gneiss parallels the hammer handle while that in the porphyritic granite parallels the contact.



a



b



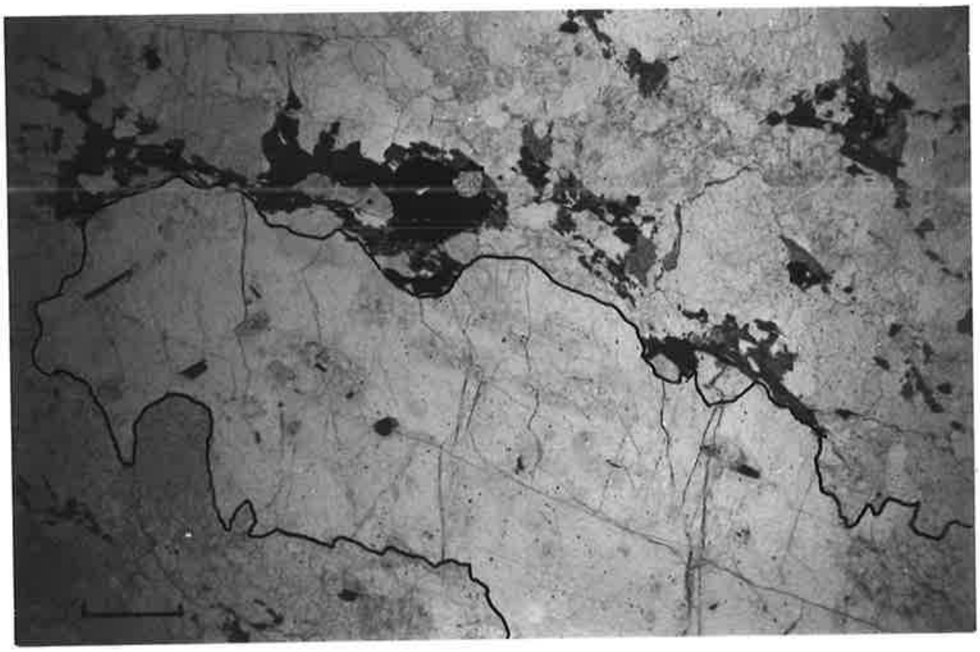
c

Figure 2.15

a. Porphyritic K feldspar crystal aligned parallel to schistosity, in porphyritic granite gneiss, defined by biotites; uncrossed polars. Length of bar 1.0mm.

b. Same as above but with crossed polars showing twin plane of K feldspar parallel to schistosity. Length of bar 1.0mm.

c. Xenolith in aplite.



a

b

c

Figure 2.16

Pegmatite distribution on Clark Peninsula.

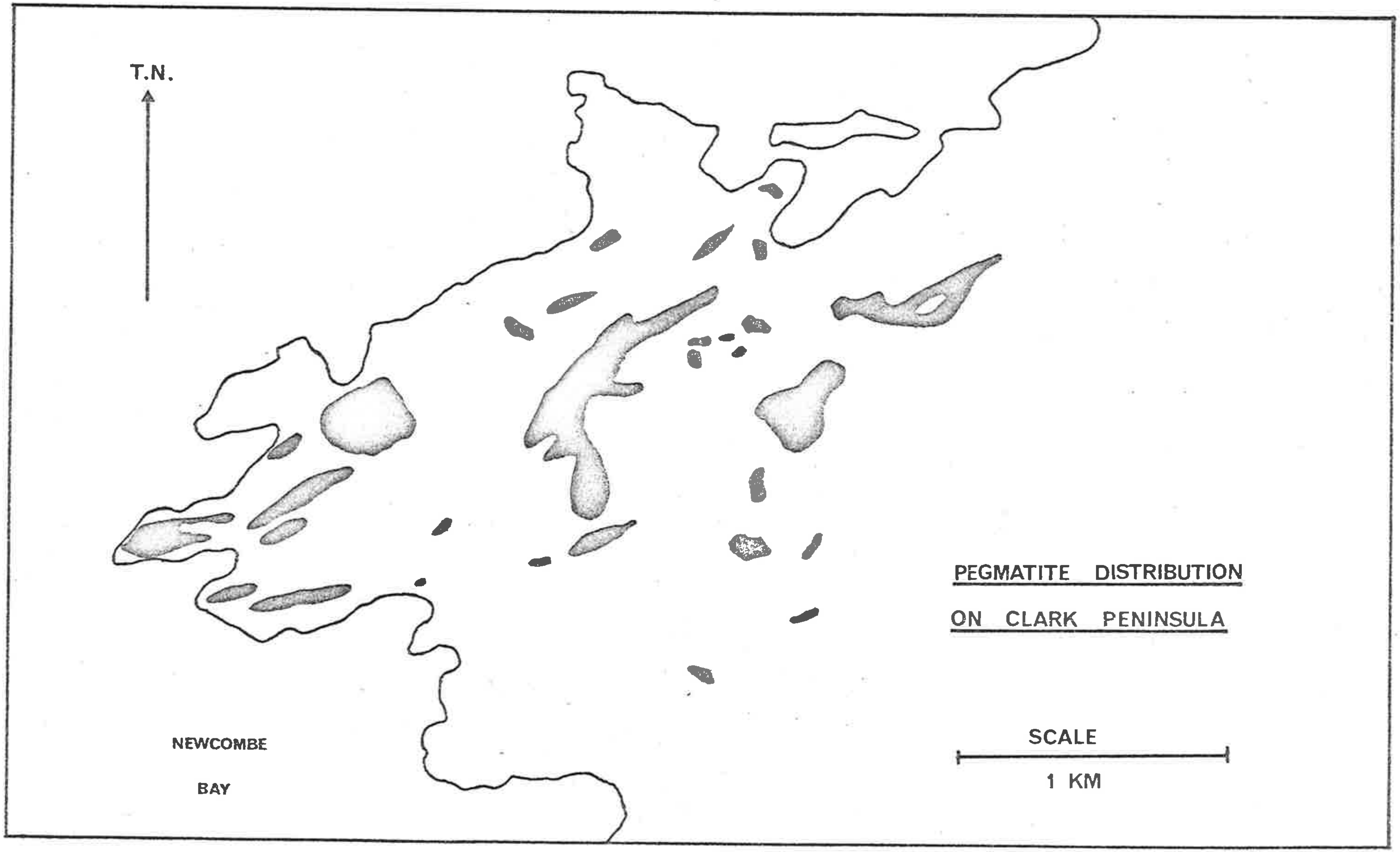
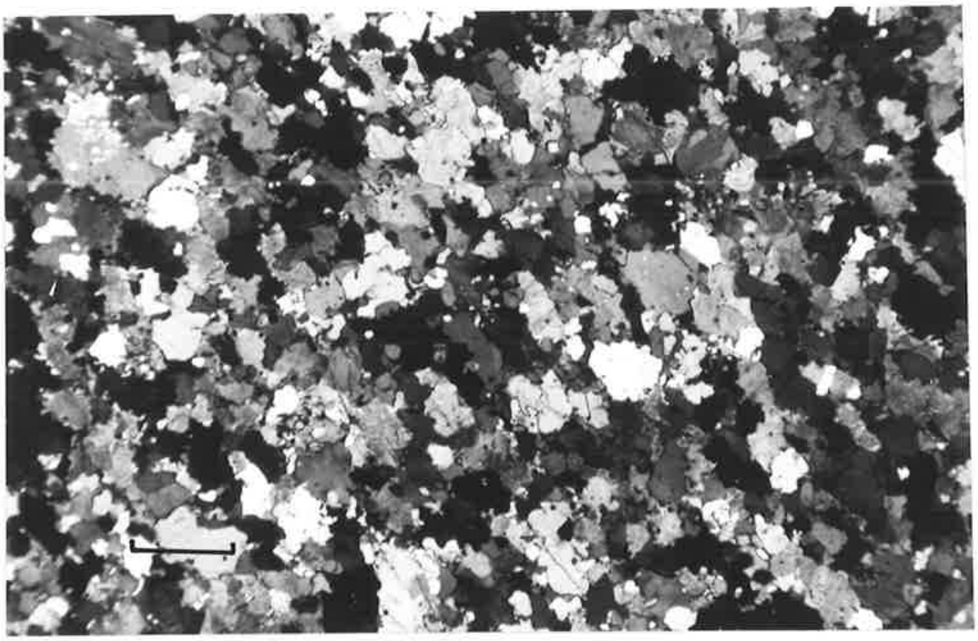

T.N.
PEGMATITE DISTRIBUTION
ON CLARK PENINSULA
SCALE
1 KM
NEWCOMBE
BAY

Figure 2.17

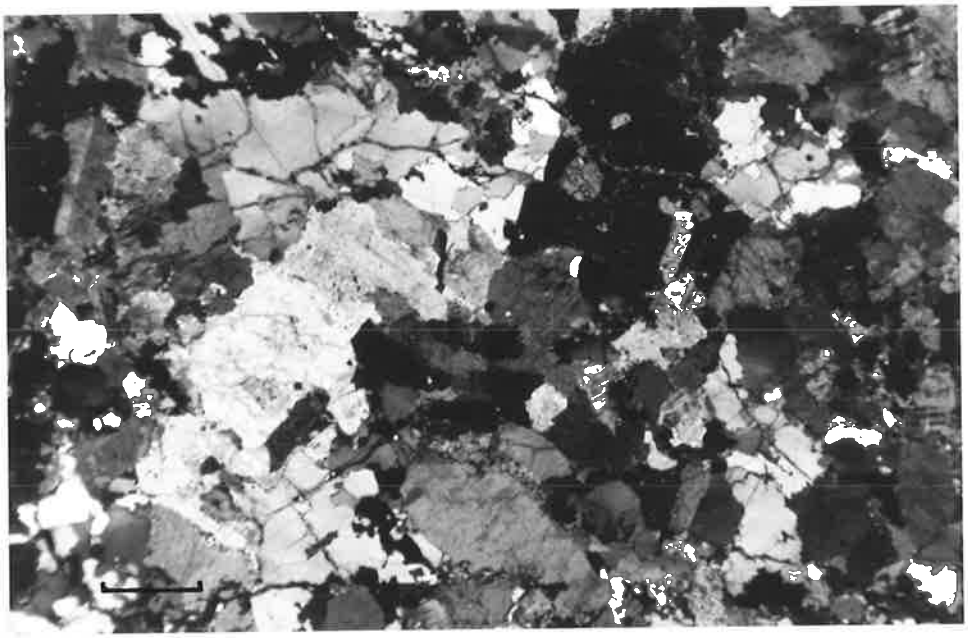
a. Type (i) aplite (335-15); crossed polars.
Length of bar 1.0mm.

b. Type (ii) aplite (335-400B); crossed polars.
Length of bar 1.0mm.

c. Type (iii) aplite (335-219); crossed polars.
Length of bar 1.0mm.



a



b

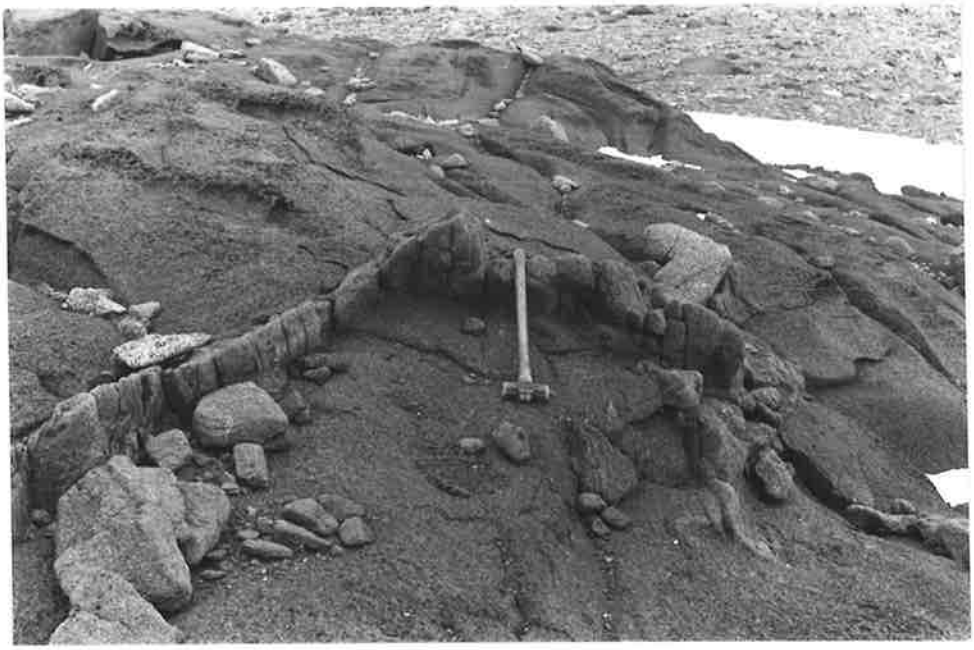
c

Figure 2.18

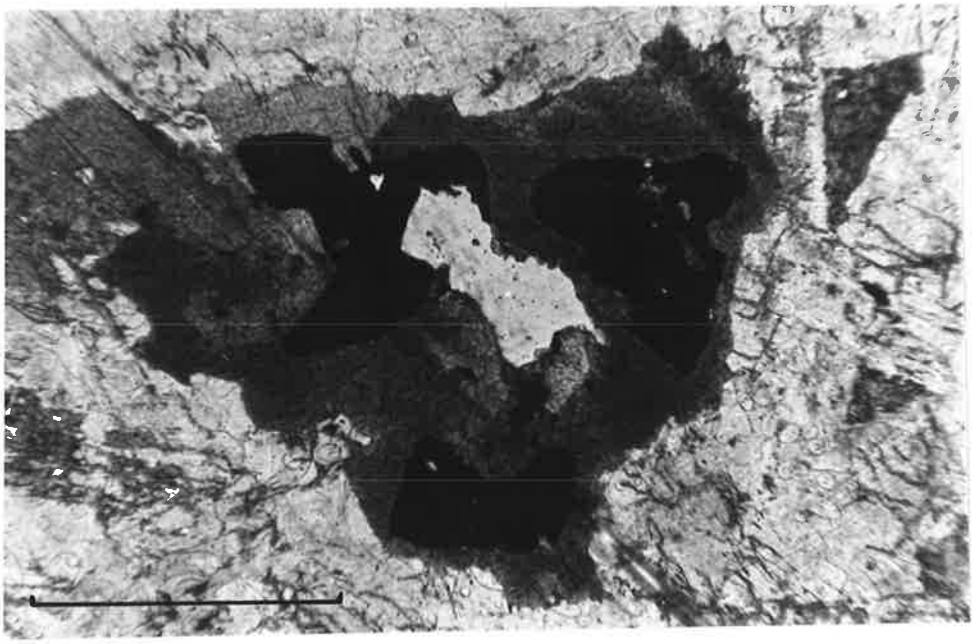
a. Folded aplite (335-219) in charnockite with axial plane parallel to schistosity of charnockite (parallel to hammer handle).

b. Biotite developing about opaques in olivine gabbro dyke; uncrossed polars. Length of bar 1.0mm.

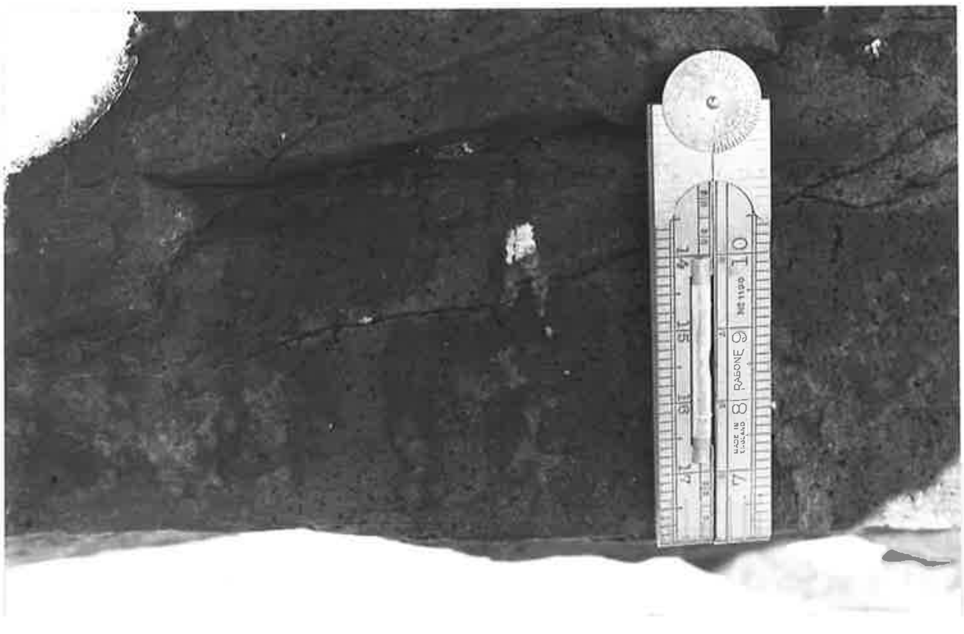
c. Flow structure, parallel to rule, in dolerite dyke, defined by weathered out feldspar pheocrysts.



a



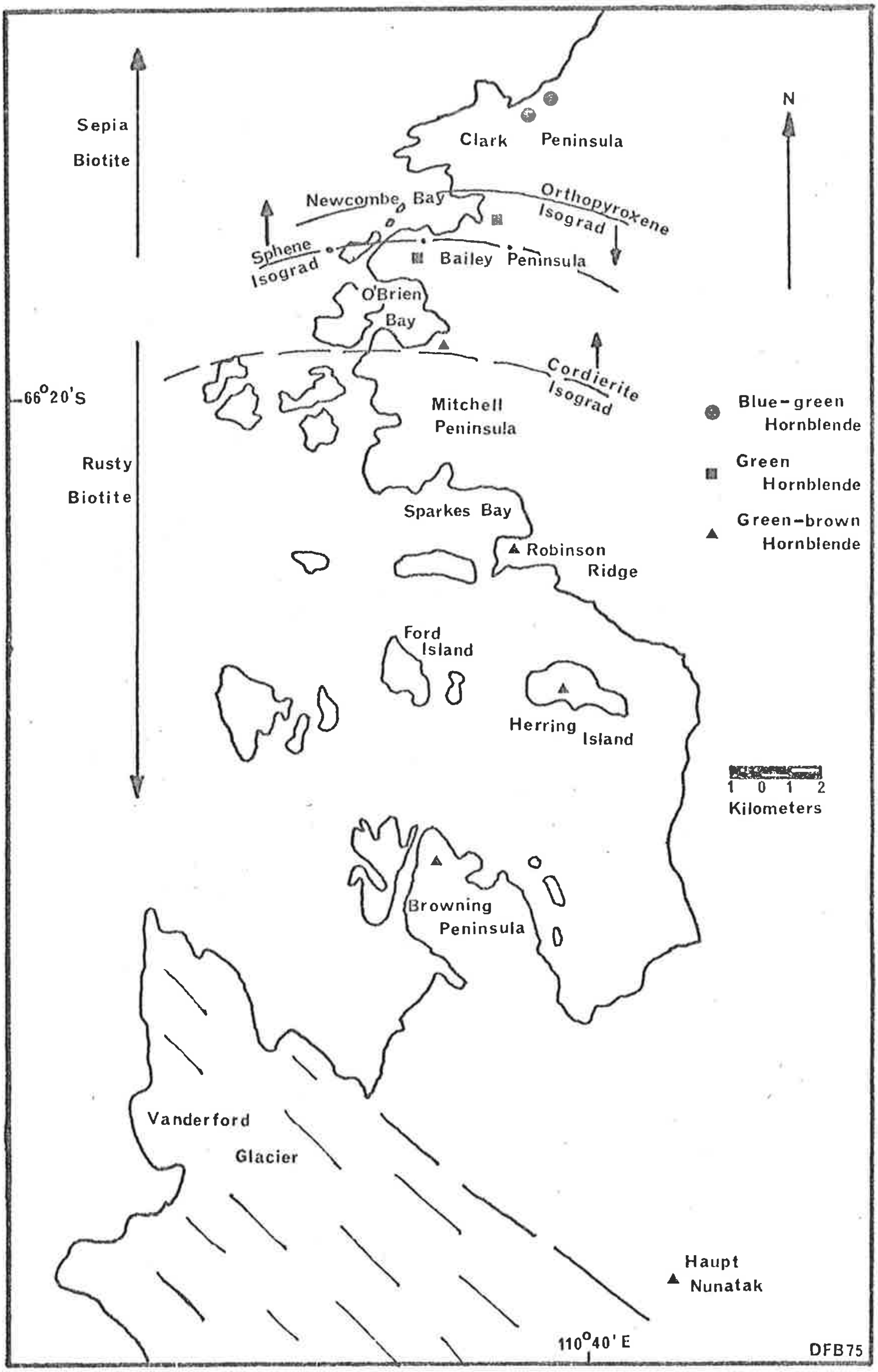
b



c

Figure 2.19

Isograd map of the Windmill Islands. Also shows the colour of biotites and hornblendes.



Sepia
Biotite
Clark Peninsula
N
Newcombe Bay
Orthopyroxene
Isograd
Sphene
Isograd
Bailey Peninsula
O'Brien
Bay
Cordierite
Isograd
66°20'S
Mitchell
Peninsula
Blue-green
Hornblende
Green
Hornblende
Green-brown
Hornblende
Rusty
Biotite
Sparkes Bay
Robinson
Ridge
Ford
Island
Herring
Island
1 0 1 2
Kilometers
Browning
Peninsula
Vanderford
Glacier
Haupt
Nunatak
110°40'E
DFB75

Figure 3.1

Interpretative structural map of the Windmill Islands, Antarctica. (Located in pocket in the back of Volume 2).

Figure 3.2

Sketches of mesoscopic folds

a,b & c. F_2 fold profiles.

d. F_2 fold overprinted by F_3 fold.

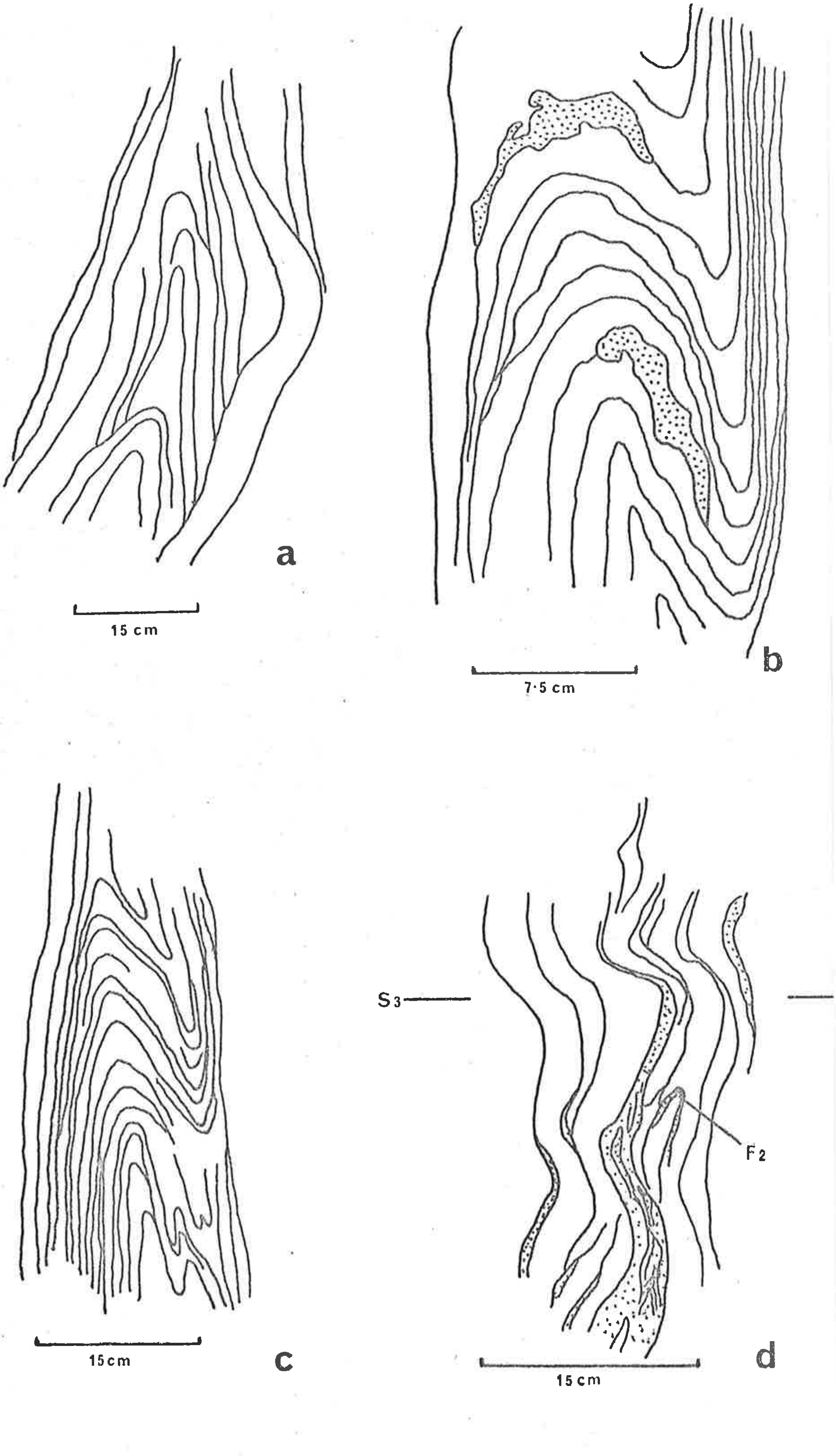

a
15 cm
b
7·5 cm
c
15cm
S_3
F_2
d
15 cm

Figure 3.3

Sketches of mesoscopic folds.

a. Pinch and swell features in layered granite gneiss developed by F_3 folds, (see also Fig. 3.5a).

b, c & d. F_3 fold profiles.

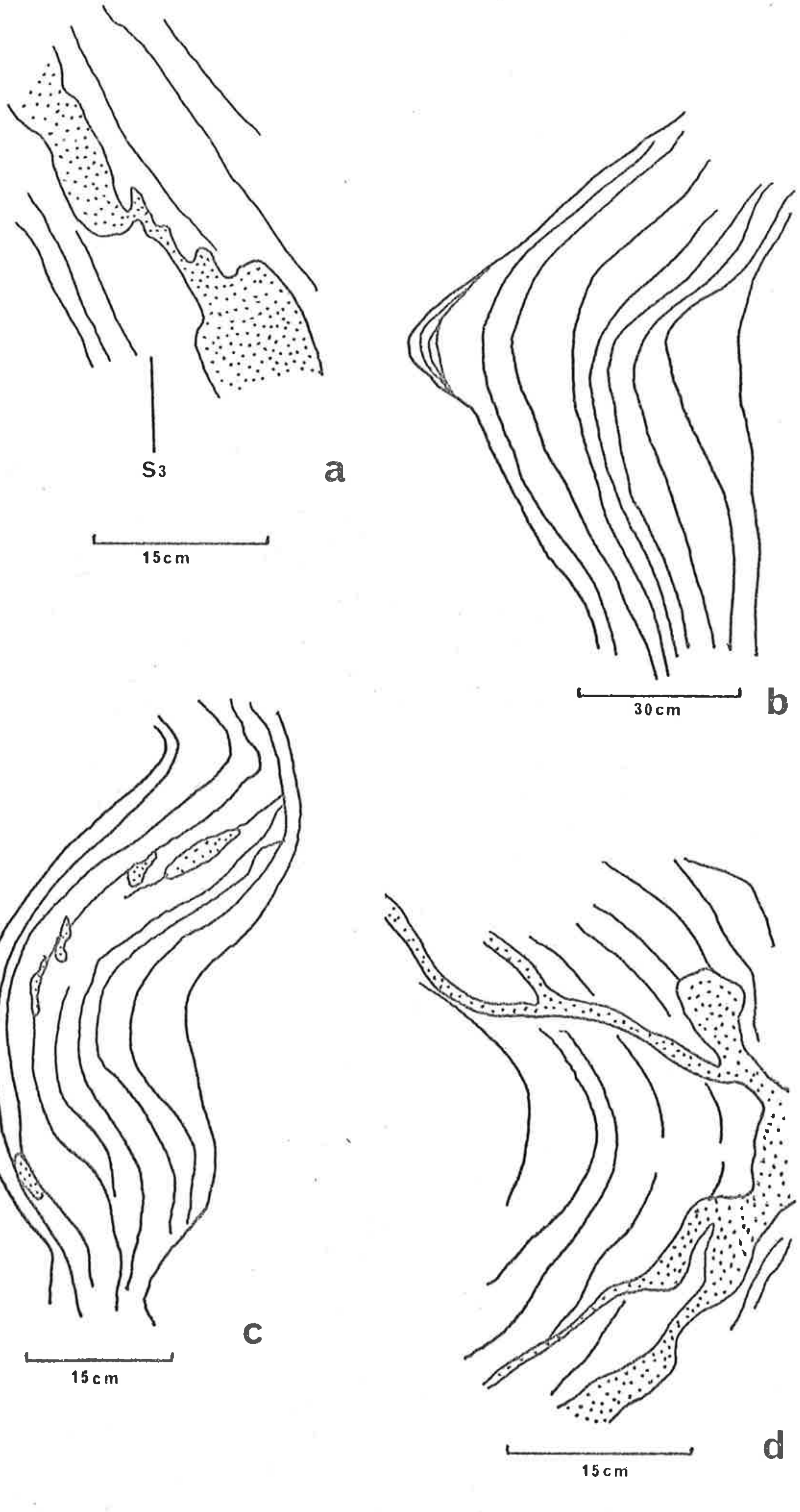
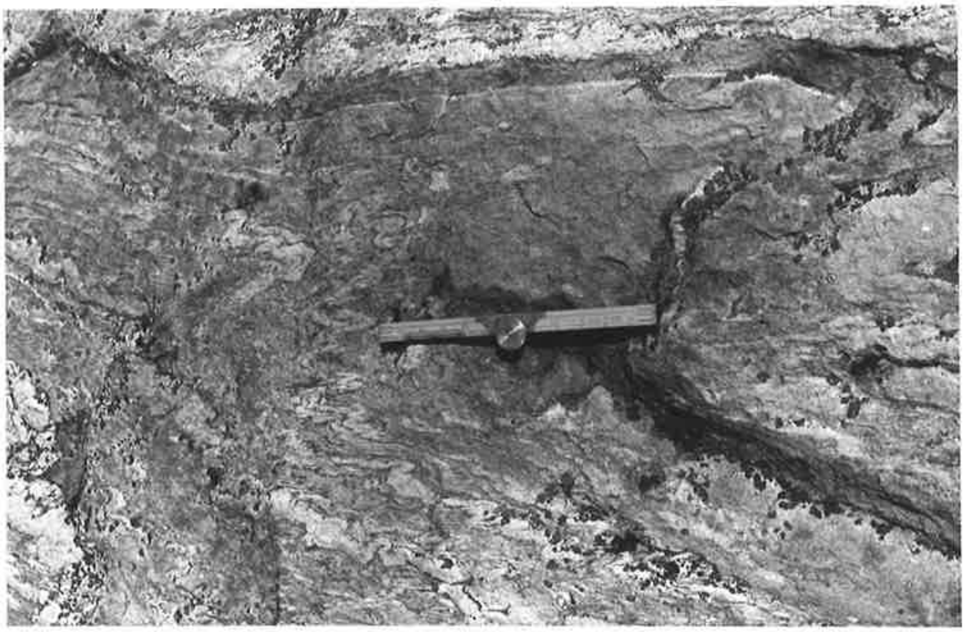

S3
a
15cm
b
30cm
c
15cm
d
15cm

Figure 3.4

a. F_2 fold (Bailey Peninsula)

b. F_3 folds in the core of the major F_3 antiform, northern Clark Peninsula.



a

b

Figure 3.5

a. "Pinch and swell" features developed in layered granite gneiss from F_3 folds. Rule parallel to axial plane schistosity (S_3).

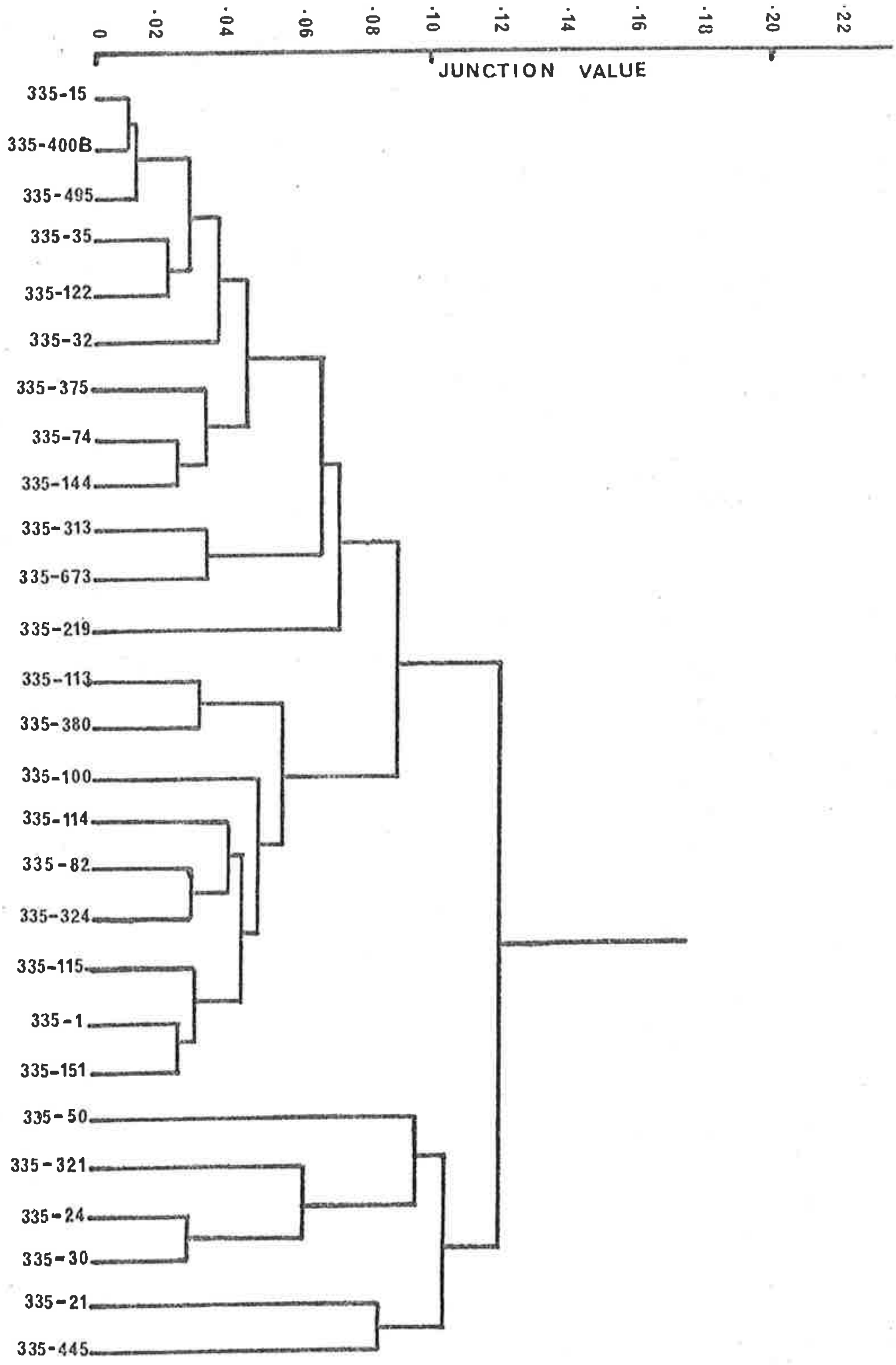
b. Mineral lineation developed in core of major F_3 antiform, northern Clark Peninsula.

a

b

Figure 4.1

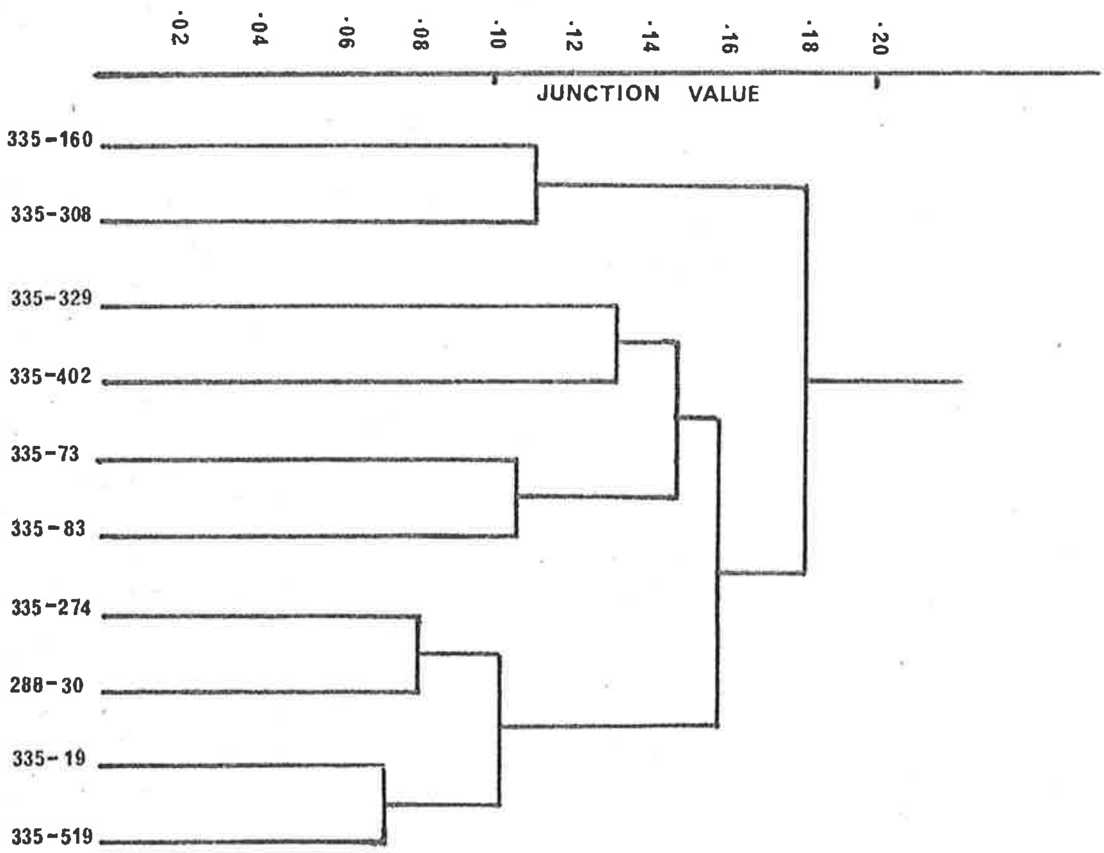
Dendogram (cluster analysis) compiled from analyses of acid rocks.


0
·02
·04
·06
·08
·10
·12
·14
·16
·18
·20
·22
JUNCTION VALUE
335-15
335-400B
335-495
335-35
335-122
335-32
335-375
335-74
335-144
335-313
335-673
335-219
335-113
335-380
335-100
335-114
335-82
335-324
335-115
335-1
335-151
335-50
335-321
335-24
335-30
335-21
335-445

ACID ROCKS

Figure 4.2

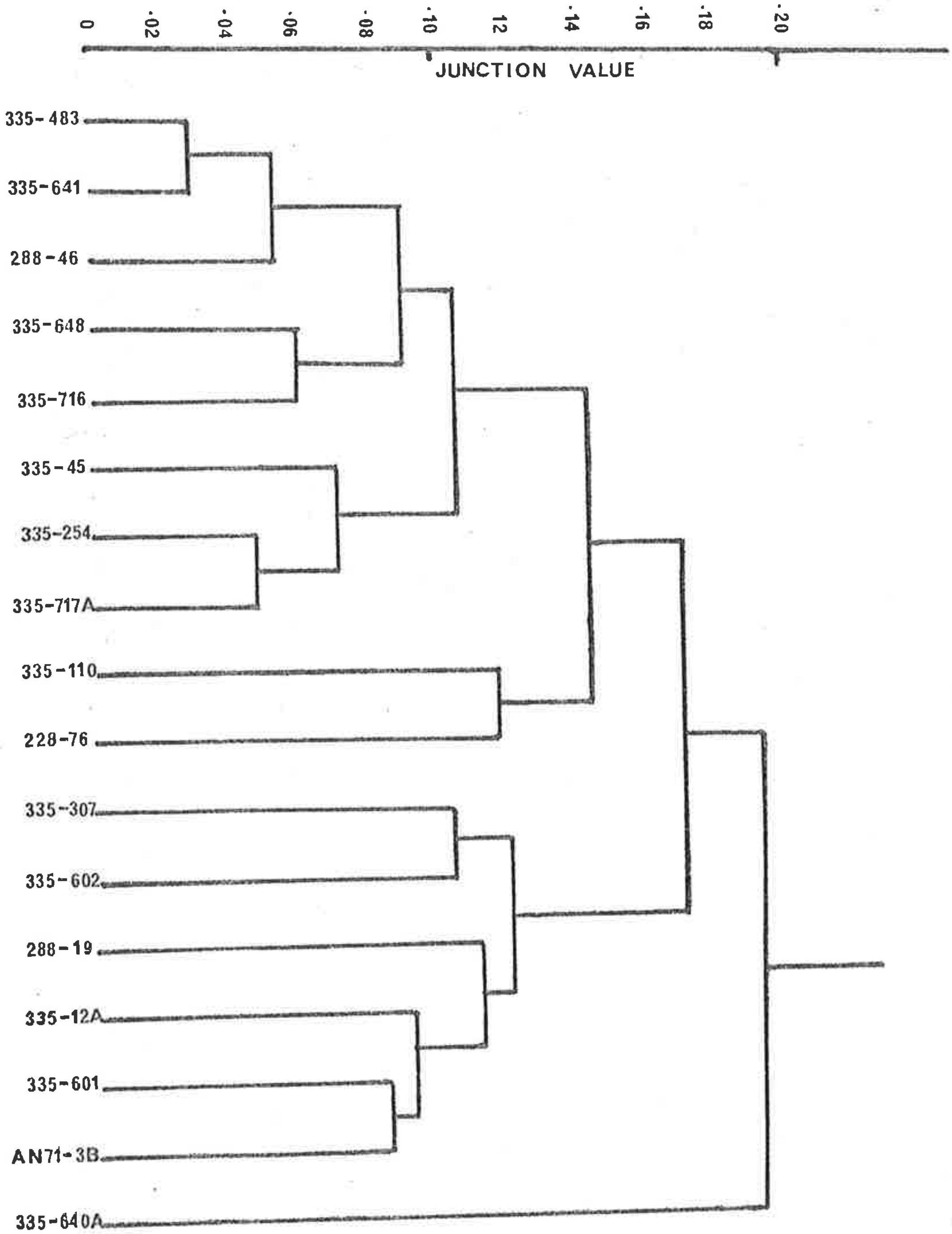
Dendogram (cluster analysis) compiled from analyses of pelitic and intermediate rocks.



PELITIC & INTERMEDIATE ROCKS

Figure 4.3

Dendogram (cluster analysis) compiled from analyses of basic rocks.


0
·02
·04
·06
·08
·10
12
·14
·16
·18
·20
JUNCTION VALUE
335-483
335-641
288-46
335-648
335-716
335-45
335-254
335-717A
335-110
228-76
335-307
335-602
288-19
335-12A
335-601
AN71-3B
335-640A

BASIC ROCKS

Figure 4.4

Comparison of Windmill Islands rocks with "average" rocks.

(For explanation of symbols see Table 4.8).

a. A.C.F. plot; acid rocks.

b. A.K.F. plot; acid rocks.

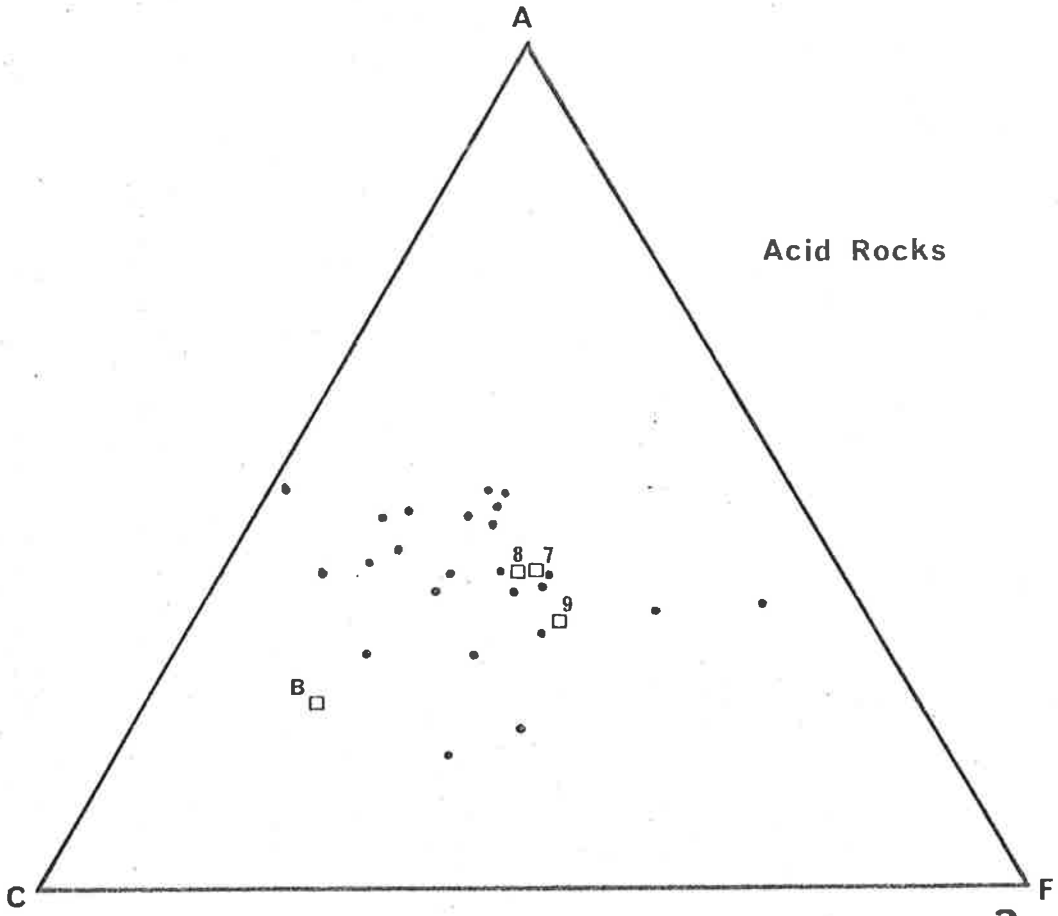
c. A.F.M. plot; acid rocks.

d. A.C.F. plot; basic rocks.

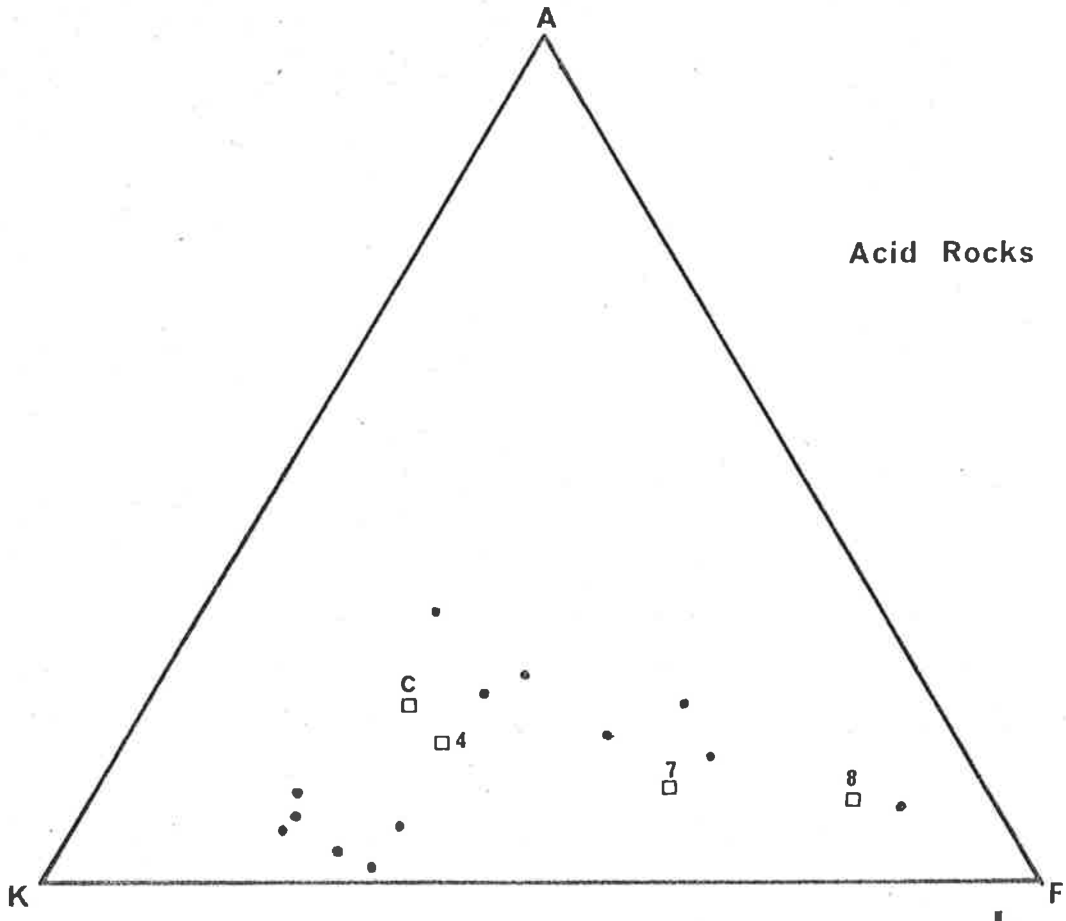
e. A.F.M. plot; pelitic and intermediate rocks.

f. A.K.F. plot; pelitic and intermediate rocks.

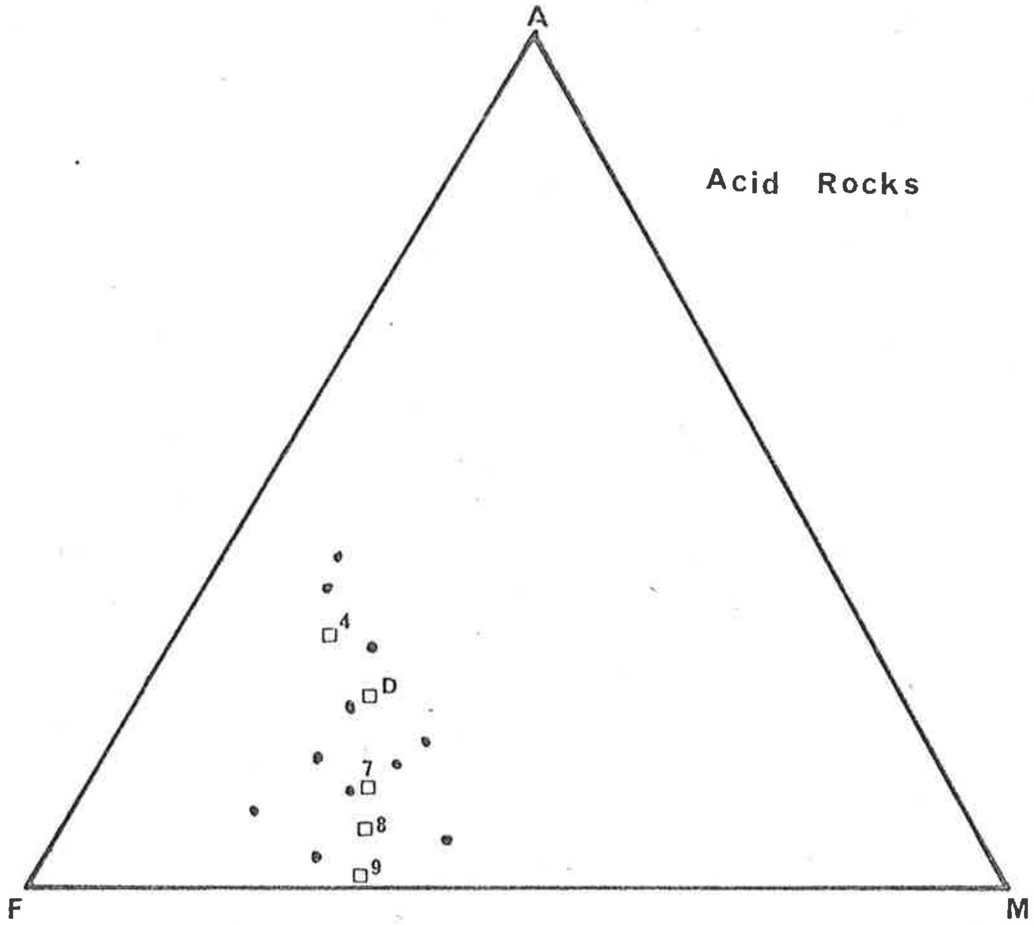
g. A.C.F. plot; pelitic and intermediate rocks.



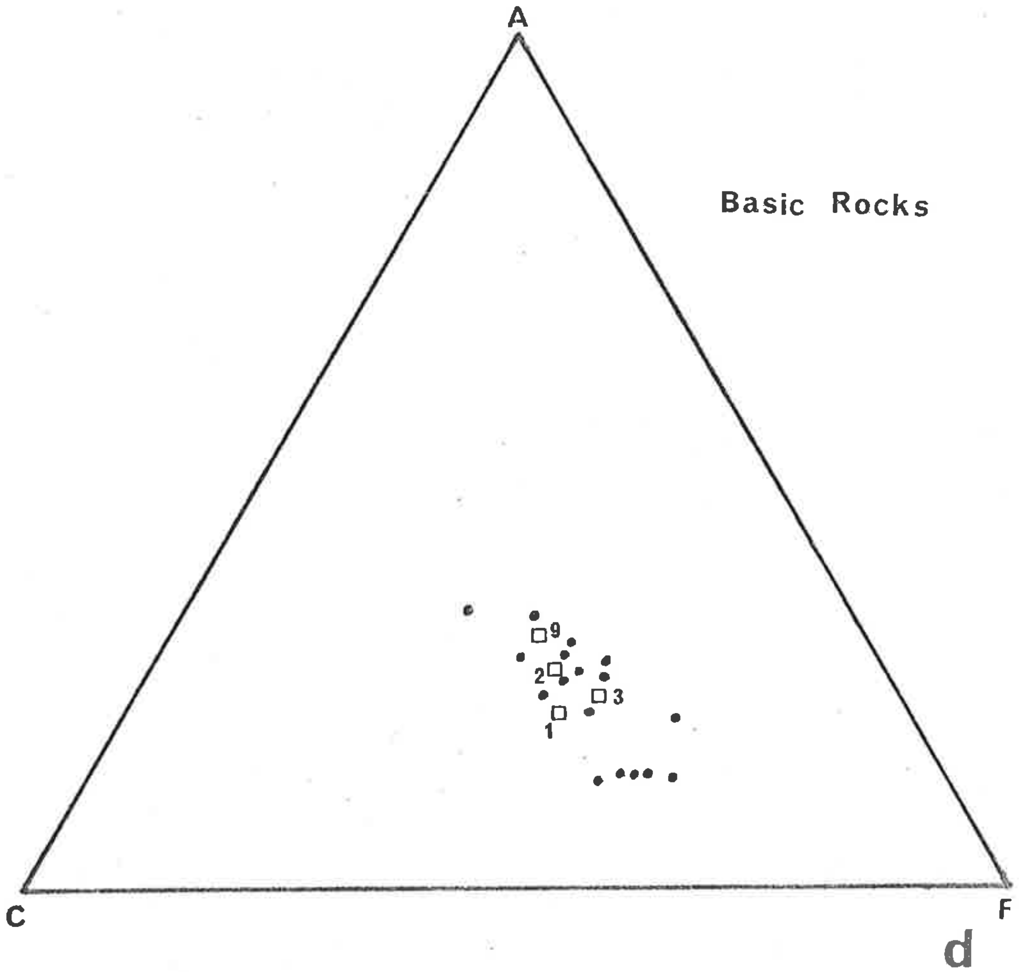
a



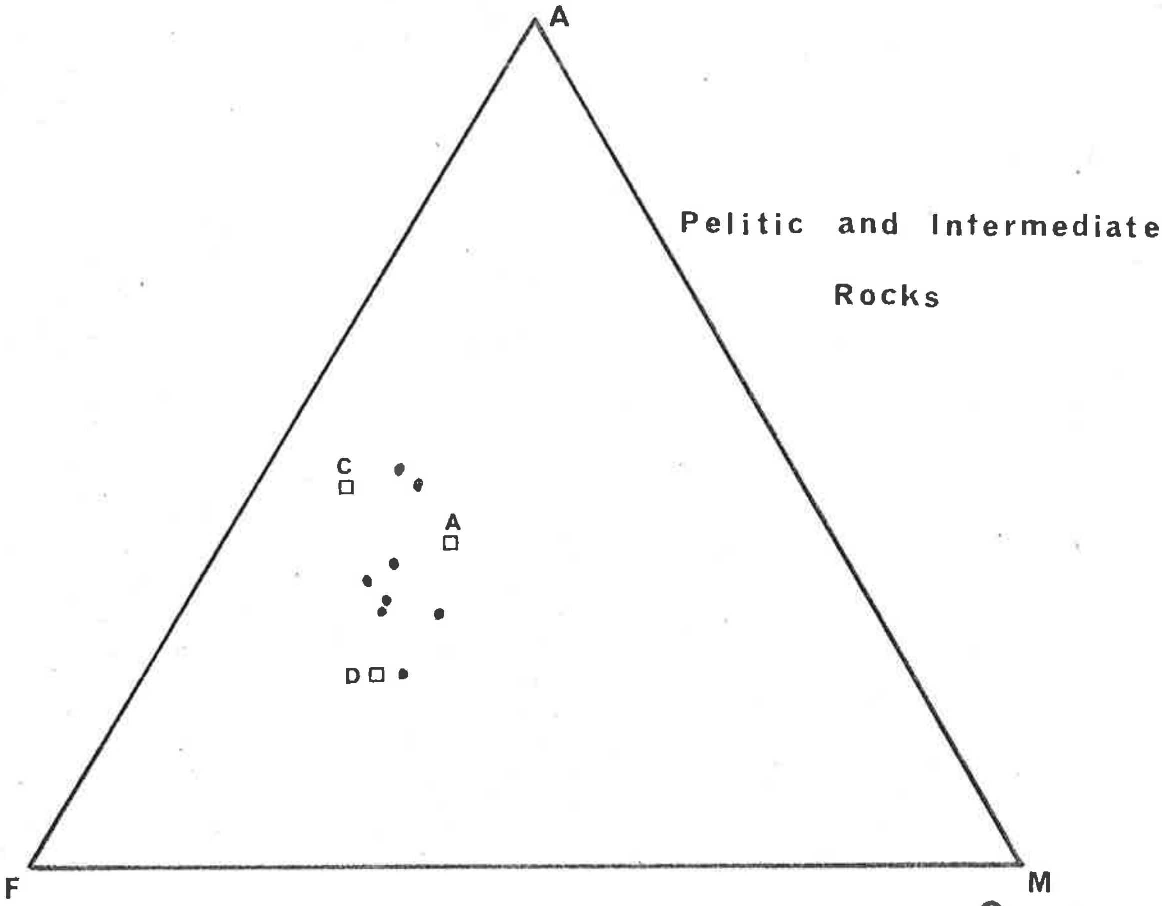
b



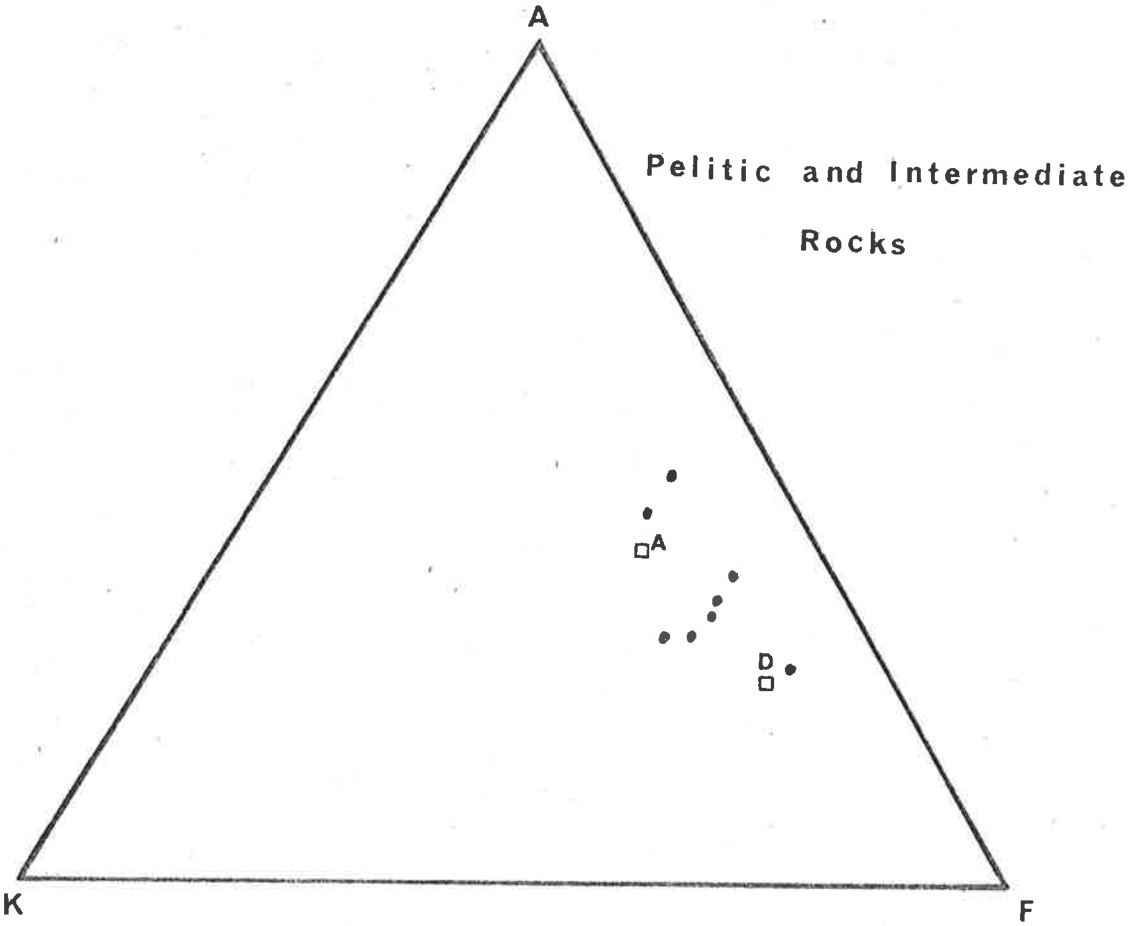
c



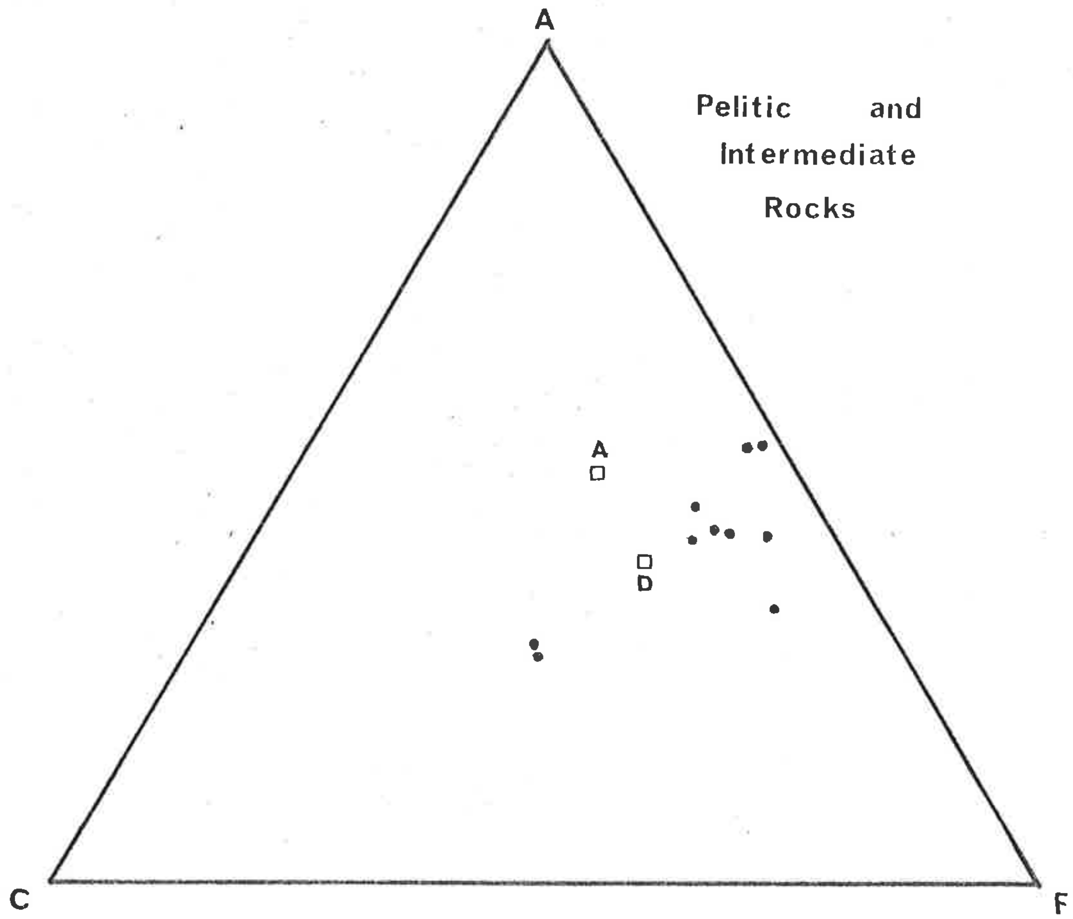
d


A
Pelitic and Intermediate
Rocks
C
A
D
F
M

e


A
Pelitic and Intermediate
Rocks
A
D
K
F

f



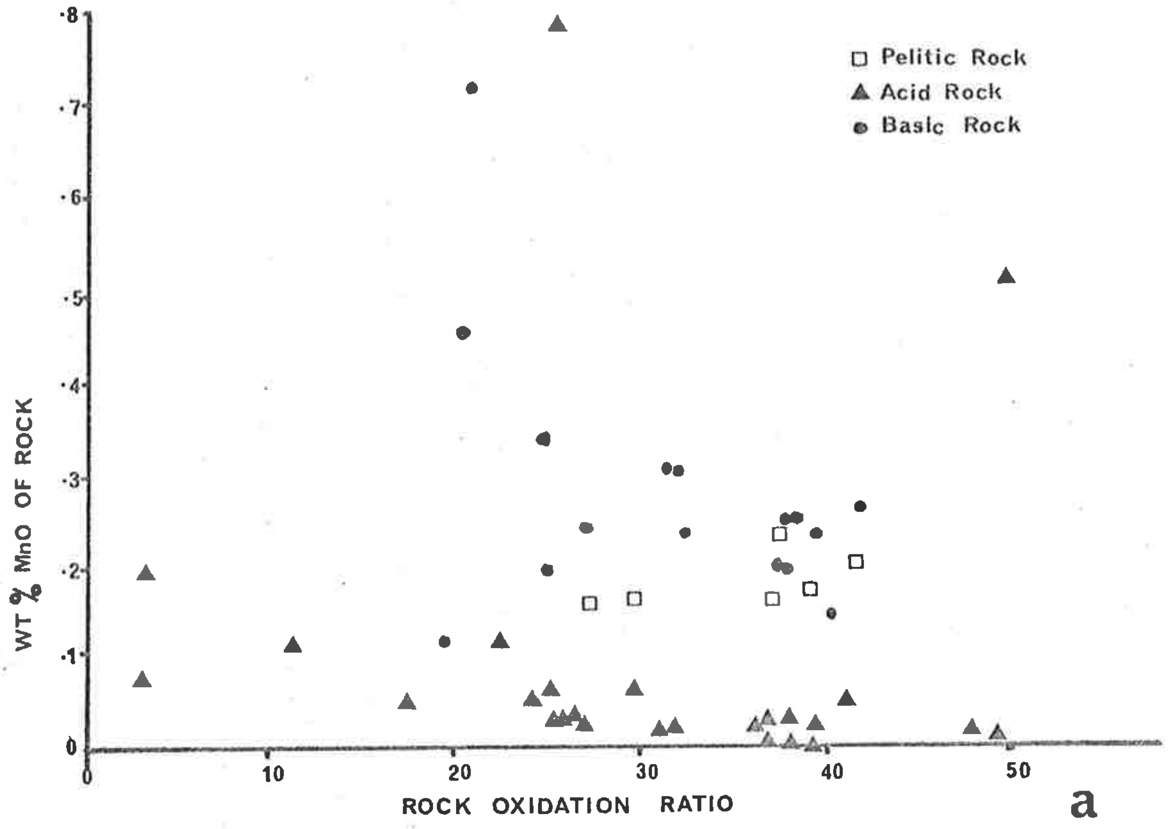
g

Figure 4.5

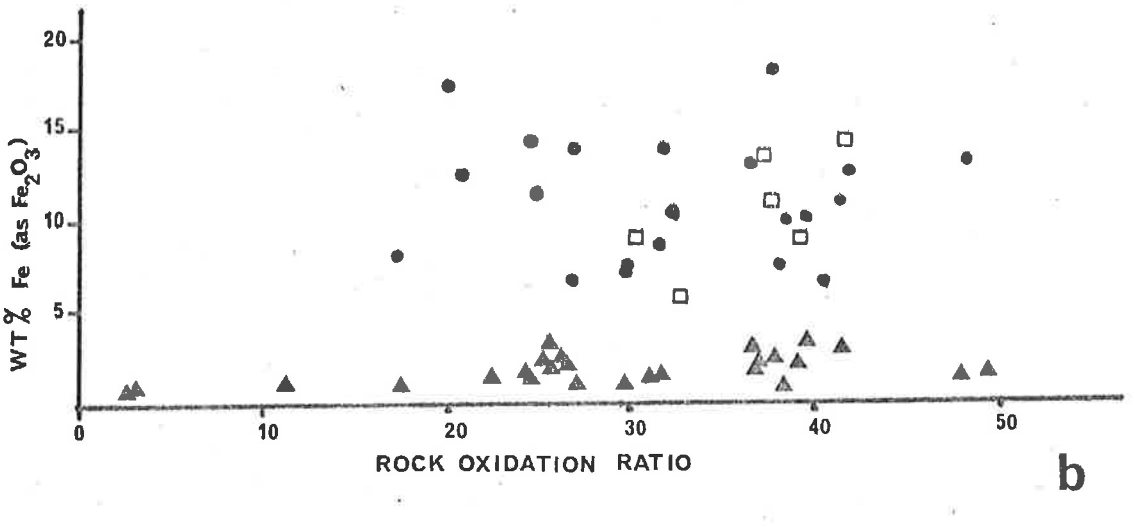
Influence of rock oxidation ratio on rock chemistry.

a. Wt.% MnO of rock against rock oxidation ratio.

b. Wt.% Fe (as Fe_2O_3) of rock against rock oxidation ratio (symbols as in 4.5a).



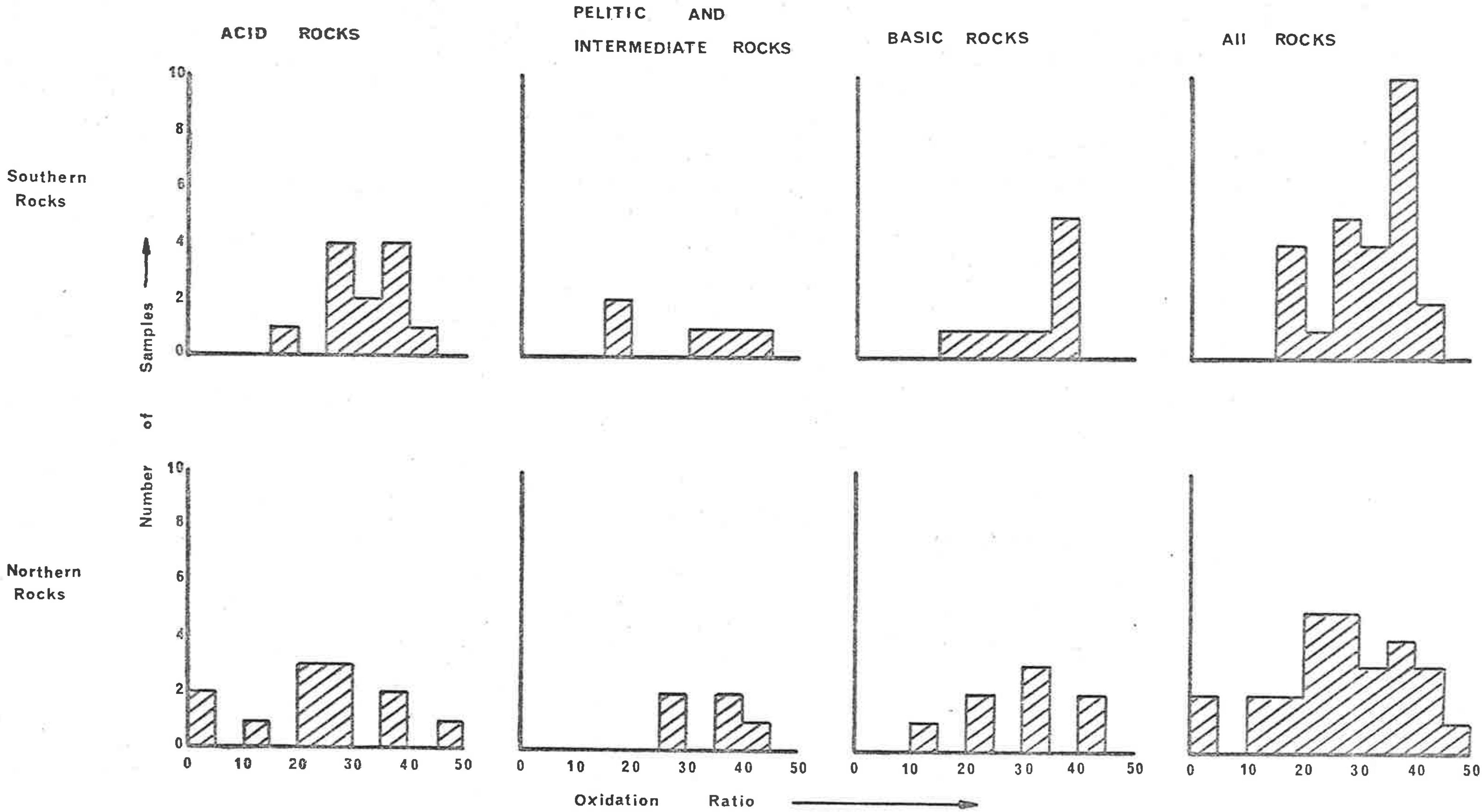
·8
·7
·6
·5
·4
·3
·2
·1
0
WT % MnO OF ROCK
Pelitic Rock
Acid Rock
Basic Rock
0
10
20
30
40
50
ROCK OXIDATION RATIO
a



20
15
10
5
WT % Fe (as Fe_2O_3)
0
10
20
30
40
50
ROCK OXIDATION RATIO
b

Figure 4.6

Dendograms comparing oxidation ratio of rocks from northern areas (north of O'Brien Bay) to that of rocks from the southern areas.

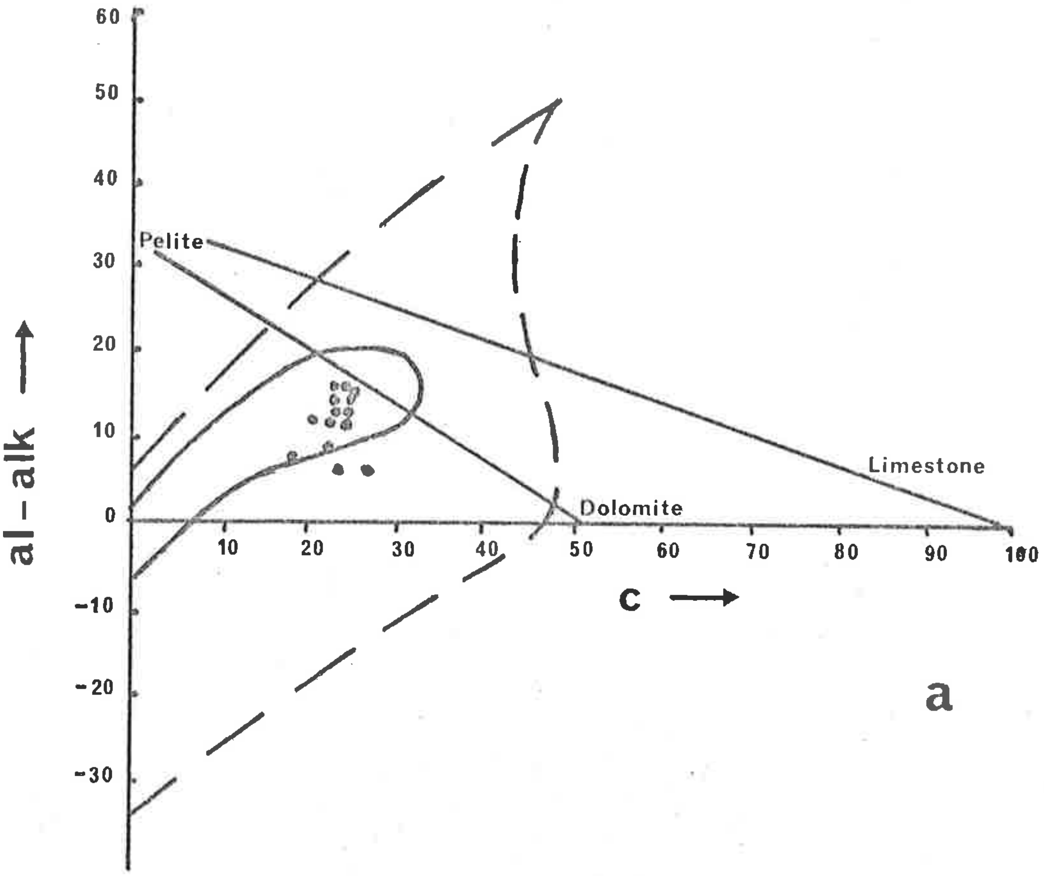


ACID ROCKS
PELITIC AND INTERMEDIATE ROCKS
BASIC ROCKS
All ROCKS
Southern Rocks
Northern Rocks
Number of Samples
0
2
4
6
8
10
0 10 20 30 40 50
Oxidation Ratio

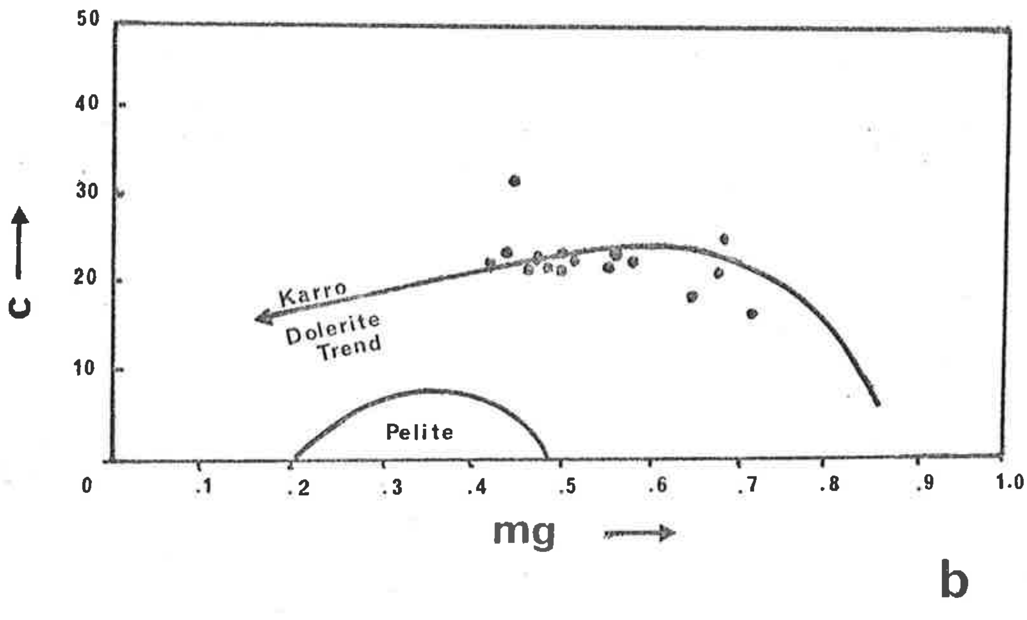
Figure 4.7

a. Plot of Niggli c against Niggli (al-alk) for the basic rocks of the Windmill Islands. Dashed curve contains field of all igneous basic rocks. Solid curve contains field of Karoo Dolerites (from Leake, 1964).

b. Plot of Niggli c against Niggli mg for the basic rocks of the Windmill Islands (from Leake, 1964).



al - alk
c
Pelite
Dolomite
Limestone
a



c
mg
Karro
Dolerite
Trend
Pelite
b

Figure 4.8

Niggli plot of 100mg against c against (al-alk) for the basic rock of the Windmill Islands (from Leake, 1964).

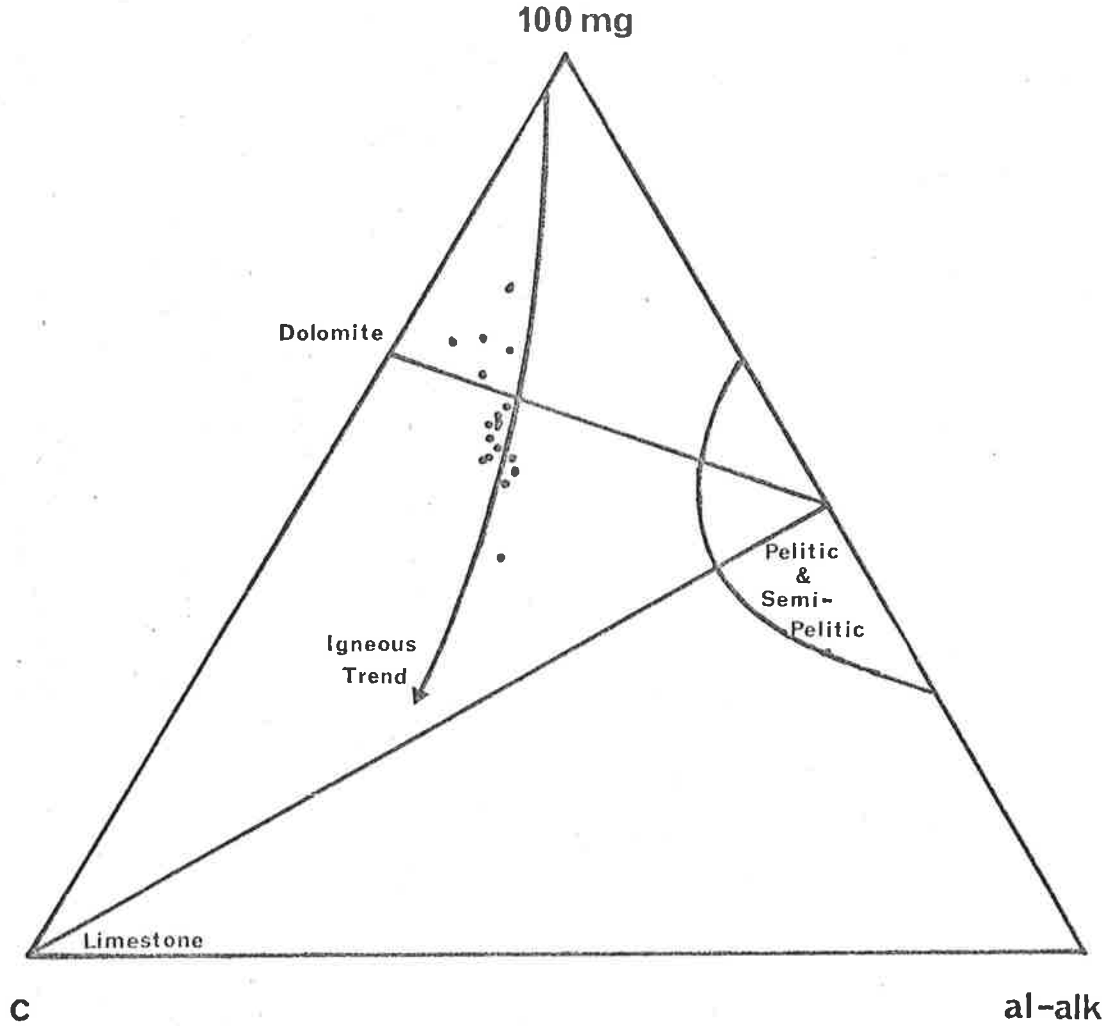

100 mg
Dolomite
Pelitic
&
Semi-
Pelitic
Igneous
Trend
Limestone
c
al-alk

Figure 4.9

a. Basic dyke(?) transgressive to country rock layering, north Robinson Ridge. Hammer parallel to country rock layering.

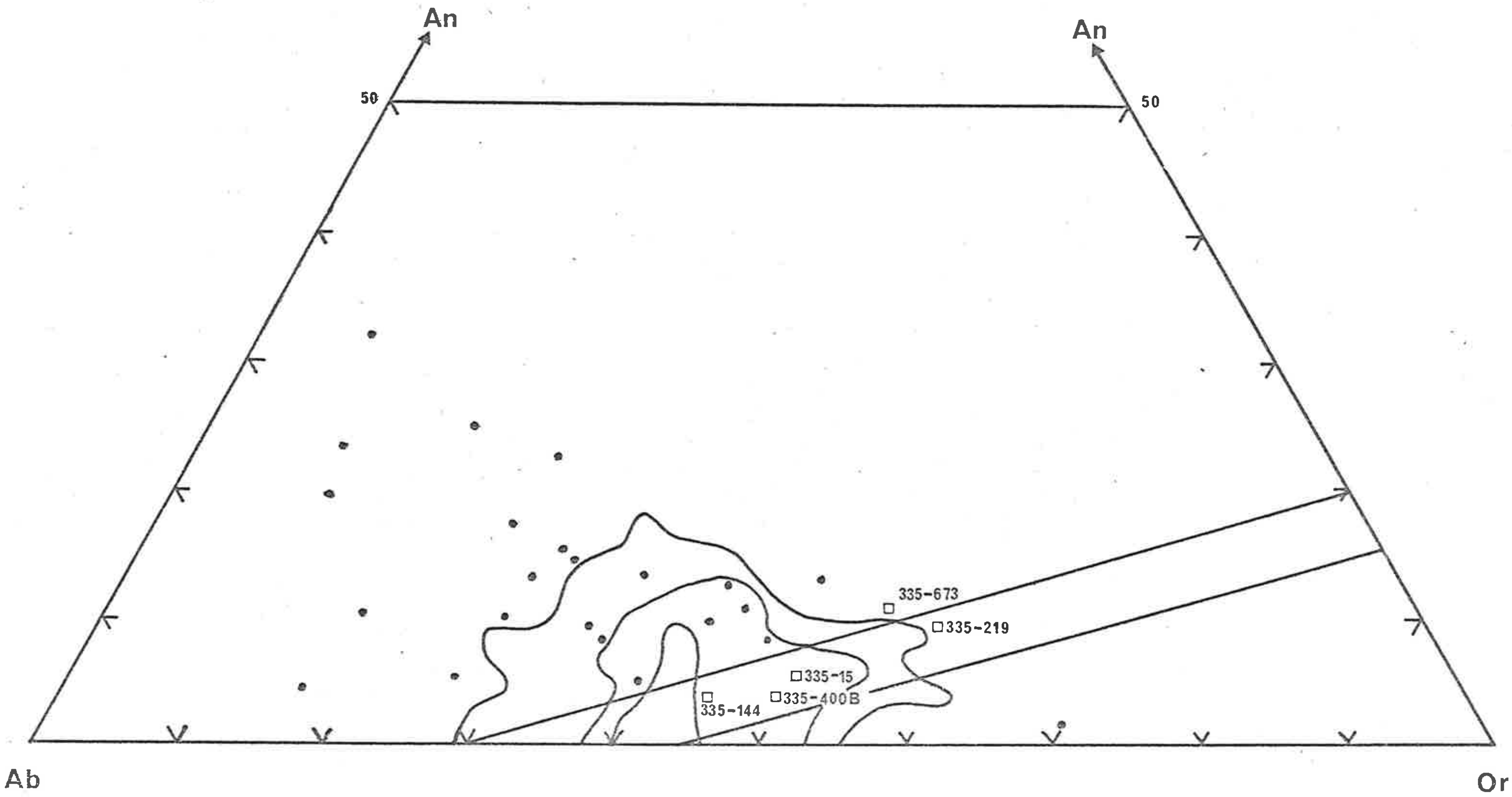
b. Skialith in Ribbon Gneiss. Note leucocratic reaction rim (especially near hammer handle).

a

b

Figure 4.10

Plot of Windmill Islands granitic rocks on normative $Or-Ab-An-SiO_2$ system. The contours represent the normative Or-Ab-An ratio in 1,269 rock which carry more than 80% Ab+Or+Q. The other straight lines represent the low temperature trough of the $Or-Ab-An-SiO_2$ system (after Kleeman, 1965).



An
An
50
50
335-673
335-219
335-15
335-144
335-400B
Ab
Or

Figure 4.11

Log log plot of potassium against rubidium for Windmill Islands rocks.

A. Main trend of Shaw (1968).

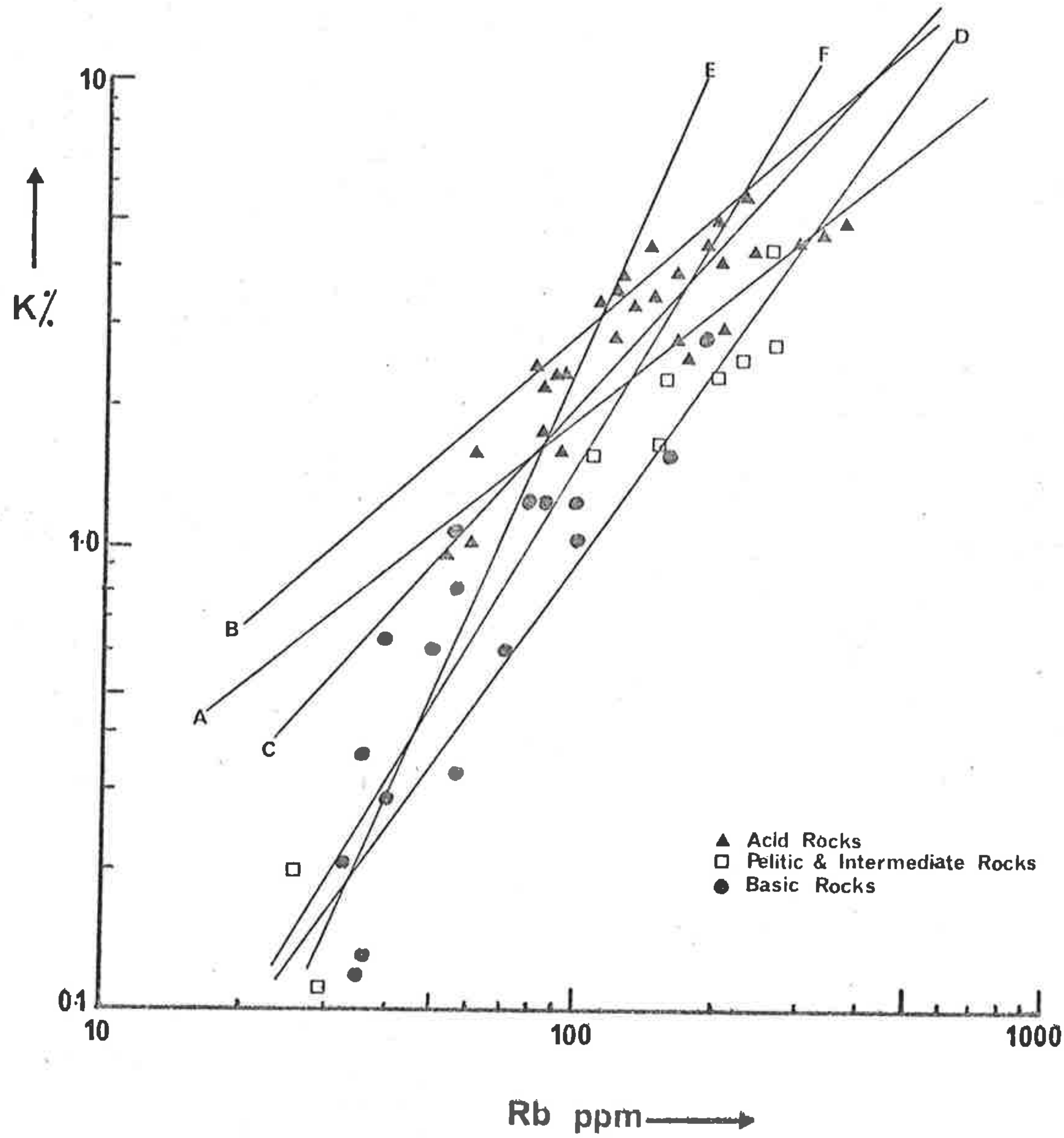
B. Metamorphic trend of Lewis & Spooner, (1973).

C. Linear regression of acid rocks.

D. Linear regression of pelitic and intermediate rocks.

E. Linear regression of basic rocks.

F. Linear regression of all Windmill Islands rocks.



10
1·0
0·1
K%
10
100
1000
Rb ppm
A
B
C
D
E
F
Acid Rocks
Pelitic & Intermediate Rocks
Basic Rocks

Figure 4.12

Log log plot of thorium against potassium for Windmill Islands rocks.

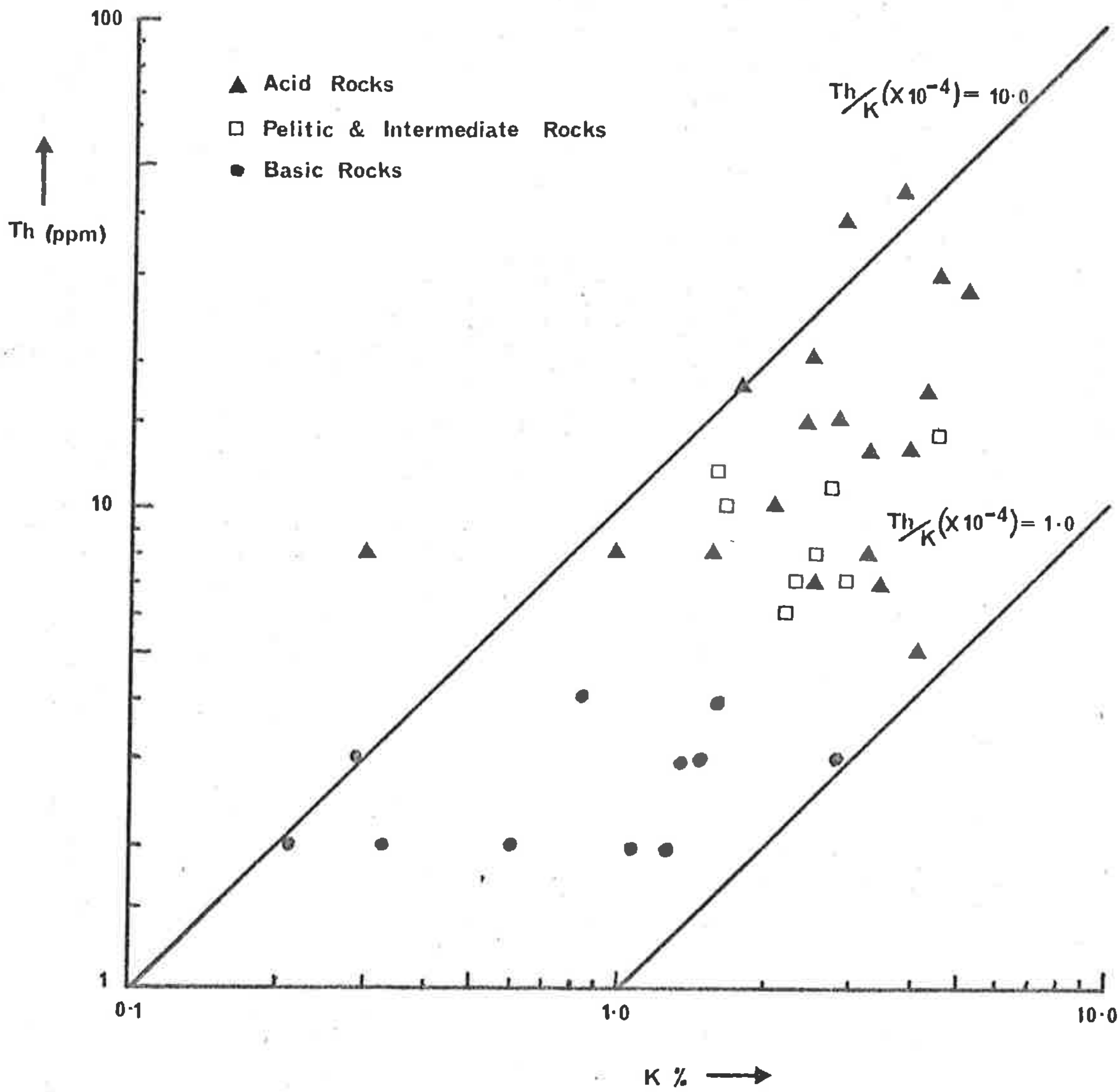
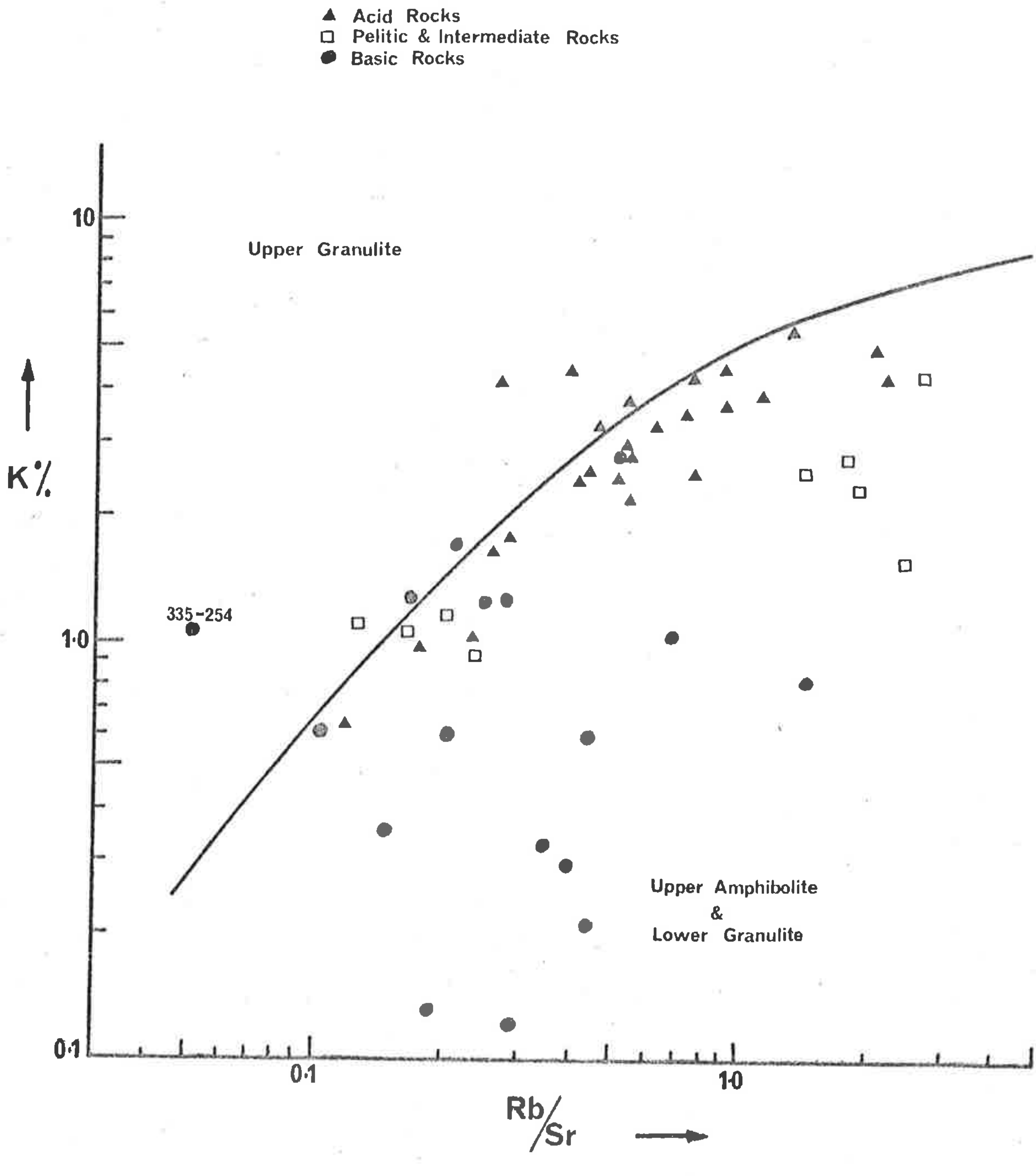

100
10
1
Th (ppm)
Acid Rocks
Pelitic & Intermediate Rocks
Basic Rocks
Th/K (X 10^-4) = 10·0
Th/K (X 10^-4) = 1·0
0·1
1·0
10·0
K %

Figure 4.13

Log log plot of potassium against Rb/Sr for Windmill Islands rocks. Curve dividing Upper Granulite field from Upper Amphibolite and Lower Granulite field from Sighinolfi (1971a).



Acid Rocks
Pelitic & Intermediate Rocks
Basic Rocks
10
1·0
0·1
K%
Upper Granulite
335-254
Upper Amphibolite
&
Lower Granulite
0·1
1·0
Rb/Sr

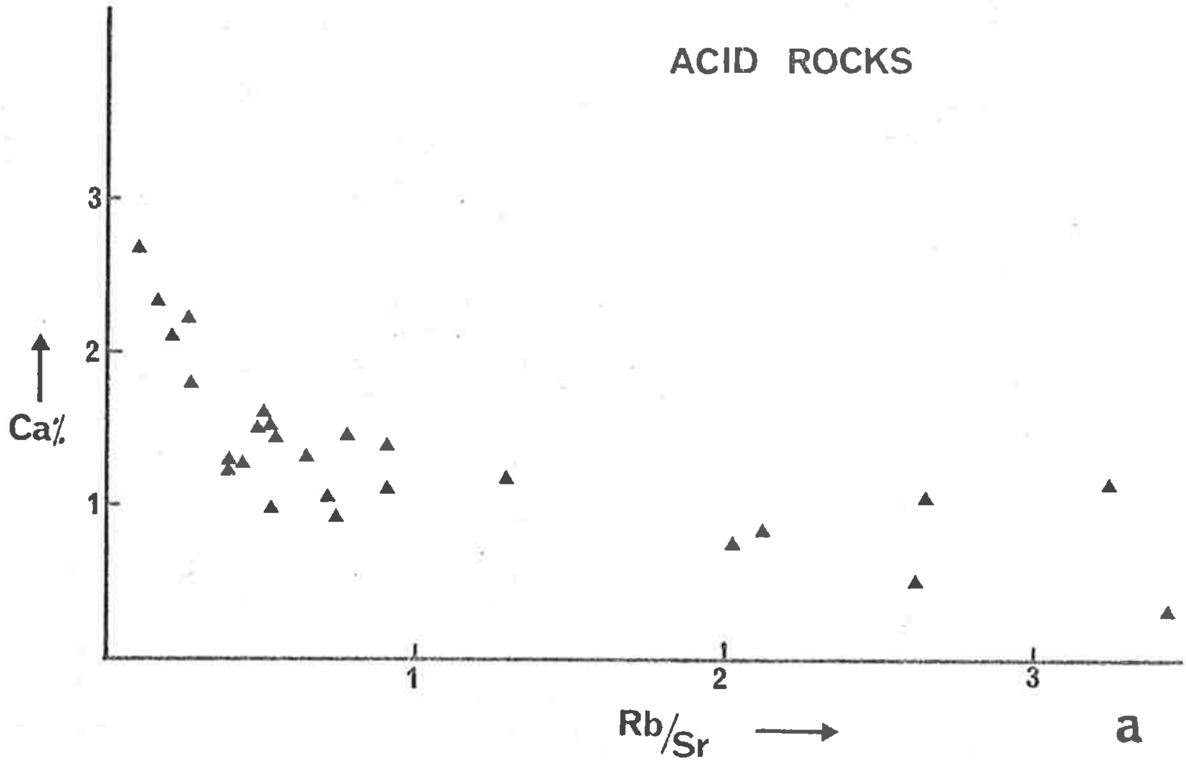
Figure 4.14

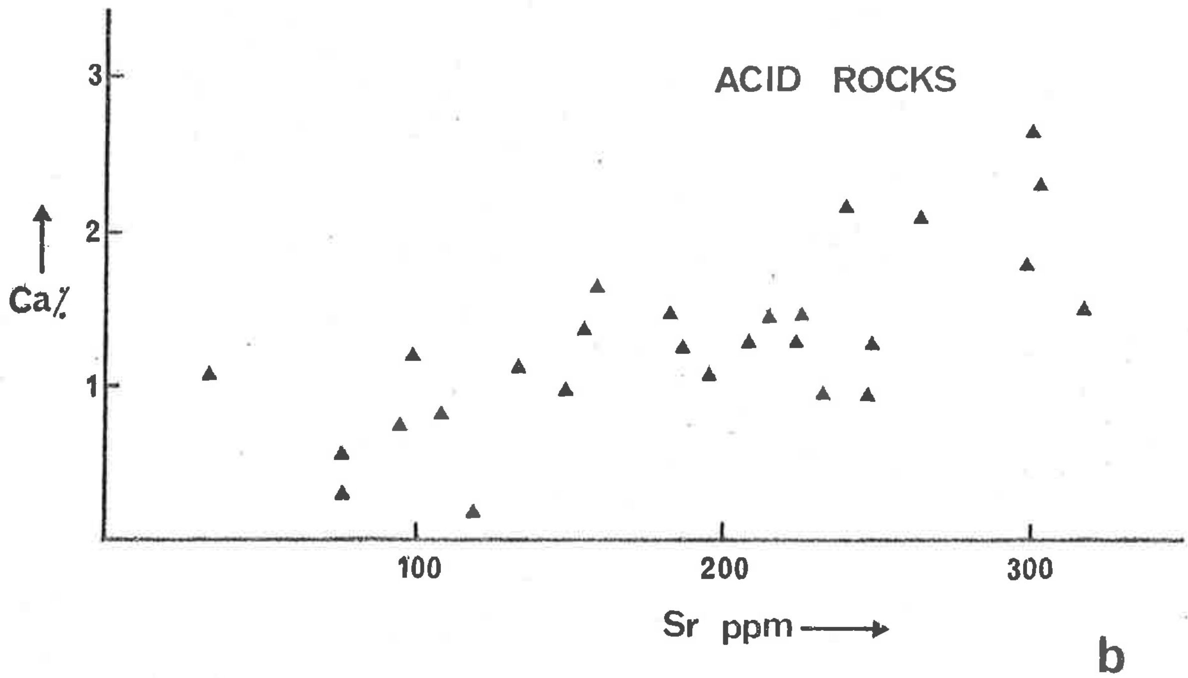
a. Calcium against Rb/Sr for Windmill Islands acid rocks.

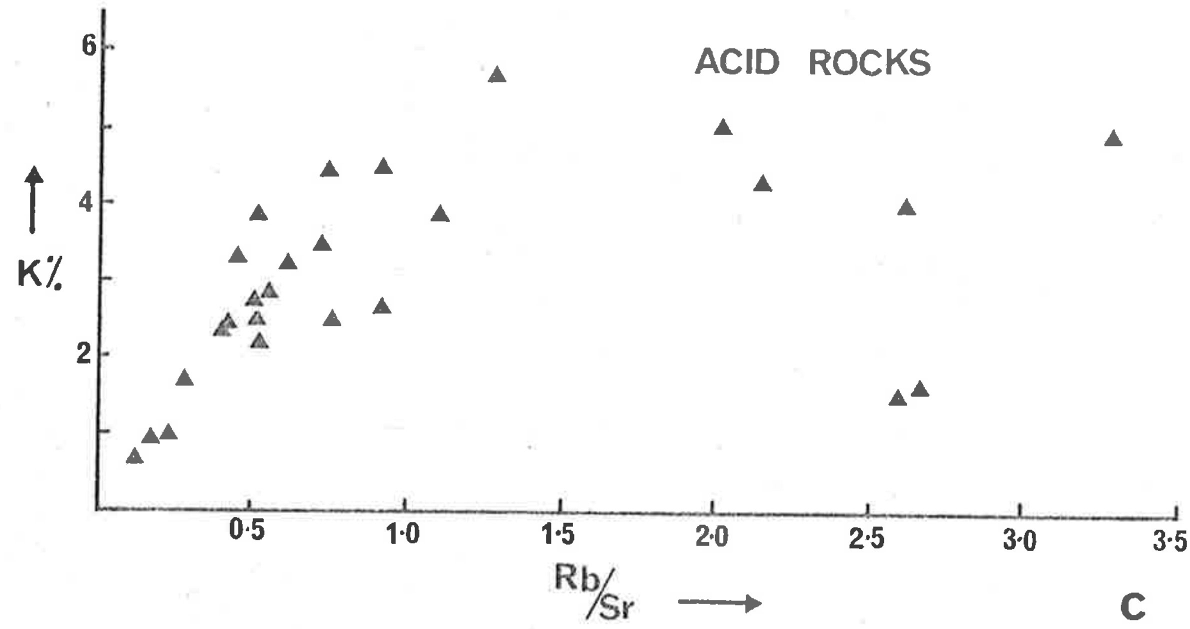
b. Calcium against Sr for Windmill Islands acid rocks.

c. Potassium against Rb/Sr for Windmill Islands acid rocks.

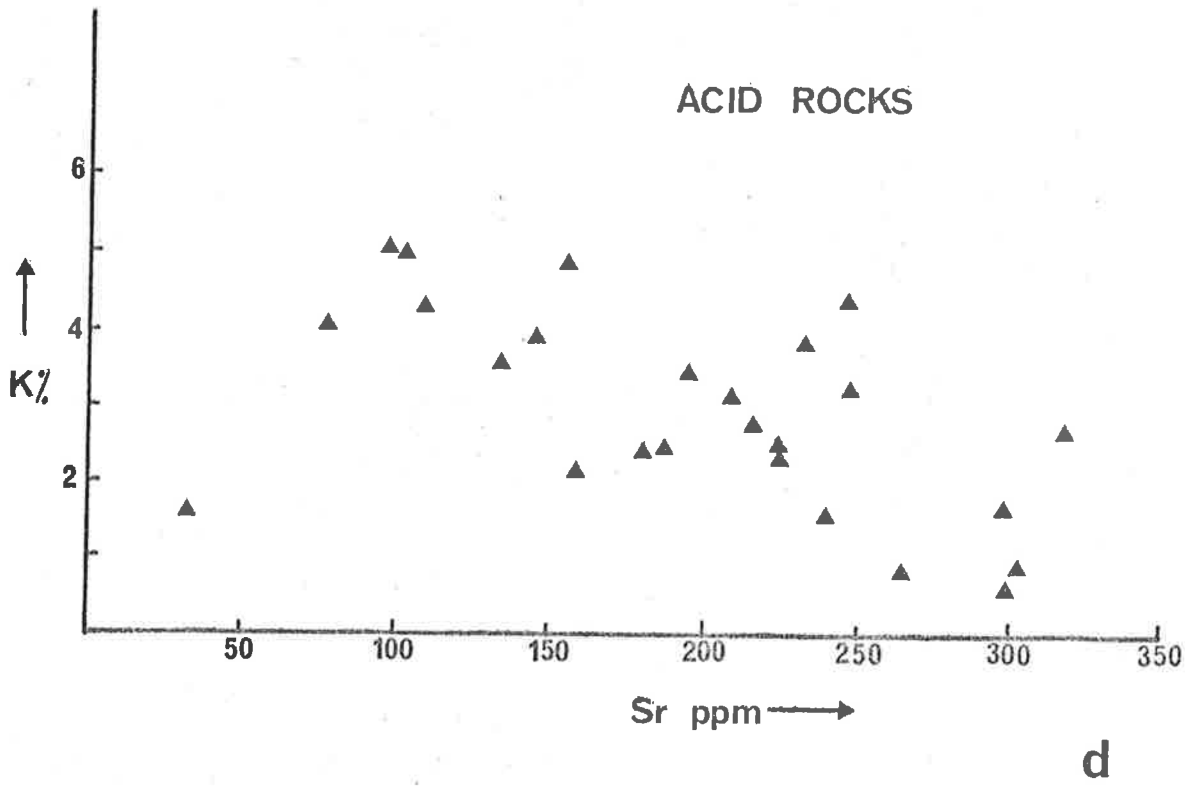
d. Potassium against Sr for Windmill Islands acid rocks.


ACID ROCKS
Ca%
3
2
1
1
2
3
Rb/Sr
a


ACID ROCKS
Ca%
3
2
1
100
200
300
Sr ppm
b



ACID ROCKS
K%
6
4
2
0·5
1·0
1·5
2·0
2·5
3·0
3·5
Rb/Sr
c



ACID ROCKS
K%
6
4
2
50
100
150
200
250
300
350
Sr ppm
d

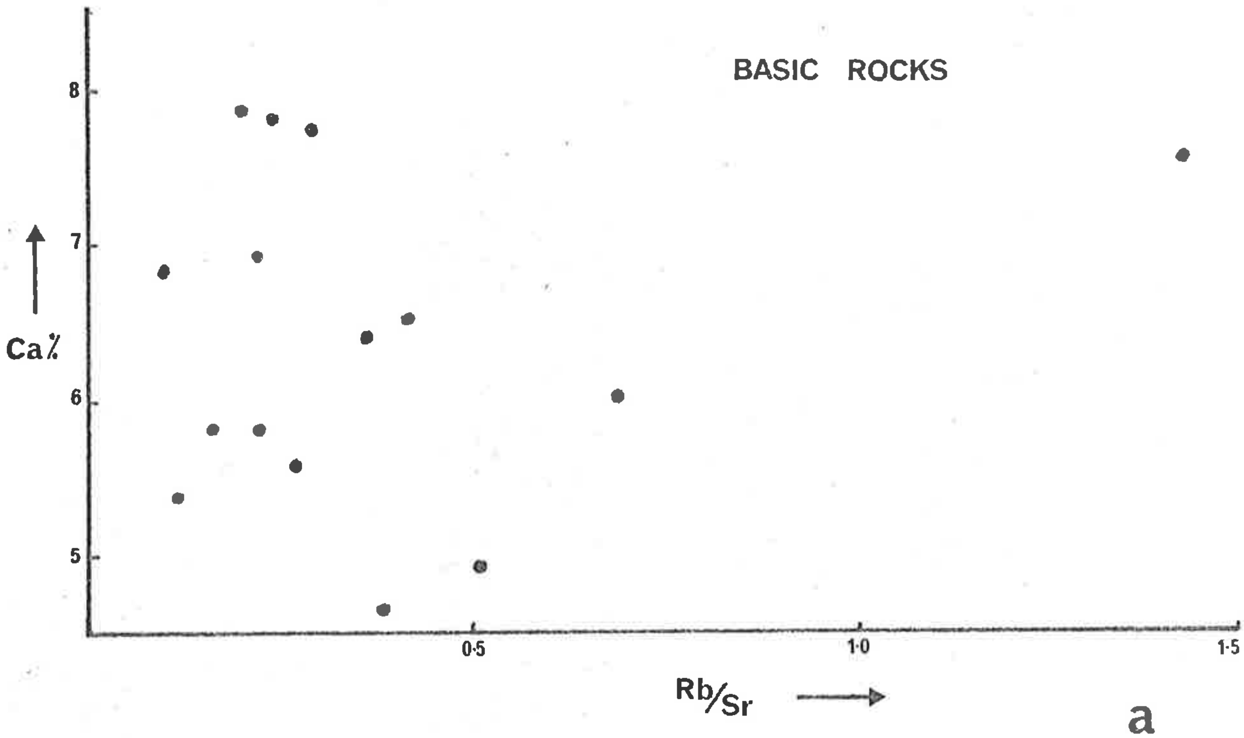
Figure 4.15

a. Calcium against Rb/Sr for Windmill Islands basic rocks.

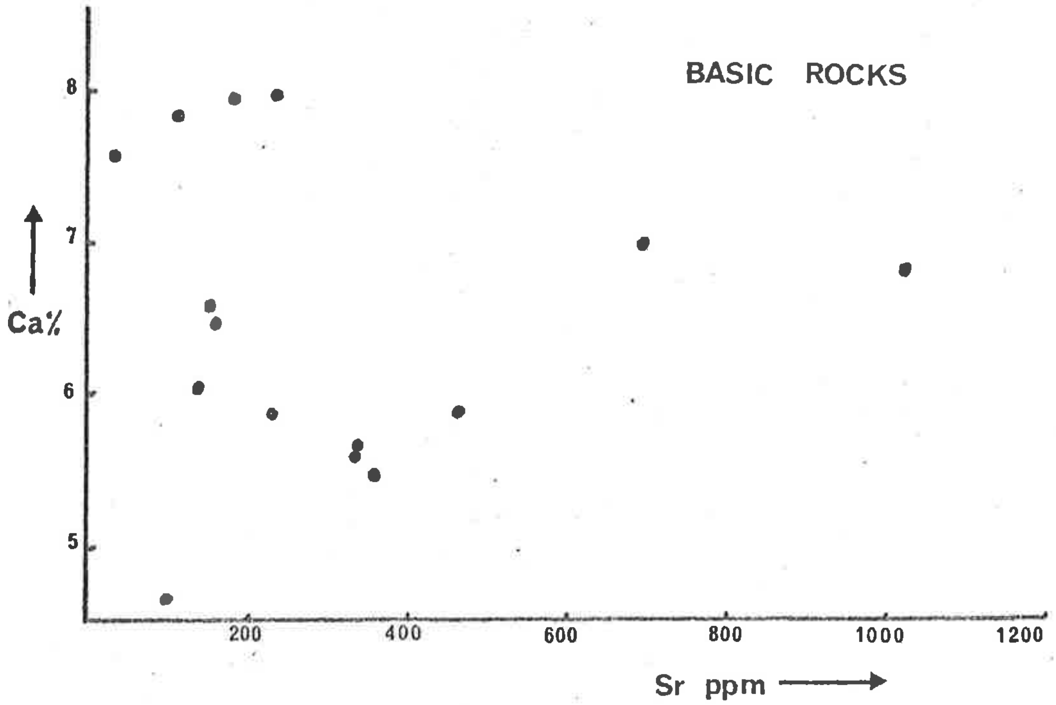
b. Calcium against Sr for Windmill Islands basic rocks.

c. Potassium against Rb/Sr for Windmill Islands basic rocks.

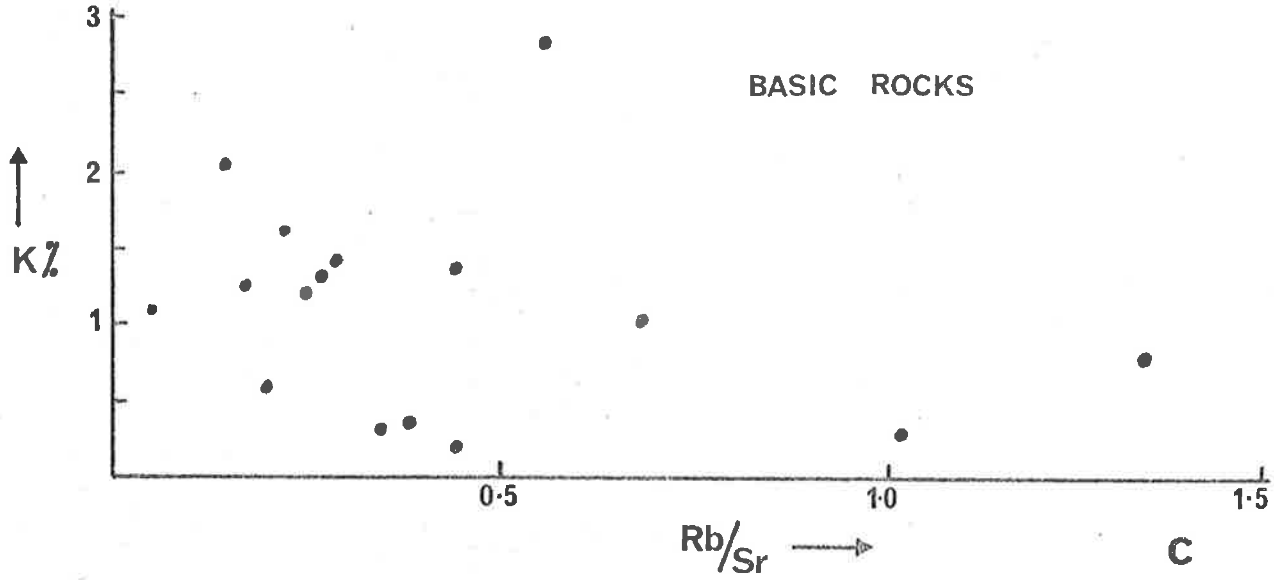
d. Potassium against Sr for Windmill Islands basic rocks.


BASIC ROCKS
8
7
6
5
Ca%
0·5
1·0
1·5
Rb/Sr

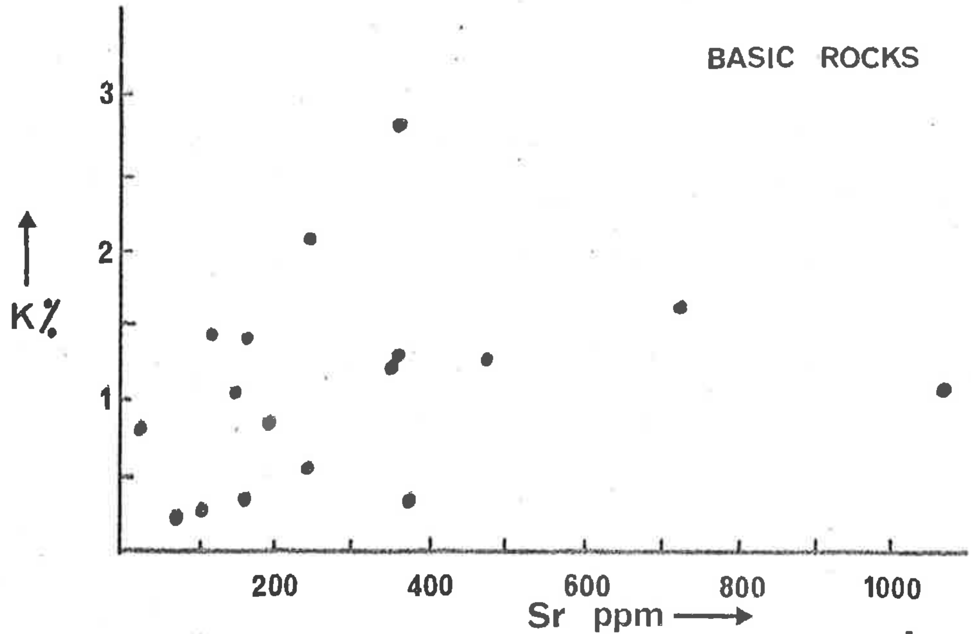
a


BASIC ROCKS
8
7
6
5
Ca%
200
400
600
800
1000
1200
Sr ppm

b


BASIC ROCKS
K%
3
2
1
0·5
1·0
1·5
Rb/Sr

C


BASIC ROCKS
K%
3
2
1
200
400
600
800
1000
Sr ppm

d

Figure 5.1

$(\frac{Mg}{Mg+Fe+Mn})$ mineral against $(\frac{Mg}{Mg+Fe+Mn})$ host rock for Windmill Islands rocks

a. Clinopyroxene

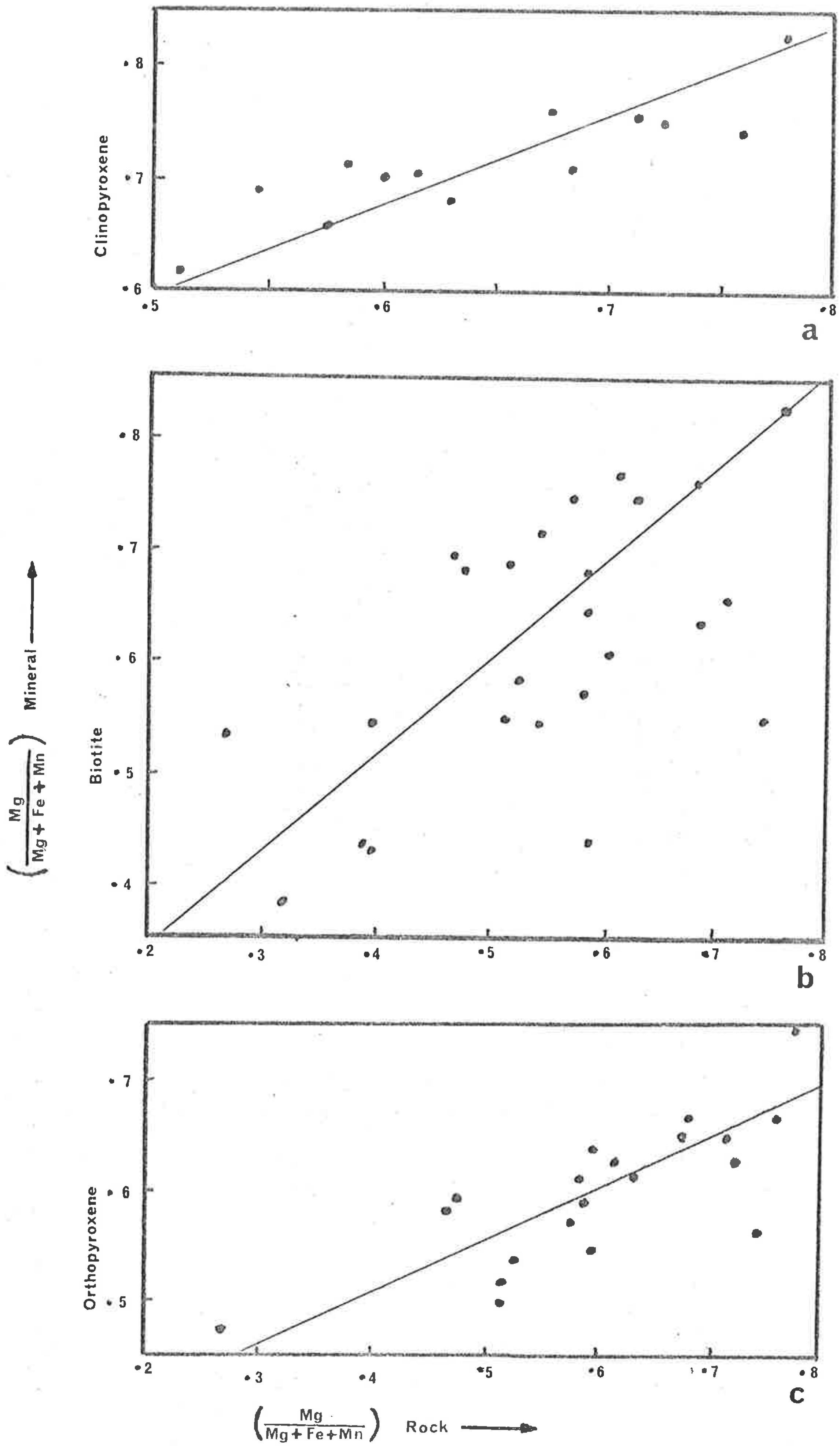
b. Biotite

c. Orthopyroxene

d. Cordierite

e. Garnet

f. Hornblende



Clinopyroxene
.8
.7
.6
.5
.6
.7
.8
a
Biotite
.8
.7
.6
.5
.4
.2
.3
.4
.5
.6
.7
.8
b
Orthopyroxene
.7
.6
.5
.2
.3
.4
.5
.6
.7
.8
c
(Mg / Mg + Fe + Mn) Mineral
(Mg / Mg+Fe+Mn) Rock

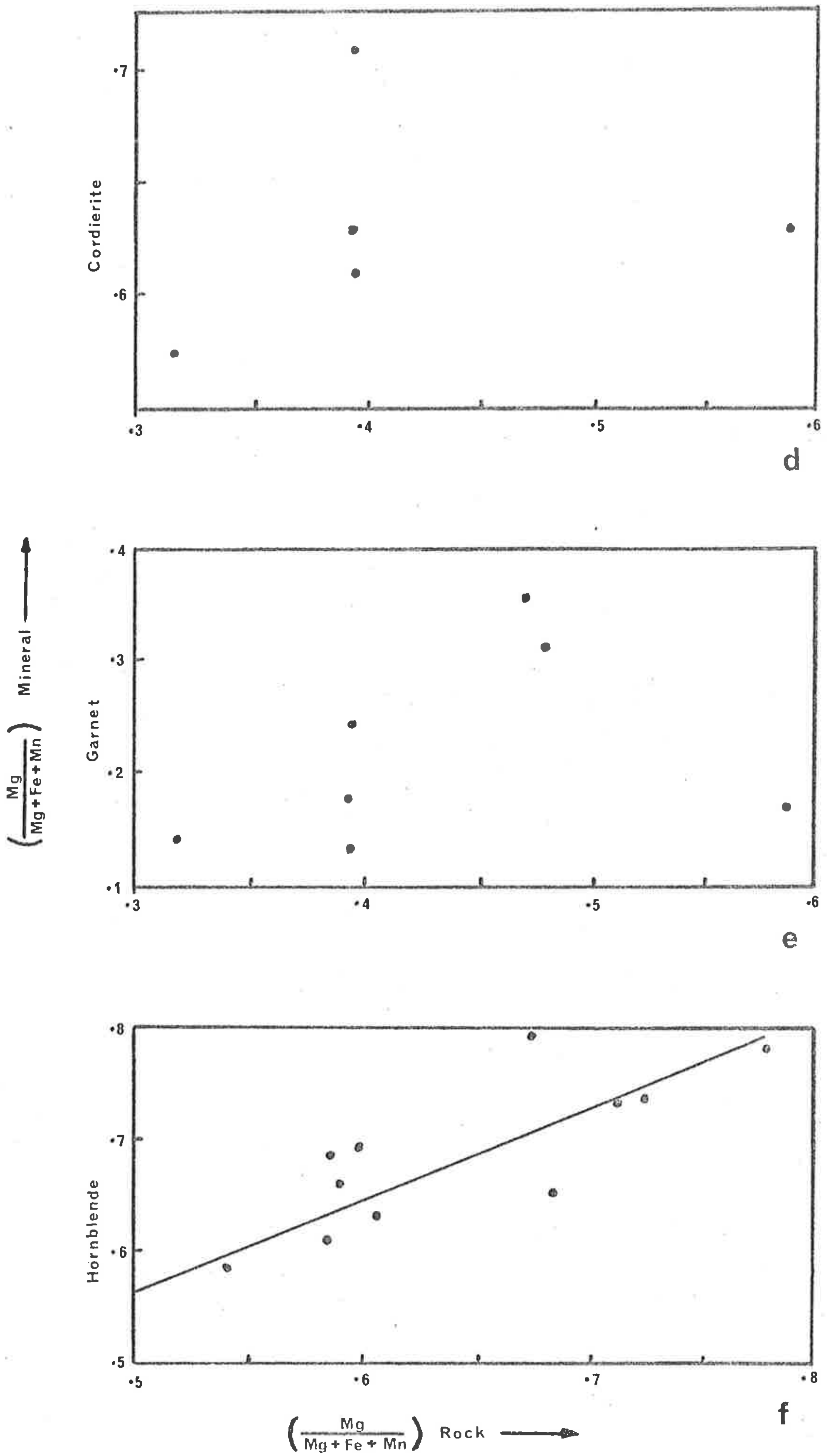

Cordierite
·7
·6
·3
·4
·5
·6
d
Garnet
·4
·3
·2
·1
·3
·4
·5
·6
e
Hornblende
·8
·7
·6
·5
·5
·6
·7
·8
f
(Mg / Mg+Fe+Mn) Mineral
(Mg / Mg+Fe+Mn) Rock

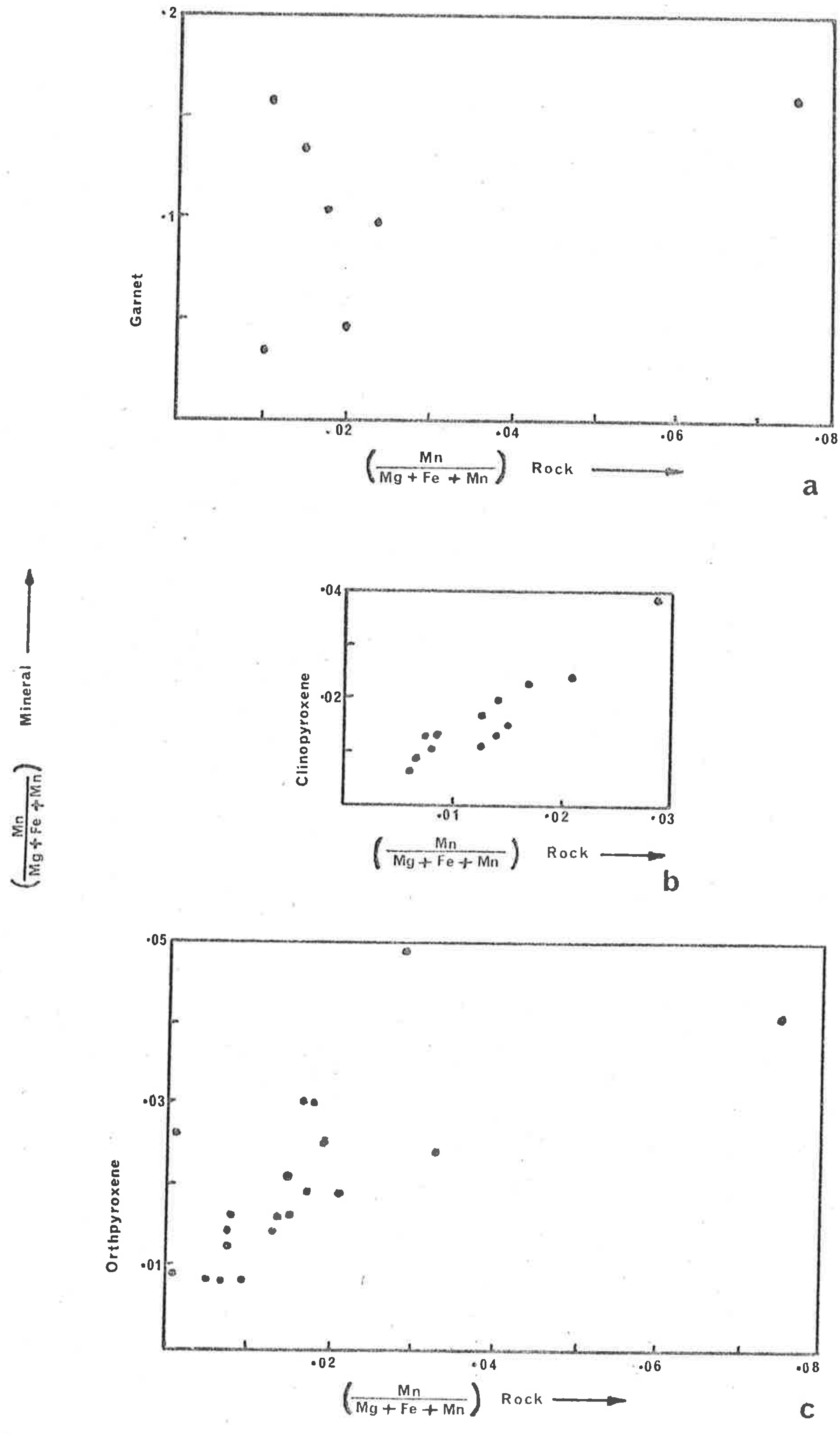
Figure 5.2

$(\frac{Mn}{Mg+Fe+Mn})$ mineral against $(\frac{Mn}{Mg+Fe+Mn})$ host rock for Windmill Islands rocks

a. Garnet

b. Clinopyroxene

c. Orthopyroxene



Garnet
·2
·1
·02
·04
·06
·08
(Mn / Mg + Fe + Mn) Rock
a
Clinopyroxene
·04
·02
·01
·02
·03
(Mn / Mg + Fe + Mn) Rock
b
(Mn / Mg + Fe + Mn) Mineral
Orthpyroxene
·05
·03
·01
·02
·04
·06
·08
(Mn / Mg + Fe + Mn) Rock
c

Figure 5.3

Rock oxidation ratio against mol $\left(\frac{Mg}{Mg+Fe} \times 100\right)$ mineral, for Windmill Island rocks.

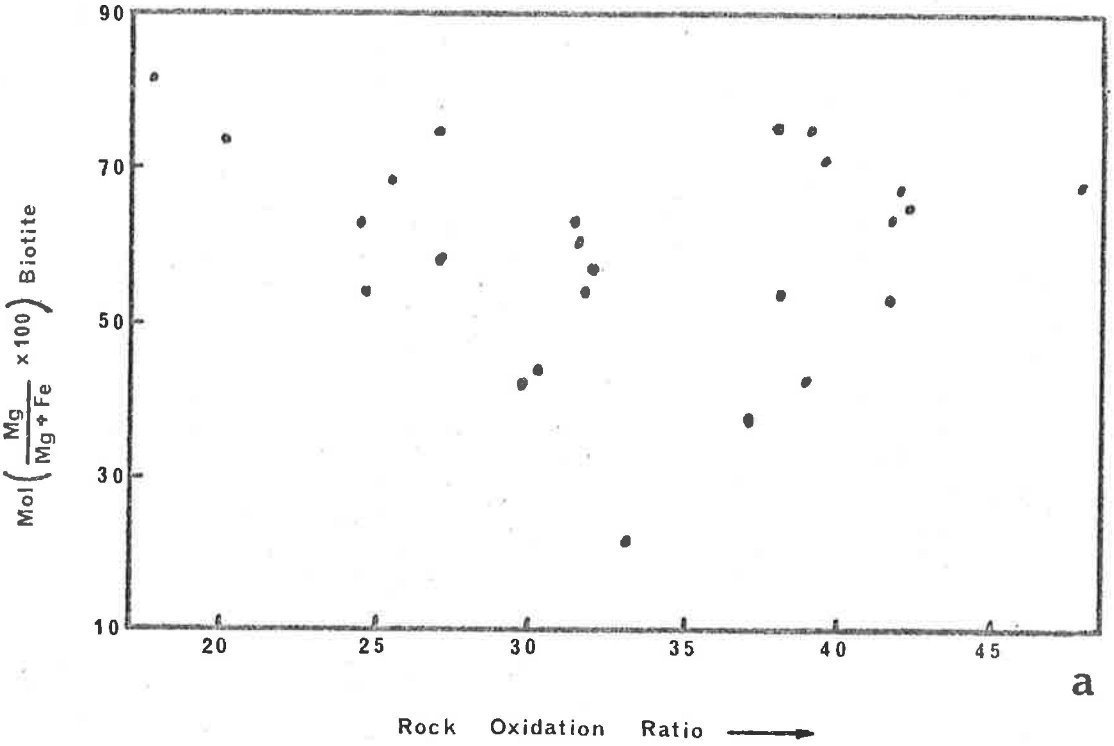
a. Biotite

b. Orthopyroxene

c. Garnet

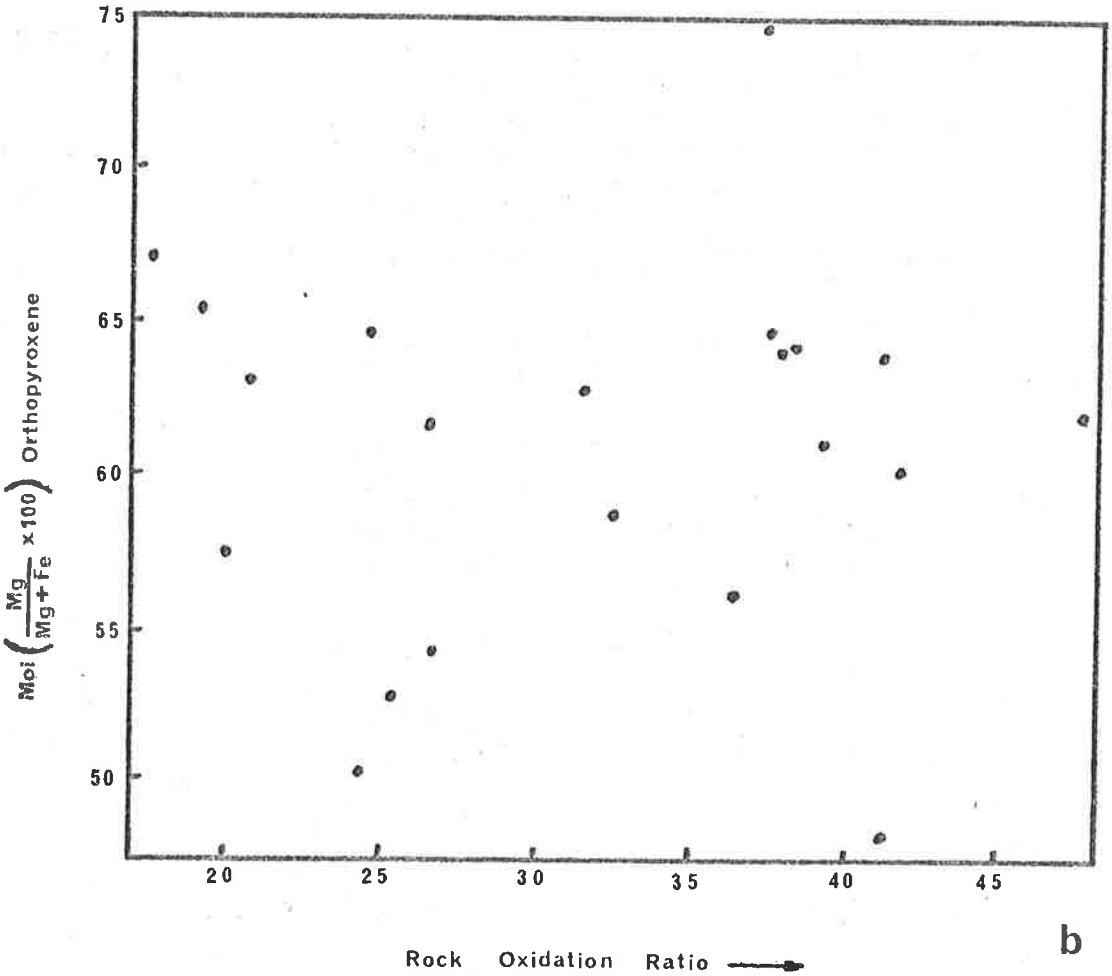
d. Hornblende

e. Clinopyroxene



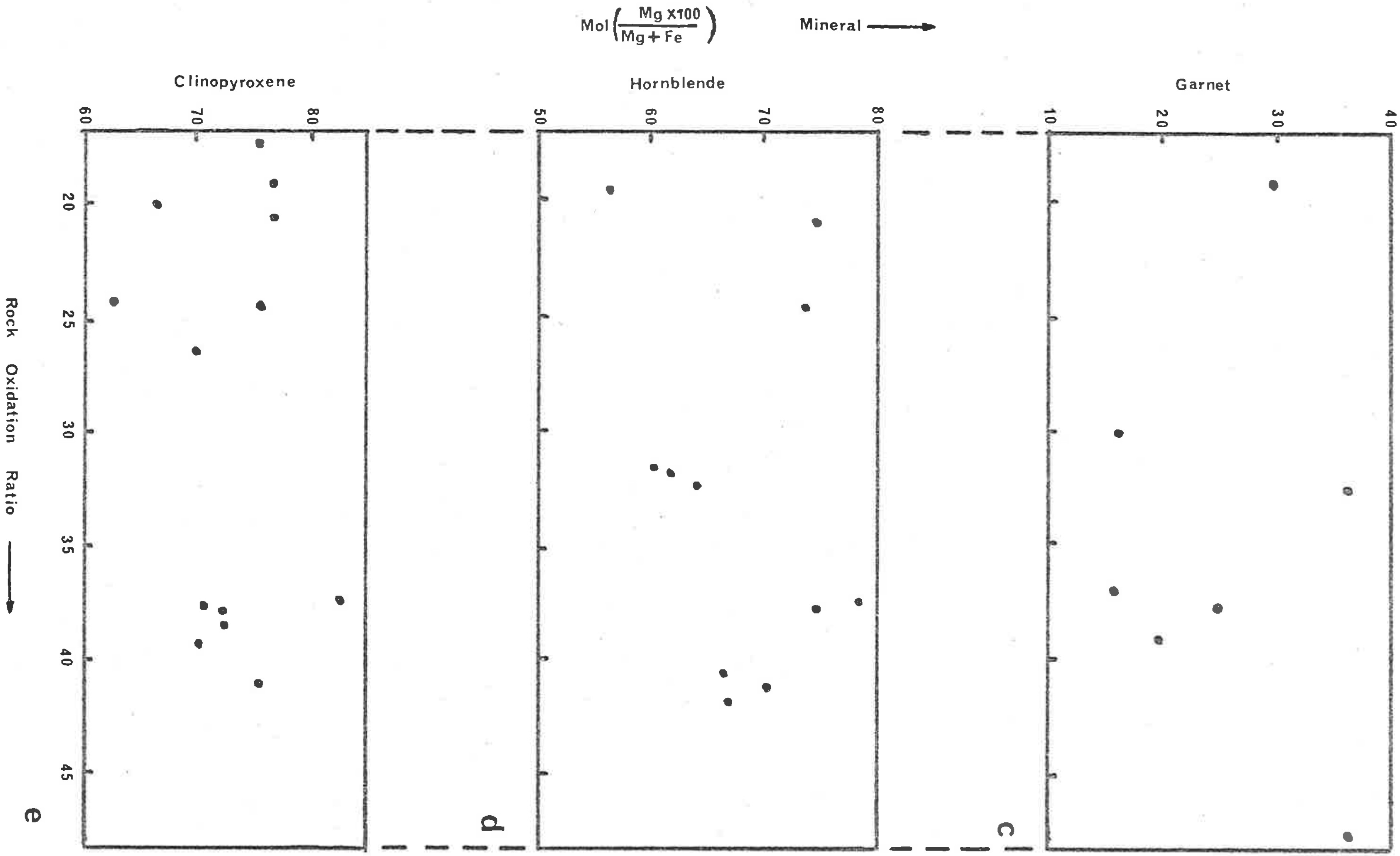
90
70
50
30
10
20
25
30
35
40
45
Mol (Mg / Mg+Fe × 100) Biotite
Rock Oxidation Ratio

a



75
70
65
60
55
50
20
25
30
35
40
45
Mol (Mg / Mg+Fe × 100) Orthopyroxene
Rock Oxidation Ratio

b



Mol (Mg X100 / Mg + Fe)
Mineral
Clinopyroxene
Hornblende
Garnet
Rock Oxidation Ratio
c
d
e

Figure 5.4

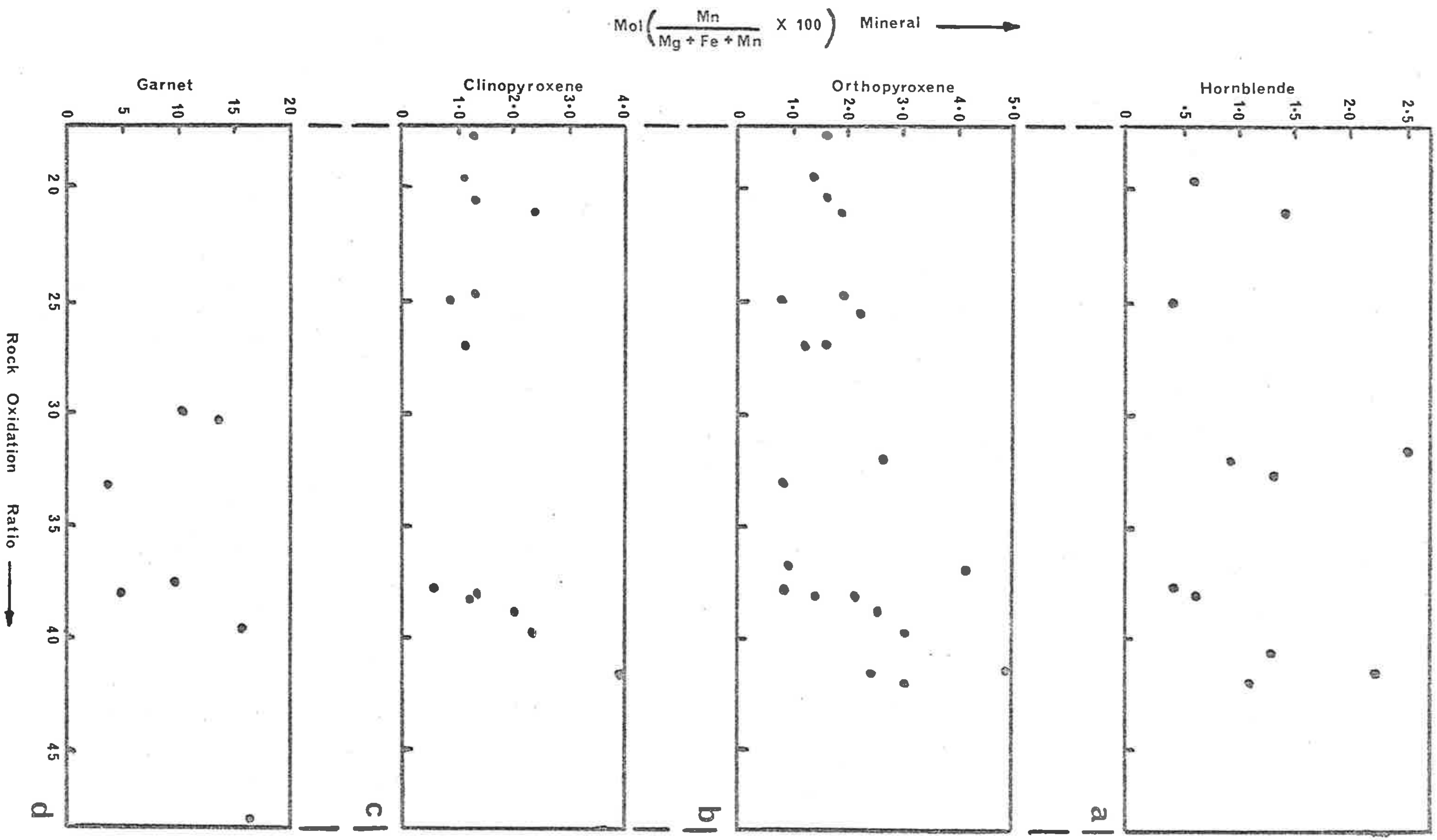
Rock oxidation ratio against mol $(\frac{Mn}{Mg+Fe+Mn} \times 100)$ mineral, for Windmill Islands rocks.

a. Hornblende

b. Orthopyroxene

c. Clinopyroxene

d. Garnet.



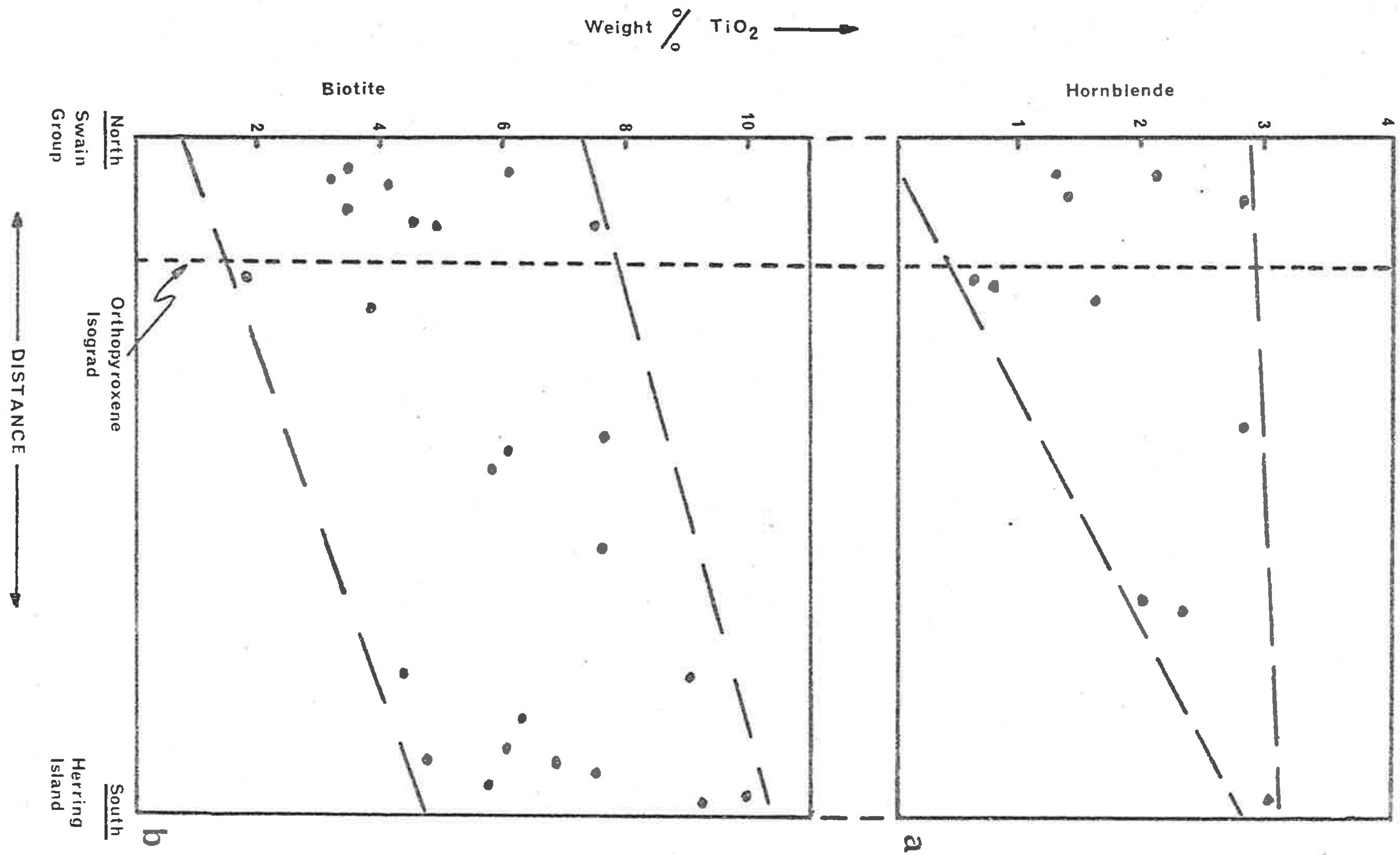
Mol (Mn / Mg + Fe + Mn X 100) Mineral
Hornblende
Orthopyroxene
Clinopyroxene
Garnet
Rock Oxidation Ratio
a
b
c
d

Figure 5.5

W+% TiO_2 in mineral against the north-south distance through the Windmill Islands.

a. Hornblende

b. Biotite.



Weight % TiO_2
Biotite
Hornblende
2
4
6
8
10
1
2
3
4
North
Swain Group
Orthopyroxene Isograd
South
Herring Island
DISTANCE
a
b

Figure 5.6

a. Si per unit cell against Al^{VI} per unit cell of hornblendes from the Windmill Islands. Symbols are:

Solid squares - samples north of Sparkes Bay;

open circles - samples south of Sparkes Bay;

open squares - charnockite (Peterson Island)

b. Al^{VI} per unit cell against (Na+K) per unit cell of hornblendes from the Windmill Islands. Symbols as above.

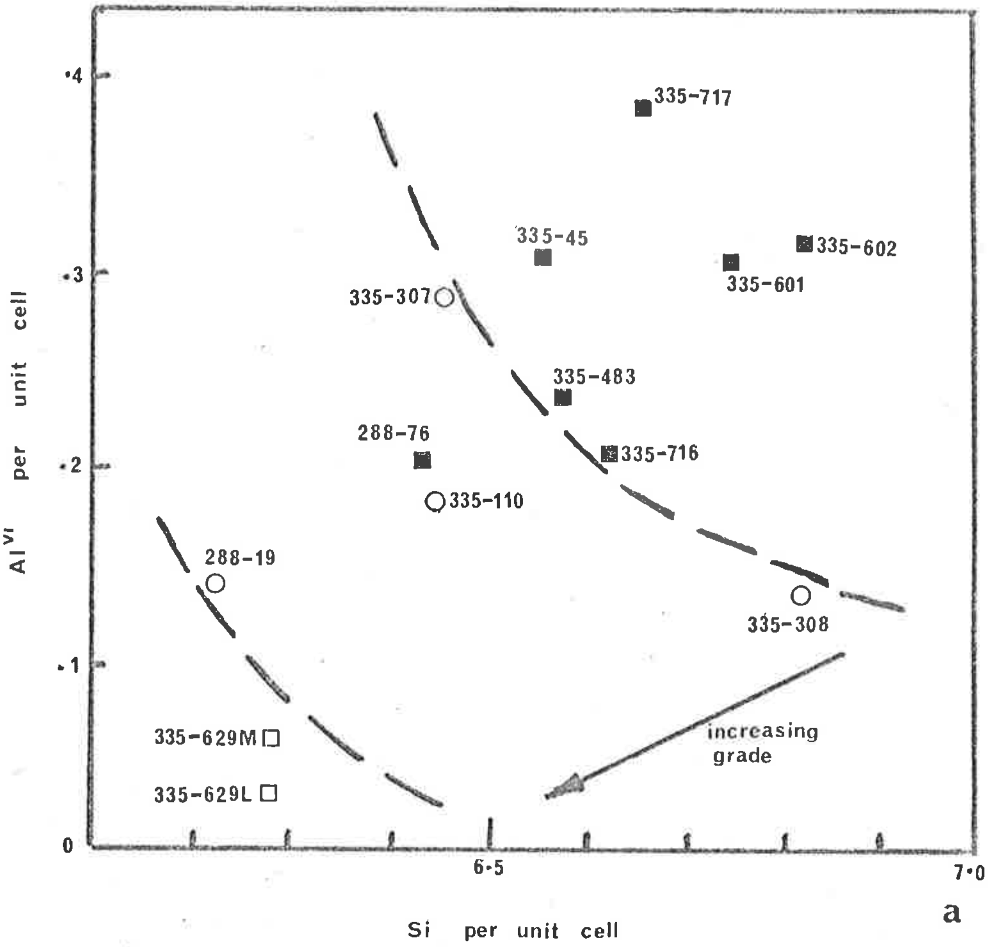
Fields indicated are after Binns, (1969a)

A. epidote amphibolite facies;

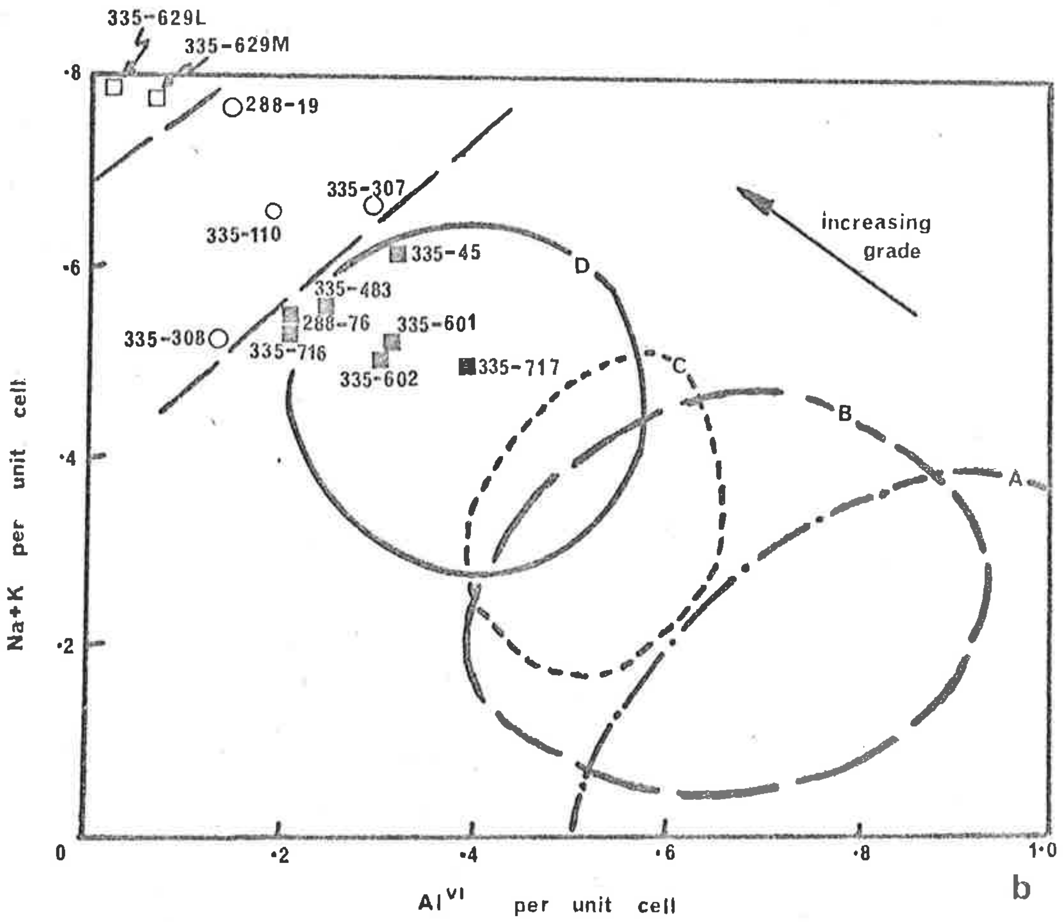
B. lower amphibolite facies;

C. higher amphibolite facies;

D. granulite facies.



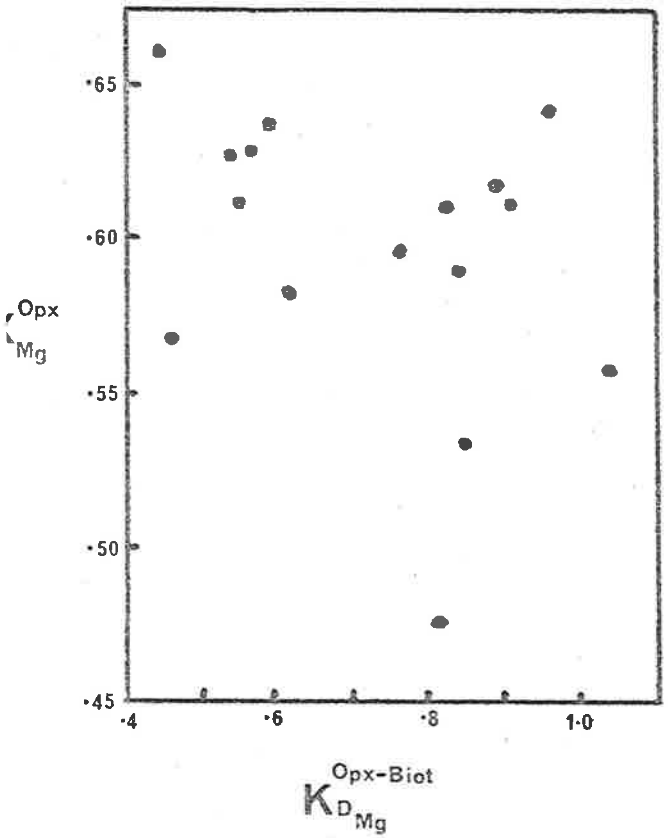
·4
·3
·2
·1
0
335-717
335-45
335-602
335-601
335-307
335-483
288-76
335-716
335-110
288-19
335-308
335-629M
335-629L
increasing
grade
6·5
7·0
Al^{VI} per unit cell
Si per unit cell
a



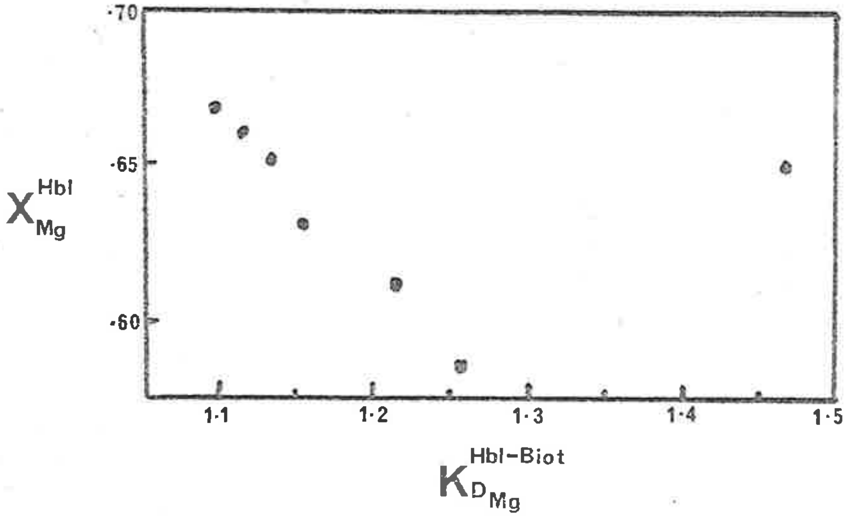
335-629L
335-629M
288-19
·8
·6
·4
·2
0
335-307
335-110
335-45
335-483
288-76
335-601
335-308
335-716
335-602
335-717
D
C
B
A
increasing
grade
·2
·4
·6
·8
1·0
Na+K per unit cell
Al^{VI} per unit cell
b

Figure 5.7

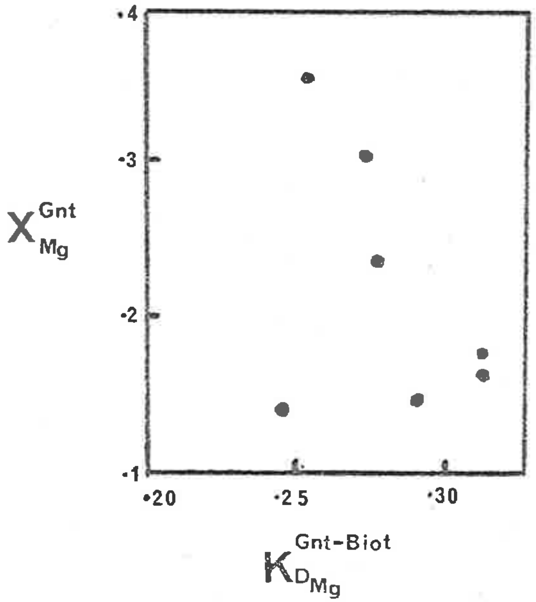
$K_{D_{Mg}}$ against X_{Mg} and $K_{D_{Mn}}$ against X_{Mn} for minerals from the Windmill Islands.



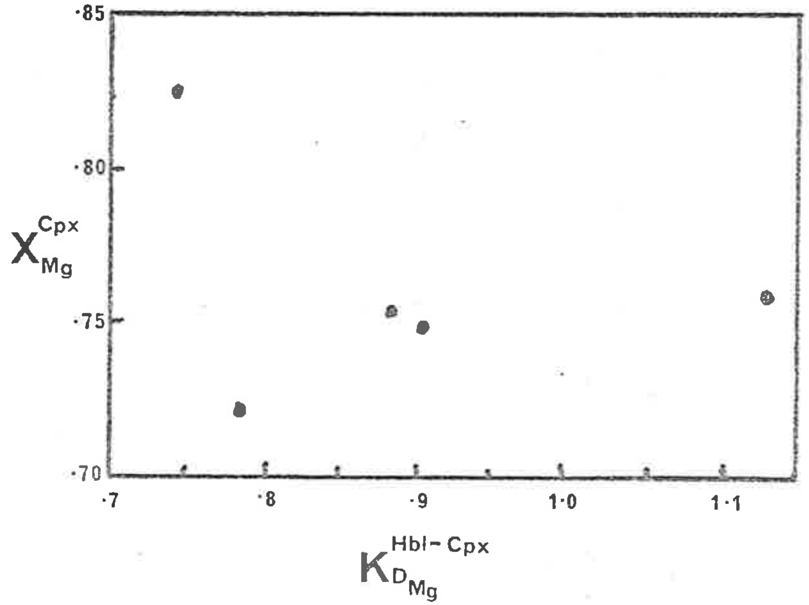
·65
·60
·55
·50
·45
Opx
Mg
·4
·6
·8
1·0
Opx-Biot
K D Mg



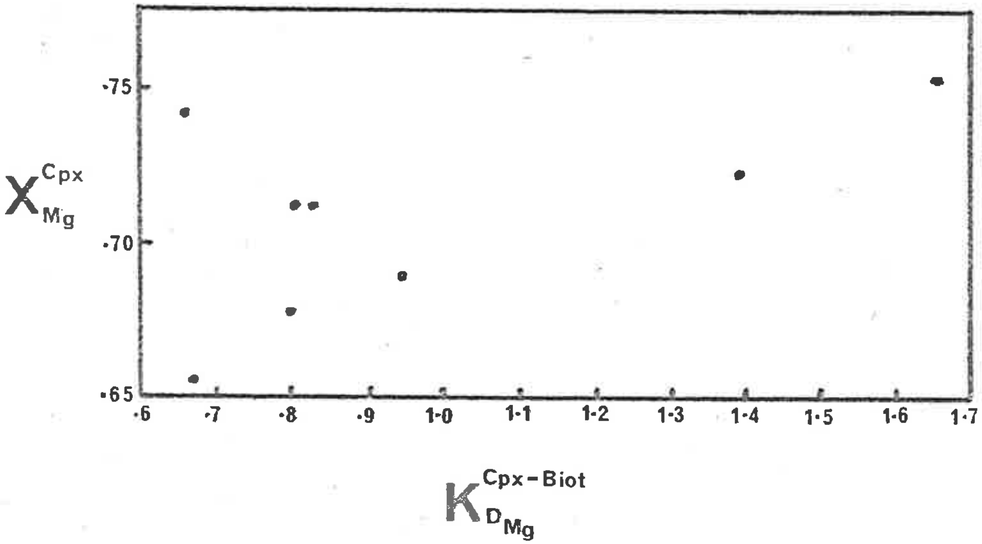
·70
·65
·60
X Hbl Mg
1·1
1·2
1·3
1·4
1·5
Hbl-Biot
K D Mg



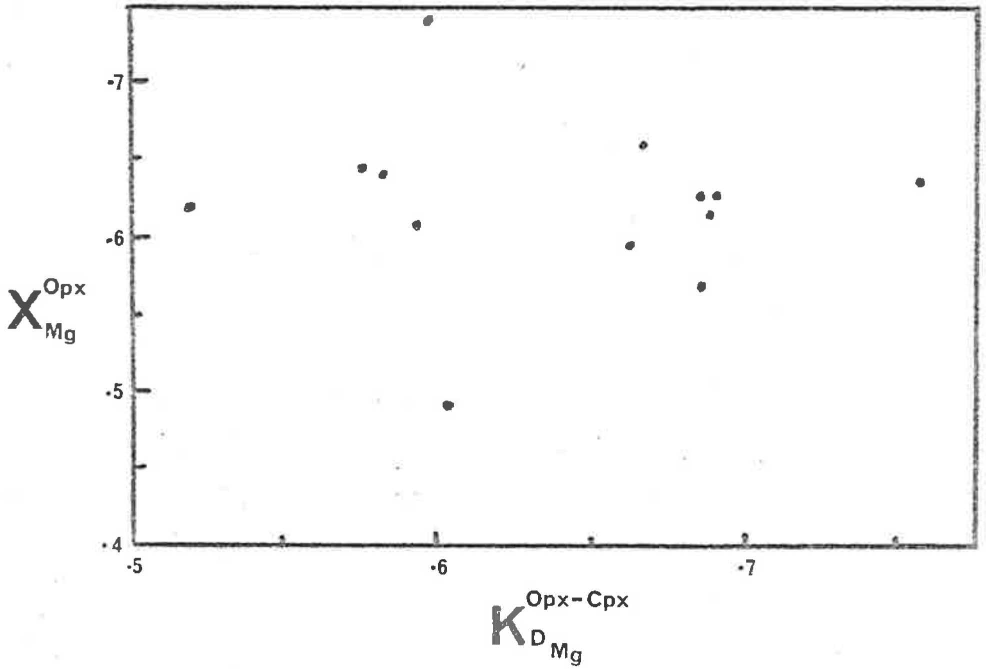
·4
·3
·2
·1
X Gnt Mg
·20
·25
·30
Gnt-Biot
K D Mg



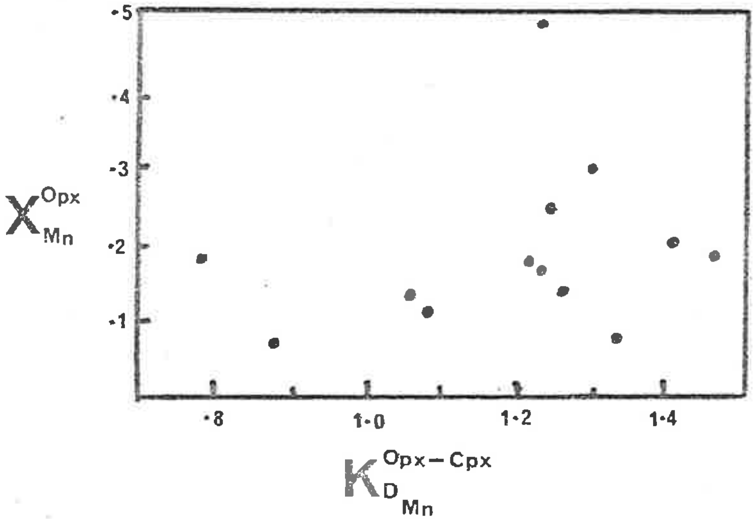
·85
·80
·75
·70
X Cpx Mg
·7
·8
·9
1·0
1·1
Hbl- Cpx
K D Mg



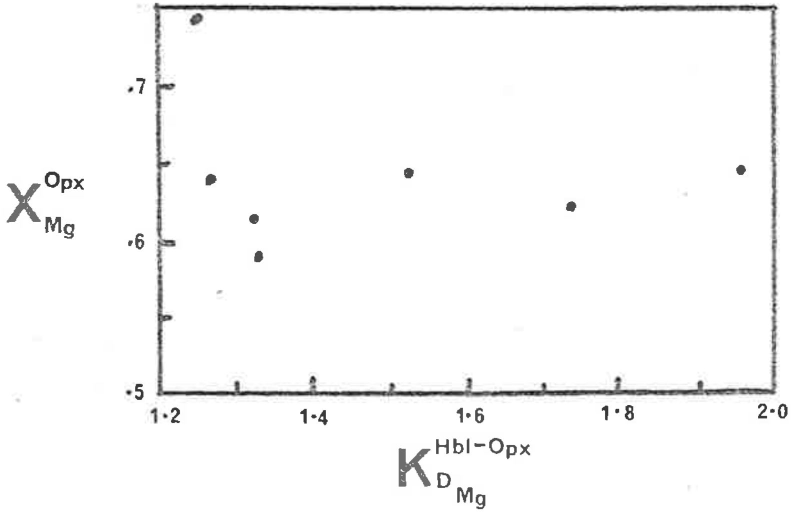
·75
·70
·65
·6
·7
·8
·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
X_{Mg}^{Cpx}
$K_{D_{Mg}}^{Cpx-Biot}$



·7
·6
·5
·4
·5
·6
·7
X_{Mg}^{Opx}
$K_{D_{Mg}}^{Opx-Cpx}$



·5
·4
·3
·2
·1
·8
1·0
1·2
1·4
X_{Mn}^{Opx}
$K_{D_{Mn}}^{Opx-Cpx}$

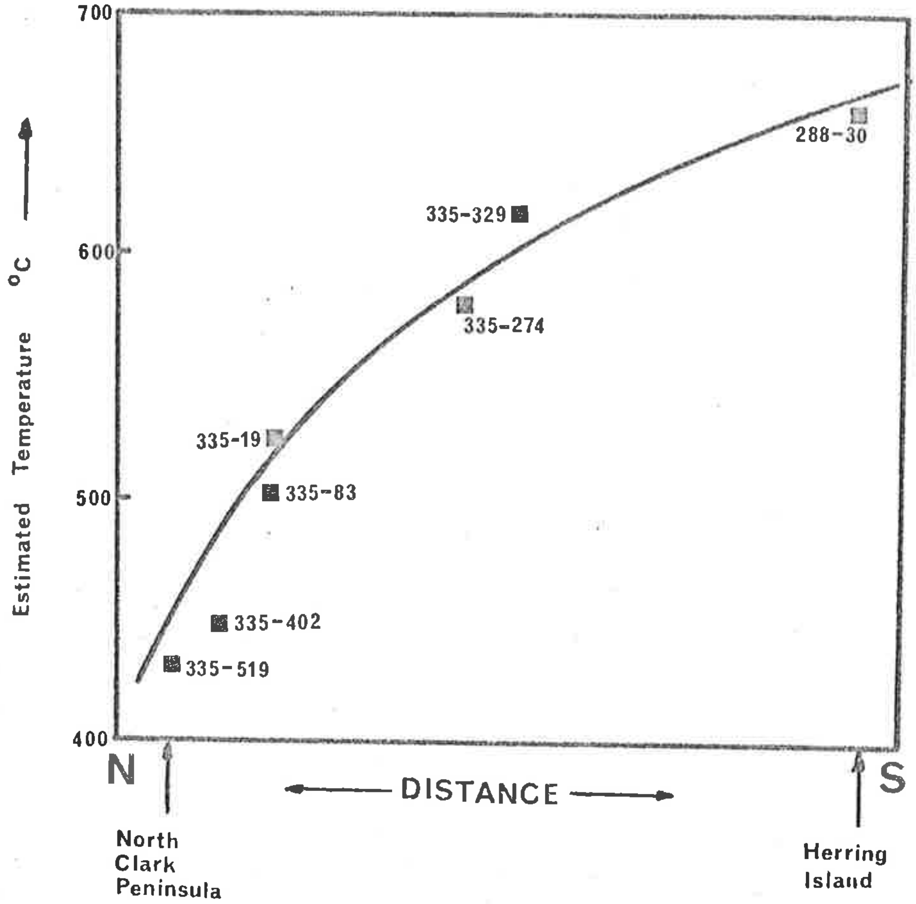


·7
·6
·5
1·2
1·4
1·6
1·8
2·0
X_{Mg}^{Opx}
$K_{D_{Mg}}^{Hbl-Opx}$

Figure 5.8

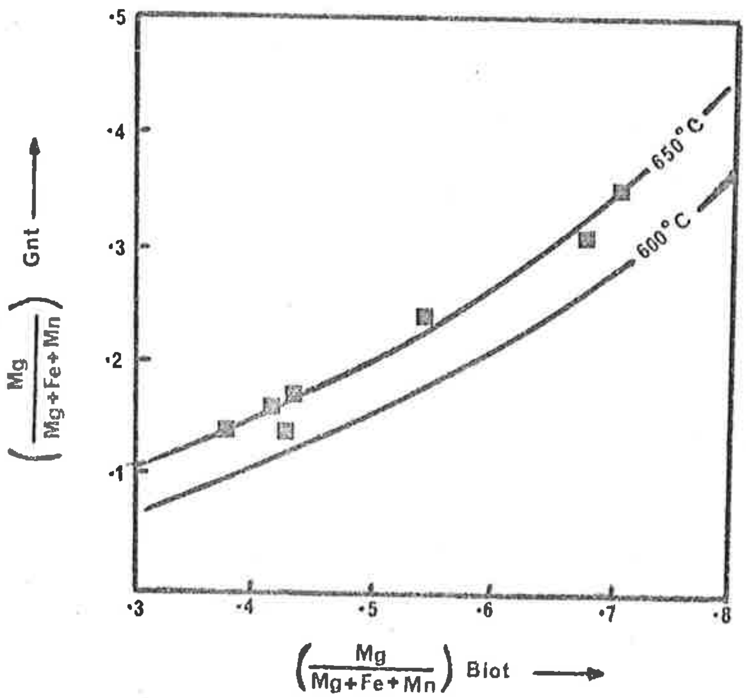
a. Estimated temperature of crystallization from the garnet-biotite pair (Saxena, 1969a) plotted against north south distance through the Windmill Islands.

b. "Roozenboom" Mg distribution diagram for Windmill Islands co-existing garnet and biotite. Isotherms are from Perchuck (1969).



700
600
500
400
Estimated Temperature °C
288-30
335-329
335-274
335-19
335-83
335-402
335-519
N
DISTANCE
S
North Clark Peninsula
Herring Island

a



·5
·4
·3
·2
·1
650°C
600°C
(Mg / Mg+Fe+Mn) Gnt
·3
·4
·5
·6
·7
·8
(Mg / Mg+Fe+Mn) Biot

b

Figure 5.9

a. $K_{D_{Mg}}^{opx-cpx}$ against X_{Fe}^{opx} . "Ideal" and "non-ideal" trends from Davidson, (1969).

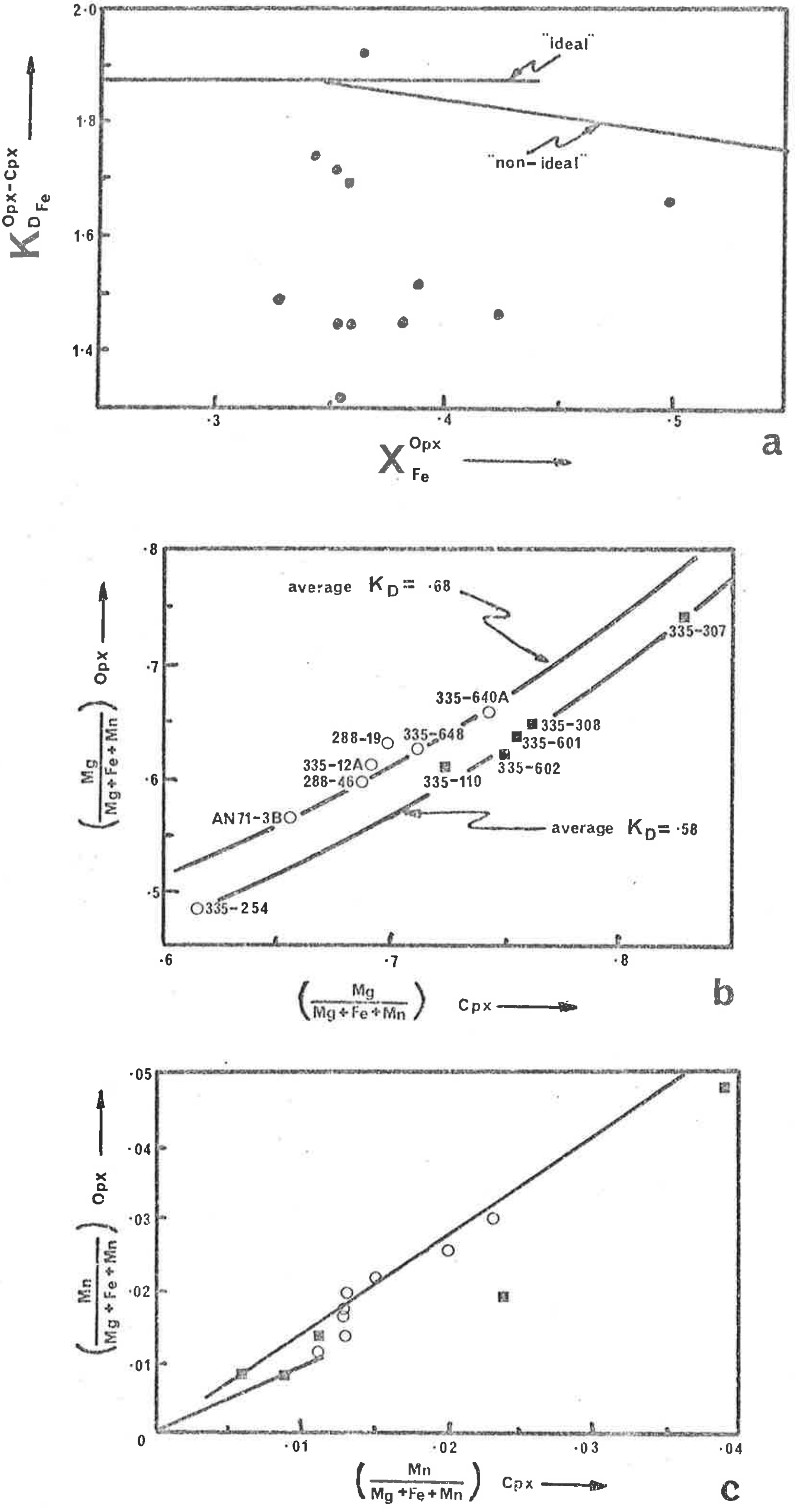
b. "Roozenboom" Mg distribution diagram for co-existing orthopyroxene and clinopyroxene from the Windmill Islands.

Symbols are:

open circles - samples south of Robinson Ridge

solid squares - sample north of and including Robinson Ridge.

c. "Roozenboom" Mn distribution diagram for co-existing orthopyroxene and clinopyroxene from the Windmill Islands. Symbols as in figure 5.9b. Linear trends indicated are from Lindh (1974).



"ideal"
"non-ideal"
2·0
1·8
1·6
1·4
·3
·4
·5
a
average K_D= ·68
average K_D= ·58
335-307
335-640A
335-308
335-601
335-602
335-110
288-19
335-648
335-12A
288-46
AN71-3B
335-254
·8
·7
·6
·5
b
Cpx
Opx
·05
·04
·03
·02
·01
0
c

Figure 5.10

a. $K_{D_{Mg}}^{Hbl-cpx}$ against Al^{IV} Hbl

Symbols are:

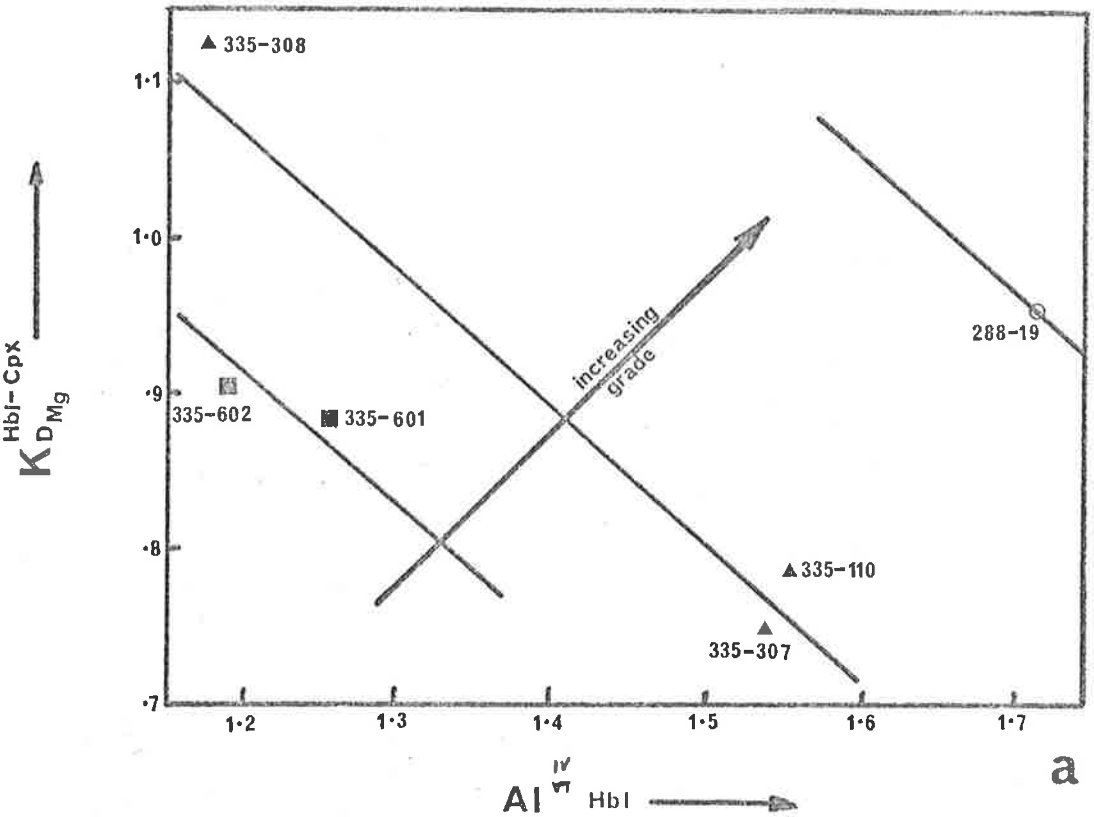
solid squares - samples from Bailey Peninsula;

solid triangles - samples from Mitchell Peninsula and Robinson Ridge;

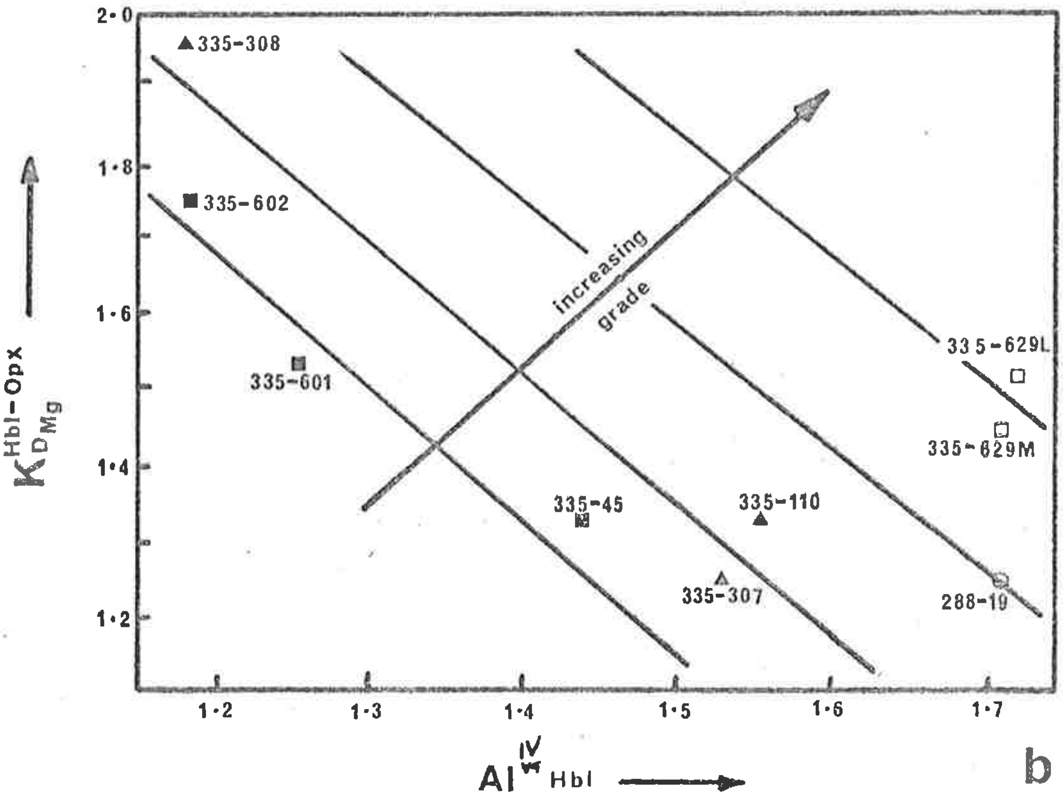
open circles - samples from Ford and Cloyd Islands.

b. $K_{D_{Mg}}^{Hbl-opx}$ against Al^{IV} Hbl.

Symbols are as above and open squares - samples from the charnockite (Peterson Island).



335-308
1·1
1·0
·9
·8
·7
335-602
335-601
increasing grade
288-19
335-110
335-307
1·2
1·3
1·4
1·5
1·6
1·7
$K_{D_{Mg}}^{Hbl-Cpx}$
Al^{IV}_{Hbl}
a



2·0
1·8
1·6
1·4
1·2
335-308
335-602
335-601
increasing grade
335-629L
335-629M
335-45
335-110
335-307
288-19
1·2
1·3
1·4
1·5
1·6
1·7
$K_{D_{Mg}}^{Hbl-Opx}$
Al^{IV}_{Hbl}
b

Figure 5.11

a. $(\frac{Na}{Ca})_{Hbl}$ against $(\frac{Na}{Ca})_{Cpx}$

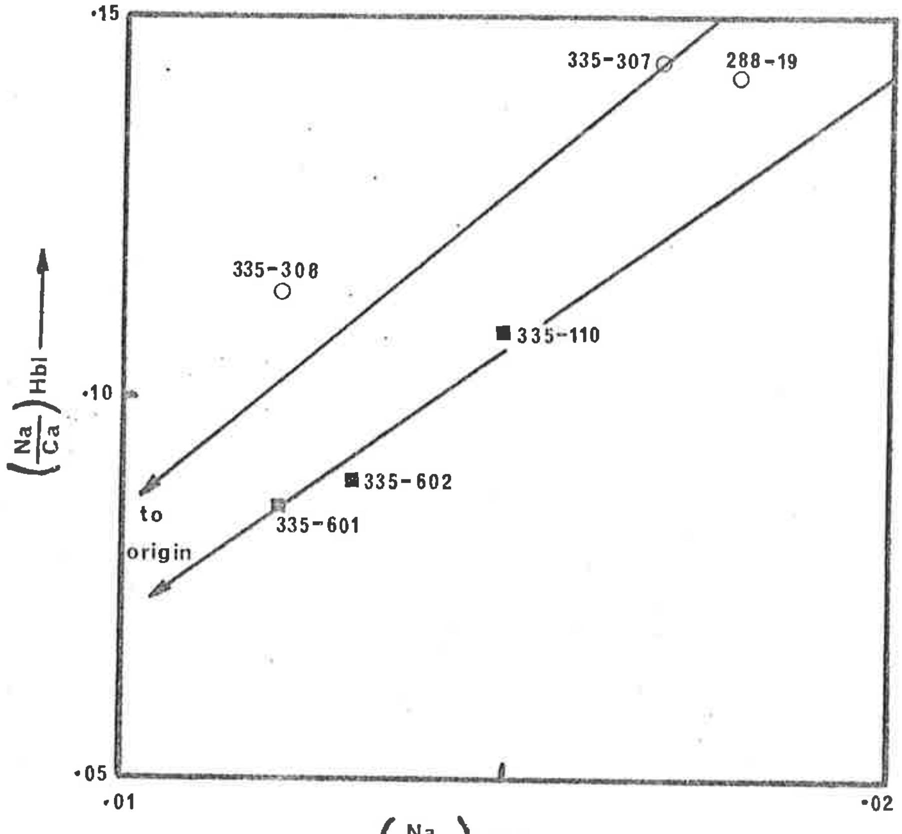
Symbols are:

solid squares - samples north of Sparkes Bay;

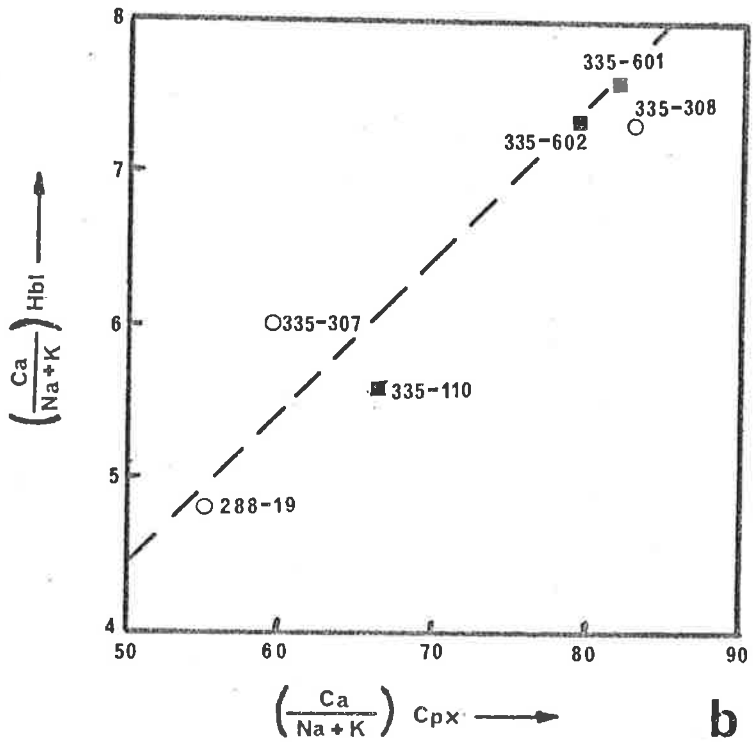
open circles - samples south of Sparkes Bay.

b. $(\frac{Ca}{Na+K})_{Hbl}$ against $(\frac{Ca}{Na+K})_{Cpx}$

Symbols as above.


·15
·10
·05
·01
·02
335-307
288-19
335-308
335-110
335-602
335-601
to
origin
(Na/Ca) Hbl
(Na/Ca) Cpx

a


8
7
6
5
4
50
60
70
80
90
335-601
335-308
335-602
335-307
335-110
288-19
(Ca/Na+K) Hbl
(Ca/Na+K) Cpx

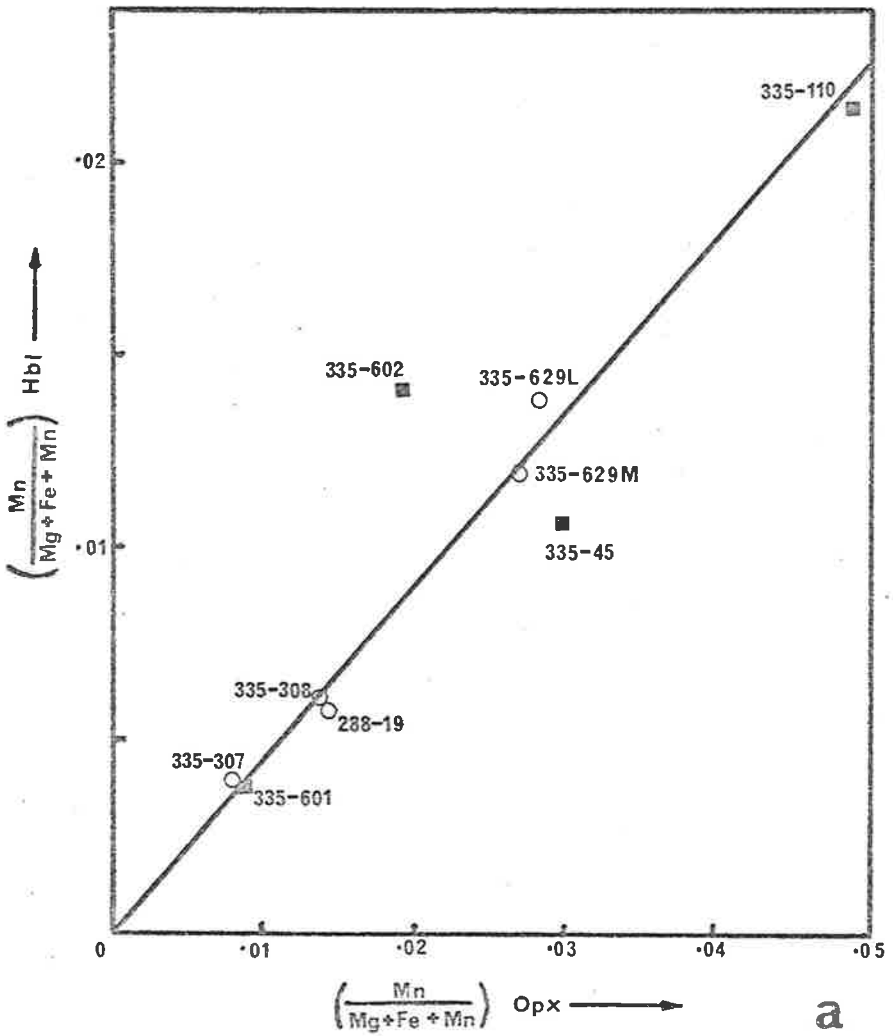
b

Figure 5.12

"Roozenboom" Mn distribution diagrams for co-existing hornblende and pyroxene from the Windmill Islands. Symbols as in Fig. 5.11.

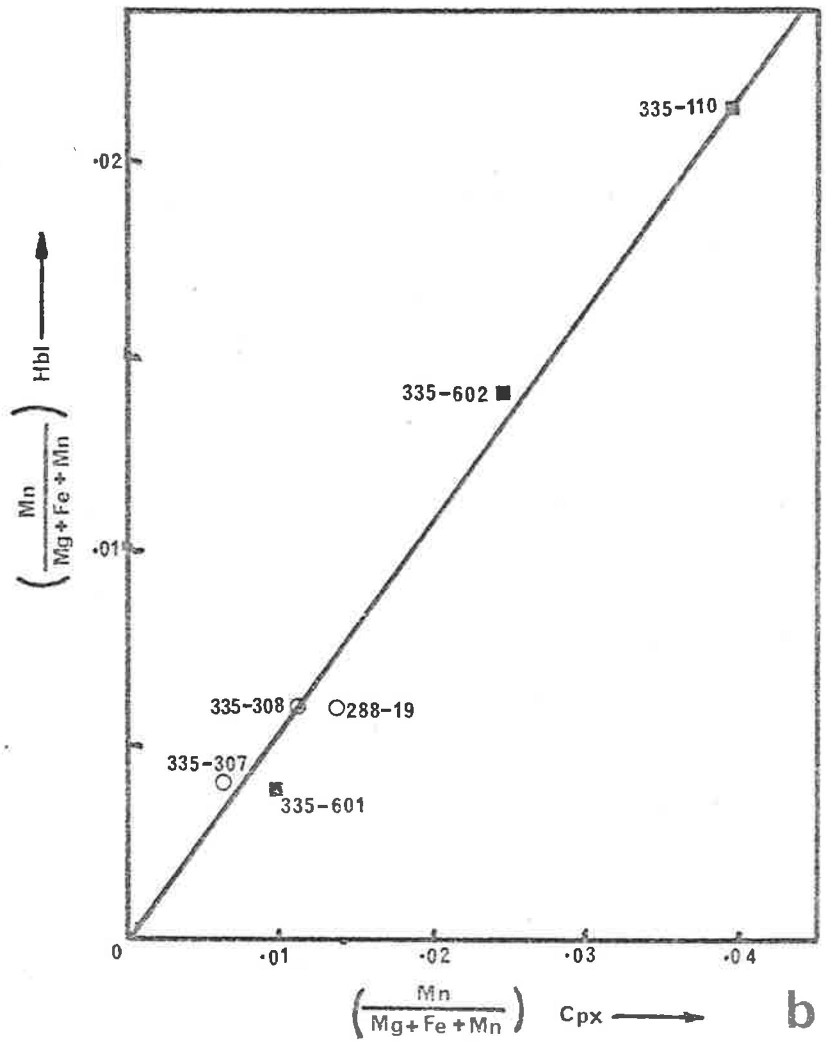
a. Hornblende - orthopyroxene

b. Hornblende - clinopyroxene



335-110
335-602
335-629L
335-629M
335-45
335-308
288-19
335-307
335-601
·02
·01
0
·01
·02
·03
·04
·05
(Mn / Mg+Fe+Mn) Hbl
(Mn / Mg+Fe+Mn) Opx

a



335-110
335-602
335-308
288-19
335-307
335-601
·02
·01
0
·01
·02
·03
·04
(Mn / Mg+Fe+Mn) Hbl
(Mn / Mg+Fe+Mn) Cpx

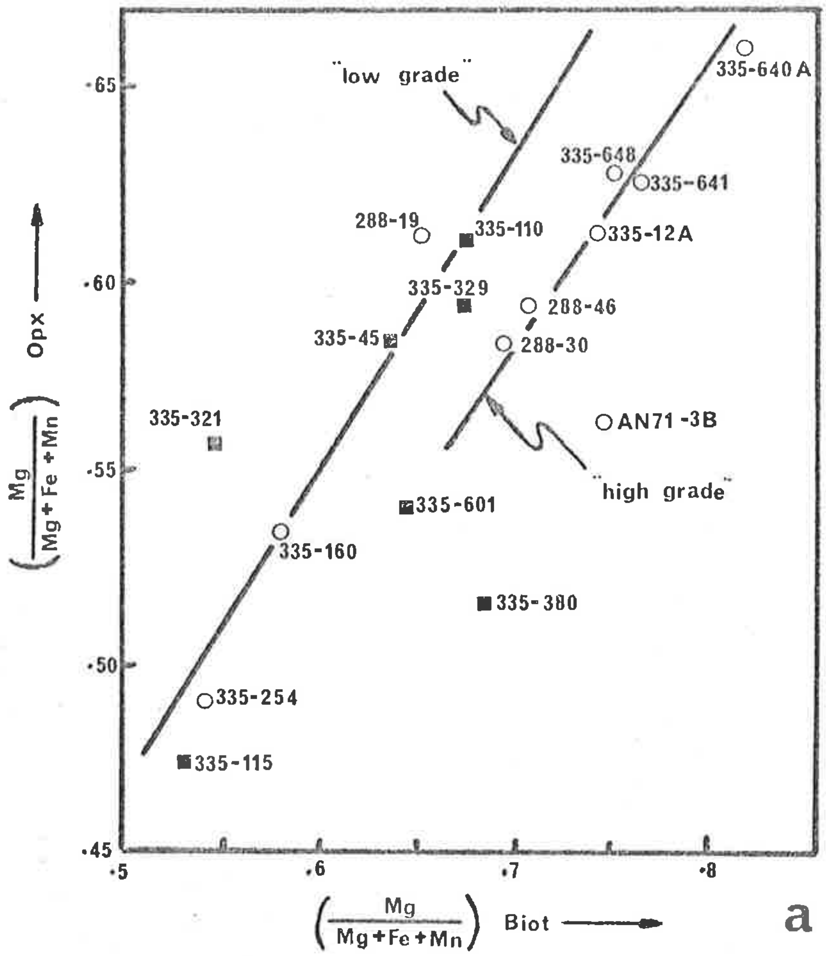
b

Figure 5.13

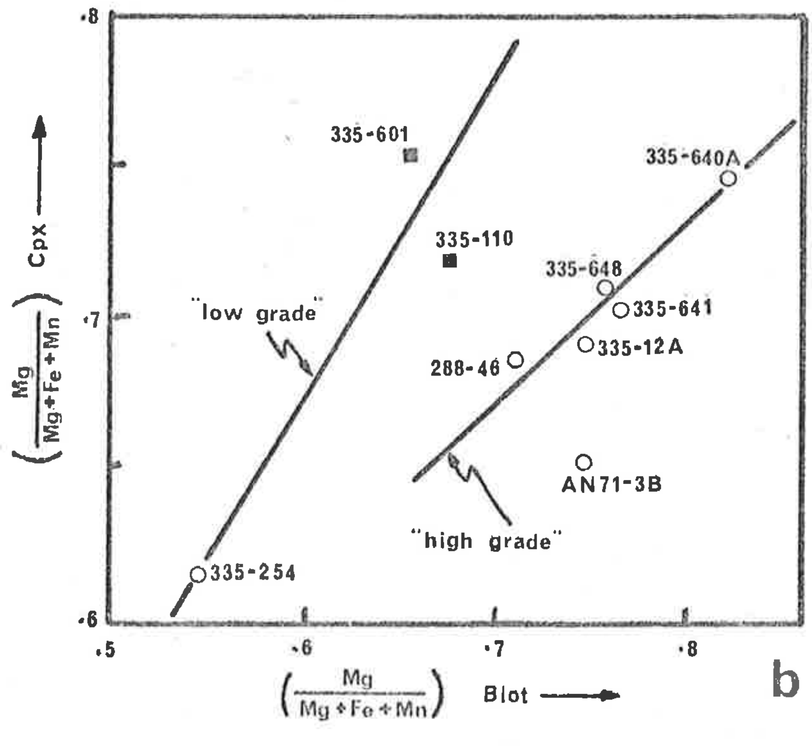
"Roozenboom" Mg distribution diagrams for co-existing biotite and pyroxene from the Windmill Islands. Symbols as in Fig. 5.11.

a. Biotite - orthopyroxene

b. Biotite - clinopyroxene.



"low grade"
"high grade"
335-640 A
335-648
335-641
288-19
335-110
335-12A
335-329
288-46
335-45
288-30
335-321
AN71 -3B
335-601
335-160
335-380
335-254
335-115
·65
·60
·55
·50
·45
·5
·6
·7
·8
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Opx
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Biot
a



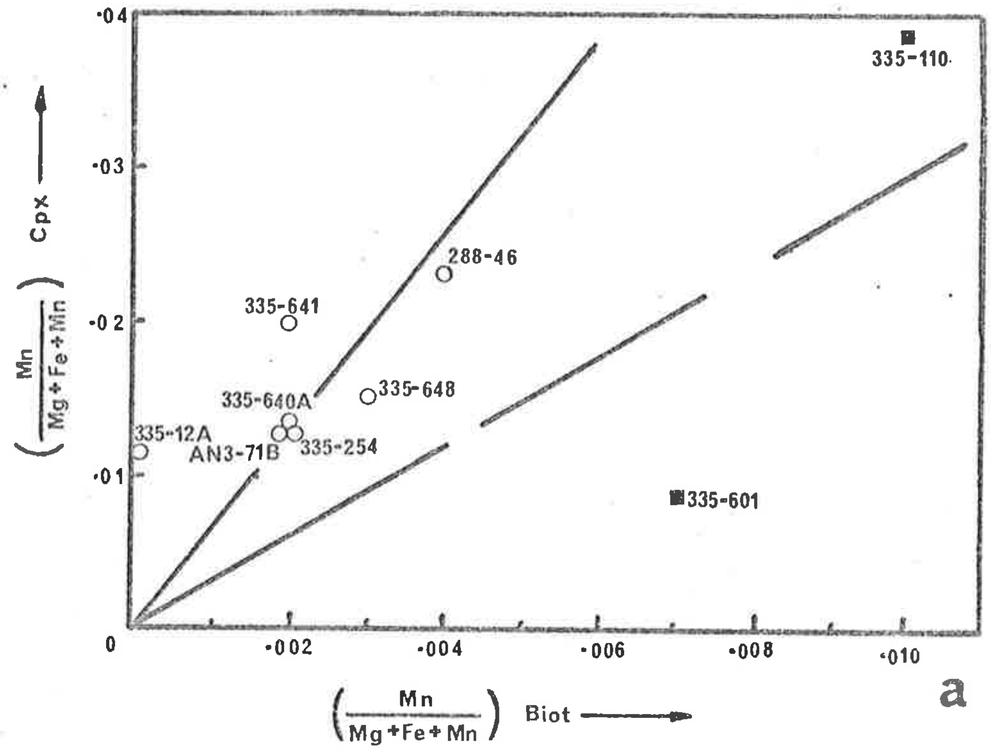
335-601
335-640A
335-110
335-648
335-641
"low grade"
335-12A
288-46
AN71-3B
"high grade"
335-254
·8
·7
·6
·5
·6
·7
·8
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Cpx
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Biot
b

Figure 5.14

"Roozenboom" Mn distribution diagrams for co-existing biotite and pyroxene from the Windmill Islands. Symbols as in Fig. 5.11.

a. Biotite - clinopyroxene

b. Biotite - orthopyroxene.


·04
·03
·02
·01
0
·002
·004
·006
·008
·010
335-110
288-46
335-641
335-648
335-640A
335-12A
AN3-71B
335-254
335-601
Mn / Mg + Fe + Mn Cpx
Mn / Mg + Fe + Mn Biot
a

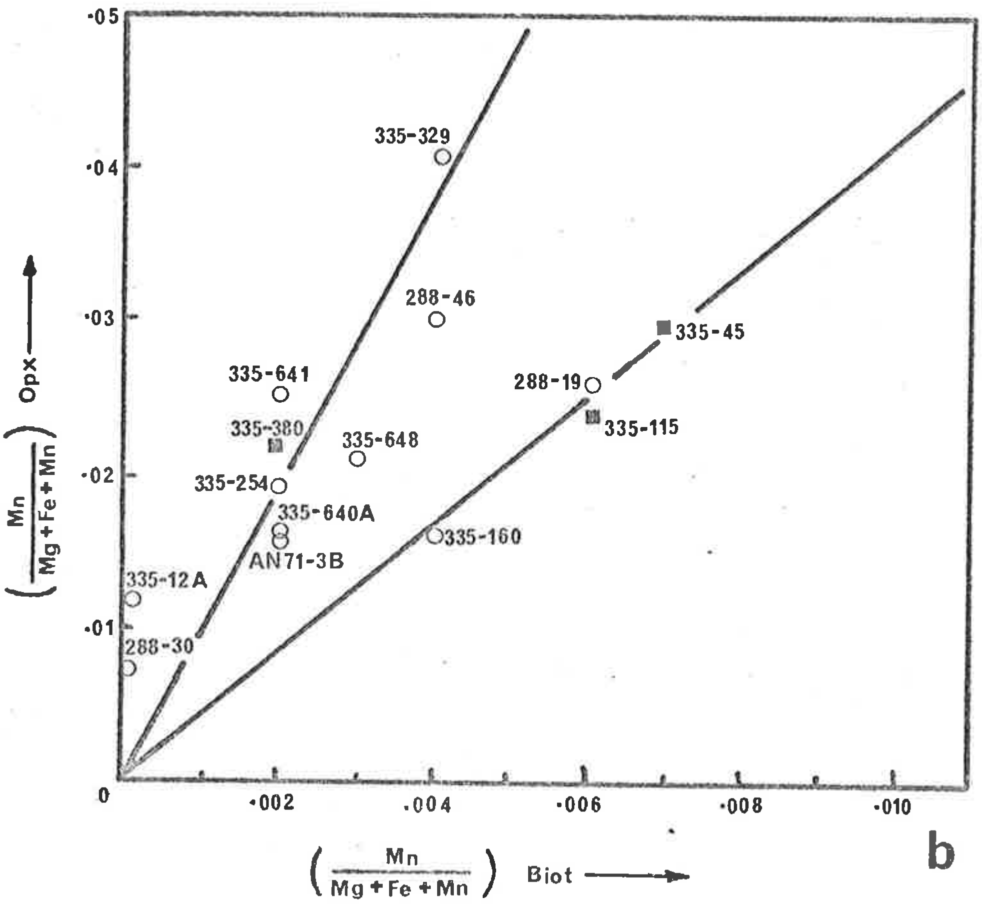
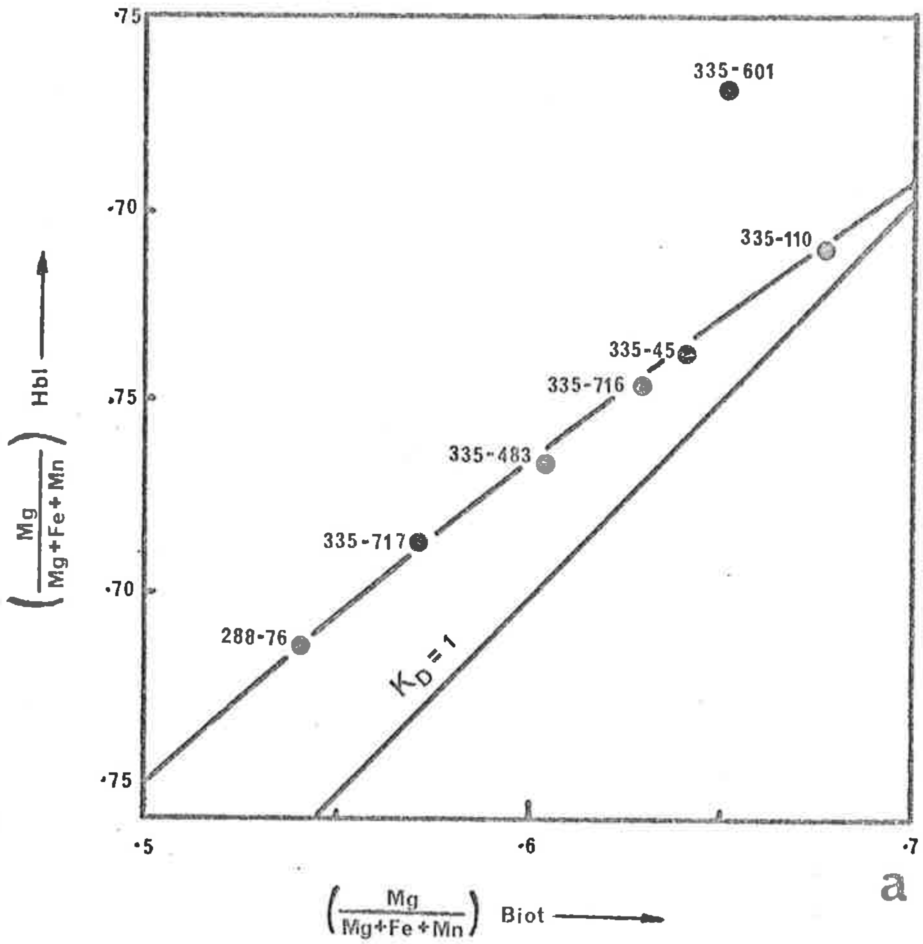

·05
·04
·03
·02
·01
0
·002
·004
·006
·008
·010
335-329
288-46
335-45
335-641
288-19
335-380
335-115
335-648
335-254
335-640A
335-160
AN71-3B
335-12A
288-30
Mn / Mg + Fe + Mn Opx
Mn / Mg + Fe + Mn Biot
b

Figure 5.15

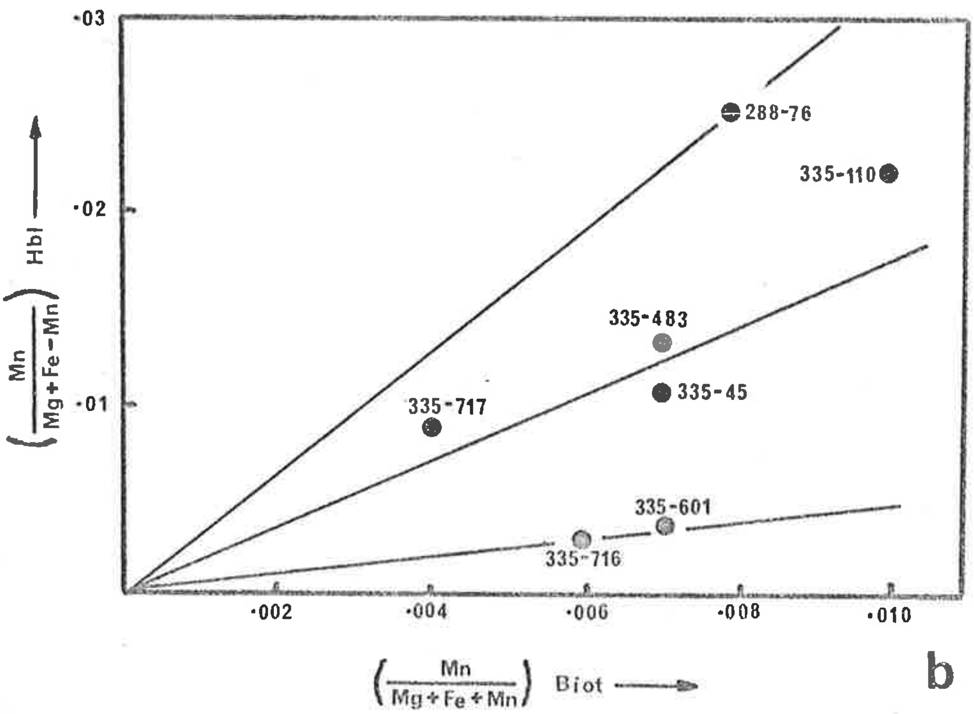
a. "Roozenboom" Mg distribution diagram for co-existing hornblende and biotite from the Windmill Islands.

b. "Roozenboom" Mn distribution diagram for co-existing hornblende and biotite from the Windmill Islands.



·75
·70
·75
·70
·75
335-601
335-110
335-45
335-716
335-483
335-717
288-76
$K_D = 1$
·5
·6
·7
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Hbl
$\left(\frac{Mg}{Mg+Fe+Mn}\right)$ Biot

a



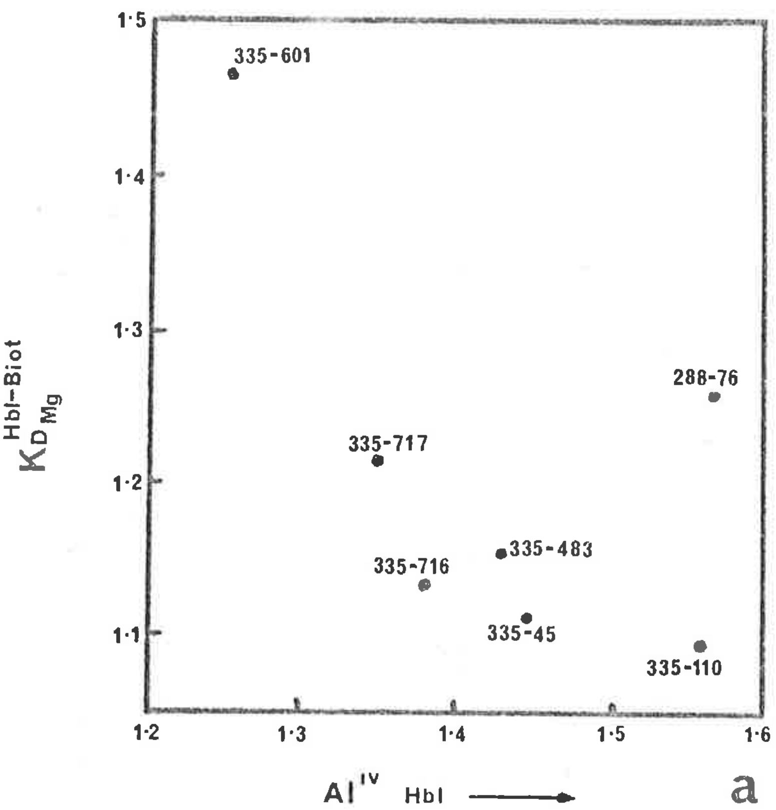
·03
·02
·01
288-76
335-110
335-483
335-45
335-717
335-601
335-716
·002
·004
·006
·008
·010
$\left(\frac{Mn}{Mg+Fe-Mn}\right)$ Hbl
$\left(\frac{Mn}{Mg+Fe+Mn}\right)$ Biot

b

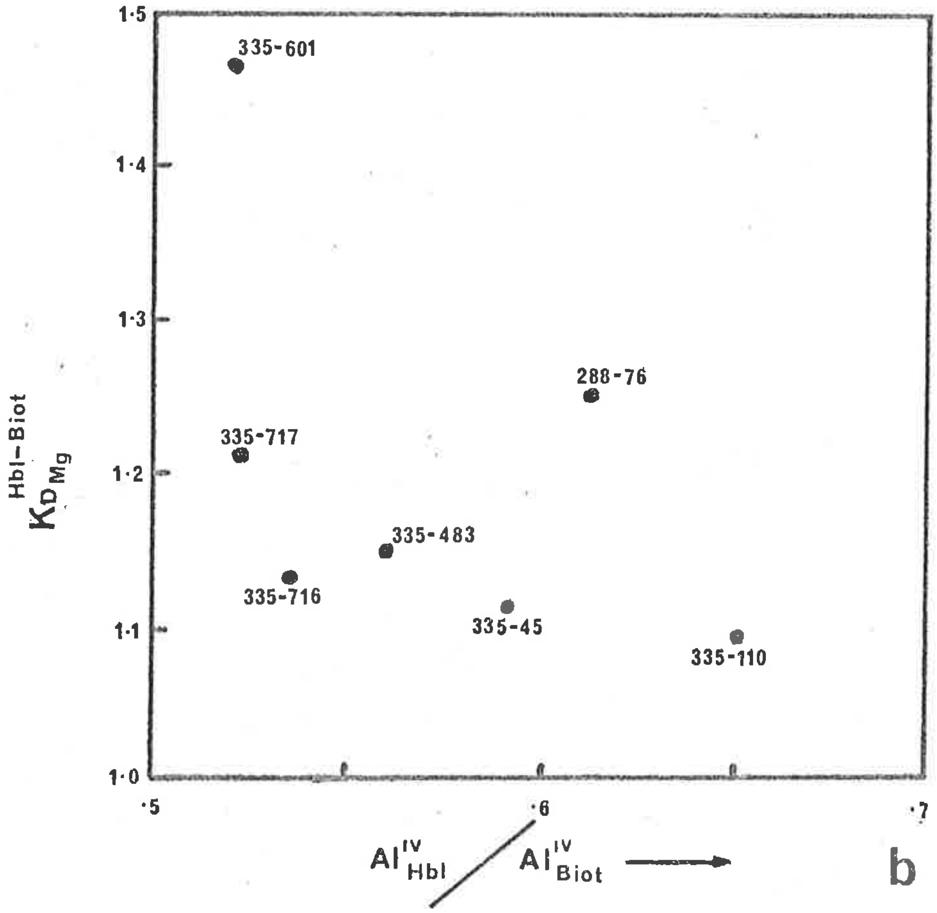
Figure 5.16

a. $K_{D_{Mg}}^{Hbl-Biot}$ against Al^{IV}_{Hbl}

b. $K_{D_{Mg}}^{Hbl-Biot}$ against $Al^{IV}_{Hbl} / Al^{IV}_{Biot}$



1·5
1·4
1·3
1·2
1·1
1·2
1·3
1·4
1·5
1·6
335-601
288-76
335-717
335-716
335-483
335-45
335-110
$K_{D_{Mg}}^{Hbl-Biot}$
Al^{IV} Hbl
a

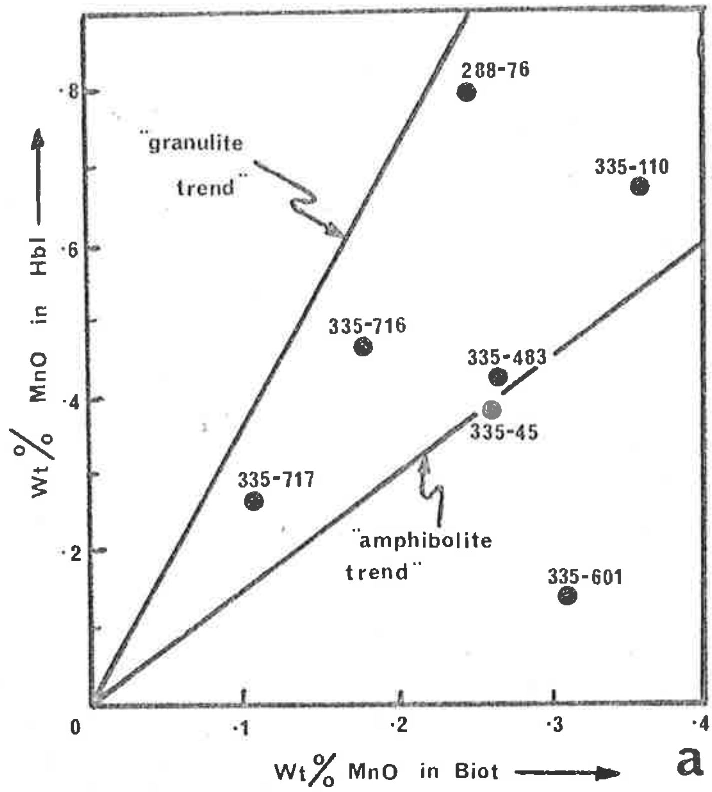


1·5
1·4
1·3
1·2
1·1
1·0
·5
·6
·7
335-601
288-76
335-717
335-483
335-716
335-45
335-110
$K_{D_{Mg}}^{Hbl-Biot}$
Al^{IV}_{Hbl} / Al^{IV}_{Biot}
b

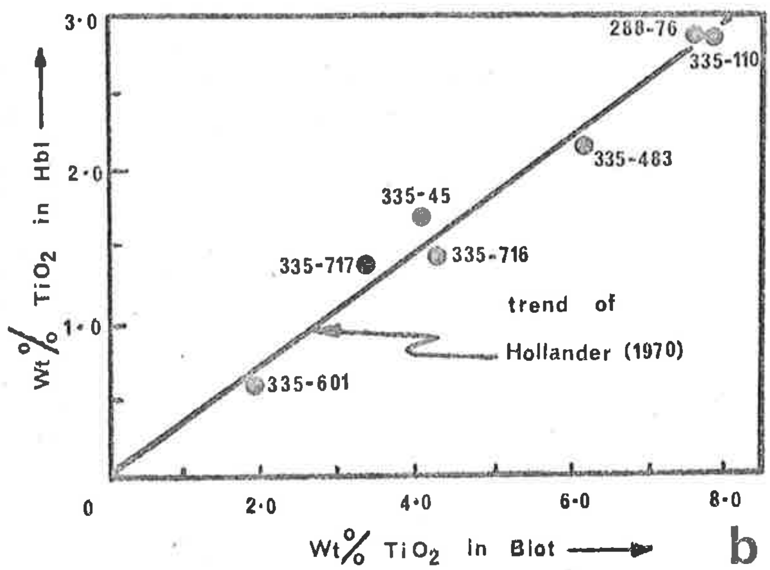
Figure 5.17

a. W+% MnO distribution between hornblende and biotite. "Granulite trend" and "Amphibolite trend" from Hollander (1970).

b. W+% TiO_2 distribution between hornblende and biotite. "Trend of Hollander (1970)" is for upper amphibolite facies rocks.



288-76
335-110
"granulite trend"
335-716
335-483
335-45
335-717
"amphibolite trend"
335-601
·8
·6
·4
·2
0
·1
·2
·3
·4
Wt% MnO in Hbl
Wt% MnO in Biot
a



3·0
2·0
1·0
288-76
335-110
335-483
335-45
335-717
335-716
trend of
Hollander (1970)
335-601
0
2·0
4·0
6·0
8·0
Wt% TiO2 in Hbl
Wt% TiO2 in Biot
b

Figure 6.1

Petrogenetic grid showing estimated P-T conditions of co-existing garnet and cordierite pairs from the literature. Symbols are:

triangles - calibration of Hensen and Green (1973)

squares - calibration of Currie (1971)

circles - calibration of Hutcheon, Froese and Gordon (1974).

1. Muscovite + quartz $\rightleftarrows$ K feldspar + Al_2SiO_5 + H_2O PH_2O = PL (Winkler 1967)

1a. ditto PH_2O = 2 K bars (Winkler 1967)

2. Orthoamphibole $\rightleftarrows$ orthopyroxene PH_2O=PL (Touret 1971a)

2a. ditto PH_2O=2 K bars (Touret 1971a)

3. Hornblende breakdown. PH_2O = PL (Touret 1971a)

3a. ditto PH_2O = 2 K bars (Touret 1971a)

3b. ditto at higher PH_2O=PL (Lambert and Wyllie, 1972)

4. Hornblende (i) + quartz $\rightleftarrows$ Hornblende (2) + orthopyroxene + clinopyroxene + plagioclase PH_2O = PL (Binns, 1969b)

4a. ditto PH_2O = 0.5PL (Binns, 1969b)

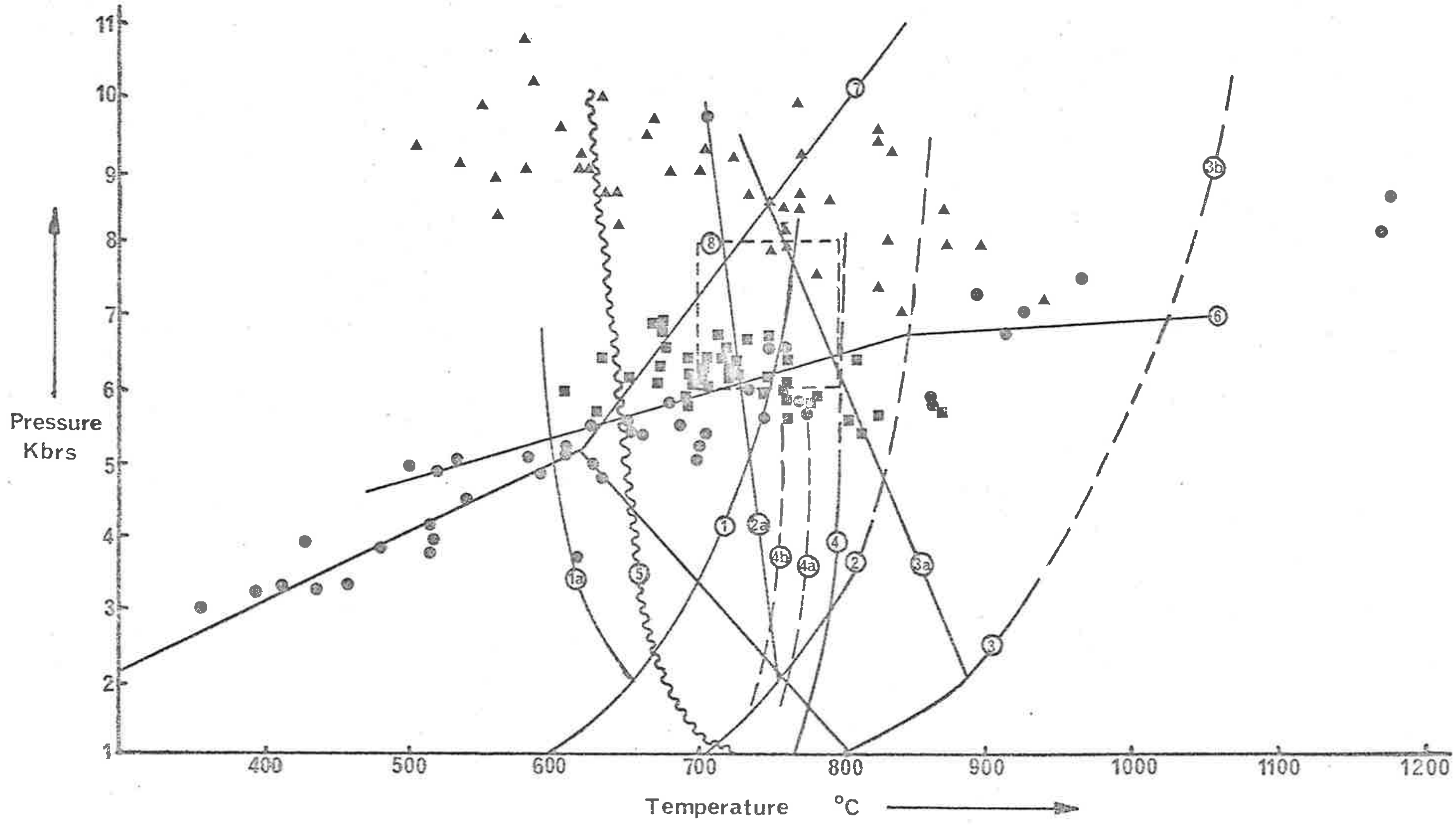
4b. ditto PH_2O = 0.3PL (Binns, 1969b)

5. Beginning of melting of hydrous granite (Winkler, 1967)

6. Upper stability limit for anhydrous Mg cordierite (Newton et. al. 1974)

7. Al_2SiO_5 stability fields (Richardson et. al. 1969)

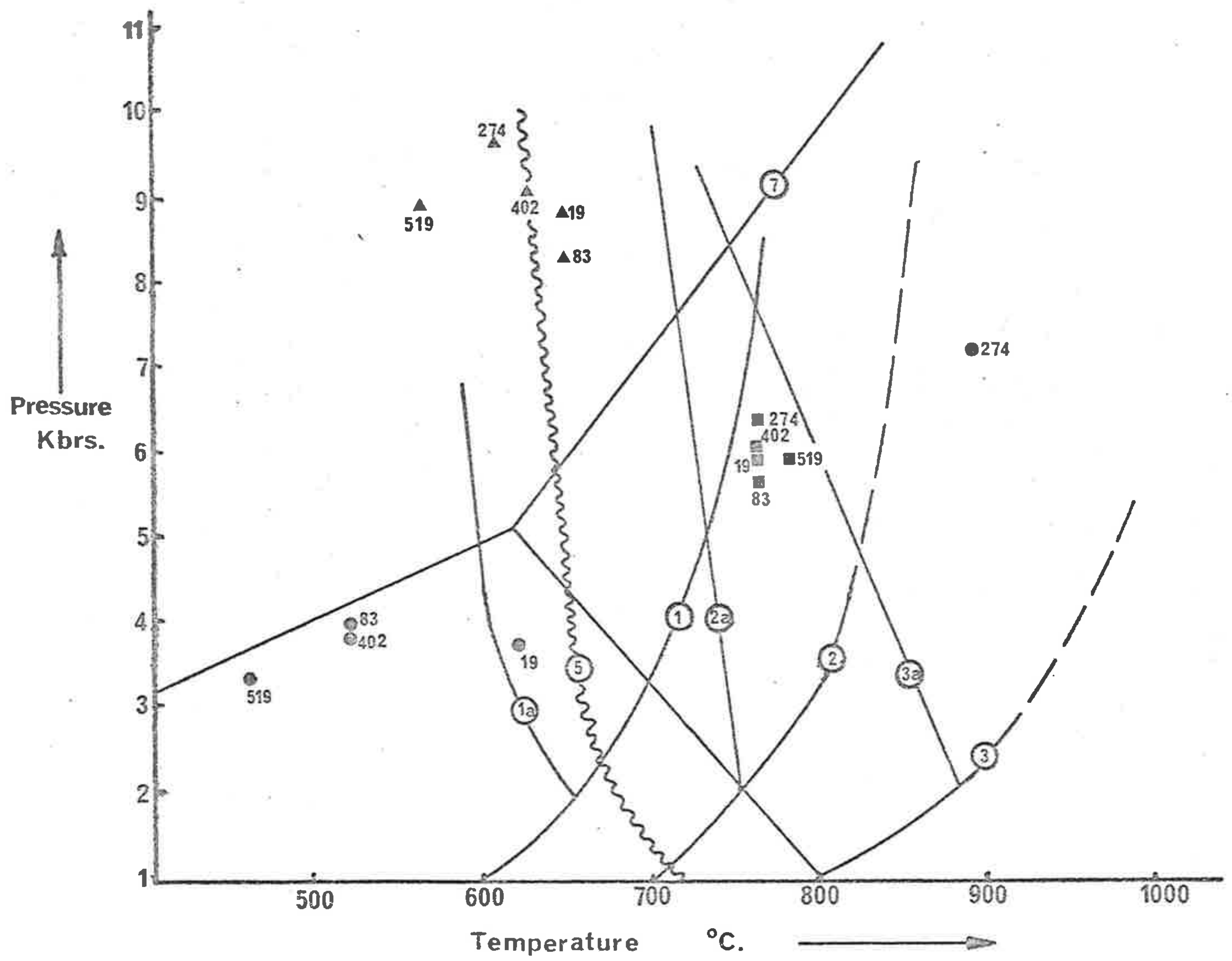
8. Field of granulites from fluid inclusion studies (Touret, 1971b).



Pressure
Kbrs
Temperature °C
1
2
3
4
5
6
7
8
9
10
11
400
500
600
700
800
900
1000
1100
1200
1
1a
2
2a
3
3a
3b
4
4a
4b
5
6
7
8

Figure 6.2

Petrogenetic grid showing estimated P-T conditions of co-existing garnet and cordierite pairs from rocks of the Windmill Islands. Symbols and curve numbers as in Fig. 6.1.



Pressure
Kbrs.
Temperature °C.
11
10
9
8
7
6
5
4
3
2
1
500
600
700
800
900
1000
1
1a
2
2a
3
3a
5
7
274
402
519
19
83
274
402
519
19
83
274
83
402
519
19
274

WHOLE ROCK ANALYSES: ACID LITHOLOGIES

	335-1	335-15	335-21	335-24	335-30	335-32	335-35	335-50	335-74	335-82	335-100	335-113	335-114	335-115	335-122
SiO_2	73.55	74.23	72.35	73.14	73.76	75.69	74.77	70.60	74.23	71.42	73.67	76.19	73.95	71.16	75.67
Al_2O_3	14.23	13.60	14.77	15.22	14.85	13.17	13.75	15.67	15.01	14.79	14.57	12.88	13.24	15.09	12.93
Fe_2O_3	.35	*1.24	.36	.48	.45	.14	.65	1.05	.02	.54	.83	.47	.92	1.18	.74
FeO	.98	-	1.13	1.35	1.18	1.00	.64	1.54	.59	1.35	1.28	.94	1.29	1.51	1.15
CaO	1.83	.94	2.52	3.25	2.99	1.54	1.32	3.15	.71	2.15	2.27	1.79	1.69	2.03	1.32
Na_2O	4.63	3.63	6.87	5.13	5.34	3.35	3.79	4.20	4.85	5.21	4.26	4.18	5.30	4.35	3.36
MgO	.28	.13	.61	.54	.48	.47	.32	1.12	.13	1.06	.50	.40	.16	.34	.63
K_2O	3.90	5.70	2.12	1.14	1.20	4.36	4.72	1.89	4.92	3.36	2.65	2.86	2.98	3.39	4.61
TiO_2	.13	.11	.07	.13	.13	.01	.09	.21	.02	.27	.18	.12	.08	.31	.13
MnO	.01	.00	.11	.05	.03	.11	.02	.03	.07	.03	.03	.01	.00	.05	.00
P_2O_5	.00	.11	.01	.00	.00	.01	.01	.00	.00	.06	.03	.00	.04	.10	.00
H_2O^+	.28	.22	.32	.31	.27	.19	.42	.40	.33	.74	.62	.55	.26	.32	.37
Total	100.17	99.91	101.24	100.74	100.68	100.04	100.50	99.86	100.88	100.97	100.89	100.39	99.91	99.83	100.91
Rb (ppm)	131	325	85	53	61	121	163	62	205	162	85	91	81	119	123
Sr "	209	25	298	301	265	134	147	240	78	317	158	223	186	215	233
Pb "	39	-	32	25	24	42	35	27	62	34	30	26	30	36	51
Th "	8	-	18	<2	8	<2	13	8	5	15	10	6	21	39	45
K/Rb	298	175	249	215	197	360	290	305	240	207	312	314	368	285	375
Rb/Sr	.627	13.0	.285	.176	.23	.903	1.109	.258	2.628	.511	.538	.408	.435	.553	.528
Th/K(x10^4)	2.05	-	29.51	-	6.67	-	2.75	4.23	1.02	4.46	3.77	2.10	7.05	11.5	9.76
K/Pb	1000	-	663	456	500	1038	1349	700	793	988	833	1100	993	942	904
Oxidation Ratio	24.3	-	22.3	24.2	25.5	11.2	47.7	38.0	2.9	26.5	36.8	31.0	39.1	41.3	36.7

	335-144	335-151	335-219	335-313	335-321	335-324	335-375	335-380	335-400B	335-445	335-495	335-502	335-673	288-12
SiO_2	74.13	73.53	69.76	71.57	71.20	72.73	73.67	70.52	74.41	75.37	74.95	72.78	69.47	76.48
Al_2O_3	13.86	13.97	14.74	14.19	14.47	14.49	14.42	14.33	13.67	14.89	14.16	15.19	14.28	12.81
Fe_2O_3	.16	.40	*2.45	.70	1.10	.57	.28	.86	.78	.03	.35	.07	1.38	.50
FeO	.68	.58	-	1.77	1.72	1.53	.68	2.27	.72	.86	.75	.13	1.90	.97
CaO	1.27	1.79	1.63	1.95	3.75	2.06	1.50	2.09	.40	1.47	1.14	.21	1.66	1.01
Na_2O	4.34	3.96	2.78	3.09	4.06	5.00	4.72	4.01	3.63	5.41	3.53	2.66	2.80	2.44
MgO	.67	.23	.40	.32	2.77	.59	.19	1.84	.21	.22	.32	.16	.68	.11
K_2O	5.33	3.95	6.80	5.40	.76	2.91	4.21	3.02	5.39	1.95	5.20	9.29	6.03	6.06
TiO_2	.04	.05	.69	.39	.09	.19	.07	.34	.12	.01	.08	.01	.50	.23
MnO	.05	.00	.00	.03	.02	.06	.02	.79	.01	.19	.06	.00	.02	.02
P_2O_5	.03	.03	.16	.15	.06	.03	.00	.14	.00	.03	.00	.00	.21	.11
H_2O^+	.19	.26	.23	.26	.37	.52	.30	.21	.29	.16	.27	.11	.30	.17
Total	100.75	98.75	99.64	99.82	100.37	100.68	100.06	100.42	99.63	100.59	100.81	100.61	99.23	100.91
Rb (ppm)	185	112	243	140	35	94	143	172	298	91	234	263	335	196
Sr "	247	247	188	155	300	183	194	225	77	34	109	118	102	97
Pb "	34	333	-	25	14	41	43	36	45	52	68	90	61	49
Th "	<2	13	-	14	<2	15	7	7	30	<2	17	<2	135	28
K/Rb	288	353	280	386	217	310	294	176	181	214	222	353	180	309
Rb/Sr	.749	.453	1.29	.903	.117	.514	.737	.764	3.87	2.676	2.147	2.229	3.284	2.021
Th/K(x10^4)	-	3.29	-	2.59	-	5.15	1.66	2.32	5.57	-	3.27	-	22.39	4.62
K/Pb	1568	119	-	2160	543	710	797	839	1198	375	765	1032	988	1237
Oxidation Ratio	17.5	38.3	-	26.2	36.5	25.1	27.0	25.4	49.3	3.0	29.6	-	39.5	31.7

*Total Fe as Fe_2O_3

WHOLE ROCK ANALYSES: PELITIC & INTERMEDIATE LITHOLOGIES

	335-19	335-73	335-83	335-274	335-402	335-519	335-329	335-160	335-308	288-30
SiO_2	70.46	50.73	61.07	64.87	64.44	63.32	66.17	68.44	68.82	73.99
Al_2O_3	13.31	20.65	17.42	14.78	14.40	15.80	9.03	12.96	11.90	11.57
Fe_2O_3	2.15	6.20	5.10	4.16	3.66	2.78	6.39	1.80	.93	1.96
FeO	4.57	7.82	7.77	6.18	5.11	5.85	6.22	4.42	3.48	3.63
CaO	1.87	.65	.80	2.02	1.25	1.95	1.87	5.65	7.97	1.33
Na_2O	2.02	.70	1.12	1.81	1.56	2.52	1.62	2.83	1.21	1.17
MgO	1.74	3.19	2.11	2.33	4.19	2.16	3.48	2.90	4.19	1.87
K_2O	2.79	5.33	2.78	2.00	3.07	3.25	1.91	.24	.13	3.54
TiO_2	.82	1.39	1.66	1.08	1.12	.99	1.43	.26	.31	.62
MnO	.16	.20	.16	.23	.17	.15	.51	.15	.11	.09
P_2O_5	.17	.23	.23	.21	.16	.26	.40	.10	.15	.07
H_2O^+	.50	3.09	.72	1.05	1.81	1.07	.28	.33	.49	.31
Total	100.56	100.18	100.94	100.72	100.94	100.10	99.31	100.08	99.69	100.15
Rb (ppm)	153	257	198	150	225	266	108	26	29	209
Sr "	166	71	105	143	163	154	44	225	225	89
Pb "	28	17	17	26	27	25	14	13	11	22
Th "	6	14	7	10	8	11	12	<2	2	7
K/Rb	182	207	140	133	136	122	177	92	45	169
Rb/Sr	.922	3.62	1.886	1.049	1.38	1.727	2.454	.116	.129	2.348
Th/K ($\times 10^4$)	2.15	2.63	2.52	5.0	2.6	3.38	6.28	-	15.38	1.98
K/Pb	996	3135	1635	769	1137	1300	1364	185	118	1609
Oxidation Ratio	29.7	41.6	37.1	37.7	39.2	30	48.0	26.8	19.4	32.7

WHOLE ROCK ANALYSES: BASIC LITHOLOGIES

	335-12A	335-45	335-110	335-254	335-307	335-483	335-601	335-602	335-640A	335-641	335-648	335-716	335-717A	AN71-3B	288-19	288-46	288-76
SiO_2	45.41	54.85	63.08	47.50	45.00	53.03	49.38	47.52	52.76	51.65	57.10	58.71	49.64	46.47	41.85	55.08	56.61
Al_2O_3	11.69	15.19	10.15	14.74	8.58	16.33	14.06	10.20	13.73	15.67	15.84	15.96	14.75	12.58	15.04	16.74	17.04
Fe_2O_3	3.85	5.34	4.55	3.59	5.04	3.50	2.93	2.60	1.39	3.92	2.92	2.66	4.44	3.52	6.99	3.99	2.80
FeO	9.53	6.71	5.83	9.98	7.55	6.60	8.03	8.92	5.91	5.64	4.30	3.51	8.62	12.52	10.33	5.51	5.48
CaO	9.67	8.12	6.47	9.56	13.46	8.94	8.44	10.58	6.88	8.14	7.89	7.58	9.12	10.89	10.98	7.75	11.01
Na_2O	1.96	2.38	1.27	2.65	1.70	3.76	2.02	1.49	2.87	3.90	2.78	3.93	2.56	1.71	1.70	3.69	1.30
MgO	9.40	5.61	4.97	6.09	15.25	5.89	11.52	14.19	10.86	5.29	5.44	4.49	7.07	9.71	8.89	3.86	3.80
K_2O	1.93	.72	.35	1.29	.25	.40	1.26	.98	3.39	1.53	1.54	.76	.72	.15	.43	1.50	.16
TiO_2	3.40	.78	.76	1.36	1.55	.70	.42	.43	.48	1.47	1.05	.36	1.67	1.71	2.46	1.49	1.04
MnO	.24	.26	.40	.33	.20	.23	.19	.72	.23	.25	.19	.14	.30	.45	.24	.23	.30
P_2O_5	1.50	.21	.30	.69	.22	.17	.13	.06	.26	.80	.37	.18	.06	.20	.27	.55	.23
H_2O^+	1.12	.67	.66	1.44	.51	.41	1.09	2.13	1.26	.78	.69	.67	.64	.81	.38	.25	.86
Total	99.68	100.19	98.97	99.22	99.31	99.96	99.34	99.82	100.02	99.04	100.11	98.97	99.59	100.72	99.56	100.64	100.63
Rb (ppm)	155	50	40	55	33	57	100	56	186	79	98	39	71	35	36	87	36
Sr "	724	243	103	1063	74	161	147	39	362	478	359	371	161	121	248	351	192
Pb "	12	13	14	15	13	11	14	12	20	16	13	29	12	<10	11	17	16
Th "	4	2	3	2	2	2	<2	4	3	2	<2	8	3	3	2	2	9
K/Rb	125	144	87	235	76	70	129	175	182	194	157	200	101	43	119	172	44
Rb/Sr	.214	.206	.388	.052	.446	.354	.68	1.436	.514	.165	.273	.105	.441	.289	.145	.248	.187
Th/K($\times 10^4$)	2.07	2.78	8.57	1.55	8.0	5.0	-	4.08	.88	1.31	-	10.53	4.17	20.0	4.65	1.33	56.25
K/Pb	1608	554	250	860	192	364	900	817	1695	956	1185	262	600	-	391	882	100
Oxidation Ratio	26.7	41.7	41.3	24.5	37.5	32.3	24.7	20.8	17.4	38.5	38.0	40.5	31.7	20.2	37.8	39.5	31.5

C.I.P.W. NORMS: ACID LITHOLOGIES

	335-1	335-15	335-21	335-24	335-30	335-32	335-35	335-50	335-74	335-82	335-100	335-113	335-114	335-115	335-122
Qtz	27.30	29.22	19.14	30.49	30.63	34.67	31.14	29.76	24.94	22.17	32.57	36.17	28.29	27.68	34.13
Corun	-	.01	-	-	-	.16	.03	.99	.42	-	.64	-	-	.81	.01
Or	23.05	33.69	12.53	6.74	7.09	25.77	27.89	11.17	29.08	19.86	15.66	16.90	17.61	20.03	27.24
Ab	39.18	30.72	58.13	3.41	45.19	28.35	32.07	35.54	41.04	44.09	36.05	35.37	44.85	36.81	28.43
An	6.53	3.94	3.20	15.14	13.01	7.57	6.48	15.63	3.52	7.05	11.07	7.94	3.54	9.42	6.55
Di Wo	1.07	-	3.40	.41	.76	-	-	-	-	1.35	-	.39	1.76	-	-
En	.38	-	1.52	.17	.32	-	-	-	-	.79	-	.18	.40	-	-
Fs	.71	-	1.87	.25	.44	-	-	-	-	.49	-	.21	1.48	-	-
Wo	-	-	.45	-	-	-	-	-	-	-	-	-	.15	-	-
Hy En	.32	.32	-	1.18	.87	1.17	.80	2.79	.32	1.85	1.25	.82	-	.85	1.57
Fs	.60	.39	-	1.71	1.19	1.91	.53	1.67	1.16	1.15	1.42	.95	-	1.38	1.29
Mag	.51	1.03	.52	.70	.65	.20	.94	1.52	.03	.78	1.20	.68	1.33	1.71	1.07
Ilm	.25	.21	.13	.25	.25	.02	.17	.40	.04	.51	.34	.23	.15	.59	.25
Hem	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apat	-	.26	.02	-	-	.02	.02	-	-	.14	.07	-	.09	.23	-
TOTAL	99.89	99.79	100.92	100.43	100.41	99.85	100.08	99.46	100.55	100.23	100.27	99.84	99.65	99.51	100.54
Or	33.5	49.3	17.0	10.3	10.9	41.8	42.0	17.9	39.5	28.0	25.0	28.1	26.7	30.2	43.8
Ab	57.0	44.9	78.7	66.5	69.2	45.9	48.2	57.0	55.7	62.1	57.1	58.7	67.9	55.6	45.7
An	9.5	5.8	4.3	23.2	19.9	12.3	9.8	25.1	4.8	9.9	9.9	13.2	5.4	14.2	10.5

	335-144	335-151	335-219	335-313	335-321	335-324	335-375	335-380	335-400B	335-445	335-495	335-502	335-673	288-12
Qtz	25.09	30.99	23.93	27.75	31.71	26.65	26.55	26.82	31.27	32.18	31.11	20.99	25.41	36.61
Corun	-	-	.23	.08	.29	-	-	1.00	1.14	1.28	.65	.38	.63	.66
Or	31.50	23.34	40.19	31.91	4.49	17.20	24.88	17.85	31.85	11.52	30.73	54.90	35.64	35.81
Ab	36.72	33.51	23.52	26.15	34.36	42.31	39.94	33.93	30.72	45.78	29.87	22.51	23.69	20.65
An	2.60	8.68	7.04	8.69	18.21	8.50	5.73	9.45	1.98	7.10	5.66	1.04	6.86	4.29
Di Wo	1.46	-	-	-	-	.64	.72	-	-	-	-	-	-	-
En	.83	-	-	-	-	.26	.25	-	-	-	-	-	-	-
Fs	.57	-	-	-	-	.38	.49	-	-	-	-	-	-	-
Wo	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hy En	.84	.57	1.00	.80	6.90	1.21	.23	4.58	.52	.55	.80	.40	1.69	.27
Fs	.57	.65	-	2.08	2.14	1.76	.45	4.37	.50	1.89	1.07	.16	1.56	1.03
Mag	.23	.58	1.39	1.01	1.59	.83	.41	1.25	1.13	.04	.51	.10	2.00	.72
Ilm	.08	.09	1.31	.74	.17	.36	.13	.65	.23	.02	.15	.02	.95	.44
Hem	-	-	.44	-	-	-	-	-	-	-	-	-	-	-
Apat	.07	.07	.37	.35	.14	.07	-	.33	-	.07	-	-	.49	.26
TOTAL	100.56	99.49	99.41	99.56	100.00	100.16	99.76	100.22	99.34	100.43	100.54	100.50	98.93	100.74
Or	44.5	35.6	56.8	47.8	7.9	25.3	35.3	29.2	49.3	17.9	46.4	70.0	53.8	58.9
Ab	51.8	51.1	33.2	39.2	60.2	62.2	56.6	55.4	47.6	71.1	45.1	28.7	35.8	34.0
An	3.7	13.3	10.0	13.0	31.9	12.5	8.1	15.4	3.1	11.0	8.5	1.3	10.4	7.1

CATANORMS: PELITIC & INTERMEDIATE LITHOLOGIES

	335-19	225-73	335-83	335-274	335-402	335-519	335-329	335-160	335-308	288-30
Qtz	36.30	6.05	25.24	31.66	29.30	23.24	38.66	31.26	36.75	43.46
Or	17.02	33.57	17.18	12.33	18.81	19.87	12.01	1.45	.80	21.77
Ab	18.73	6.70	10.52	16.96	14.53	23.41	15.48	26.04	11.26	10.93
An	8.43	1.84	2.58	9.03	5.35	8.25	7.09	22.50	27.62	6.39
Sill	-	-	.76	-	-	-	-	-	-	-
Diop	-	-	-	-	-	-	-	3.71	8.97	-
Hyp	-	-	-	-	-	-	8.01	12.33	12.59	-
Pyral	10.65	1.45	-	10.23	17.45	12.94	8.62	-	-	10.01
Cord	5.00	40.92	35.22	13.23	8.62	7.30	-	-	-	4.25
Apat	.37	.51	.50	.46	.35	.56	.89	.21	.33	.15
Mag	2.32	6.91	5.58	4.54	3.97	3.01	7.11	1.93	1.01	2.13
Ilm	1.18	2.06	2.42	1.57	1.62	1.43	2.12	-	-	.90
Sph	-	-	-	-	-	-	-	.56	.67	-

CATANORMS: BASIC LITHOLOGIES

	335-12A	335-45	335-110	335-254	335-307	335-483	335-601	335-602	335-640A	335-641	335-648	335-716	335-717A	AN71-3B	288-19	288-46	288-76
Qtz	-	10.83	31.84	-	-	1.29	-	-	-	-	10.00	10.54	.21	-	-	5.55	17.97
Or	11.76	4.33	2.19	7.92	1.48	2.37	7.50	5.87	19.81	9.22	9.20	4.56	4.36	.90	2.62	8.91	.97
Ab	18.15	21.78	12.10	24.72	11.34	33.92	18.27	13.55	25.49	35.70	25.25	35.81	23.56	15.65	15.75	33.33	12.03
An	17.94	29.19	22.25	25.48	15.11	26.63	25.77	18.49	14.41	21.14	26.50	24.02	27.30	26.72	33.17	24.84	41.41
Neph	-	-	-	-	2.39	-	-	-	-	-	-	-	-	-	-	-	-
Diop	7.37	6.16	5.54	11.36	36.08	11.50	11.27	26.22	12.82	7.59	5.56	9.35	10.18	16.77	9.91	4.01	7.67
Hyp	12.55	19.92	18.67	11.28	-	18.78	20.30	8.66	2.89	16.48	17.39	11.77	25.92	17.68	3.67	-	14.19
Ol	17.53	-	-	10.89	24.59	-	12.66	23.47	21.62	.86	-	-	-	14.45	21.43	14.87	-
Apat	3.23	.45	.67	1.50	.46	.36	.27	.13	.54	1.71	.78	.38	.13	.43	.58	1.16	.50
Mag	4.15	5.69	5.05	3.90	5.29	3.68	3.09	2.75	1.44	4.18	3.09	2.82	4.76	3.75	7.54	4.20	3.02
Ilm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sph	7.33	1.66	1.69	2.95	3.25	1.47	.88	.91	.99	3.13	2.22	.76	3.58	3.64	5.31	3.13	2.24

TABLE 5.1: GARNET ANALYSES

	335-19	335-83	335-274	335-329	335-402	335-519	288-30
SiO_2	37.05	36.05	37.54	37.95	37.23	37.06	38.05
Al_2O_3	21.00	20.87	21.34	21.65	21.00	21.03	21.52
* Fe_2O_3	1.56	1.65	1.59	1.23	1.49	1.59	1.43
FeO	29.56	31.30	30.24	23.39	28.39	30.13	27.18
CaO	.75	.93	1.24	1.52	.98	1.12	1.04
Na_2O	.01	.01	.03	-	.04	.05	.04
MgO	3.97	3.27	5.64	7.63	3.94	3.28	8.37
K_2O	.01	-	-	-	-	-	-
TiO_2	-	-	.03	.06	-	.02	.07
MnO	4.20	4.04	1.94	7.03	6.52	5.61	1.66
Cr_2O_3	.01	.02	.04	-	.01	.03	-
BaO	-	-	-	-	.04	.03	-
Total	98.12	98.14	99.63	100.46	99.64	99.95	99.36

* $\frac{Fe(total)}{Fe^{3+}} = 20$

Mg/(Mg+Fe+Mn)	.173	.141	.238	.308	.168	.140	.351

MINERAL FORMULA (0 = 24)

	335-19	335-83	335-274	335-329	335-402	335-519	288-30
Si	6.007	5.911	5.951	5.908	5.976	5.959	5.944
Al^{IV}	-	.089	.049	.092	.024	.041	.056
Al^{VI}	4.013	3.945	3.938	3.880	3.949	3.945	3.906
Fe^{3+}	.190	.204	.190	.144	.180	.192	.168
Fe^{2+}	4.008	4.292	4.009	3.045	3.811	4.052	3.551
Ti	-	-	.004	.007	-	.002	.008
Cr	.001	.003	.005	-	.001	.004	-
Mg	.960	.799	1.333	1.771	.943	.786	1.949
Mn	.577	.561	.261	.927	.886	.764	.220
Ca	.130	.163	.211	.254	.169	.193	.174
Na	.003	.003	.009	-	.012	.016	.012

TABLE 5.2: CORDIERITE ANALYSES

	335-19	335-83	335-274	335-402	335-519
SiO_2	47.88	47.24	48.49	47.87	48.09
Al_2O_3	32.68	32.47	32.75	32.69	32.99
*Fe_2O_3	.42	.49	.34	.39	.44
FeO	7.90	9.29	6.45	7.49	8.35
CaO	-	.02	-	.03	.02
Na_2O	.13	.07	.21	.46	.12
MgO	7.85	7.22	9.01	7.69	7.65
K_2O	.01	-	-	.01	-
TiO_2	-	.01	-	-	-
MnO	.32	.25	.12	.56	.45
Cr_2O_3	.02	-	.03	-	-
BaO	-	-	-	-	.01
Total	97.21	97.06	97.39	97.19	98.12

*$\frac{Fe(total)}{Fe^{3+}} = 20$

Mg/(Mg+Fe+Mn)	.629	.574	.709	.630	.609

MINERAL FORMULA (O = 18)

Si	4.989	4.964	5.004	4.988	4.977
Al^{IV}	1.011	1.036	.996	1.012	1.023
Al^{VI}	3.002	2.985	2.987	3.003	3.001
Fe^{3+}	.033	.038	.027	.031	.034
Fe^{2+}	.689	.816	.557	.653	.723
Mg	1.219	1.131	1.386	1.195	1.180
Mn	.028	.022	.010	.050	.040
Na	.026	.014	.042	.093	.024
OH	1.250	1.260	1.240	1.250	1.240

TABLE 5.3: HORNBLENDE ANALYSES

	335-45	335-110	335-307	335-308	335-483	335-601	335-602	335-629L	335-629M	335-716	335-717A	288-19	288-76
SiO_2	43.57	42.74	44.34	47.11	44.51	45.80	46.46	41.53	41.26	44.63	44.46	42.33	43.42
Al_2O_3	9.88	9.78	10.59	7.73	9.56	8.98	8.61	10.00	9.69	9.06	9.82	10.62	10.31
*Fe_2O_3	3.49	3.17	2.41	2.55	3.91	3.05	2.90	4.71	4.90	3.76	4.03	3.30	4.16
FeO	10.48	9.53	7.23	7.65	11.75	9.13	8.71	14.13	14.70	11.27	12.08	9.92	12.47
CaO	11.92	11.32	12.14	12.31	11.85	12.33	11.92	11.55	11.35	12.32	11.52	11.90	11.80
Na_2O	1.33	1.39	1.92	1.55	1.55	1.15	1.17	1.62	1.68	1.33	1.31	1.85	1.41
MgO	11.93	12.70	15.03	15.88	11.68	14.33	14.55	8.94	9.00	12.39	11.00	12.94	10.58
K_2O	1.15	1.31	.64	.46	.60	.97	.90	1.54	1.52	.81	.61	1.31	.73
TiO_2	1.69	2.87	2.29	1.88	2.14	.60	.75	3.68	3.31	1.43	1.37	2.96	2.88
MnO	.39	.68	.12	.20	.43	.14	.53	.42	.34	.46	.27	.24	.80
Cr_2O_3	.01	.04	.21	.04	.02	.26	.32	.05	-	.05	.03	.05	.00
BaO	.07	.10	.14	.14	.04	.01	.02	.10	.10	.03	.10	.15	.06
Total	95.92	95.63	97.06	97.50	98.04	96.75	96.84	98.27	97.85	97.53	96.60	97.57	98.62
*$\frac{Fe(total)}{Fe^{3+}} = 4$													
$\frac{Mg}{(Mg+Fe+Mn)}$	.662	.688	.784	.783	.632	.733	.738	.522	.515	.653	.613	.695	.586
MINERAL FORMULA (O = 23)													
Si	6.558	6.444	6.467	6.818	6.572	6.744	6.813	6.279	6.286	6.621	6.653	6.285	6.436
Al^{IV}	1.442	1.556	1.533	1.182	1.428	1.256	1.187	1.721	1.714	1.379	1.347	1.715	1.564
Al^{VI}	.311	.182	.287	.137	.235	.303	.302	.061	.026	.205	.385	.144	.206
Fe^{3+}	.395	.360	.265	.278	.434	.338	.320	.536	.562	.420	.454	.369	.464
Fe^{2+}	1.319	1.202	.882	.926	1.451	1.124	1.068	1.787	1.873	1.398	1.512	1.232	1.546
Ti	.191	.325	.251	.205	.238	.066	.083	.418	.379	.160	.154	.331	.321
Cr	.001	.005	.024	.005	.002	.030	.037	.006	-	.006	.004	.006	-
Mg	2.677	2.854	3.268	3.426	2.571	3.146	3.181	2.015	2.044	2.740	2.454	2.864	2.338
Mn	.050	.087	.015	.025	.054	.017	.066	.054	.044	.058	.034	.030	.100
Ca	1.922	1.829	1.897	1.909	1.875	1.945	1.873	1.871	1.853	1.958	1.847	1.893	1.874
Na	.388	.406	.543	.435	.444	.328	.333	.475	.496	.383	.380	.533	.405
K	.221	.252	.119	.085	.113	.182	.168	.297	.295	.153	.116	.248	.138
OH	1.506	1.509	1.459	1.448	1.477	1.473	1.467	1.513	1.525	1.484	1.497	1.486	1.483

TABLE 5.4: CLINOPYROXENE ANALYSES

	335-12A	335-110	335-254	335-307	335-308	335-601	335-602	335-640A	335-641	335-648	AN71-3B	288-19	288-46
SiO_2	51.22	52.20	50.52	52.44	52.23	52.93	52.31	51.43	49.67	51.01	51.11	50.31	51.35
Al_2O_3	1.95	1.66	1.51	1.99	1.56	1.41	1.20	1.82	1.86	2.19	2.03	2.78	1.78
$*Fe_2O_3$	.68	.57	.84	.39	.55	.56	.53	.57	.62	.65	.80	.69	.69
FeO	9.54	7.98	11.83	5.41	7.72	7.87	7.42	7.98	8.75	9.15	11.13	9.66	9.73
CaO	20.60	22.33	22.02	23.17	23.04	22.86	22.14	22.51	21.69	22.24	21.81	21.65	21.90
Na_2O	.56	.36	.31	.29	.34	.32	.32	.67	.51	.39	.30	.44	.48
MgO	12.55	13.50	11.11	15.03	14.24	13.86	13.71	13.63	12.96	13.32	12.33	13.15	12.93
K_2O	-	-	-	.01	.01	-	-	-	-	-	-	-	-
TiO_2	.41	.26	.25	.41	.31	.08	.09	.31	.28	.48	.41	.71	.48
MnO	.34	1.28	.46	.21	.35	.29	.78	.44	.63	.51	.40	.40	.76
Cr_2O_3	.02	-	-	.13	.01	.08	.07	.21	.04	-	.04	-	-
BaO	.01	-	.05	.01	.01	.04	-	-	-	.02	.03	.02	-
Total	97.88	99.14	98.90	99.49	100.37	100.30	98.57	99.57	97.01	99.96	100.39	99.81	100.10
Mg/(Mg+Fe+Mn)	.678	.722	.617	.827	.759	.753	.749	.743	.711	.711	.655	.699	.687
MINERAL FORMULA (O = 6)													
Si	1.959	1.938	1.946	1.944	1.943	1.966	1.975	1.934	1.926	1.919	1.928	1.898	1.934
Al^{IV}	.041	.062	.054	.056	.057	.034	.025	.066	.074	.081	.072	.102	.066
Al^{VI}	.047	.012	.014	.031	.011	.028	.029	.014	.011	.016	.018	.022	.013
Fe^{3+}	.020	.016	.024	.011	.015	.016	.015	.016	.018	.018	.023	.020	.020
Fe^{2+}	.305	.253	.381	.168	.240	.245	.234	.251	.284	.288	.351	.305	.306
Ti	.012	.007	.007	.011	.009	.002	.003	.009	.008	.014	.012	.020	.014
Cr	.001	-	-	.004	-	.002	.002	.006	.001	-	.001	-	-
Mg	.715	.762	.638	.831	.789	.768	.772	.764	.749	.747	.693	.740	.726
Mn	.011	.041	.015	.007	.011	.009	.025	.014	.021	.016	.013	.013	.024
Ca	.844	.905	.909	.920	.918	.910	.896	.907	.901	.896	.881	.875	.884
Na	.042	.026	.023	.021	.025	.023	.023	.049	.038	.028	.022	.032	.035

$*\frac{Fe(total)}{Fe^{3+}} = 15$

TABLE 5.5: BIOTITE ANALYSES

	335-12A	335-19	335-45	335-83	335-110	335-115	335-160	335-254	335-274	335-321	335-329	335-380	335-402	335-483	335-519	335-601	335-640A	335-641	335-648	335-716	335-717A	AN71-3B	288-12	288-30	288-46	288-76
SiO_2	37.96	34.17	36.56	33.57	36.51	35.58	35.64	35.53	35.64	28.34	35.51	36.64	34.51	36.42	34.35	36.50	39.41	37.17	38.00	35.91	34.70	37.41	36.42	36.30	38.04	36.26
Al_2O_3	12.71	17.76	13.86	17.63	13.70	15.38	14.19	13.43	15.81	14.38	14.99	14.34	18.25	14.64	18.75	14.51	12.72	12.53	13.03	15.18	15.02	13.37	15.08	14.76	13.25	14.89
$*Fe_2O_3$	1.58	2.74	2.08	2.97	1.81	2.57	2.36	2.52	2.38	3.08	1.80	1.84	2.68	2.31	2.73	2.14	1.18	1.43	1.52	2.15	2.48	1.56	2.06	1.75	1.72	2.57
FeO	10.24	17.80	13.56	19.32	11.79	16.69	15.34	16.39	15.46	20.00	11.71	11.97	17.43	15.05	17.78	13.90	7.71	9.31	9.91	14.00	16.16	10.13	13.41	11.41	11.19	16.73
CaO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na_2O	.10	.15	.07	.11	.16	.14	.02	.04	.16	.03	.13	.08	.10	.01	.15	.08	.06	.05	.03	.04	.04	-	.03	.16	.04	.04
MgO	16.82	7.61	13.87	6.84	14.31	10.76	12.00	11.14	10.38	13.74	13.95	14.79	7.75	13.01	7.81	14.79	19.84	17.00	17.54	13.55	12.13	16.69	14.09	14.50	15.61	11.24
K_2O	9.83	8.94	9.59	9.77	9.16	9.48	9.08	9.13	9.83	1.59	10.46	10.09	9.05	9.74	9.34	8.74	9.94	9.38	9.44	9.15	8.21	10.19	9.44	10.84	9.45	9.11
TiO_2	6.24	4.96	3.96	4.58	7.70	5.88	6.48	6.21	6.04	4.26	9.08	7.69	3.53	6.11	3.51	1.83	4.60	6.73	5.97	4.24	3.31	7.45	5.67	9.13	9.94	7.59
MnO	.04	.15	.26	.06	.36	.23	.13	.10	.07	.29	.12	.10	.26	.27	.20	.31	.07	.10	.11	.18	.11	.06	.18	.02	.15	.25
Cr_2O_3	.13	.03	.02	.02	-	.03	-	.04	-	.09	.07	.02	.01	-	.02	.29	.40	-	.02	.04	.05	.04	-	.02	.01	.04
BaO	1.12	.38	.53	.25	.94	.25	1.66	1.05	.44	.20	.57	.34	.39	.37	.35	.13	.28	.89	.51	.50	.53	.63	.27	.36	.58	.57
Total	96.77	94.69	94.36	95.12	96.44	96.99	96.90	95.58	96.21	86.00	98.39	97.90	93.96	97.93	94.99	93.22	96.21	94.59	96.08	94.94	92.74	97.53	96.65	99.25	99.98	99.27
$*\frac{Fe(total)}{Fe^{3+}}$ = 7.5																										
$\frac{Mg}{(Mg+Fe+Mn)}$	.745	.431	.641	.386	.677	.532	.580	.547	.544	.547	.677	.686	.438	.603	.437	.651	.820	.763	.757	.629	.570	.745	.647	.694	.710	.541
MINERAL FORMULA (O = 22)																										
Si	5.560	5.269	5.563	5.222	5.400	5.339	5.368	5.439	5.368	-	5.173	5.335	5.346	5.374	5.279	5.584	5.681	5.532	5.550	5.424	5.415	5.428	5.382	5.226	5.383	5.310
Al^{IV}	2.194	2.731	2.437	2.778	2.389	2.661	2.519	2.423	2.632	-	2.574	2.461	2.654	2.546	2.721	2.416	2.161	2.198	2.244	2.576	2.585	2.287	2.618	2.505	2.210	2.570
Al^{VI}	-	.496	.049	.455	-	.060	-	-	.175	-	-	-	.683	-	.675	.200	-	-	-	.127	.178	-	.008	-	-	-
Fe^{3+}	.174	.318	.238	.348	.201	.290	.267	.290	.270	-	.197	.202	.312	.256	.316	.246	.128	.160	.168	.244	.291	.170	.229	.190	.183	.283
Fe^{2+}	1.254	2.295	1.726	2.514	1.459	2.095	1.932	2.098	1.947	-	1.427	1.458	2.258	1.857	2.285	1.778	.929	1.159	1.212	1.769	2.109	1.229	1.657	1.374	1.324	2.049
Ti	.687	.575	.453	.536	.857	.664	.734	.715	.684	-	.995	.842	.412	.678	.406	.211	.499	.753	.656	.482	.388	.813	.630	.989	1.058	.836
Cr	.015	.004	.002	.002	-	.004	-	.005	-	-	.008	.002	.001	-	.002	.035	.046	-	.001	.005	.006	.005	-	.002	.001	.005
Mg	3.673	1.749	3.146	1.586	3.155	2.407	2.694	2.542	2.331	-	3.030	3.210	1.789	2.862	1.789	3.373	4.263	3.772	3.822	3.051	2.822	3.610	3.104	3.112	3.293	2.453
Mn	.005	.020	.034	.008	.045	.029	.017	.013	.009	-	.015	.012	.034	.034	.026	.040	.009	.013	.013	.023	.015	.007	.023	.002	.018	.031
Na	.028	.045	.021	.033	.046	.041	.006	.012	.047	-	.037	.023	.030	.003	.045	.024	.017	.014	.009	.012	.012	-	.009	.045	.011	.011
K	1.837	1.759	1.862	1.939	1.729	1.815	1.745	1.783	1.889	-	1.944	1.874	1.789	1.834	1.831	1.706	1.828	1.781	1.760	1.763	1.635	1.886	1.780	1.991	1.706	1.702
Ba	.064	.023	.032	.015	.054	.015	.098	.063	.026	-	.033	.019	.023	.021	.021	.008	.016	.052	.029	.030	.032	.036	.016	.020	.032	.033

TABLE 5.6: ORTHOPYROXENE ANALYSES

	335-12A	335-45	335-110	335-115	335-160	335-254	335-307	335-308	335-321	335-329	335-380
SiO_2	51.95	51.45	50.49	48.29	51.72	50.19	53.80	52.42	51.48	48.59	47.97
Al_2O_3	.75	.94	1.04	3.01	.71	.82	1.16	.94	.71	5.13	5.24
$*Fe_2O_3$	1.90	1.86	1.65	2.38	2.13	2.29	1.32	1.75	2.14	1.77	2.18
FeO	22.74	22.30	19.85	28.52	25.62	27.48	15.89	21.01	25.65	21.26	26.11
CaO	.65	.65	.69	.08	.58	.67	.42	.57	.60	.11	.07
Na_2O	-	.01	-	.02	.04	-	.16	.04	-	-	.02
MgO	20.60	19.10	19.93	15.13	17.17	15.73	24.47	22.39	18.51	19.55	16.44
K_2O	-	-	-	-	.01	-	.01	.01	-	-	-
TiO_2	.10	.10	.19	.14	.08	.05	.18	.15	.12	.23	.27
MnO	.70	1.69	2.83	1.34	.94	1.05	.52	.87	.49	2.36	1.20
Cr_2O_3	.01	.01	.03	.01	-	.01	.06	.04	-	.02	.03
BaO	.03	.02	-	-	.01	-	-	.04	.02	.04	-
Total	99.43	98.13	96.70	98.92	99.01	98.29	99.99	100.23	99.72	99.06	99.53
Mg/(Mg+Fe+Mn)	.611	.587	.610	.474	.536	.496	.742	.646	.558	.596	.518
MINERAL FORMULA (O = 6)											
Si	1.966	1.978	1.961	1.900	1.993	1.974	1.953	1.952	1.968	1.849	1.850
Al^{IV}	.033	.022	.039	.100	.010	.026	.047	.041	.032	.151	.150
Al^{VI}	-	.020	.009	.040	.022	.012	.003	-	-	.079	.088
Fe^{3+}	.054	.054	.048	.070	.062	.068	.036	.049	.062	.051	.063
Fe^{2+}	.720	.717	.645	.802	.826	.904	.482	.654	.820	.677	.842
Ti	.003	.003	.006	.004	.002	.001	.005	.004	.003	.007	.008
Cr	-	-	.001	-	-	-	.002	.001	-	.001	.001
Mg	1.162	1.094	1.154	.986	.987	.922	1.432	1.243	1.055	1.109	.945
Mn	.022	.055	.093	.030	.030	.035	.016	.027	.016	.076	.039
Ca	.026	.027	.029	.023	.024	.028	.016	.023	.025	.004	.003
Na	-	.001	-	.003	.002	-	.011	.003	-	-	.001

	335-601	335-602	335-629L	335-629M	335-640A	335-641	335-648	AN71-3B	288-12	288-19	288-30	288-46
SiO_2	52.78	50.98	49.26	48.56	52.55	50.50	51.54	50.99	50.57	51.94	46.13	52.18
Al_2O_3	1.02	.90	.62	.70	.85	.83	1.19	1.06	3.15	.96	7.48	.89
$*Fe_2O_3$	1.75	1.78	2.61	2.57	1.64	1.69	1.78	2.03	1.80	1.75	1.95	1.88
FeO	21.02	21.42	31.29	30.86	19.72	20.28	21.33	24.33	21.64	20.95	23.45	22.56
CaO	.57	.73	1.17	.72	.63	.61	.69	.85	.14	.54	.06	.90
Na_2O	-	-	-	-	-	-	.01	.02	.06	.03	-	.02
MgO	21.67	20.64	13.01	12.99	22.50	20.63	25.51	18.51	20.48	21.74	18.63	20.00
K_2O	-	.01	.02	.02	-	-	.01	-	.01	-	-	-
TiO_2	.01	.04	.22	.15	-	.17	.18	.20	.12	.10	.14	.24
MnO	.50	1.13	1.56	1.51	1.00	1.40	1.31	.96	1.53	.85	.45	1.75
Cr_2O_3	.07	.06	.02	.01	.07	.01	.02	.04	-	.03	.04	.02
BaO	-	-	-	.04	.02	.01	.03	.02	-	.02	-	-
Total	99.39	97.69	99.80	98.13	98.98	96.13	99.60	99.01	99.50	98.91	99.33	100.44
Mg/(Mg+Fe+Mn)	.642	.620	.414	.417	.660	.629	.668	.566	.611	.639	.582	.594
MINERAL FORMULA (O = 6)												
Si	1.975	1.959	1.956	1.959	1.969	1.965	1.942	1.959	1.908	1.960	1.777	1.962
Al^{IV}	.025	.041	.029	.033	.031	.035	.053	.041	.092	.040	.223	.038
Al^{VI}	.020	-	-	-	.007	.003	-	.007	.048	.003	.116	.001
Fe^{3+}	.049	.051	.078	.078	.046	.049	.050	.059	.051	.050	.057	.053
Fe^{2+}	.658	.688	1.039	1.041	.618	.660	.672	.782	.683	.661	.755	.709
Ti	-	.001	.007	.005	-	.005	.005	.006	.003	.003	.004	.007
Cr	.002	.002	.001	-	.002	-	.001	.001	-	.001	.001	.001
Mg	1.209	1.182	.770	.781	1.257	1.197	1.208	1.060	1.152	1.223	1.070	1.121
Mn	.016	.037	.052	.052	.032	.046	.042	.031	.049	.027	.015	.056
Ca	.023	.030	.050	.031	.025	.025	.028	.035	.006	.022	.002	.036
Na	-	-	-	-	-	-	.001	.001	.004	.002	-	.001

$*Fe(\frac{total}{Fe^{3+}}) = 13$