RELATIONSHIP OF THERMAL EVOLUTION TO TECTONIC PROCESSES IN A PROTEROZOIC FOLD BELT: HALLS CREEK MOBILE ZONE, EAST KIMBERLEY, WEST AUSTRALIA.

by

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A thesis submitted in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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LIST OF FIGURES

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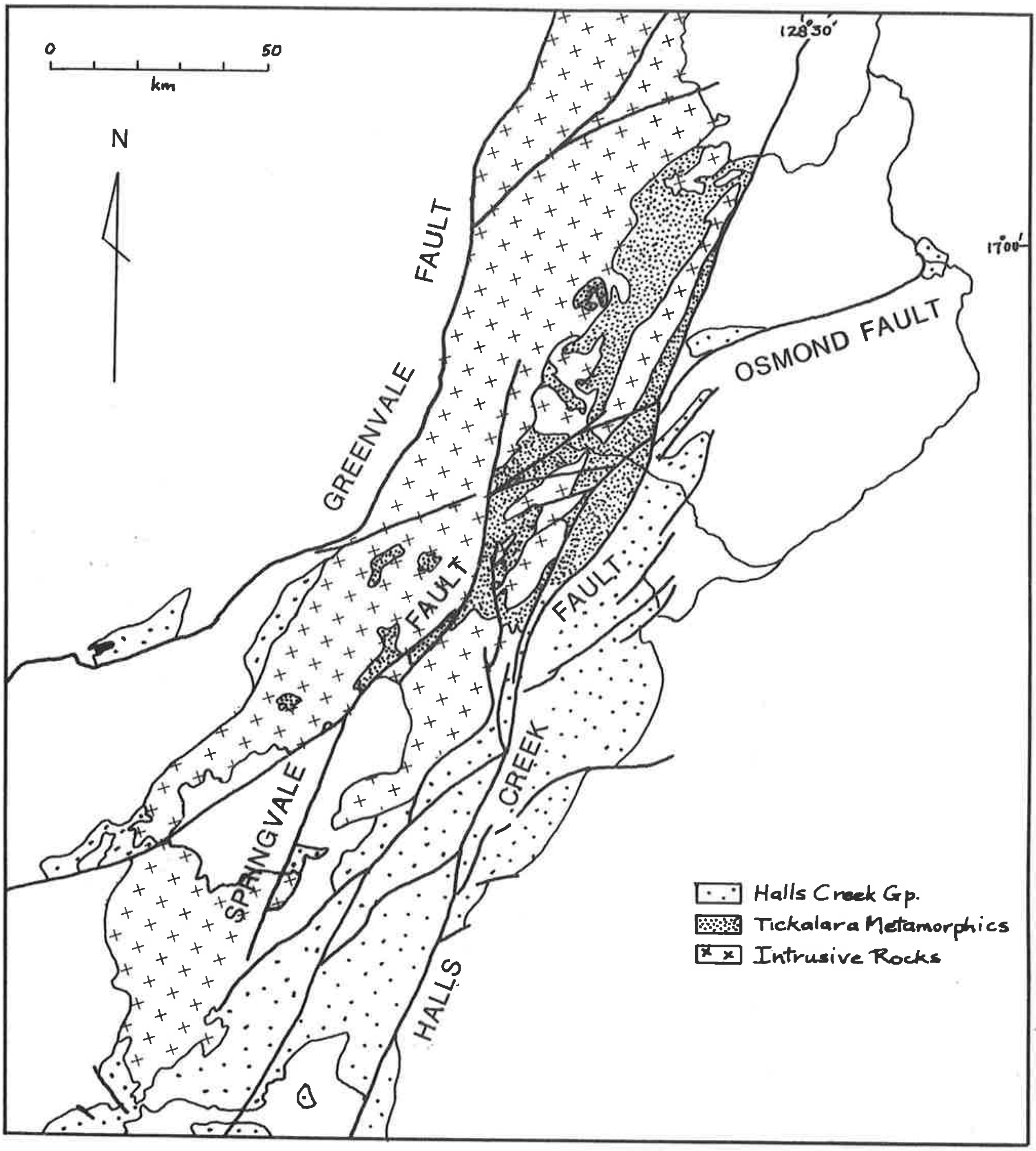

Fig 2.3 Distribution of High Grade Metamorphic Rocks

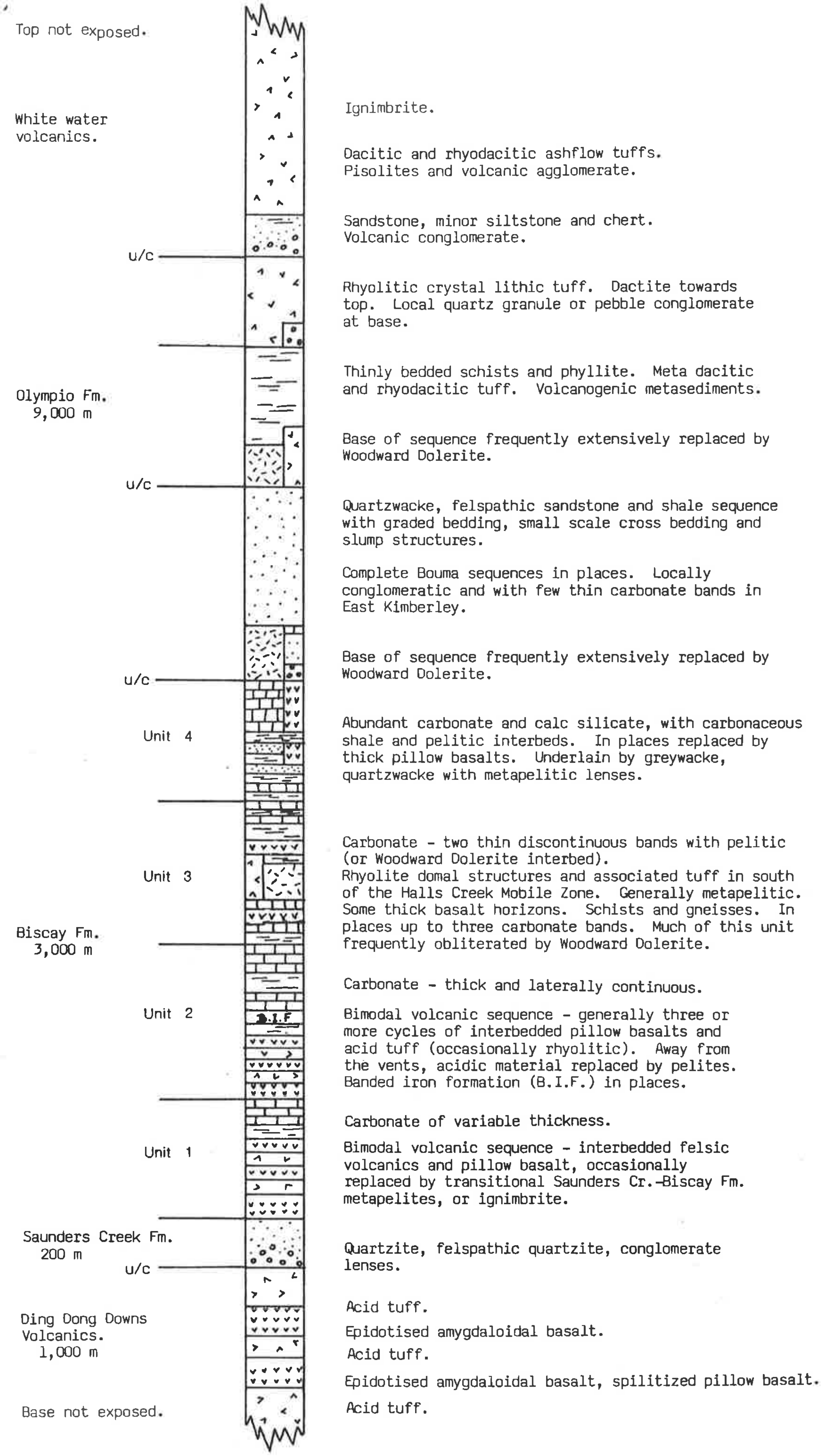

Fig 2.4 Stratigraphic Column

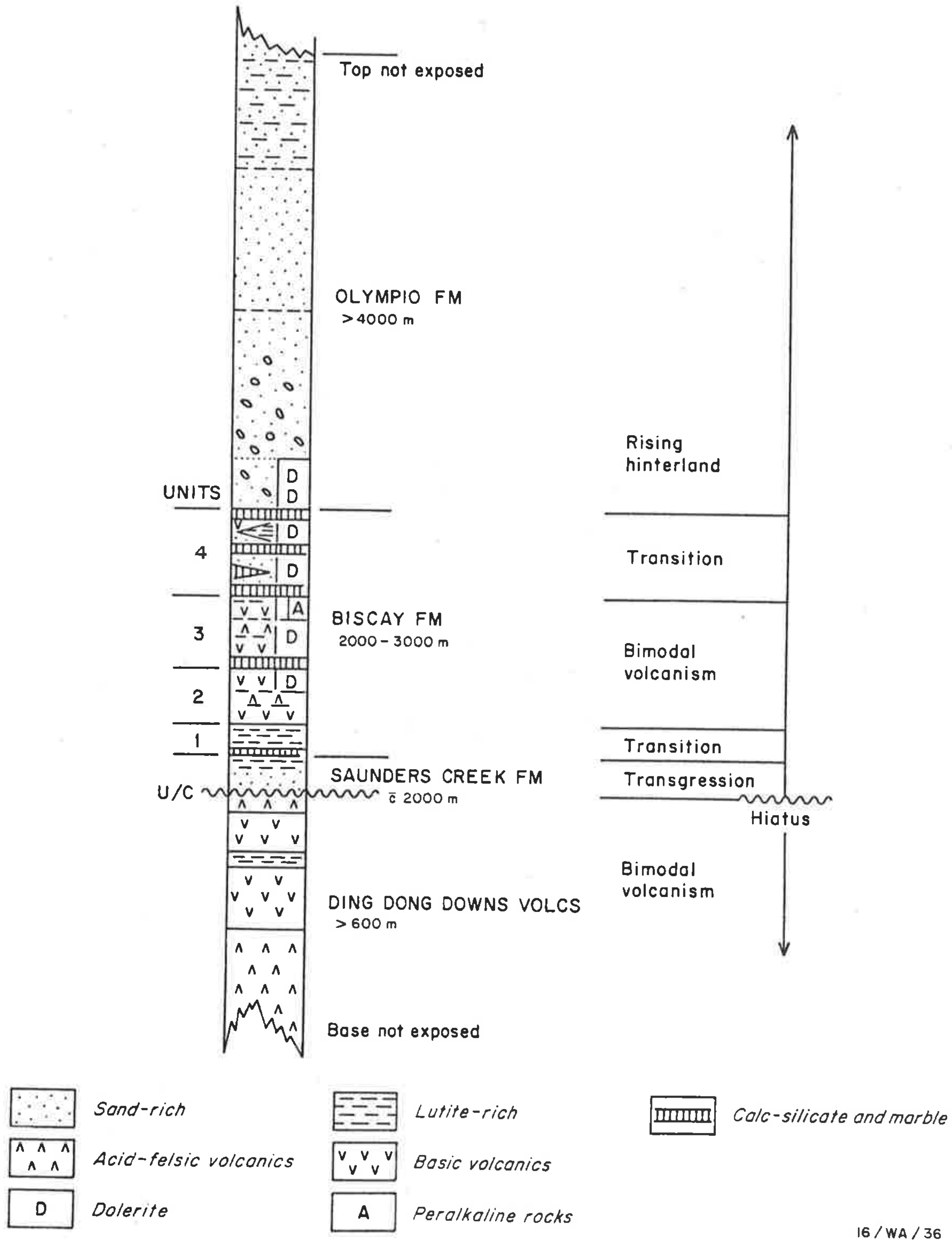

Fig. 2.5 . Diagrammatic stratigraphy of the Halls Creek Group. data of Hancock (in preparation).

Fig 2.6

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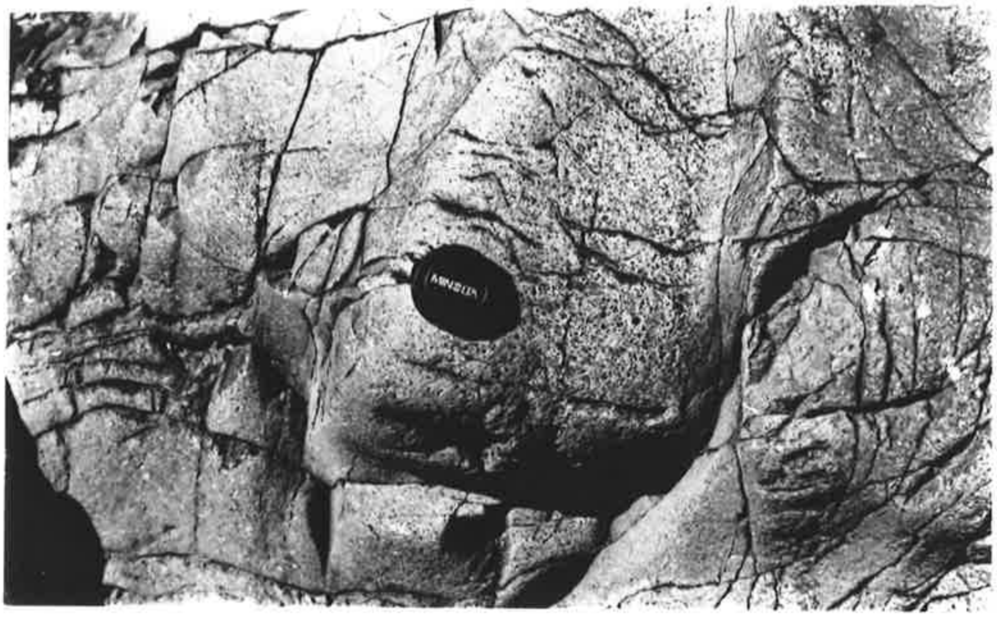


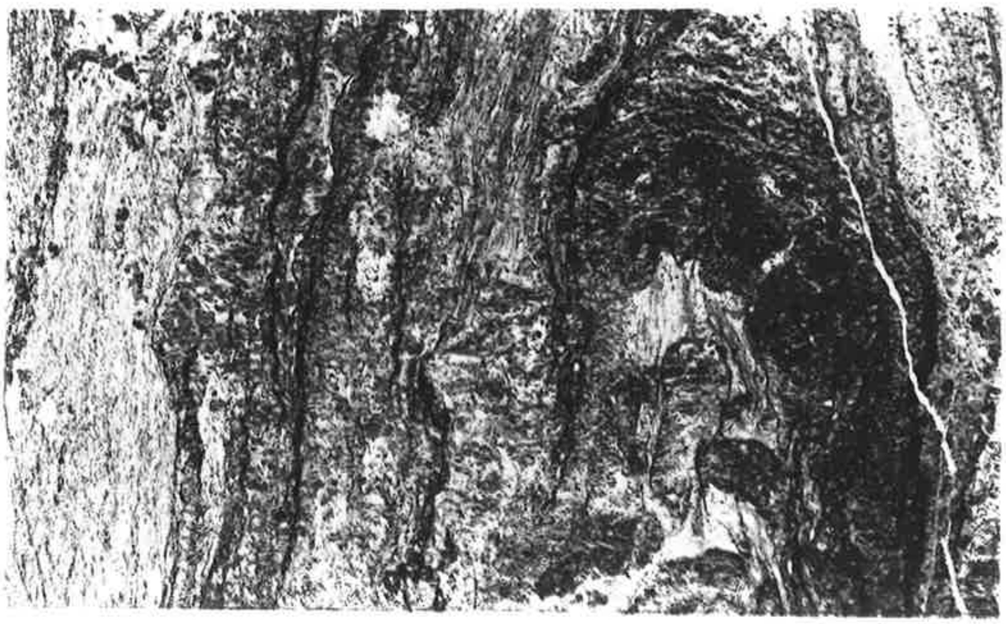


Fig 2.7

Selected photomicrographs of felsic tuffs from the Ding Dong Downs Volcanics in the Saunders Creek Dome.

(a) Rhyolitic crystal lithic tuff from middle tuff horizon. Basalt clast (quartz veined) from lower basalt unit. Strong S_1/S_2.

(b) Photomicrograph showing basalt clast (dark) and K-spar phenocryst with fine cross hatched twinning, in microcrystalline felsic matrix.

(c) Corroded felspar phenocryst (Carlsbad twinning) in fine grained felsic matrix showing development of metamorphic biotite. Fragment of devitrified glass at top of photomicrograph.

(d) Glass fragment showing spherulitic devitrification.

(e) Felspar crystal (L.H.S.) corroded and replaced by quartz, in fine grained matrix, with fragment of earlier crystal tuff (darker matrix - lower half of photomicrograph). Clast with felspar phenocryst in microcrystalline matrix. Clast outlines diffuse.

(f) Euhedral sanidine phenocryst showing Carlsbad twinning and patchy albitic replacement.

(g) F_2 folding quartz veins in microcrystalline matrix of felsic tuff, with development of axial plane S_2 schistosity.

(h) Detail of euhedral sanidine phenocryst wrapped by S_2 schistosity defined by fine grained ragged musc-chlorite. Quartz rich pressure shadows developed around phenocryst.

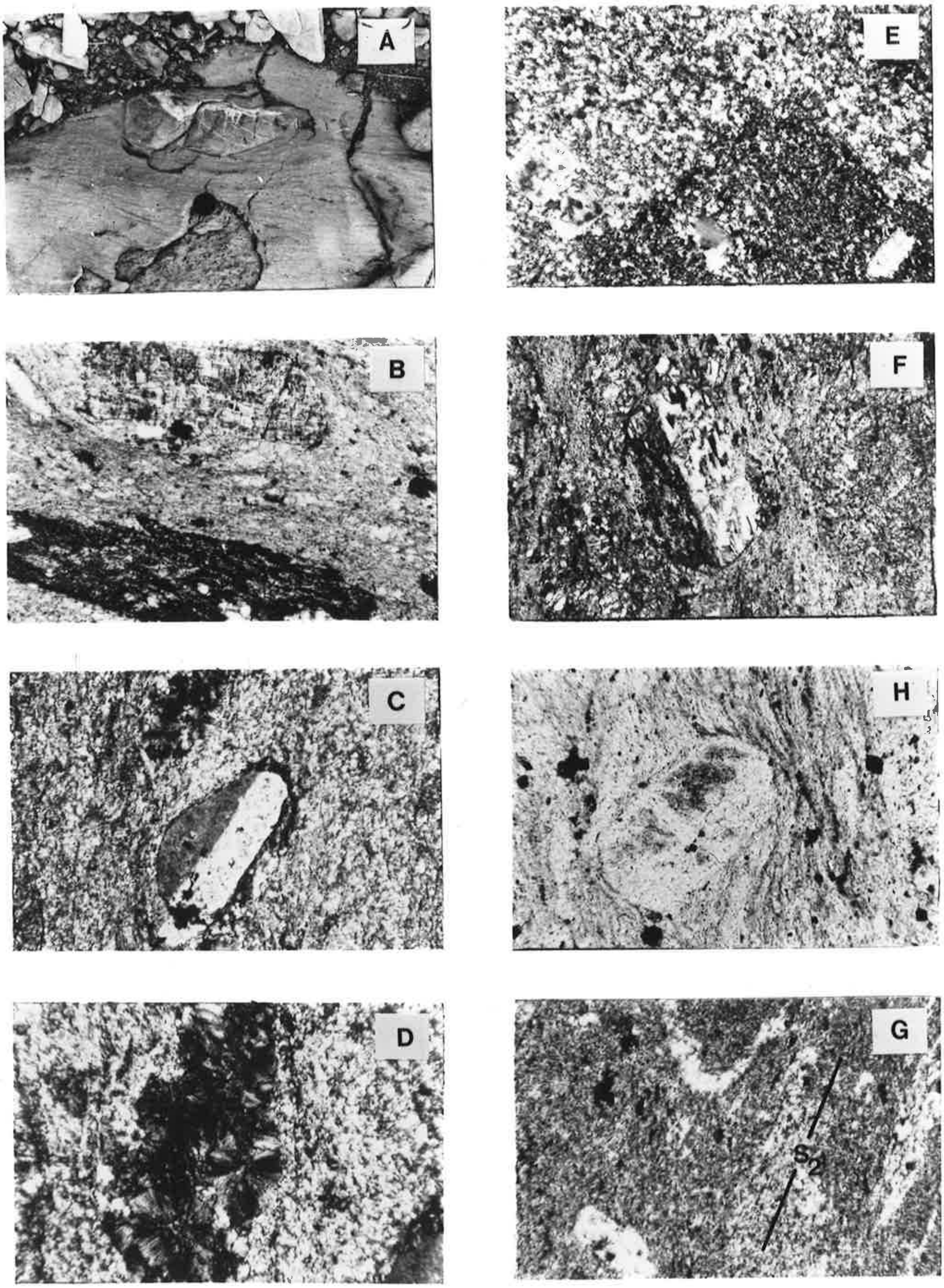

A
E
B
F
C
H
D
G
S2

Fig 2.8

Selected photographs and photomicrographs of Saunders Creek Formation.

(a) Looking East down sequence from the top of the Biscay Formation to the distinctive quartzite ridge of the Saunders Creek Formation on the horizon.
North of the Ord River, close to the Halls Creek Fault.

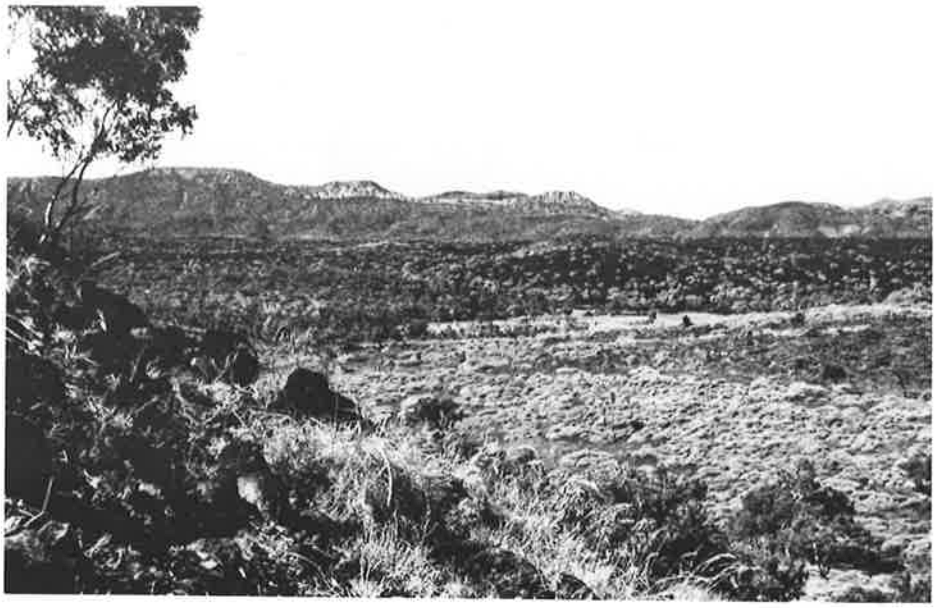
(b) Saunders Creek Formation showing conglomeratic base and cross beds marked by heavy mineral bands above and to the right of hammer head.
Saunders Creek Dome.

(c) Photomicrograph showing heavy mineral band. Two generations of heavy mineral are apparent.

(1)Fine grained and generally anhedral.

(2)Coarse grained and sub-hedral.

Saunders Creek Dome.



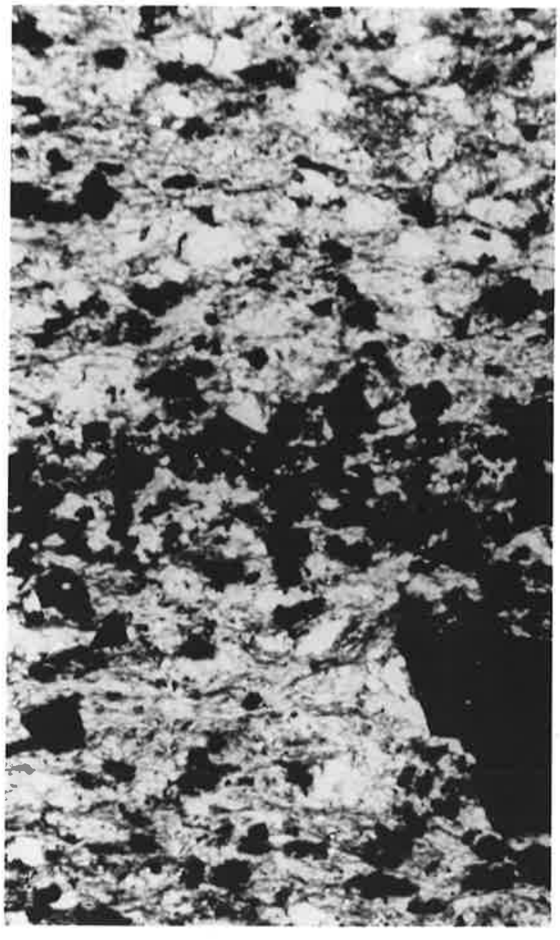


Fig 2.9 Thermoluminescence characteristics of quartzites and conglomerates

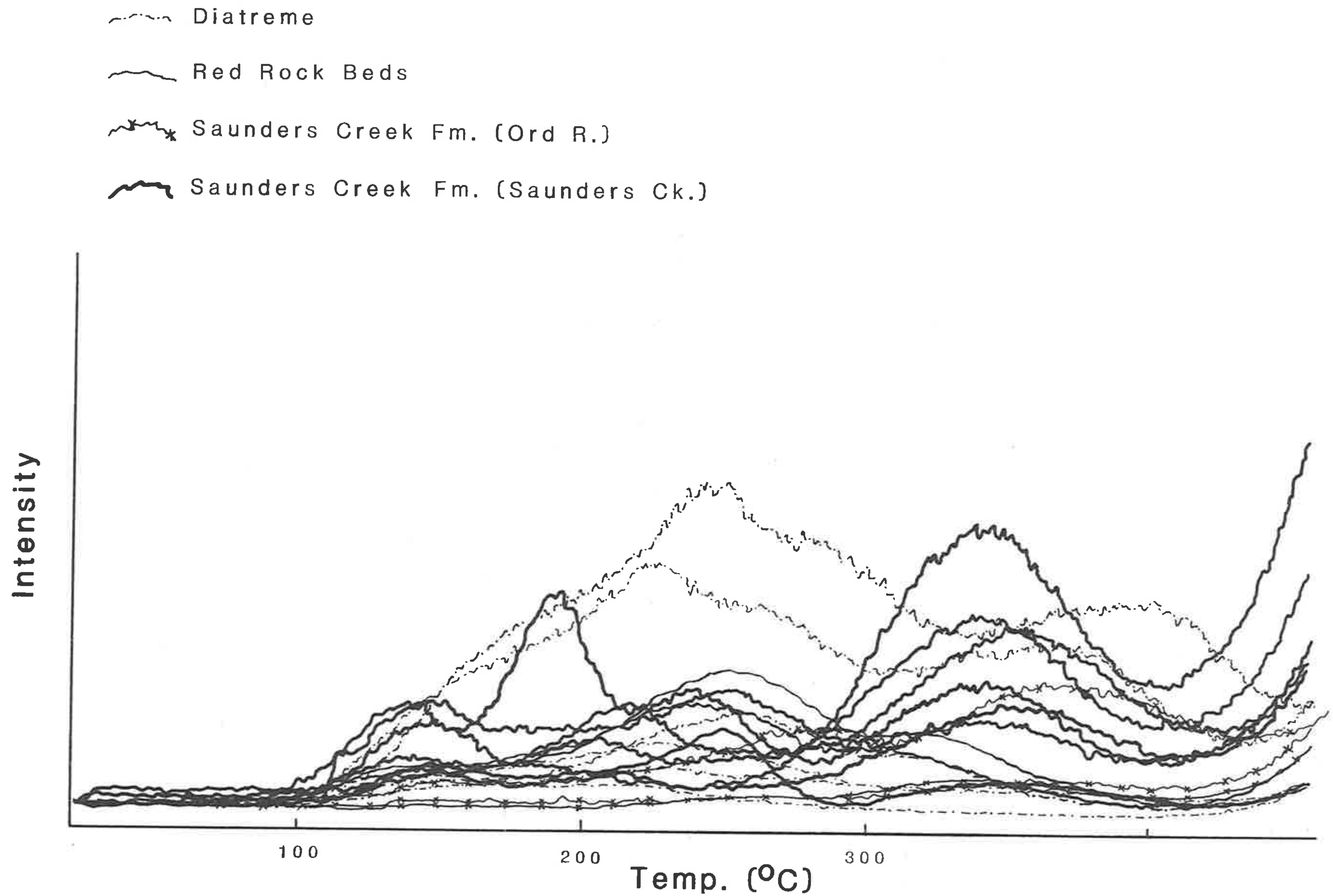


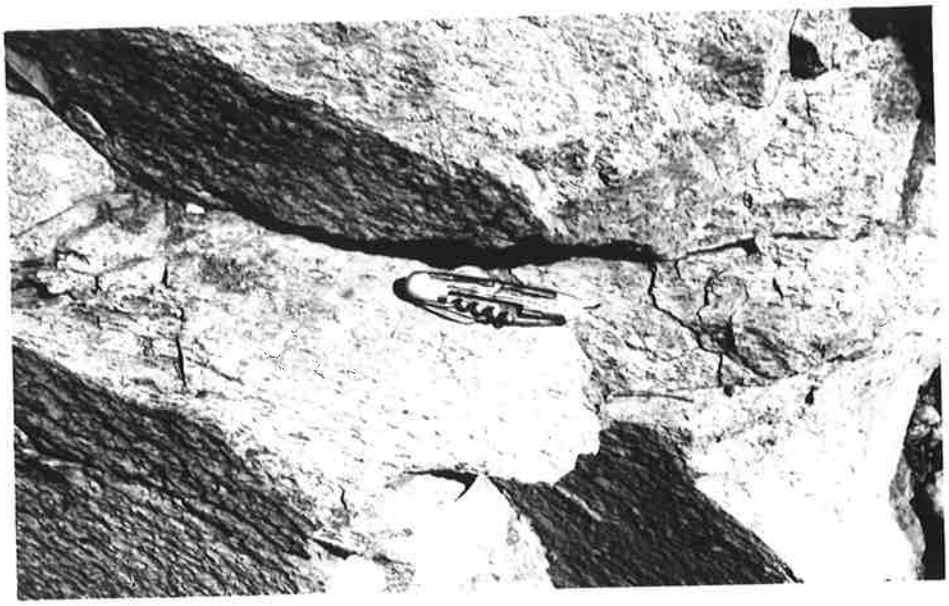
Fig 2.10

Selected photographs of acid and basic volcanic rocks from Unit 1 of the Biscay Formation.

(a) Leucocratic rock of Wills Creek Suite showing phyllosilicate lenses. Extensively devitrified and foliated rhyolitic lava.

(b) Thin felsic lava flow showing bottom °rip-up° structure, (fine grained block in centre of photograph). 'Base of bed' structures, and stratigraphic position intercalated within pillow basalt units, and overlying a beach or sub-tidal formation, indicates a shallow marine environment of deposition.

(c) Deformed and stretched pillow basalts of 'Wills Creek Suite'. Stacking relationships indicate beds are younging and dipping steeply to the west.



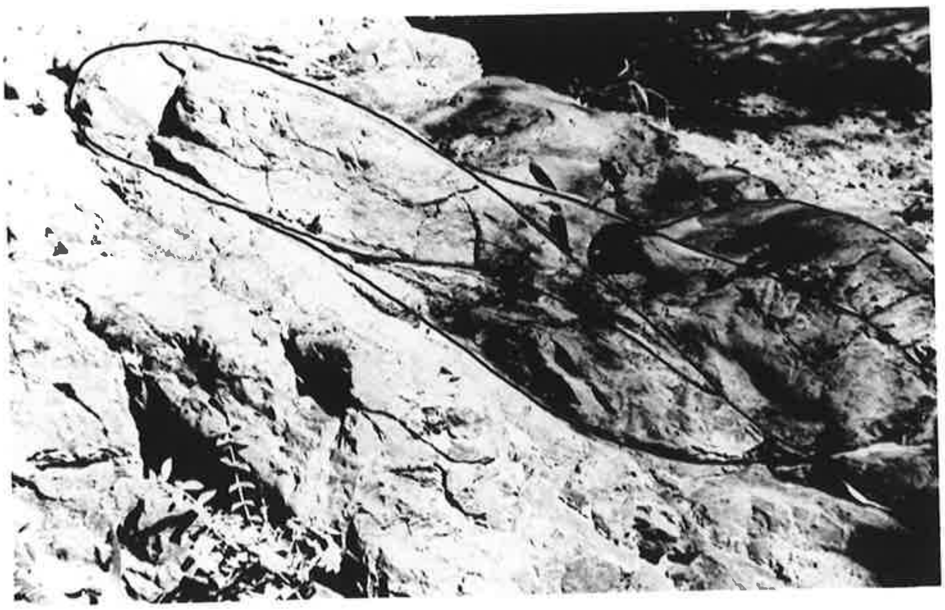


Fig 2.11

Selected photomicrographs of metamorphosed felsic volcanic rocks from Units 1 and 2 of the Biscay Formation.

(a) Photomicrographs of leucocratic rock of 'Wills Creek Suite' showing primary, igneous, zoned felspar phenocryst, and late metamorphic spessartine rich garnet (black, bottom left), in fine grained matrix, with phillosilicate patches.
Crossed polars.

(b) Composite photomicrograph of syn-tectonic, texturally zoned, almandine garnets from dacitic ignimbrite in Unit 2 of Biscay Formation ('Corkwood East Suite'). Core with fine grained quartz inclusions, zone of fibrolitic sillimanite inclusions, and euhedral rim overgrowing micaceous matrix. (Plane polarised light)

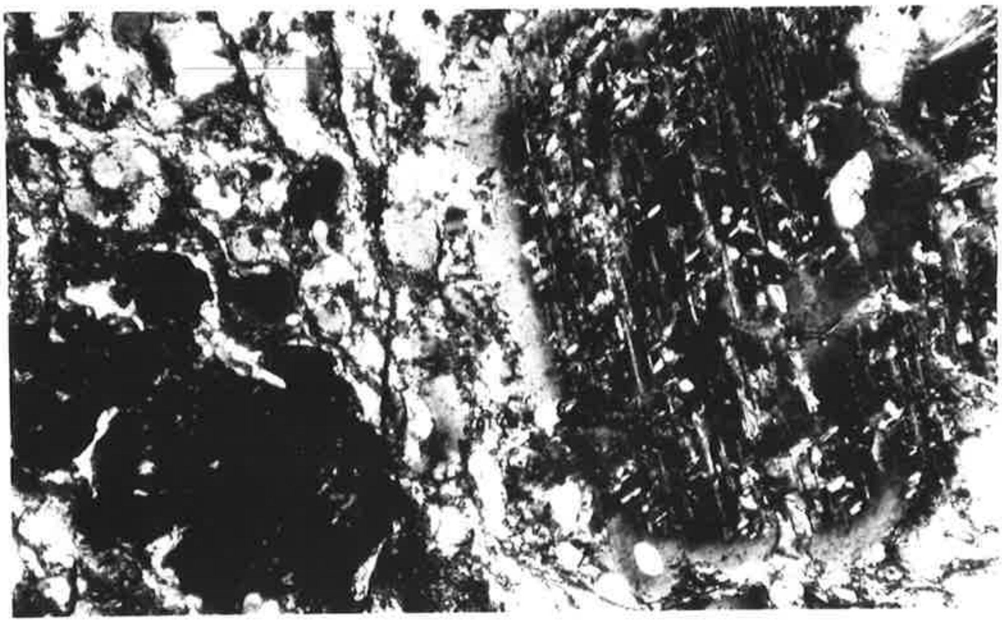


Fig 2.12

Selected photographs of ignimbrite from the lower Biscay Formation.

(d) Massive unbedded felsic volcanic rock of the 'Corkwood East Suite', showing felspar megacrysts, in a fine grained matrix. The megacrysts are thought to represent metamorphosed pisolites, and this voluminous material to have been deposited sub-aerially from collapse of an eruption column. North of Ord River.

(e) Schistose leucocratic rock of the 'Corkwood East Suite' from shear zone, with felspar megacrysts wrapped by protomylonitic fabric. South of Ord River.

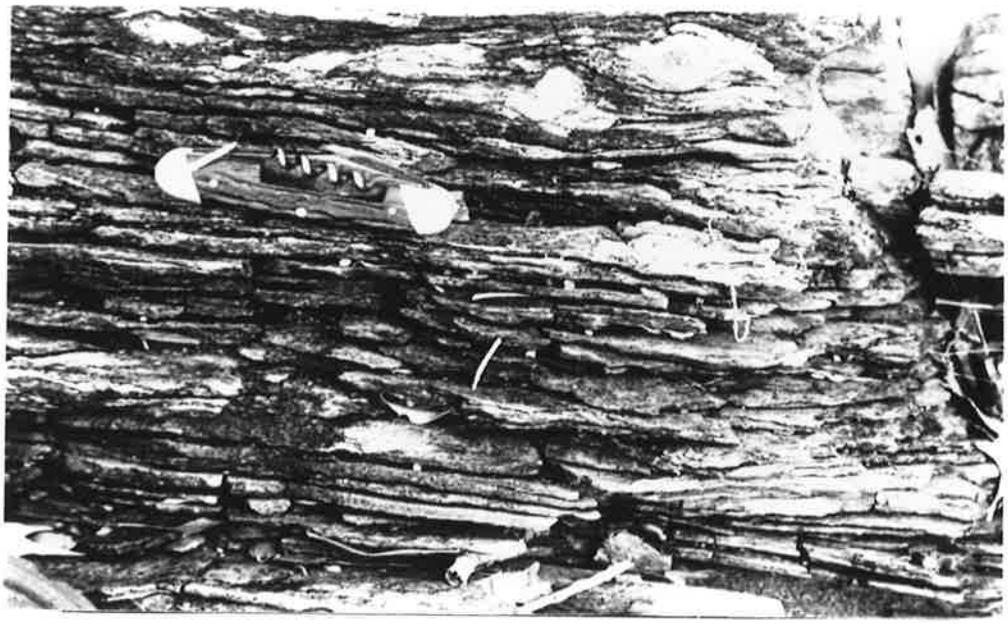


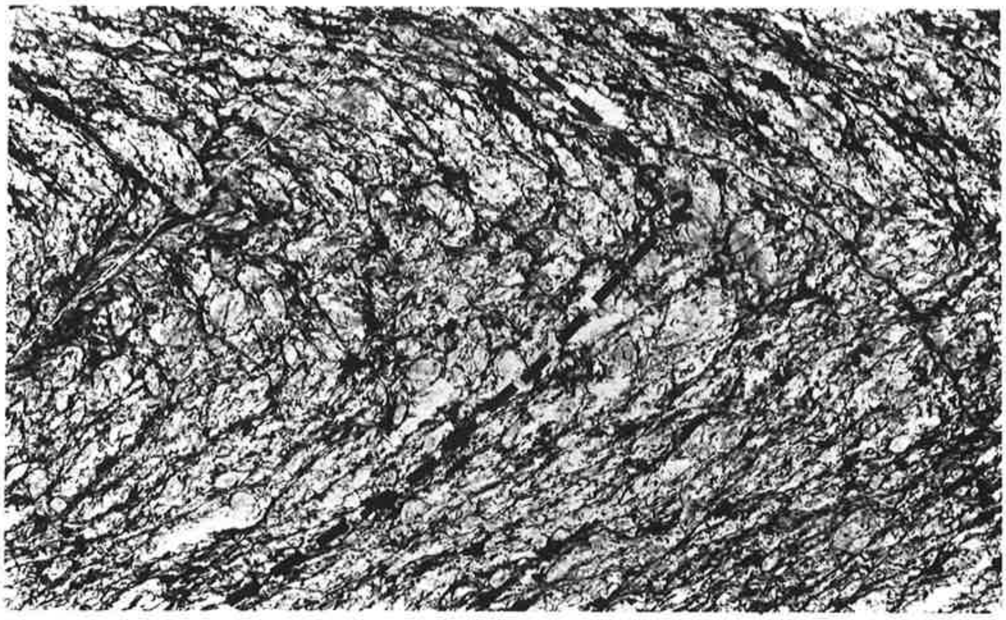
Fig 2.13

Photomicrographs of various lithologies from Unit 2 of the Biscay Formation in the White Rock Bore area.

(a) Leucocratic plagiophyric rock of volcanic origin. Densely packed rounded feldspars wrapped by micaceous S_2. Folded into open fold by F_4.

(b) Banded Iron Formation. B.I.F. occurs in areas characterised by voluminous basalt flows, and therefore a volcanic exhalative affiliation is inferred.Magnetite rich and quartz rich bands folded by F_2.

(c) Carbonaceous schist. A reducing environment of deposition in near shore bays and estuaries is suggested. S_1 folded by F_2 with development of S_2 axial plane to folds.



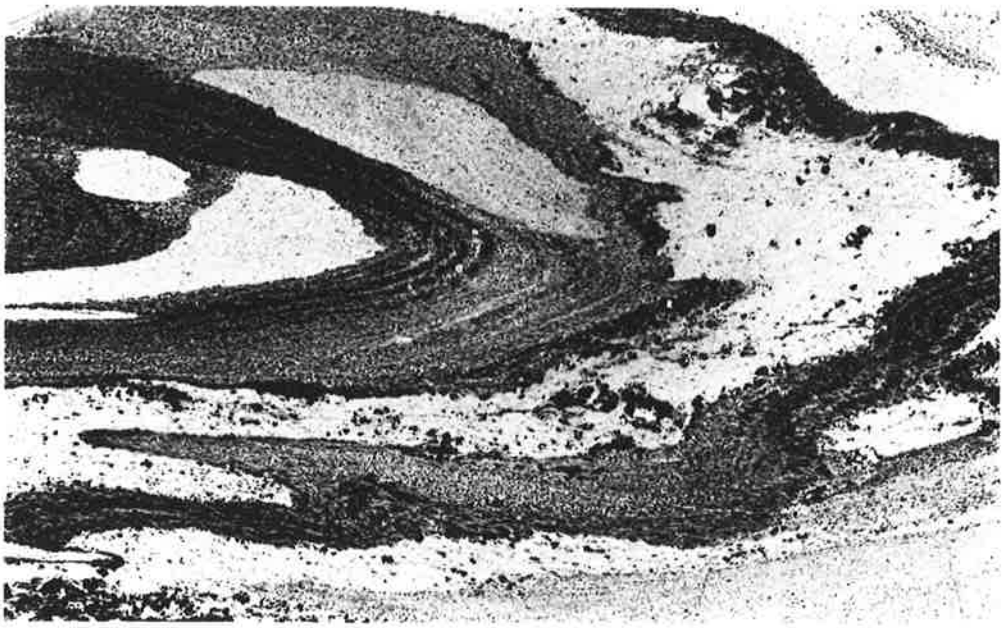


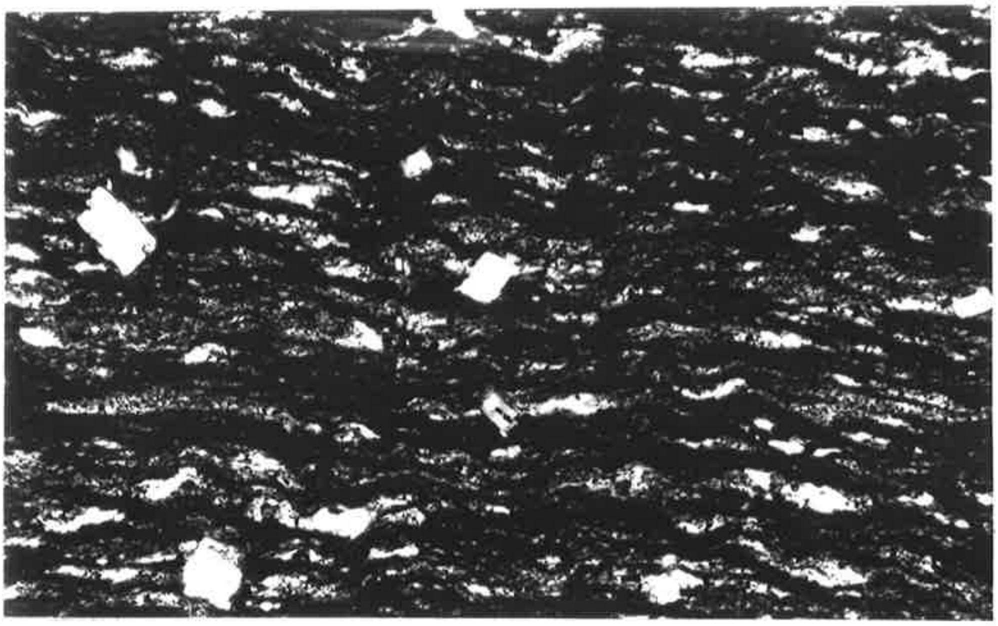
Fig 2.14

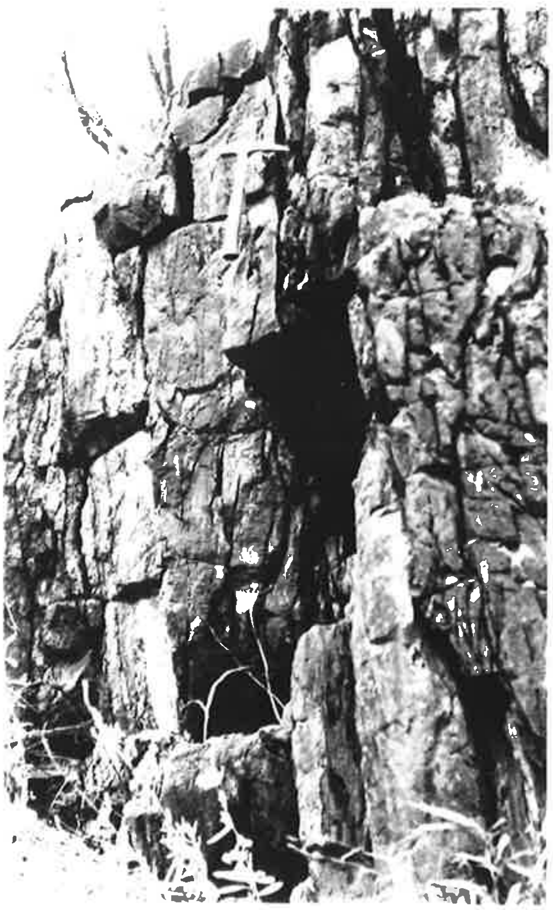
Photographs and photomicrographs of lithologies from Units 3 and 4 of the Biscay Formation.

(a) Photomicrograph of flow banded rhyolite of 'Alkali Suite'. Tiny euhedral crystals of quartz pseudomorphing alpha cristobalite ? in aphanitic felsic matrix. Unit 3 Biscay Formation. Saunders Creek area.

(b) Cliff face of pillow basalts standing on end in the White Rock Bore area. S_0 younging west, and dipping very steeply to the west. Thick unit (many tens of metres) replacing carbonate at the top of Unit 4 of the Biscay Formation.

(c) Detail of pillow basalt showing dark chilled margins and amygdules in the core, with carbonate and quartzite in the interstices between the pillows. Note folded pillow near pencil.





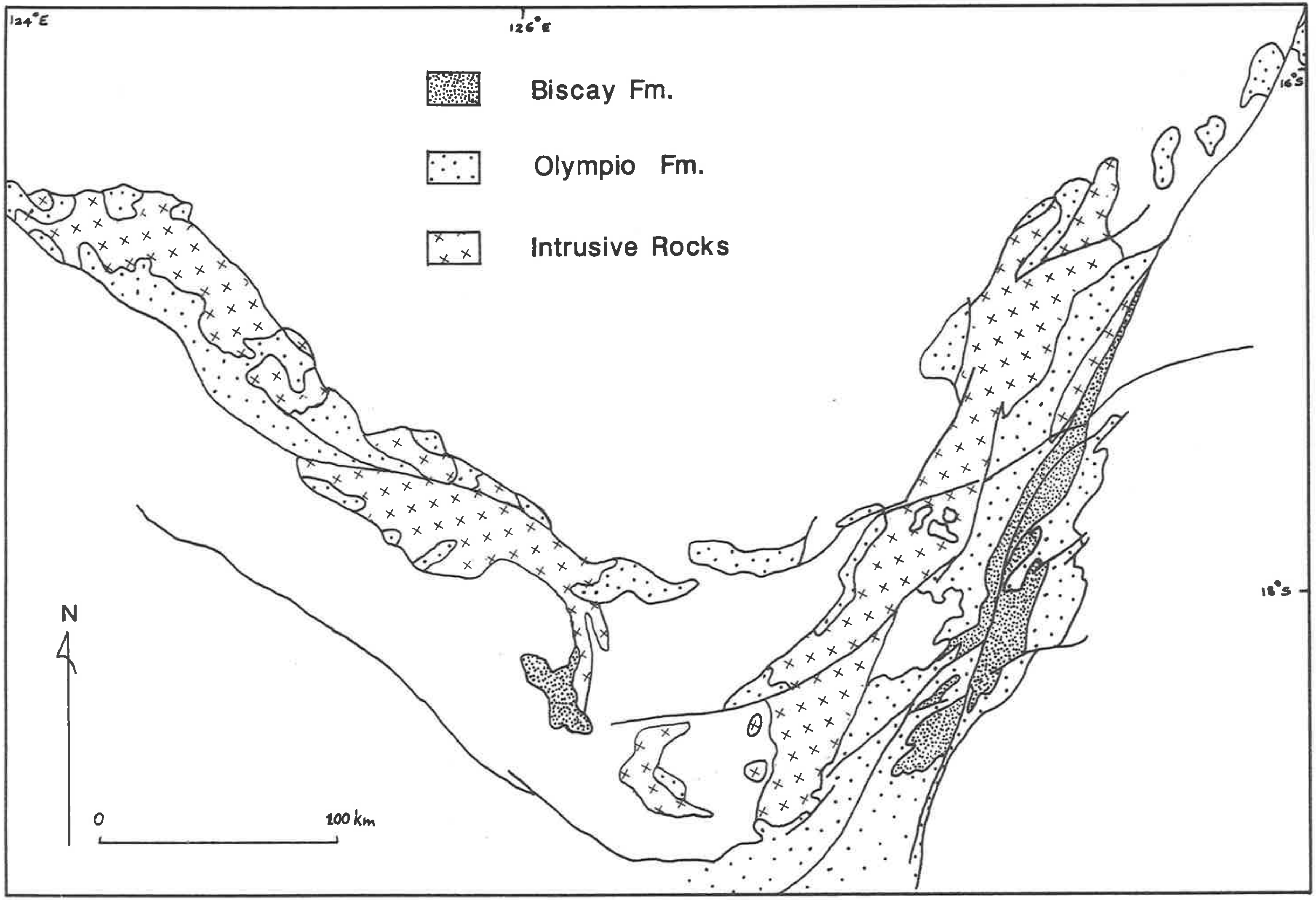
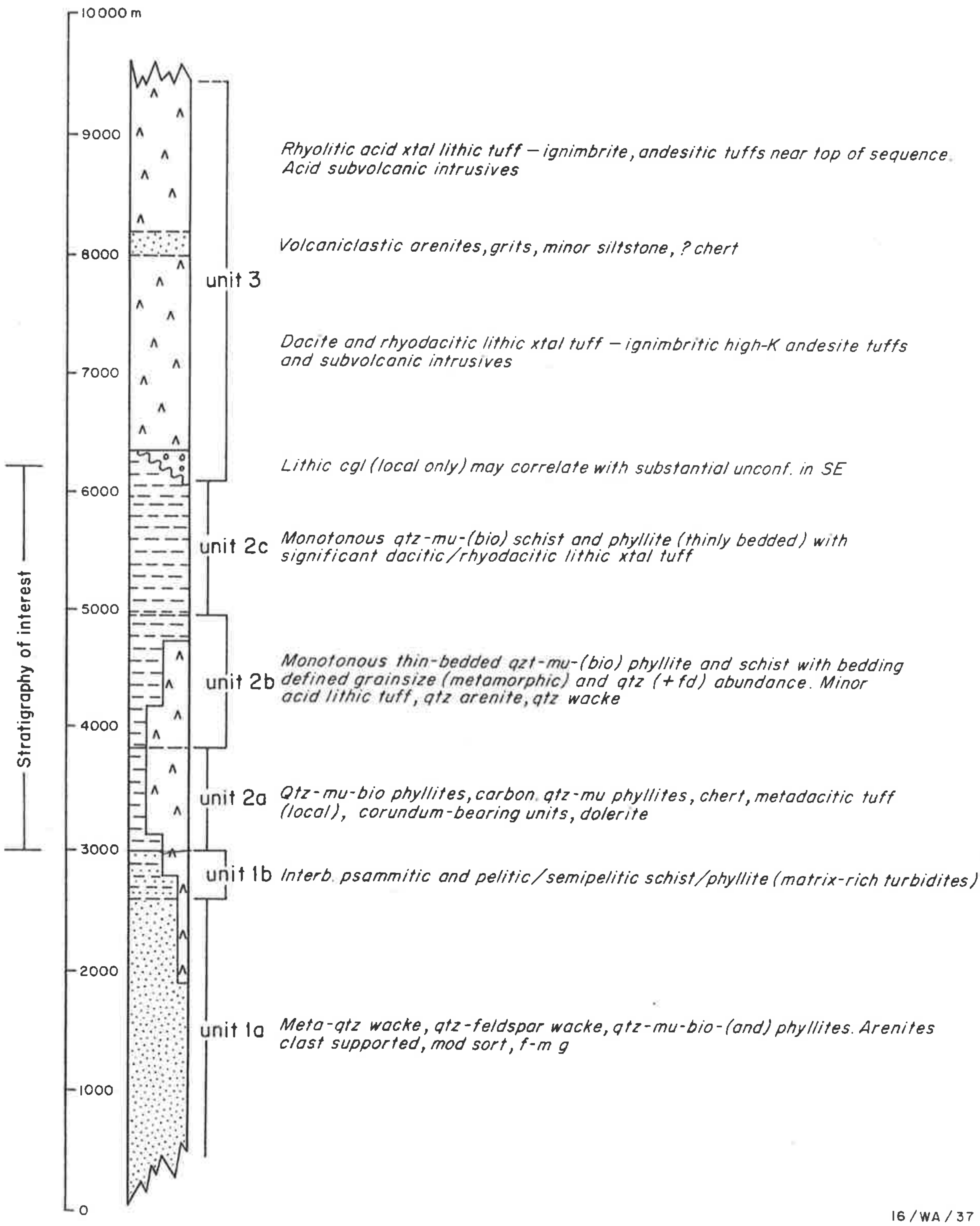


Fig 2.15 Distribution of the Biscay and Olympic Formations in the East and West Kimberleys

Fig 2.16 Olympio Formation, West Kimberley.



from Hancock + Rutland, 1984

Fig 2.17

Selected photographs and photomicroraphs of lithologies from the Olympio Formation.

(a) Banded, micaceous quartzwacke folded by D_2. Fine, layer parallel S_1 micas crenulated by F_2, with S_2 axial plane to the folds. Note high proportion of sedimentary quartz grains. Unit 1, Olympio Formation. White Rock area.

(b) Photomicrograph of quartzofelspathic gneiss from Unit 1 of Olympio Formation. Tiny rounded garnets enclosed in felspar. Ord River area.
Crossed polars.

(c) Large zoned boudins of wollastonite-grossular-diopside (+ epidote, scapolite and sphene) within white marble. McKenzie's bore.

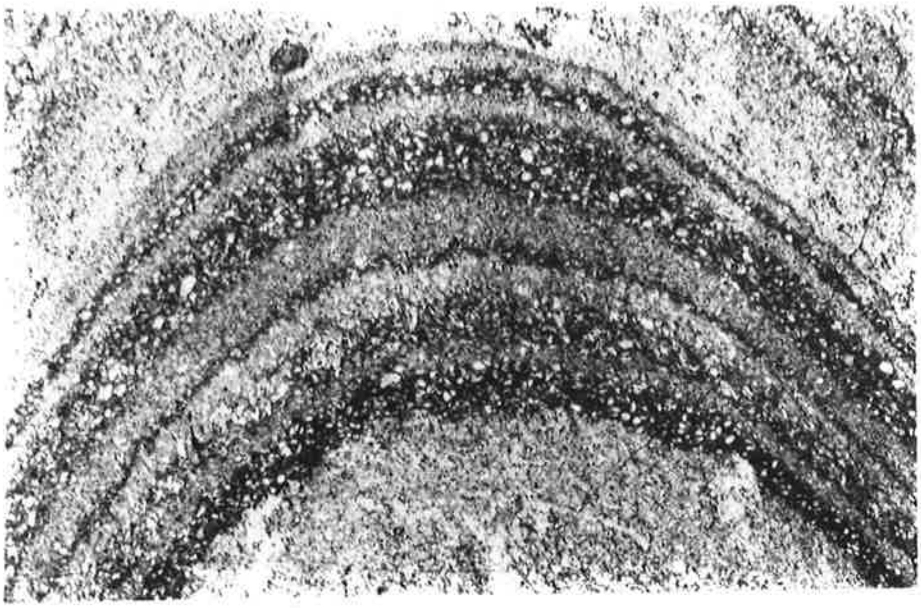
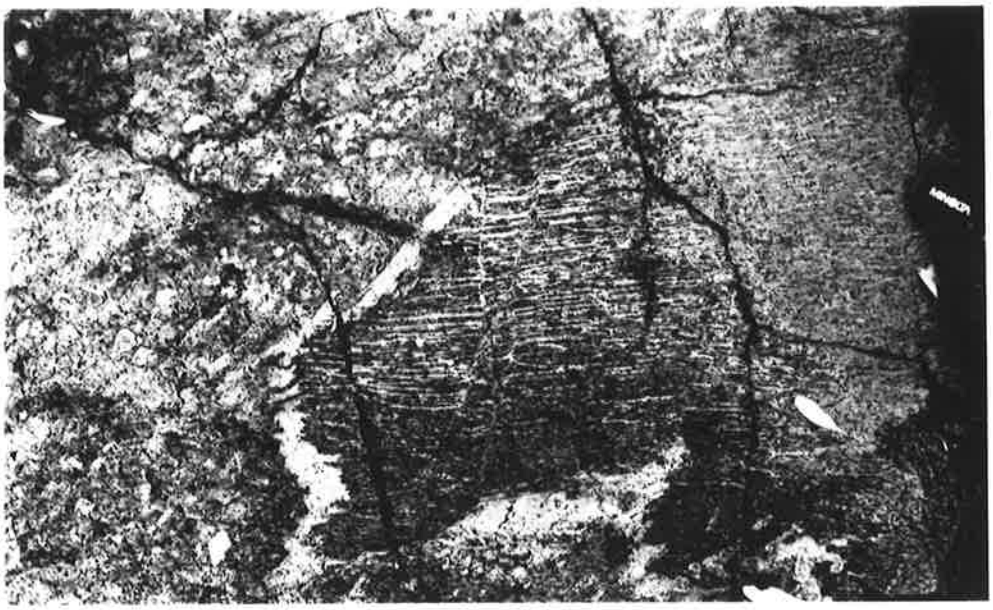


Fig 2.19

Selected photographs and photomicrographs of the Whitewater Volcanics.

(a) Very fine strings of leucocratic material, defining channelways up which streams of gas travelled through the fine grained lithified ash. Associated with volcanic autobreccia.

(b) Monolithic autobreccia. Angular fragments of a wide size range in a matrix of ash sized material. Produced in situ by gas streaming. East Kimberley.



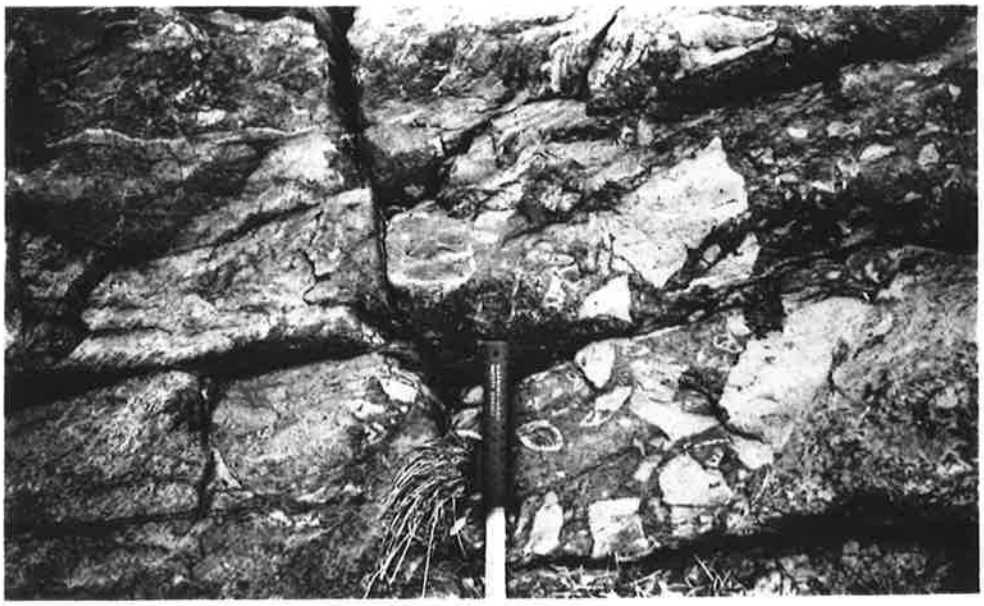


Fig 2.19

(c) Fine grained felsic volcanic rock. Tiny quartz grains and splinters, and fine grained felspar phenocrysts and lithic clasts. Ash sized matrix folded by D_3 (?) West Kimberley.

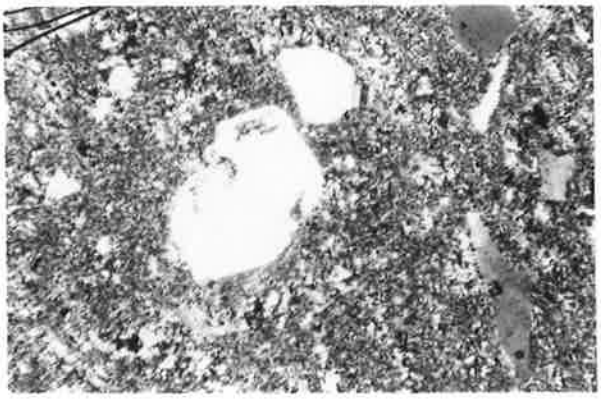
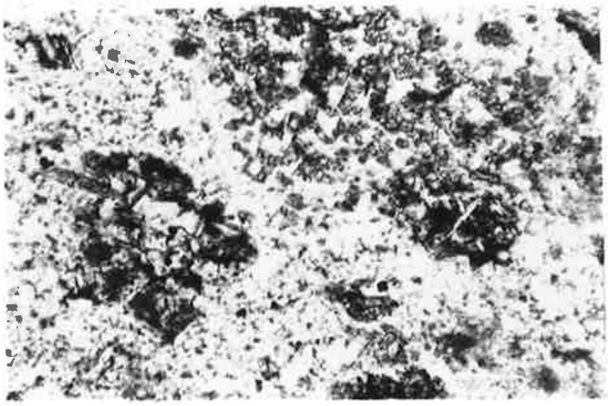
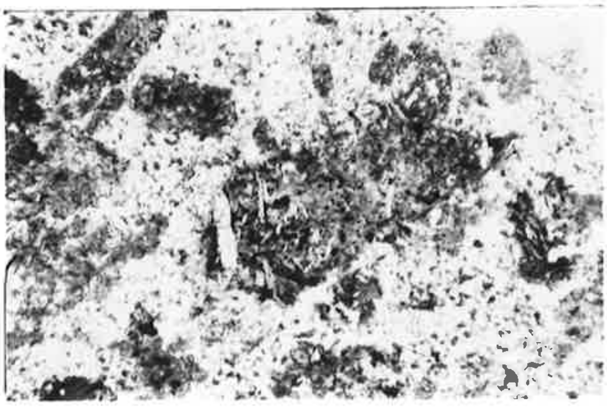
(d) Detail of rhyolitic, crystal, lithic tuff. Medium grained lithic clast containing strained embayed quartz crystal, and altered K spar in fine grained foliated matrix. West Kimberleys.

(e) Photomicrograph of rhyolitic crystal tuff. Embayed euhedral quartz crystal and quartz crystal chips and splinters in microcrystalline felsic matrix. West Kimberley.

(f) Andesitic tuff showing ferro-hypersthene remnants (high relief - OPx) in optical continuity, largely replaced by chlorite and biotite in extensively recrystallised matrix. West Kimberley.

(g) Chlorite and biotite pseudomorphs after pyroxene (large, central) and sericite pseudomorphs after felspar (two at top left) in extensively altered andesitic tuff. West Kimberley.



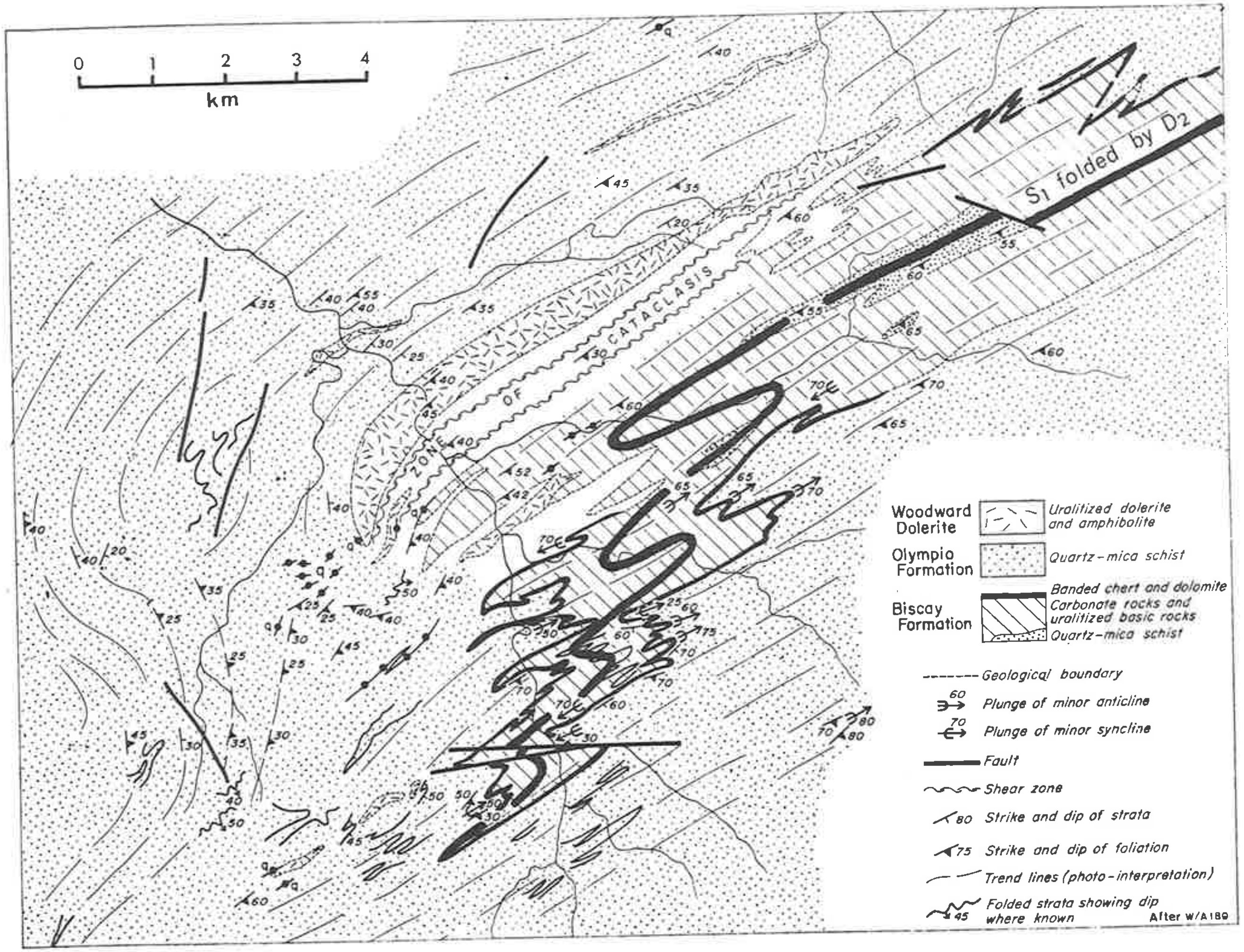


Figure 3.1 Garden Creek Anticline

Fig 3.2

F_1 folds in the Saunders Creek area.

(a) Saunders Creek Formation quartzites, forming distinctive white, resistent ridges, folded into macroscopic, overturned, anticlinal structure. Both limbs dipping steeply to the west. Ding Dong Downs Volcanics in the core of the structure, and basalts of the Biscay Formation on the flanks.
Saunders Creek Dome.

(b) Fine grained metasediment of the Biscay Formation folded into isoclinal, reclined fold by D_1. Curved axial trace indicates refolding by D_2?


MINOLTA

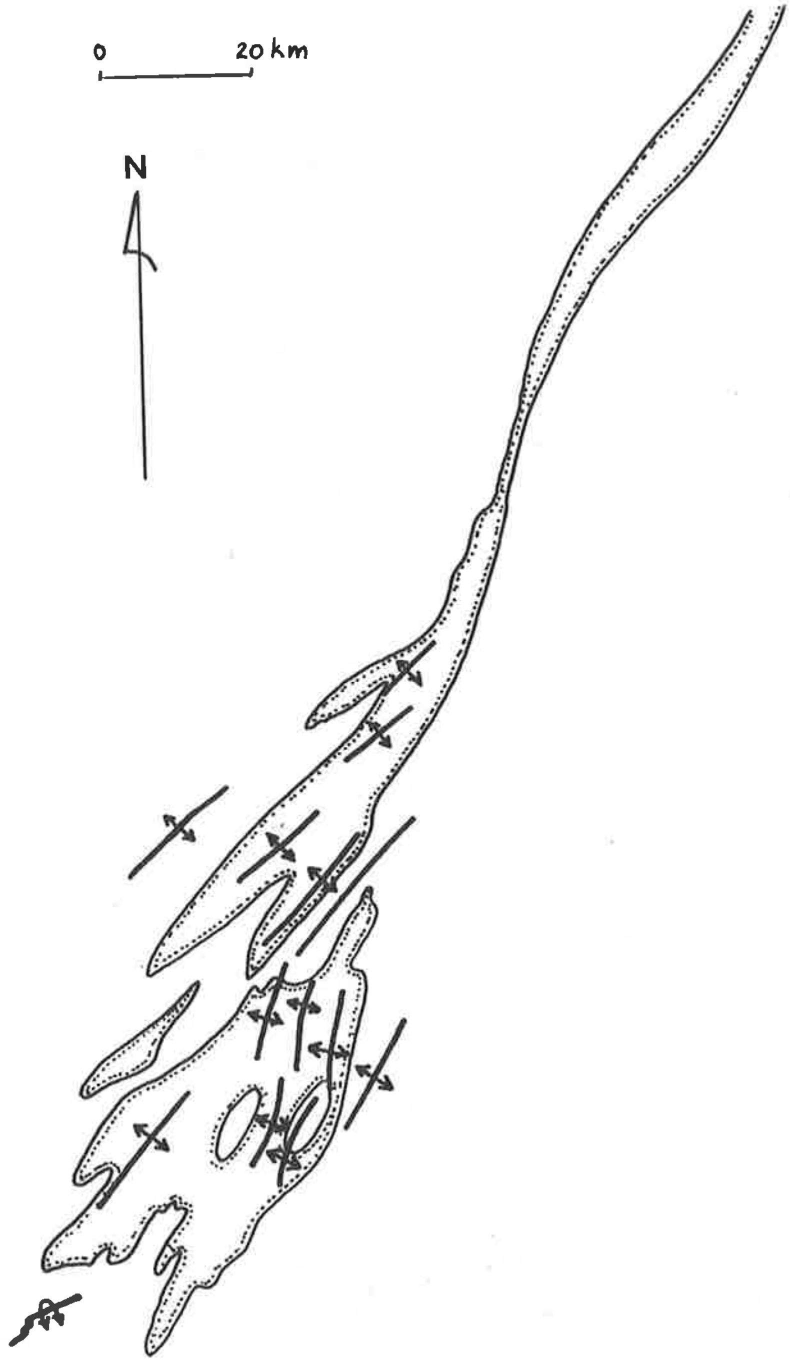


Fig 3.3 Biscay Anticlinorium restored, showing F1/F2 fold axis orientation. Biscay Formation outlined.

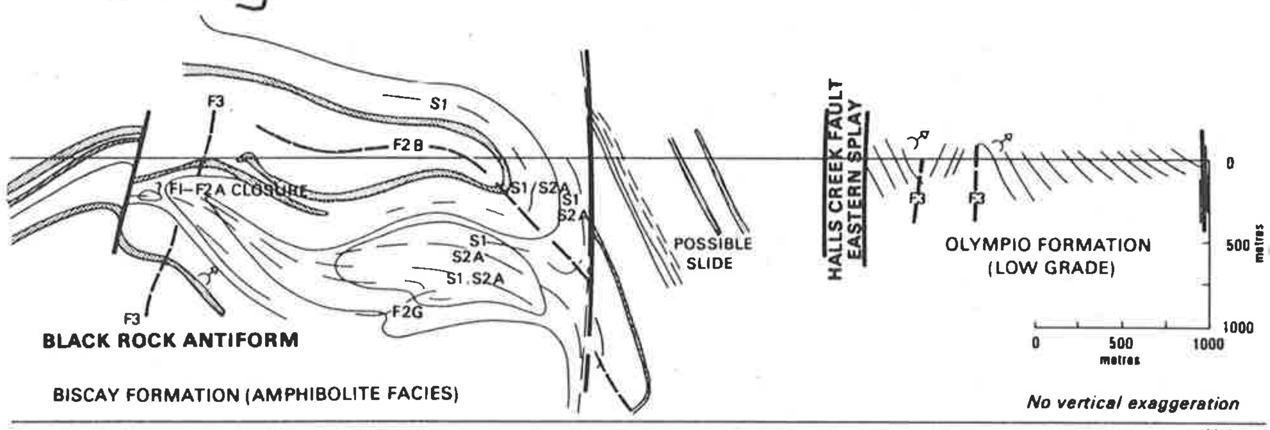


Fig. 3.4 Structure across the eastern splay of the Halls Creek Fault (line of section shown in NE corner of Fig. 6). Arrows show facing direction of sedimentary structures.

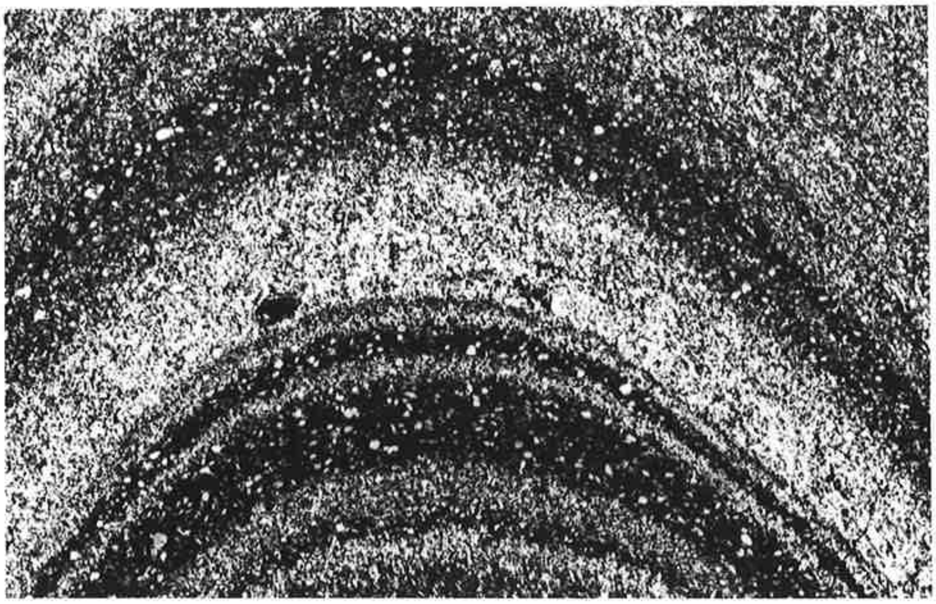
Fig 3.5

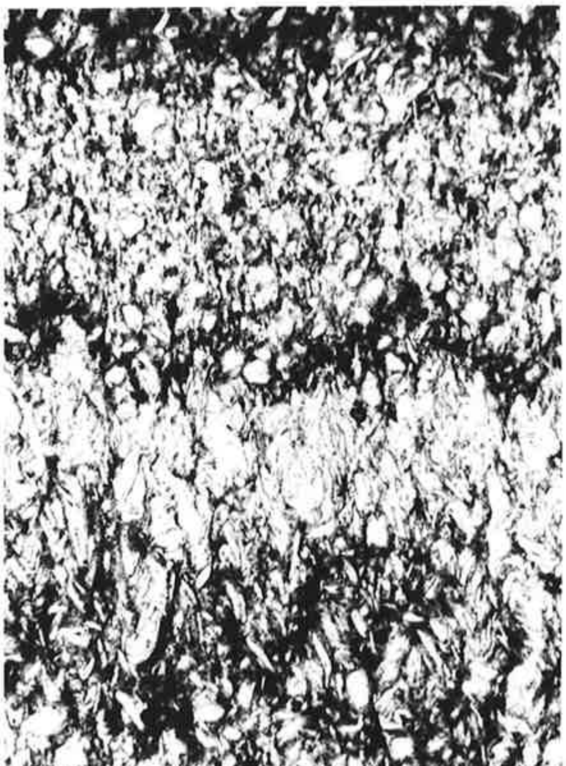
Selected photographs of rocks from the White Rock area illustrating relative development, expression and preservation of superimposed schistosities depending on rock composition and positionin fold.

a) Hinge region of F_{2a} fold in fine grained banded metasediment. Micas aligned parallel to bedding, (S_0), can be seen in the limb region at right of photograph. In the centre of the hinge, most S_1 mica flakes have been realigned or crenulated, with the production of a new schistosity, S_2, axial plane to the fold.
Spec.No. K498/413. Unit 1. Olympio Fm.

(b) Detail of (a) near hinge, showing crenulation origin of S_2.

(c) Doubly crenulated pelitic schist. S_1 biotites crenulated by F_2. This is a fine, small wavelength crenulation with coarse grained biotite, axial plane to the crenulations, defining S_2. A coarse crenulation overprints this fabric. The F_3 crenulation has a wavelength approximately twice to thrice that of the earlier crenulation, plunges south at a slightly different azimuth, and the plunge changes from shallow (10^o - 20^o) to very steep (70^o - 80^o) for L_3. Swing in strike orientation seen in curved crenulation axes.
Field of view - 45mm.
Spec No. K498/369. Unit 4. Biscay Formation.





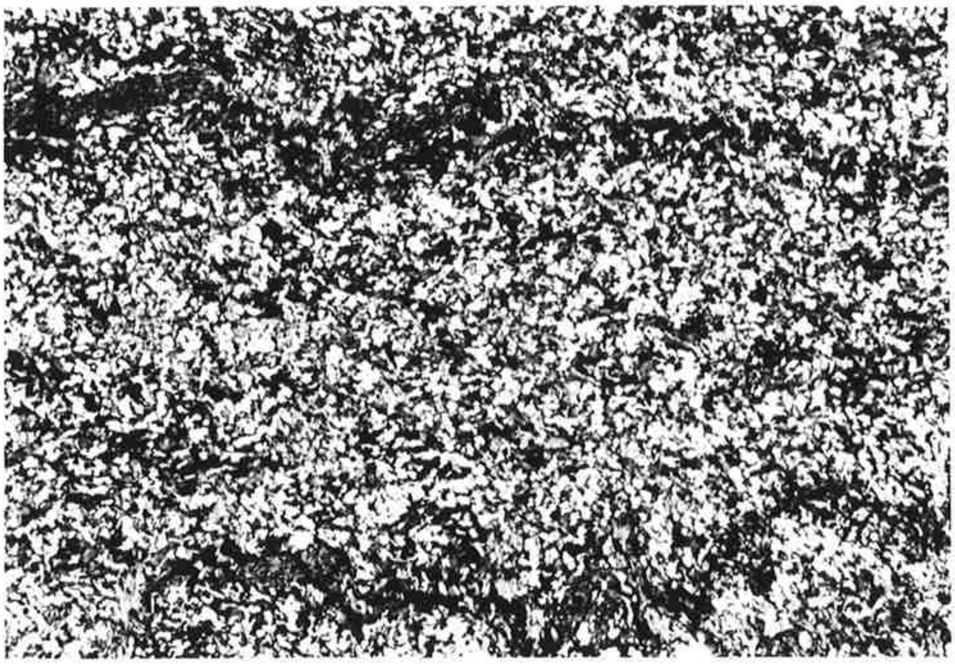

S1
S2

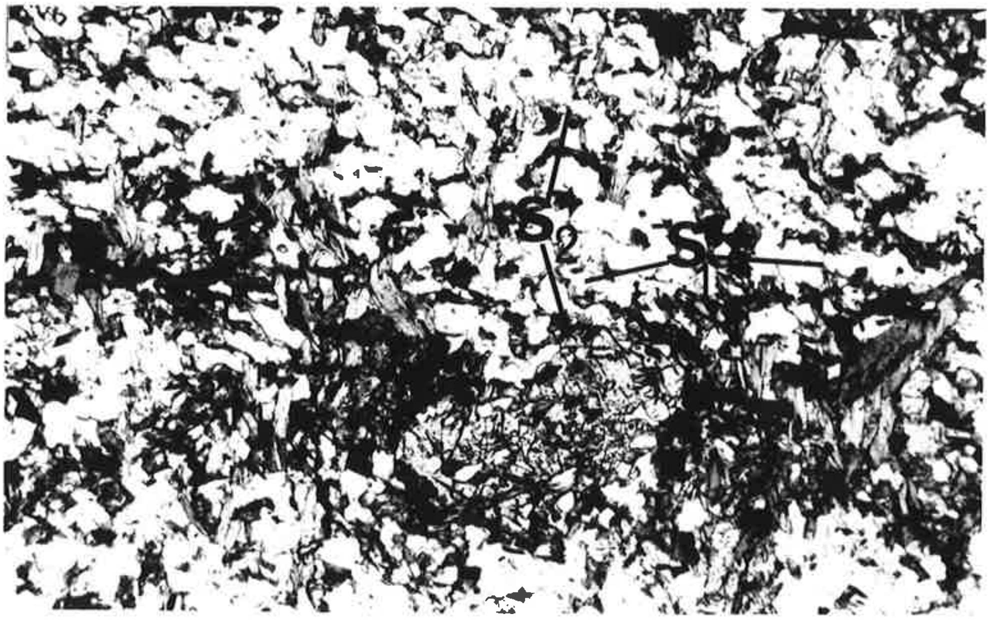
Fig 3.6

Photomicrograph of hinge region of F_2 fold in banded metasediment showing layer parallel S_1, superimposed S_2, and garnets syntectonic with F_1.

(a) Hinge region of an F_2 fold. The first schistosity, S_1, is defined by biotite, concentrated in the more pelitic bands (two of which can be seen in the photograph), aligned parallel to bedding, S_0. A later generation of coarser grained biotite, S_2, has formed at a high angle to S_1, and has been crenulated by F_3. Garnets, confined to pelitic bands, and elongate along S_0/S_1 have been rotated by F_2.
Specimen Number K498/372. Unit 1. Olympio Formation.

(b) Detail of above at higher magnification, showing superimposed schistosities and syntectonic garnet.
Field of view - 20mm.





S2
S

Fig 3.7

Superimposed schistosities and syntectonic garnets.

(a) Zoned garnets. Core of garnets shows a weakly rotational S_1 fabric of very fine elongate quartz grains, surrounded by a virtually inclusion free zone. Euhedral outlines and protrusions therefrom, overgrow the matrix schistosity, S_2, defined by large plates of biotite (cleavage indicated by dashed lines) and fibrolitic sillimanite. Note the inclusions of large metamorphic opaques towards the periphery of the garnets.

Speciman number K 498/1380. Unit 3. Biscay Formation.

Shadowmaster drawing.

(b) Skeletal garnets elongate along layer parallel schistosity in very fine grained banded metasediment. Rotated to varying degrees depending on position in fold geometry. Crenulation S_2 forming axial plane to fold.

Specimen K498/377. Unit 4. Biscay Formation.

(c) Banded metasediment. Top band rich in garnet and staurolite (Fe rich), centre band quartzo-felspathic, lower band sillimanite rich (Al rich).

Top band - S_2 defined by biotite at low angle to S_0. Some smaller corroded biotite flakes of earlier generation remain, but heavily overprinted by later generations of metamorphic minerals.

Lower band - S_2 strongly defined by fibrous sillimanite replacing biotite.


0·5 mm

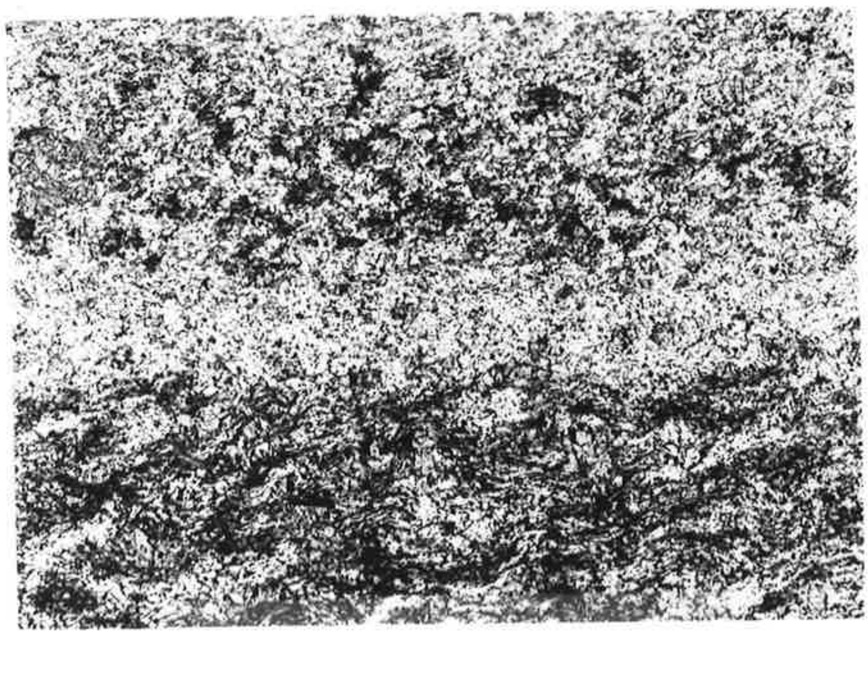


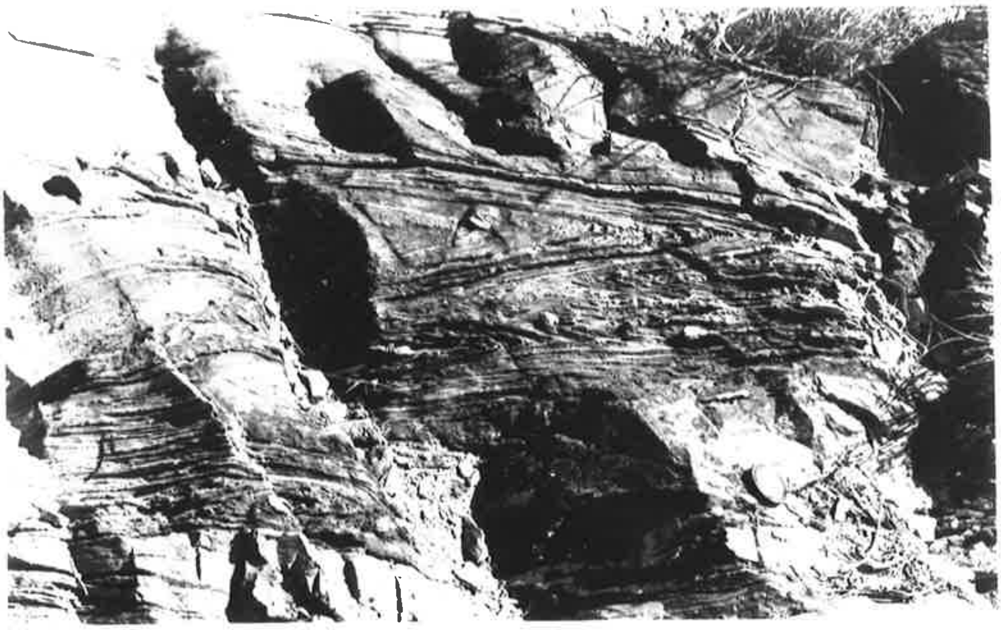
Fig 3.8

Selected photographs of profile sections of hinge regions of mesoscopic, very tight to isoclinal, recumbent, F_{2a} folds folding a layer parallel schistosity.

(a) Similar style folds in fine grained laminated metasediment. Unit 4, Biscay Formation. White Rock area.

(b) Coarsely banded greywacke showing effects of composite D_2 event. Isoclinal fold sheared out along one limb.
Unit 4, Biscay Formation. Black Rock Anticline.

(c) Banded coarse grained garnetiferous schist, folded and sheared. Unit 3, Biscay Formation. Black rock Anticline.



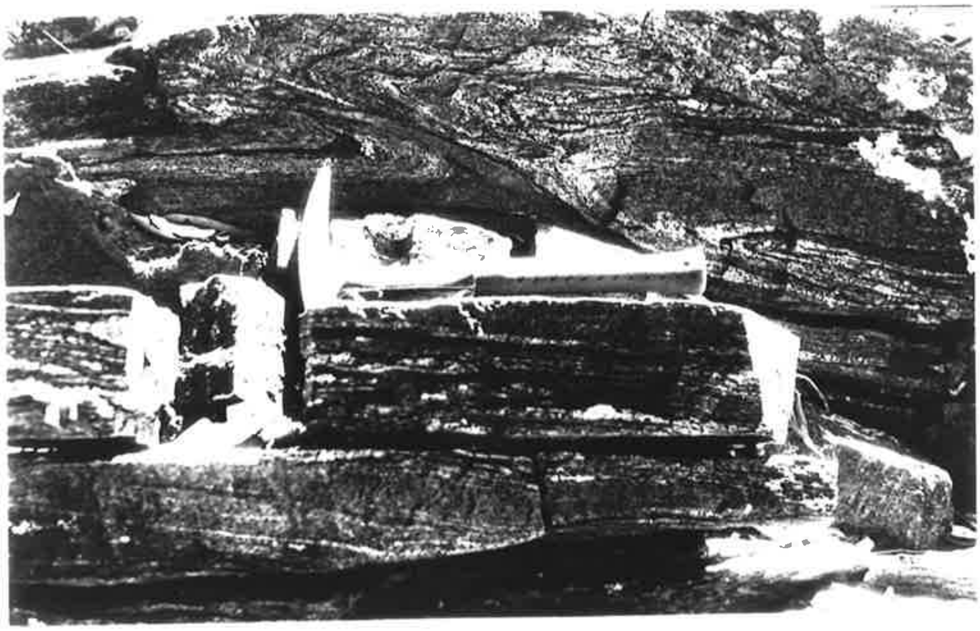


Fig 3.9

Fabric elements associated with F_{2a} folding.

(a) Well developed S_2 schistosity defined by coarse grained sillimanite (fibrous material crossing field of view obliquely) and biotite in pelitic schist. Note large garnets, eg. in centre of photograph.
Unit 3 Biscay Formation. Dougals Bore area.

(b) S_2 schistosity axial plane to rootless D_{2a} folds of granitic veins in pelitic metasediment. Unit 1, Olympio Formation. Ord River area.

(c) Large scale boudinage of impure quartzwacke bands in more pelitic matrix, and on a finer scale, boudinage of granitic veins.
Unit 4, Biscay Formation. Black Rock Anticline.

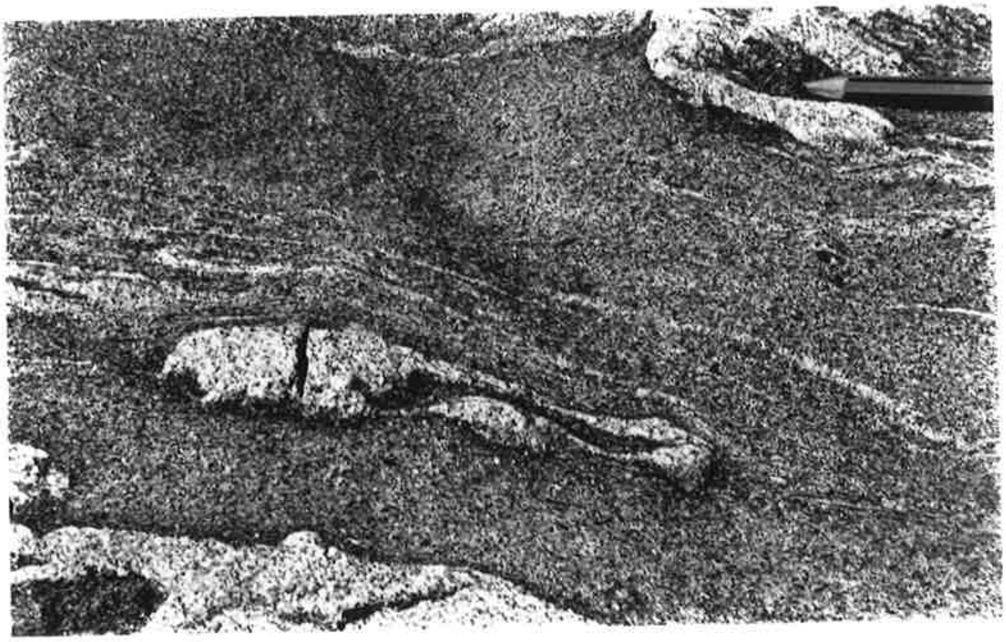
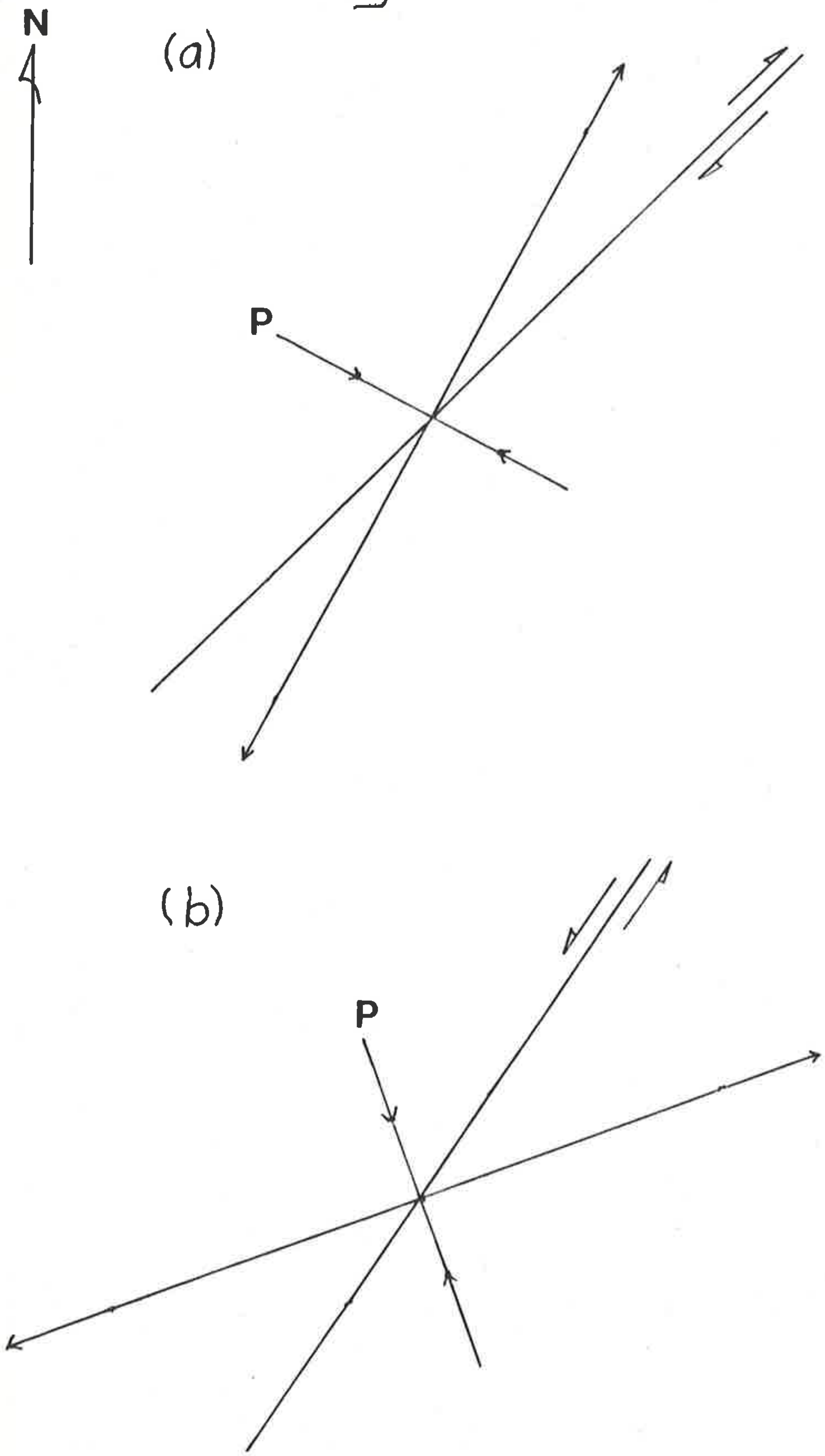


Fig 3.10



Sense of movement on major strike slip faults during deposition, D_1 + D_2 (a), and during D_3, D_4, and post tectonic (b).
P is the principal axis of compressive stress.

Fig 3.11

Vertical shear zones.

(a) Western splay of the Halls Creek Fault delimiting the Black Rock Anticline to the west. Wide, steeply east dipping, NNE trending shear zone. Basic rock completely serpentinised. Overlain to the west by Saunders Creek Formation Quartzites. Wills Creek, near its junction with Ord River. Looking northeast.

(c) Vertical, N - S trending, shear zone in carbonate bed. Unit 4, Biscay Formation. White Rock Creek. Looking south.

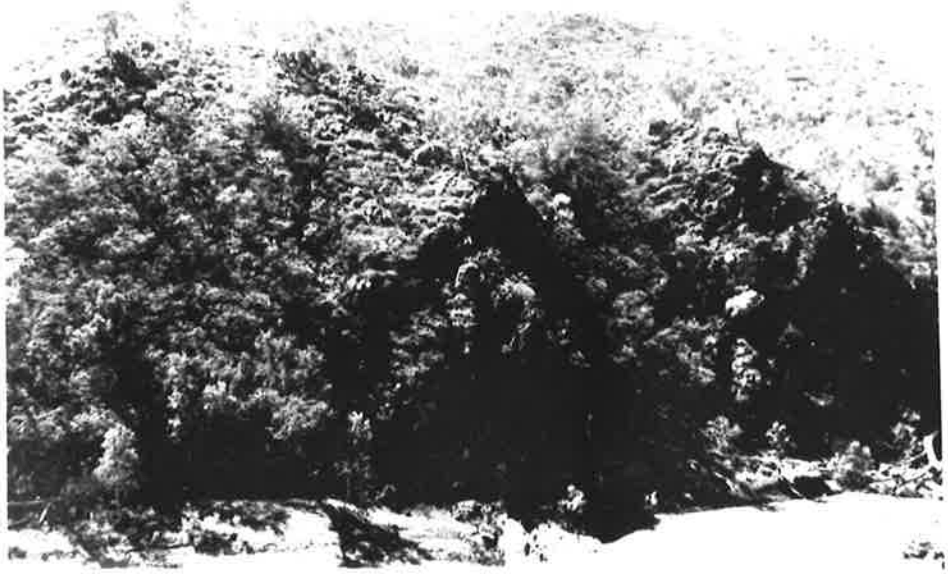


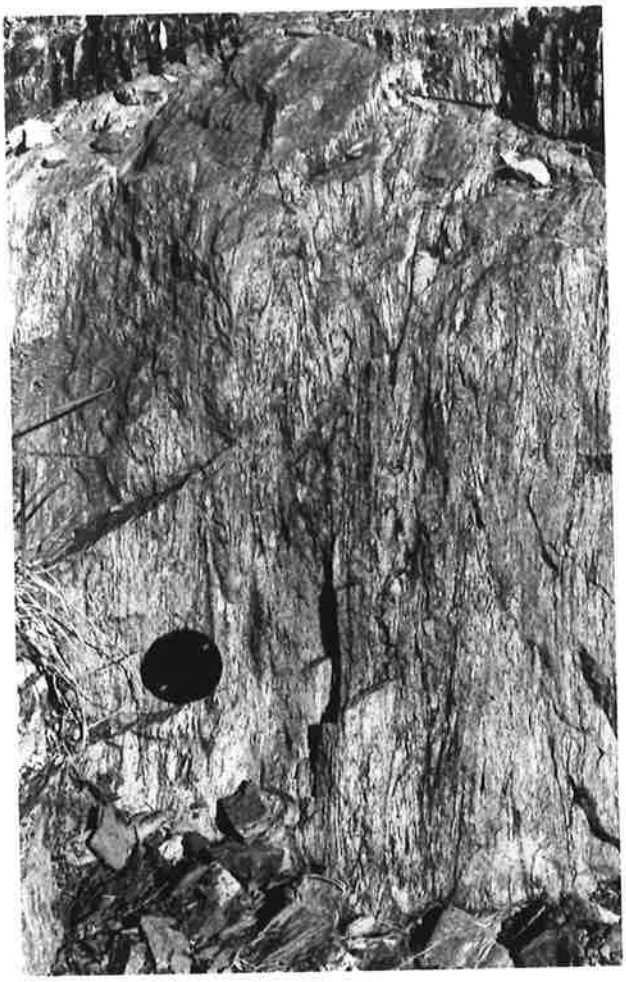
Fig 3.11

Vertical shear zones.

(c) Close up of the Halls Creek Fault, showing fine grained, strongly foliated, protomylonitic and mylonitic material, with development of sheath folds.

(d) ENE trending vertical shear zone affecting Mabel Downs Granodiorite. Coarse grained felspar xenocrysts in a mylonitic matrix. Stratigraphy offset in a dextral sense. D_3 generation.

White Rock Bore area.



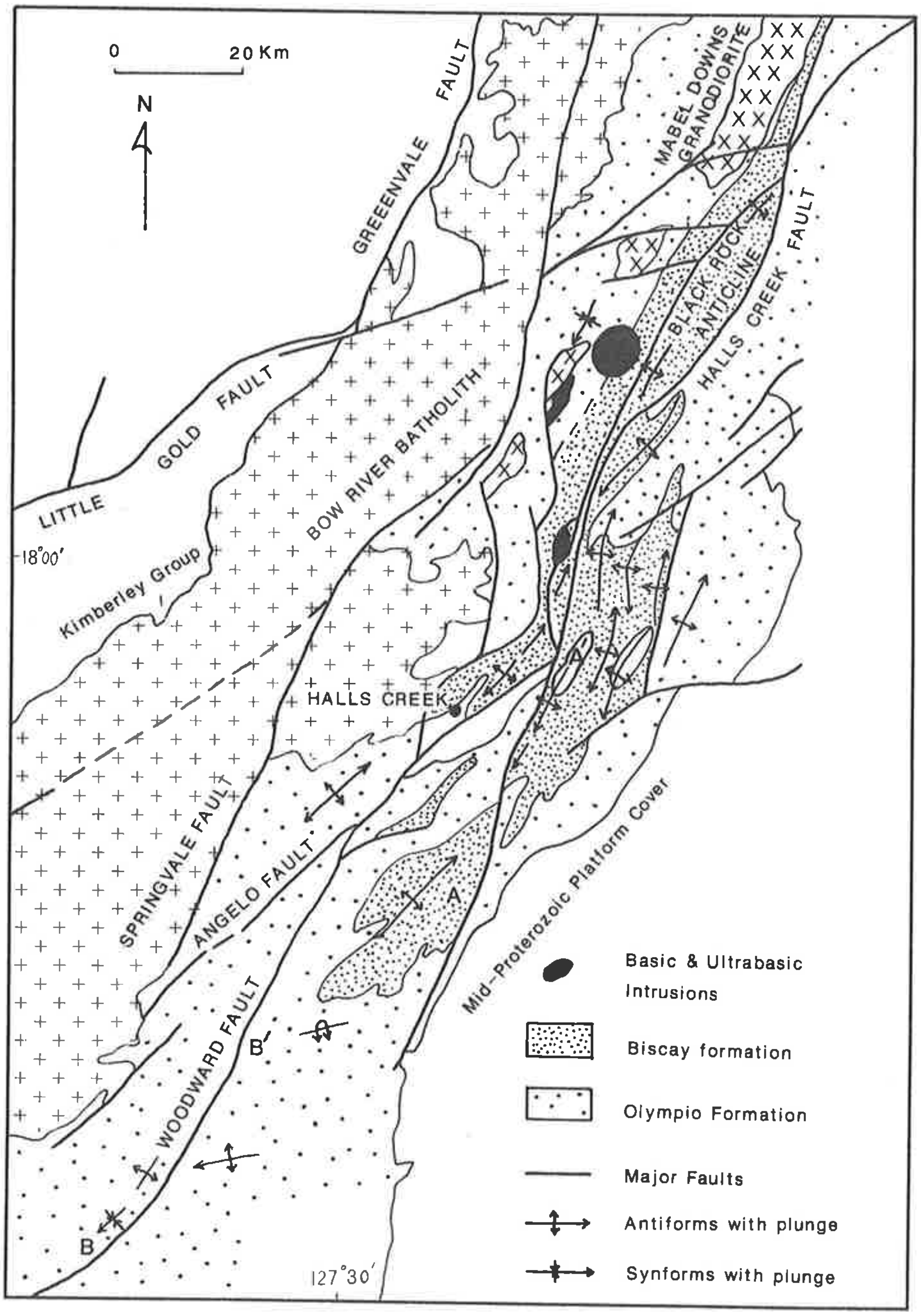

0
20 Km
N
GREEENVALE FAULT
MABEL DOWNS GRANODIORITE
BLACK ROCK ANTICLINE
HALLS CREEK FAULT
LITTLE GOLD FAULT
BOW RIVER BATHOLITH
18°00'
Kimberley Group
HALLS CREEK
SPRINGVALE FAULT
ANGELO FAULT
WOODWARD FAULT
Mid-Proterozoic Platform Cover
A
A'
B
B'
127°30'
Basic & Ultrabasic Intrusions
Biscay formation
Olympio Formation
Major Faults
Antiforms with plunge
Synforms with plunge

Fig. 3.12

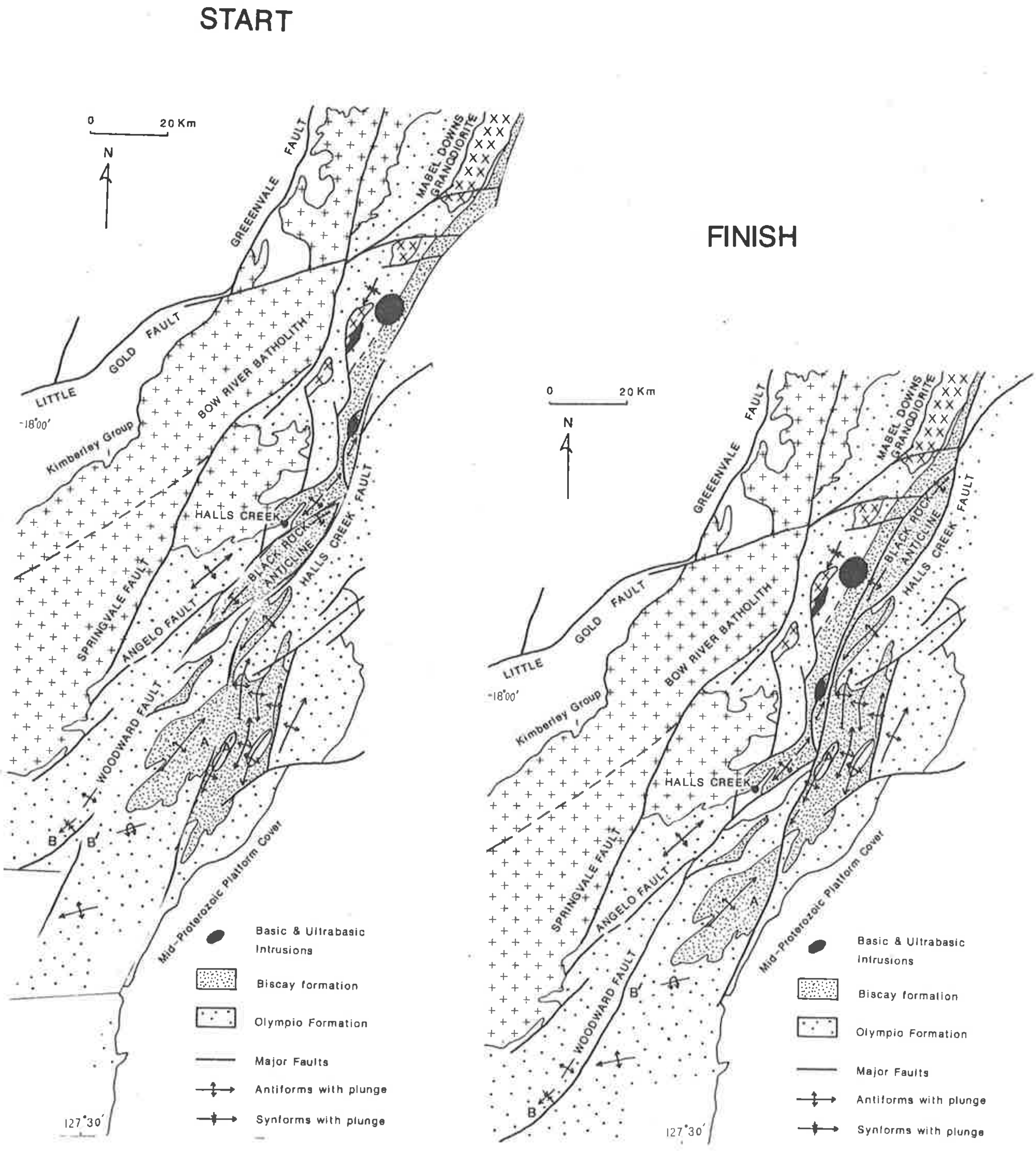
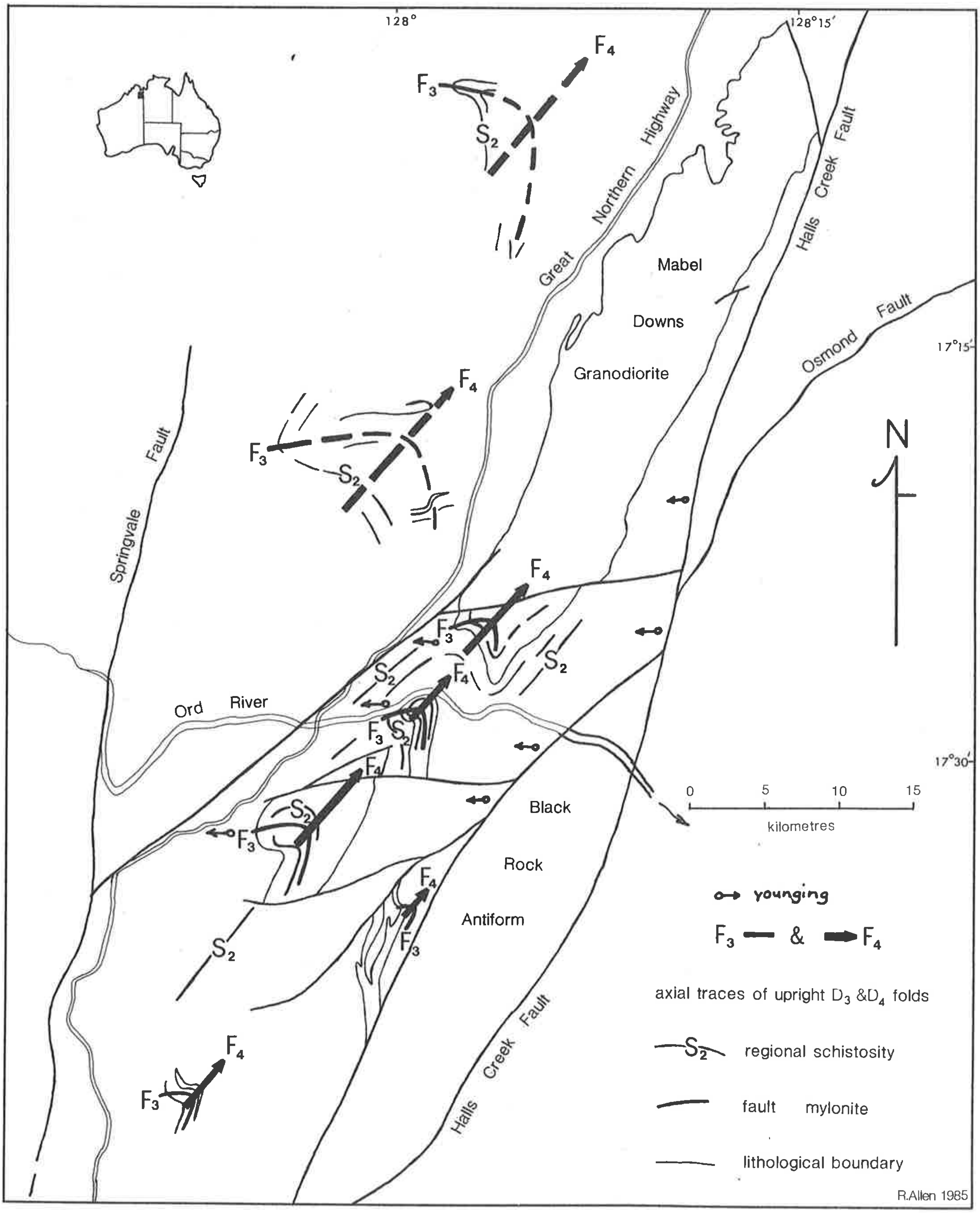


Fig. 3.13 'Horse Racing in the Kimberleys.' For explanation see text.



128°
128°15′
17°15′
17°30′
F3
F4
S2
Great Northern Highway
Halls Creek Fault
Mabel Downs Granodiorite
Osmond Fault
Springvale Fault
N
Ord River
Black Rock Antiform
0 5 10 15
kilometres
younging
F3 & F4
axial traces of upright D3 &D4 folds
S2 regional schistosity
fault mylonite
lithological boundary
R.Allen 1985

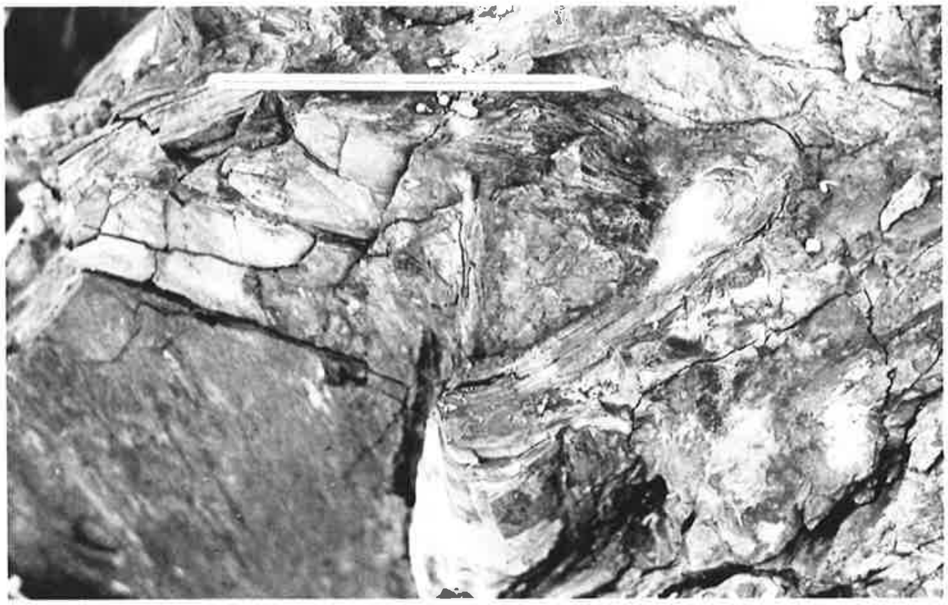
Fig 3.14

Fig 3.15

Folds in mylonite.

(a) Shear zone showing non-cylindrical 'banana folds' with curved axial traces (centre bottom of photograph) folded and refolded disharmoneously. Fine grained mylonitic fabric.

(b) Shear zone with fine bands of mylonite in a protomylonitic matrix. Folded on an E – W azimuth by F_3.



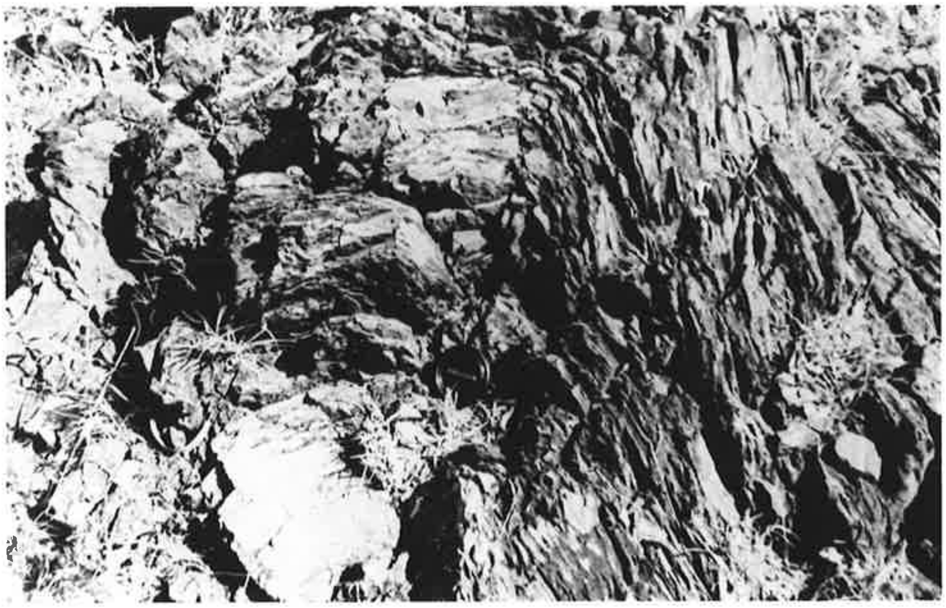


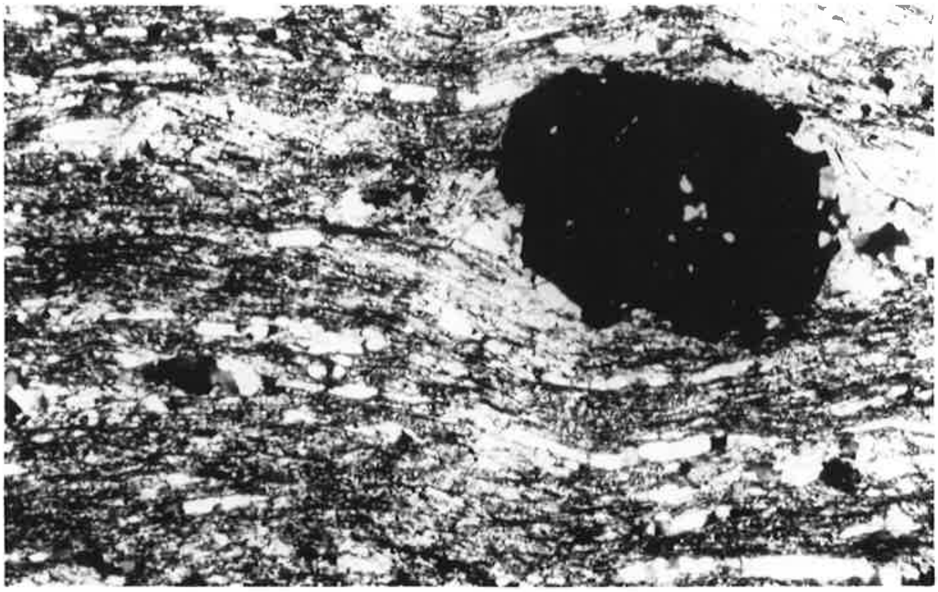
Fig 3.16

D_{2b} microfabrics.

(a) M_1 garnet in a recrystallized matrix wrapped by fine quartz ribbons (plattung).
White Rock Bore area.

(b) Plagioclase xenocryst in ignimbritic material of the 'Corkwood East Suite'. Micro shear zones with re-crystallizxation of sheared quartz grains and new grain growth around the periphery.

(c) Extremely fine grained shredded mylonitic fabric, withwisps of phyllosilicate wrapping fractured staurolite porphyroblasts, milled and rounded around the edges.



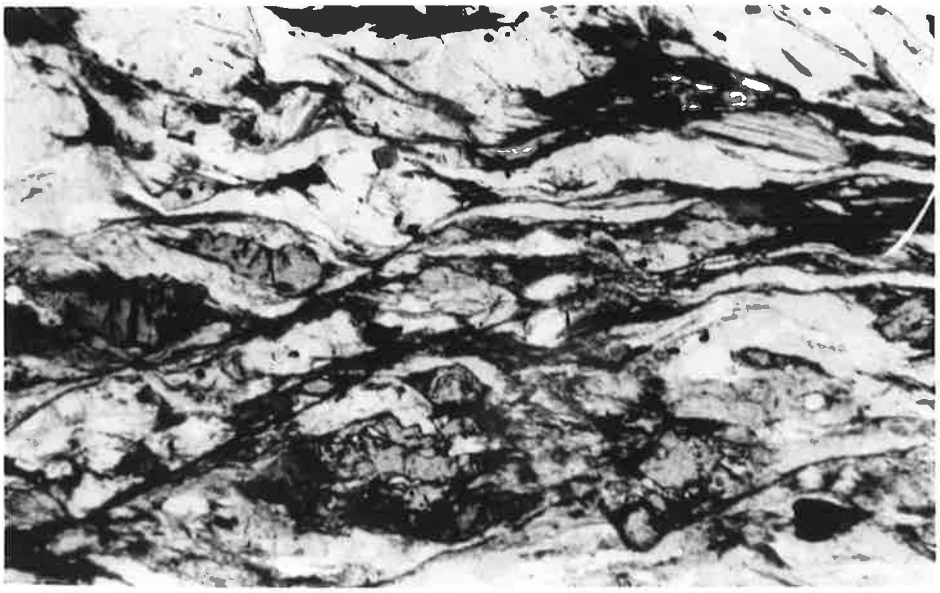


Fig 3.17

Mesoscopic D_3 folds.

(a) S_2 folded and faulted by F_3 on an E - W azimuth. Garnet mica schist.

Unit 3. Biscay formation.

Black Rock Anticline.

(b) Banded metasediment. Protomylonitic fabric with mylonitic bands in a d_{2b} shear zone, folded by F_3.

Unit 3. Biscay Formation.

White Rock area.

(c) Knotted schist with clots of sillimanite replaced by muscovite, strongly developed S_2, gently folded by F_3.

Unit 2. Biscay Formation.

Ord River area.

Fig 3.18

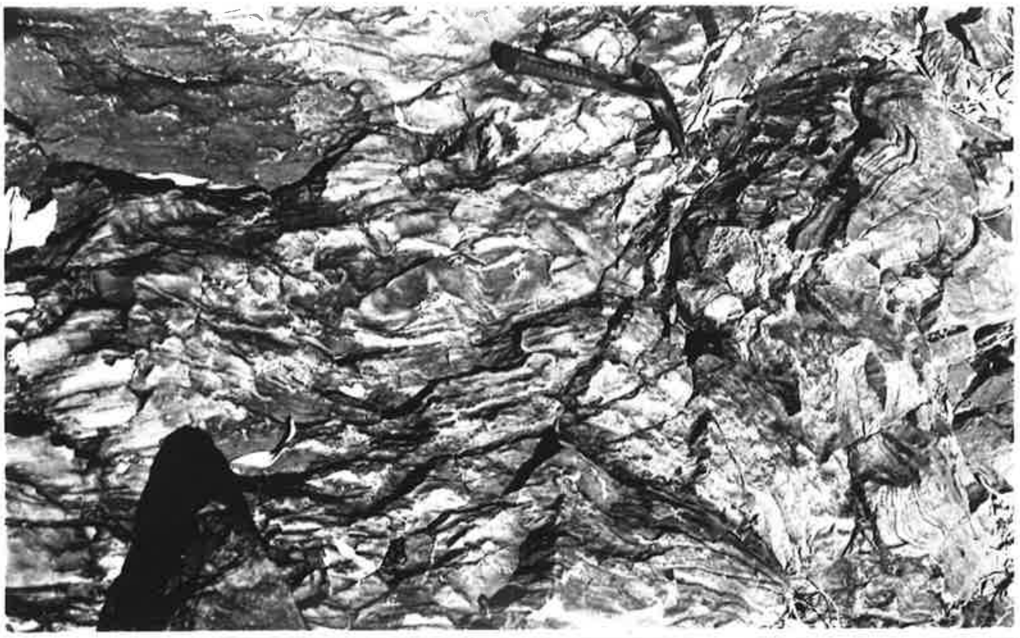
Effect of F_3 on F_2 folds.

Type 3 interference pattern (Ramsay, 1967) produced by superimposing F_3 folding on F_{2a} folds. Refolded folds in finely banded tuffaceous metasediment.

Unit 2. Biscay Formation.

Sally Malay Bore area.

(b) Tracing of schistosity and fold closures in (a) above. F_{2a} fold closuresto the right of hammer head, F_3 fold closures to the left of hammer handle.



F3
F3
F1/F2
S2
F3
F1/F2

Fig 3.19

D_3 faults.

(a) Near vertical dip on E - W fault of D_3 generation, cross cutting metasediments with well developed S_2 parallel to hammer handle.
Black rock anticline.

(b) Dextral offsets on a quartz hornblende dyke, by a swarm of E - w faults of D_3 generation.
Sally Malay Bore area.

Fig 3.20

Mesoscopic F_4 folds.

(a) Garnet schist with a strongly developed S_2, folded by F_4 into a tight, shallowly plunging anticline.

Unit 2. Biscay Formation.

Black Rock Anticline.

(b) Calc silicate beds with flat lying S_2 folded by F_4. Shallowly plunging L_4.

Unit 4. Biscay Formation.

Ord River area.

(c) S_2 folded by F_4 into shallowly plunging overturned syncline.

Unit 3. Biscay Formation.

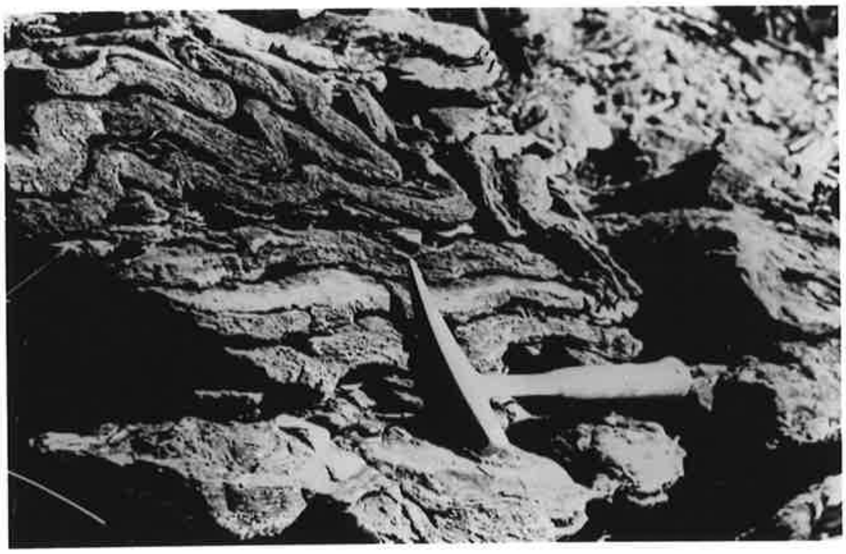


Fig 3.21

(a) Vertical plunge on F_4 fold folding mylonitic S_2. Axial trace N - S. Note open hinge area. Metasediment. Unit 2, Biscay Formation. White Rock area.

(b) Steep (near vertical) dips on fold limbs of D_{2a} fold, plunging steeply to the north from same area as (a).
Metasediment. Unit 4. Biscay Formation. White Rock area.

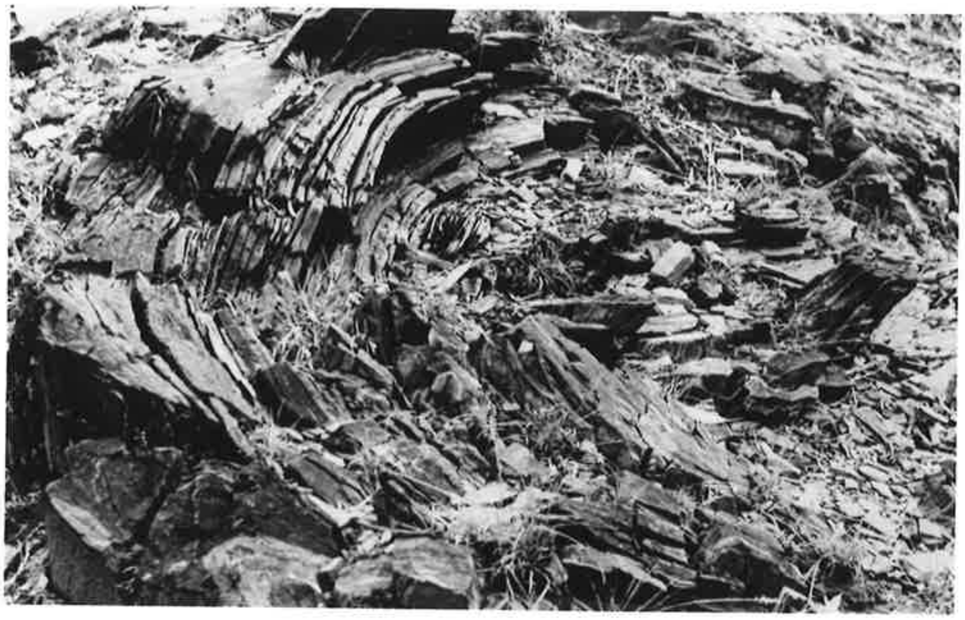


Fig 3.22

F_{2a} folds refolded by F_4.

(a) Isoclinal F_2 folds folding a schistosity in Woodward Dolerite. The recumbent F_2 folds have been refolded by F_3 with the production of a Type 3 interference pattern (folded axial trace).

Sally Malay Bore area.

(b) Isoclinal recumbent F_2 folds folding a schistosity, refolded by F_3. Interbedded pelitic and quartzofelspathic metasediment.

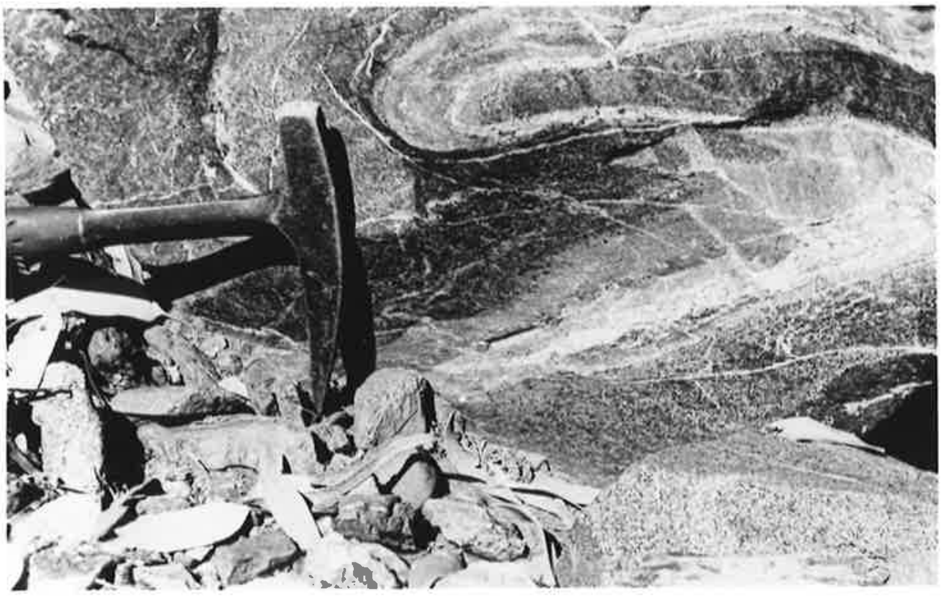
Olympio Formation.

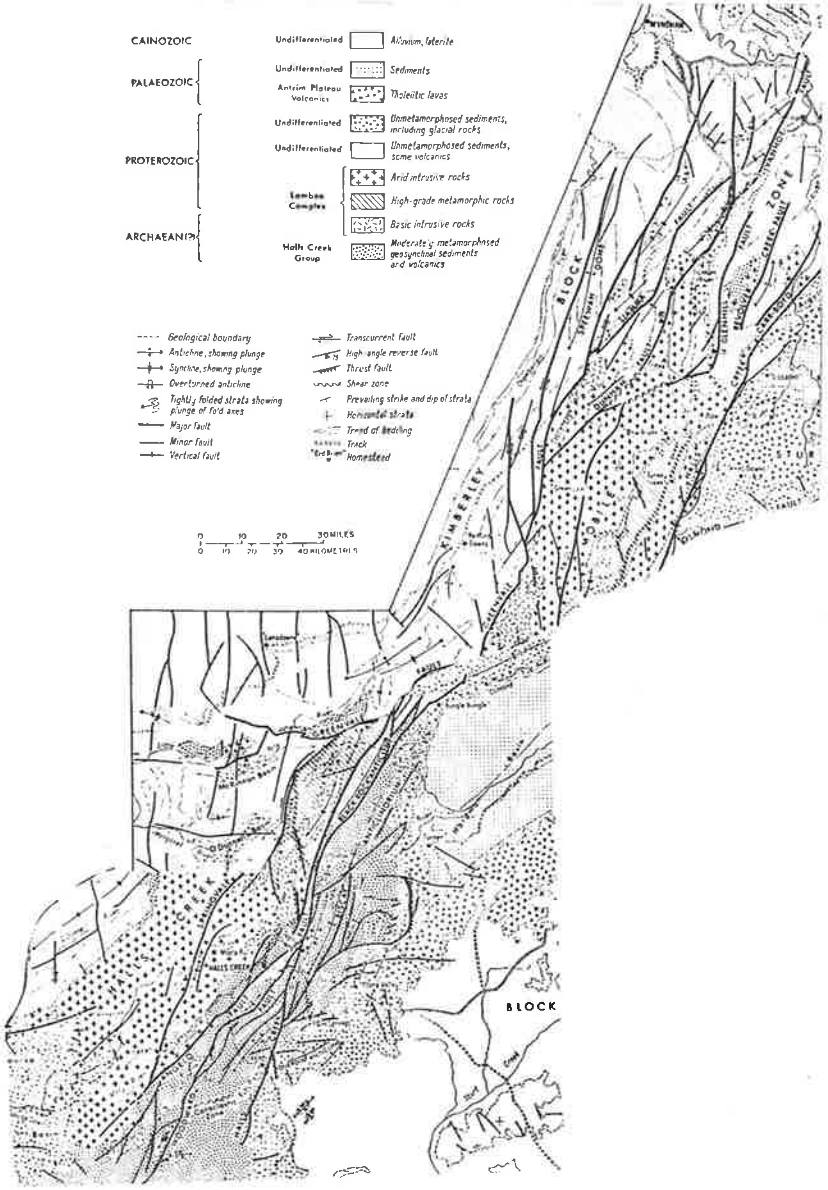
Ord River area.

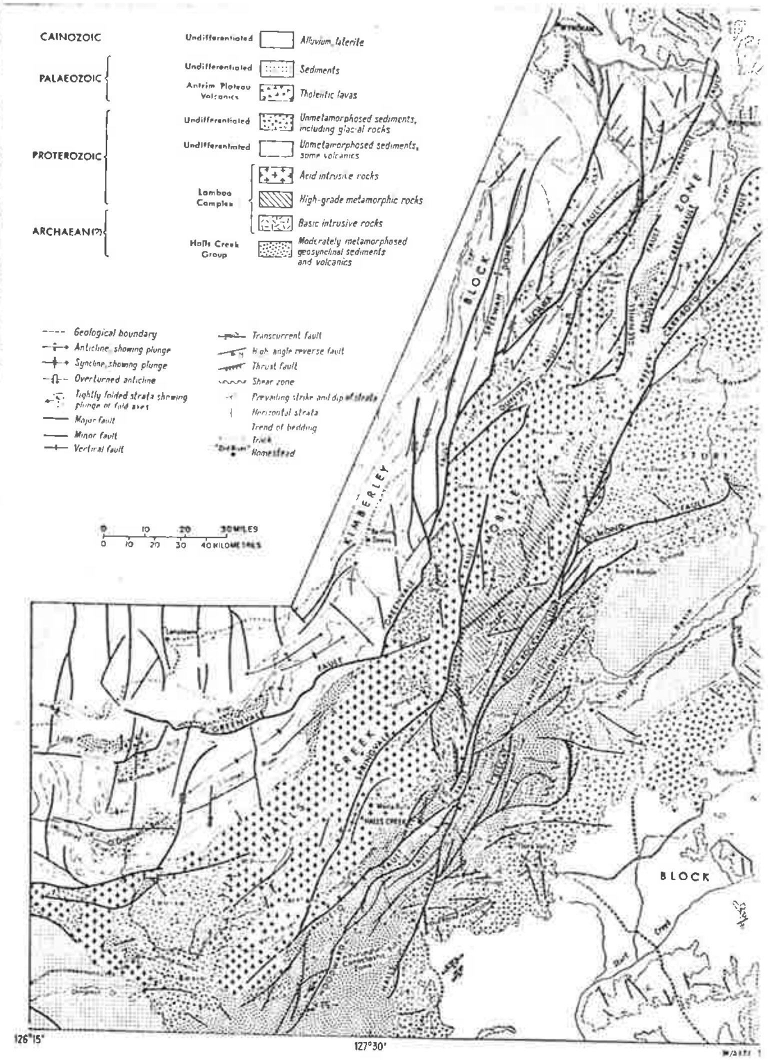
(c) Near flat lying S_2 folded into a shallowly plunging overturned syncline by F_4. Tuffaceous metasediment.

Unit 2. Biscay Formation.

Black Rock Anticline.







after Gemuts, 1971

Fig 3.23 D_1 strike slip movement on Greenvale – Little Gold – Osmond Fault System.

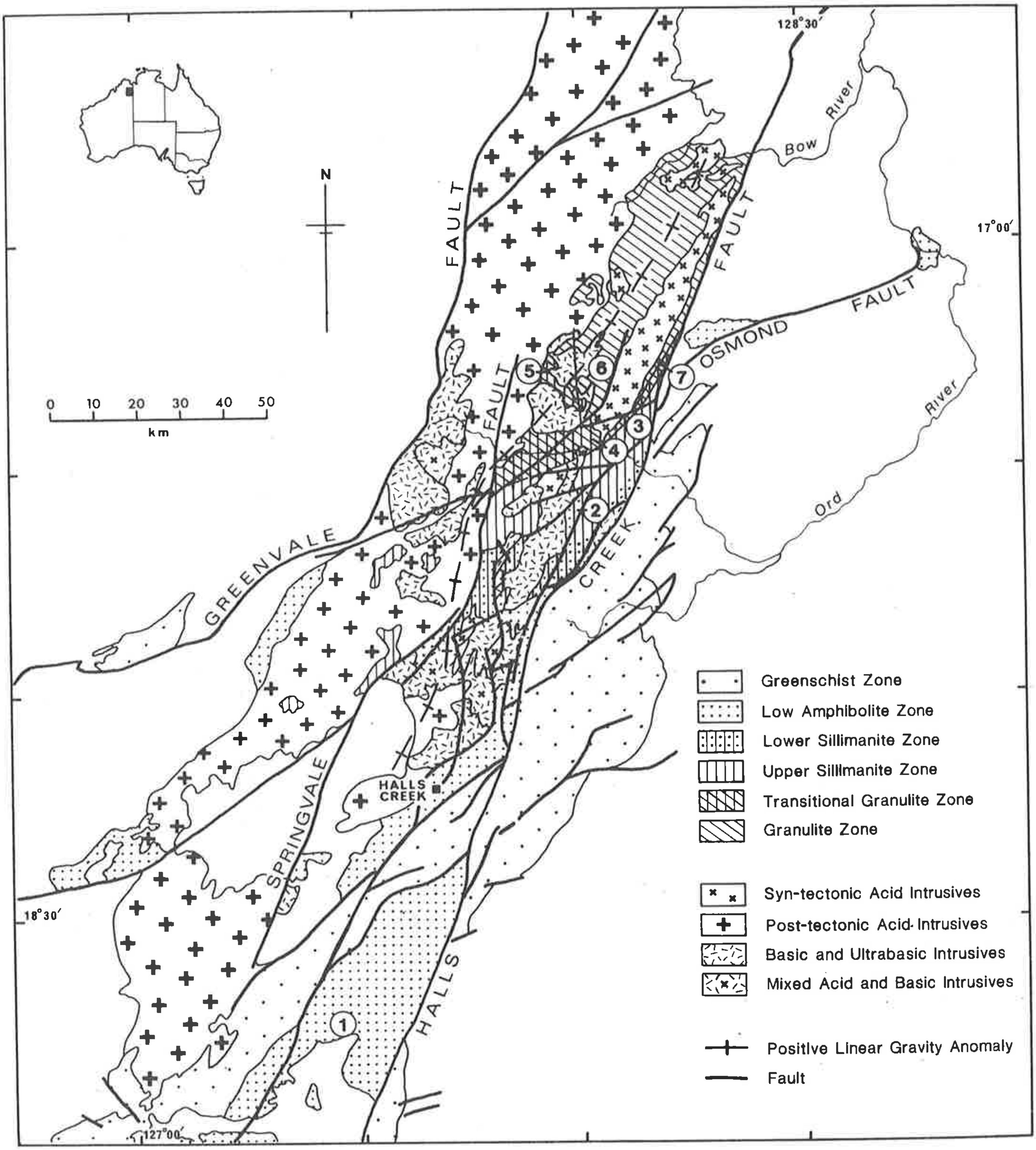


Fig. 4.1 Metamorphic zonation in the East Kimberley

Fig 4.2 Relationship between Deformation and Metamorphism in The Halls Creek Mobile Zone

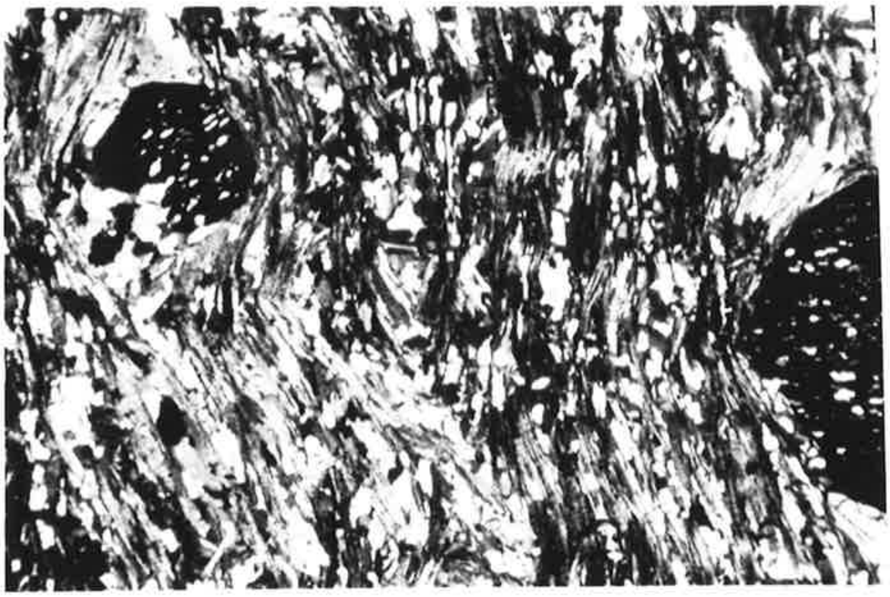
Deformation Event	Attitude and Orientation	Associated Structural Elements	Metamorphic Event	Metamorphic Fabric
D4	Upright Open-tight folds Axes vary with location in fold belt, & degree of rotation of pre-existing structures. NNE in North. ENE in South. Refolding of D3 folds.	Crenulation Lineation	M4 Transitional Granulite & Granulite	Granoblastic. Corona testures
D3	Upright Tight folds Widespread major faulting E-W axes	Sporadic coarse crenulation	M3 Zones Only	Migmatization. Wrapping pre-existing phases. High grade mineral nucleation
			M2c	Anisotropic. Inclusion free, euhedral, newminerals & overgrowths. (RetrogradeinLower Sill. Zone) (Migmatization in Upper Sill. Zone)
D2b	High angle mylonite zones ?Sub-listric slide zones NNE in North ENE in South	S2, S1, S0 transposed into near parallelism. Sinistal movement on major fault systems, incl. Halls Creek Fault. Uplift.	M2b	Mylonitic Replacement by hydrous phases in Lower Sillimanite Zone
D2a	Reclined - recumbent Tight - isoclinal folds. NNE in North ENE in South ?Restored NE-SW	S2-strongly developed crenulation cleavage crenulation lineation elongation lineation	M2a	Strongly isotropic Porphyroblasts poikolitic with rotational Si
D1	Reclined - ?recumbent Isoclinal ?NE-SW	S1-layer parallel. Overprinted in Lower Amphibolite Zone Largely obliterated at high grade. L1 - elongation lineation	M1	Fine grained Rotational Si

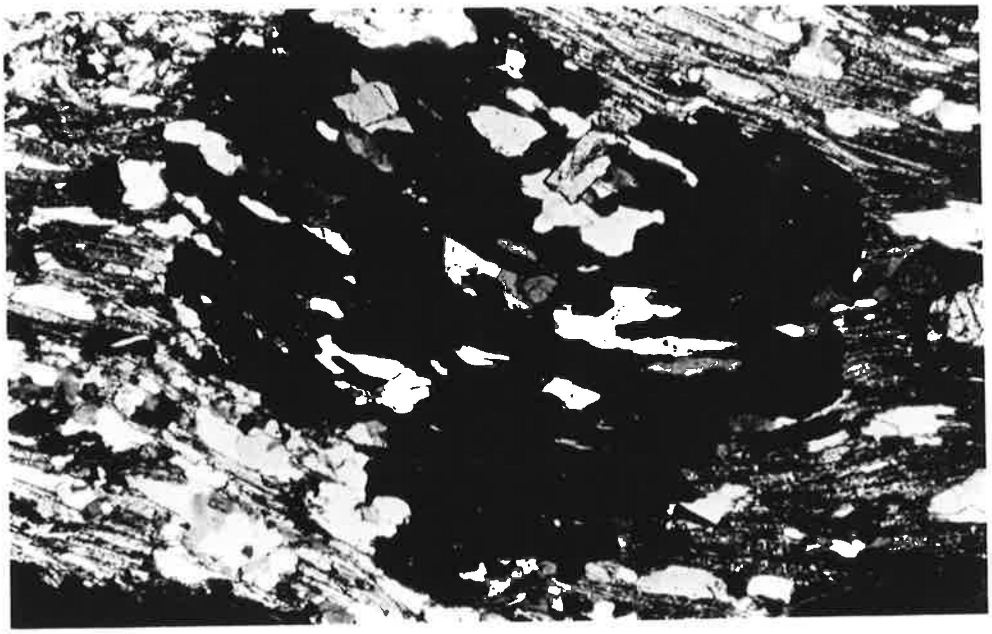
Fig 4.3

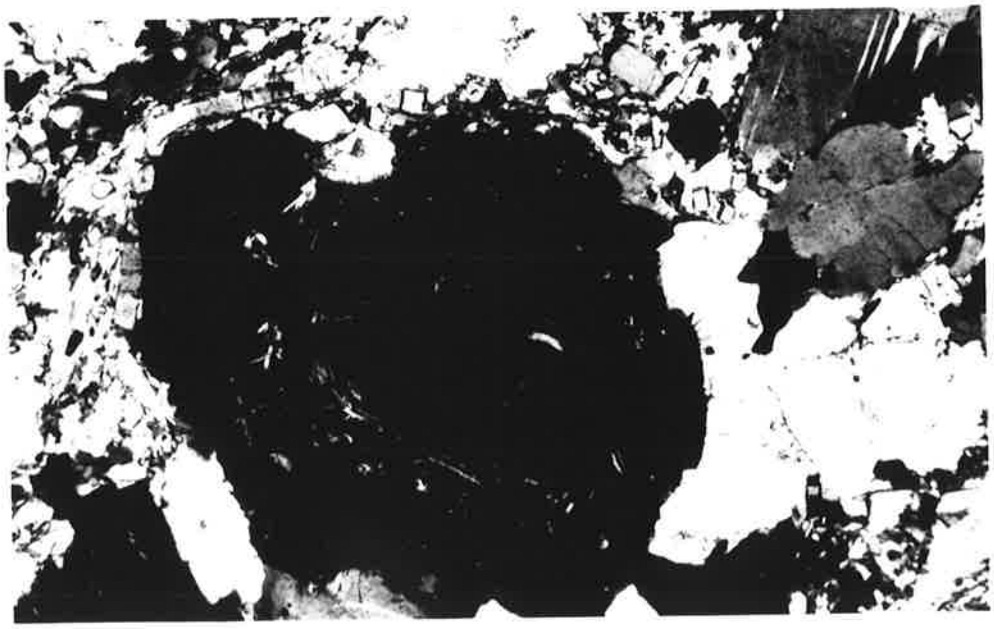
(a) M_1 garnets with a linear internal fabric of fine elongate quartz inclusions, finer grained than and discontinuous with wrapping S_2. Matrix S_2 is a coarse grained differentiated fabric defined by quartz rich and mica rich areas, crenulated by D_4.
Metapelite. Unit 3. Biscay Formation. Lower Sillimanite Zone.
White Rock area.

(b) M_{2a} garnets with a rotational internal fabric of the same grain size as, and continuous with the matrix schistosity, S_2. The coarse, strained, quartz grains in the matrix are being recrystallized into a protomylonitic fabric.
Metapelite. Unit 3. Biscay Formation. Upper Sillimanite Zone.
Ord River area.

(c) Pyrope rich zoned garnet. M_1 core wrapped by fine grained M_{2a} sillimanite in an onion skin texture. Overgrowth of M_{2c} garnet wrapped by coarse grained matrix sillimanite of M_3 generation. Note cordierite grain with incomplete twinning in top right corner.
Metapelite. Unit 4. Biscay Formation. Transitional Granulite Zone.
Sally Malay Bore area.







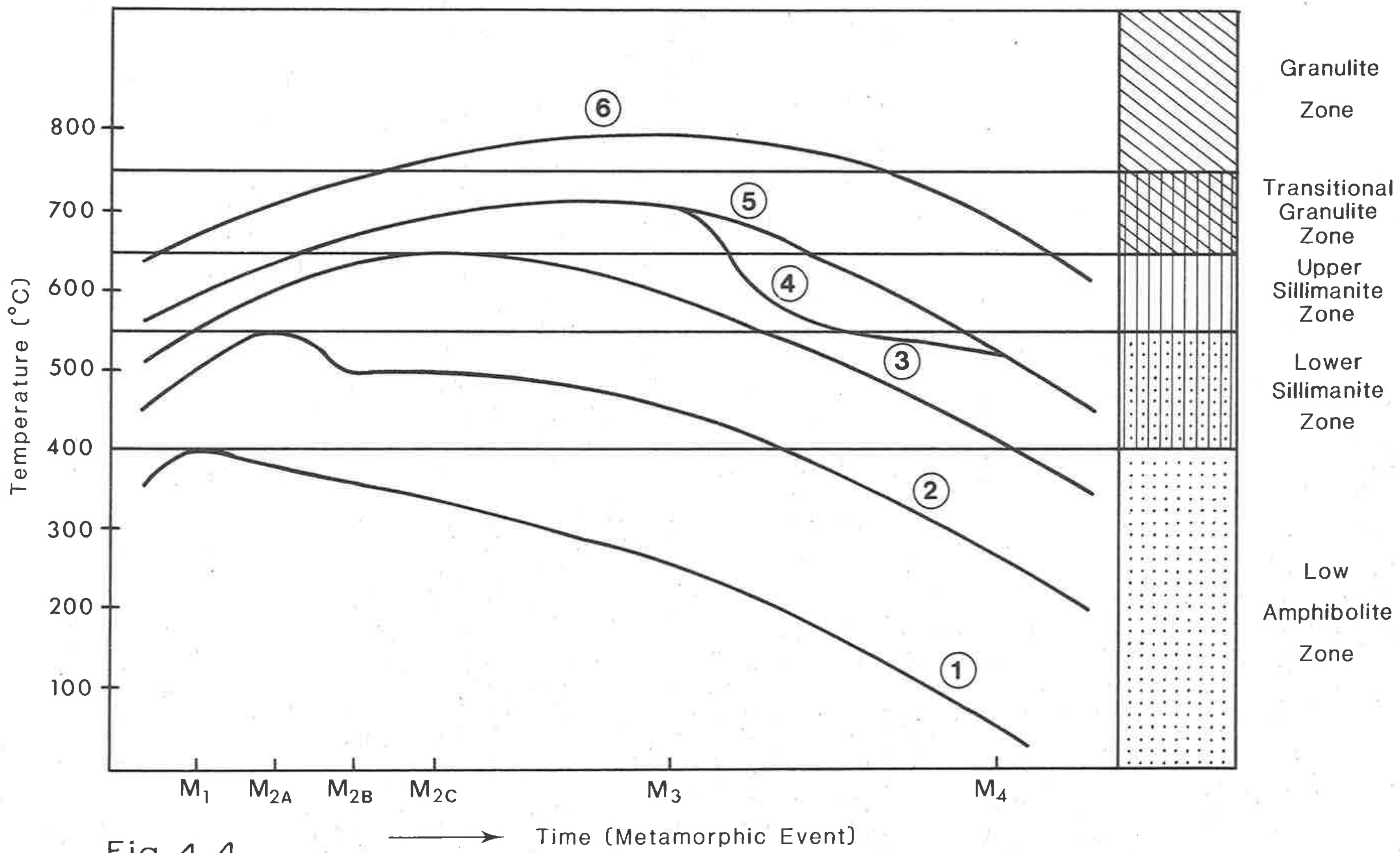


Fig 4.4

Thermal history of rocks from different areas of the Halls Creek Mobile Zone. Numbers and legend as in map of metamorphic zones.

Figure 4.5

Metamorphic Event	Lower Sillimanite Zone	Upper Sillimanite Zone	Transitional Granulite Zone
M3			sill
M2c	gt-staur-andal	sill	gt
M2b	musc		
M2a	bio-gt-sill	bio-gt-sill	gt-cord-sill
M1	bio-gt-staur	bio-gt-staur	bio-gt

Stable Parageneses of Metapelites in the Amphibolite Facies.

Fig 4.6

(a) M_1 staurolite and quartz inclusions in core of M_{2a} garnet. Staurolite (five grains in a line trending ENE above plagioclase mozaic inclusions) in optical continuity and totally enclosed in garnet - never in contact with quartz. Fibrous sillimanite inclusions in outer zone.

Crossed polars. Upper Sillimanite Zone.

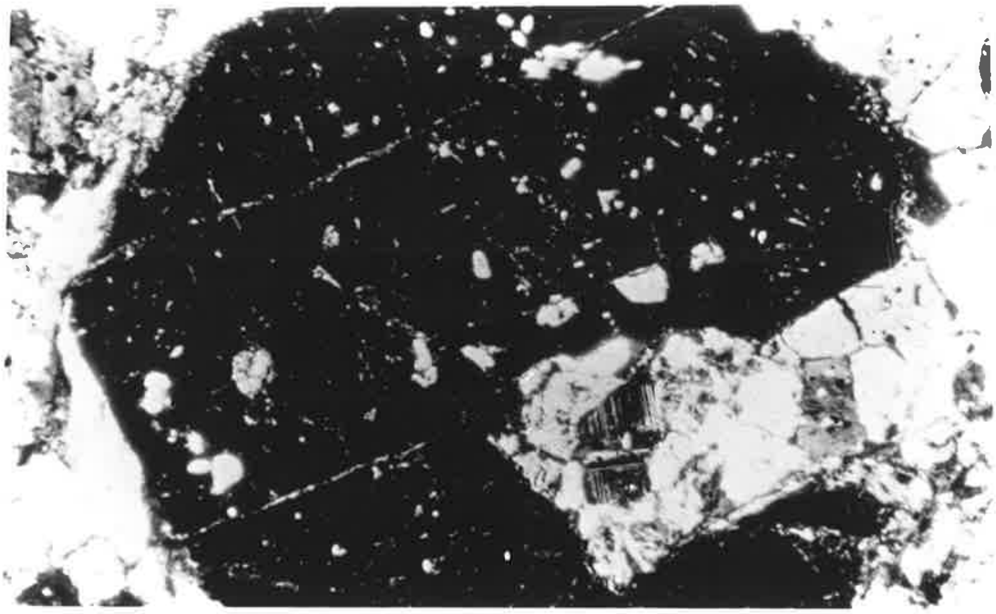
(b) Rim of same M_{2a} garnet with fibrolitic sillimanite inclusions (top right corner) and sillimanite and small remnant staurolite (high R.I.) associated with plagioclase mozaic. Staurolite inclusions in garnet not obvious without crossed polars - little distinction in colour or R.I. Same orientation, slightly higher magnification.

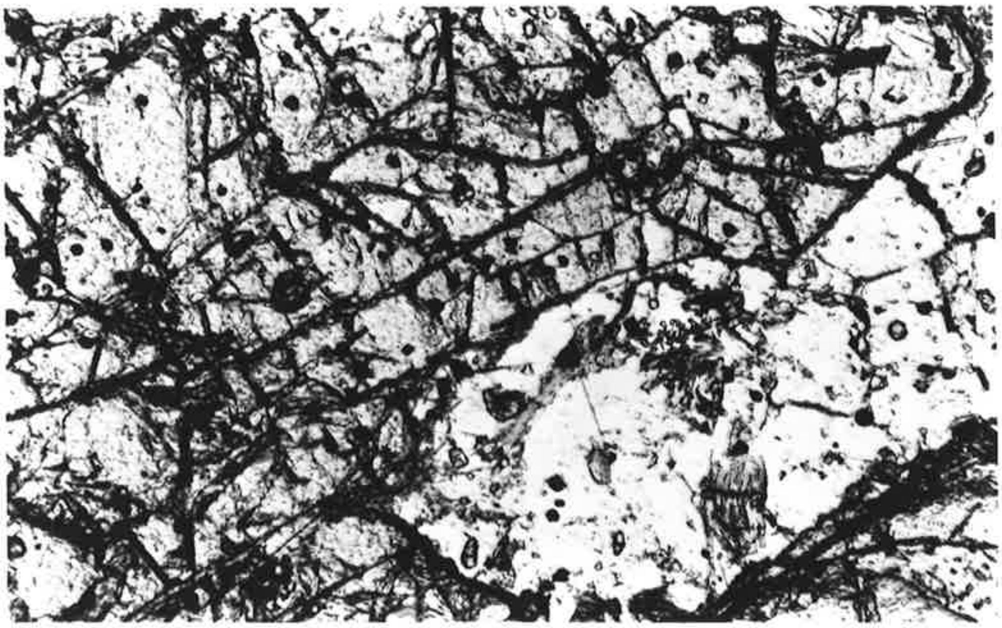
Plane polarised light.

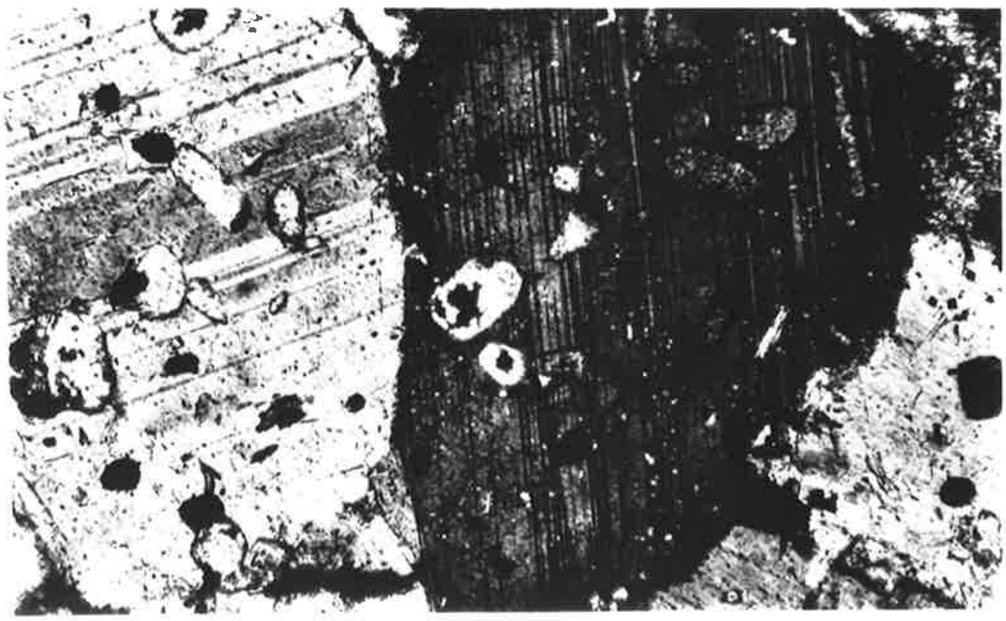
Fig 4.10

(a) Fine droplets of remnant M_1 staurolite(high R.I.) in optical continuity in M_{2a} plagioclase mozaic. Scattered metamorphic opaques. Abundant M_{2a} fibrolitic sillimanite within the thin section. Crossed Polars.

Specimen 366. Lower Sillimanite Zone







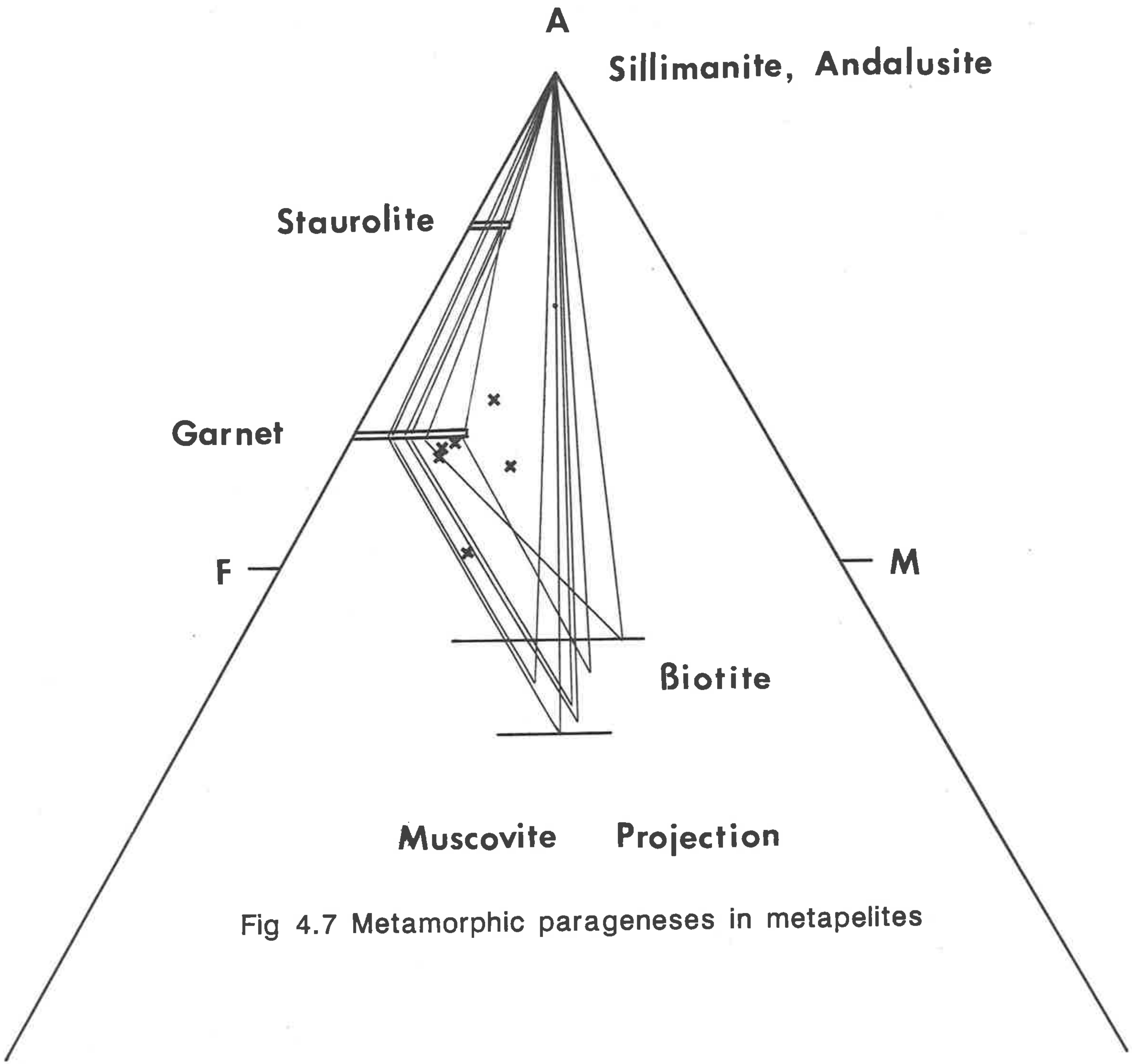


Fig 4.7 Metamorphic parageneses in metapelites

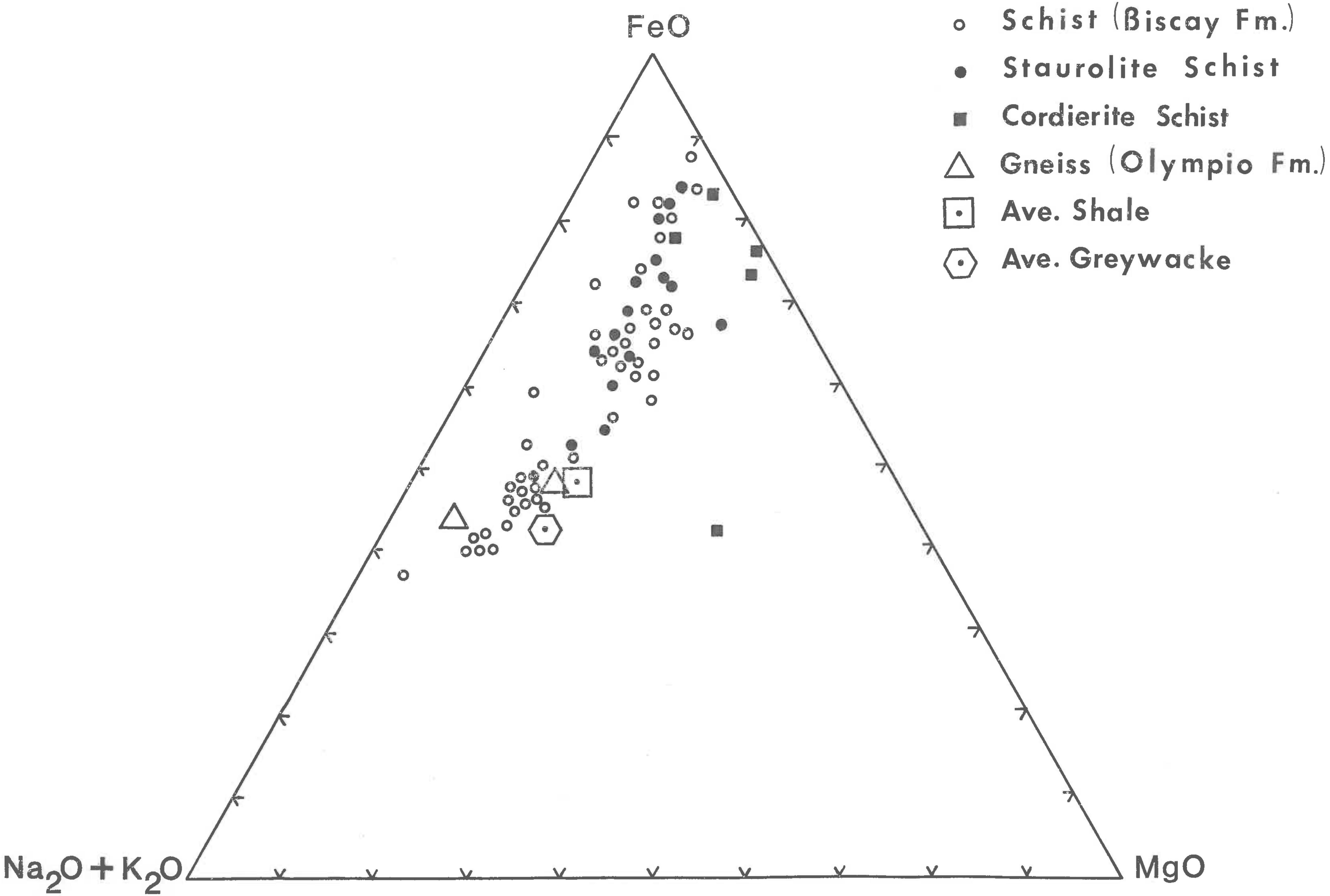


Fig 4.8 Chemical composition of pelitic and semi-pelitic metasediments

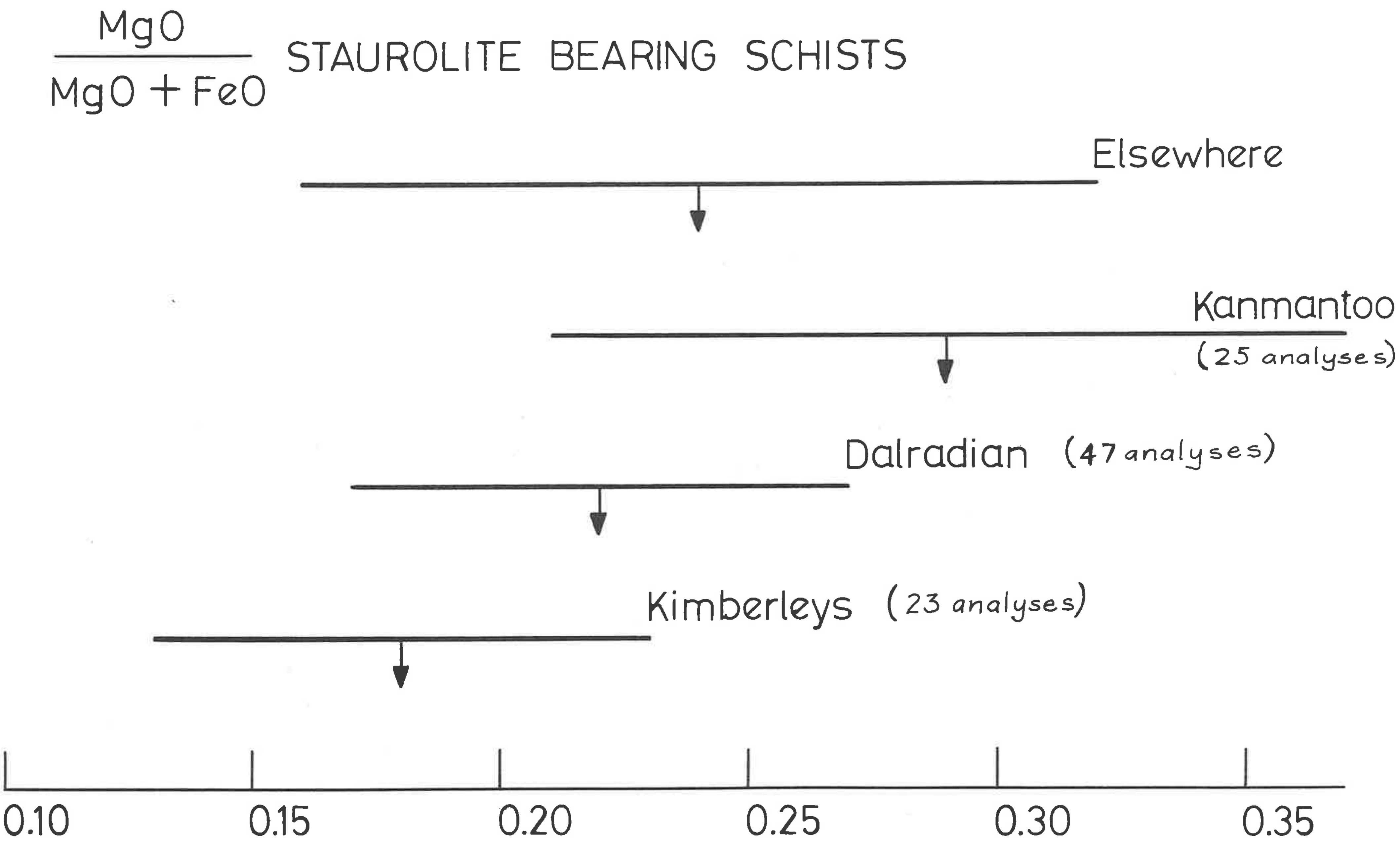


Fig 4.9 Statistical analysis of FeO:MgO of Staurolite bearing schists

ZnO contents of reactant staurolite, product phases and late staurolite

	1412 B		366		1380	
	M_1(gt)	M_1(plag)	M_1	M_3	M_1	M_3
Staurolite	2·46	2·01	0·18	0·11	0·94	1·00
Ilmenite		0·23	0·60		0·10	
Garnet	0·00–0·20		0·00–0·20		0·03–0·17	
Plagioclase		An 26 0·06	An 38 0·14		An 36 0·00–0·28	

Fig 4.11 Zn contents of products of staurolite breakdown

GARNET — BIOTITE GEOTHERMOMETRY

	PERCHUK	FERRY & SPEAR	THOMPSON
1412 B	478	416	445
	502	453	475
	493	438	465
	504	455	475
366	513	469	485
	510	465	480
	519	479	490

Fig 4. 12

Fig 4.13

(a) Basal plate of biotite with sillimanite needles arranged at 30^{o} and 60^{o} to one another. Sillimanite needles with cladding of metamorphic ilmenite.

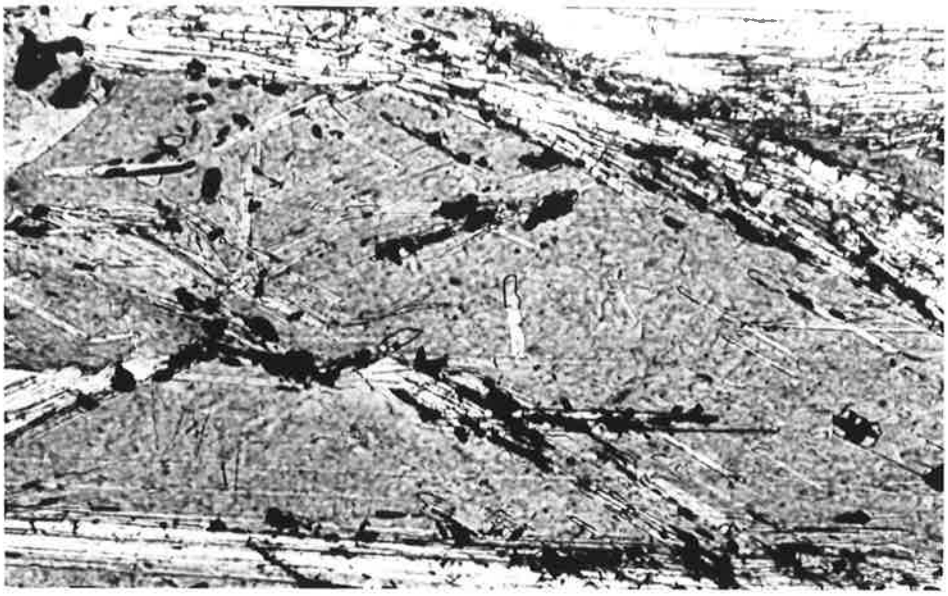
Plane Polarised Light.

Specimen 901. Upper Sillimanite Zone.

(b) Euhedral sillimanite crystals replacing biotite. Orientation of sillimanite controlled by lattice structure of biotite.

Crossed Polars.

Specimen 811. Upper Sillimanite Zone.



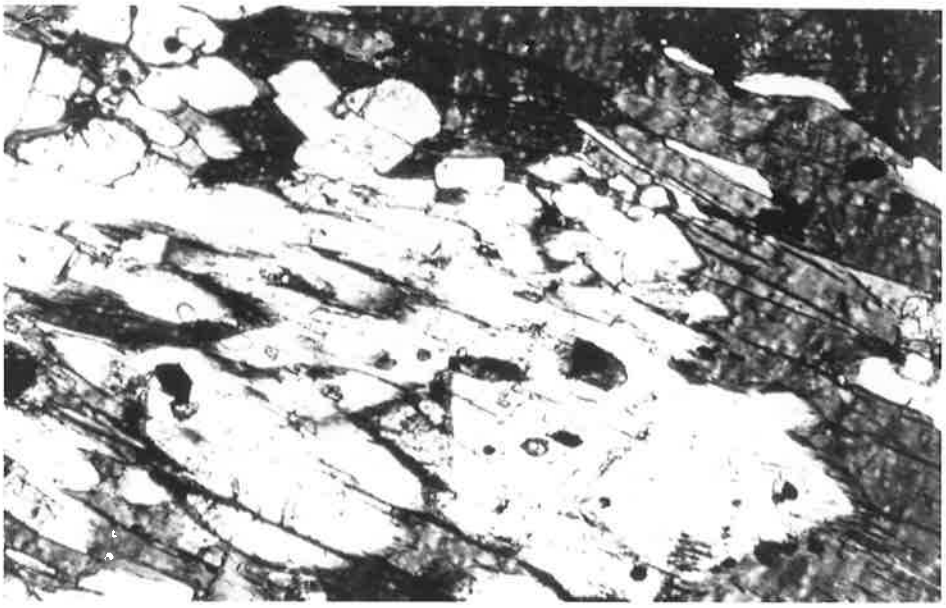
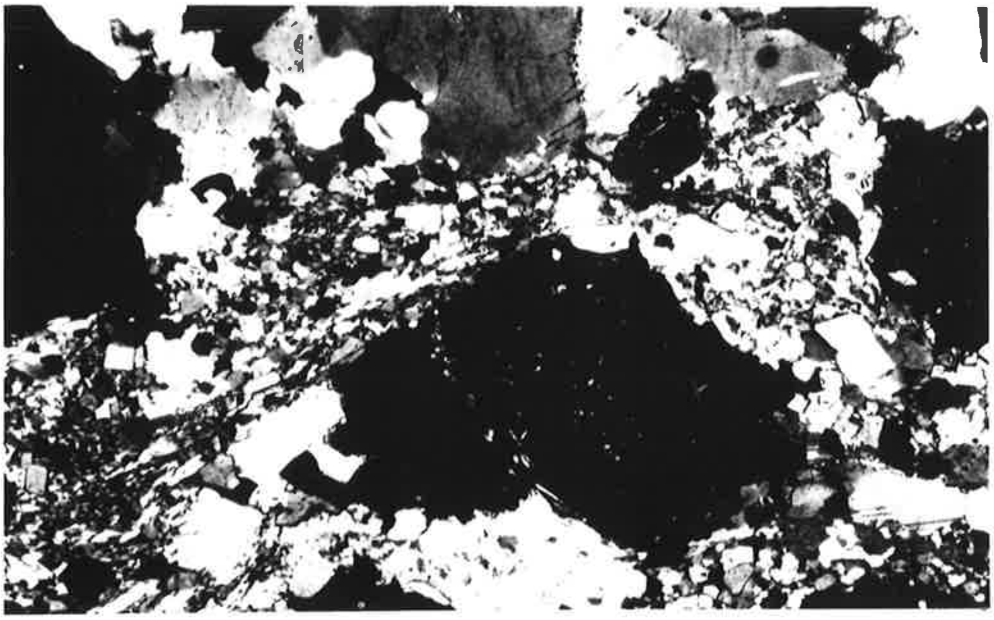


Fig 4.14

(a) Garnets with M_1 core, a fine grained M_{2a} sillimanite inclusion zone and M_{2c} overgrowths (as in Fig 4.3c). Coarse grained M_3 sillimanite in matrix. M_{2a} cordierite (two grey grains centre top) with faint twinning and the grain on the right showing a dark pleochroic halo around zircon, replaced around edges by simplectite of sillimanite and quartz with granular magnetite of M_4 generation. Specimen 960. Transitional Granulite Zone.

(b) Coexisting garnet, fine grained sillimanite (rotational inclusion trails in garnet) and cordierite of M_{2a} generation. The cordierite is corroded around the edges during M_3. Coarse grained M_3 sillimanite in matrix.
Crossed Polars
Specimen 804. Transitional Granulite Zone.

(c) Same specimen as (a) above showing sillimanite-quartz-magnetite simplectite coronas around cordierite and late stage fibrous sillimanite in grain boundaries. The simplectite is normally very fine grained, granular, high R.I. material (around the two grains in lower left corner), and only resolved with electron microscopy. The late stage sillimanite is always fibrous, and sometimes nucleates on the simplectite.
Plane polarised light.



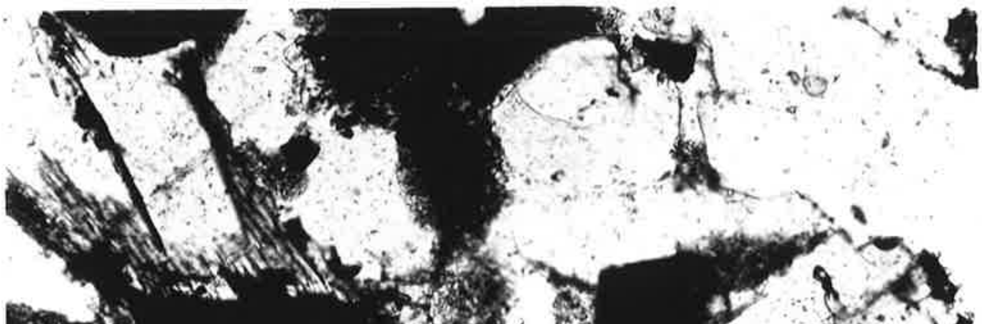


Fig 4.16

Atomic number contrast in polished thin section. Garnet from Specimen 960. Scanning Electron Microscope Environmental Cell Image. (back scattered electron and low vacuum). Area with lower atomic number shows up darker. A narrow zone around the microfractures is enriched in Mg (ie higher pyrope content) relative to Fe, due to preferential migration of Fe ions along microfractures to rim and possibly across grain boundary (see text).
(Vertical dark lines are an artifact of the scanning process).

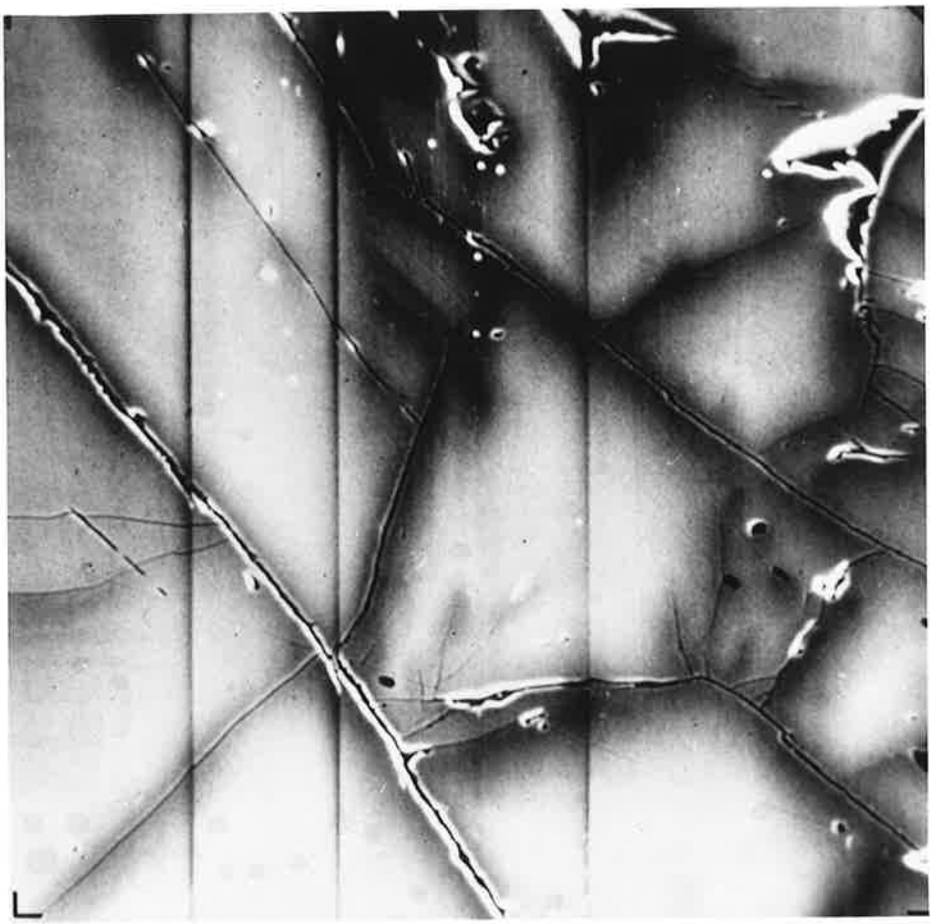


Fig 4.18

(a) Fine grained M_1 biotite corroded and included by M_{2a} plagioclase. Concommitant formation of coarse grained M_{2a} sillimanite (strings of high R.I. mineral). Open, wavy crenulation resulting from D_4 deformation. (Coarse grained M_{2a} biotite visible in other parts of same thin section).

Plane Polarised Light

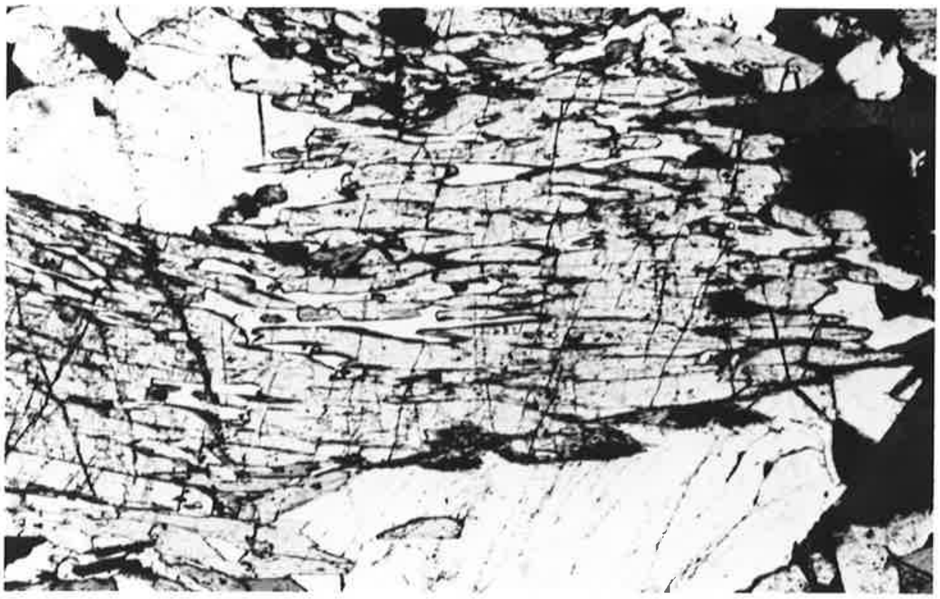
Specimen 811. Upper Sillimanite Zone.

(b) Very coarse grained sillimanite with plagioclase inclusions.

Plane Polarised Light.

Specimen 813. Upper Sillimanite Zone.

(c) Same field of view as above. Crossed polars. Plagioclase inclusions in optical continuity.



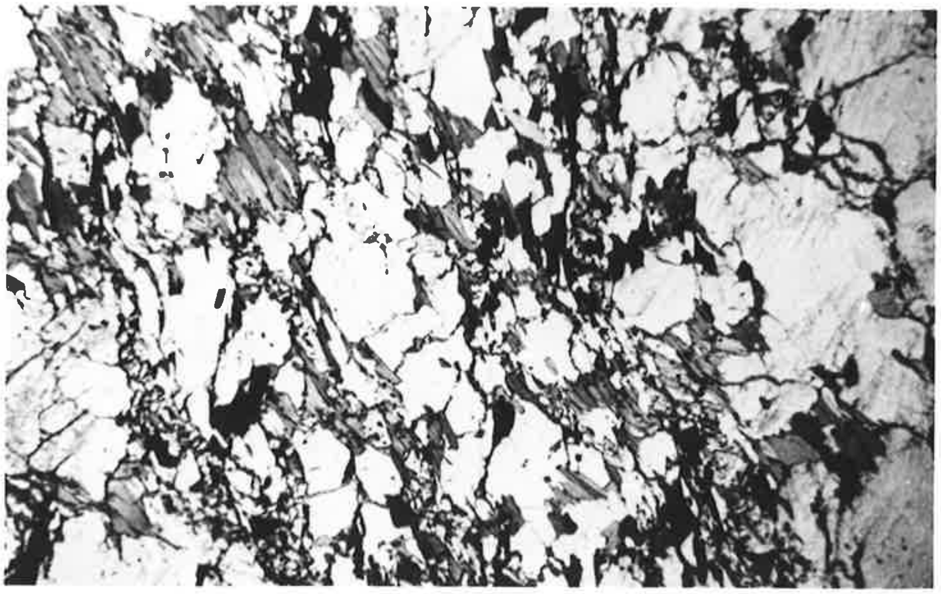


Fig 4.19

(a) M_{2a} sillimanite pseudomorphs after M_1 andalusite. Matrix predominantly carbonaceous material and pyrite.

Plane Polarised Light

Specimen DDH 44.5

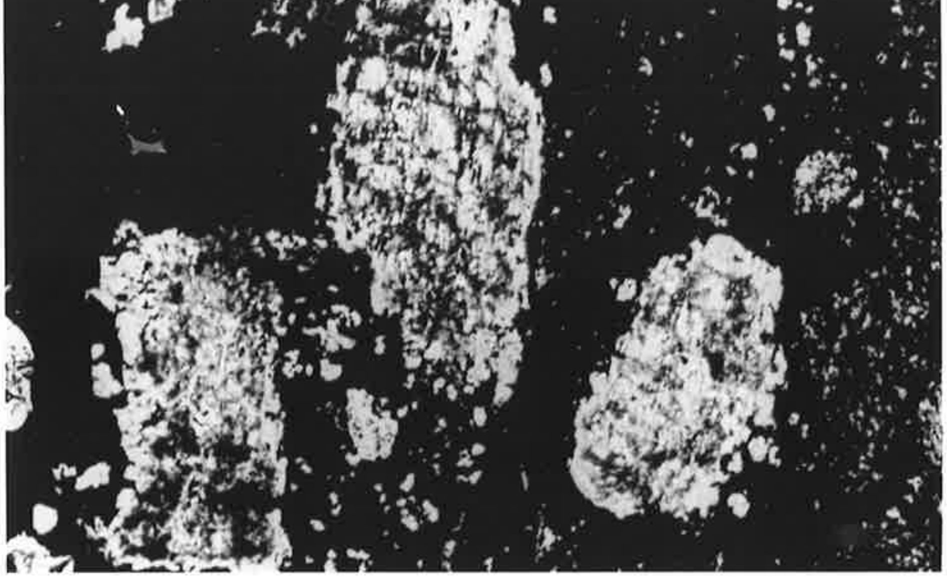
Eileen Bore Prospect.

Lower Sillimanite Zone.

(b) At higher magnification, pseudomorphic sillimanite replaced around the edges by fine grained intergrown muscovite of M_{2b} generation.

Same specimen.

Crossed Polars.



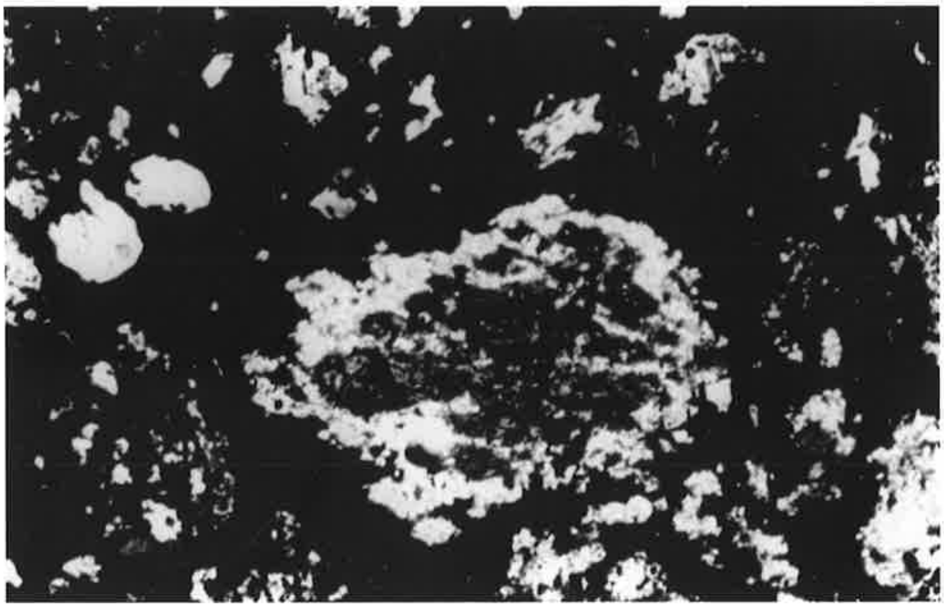
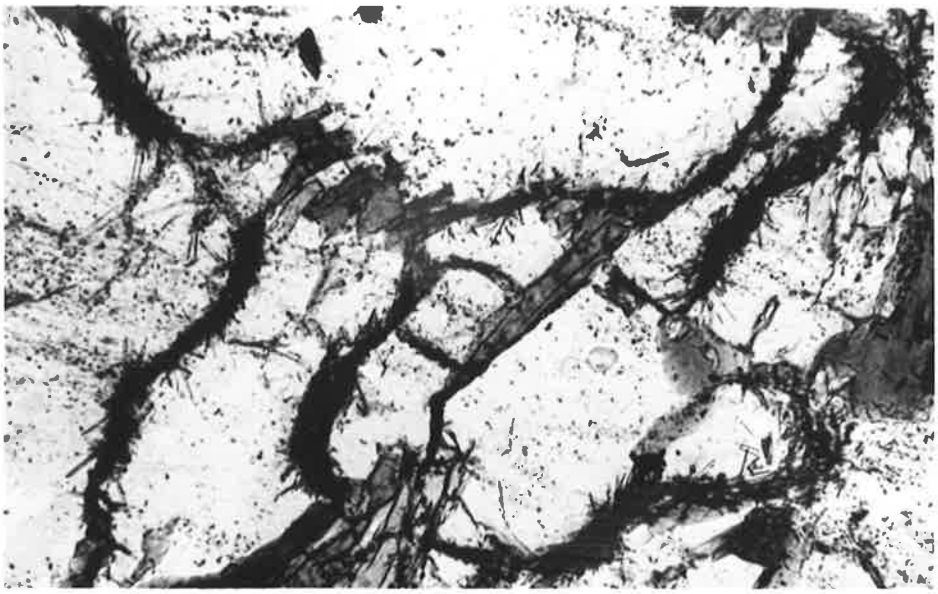


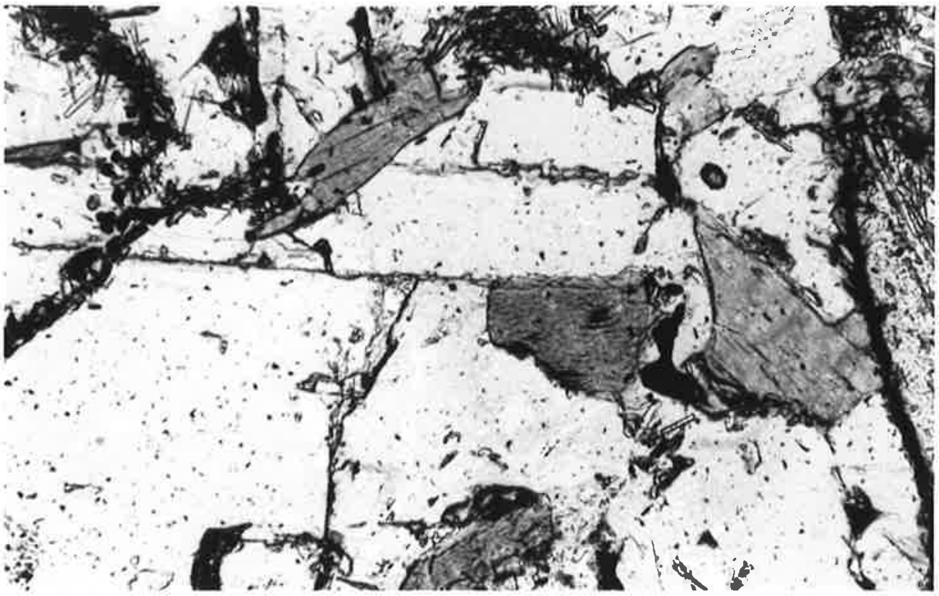
Fig 4.20

(a) Clumps and thickets of sillimanite fibres crowd grain boundaries and project into adjacent grains. The fibrolite is nucleating preferentially on feldspar, with a lesser development on biotite. Plane Polarised Light.

(b) Radiating fibres of sillimanite on feldspar grain boundary. Note M_{2a} sillimanite inclusions in M_{2a} garnet (right edge of photograph) and the late stage fibrolite nucleating on its boundary.
Plane Polarised Light.

(c) Large plate of M_{2b} muscovite (centre of photograph) with M_{2a} sillimanite inclusions, and late stage fibrolite nucleating on the edge and projecting into the muscovite. Also coarse grained euhedral, M_{2c} staurolite (bottom left corner) with quartz inclusion containing M_{2a} sillimanite. Plane Polarised Light.
Specimen 366. Lower Sillimanite Zone.





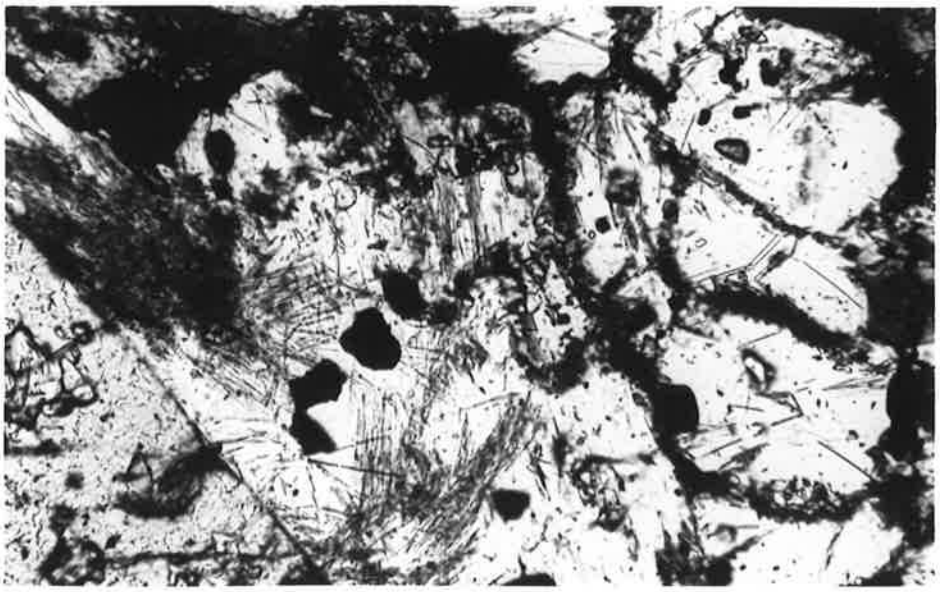
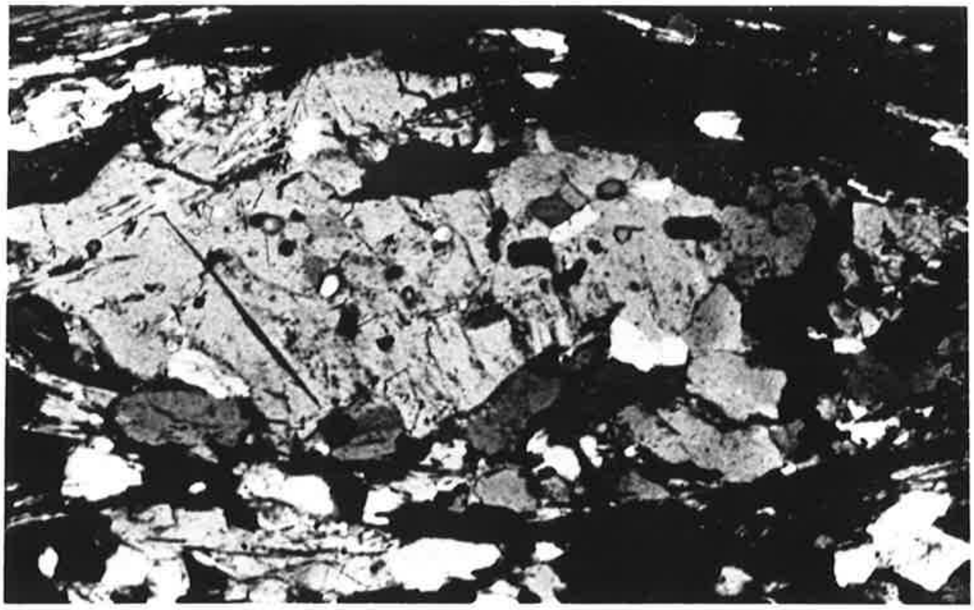


Fig 4.21

(a) Large M_{2a} K apar porphyroblast elongate along S_2. Partly overgrowing, partly wrapped by S_2 schistosity, defined by biotite and sillimanite.
Specimen 1176 A. Transitional Granulite Zone

(b) Garnet-cordierite-sillimanite Gneiss showing sector twinning in cordierite grains which are corroded around the edges.
Transitional Granulite Zone

(c) Tiny scattered M_1 garnets, and fine orientated M_1 biotite inclusions in very coarse M_{2a} microcline, part wrapped by, part overgrowing S_2 schistosity defined by biotite and sillimanite. (Well developed perthite and some myrmikite in other parts of same thin section).
Specimen 1474. Transitional Granulite Zone.



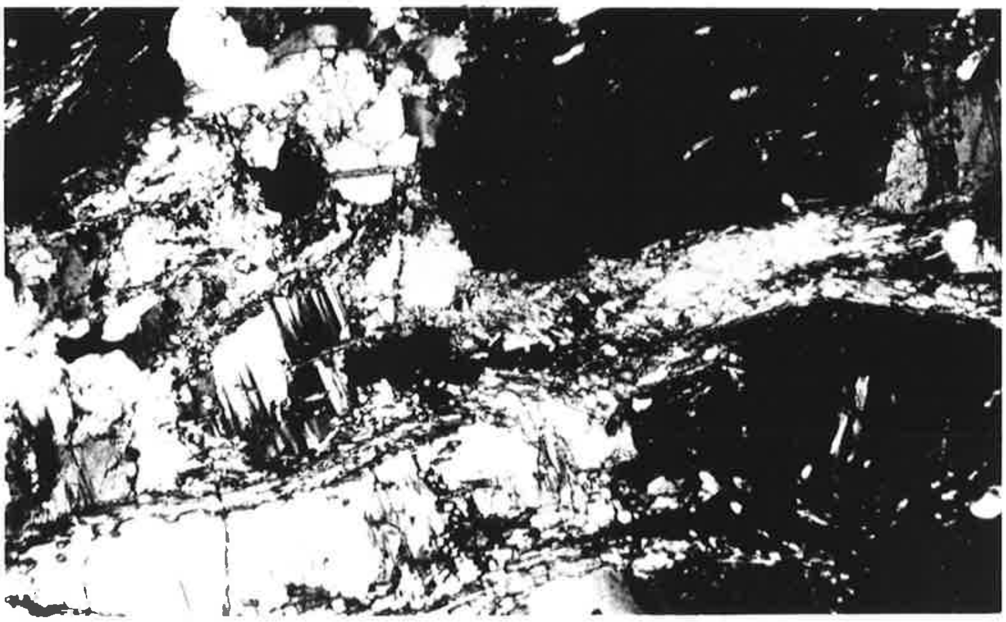


Fig 4.22

(a) Minute, euhedral M_{2c} staurolite nucleating on M_{2a} garnet, and in M_{2b} muscovite which overgrows M_{2a} sillimanite.

Plane Polarised Light.

Specimen 68. Lower Sillimanite Zone.

Fig 4.23

(a) M_{2a} sillimanite remnants in M_{2b} muscovite plate (large grain left of central band of biotite). Coarse grained euhedral M_{2c} staurolite in top right corner. Note clump of M_1 staurolite relicts (tiny, rounded, high R.I.) in plagioclase grain (above and to left of muscovite).

Plane Polarised Light.

Specimen 366. Lower Sillimanite Zone.

(b) Garnet with M_{2c} euhedral outline overgrowing intergrown felt of fine grained M_{2b} muscovite which replaces M_{2a} sillimanite. Tiny euhedral staurolite grains nucleating in muscovite and overgrowing remnant sillimanite.

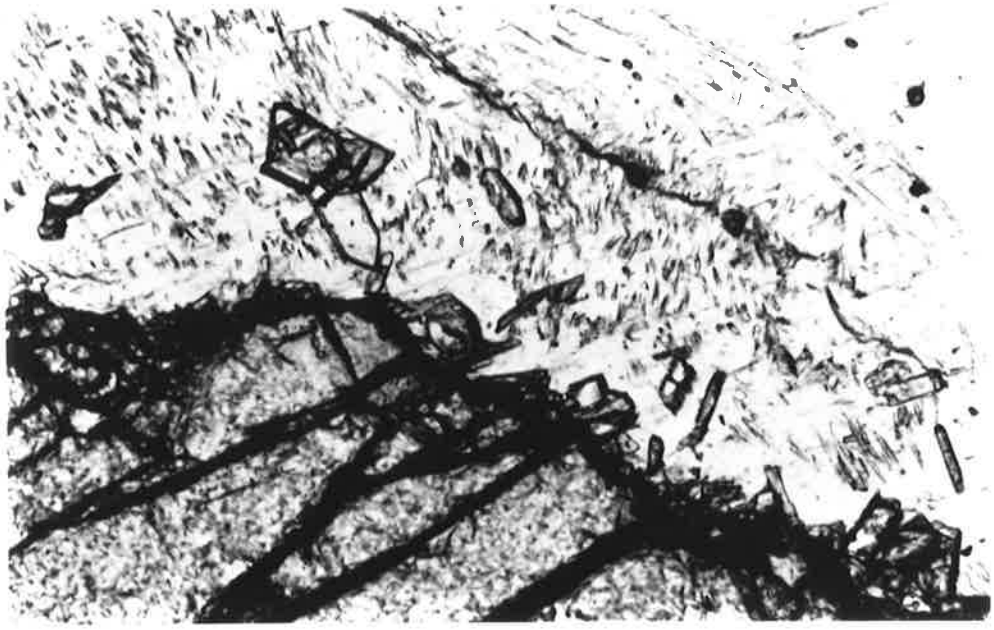
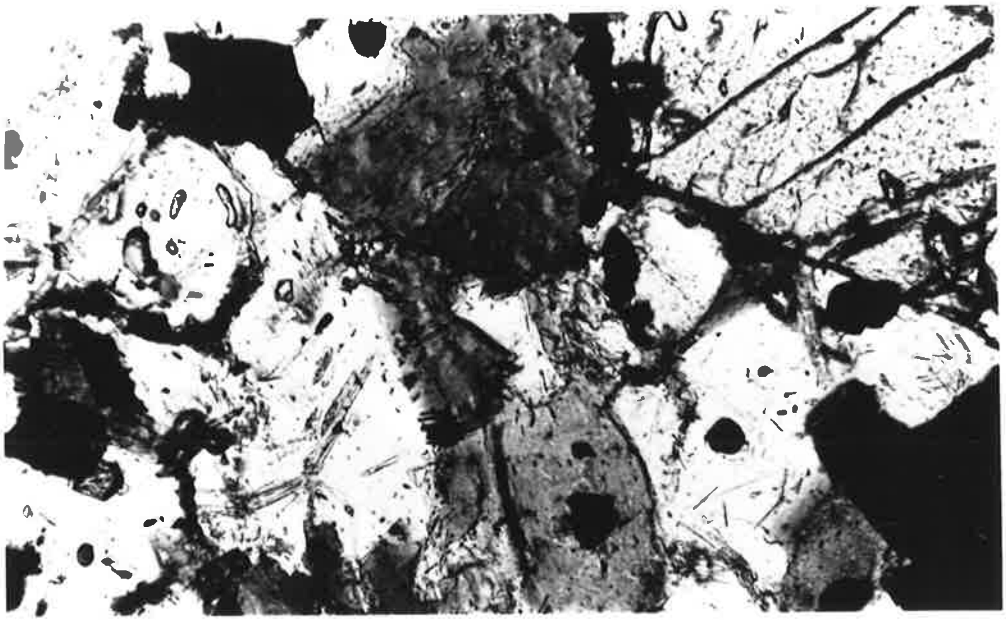
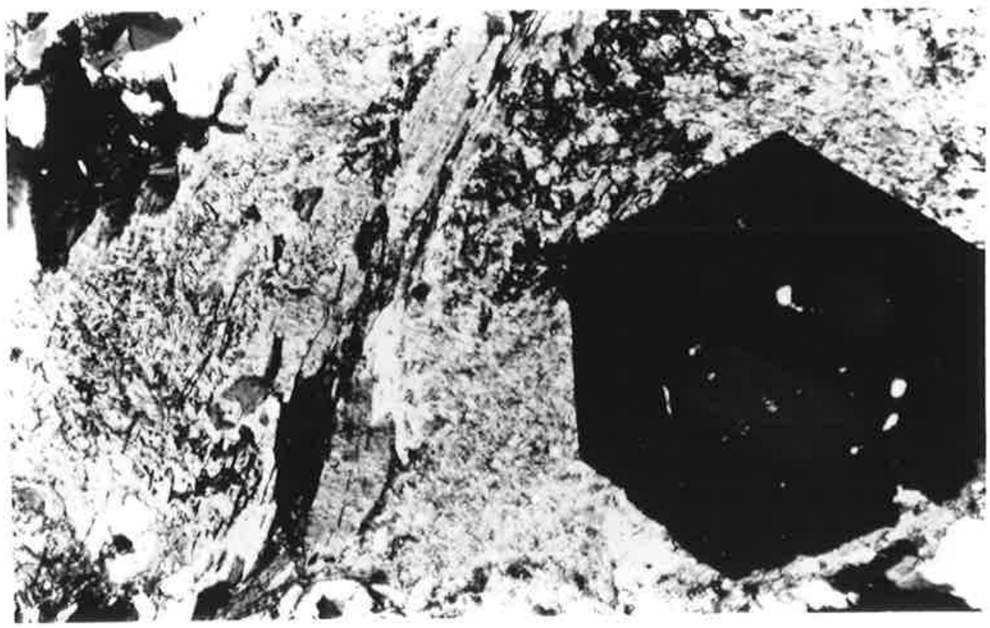




Figure 4.24

Prograde Metamorphic Mineral Occurrencs for Metabasites
and Calcareous Rocks

```
Rock  Mineral    Lower      Lower         Upper    Transitional Granulite
             Amphibolite Sillimanite  Sillimanite  Granulite

     Dolomite  -----------
C    Calcite   -----------------------------------------------------------
A    Tremolite/           ------------------------
L    Actinolite
C    Diopside                   ------------------------------------------
A    Wollastonite               ------------------------------------------
R    Grossular                  ----------------------- ? ----------------
E    Epidote    ---------------------
O    Scapolite                  ----------- ? ------            ---------
U    Plagioclase-------------------------------------------------
S    Quartz     -------------------------------------------------
     Magnetite            ------------------------

===========================================================================

     Tremolite/ ----------
M    Actinolite
E    Hornblende           ------------------------------ -----
T    Cummingtonite                                  ---  ---  ---
A    Clinopyroxene                                  ----------------------
B    Orthopyroxene                                            ------------
A    Plagioclase -----------------------------------------------------------
S                          Increase in An content=====>
I    Sphene    ------------------------------------
T    Epidote   -----------------
E    Chlorite  ----------
S  Quartz    ---------------------------------------  ---  ---  ---  ---
                           Decrease in quartz content=====>
```

===

Compiled by R.Allen from data of Allen, Gemuts, Neville, Thornett.

===

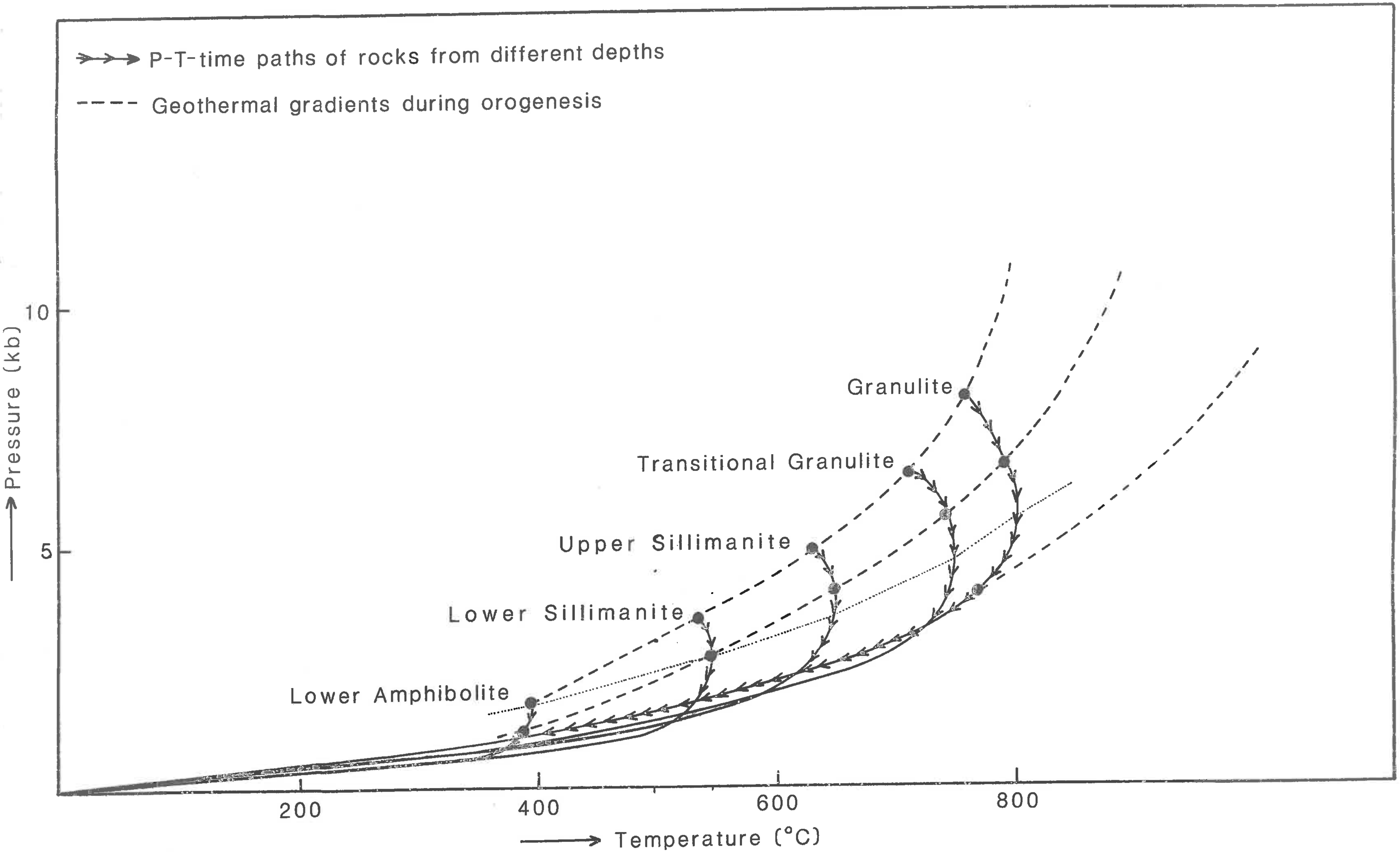


Fig 4.25 Pressure/Temperature/Time Curves

Fig 5.2 History of Lower Proterozoic Igneous Events in the Kimberley Sub Province

Date	Deformation	Rock Unit	Distribution (East or West)	Lithology	Stratigraphic Relations
		Late "Granitoids"	W	Granodiorite, tonalite, granite	Intrude Lennard Gr./cut F3.
		Violet Valley Tonalite	E	Bio tonalite, granodiorite	Intrudes Bow R. Granite
1840+50		Lennard Granite etc.	W	Coarse porphyritic bio granite	Intrudes Whitewaters & Halls Ck Gp.
1834+32		Bow River, & McHales Granodiorite	E E	Coarse k-spar porphyritic granite Bio granodiorite	Intr Castlereigh Hill Porph,Whitewaters Intr. crenulated, metamorph. Halls Ck Gp
		Castlereigh Hill Porphyry Mount Disaster/Bickleys Porphyries Whitewater Volcanics	E W E & W E & W	Quartz-feldspar porphry Porph. microgr., qtz-fels porph. Dacite-rhyolite tuff,conglom.base	Equivalent of Whitewater volcs. Unconformably overlies Halls Ck Gp
	u/c F4	Sally Malay, Corkwood, Bow R mafics and u/m (Ni-Cu bearing)	E	Multiple intrusions. Peridotite, troctolite, norite, gabbro. U/m granulite. Younger norite.	Mineralised suite postdates peak metamorphism (M3) Intrudes early u/m. Intruded by norite.
	F3	McSherrys Granodiorite	W	Foliated bio-hbe granodiorite	With S4.Intr.Halls Ck Gp, Whitewaters. Intruded by Lennard Gr
		Whitewater Volcanics	W E & W	Andesite-dacite tuff,conglom base	Interbedded top of Olympio. Folded by F3
	u/c D2b	McIntosh Sill Complex Toby Sill Complex	E E	Troctolite, ol gabbro, gabbro- norite, minor anorthosite. Gabbro.	Circular sills unmetamorphosed.Primary minerals preserved.Gabbros sheared & metamorph. No hornfels or chilled margin
1850-1880	F2a	Mabel Downs Granodiorite "Dougals Tonalite" McIntosh Gabbro	E E E	Foliated hbe granodiorite, tonalite. Foliatedgabbro.	With S2, Folded by F3 & F4.Intrudes "Melon Patch Granite",Halls Ck Gp. IntrudedbyMabelDowns Granodiorite
?		Wombarella Quartz Gabbro Alice Downs Ultrabasics	W E	Opx qtz gabbro, norite, tonalite. Harzburgite, dunite, peridotite, troctolite. Gabbro	Early syn-metamorphic. U/b's completely metamorphosed by M2a. O'lying gabbros metamorphosed. Contact zone sheared,intruded by trondhjemite.
		"Melon Patch Granite" "Black Rock Tonalite" "White Rock Leucogranite" Sophie Downs Granite	 E E E	Fine-med even gr. bio granite Coarse grained bio-hbe tonalite Leucogranite. Bio or gt variants Granophyric granite	With S2. With S2. Folded by F2, F3 & F4. Intruded by Mabel Downs Granodiorite Pre F2
	F1	Woodward Dolerite	E & W	Altereddolerite sills & dykes	Folded & metamorphosed.Intrudes Halls Ck Gr base of Biscay into Olympio Fm.
		Biscay Fm	E & W	Basalt, dacitic-rhyolitic tuff	Acid tuffs confined to two lower units. Basalts throughout
?ca 2,000Ma		Ding Dong Downs Volcanics	E	Basalt, dacitic-rhyolitic tuff	Base not exposed. Unconformably underlies Saunders Ck Fm.

Correlation of Deformational Events between East and West Kimberleys pre D2b is tentative.

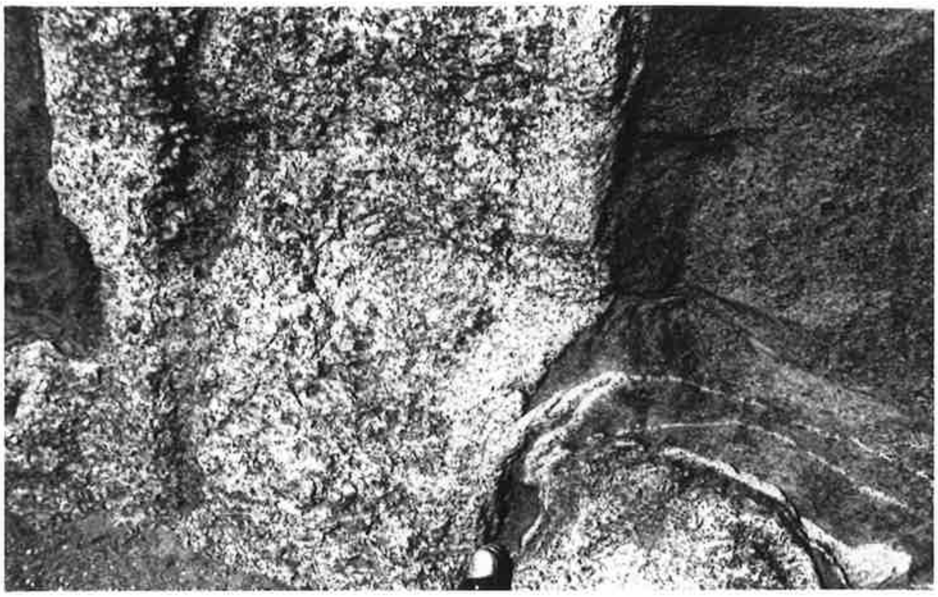
Complied by R. Allen from data of- Allen, Dow & Gemuts, Giles & Mancktelow, Hamlyn, Hancock & Rutland, Plumb & Gemuts, Thornett.

Figure 5.3

(a) Xenolith of Woodward Dolerite with quartzose veins folded by D_{2a} and framboidal garnets in Mabel Downs Granodiorite

(b) Apophysis of Mabel Downs Granodiorite in Woodward Dolerite, folded by D_{2a}

(c) Melon Patch Granite intruded by coarse grain hornblende bearing phase of Mabel Downs Granodiorite. Strongly developed S_2 fabric evident in both



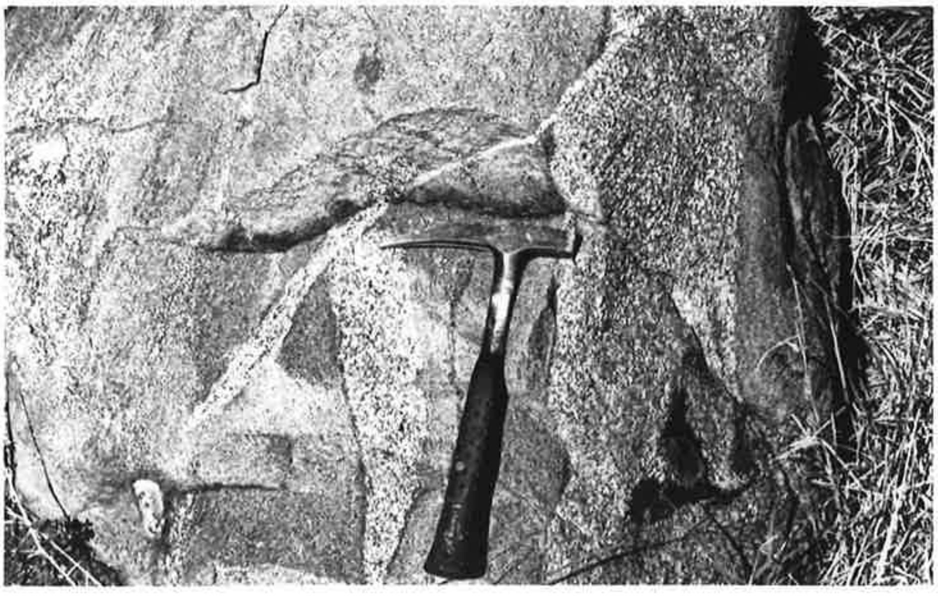


Figure 5.4

(a) Complex folding of fine biotite rich films and quartz rich segregation bands in White Rock Leucogranite

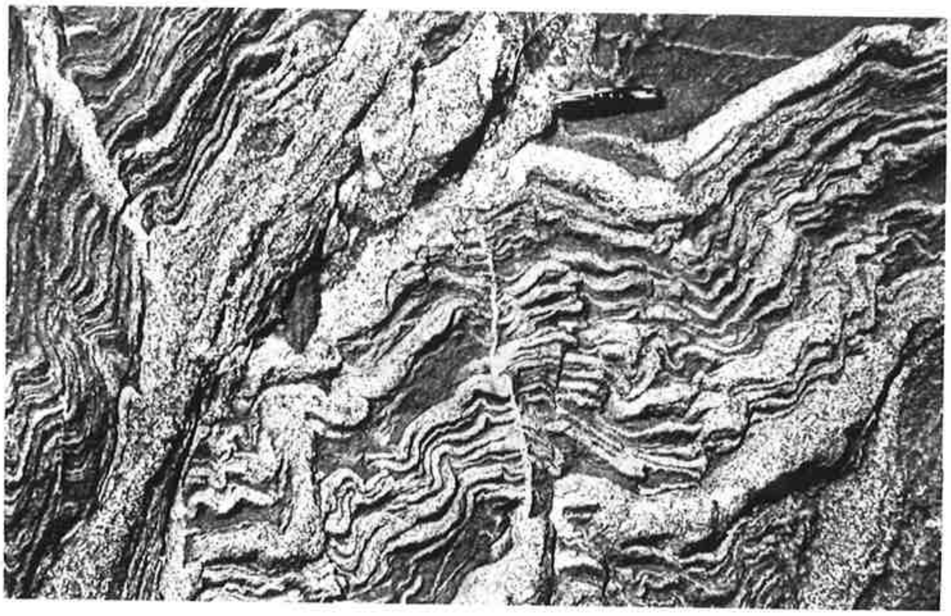
(b) Xenolith of White Rock Leucogranite in Mabel Downs Granodiorite

(c) Gradational contact between K spar megacrystic phase (by hammer head) and hornblende bearing phase of the Mabel Downs Granodiorite

Figure 5.5

(a) F_4 folds in hornblende bearing Mabel Downs Granodiorite intruded into Woodward Dolerite

(b) Agmatitic blocks of Woodward Dolerite in hornblende bearing Mabel Downs Granodiorite



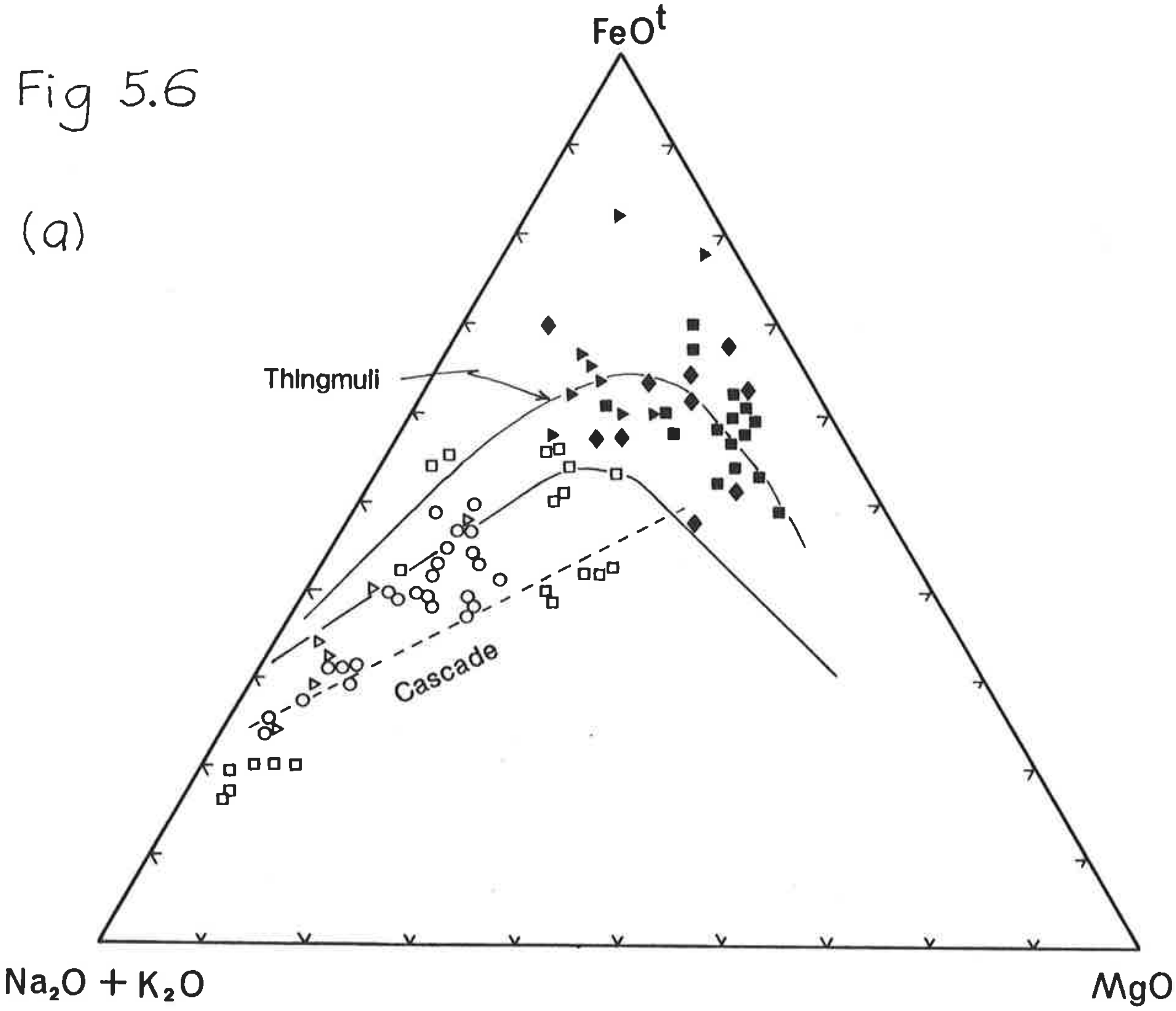
In chemical diagrams in chapters 5 and 6 the following symbols are used

Open circles for Biscay felsic volcanics
Open triangles for Ding Dong Downs felsic volcanics
Open squares for White Water volcanics
Open pentagons for White Water volcanics (West Kimberleys)

Closed triangles for Ding Dong Downs basic volcanics
Closed squares for Biscay basic volcanics
Closed diamonds for Woodward Dolerite

Fig 5.6

(a)



(b)

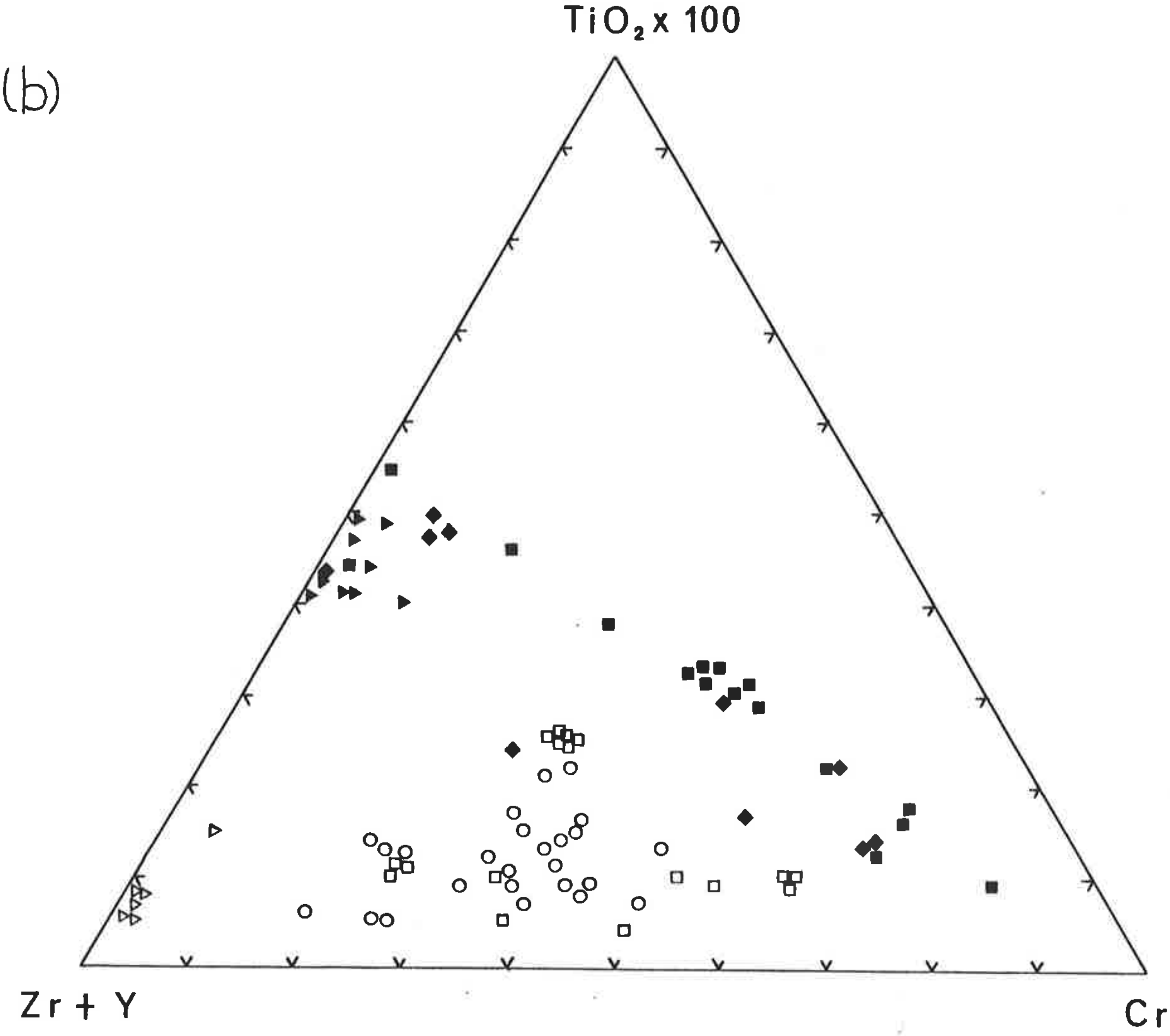
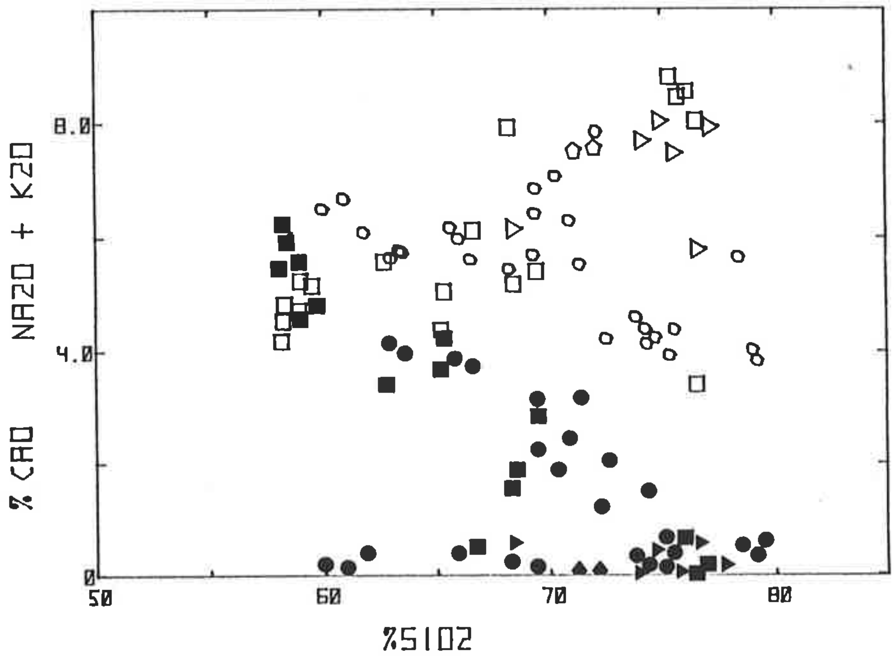


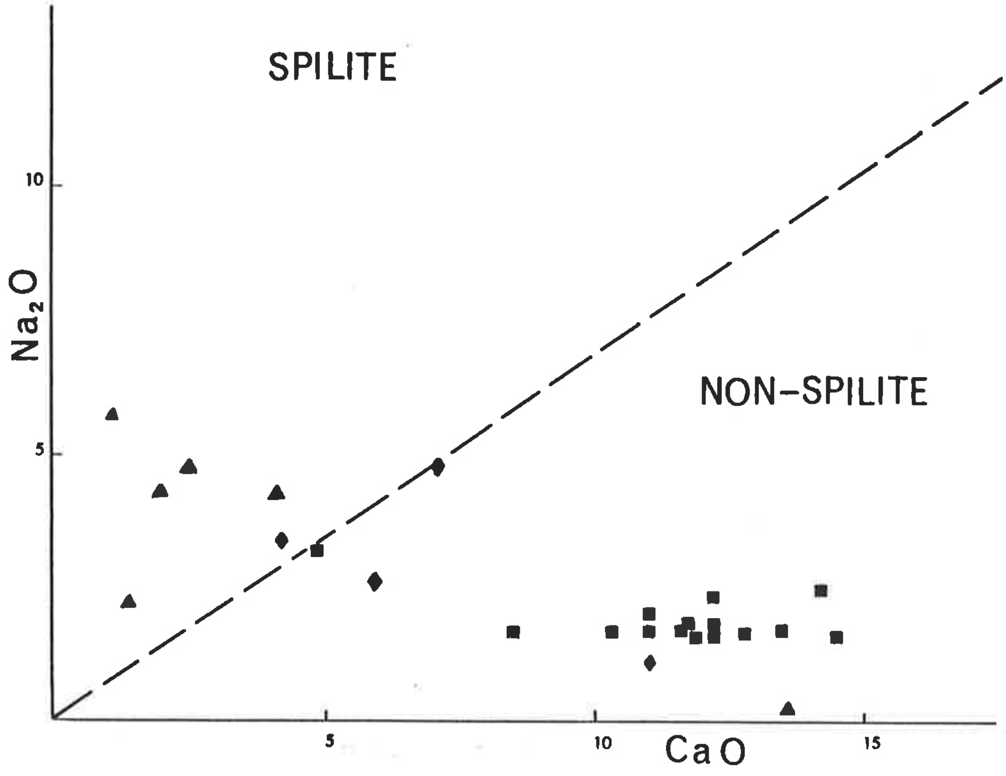
Fig 5.6

(c)



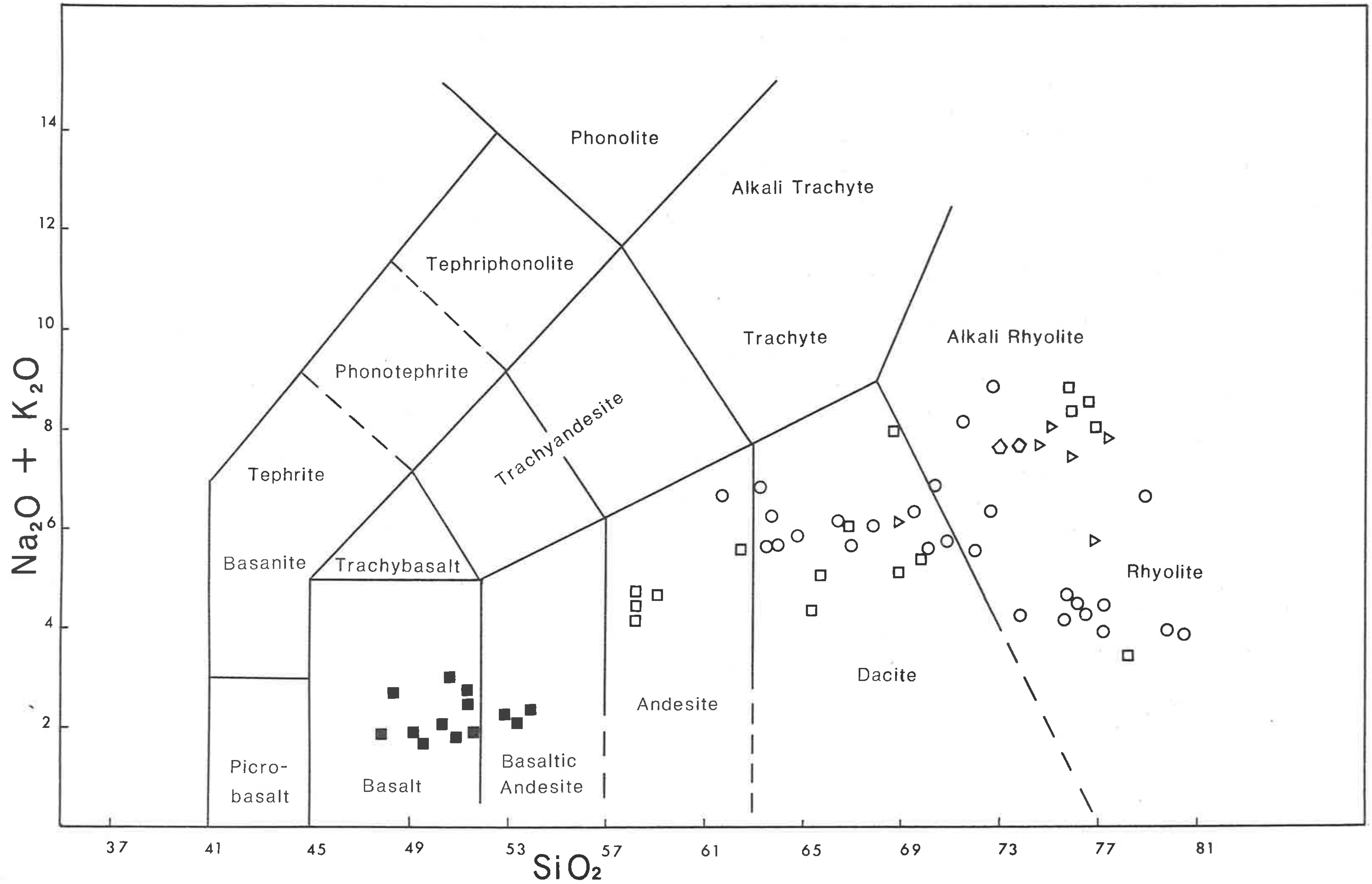
8.0
4.0
0
NA2O + K2O
% CAO
50
60
70
80
%SIO2

(d)



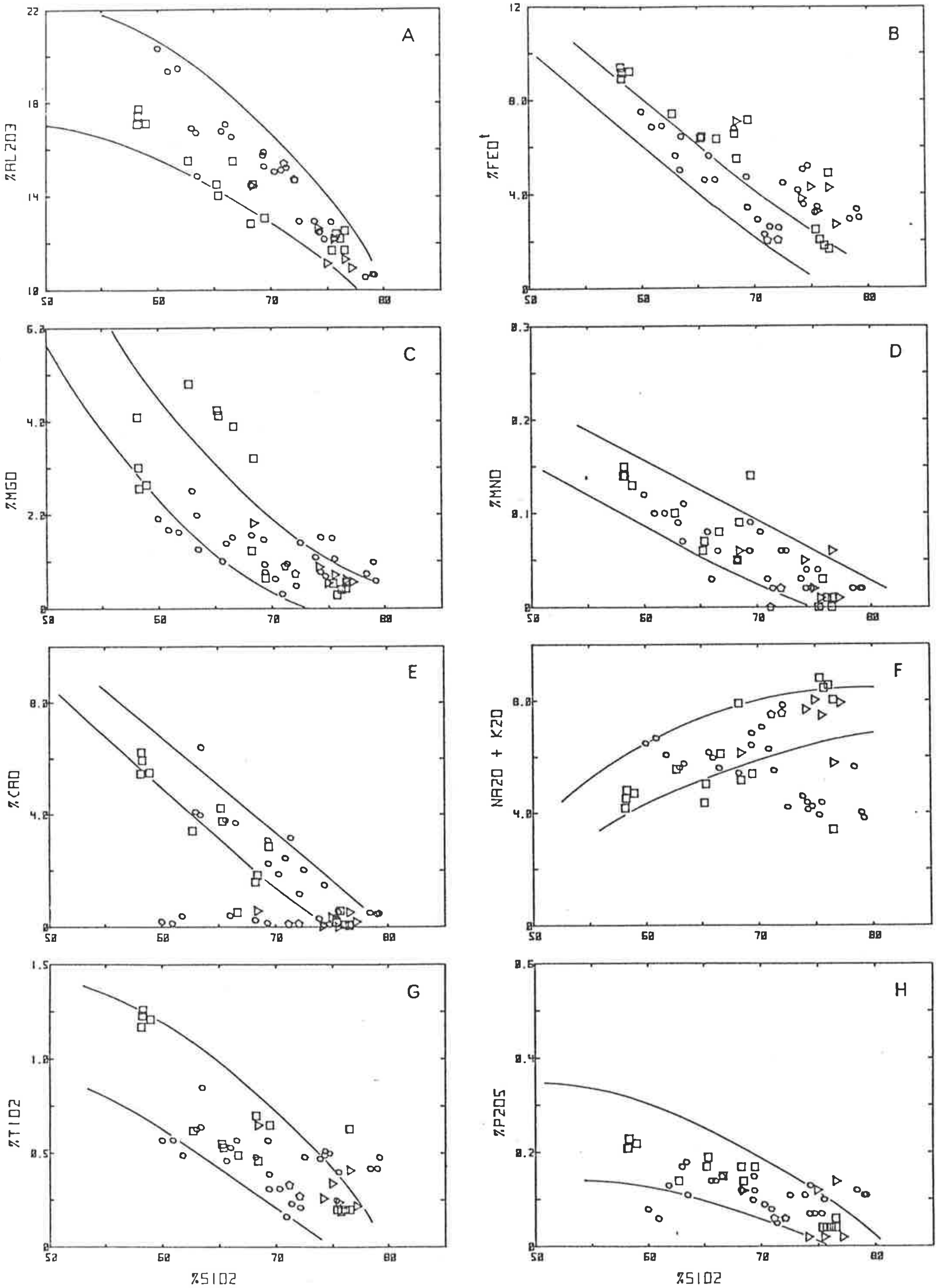
SPILITE
NON-SPILITE
10
5
Na₂O
5
10
15
CaO

Fig 5.7



Phonolite
Alkali Trachyte
Tephriphonolite
Phonotephrite
Trachyandesite
Trachyte
Alkali Rhyolite
Tephrite
Basanite
Trachybasalt
Rhyolite
Dacite
Andesite
Picro-
basalt
Basalt
Basaltic
Andesite
$Na_2O + K_2O$
14
12
10
8
6
4
2
37
41
45
49
53
57
61
65
69
73
77
81
SiO_2

Fig. 5.8 Major elements v/s SiO_2 for Kimberley felsic volcanic rocks. Symbols as for Fig. 5.7 Solid lines enclose the field of Cainozoic calc-alkaline volcanics.



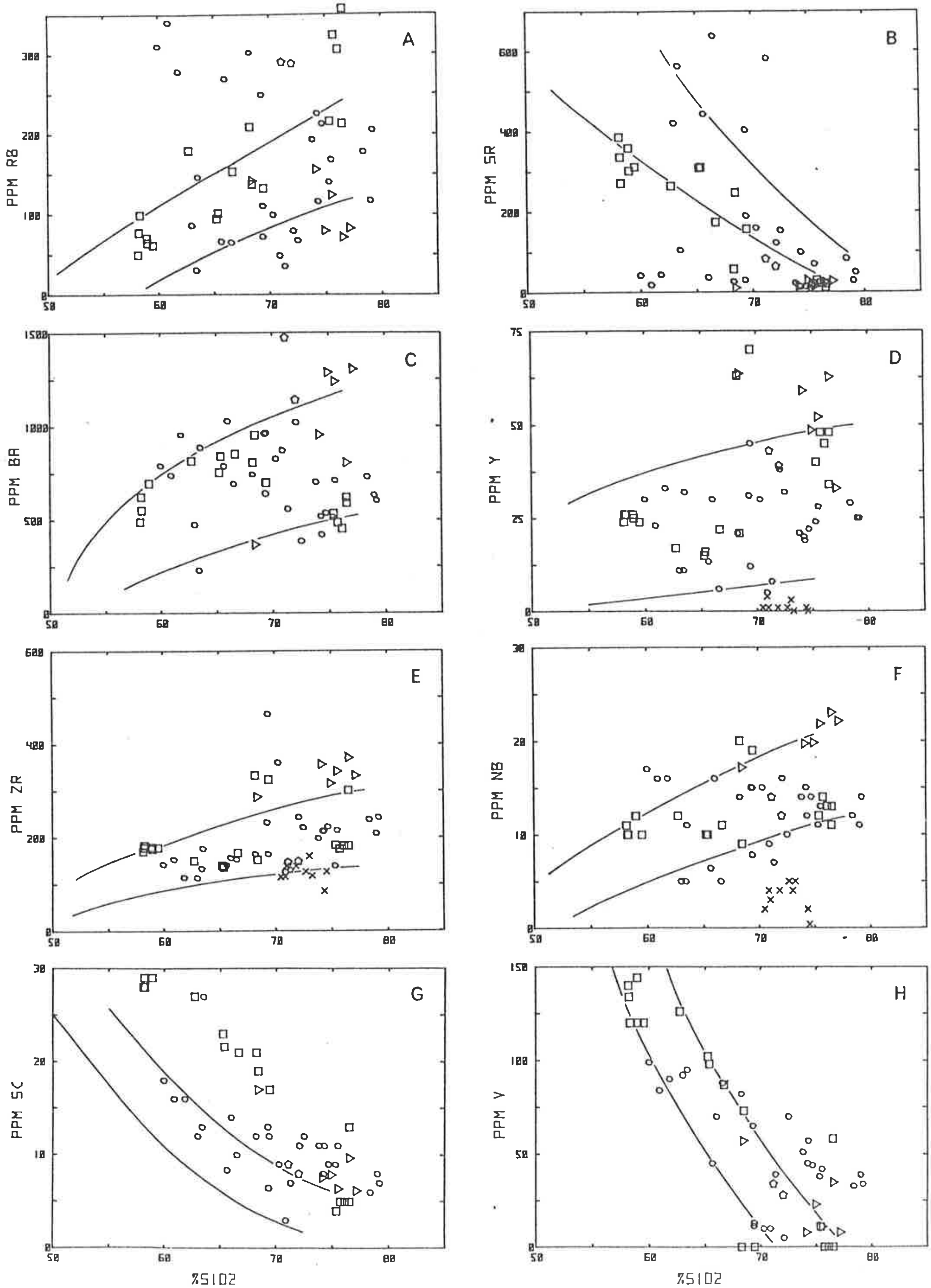
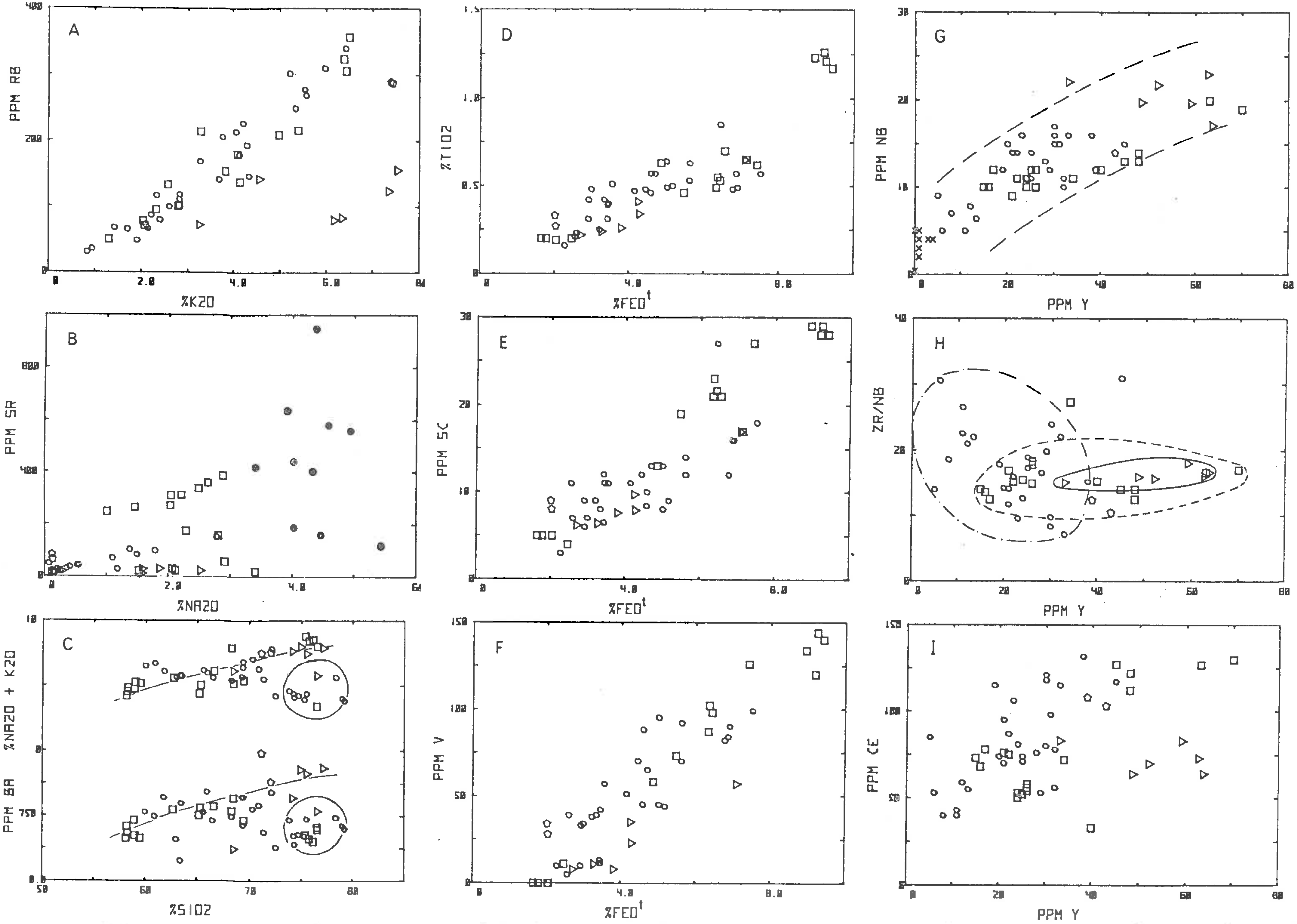


Fig. 5.9 Trace elements v/s SiO_2 for Kimberley felsic volcanic rocks. Symbols as for Fig 5.8 with addition of x leucogranites.

Fig. 5.10 Selected variation diagrams for Kimberley felsic volcanic rocks. Symbols as for Figs. 5.8 & 5.9 Explanation in the text.



CORK

Fig 5.11

INPUT DATA

****

	FELS4*	1242*	MAG2	1080B*
SIO2	62.40	75.71	0.73	70.09
AL2O3	23.45	13.26	0.05	14.85
FE2O3	0.00	4.27	98.98	6.96
MNO	0.00	0.03	0.05	0.05
MGO	0.00	1.25	0.18	1.60
CAO	5.63	0.31	0.01	0.26
NA2O	8.52	0.30	0.00	0.22
TIO2	0.00	0.48	0.05	0.49
P2O5	0.00	0.11	0.00	0.12

RESULTS

****

	Y EST	Y OBS	RESIDUALS
SIO2	70.27	70.09	0.1843
AL2O3	13.81	14.85	-1.0358
FE2O3	6.96	6.96	0.0002
MNO	0.03	0.05	-0.0234
MGO	1.04	1.60	-0.5581
CAO	0.94	0.26	0.6757
NA2O	1.28	0.22	1.0553
TIO2	0.40	0.49	-0.0906
P2O5	0.09	0.12	-0.0289

COMPONENT	WEIGHT FRACTION	STD DEV
FELS4*	0.1205	0.0447
1242*	0.8285	0.0392
MAG2	0.0346	0.0073

SUM OF SQUARES OF RESIDUALS = 2.9981

Fig 5.12 Corkwood East Suite bracketed

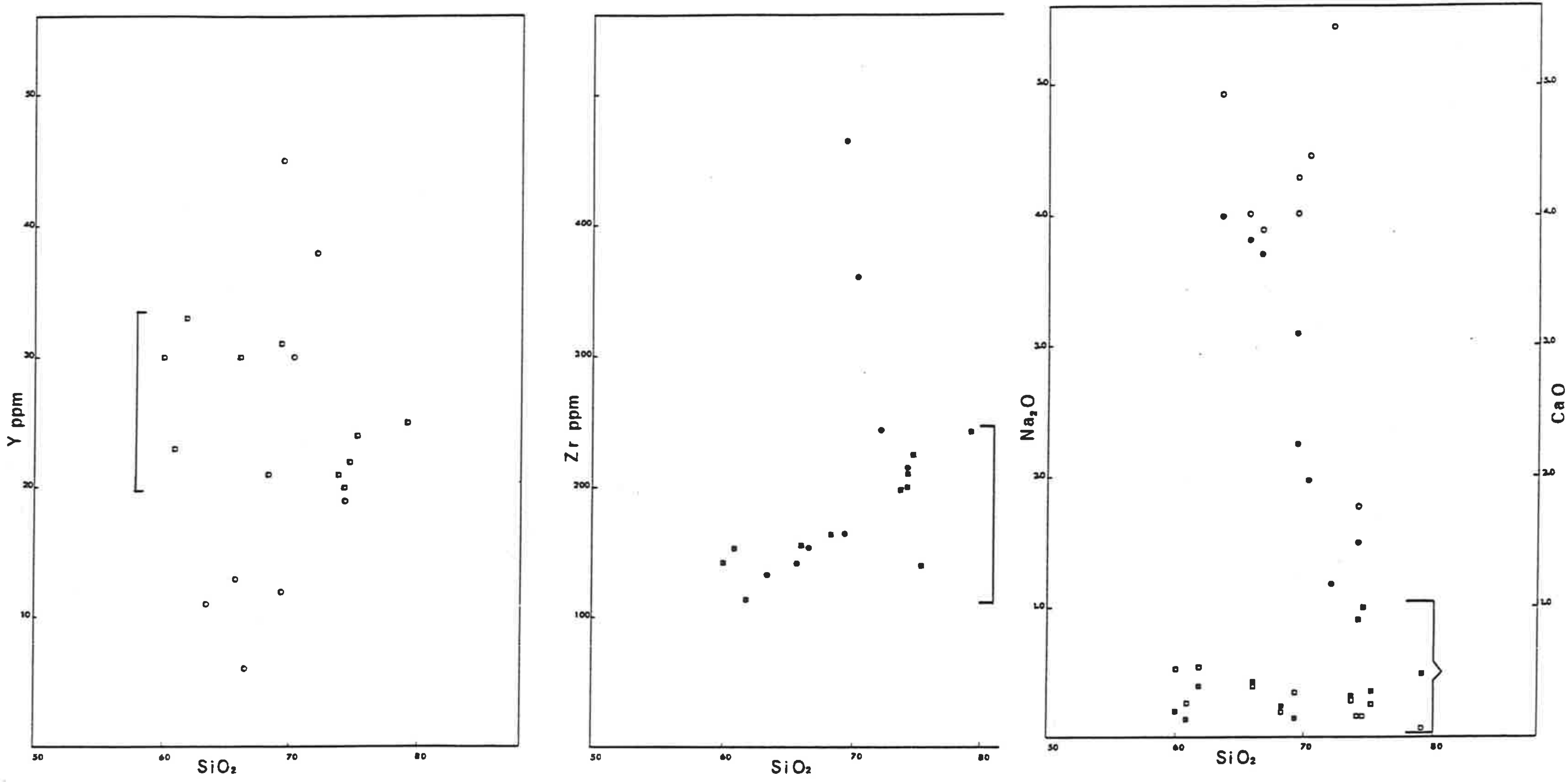


Fig 5.13

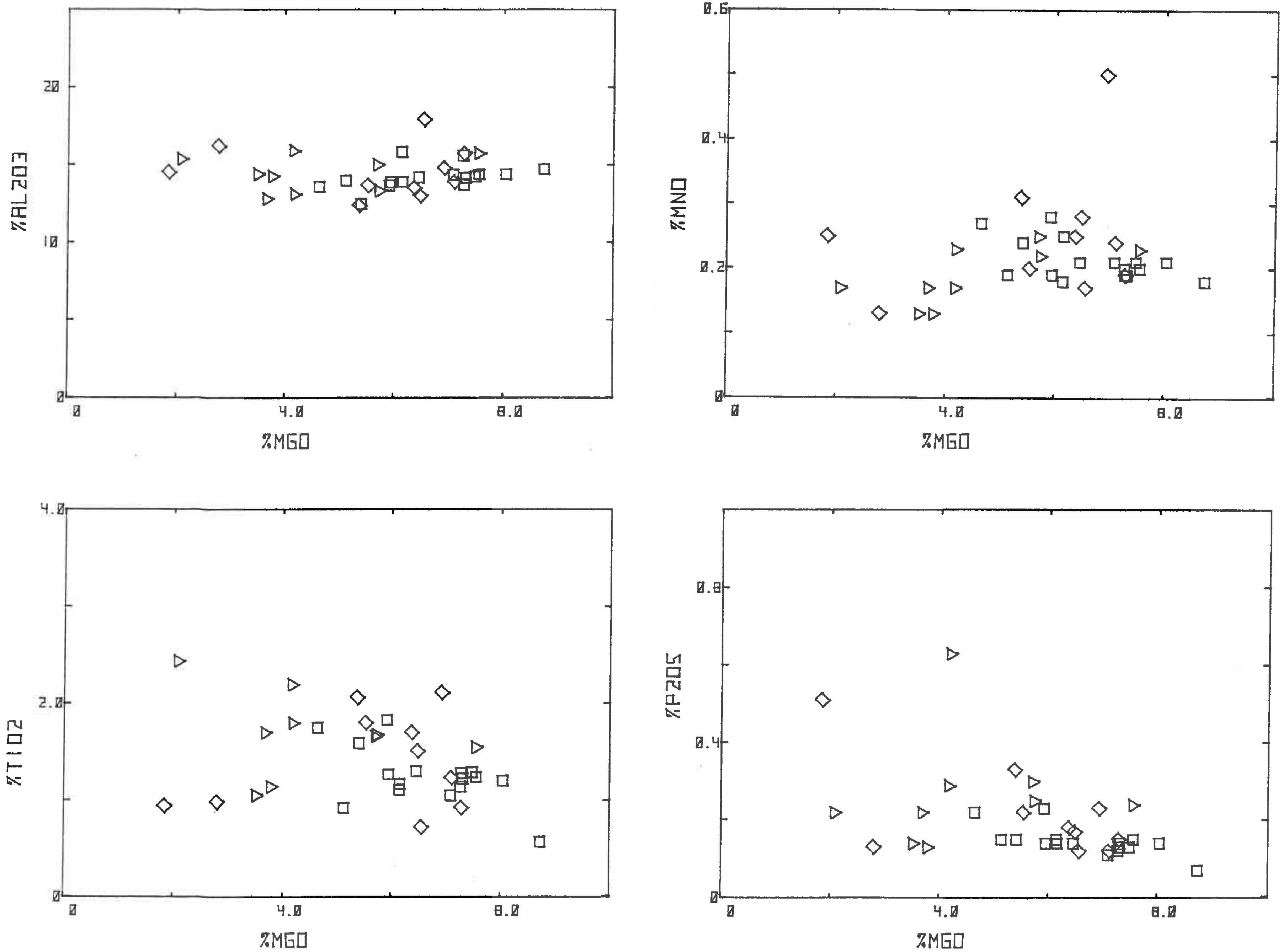
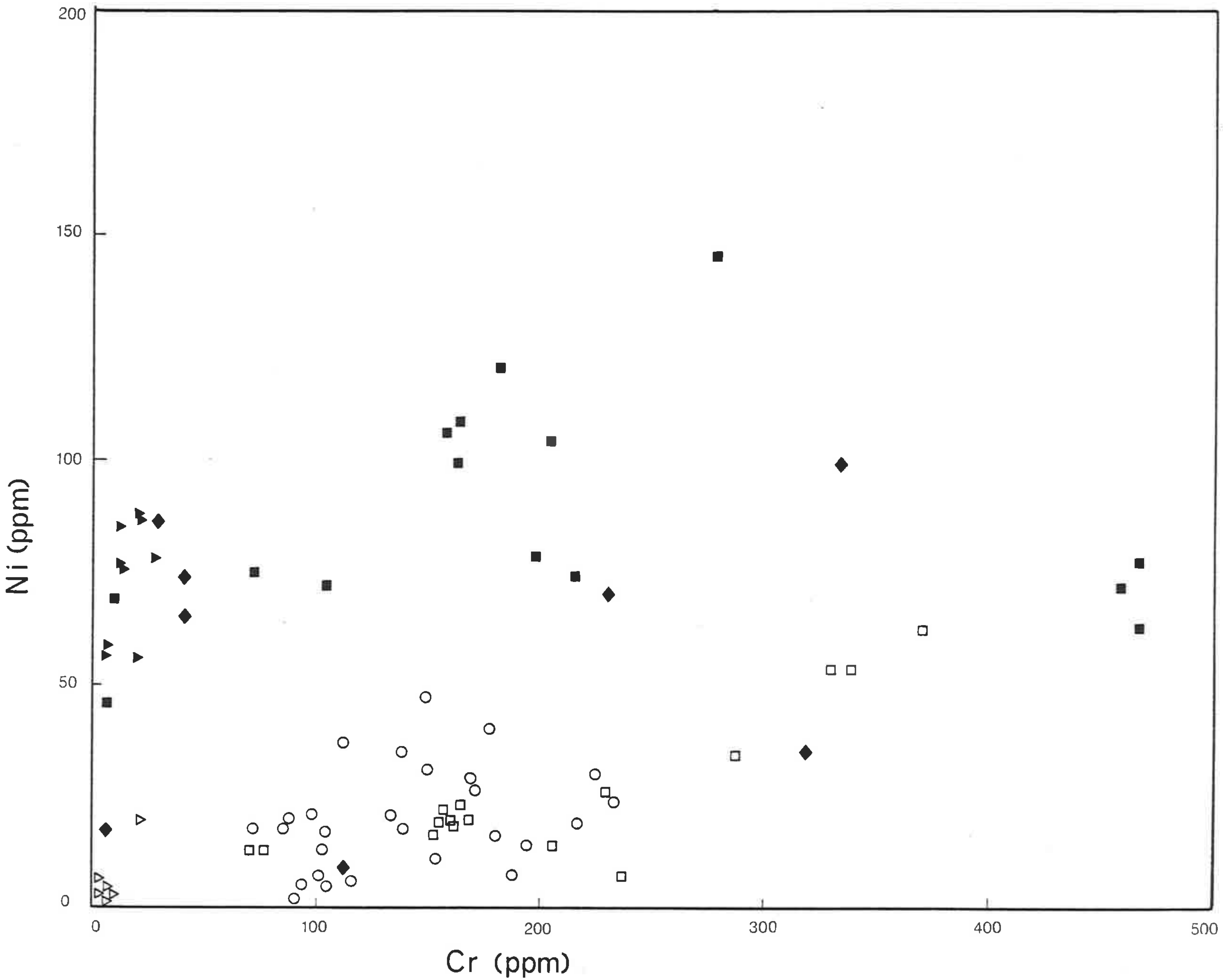

20
10
0
%AL2O3
0
4.0
8.0
%MGO
0.6
0.4
0.2
0
%MNO
0
4.0
8.0
%MGO
4.0
2.0
0
%TIO2
0
4.0
8.0
%MGO
0.8
0.4
0
%P2O5
0
4.0
8.0
%MGO

Fig 5.14



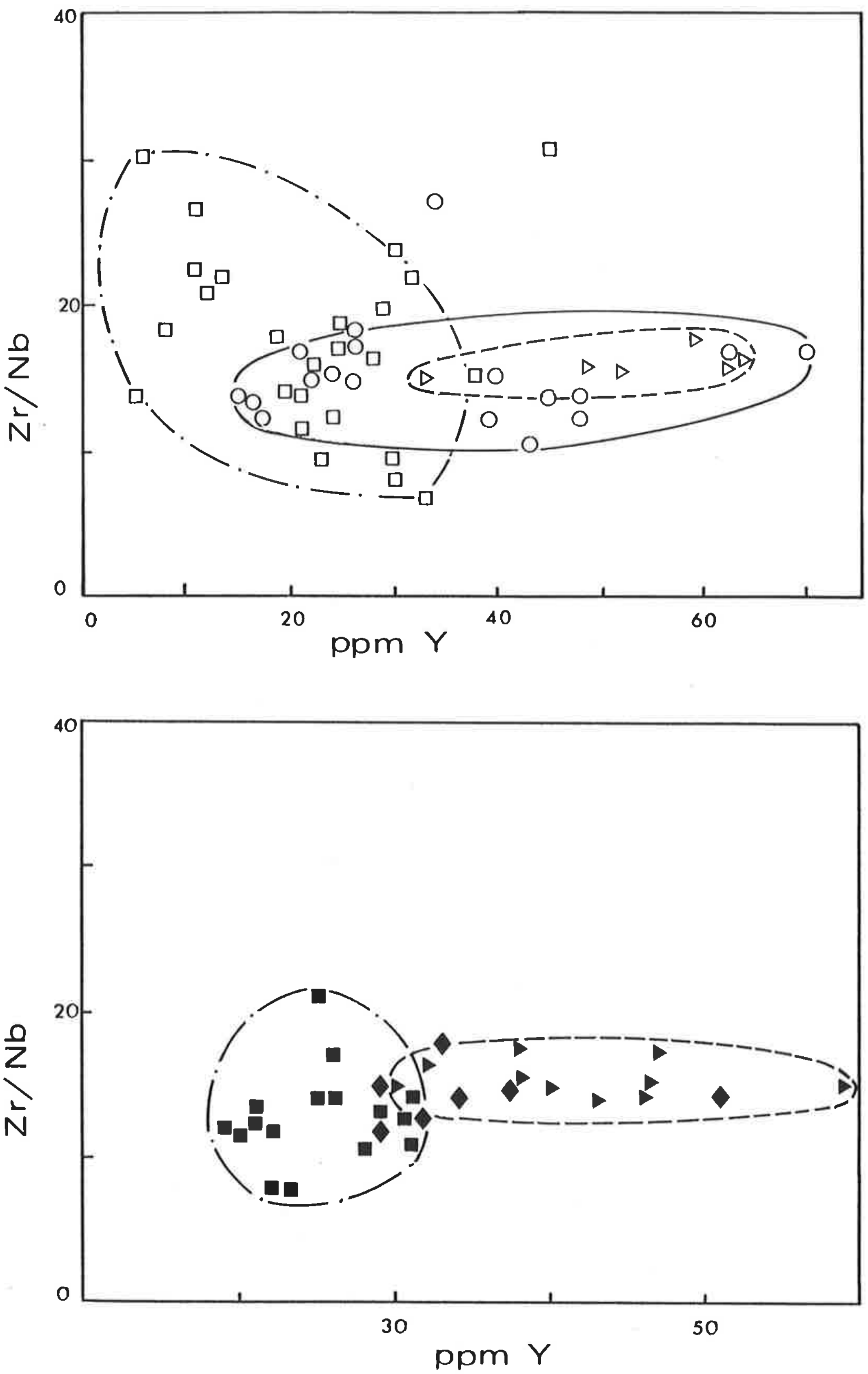
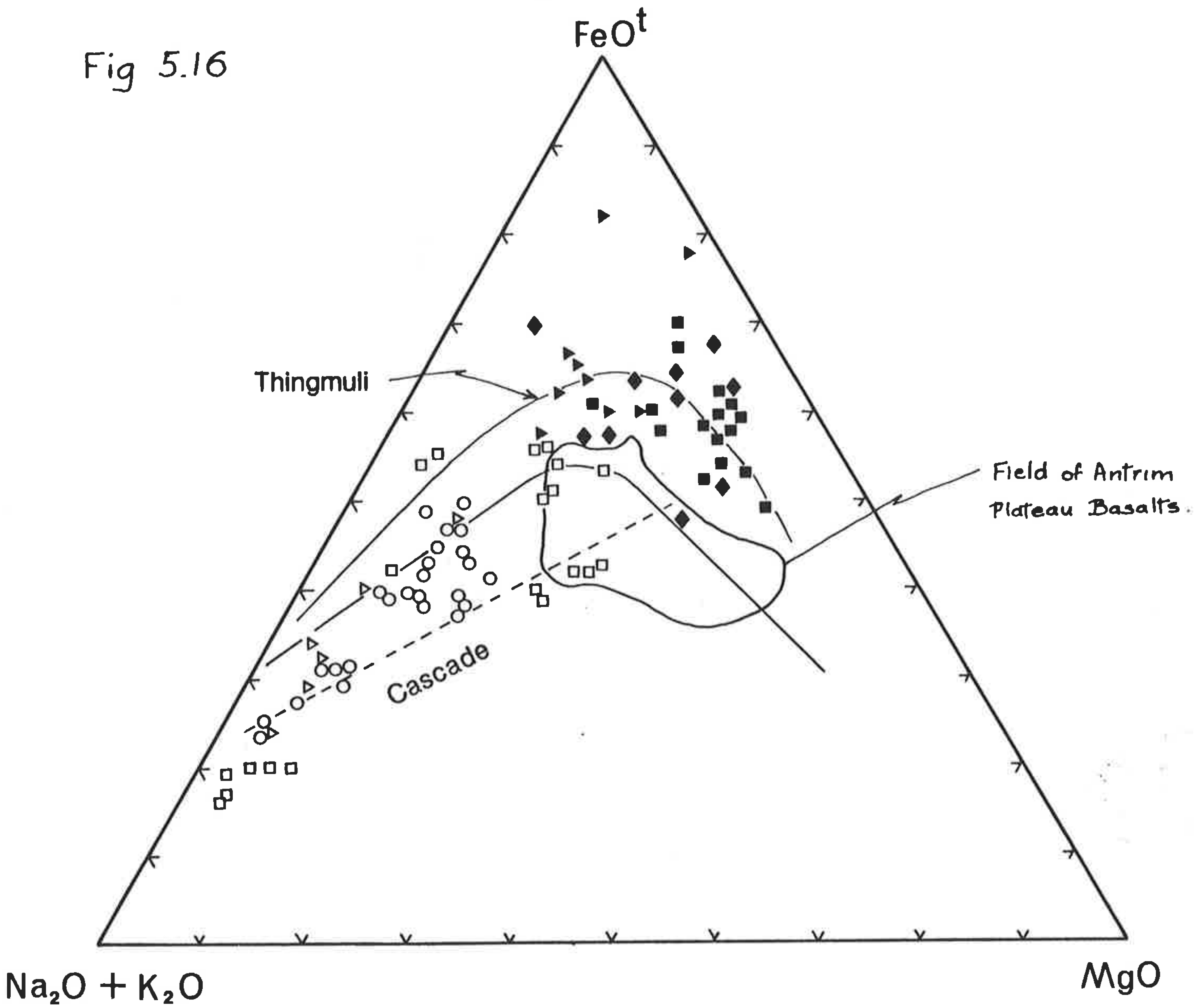


Fig 5.15

Fig 5.16



FeO^t
Thingmuli
Field of Antrim Plateau Basalts.
Cascade
$Na_2O + K_2O$
MgO

Proterozoic volcanic terrains blacked out.

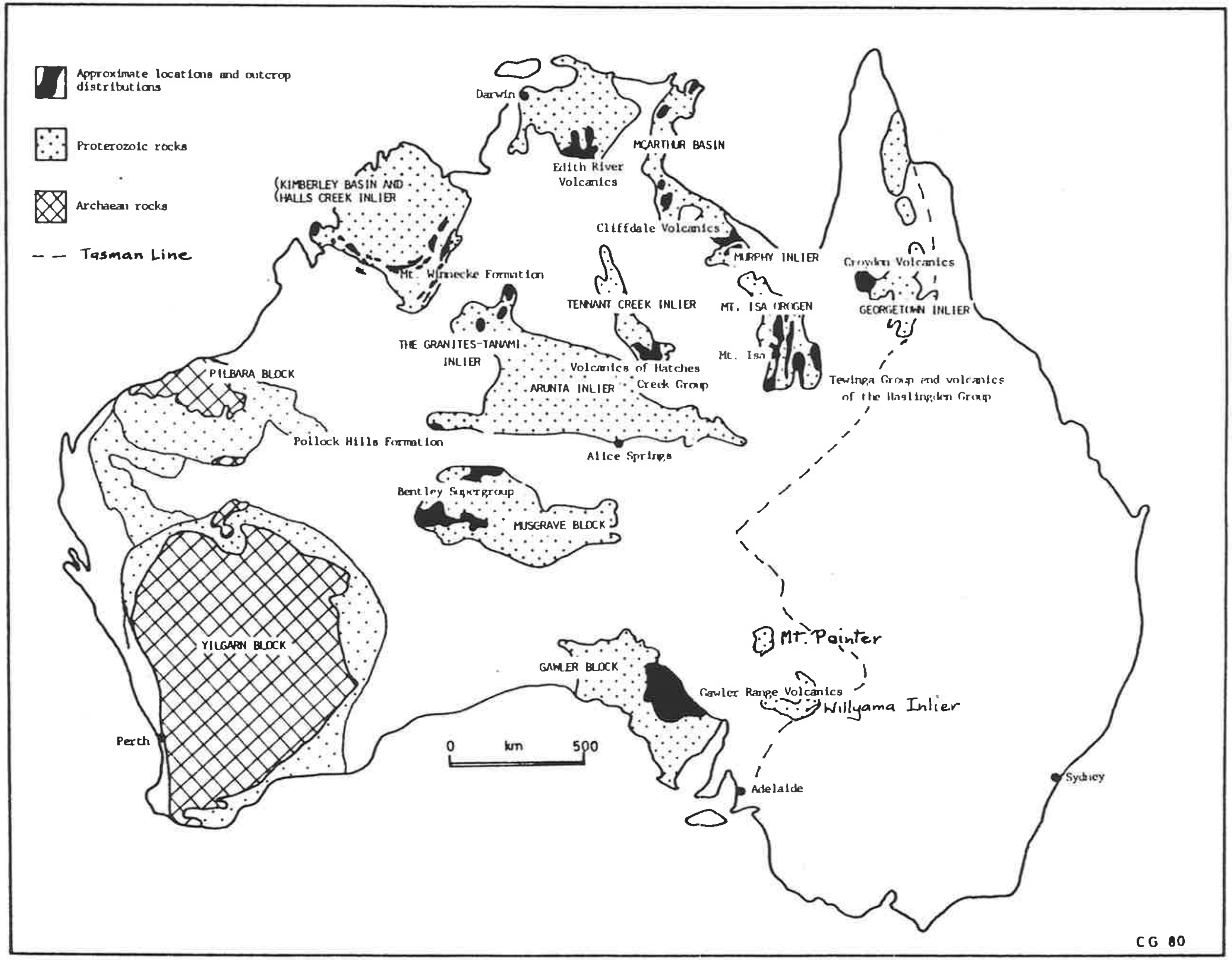


Fig 6.1 Distribution of Australian Proterozoic Fold Belts

Fig 6.2 Comparison of Salient Features of Australian Lower-Mid Proterozoic Fold Belts

	Lithofacies	Flysch	Basement	Hot Spot	Bimodal Volcanics	Felsics Variable	Basalt Comp	Metamorphism *	Nappe Tectonics
Halls Creek Mobile Zone	(iii) then (i)	✓	Thin Sial/Sima ? Continent margin	✓	B>A ×	✓	Oceanic MORB-ARC-BACK ARC	HT/LPG	—
Pine Creek Geosyncline	(iii)	✓	Archaean Gneiss	—	A>B	✓	CONTINENTAL THOLEIITE	LT/LP and HT/LP	—
Granites-Tanami	(iii)	?	Thin Sial/Sima ? Continent margin	—	B>A	—	?	LT/LP	—
Tennant Creek	(iii)	?	" " ?	—	?	—	?	?	—
Davenport	(iii) then (ii)	—	" " ?	—	B>A	—	?	LT/LP	—
Mt. Isa	(ii)	—	Thick Sialic ?	—	B>A	✓	CONTINENTAL THOLEIITE	HT/LP	✓
Georgetown		—	Continent margin	—	?	?	?	HT/LP	—
Arunta	? then (i)	—	Thin Sial/Sima ? Continent margin	—	B>A?	— ?	CONTINENTAL THOLEIITE	HT/LPG	✓
Musgrave	?	—	" "	—	B>A?	— ?	?	HT/LPG	✓
Gawler	(ii)	—	Archaean Gneiss	✓	A>B	—	?	HT/LP	—
Willyama	(iii) then (i)	✓	Thin Sial/Sima ? Continent margin		A>B	—	OCEANIC	HT/LP	✓
Mt Painter	(ii)	✓	Continental Sialic ?	✓	A>B	✓	CONTINENTAL THOLEIITE	HT/LPG	—

* L.P.G — Low Pressure Granulite

× B>A Basic Volcanics volumetrically exceed Acidic Volcanics

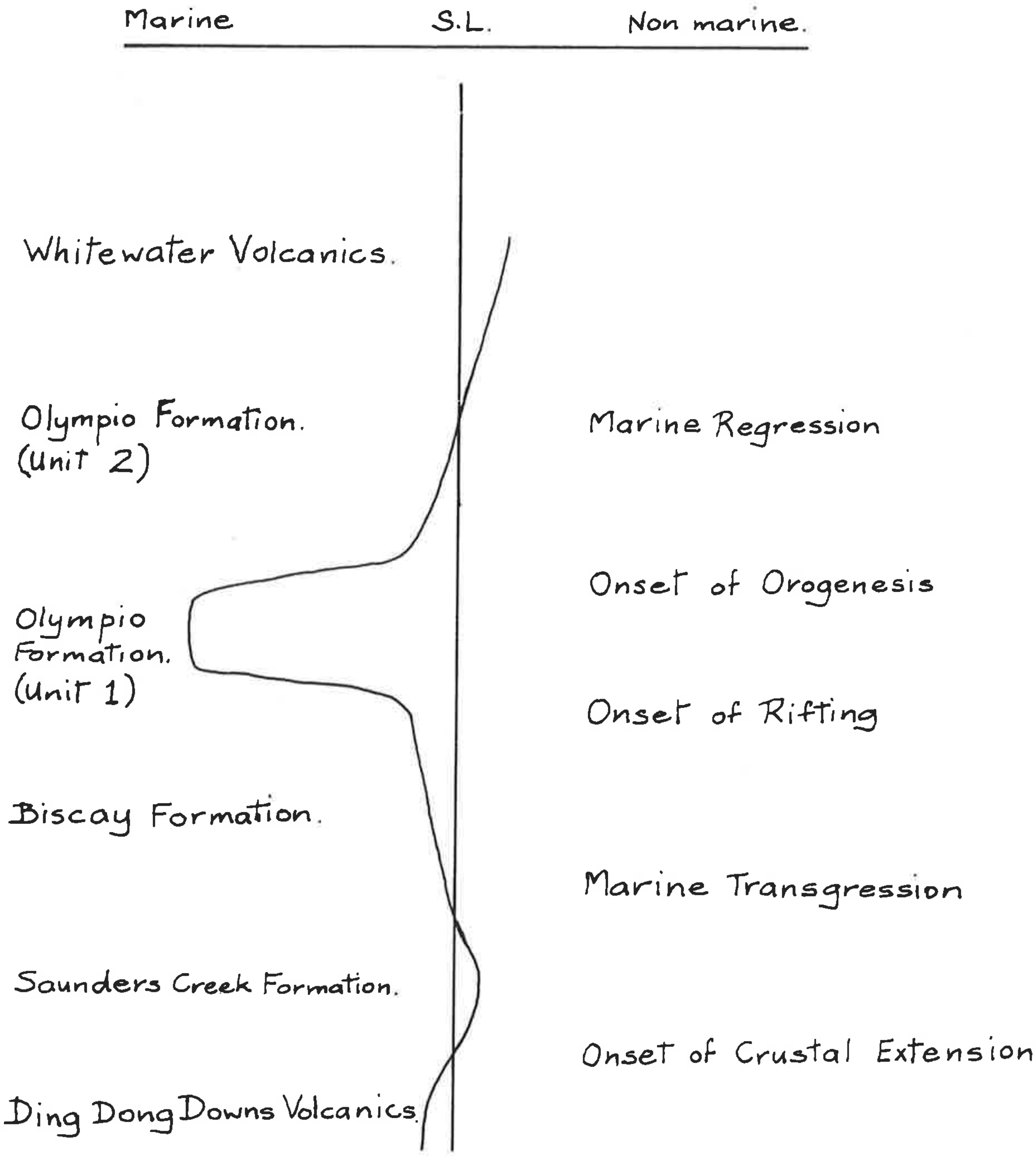


Fig 6.3 Depositional Environments in the Kimberleys

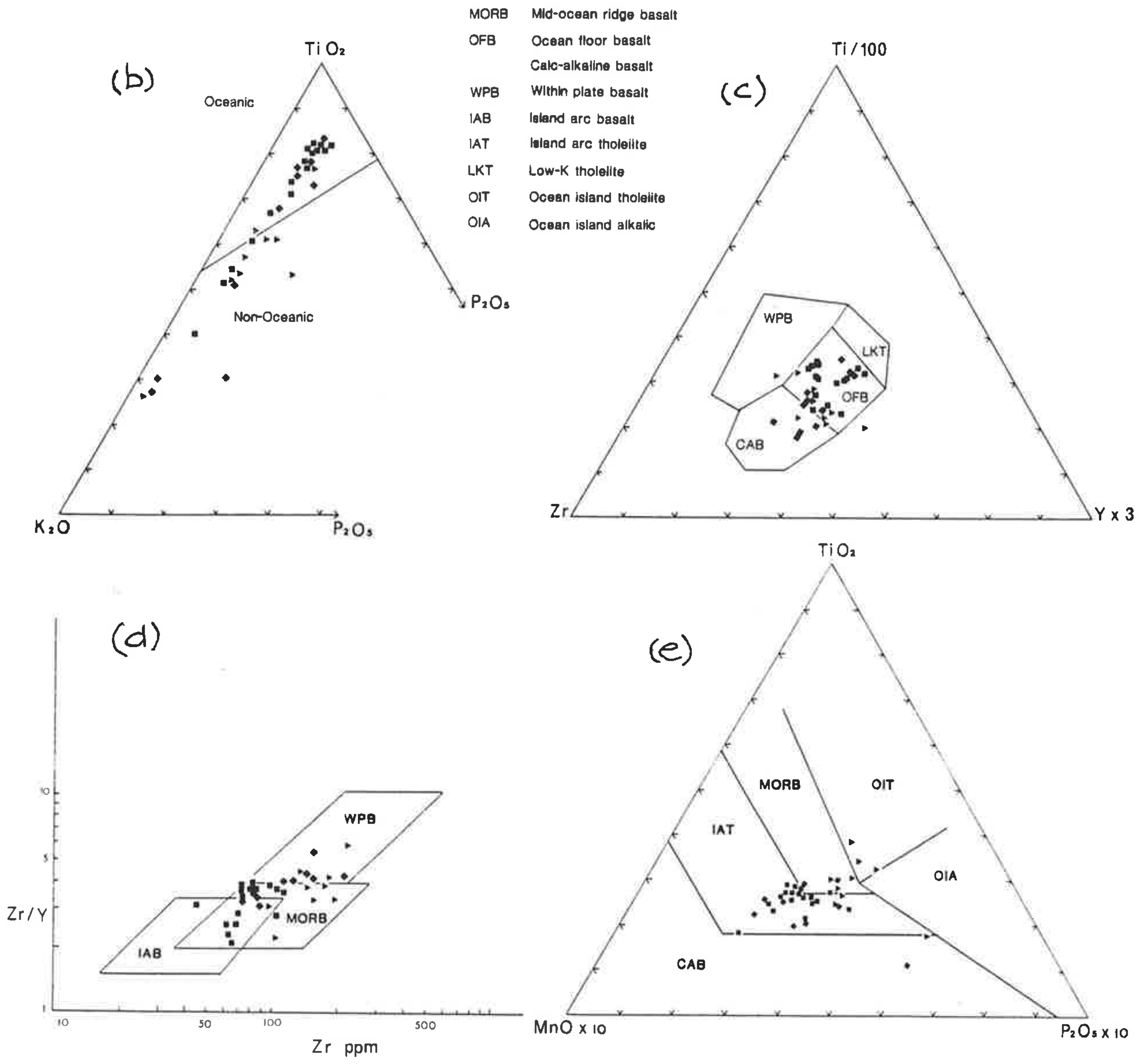

MORB Mid-ocean ridge basalt
OFB Ocean floor basalt
Calc-alkaline basalt
WPB Within plate basalt
IAB Island arc basalt
IAT Island arc tholeiite
LKT Low-K tholeiite
OIT Ocean island tholeiite
OIA Ocean island alkalic
(b)
TiO2
Oceanic
Non-Oceanic
K2O
P2O5
P2O5
(c)
Ti/100
WPB
LKT
OFB
CAB
Zr
Y x 3
(d)
WPB
MORB
IAB
Zr/Y
Zr ppm
10
5
1
10
50
100
500
(e)
TiO2
MORB
OIT
IAT
OIA
CAB
MnO x 10
P2O5 x 10

Fig 6.4

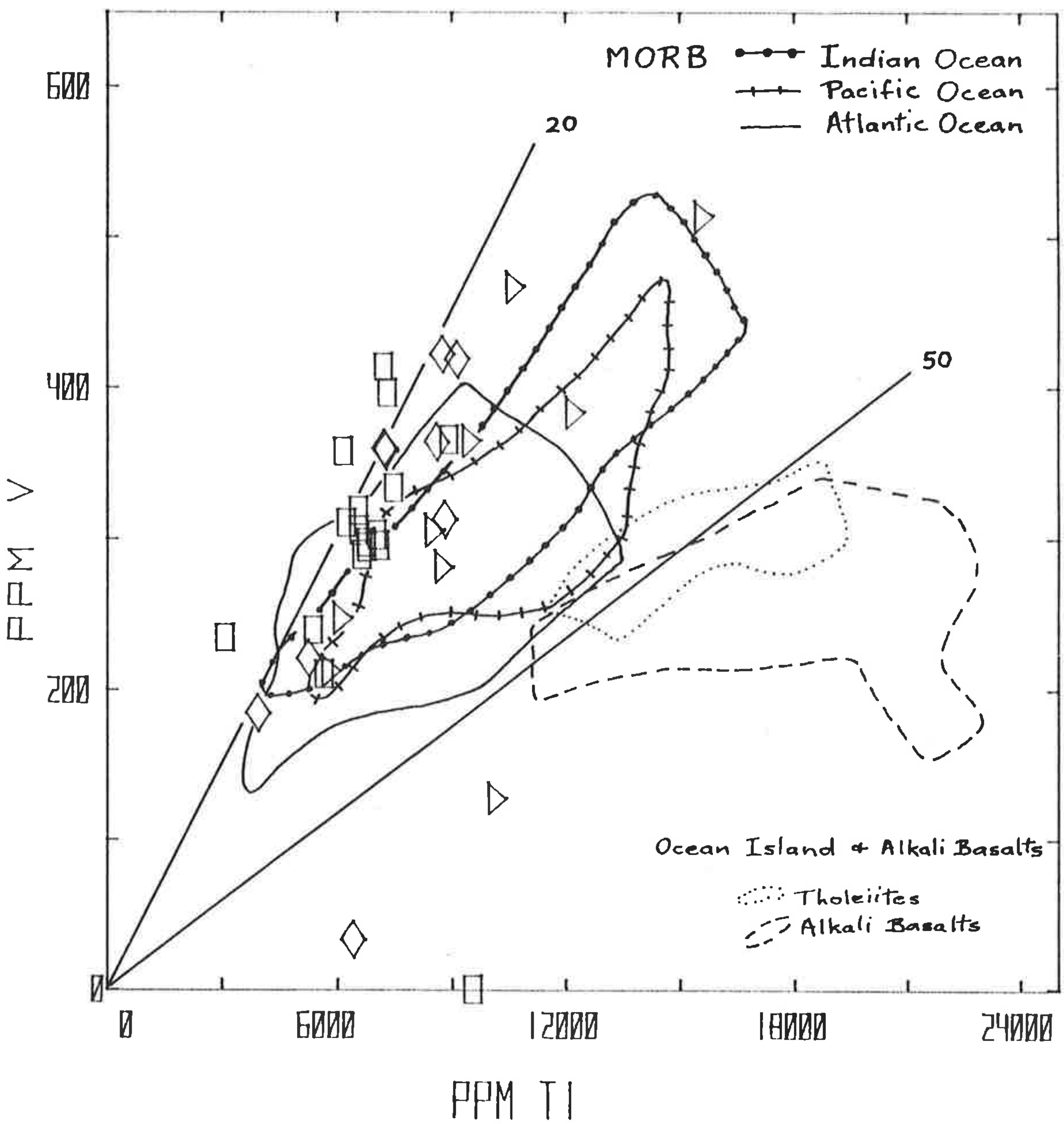

MORB
Indian Ocean
Pacific Ocean
Atlantic Ocean
20
50
600
400
200
0
PPM V
0
6000
12000
18000
24000
PPM TI
Ocean Island & Alkali Basalts
Tholeiites
Alkali Basalts

Fig 6.5

TABLE 1. SUMMARY OF ARCHAEAN TO MIDDLE PROTEROZOIC STRATIGRAPHY OF THE PINE CREEK GEOSYNCLINE

	Unit	Lithology	Thickness (m)	Age (Ma)
MIDDLE TO LATE PROTEROZOIC	MINOR DOLERITE	quartz dolerite dykes and small plug-like bodies		1200 ± 35
	MUDGINBERRI PHONOLITE MUNMARLARY PHONOLITE	phonolite dykes	1	1316 ± 50
	TOLMER GROUP	sandstone, dolomite, siltstone	1000	
	KATHERINE RIVER GROUP	sandstone, conglomerate, minor greywacke, siltstone. Interbedded basalt-andesite volcanics and pyroclastics	1200	1648 ± 29 (basalt)
late EARLY PROTEROZOIC TRANSITIONAL IGNEOUS ACTIVITY -1870-1650 Ma	OENPELLI DOLERITE	layered tholeiitic dolerite lopoliths	<250	1688 ± 13
	POST-OROGENIC GRANITE EMPLACEMENT	biotite granite, adamellite, syenite, granodiorite (numerous plutons)		1780 - 18[illegible]0
	MYRA FALLS METAMORPHICS & NOURLANGIE SCHIST	layered schist, gneiss (metamorphosed and partly migmatised Early Proterozoic sediments)		1800
	EDITH RIVER GROUP	ignimbrite, microgranite, rhyolite, minor basalt and cherty sediments; basal sandstone, arkose	1200	1850 (ignimbrite)
	EL SHERANA GROUP	rhyolite, greywacke, siltstone, sandstone, basalt		1860
	ZAMU DOLERITE	layered tholeiitic dolerite sills and minor dykes	<2500	1914 ± 170
EARLY PROTEROZOIC SEDIMENTATION -1870-2400 Ma	FINNISS RIVER GROUP (flysch)	siltstone, slate, shale, greywacke, arkose quartzite, schist, minor interbedded volcanics	1500-5000	
	NIMBUWAH COMPLEX	granitoid migmatite, granite, gneiss, schist (anatexis of Early Proterozoic granite)		1803 - 1870 1886 ± 5
	SOUTH ALLIGATOR GROUP (shallow marine chemical, volcanic)	pyritic black shale and siltstone, chert-banded and nodulated hematitic siltstone and black shale, algal carbonate, banded iron formation, jaspilite, tuff, greywacke near top	<5000	1884 ± 3 (dacite) 1888 ± 3 (Gerowie tuff)
	MOUNT PARTRIDGE GROUP (fluviatile, near-shore chemical, supra-tidal)	sandstone, siltstone, arkose, shale, conglomerate, quartzite, carbonaceous siltstone & shale, dolomite, magnesite; minor interbedded volcanics	<5000	
	CAHILL FORMATION (supratidal, fluviatile)	quartz schist, pelitic and partly carbonaceous near base with lenses magnesite	3000	
	NAMOONA GROUP (shallow marine, chemical, detrital, supratidal)	pyritic carbonaceous shale and siltstone calcareous in places, calcareous sandstone, tuff, agglomerate; arkose, sandstone and massive dolomite in west.	<3500	
	KAKADU GROUP (fluviatile)	sandstone, arkose, siltstone, conglomerate, quartzite, schist, gneiss	~1000	
ARCHAEAN BASEMENT	NANAMBU COMPLEX	granite, augen gneiss, leucogneiss, minor quartzite and schist (includes accreted Early Proterozoic metamorphics)		1800 (gneiss) ~2500 (granite)
	RUM JUNGLE COMPLEX WATERHOUSE COMPLEX	coarse, medium, and porphyritic adamellite, biotite-muscovite granite, migmatite, gneiss, schist, pegmatite, meta-diorite, banded iron formation		2500

after Stuart-Smith + Needham, + Page, 1985

Fig 6.6

Fig 6.7

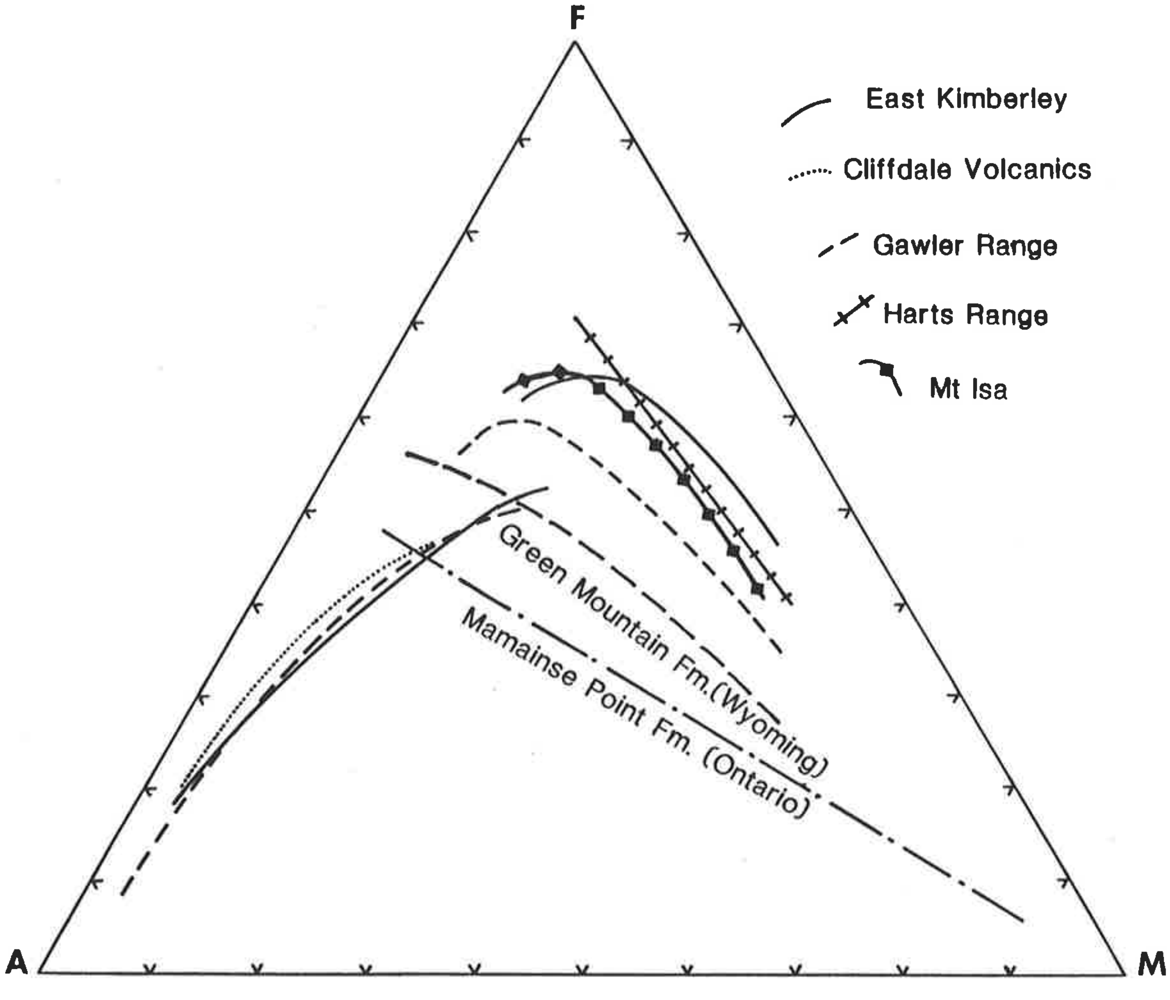

F
A
M
East Kimberley
Cliffdale Volcanics
Gawler Range
Harts Range
Mt Isa
Green Mountain Fm.(Wyoming)
Mamainse Point Fm. (Ontario)

Fig 6.8

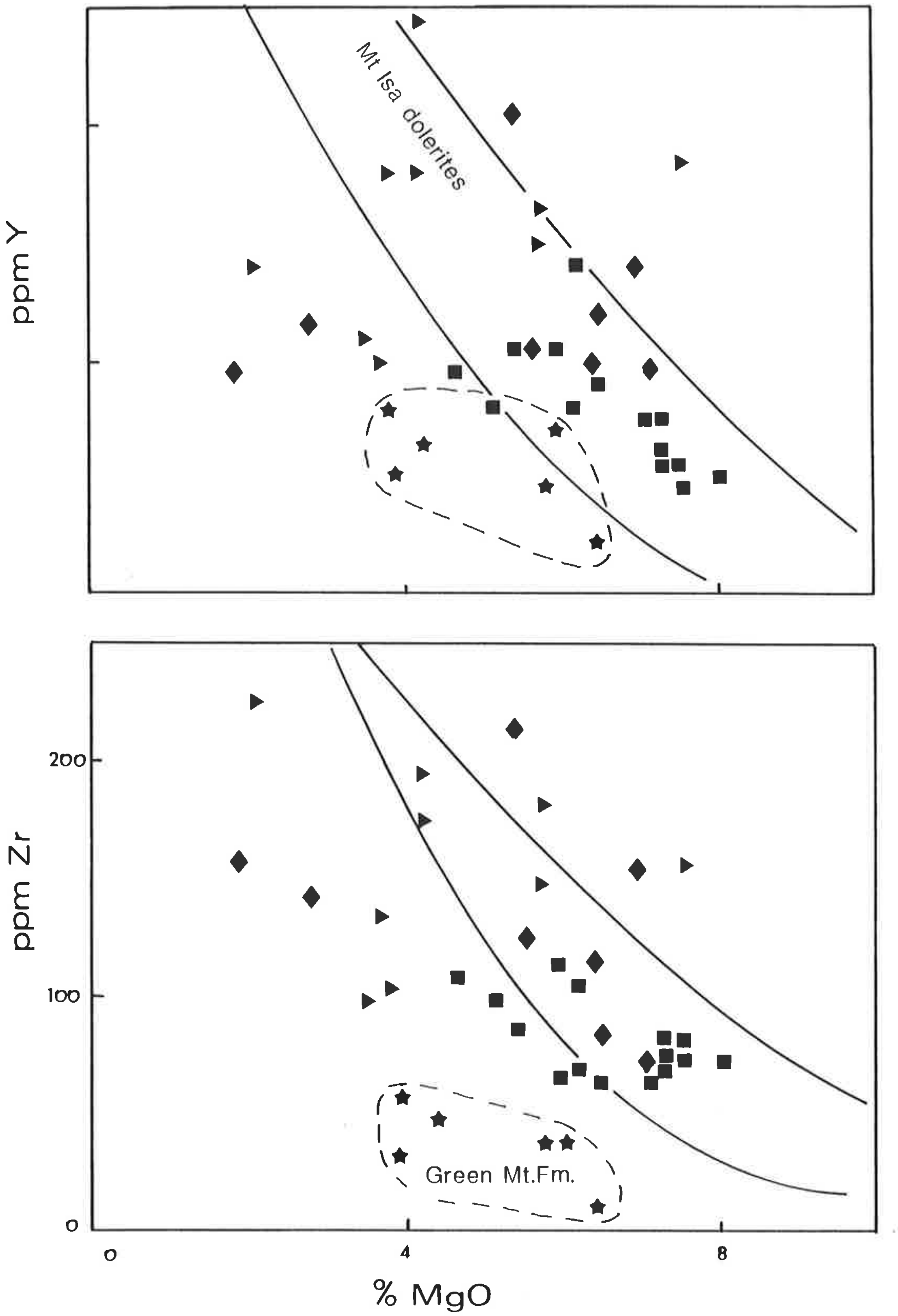
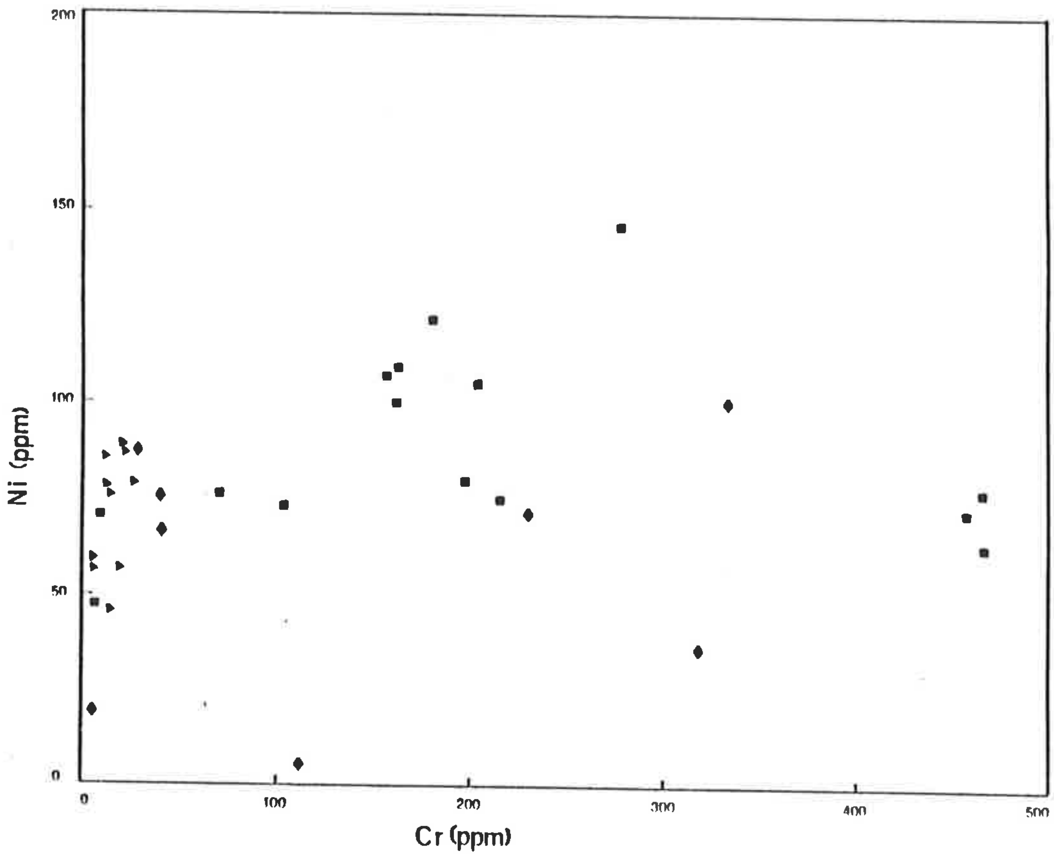
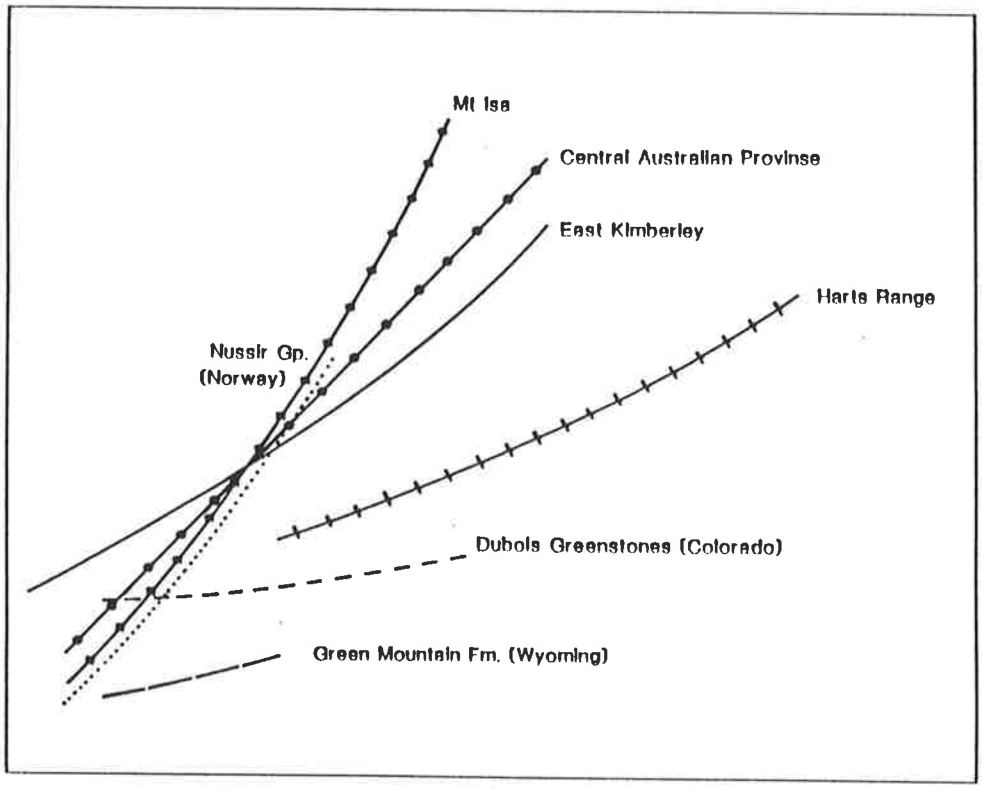


Fig 6.9

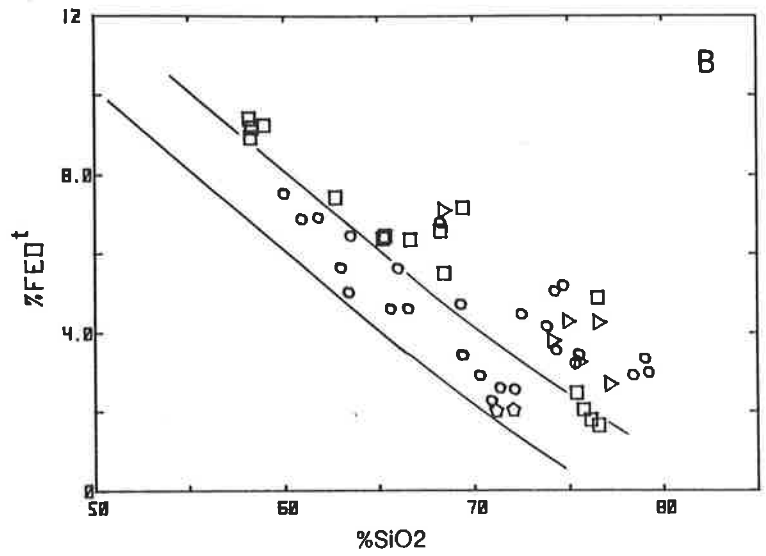


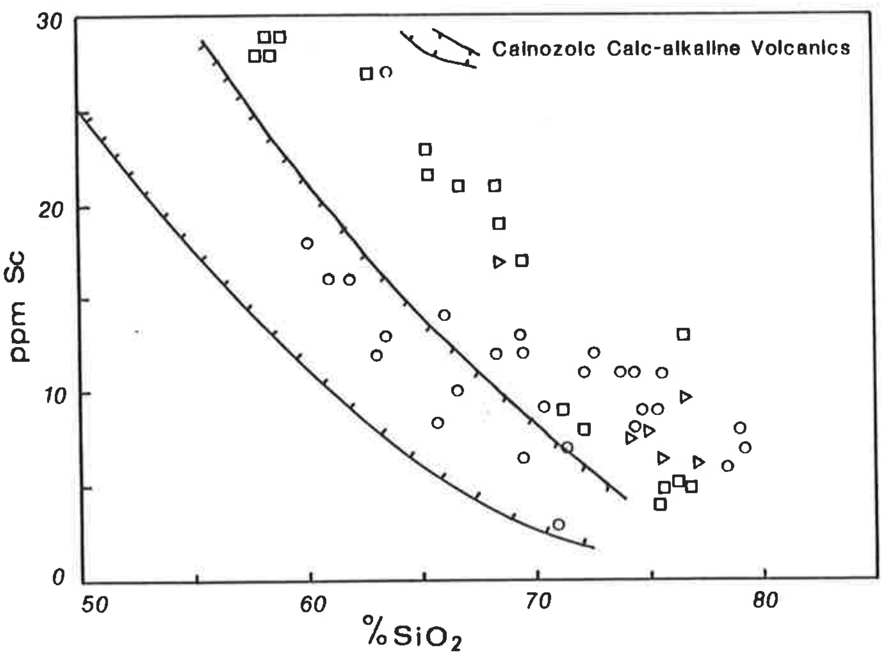
200
150
100
50
0
Ni (ppm)
0
100
200
300
400
500
Cr (ppm)

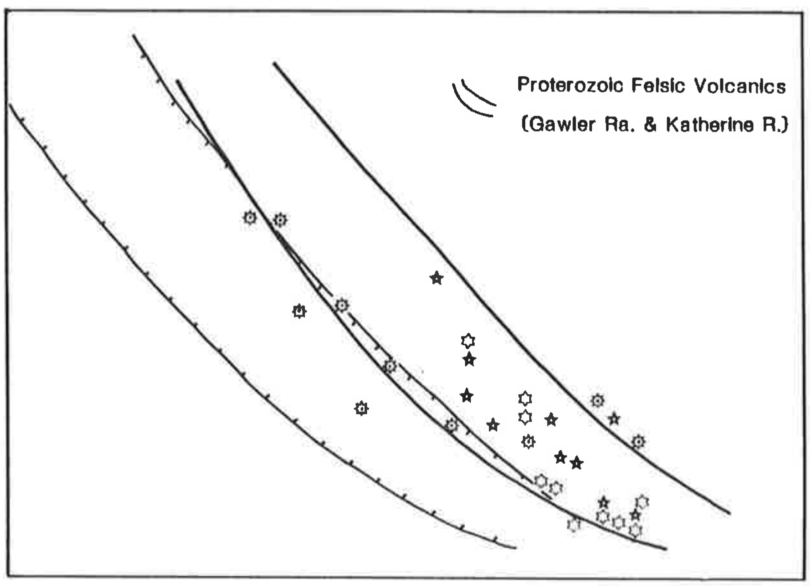


Mt Isa
Central Australian Provinse
East Kimberley
Harts Range
Nussir Gp.
(Norway)
Dubois Greenstones (Colorado)
Green Mountain Fm. (Wyoming)

Fig 6.10







5,6,&8 point stars resp. Gold Hill (New Mexico), Dubois Succession (Colorado) & Green Mt. Fm.(Wyoming)

APPENDIX 2

Table 1

Tuffs Ding Dong Downs Volcanics Saunders Creek Area

Sample No	Rock Name	Description	% Minerals	Alteration	W.R.A.	T.E.	Comments
210	Crystal-Lithic Tuff	Fine-coarse gr. subhedral phenocrysts plag med-coarse gr fragments of basalt in v. fine gr patchy qtz-musc matrix. Areas of fine gr granular qtz some with incl. phenocs.plag-possibly fragments of earlier xtal tuff?	Phenocs 15 Lithic 25 fragments	Plag phenocs show patchy replacement are corroded around periphery	√	√	Musc aligned -> schistosity Fragments elongate along schistosity, with bending of elongate plag.
212 photo	Rhyolitic Crystal-Lithic Tuff	Similar to 210, but fewer basalt fragments sub-rect-ovoid patches of recrystallised qtz-pseudomorphs after fels. Grannular aggregates of qtz & K-spar orig. glomero-porphyritic. Tuff fragments- qtz phenocs, or coarse gr. fels phenocs. largely repl by qtz-seriate.	Phenocs 10 Lithic 15 fragments	Advanced repl of fels by qtz around periphery alongmicrofractures one twin of Carlsbad twin, or completely pseudormorphing	√	√	Chl repl by 'bio' Recrystallisation more adv than210 Seriate schistosity wrapping orig phenocs & fragments
213 photo	Rhyolitic Crystal-Lithic Tuff	Fine-coarse gr euhedral-subhedral phenoes fels, coarse gr acid tuff & basalt fragments in v fine gr qtz-fels-seicite matrix. Some basalt frags with amgydules infilled with coarse gr chl, calc, epidote	Phenocs 10 Lithic 20 fragments	Similar to 210	√	√	Basalt amgydules infilled prior to eruption of felsic volcanics.
230 photo	Rhyolitic Crystal Lithic Tuff	Fine-coarse gr euhedral-subhedral phenocs. qtz & fels fine-coarse gr acid tuff & basalt fragments in v fine gr.qtz-sericite matrix. Ground mass texture suggestive of orig. shard rich matrix	Phenocs 10 Lithic 20 fragments	Phenocs partially resorbed & replaced along microfractures & around periphery by recrystallised qtz.	√	√	Microfractures, infilled by qtz offset phenocs & fragments
231 photo	Rhyolitic Crystal Lithic Tuff	Fine-coarse gr euhedral-subhedral qtz, plag & K-spar phenocs, med-coarse gr basalt & acid tuff fragments in v. fine gr. qtz-sericite matrix	Phenocs 10 Lithic 15 fragments	Patchy replacement of fels. Microfractures haematitic. Bio replacing chl. Badly weathered	√	√	Cross hatched twinning in K-spar well preserved Perlitic cracking in acid porphry fragment
232	Rhyolitic Crystal Vitric Lithic Tuff	Similar to 231, but no K-spar phenocs identifiable & numerous fragments with spheroidal devitrification texture, generally partially resorbed	Phenocs 10 Lithic 10 fragments Orig 15 glass	Also badly weathered	√	√	One very coarse gr glomero-porphyritic aggregate of felspar

Basalt   Ding Dong Downs Volcanics   Saunders Creek Area

Sample No.	Rock name	Description	% minerals	Alteration	WRA	TE	Comments
205	Altered Amygdaloidal Basalt	v.fine gr. plag.laths & fine gr. anhedral-subhedral opaques in plag-qtz groundmass. Minute needles of actinolite & fine gr. subhedral chlorite define schistosity. Granular sphene scattered throughout. Areas of recrystallised qtz - ill-defined amygdules. Sometimes associated with chl. & epidote.	plag 40 qtz 15 act 20 chl 15 op + sphene 10 amygdules 10% rock qtz 95	Orig.plag.laths cloudy & corroded	✓	✓	Amygdules elongate along schistosity. Second schistosity defined by chlorite, developed at ~30° to first schistosity. Veinlets of qtz parallel S_2
206	Altered Amygdaloidal Basalt	Similar to 205 but highly amygdalar, amygdules infilled with qtz & epidote. Lenses of white mica & veins of recrystallised qtz define strong tectonic fabric - S_2 by analogy with 205.	plag 40 qtz 10 act 25 chl 10 musc 5 op + sphene 10 amygdules 25% rock qtz 45 epidote 45 sphene 10	Strongly altered. Rock has phyllitic sheen. Coarser grained white mica rep. chl.	✓	✓	Diffuse strings of granular sphene (+leucoxene?) define weak internal fabric in amygdules, discontinuous with enwrapping white mica, randomly aligned within section suggesting rotation of amygdules during F_2. Later epidote cross cuts both fabrics (M_3).
207	Altered Amygdaloidal Basalt	v.fine gr. plag. laths in chlorite matrix Irregular - Sub-rounded amygdules infilled with well crystallised epidote & recrystallised qtz. Fine gr. anhedral opaques & finely granular sphene disseminated throughout.	felspar 30 qtz 5 chl 55 op & sphene 5 epidote <5 amygdules 50% rock epidote 70 qtz 30	Orig. plag. laths cloudy & corroded. Prob. orig. interstitial texture.	✓	✓	Metamorphosed to greenschist facies. Chl. repl. by bio. Recrystallised qtz veins with minor epidote.
211	Altered Amygdaloidal Basalt	Fine gr. anhedral opaques & granular sphene disseminated through fine gr. recrystallised quartz, epidote, actinolite, chlorite. Sub-rounded amygdules infilled with qtz, epidote & calcite. Little late stage calcite also in matrix.	epidote 50 qtz 30 act 10 op + sphene 5 chl 5 amygdules 20% rock qtz 60 epidote 35 calc 5	Primary mineralogy completely altered. Extensively repl. by qtz, act. epi.	✓	✓	Metamorphosed to greenschist facies. Irregular recrystallised qtz & carbonate veins with minor epidote.
215	Altered Amygdaloidal Basalt	v.fine gr. plag. laths in qtzofelspathic matrix, with development of minute actinolite needles. v.fine gr. anhedral op. & granular sphene disseminated throughout. Amygdules infilled with qtz, epidote, chlorite, white mica - in that order. Prob. orig. interstitial texture. Plag. laths aligned ~amygdules in flow structure. Few med. gr.plag.laths cloudy & corroded.	plag 40 qtz 10 act 15 chl 25 op + sphene 10 amygdules 20% rock qtz 50 chl 10 epidote 40 white mica tr.	Trachytic texture well preserved. No discernable calc. Epidote in amygdule only.	✓	✓	Greenschist facies.
217	Altered Amygdaloidal Basalt	Anhedral opaques scattered thru recrystallised qtz - epidote - chlorite. Sub-rounded-irregular amygdules infilled with qtz, epidote, chl -in that order. Opaques with better developed crystal faces & aggregates of granular sphene concentrated around amygdules.	epidote 65 qtz 5 plag 15? chl 5 op + sphene 10 amygdules 40% rock qtz 85 epidote 10 chl 5	Amygdalar texture well preserved.Orig mineralogy completely obliterated. Highly epidotised.	✓	✓	Similar to 207.
218	Altered Basalt	Fine gr.plag. laths in chloritic matrix. Fine gr. anhedral disseminated opaques. Granular sphene rimming plag laths. Few grains of interstitial epidote. Orig. intersertal texture?	plag 50 qtz 10 chl 30 op + sphene 10	Orig. plag. laths cloudy. Prob. orig. glassy matrix now chloritised.	✓	✓	Epidote developed along microfracture. Qtz-chl. vein.
219	Altered Amygdaloidal Basalt	Trains of v.fine gr-milled opaques. Bands of v.fine gr. plag. in qtzofelspathic matrix alternating with bands highly chlorifised & epidotised with all primary texture & mineralogy obliterated. Large patches & veins of calcite. Few amygdules with quartz & epidote infilling rimmed by granular sphene.	Impossible to tell.	Extreme	✓	✓	Isoclinally folded mylonitised amygdaloidal basalt.
220	Altered Amygdaloidal Basalt	v.fine gr.plag. laths in qtzofelspathic matrix. Patchy chloritization. Subhedral-euhedral fine gr. disseminated opaques & granular sphene. Well rounded amygdules infilled with qtz, then epidote, then chlorite. Matrix chloritised at periphery of amygdules with chl growing in. Pods of calc, some with epidote incl.	plag 40 qtz 10 chl 35 op + sphene 15 Amygdules 20% rock epidote 80 qtz 15 chl <5 calc <5	Trachytic texture well preserved.	✓	✓	Similar to 215.
221	Altered Basalt	Fine gr. plag.laths in v.fine groundmass of plag-qtz-actinolite. Fine gr. subhedral chl. defines schistosity with plag. & actinolite elongate along schistosity. Anhedral opaques repl. by sphene. Epidote cross cuts schistosity. Interstitial pools of late calcite with incl. of plag. epidote, actinolite, op.	plag 40 act 15 chl 25 op + sphene <5 qtz 10 epidote 5 calc <5	Plag cloudy with incl. Chl. repl. act. Sphene repl. op.	✓	✓	Metamorphosed to greenschist facies. Strong tectonic fabric.
222	Altered Amygdaloidal Basalt	v.fine gr.plag. laths in groundmass of qtz-chl. Chl. defines schistosity. Plag. laths aligned along schistosity. Fine gr. interstitial epidote. Amygdules flattened in schistosity infilled with recrystallised qtz, epidote & white mica.	plag 40 qtz 10 chl 40 op & sphene 10 epidote <5 Amygdules 20% rock qtz 90 white mica 5 epi + chl 5	No discernable calcite. Little epidote. Minor replacement of chl. by bio.	✓	✓	Metamorphosed to greenschist facies. Weak fabric defined by chl, plag alignment, & trails of fine gr. anhedral opaques. Similar to 215, 220.
560/94	Altered Basalt	Fine gr. plag. laths in groundmass of chlorite, epidote, calcite. Speckled with minute opaques. Patches of finely granular sphene largely obscuring mineralogy & texture.	plag 30 epidote 25 calc 5 chl 20 op + sphene 10 qtz 10	strongly altered	✓	✓	Veins of chl replaced by late epidote & calcite.

WRA = Whole Rock Analyses
TE = Trace Element Analyses

Selected analyses of minerals in volcanic rocks

Spec. N^{o}.	(a) 1454	(b) 210	(c) 210
Rock Unit	Corkwood East Suite	Ding Dong Downs Volcanics	Ding Dong Downs Volcanics
Mineral	Plagioclase (megacryst)	K-spar (phenocryst)	Albite (phenocryst)

Spec. N^{o}.	(d) WWV 6	(e) 1452	(f) 1084
Rock Unit	Whitewater Volcanics	Wills Creek Suite	Corkwood East Suite
Mineral	Ferrohypersthene	Spessartine Garnet	Almandine Garnet

Spec. N^{o}.	(g) 1452	(h) 1406
Rock Unit	Wills Creek Suite	Corkwood East Suite
Mineral	Plagioclase phenocryst	Plagioclase megacryst

(a)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	55.9823	62.4231	11.1204	0.7817	0.7010
AL2O3	21.2867	22.8900	4.8059	0.7352	0.6837
FEO	0.0000	0.0000	0.0000	1.2654	0.7980
CAO	5.7081	5.9268	1.1312	0.8843	0.8517
NA2O	7.7611	8.1148	2.8028	0.4778	0.4687
K 2O	0.0915	0.0923	0.0210	0.8247	0.8177
BAO	0.0000	0.0000	0.0000	0.6840	0.6044
SRO	0.0553	0.0697	0.0072	0.6693	0.5308
(O)			32.0000		
TOTAL	91.0850	99.5167	51.8886	ITERATION	3

(b)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	61.8195	65.3243	12.0517	0.7817	0.7398
TIO2	0.0000	0.0000	0.0000	1.6178	0.7861
AL2O3	17.2476	17.8135	3.8733	0.7352	0.7118
CR2O3	0.0249	0.0446	0.0065	1.4289	0.7973
FEO	0.0294	0.0465	0.0072	1.2654	0.8008
MNO	0.0000	0.0000	0.0000	1.2664	0.7854
MGO	0.0050	0.0055	0.0015	0.6787	0.6149
CAO	0.0165	0.0177	0.0035	0.8843	0.8249
NA2O	0.2136	0.2211	0.0802	0.4778	0.4554
K 2O	17.1493	17.1578	4.0383	0.8247	0.8243
F 2O	0.0096	0.0267	0.0110	0.4953	0.1787
(O)			32.0000		
TOTAL	96.5154	100.6608	52.0731	ITERATION	2

(c)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	61.8737	68.5985	11.9719	0.7817	0.7051
TIO2	0.0000	0.0000	0.0000	1.6178	0.7940
AL2O3	17.7519	19.3691	3.9839	0.7352	0.6738
CR2O3	0.0093	0.0166	0.0023	1.4289	0.7981
FEO	0.0234	0.0371	0.0054	1.2654	0.7972
MNO	0.0000	0.0000	0.0000	1.2664	0.7837
MGO	0.0000	0.0000	0.0000	0.6787	0.5708
CAO	0.0723	0.0754	0.0141	0.8843	0.8471
NA2O	12.1475	12.1152	4.0994	0.4778	0.4791
K 2O	0.0679	0.0693	0.0154	0.8247	0.8078
F 2O	0.0000	0.0000	0.0000	0.4953	0.1942
(O)			32.0000		
TOTAL	91.9459	100.2813	52.0925	ITERATION	3

(d)

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	46.7027	53.2339	7.9179	0.7817	0.6858
TIO2	0.0149	0.0287	0.0032	1.6178	0.8367
AL2O3	0.9713	1.2619	0.2212	0.7352	0.5659
CR2O3	0.0000	0.0000	0.0000	1.4289	0.8730
FEO	15.7340	21.2289	3.0138	1.2654	0.8217
MNO	0.3399	0.5332	0.0672	1.2664	0.8075
MGO	15.5403	21.2359	4.7087	0.6787	0.5289
CAO	0.1902	0.1913	0.0305	0.8843	0.8794
NA2O	0.0201	0.0260	0.0075	0.4778	0.3700
K 2O	0.0222	0.0219	0.0042	0.8247	0.8369
F 2O	0.0000	0.0000	0.0000	0.4953	0.2471
(O)			24.0000		
TOTAL	80.5437	100.7617	39.9741	ITERATION	4

(e)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	32.3575	37.5401	6.0704	0.7817	0.6738
TIO2	0.0433	0.0021	0.0100	1.6178	0.8341
AL2O3	17.0667	20.4218	3.8920	0.7352	0.6151
CR2O3	0.0138	0.0224	0.0029	1.4289	0.8780
FEO	14.8091	22.3568	3.0234	1.2654	0.8382
MNO	7.2320	11.1317	1.5247	1.2664	0.8227
MGO	0.4793	0.6491	0.1565	0.6787	0.5012
CAO	7.6142	7.4384	1.2887	0.8843	0.9052
NA2O	0.0164	0.0229	0.0072	0.4778	0.3417
K 2O	0.0000	0.0000	0.0000	0.8247	0.8679
F 2O	0.0000	0.0000	0.0000	0.4953	0.2120
(O)			24.0000		
TOTAL	79.6520	99.6653	39.9757	ITERATION	3

(f)

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	30.8711	36.6155	5.9737	0.7817	0.6591
TIO2	0.0106	0.0197	0.0024	1.6178	0.8668
AL2O3	16.9495	20.8901	4.0167	0.7352	0.5965
CR2O3	0.0128	0.0200	0.0026	1.4289	0.9195
FEO	24.3655	36.5966	4.9731	1.2654	0.8425
MNO	1.1536	1.7655	0.2440	1.2664	0.8075
MGO	1.5251	2.1297	0.5190	0.6787	0.4860
CAO	1.4748	1.4493	0.2518	0.8843	0.9055
NA2O	0.0177	0.0257	0.0081	0.4778	0.3380
K 2O	0.0052	0.0049	0.0010	0.8247	0.8616
F 2O	0.0230	0.0113	0.0150	0.4953	0.2763
(O)			24.0000		
TOTAL	76.4090	99.5493	40.0263	ITERATION	3

(g)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	60.3462	66.7078	11.7479	0.7817	0.7072
AL2O3	18.5811	20.0842	4.1686	0.7352	0.6802
FEO	0.0143	0.0227	0.0033	1.2654	0.7774
CAO	3.0620	3.1805	0.6016	0.8843	0.8492
NA2O	9.1863	9.5989	3.2749	0.4778	0.4726
K 2O	0.0356	0.0361	0.0081	0.8247	0.8126
BAO	0.0000	0.0000	0.0000	0.6840	0.6053
SRO	0.0372	0.0466	0.0048	0.6693	0.5349
(O)			32.0000		
TOTAL	91.5628	99.6767	51.8092	ITERATION	3

(h)

SPECIMEN COMPOSITION

OXIDE	MESC(%)	CONC(%)	N.IONS	STD.F	UNK.F
SIO2	56.2891	62.7680	8.3970	0.7817	0.7010
TIO2	0.0000	0.0000	0.0000	1.6178	0.7711
AL2O3	21.1253	22.7219	3.5825	0.7352	0.6835
CR2O3	0.0031	0.0056	0.0006	1.4289	0.7973
FEO	0.0003	0.0005	0.0001	1.2654	0.7770
MNO	0.0000	0.0000	0.0000	1.2664	0.7837
MGO	0.0004	0.0005	0.0001	0.6787	0.5829
CAO	5.0281	5.2248	0.7489	0.8843	0.8510
NA2O	8.1152	8.2552	2.1412	0.4778	0.4697
K 2O	0.1365	0.1379	0.0235	0.8247	0.8166
F 2O	0.0000	0.0000	0.0000	0.4953	0.1879
(O)			24.0000		
TOTAL	90.6982	99.1144	38.8938	ITERATION	3

APPENDIX 4

Petrographic descriptions of metapelites of the Biscay Formation

STAUROLITE BEARING SCHISTS

Spec.No[a]	Name	Mineralogy - Modal %	Deformation History - Texture + Fabric	Metamorphic History - Coexisting Phases[b]	Comments
1412B	Staur-Sill-Gt Schist	Qtz 20 Gt 30 Plag 20 Staur 5 Bio 20 Sill 5 Musc - Op <5	Matrix-med.gr.strained qtz & plag.mozaic. Large gs fine staur-round incl, euhedral xtals. Fibrolitic sill. S_2-corroded bio.	M_1 Staur-(Bio)(c) M_2A Bio-Sill-Gt-Plag-Il M_3 Staur Late Sill.	Zoned qtz-core staur. incl, rim sill incl. Staur. incl. in plag. mosaic.
1338A	Staur-Gt-Sill Schist	Qtz 20 Gt 5 Plag 5 Staur <5 Bio 25 Sill 30 Musc <5 Op 10	Matrix-med.gr.rextallised qtz. Coarse sill porph.S_2-coarse bio.& sill, overgrown by med. gr.incl-free gt.clumps & minute staur.	M_1 Staur-(Bio) M_2A Bio-Sill-Op M_2B Musc M_3 Staur-Gt Late Sill.	M_2A Sill - 2 gens. Coarse gr. repl. fibrolite. Random plates musc. cross-cut bio. Large sub-hedral opaques.
1382	Gt-Sill-Staur Schist	Qtz 30 Gt 5 Plag 10 Staur 10 Bio 20 Sill 10 Musc - Op 10 Andal <5	Matrix-Fine-med.gr.qtz-plag. mozaic. V.large zoned qtz-coarse qtz incl.with fib. needles in rim. S_2 bio. repl. by fib. Med-coarse staur. overgrowing fib. Fine euhedral andal.	M_1 Staur-(Bio) M_2A Bio-Sill-Plag-Op M_3 Gt-Staur-Andal Late Sill	Staur. remnants in plag. M_3 minerals v well developed but no M_2B musc.
1336	Staur-Gt-Sill Schist	Qtz 20 Gt 5 Plag 15 Staur <5 Bio 35 Sill 10 Musc <5 Op 10 Andal <5	Matrix-Med.gr.qtz-plag. mozaic. S_2-coarse bio & sill. Fine staur.incl. in plag. corroding bio. Sill repl. bio. Small gt clumps + staur. xtals overgrowing bio & sill.	M_1 staur-(Bio) M_2A Bio-Plag-Sill-Op M_2B Musc. M_3 Staur-Gt-Andal	Abundant metamorphic opaques. Staur.+Bio → Plag + sill + Op.
33	Mylonitic Staur-Gt Schist	Qtz 35 Gt 5 Plag 5 Staur 5 Bio 5 Sill tr Musc 40 Op 5	Matrix-Mylonitic qtz & micas. Bio repl.by musc. Zoned qtz M_1 core M_3 rim. M_3 staur. overgrowing M_2B mylonite fabric defining S_2. Rims of porphyroblasts milled.	M_1 Gt-(Bio) M_2A Bio-Sill M_2B Musc M_3 Gt-staur	Mylonite reactivated post M_3.
366	Banded Gt-Sill-Staur Schist	Qtz 35-40 Gt 5-10 Plag 5-10 Staur 10-15 Bio 10-15 Sill 5-10 Musc 5 Op 5-10 Andal tr.	Qtz-fels.bands-fine-med.gr. M_1 staur.relics. Large qtz. Stumpy bio. Large plates musc. Med.gr.random euhedral M_3 staur. Pelitic bands - Abundant fib. Minute-coarse M_3 staur. Large op.	M_1 Bio-Staur M_2A Bio-Sill-Gt M_2B Musc M_3 Staur-Andal Late Sill	S_2 defined by fib. at low angle to S_1 || S_0 S_2 crenulated.

(a) Underlined if analysed for major elements
(b) Probed phases underlined.
(c) Earlier phases assumed-bracketed.

STAUROLITE BEARING SCHISTS (cont'd)

Spec.No[a]	Name	Mineralogy - Modal %				Deformation History - Texture + Fabric	Metamorphic History - Coexisting Phases[b]		Comments
68	Staur-Gt-Musc Schist	Qtz Plag Bio Musc	20 5 10 50	Gt Staur Sill Op	10 5 <5 <5	Matrix-med.gr.strained & recrystallised qtz. S_2-coarse bio.repl. by coarse musc.plates & fine inter-growths. Zoned gts. M_3 staur. on gt.	M_1 M_2A M_2B M_3	Gt-(Bio) Bio-Sill Musc Staur-gt	Fib. incl. trails in musc. M_3 staur-fine euhedra nucleating in musc. & on gt.
1469	Gt-Sill-Bio Gneiss	Qtz Plag K-spar Bio	30 <5 <5 20	Gt Sill Staur Op	30 15 tr <5	Matrix-med.gr.strained qtz-fels. mozaic. Large zoned gts. S_2-bio. repl. by sill, crenulated & polygonised.	M_1 M_2 M_3	Staur-Bio Gt-Sill-Bio Sill-Op	Zoned gts-core staur. incl, rim sill incl. Sill derived from staur. reaction also repl. bio. Matrix sill coarser.
127	Muscovitised Gt-Sill Schist	Musc Bio Sill	65 20 <5	Gt Staur Tourm	5 tr 5	S_2-coarse bio & fibrolitic sill repl.by large plates & felted aggregates of musc. & coarse tourm. Folded by D_3. Zoned gts. Med.gr.euhedral staur. over-growing musc.	M_1 M_2A M_2B M_3	Gt-(Bio) Sill-Bio Musc-Tourm. Staur	Gts-v.fine qtz incl. in core, incl. free rim, corroded & iron stained.
619B	Bio-Sill Schist	Qtz Bio Sill Gt	45 15 30 <5	Op Musc Staur Andal	10 <5 tr tr	Matrix-fine gr.qtz. S_2 med-coarse gr.bio & fib. repl. by coarse sill. Anhedral med.gr. gts. incl.coarse sill. Minute euhedral staur. & andal. over-grow fib.	M_1 M_2A M_2B M_3	Sill-Bio Bio-Sill Musc Gt-Staur-Andal	Fine gr.equant op. evenly dis-tributed. Med-coarse gr. anhedral op. elongate along schistosity.
1327A	Gt-Bio-Musc Schist	Qtz Bio Musc Gt	40 10 40 5	Staur Sill	<5 tr	S_2-strong domainal anastromo-sing fabric. Qtz domains-fine gr.strained & recrystallised. Mica rich domains-med.gr.elon-gate bio.repl. by musc, weakly crenulated. Syntectonic gt. Post-tectonic staur.	M_1 M_2A M_2B M_3	(Bio) Bio-Sill-Gr Musc Staur	Poikiloblastic med.gr. gts. Rotational $S_i \equiv S_e$. Sill needles incl. in gt,qtz,musc. Fine gr. euhedral random staur.
1380	Staur-Sill-Gt Schist	Qtz Plag Bio Musc	30 10 20 15	Sill Gt Staur Op	5 15 <5 5	Matrix-fine gr.qtz-fels. mozaic. Plag.incl. fine staur. remnants. S_2 well defined med.gr. bio. repl. by fib, both overgrown by musc. Zoned gts. 2nd gen.staur. nucl.on gt/bio, overgrows sill.	M_1 M_2A M_2B M_3	Staur-Gt-(Bio) Bio-Sill-Plag Musc Gt-Staur	Zoned gts-core v.fine gr. qtz. incl. with rotational S_i, incl. free rim (some sill incl.). Subhedral outline, some outgrowths on bio.

Staurolite Bearing Schists (cont'd)

Spec. No.	Name	Mineralogy - Modal %				Deformation History Texture & Fabric	Metamorphic History Coexisting Phases	Comments
1027B	Muscovitised Andal-Staur-Gt Schist	Qtz Musc Bio	10 40 20	Gt Staur Andal Sill	15 10 5 tr	S_2 - med gr aligned bio, heavily repl. by musc. Zoned gts. v.fine-coarse random euhedral staur. nucl. on gt/bio/musc. Med gr. andal overgrows musc.	M_1 Gt-(Bio) M_2A Bio-Gt-Sill M_2B Musc M_3 Staur-Andal	Zoned gts-core v.fine qtz incl, outer incl. poor zone, some sill needles, heavily fractured & some rims apparently corroded by staur.
687A	Banded Staur-Sill-Gt Schist	Qtz Bio Gt	60 5 15	Sill Staur Op	10 5 5	Bands coarse sill, abundant fine -coarse anhedral op. elongate along S_2, med. gr. gts with fine staur & op incl. wrapped by & incl. sill, post-tectonic staur. Bands of qtz with small rounded gts, S_2 def. by remnant bio & sill needles.	M_1 Staur-Bio M_2 Sill-Gt-Op M_3 Staur.	$S_2 \parallel S_1 \parallel S_0$ M_3 med. gr. euhedral staur. nucl. preferentially along microfractures cutting coarse sill bands at high angle.
121	Sill-Staur-Gt Schist	Qtz Bio Gt	40 25 15	Staur Sill Op Cli	10 <5 <5 tr	Matrix-coarse gr.qtz, bands of recrystallised mylonite wrapping porphyroblasts. S_2 coarse gr. bio at high angle to earlier fabric (finer). Poikiloblastic zoned gt & staur.	M_1 Bio M_2 Bio-Gt-Staur-Sill-Op M_3 Chl-Gt	Earliest S_i fine elongate qtz. Later S_i coarse, equant. Some gt rims inclusion poor over-growing fine mylonite, staur & op.
1337	Staur-Gt-Sill Schist	Qtz Plag Bio Sill	30 <5 20 15	Gt Staur Op Andal	10 10 10 5	Matrix-fine gr. recryst. qtz. S_2 well def. by coarse green bio repl. by sill. Large zoned gts. V.fine-med, euhedral staur & andal overgrowing fib. Op-fine random.	M_1 Staur-Bio M_2 Bio-Sill-Gt-Plag-Op M_3 Staur-Andal-Chl	Fine, rounded staur incl. in plag-qtz mozaic. Gt core - many fine op, rim-few, large, op, qtz, staur, sill.
369	Crenulated Muscovitised Gt Schist	Qtz Plag Bio Musc	20 <5 25 40	Gt Sill Staur Op	10 <5 tr 5	S_2 def. by med. gr. bio axial plane to fine crenulations. Coarser crenulations overprint. Large plates musc. overgrow bio & incl. fibrolitic sill, gt, op. Wavy extinction. Minute euhedral staur nucl. on gt/bio & overgrows sill.	M_1 Bio M_2A Bio-Sill-Gt-Op M_2B Musc-Op M_3 Staur Late Sill.	Opaques-v.fine trails complexly folded, sometimes in bands, possibly S_0- coarse gr. anhedral sometimes incl. gt.
1383	Sill-Staur-Gt Schist	Qtz Gt Bio	30 30 10	Staur Sill Andal Op	15 10 tr 5	Matrix - fine-med qtz. Coarse bio & fib sill define S_2. Large zoned gts. Staur-v.coarse, qtz incl. cont sill needles, or small idioblastic nucl. on gt/bio. Small euhedral andal overgrow fib.	M_1 Staur-(Bio) M_2 Bio-Sill-Gt-Op M_3 Staur-Andal Late Sill.	Zoned gts-small qtz incl. in core, fewer larger staur, op, qtz incl. in rim, heavily fractured. M_3 minerals well developed. Little musc. Op fine-coarse gr.

Selected Garnet-Biotite Schists and Gneisses

Spec	Rock Name	Mineralogy Modal %				Deformation History Texture and Fabric.	Metamorphic History Coexisting Phases	Comments
8	Gt-Bio-Musc Schist	Qtz Bio Musc Gt	35 15 45 5	Tourm Op	<5 tr	Med-Coarse gr. Strong S_2; bio repl by musc, wrapping large gts with discontinuous S_i, overgrown by random plates musc. S_2 crenulated by D_3.	M 1 Gt-(Bio) M 2A Bio M 2B Musc-Tourm M 3 Musc	Gt S_i-linear fabric of rounded qtz Incl, finer gr than matrix qtz.
53	Muscovitised Gt-Bio Schist	Qtz Musc Bio	40 40 15	Gt Sill Apatite Op	5 tr tr tr	Matrix fine interlobate qtz. S_2coarse bio. wrapping musc, pseudomorphs after andel.(Felted mat. fine musc, rectangular outline, elongate along S_2). Bio replaced by musc. Both micas overgrown by equant subhedral med. gr. gt.	M 1 (Andal) M 2A Bio-Sill M 2B Musc-Apatite M 3 Gt	Fib fibres in musc pseudomorphs.
82	Gt-Bio Musc Schist	Qtz Plag Bio Musc	50 25 10 15	Gt Op	<5 tr	Matrix qtz strained & recrystallised, seriate, amoeboid. Med gr plag sericitised & corroded. S_2 bio repl by musc-fine aggregates & deformed plates. Few large gts with few large qtz & musc incl.	M 1 (Bio) M 2A Bio M 2B Musc-Gt M 3 Gt	Musc part wraps, & is part incl by & overgrown by gt. Orig fels poss volcaniclastic.
85B	Gt-Bio Musc Schist	Qtz Bio Musc Gt	30 15 50 5	Op	<5	Matrix qtz fine gr recrystallised. S_2 coarse bio remnants repl by musc part wraps part overgrown by large zoned gts. S_2 crenulated by D_3.	M 1 (Bio) M 2A Bio-Sill M 2B Musc-Gt M 3 Gt	Zoned gts-core, many fine qtz incl defining weak S_i, zone with few large qtz incl containing fibrolite, narrow zone with many Fine qtz, op, micas continuous with Sc, euhedral rim.
104	Gt-Bio Schist	Qtz Bio Plag	50 45 <5	Gt Op	5 tr	Fine-med gr strained qtz. 2 gens bio at high angle to each other, both fine gr, sub-equant, corroded∴fabric ill defined. Med gr zoned gts part overgrow bio.	M 1 Bio M 2 Gt-Bio M 3 Gt	Zoned gts-core fine, rounded qtz & bio incl, zone with few large qtz & bio incl & rotational fabric, rim overgrowing ragged bio.
106	Banded Gt-Musc Schist	Qtz Musc Bio Gt	20 30 5 45	Sill Op Chl	tr 5 tr	A. Qtz rich bed. Matrix; med gr strained & recrystallised qtz. S_2 med gr bio repl by musc. Zoned gts elongate//S_0. Few op. B. Qtz poor bed. S_2 musc with many op & few bio, large equant zoned gts, many op incl.	M 1 (Bio) M 2A Gt-Bio M 2B Musc-Op M 3 Gt	A.Gt cores-linear fabric 11 S_0 fine elongate qtz incl & few bio, terminal zone incl poor. B.Gt cores-rotational fabric many v. fine op, rim few fine op. Rim overgrows S_2.

138	Gt-Bio Schist	Qtz Bio Gt	50 15 30	Op Epidote	5 tr	Matrix fine-med gr recrystallised qtz. Indistinct fabric of ragged bio wrapping large equant rotated gts with discontinuous linear S_i of med gr elongate qtz & non-corroded bio.	M_1 Bio M_2 Gt-Bio M_3 Gt Late Epidote	Matrix bio shredded during D_{2B}. Some gt rims & incl poor small gts overgrow sheared fabric.
372	Banded Gt-Bio Schist	Qtz Bio Gt Epidote	45 40 5 5	Plag Op Chl	<5 <5 <5	Fine gr strained qtz, bio rich wavy band (S_0) bio remnants (S_1)//S_0. Small-med elongate zoned gts in bio rich bands, rotated, part wapped by S_2. S_2 crenulated by D_3.	M_1 Gt M_2 Bio-Il M_3 Gt Late Epidote	Gt linear S_i fine gr elongate qtz. Terminal inc poor zone overgrowing wrapping S_2.
377	Banded Hbe-Gt-Bio Schist	Qtz Fels Bio Musc	50 15 10 10	Gt Hbe Op	10 5 tr	Bands of v. fine gr amoeboid qtz & fine gr fels interbedded with more bio & Lbe rich bands & laminae. S_1 fine corroded bio & Lbe//S_0 folded by D_2 weak axial plane S_2, weakly crenulated by D_3. Zoned gts rotated by D_2.	M_1 Bio-Gt-Hbe M_2 Bio-Hbe-Gt	Large gts elongate along S_1 with few op incl in core & granular rim zone, with bio poor coronas, rotated & disrupted by D_2.
413	Banded Musc Schist (Garnet bearing)	Qtz Fels Gt Musc	50 20 tr 30	Bio Op	tr tr	Well defined interbedded fine gr. qtzofels & metapelitic bands of laminae. S_1 fine gr musc // S_0 folded by D_2 weak axial plane S_2 Micas bent & crenulated in hinge(some polygonisation) grain growth on limbs.	M_1 Bio-Musc-Gt M_2 Musc	Small gts slightly elongate along S_1 // S_0.
608	Gt-Musc Schist	Qtz Bio Musc	30 10 40	Gt Op Tourm	20 <5 tr	Zonal anastomosing mylonitic fabric part wrapping zoned gts. Qtz areas seriate, amoeboid. S_2 bio shredded & largely repl by fine musc. Overgrowing coarse musc deformed by D_3.	M_1 Gt M_{2A} Gt-Bio-Op M_{2B} Musc-Tourm M_3 Gt-Musc	Gt cores-rotational fabric with many fine rounded qtz incl, incl poor zone with op & coarser qtz, Subhedral rim overgrowing fine musc.
660	Gt-Bio Schist	Qtz Plag Gt	40 10 40	Bio Op	10 <5	Med-coarse gr strained & recrystallised qtz. S_2 med gr bio. Large zoned gts generally equant, some elongate along S_2. Variable S_i.	M_1 Bio M_2 Gt-Bio M_3 Gt	Some gts with qtz & bio incl same gr size & cont with matrix. Some gts with minute op & qtz incl & rotational fabric. Some skeletal gts overgrow S_2.
723	Gt-Bio Gneiss	Qtz Plag Gt	40 15 25	Bio Op Sill Herc	15 5 tr tr	Coarse gr polygonal qtz-fels. Well defined S -coarse bio. V. large gts, elongate along S_2, zoned, part overgrow wrapping S_2. S_2 deformed by D_3-wavy extinction.	M_1 Bio M_2 Gt-Bio M_3 Gt Late Sill-Op	Gt core-fine rounded bio & op, outer zone-med gr elongate op (some mag-herc intergrowths), med bio & qtz. Bio exsolving mag on grain boundaries.

749	Gt-Bio Gneiss	Qtz Plag Bio	30 40 20	Gt Op Sill Herc	10 <5 tr tr	Matrix - inequigranular interlobate qtz & sericitised plag. S_2-v coarse gr bio euhedral & exsolving mag along grain boundaries & cleavages. Larrge skeletal gts part continuous with S_2, part overgrowing.	M_1 Bio M_2 Gt-Bio-Fels-Sill M_3 Gt Late Sill-Op	Earlier ragged bio corroded by & forming incl in fels. Occ. clumps of fine sill incl in fels. Late grain boundary sill.
763	Gt-Bio Schist	Qtz Plag Bio	25 25 30	Gt Op	20 tr	Seriate, interlobate qtz & fels. S_2 med gr well crystallised bio & elongate zoned gts folded by D_3 with production of weak overprinting schistosity S_3.	M_1 (Bio) M_2 Gt-Bio M_3 Gt-Bio M_4 Bio	Gts-ill defined int zone with fine rounded qtz incl, outer zone with qtz & bio continuous with matrix. S_2 bio deformed during D_3 have recovered & polgonised.
768	Gt-Bio Gneiss	Qtz Plag Bio	30 25 20	Gt Op Sill Herc	25 <5 tr tr	Matrix-inequigranular interlobate qtz-fels. S_2-v. coarse gr bio part wrapping large equant zoned gts. Earlier med gr corroded bio. Coarse bio unstrained & polygonised (post D_3)	M_1 Bio M_2 Gt-Bio-Fels-Sill M_3 Gt Late Sill-Op	Gt core-fine rounded qtz & bio incl, rim zone with few large qtz, bio, op (some mag/herc)+/or trails of sill. Grain boundary mag & sill
790	Gt-Bio Gneiss	Qtz Plag Bio	35 15 25	Gt Op	25 <5	Matrix- strained qtz (deformation lamellae) partly recrystallised(seriate interlobate) & fels fine-coarse, frequently zoned. S_2-med-coarse bio part wrapping part overgrown by large equant gts. S_2 bio shredded by D_{2B}.	M_1 Bio M_2 Gt-Bio-Fels M_3 Gt	Gt core-fine rounded qtz & bio. Rim zone incl poor.
800	Gt-OPx Bio-bearing Gneiss	Qtz Fels Bio Gt	50 40 5 tr	Hbe OPx Op	tr 5 <5	Seriate amoeboid qtz-fels matrix, clumps of ferro-mags. Tiny rounded gt remnants in fels & OPx. OPx fractured, corroded & part replaced by Lbe, bio & mag.	M_1 Gt-Bio M_{2A} OPx-Fels M_{2B} Hbe-Bio-Op	No fabric discernible in thin section.
807	Gt-Bio Schist	Qtz Fels Bio	30 20 30	Gt Op	20 <5	Seriate amoeboid qtz & fels. S_2 fine-med gt. bio, corroded & repl by fels, part wrapping gt, crenulated by D_3. Coarse gr bio replaces S_2 forming weak fabric coexisting with incl poor gt. rims.	M_1 Bio M_2 Gt-Bio M_3 Fels M_4 Bio-Gt	Some late skeletal gts with coarse gr incl, others with fine rounded incl.
815A	Gt Gneiss	Qtz Plag Bio	40 40 10	Gt Op	10 tr	Seriate interlobate qtz & fels. Weak fabric, S_2, crystallographic orientation of interstitial bio, & shape & crystallographic preferred orientation of fels. Large skeletal gts.	M_1 Fels-Bio M_2 Fels M_3 Gt-Bio	Scraps of remnant bio are engulfed by fels. Coarse incl in gt strained & recrystallysed.

Gt-Sill Schists & Gneisses

Spec	Rock Name	Mineralogy Modal %				Deformation History Texture and Fabric.			
73	Gt-Sill- Bio Schist	Qtz Bio Gt	5 50 25	Sill Chl Op	20 <5 <5	S_2 coarse bio heavily repl by sill part wrapping large zoned gts slightly elongate along S_2. S_2 crenulated by D_3.	M_1 M_2 M_3	Bio Gt-Bio-Sill Gt	Gt core fine rounded qtz & occ. bio, few sill incl in rim zone partly overgrowing S_2.
111	Gt-Sill- Bio Schist	Qtz Bio Sill	35 35 15	Gt Musc Op	15 tr <5	S_2 coarse bio part wrapping large zoned gts. Bio heavily repl by sill. Large anhedral matrix op. S_2 crenulated by D_3.	M_1 M_2 M_3	Bio Gt-Bio-Sill-Op Gt	Gt core rotational S_1 fine elonga qtz, op & occ bio. S_1 finer than discontinuous with S_e. Some gts have rim zone with few coarse qtz qtz & sill incl.
139	Gt-Sill- Bio Schist	Qtz Fels Bio	35 15 20	Gt Sill Op	15 15 <5	Matrix inequigranular, interlobate fine-med qtz & med gr fels. S_2 med gr elongate bio part wraps large equant zoned gts & is heavily corroded & repl by fels & fine-coarse sill. Large plates of random sub-equant bio overgrow S_2 & incl coarse op.	M_1 M_2 M_3	Gt-(Bio Gt-Bio-Sill-Op-Fels Gt-Bio-Sill Late Sill	Gt core fine rounded op & qtz, intermediate zone of med gr anhedral qtz, larger op & fine si needles, rim overgrows S_2 & occ incl coarse sill.
680A	Gt-Sill- Bio Gneiss	Qtz Fels Bio	55 15 10	Gt Sill Op	15 5 <5	S_0-Qtz-fels bands & gt-sill-bio bands. S_2//S_0-med bio repl by coarse sill. Large zoned gts equant-elongate along S_2. Matrix plag repl bio.	M_1 M_2 M_3	Bio Gt-Bio-Sill-Plag-Op Gt-Bio-Sill Late Sill	Gt core fine sill needles & occ rounded bio, rim with coarse sill & bio (occ bio repl by coarse sill) & qtz.
680B	Gt-Sill- Bio Schist	Qtz Fels Bio	60 10 10	Gt Sill Op	10 10 <5	Matrix seriate amoeboid qtz-fels. S_2 med bio repl by coarse sill part wraps large zoned gts equant-elongate along S_2 Matrix plag repl bio. Grain boundary fib.	M_1 M_2 M_3	Bio Gt-Bio-Sill-Fels-Op Gt-Sill Late Sill	Gt core fine sill needles & occ rounded bio, rim with coarse sill & bio & qtz.
810	Sill-Gt- Bio Gneiss	Qtz Plag K Spar Bio	10 25 5 30	Gt Sill Op	25 5 <5	S_2-med gr elongate bio repl by fels & coarse sill elongate along S_2. Med-coarse equant zoned gts part overgrow S_2. Coarse random plates M3 bio include plag & crenulated by D_3.	M_1 M_2 M_3	(Bio) Bio-Gt-Sill-Plag-Kspar-Op-Herc Gt-Bio-Sill Late Sill	Gt core fine rounded bio, rim intergrown with coarse bio & sill & including occ mag-herc intergrowths.

811	Sill-Gt- Bio Gneiss	Qtz Fels Bio	10 15 25	Gt Sill Op	25 20 5	Similar to 810 (above) but coarser grained. Very coarse grained sill porphyroblasts incl plag remnants in optical continuity.	M_1 M_2 M_3	Bio-Gt Bio-Gt-Sill-Plag Bio-Gt-Kspar Late myrmikite	Gt core choked with fine rounded qtz & few bio, surrounding zone with few med gr qtz, bio & fibrolitic sill forming sigmoidal S_i. Rim overgrowing S_2.
830A	Sill-Bio- Gt Gneisss	Qtz Plag K Spar Gt	30 10 5 30	Bio Sill Op	15 10 <5	Matrix-seriate interlobate qtz-fels. Strong S_2 bio repl by coarse sill part wrapping zoned gts. S_2 crenulated by D_3. Gts heavily fractured // crenulation lineation.	M_1 M_2 M_3 M_4	Bio Bio-Sill-Gt Gt-Sill-Op Bio Late Sill	Gts, elongate along S_2, large anhedral qtz incl cont fib, rims overgrow coarse sill. Coarse anhedral op. intergrown with coarse sill. Fine thornyclumps sill crowd grain boundaries, also nucleate on late bio.
901B	Sill-Gt- Bio	Qtz Fels	20 5	Gt Sill	25 15	Matrix qtz-fels zones & bio zones. Fine-med qtz, fine-coarse fels interlobate. Bio defines S_2 repl by sill wraps lge gts. Bio microlithons. S_2 sheared, gts heavily fractured, infilled by phlogopite.			
930	Sill bearing Bio-Gt Gneiss	Qtz Plag Bio	20 35 15	Gt Sill Op	20 <5 5-10	Matrix-mozaic of med gr qtz & fels (few fels megacrysts), polygonal outlines. Stumpy bio laths embayed by plag define schistosity (S_2) Large poikiloblastic gts include coarse plag (stumpy sill incl) med bio & rounded op.	M_1 M_2 M_3 M_4	Bio Bio-Sill-Gt-Kspar Sill-Bio Musc Late myrmikite	Gt heavily fractured & pulled apart at high angle to S_2 & S_3, fractures infilled with musc. Fib incl // S_2. String op along S_2 // S_3 & in conjugate sets at 60^o suggests healed microfractures.
1029	Crenulated Sill-Gt Bi-Mica Schist	 Qtz Bio Musc Gt	Q M 35-20 20-25 30-35 10-15	Sill Op	<5 <5	Graded bedding S_0. Qtz rich bottom of bed few large gts, mica rich top many smaller gts. S_2 strongly defined coarse bio repl by musc. Gts syntectonic, rotational S_i bio, sill-qtz. Shearing along S_2.	M_1 M_2 M_4	 Bio-Gt-Sill-Kspar Musc Late myrmikite Late sillimanite	Sill incl. in gt. Sill needles nucleate on grain boundaries of plag, gt, myrmikite, bio, musc.
1076	Sill-Gt- Bio Schist	Qtz K spar Bio	40 5 30	Musc Gt Op	10 10 5	Matrix qtz seriate (v.fine-med) amoeboid strong S_2 bio repl by sill, part wraps large gts elongate along S . Few med-coarse K spar porphs incl bio (sill at rim). Med random musc plates overgrow S_2.	M_1 M_2 M_3	Staur-Bio Bio-Gt-Fels-Sill-Op Musc-Tourm Late sillimanite	Staur incl fine rounded in optical continuity. Gt core choked with fine rounded qtz (little staur), rim zone few coarse qtz with incl Gts pulled apart S_2 infilled with musc. Late sill along grain boundaries & microfractures in fels.
1176	Gt-Sill- K spar Gneiss	Qtz K spar Plag Bio	35 30 5 15	Gt Sill Op	5 10 <5	Strong S_2 def by bio repl by sill domainal & anastomising, part wraps large zoned gts. K spar & perthite rotational S_i=S_e(sill incl).	M_1 M_2 M_3	Gt-Bio Bio-Sill-Kspar-Perthite Kspar-Sill	S_2 very well developed with zones of anastomosing fibrolite S_3 at mod angle to S_2. Grain growth at rim of fels porphyroblasts.

1249	Bio-Gt- K spar Gneiss	Qtz K spar Plag Bio	20 20 10 20	Gt Sill Op	25 tr 5	Coarse gr, recrystallised. Domainal S_2 coarse gr bio part wraps, part overgrown by lge equant zoned gts. Finer gr early bio (same orientation) embayed by & incl. in plag. Myrmikite areas repl old fels.	M_1 M_2 M_3	(Bio) Bio-Gt-Sill-Plag-Op Gt-Sill-Bio Late Sill	As 810 (above) but some gts have med gr sill incl & some gts are coeval with sill porphyroblasts.
1451B	Sill-Gt Gneiss	Qtz Plag Bio	55 5 5	Gt Sill Op	15 10 10	Qtz seriate amoeboid, str fabric. Remnant bio(S_1)//bands coarse bio(S_2)repl by short prisms sill.Coarse sill, axial plane to sill crens wraps lge gts.D_3 deforms qtz & fractures gts.Bio infills fracts.	M_1 M_2 M_3	Gt Bio-Gt-Sill-Kspar-Plag Sill-Bio-Gt	Gt cores incl poor. Fine sill incl trails in outer zones of gts discont. with wrapping S_2 overgrown by gt rim. Plag finely perthitic. Areas of myrmikite.
1457B	Sill-Gt- K spar Gneisss	Qtz K spar Plag Bio	20 35 5 15	Sill Gt Op Musc	10 10 5 5	Qtz seriate amoeboid. S_2 ragged red-br bio wraps poikiloblastic gt elongate along S_2 & Kspar. Matrix sill repl bio, strings wrap Kspar.S cren by D_3. Bio, sill, Kspar corroded by felted musc. Myrmikite in half moons along fels grain boundaries.	M_1 M_2 M_3	Bio Bio-Sill-Gt-Fels Sill-Bio-Gt Late Sill	Gts-fib needles in core, coars[e] sill incl in rim. Coarrse bio microlithons rep noses of F_2 crenulations. Some euhedral gt rims overgrow S_2.
1460	Gt-K Bio Gneiss	Qtz K spar Plag Bio	25 20 5 25	Gt Sill Musc Op	20 tr 5 5	S_2 red-brown bio, well defined in pressure shadows of syntectonic gts, & K spar, or remnants in recrystallised micro shear zones. S_2 crenulated by D_3, prod conjugate shears. Fine musc repl bio & fels. Myrmikite repl fels from grain boundaries.	M_1 M_2 M_3	Bio Sill-Plag-Op Gt	Gts chocked with sill incl, very little in matrix.
1463	Gt-Sill- Bio Gneiss	Qtz Plag Bio Musc	20 15 30 5	Gt Sill Op Staur Tourm	10 10 5-10 tr tr	S_2 green-br bio, repl by sill along fold limbs, remnant microlithons in fold hinges Large rounded zoned gts & fels (both incl staur) wrapped by sill. Stumpy random musc plates cut S_2. D_3 crenulates S_2.	M_1 M_{2a} M_{2b} M_3	(Bio) Bio-Sill-Gt Musc-Apatite Garnet	S_0 at small angle to S_2. Some subhedral gt faces at top of bed overgrow S_2.
1474	Gt-Sill- K spar Gneiss	Qtz Plag K spar Bio	20 10 25 25	Gt Sill Op Musc	10 10	S_2 bio repl by fib. Syntec fels porphs inc bio in rotational fabric & equant garnets fib at rim, wrapped by bio & fib. S_2 cren by F_3 with S_3 bio axial plane well preserved in pressure shadows.	M_1 M_2 M_3	Bio-Gt Bio-Sill-Kspar-Gt Musc-Gt	Gt S_1 (bio-qtz) finer gr. than & discontinuous with S_e. Rim overgrows S_2 & incl sill.
							M_1 M_2 M_3	Bio-Gt Bio-Sill-Kspar-Perthite Gt	2 gens. gt. Core v. fine round qtz incl, Rim few coarse qtz incl & overgrowing bio & sill.

Cordierite bearing gneisses

Sample Number	Rock Name	Mineralogy Modal %	Deformation History Texture and Fabric.	Metamorphic History Coexisting Phases	Comments
804	Sill-Gt-Cord Gneiss	Qtz 40, Gt 20, Cord 20, Sill 20, Op 5, Bio tr	Coarse gr. strong linear fabric defined by sill part wrapping, part incl by, zoned gt. Cord elongate along S_2 sill incl. Sill crenulated by D_3.	M_1 Gt-(Bio) M_2 Gt-Sill-Cord-Op M_3 Gt-Sill	Gt core-fine rounded qtz- incl (occ. bio), rim-sill incl cont with matrix. Qtz sill simplectite coronas.
784B	Sill-Gt-Cord Gneiss	Qtz 40, Plag 15, Cord 20, Gt 20, Sill 5, Op -, Bio <5	Strained and recrystallised qtz (seriate ameoboid) intergrown with fels.	M_1 Gt-(Bio) M_2 Gt-Sill-Cord-Op	
960	Sill-Cord-Gt Gneiss	Qtz 10, Plag 5, Gt 40, Sill 15, Op 10, Bio tr	Coarse gr. zoned gts, gen. rounded some xtal outlines. Recrystallised qtz & cord common triple junctions. 3 gens sill. Cord-cord cord-op grain boundary intergr	M_1 Gt-(Bio) M_2 Gt-Sill-Cord-Op M_3 Sill-Op-Gt M_4 Sill-Op	Gt zonation (core to rim) Core-fine rounded qtz incl (occ bio) incl free zone of fine sill incl incl free zone, rim may incl cord & op. Gts wrapped by coarse sill
1002	Sill-Cord-Gt Gneisss	Qtz 35, Plag 20, Gt 20, Cord 10, Sill 5, Op 10, Bio tr	Coarse gr. Zoned gts, cord incl in rim. Fine gr sill incl in gt. Coarse gr sill in matrix incl mag.	M_1 Gt-(Bio) M_2 Gt-Cord-Sill-Op M_3 Gt-Sill-Qtz-Op M_4 Sill Qtz-Op	
1011C	Sill-Cord-Gt Gneiss	Qtz 40, Plag 5, Gt 15, Cord 15, Sill 10, Op 15, Bio tr, Chl tr	Matrix-strained & recrystallised qtz intergr with felspar. Seriate amoeboid. Linear fabric def by sill & elongate opaques. Lge anhedral gts incl fine gr sill & sub-equant op. Fine-med gr cord incl fine gr sill.	M_1 (Bio)-Op M_2 Gt-Cord-Sill M_3 Sill-Op M_4 Sill-Op	3 gens sill & op. Coarse sill part wraps gt & is intergr with coarse elongate op. Cord & op with coronas of sill qtz simplectites with granular magnetite.

Selected examples of mineral analyses: garnet-biotite pairs

LOWER SILLIMANITE ZONE

	1382 Garnet	Biotite	1382 Garnet	Biotite	1382 Garnet	Biotite
SiO_2	37.51	36.11	37.24	36.99	36.81	36.71
TiO_2	0.03	1.50	0.07	1.41	0.16	1.41
Al_2O_3	20.96	18.28	20.84	18.70	21.04	18.09
FeO^t	33.98	13.71	33.50	13.62	33.43	13.34
MnO	2.89	0.06	2.73	0.02	2.99	0.04
MgO	3.94	13.88	4.04	14.51	3.98	13.95
CaO	1.61	0.00	1.54	0.00	1.56	0.00
Na_2O	0.01	0.23	0.00	0.27	0.04	0.25
K_2O	0.01	9.09	0.00	9.04	0.00	9.54
Cr_2O_3	0.08	0.00	0.08	0.04	0.00	0.08
NiO	0.00	0.12	0.07	0.13	0.06	0.00
BaO	0.00	0.22	0.00	0.15	0.00	0.12
Total	101.03	93.21	100.10	94.87	100.05	93.52

	680 B Garnet	Biotite	680 B Garnet	Biotite	680 B Garnet	Biotite
SiO_2	37.37	35.76	37.35	36.82	37.46	36.66
TiO_2	0.05	2.69	0.01	2.56	0.05	1.49
Al_2O_3	21.12	18.99	21.06	19.63	21.08	19.44
FeO^t	35.25	15.29	35.94	14.99	36.11	13.28
MnO	0.74	0.06	0.61	0.00	0.76	0.05
MgO	3.42	11.12	3.47	11.18	3.51	13.28
CaO	1.38	0.00	1.37	0.00	1.38	0.00
Na_2O	0.08	0.11	0.04	0.15	0.02	0.22
K_2O	0.00	9.60	0.00	9.48	0.00	9.75
Cr_2O_3	0.06	0.08	0.01	0.14	0.03	0.07
NiO	0.00	0.11	0.04	0.10	0.10	0.00
BaO	0.00	0.44	0.16	0.49	0.10	0.16
Total	99.47	94.25	100.06	95.52	100.60	94.41

	680 B Garnet	Biotite	680 B Garnet	Biotite	1393 B Garnet	Biotite
SiO_2	36.96	35.23	37.10	36.17	36.89	35.14
TiO_2	0.00	2.51	0.07	2.52	0.00	2.10
Al_2O_3	21.06	19.18	21.23	18.94	20.69	17.80
FeO^t	35.83	15.41	34.83	14.26	37.12	16.44
MnO	0.69	0.04	0.63	0.03	0.64	0.06
MgO	3.58	11.47	3.79	12.15	3.07	10.77
CaO	1.30	0.00	1.27	0.00	1.01	0.00
Na_2O	0.04	0.13	0.03	0.14	0.02	0.15
K_2O	0.01	9.94	0.00	10.01	0.01	9.97
Cr_2O_3	0.06	0.05	0.00	0.08	0.01	0.24
NiO	0.01	0.04	0.12	0.05	0.00	0.22
BaO	0.00	0.47	0.06	0.14	0.00	0.20
Total	99.53	94.47	99.13	94.49	99.47	93.11

LOWER SILLIMANITE ZONE

	686 C		1393 B		1393 B	
	Garnet	Biotite	Garnet	Biotite	Garnet	Biotite
SiO_2	36.77	33.56	36.68	34.67	37.34	35.27
TiO_2	0.06	2.86	0.01	2.49	0.01	2.61
Al_2O_3	20.44	17.20	20.47	17.63	20.23	18.27
FeO^t	31.81	25.41	37.84	18.05	37.21	16.37
MnO	0.51	0.02	0.53	0.00	0.56	0.00
MgO	1.91	5.28	3.14	9.62	3.15	10.70
CaO	7.82	0.00	0.95	0.00	0.98	0.00
Na_2O	0.03	0.09	0.00	0.15	0.02	0.17
K_2O	0.00	10.03	0.00	10.12	0.00	9.79
Cr_2O_3	0.02	0.09	0.05	0.17	0.09	0.22
NiO	0.00	0.01	0.12	0.21	0.00	0.23
BaO	0.02	0.10	0.10	0.21	0.00	0.17
Total	99.39	94.65	99.88	93.33	99.59	93.80

	1309		1309		1309	
	Garnet	Biotite	Garnet	Biotite	Garnet	Biotite
SiO_2	37.36	36.41	37.38	36.03	37.41	36.42
TiO_2	0.01	1.61	0.05	2.02	0.00	1.62
Al_2O_3	20.74	18.06	20.79	18.15	20.47	18.22
FeO^t	34.10	15.28	34.18	16.07	34.30	14.45
MnO	1.27	0.01	1.25	0.04	1.39	0.03
MgO	3.33	12.17	3.77	11.66	3.77	13.36
CaO	2.65	0.00	2.67	0.00	2.68	0.00
Na_2O	0.00	0.29	0.02	0.21	0.08	0.27
K_2O	0.00	9.35	0.02	9.11	0.01	9.39
Cr_2O_3	0.00	0.15	0.06	0.09	0.04	0.16
NiO	0.00	0.16	0.14	0.12	0.00	0.34
BaO	0.07	0.16	0.05	0.31	0.25	0.32
Total	99.53	93.64	100.38	93.81	100.39	94.57

	1317		1412 B		1412 B	
	Garnet	Biotite	Garnet	Biotite	Garnet	Biotite
SiO_2	37.03	32.20	37.51	35.89	37.16	34.70
TiO_2	0.09	4.26	0.00	0.95	0.01	1.31
Al_2O_3	19.96	15.54	20.90	21.53	21.32	18.63
FeO^t	28.63	27.30	35.74	13.72	33.41	16.09
MnO	1.27	0.03	0.55	0.02	0.45	0.02
MgO	0.66	3.95	3.33	12.58	5.31	12.26
CaO	10.88	0.00	1.30	0.00	1.16	0.00
Na_2O	0.02	0.08	0.01	0.27	0.02	0.23
K_2O	0.02	9.19	0.02	7.33	0.01	9.38
Cr_2O_3	0.17	0.73	0.06	0.07	0.02	0.11
NiO	0.00	0.15	0.20	0.06	0.00	0.05
BaO	0.09	0.22	0.08	0.05	0.00	0.16
Total	98.83	93.64	99.72	92.46	98.87	9.92

LOWER SILLIMANITE ZONE

	1384 Garnet	Biotite	680 A Garnet	Biotite	680 Garnet	Biotite
SiO_2	36.91	33.76	37.71	37.17	37.77	36.08
TiO_2	0.05	3.65	0.06	1.66	0.04	1.71
Al_2O_3	20.98	15.41	21.25	19.27	21.33	18.36
FeO^t	33.28	22.52	34.44	12.21	33.65	13.93
MnO	2.73	0.02	0.64	0.00	0.50	0.00
MgO	2.14	9.20	4.48	14.09	4.56	13.33
CaO	3.81	0.00	1.12	0.00	1.22	0.00
Na_2O	0.02	0.01	0.01	0.40	0.02	0.34
K_2O	0.00	9.45	0.03	9.74	0.00	9.52
Cr_2O_3	0.00	0.00	0.00	0.02	0.01	0.10
NiO	0.11	0.01	0.00	0.01	0.00	0.25
BaO	0.08	0.59	0.11	0.41	0.00	0.41
Total	100.12	94.64	99.85	94.97	99.21	94.03

	366 Garnet	Biotite	366 Garnet	Biotite	366 Garnet	Biotite
SiO_2	37.86	35.79	37.43	35.74	37.43	35.44
TiO_2	0.00	1.81	0.06	1.56	0.07	2.07
Al_2O_3	20.98	18.98	21.14	18.81	19.73	18.11
FeO^t	34.25	17.80	34.06	18.14	34.40	18.54
MnO	3.18	0.02	2.50	0.05	2.48	0.05
MgO	2.62	10.81	2.60	11.16	2.69	11.08
CaO	2.31	0.00	2.99	0.00	3.06	0.00
Na_2O	0.00	0.16	0.02	0.22	0.11	0.18
K_2O	0.01	9.58	0.02	9.58	0.03	9.87
Cr_2O_3	0.03	0.05	0.05	0.12	0.05	0.09
NiO	0.20	0.05	0.00	0.00	0.19	0.13
BaO	0.07	0.03	0.04	0.18	0.01	0.08
Total	101.51	95.07	100.90	95.55	100.25	95.64

	1380 Garnet	Biotite	1380 Garnet	Biotite	372 Garnet	Biotite
SiO_2	37.68	35.81	38.72	36.18	36.20	32.53
TiO_2	0.00	1.66	0.04	2.04	0.18	3.14
Al_2O_3	20.80	18.36	19.89	19.42	21.14	17.91
FeO^t	36.30	18.53	36.09	18.40	30.67	25.82
MnO	1.54	0.00	1.84	0.00	3.12	0.06
MgO	2.65	10.52	2.88	10.43	0.81	5.15
CaO	2.49	0.00	1.80	0.00	7.75	0.00
Na_2O	0.03	0.22	0.05	0.31	0.02	0.09
K_2O	0.02	9.90	0.00	9.92	0.03	9.84
Cr_2O_3	0.05	0.10	0.05	0.03	0.27	0.09
NiO	0.03	0.13	0.17	0.00	0.06	0.13
BaO	0.00	0.00	0.12	0.11	0.00	0.01
Total	101.49	95.23	102.93	96.84	100.25	94.78

LOWER SILLIMANITE ZONE

	372 Garnet	Biotite	372 Garnet	Biotite	372 Garnet	Biotite
SiO_2	34.56	33.11	36.86	31.71	36.59	32.82
TiO_2	0.00	2.89	0.04	3.09	0.05	3.10
Al_2O_3	19.90	17.60	20.27	15.93	20.48	15.93
FeO^t	36.64	25.86	31.40	26.02	30.35	26.02
MnO	1.11	0.05	2.91	0.12	2.62	0.12
MgO	0.74	4.96	0.77	4.72	0.72	4.72
CaO	5.96	0.00	7.83	1.45	8.59	1.45
Na_2O	0.15	0.32	0.01	0.09	0.01	0.09
K_2O	0.03	9.60	0.00	8.92	0.02	8.92
Cr_2O_3	0.09	0.07	0.05	0.17	0.12	0.17
NiO	0.03	0.00	0.04	0.00	0.00	0.00
BaO	0.00	0.00	0.00	0.23	0.00	0.23
Total	99.22	94.44	100.17	92.44	99.54	92.44

	372 Garnet	Biotite	1327 A Garnet	Biotite	1327 A Garnet	Biotite
SiO_2	36.39	32.42	34.19	33.67	36.61	34.98
TiO_2	0.17	3.36	2.92	1.48	0.01	1.53
Al_2O_3	20.59	17.71	19.53	17.43	20.71	18.57
FeO^t	36.20	26.44	36.82	19.98	36.58	19.72
MnO	1.54	0.03	0.75	0.00	1.40	0.05
MgO	0.92	4.85	2.01	9.74	2.18	9.79
CaO	4.12	0.00	3.03	0.00	2.29	0.00
Na_2O	0.00	0.10	0.03	0.28	0.00	0.20
K_2O	0.09	9.66	0.00	9.43	0.01	9.27
Cr_2O_3	0.07	0.18	0.00	0.00	0.09	0.03
NiO	0.06	0.01	0.00	0.19	0.00	0.07
BaO	0.00	0.04	0.07	0.08	0.01	0.00
Total	100.16	94.78	99.37	92.29	99.89	94.22

	1327 A Garnet	Biotite	68 Garnet	Biotite	33 Garnet	Biotite
SiO_2	36.59	37.97	37.53	35.66	36.53	34.51
TiO_2	0.03	1.35	0.00	1.38	0.05	1.47
Al_2O_3	19.97	22.35	21.29	19.60	20.66	18.21
FeO^t	36.73	16.00	36.64	18.40	37.53	20.14
MnO	1.21	0.01	1.71	0.04	0.71	0.06
MgO	2.13	7.78	2.33	10.56	1.96	9.85
CaO	2.39	0.00	1.72	0.00	1.82	0.00
Na_2O	0.01	0.41	0.03	0.33	0.03	0.14
K_2O	0.02	9.30	0.00	8.60	0.01	8.88
Cr_2O_3	0.07	0.09	0.01	0.09	0.03	0.12
NiO	0.00	0.04	0.00	0.09	0.00	0.00
BaO	0.07	0.00	0.07	0.15	0.07	0.00
Total	99.22	95.30	101.33	94.91	99.39	93.40

UPPER SILLIMANITE ZONE

	807 Garnet	Biotite	807 Garnet	Biotite	807 Garnet	Biotite
SiO_2	38.43	37.90	38.43	36.28	38.25	36.28
TiO_2	0.00	1.30	0.00	2.55	0.05	2.55
Al_2O_3	21.67	17.86	21.67	17.28	20.95	17.28
FeO^t	31.94	9.72	31.94	15.95	34.33	15.95
MnO	0.85	0.05	0.85	0.00	0.99	0.00
MgO	6.05	17.77	6.05	12.40	3.57	12.40
CaO	1.61	0.00	1.61	0.00	2.12	0.00
Na_2O	0.01	0.32	0.01	0.16	0.01	0.16
K_2O	0.01	9.01	0.01	9.63	0.02	9.63
Cr_2O_3	0.02	0.14	0.02	0.21	0.05	0.21
NiO	0.09	0.07	0.09	0.15	0.04	0.15
BaO	0.06	0.03	0.06	0.00	0.04	0.00
Total	100.74	94.17	100.74	94.60	100.41	94.60

	784 D Garnet	Biotite	784 D Garnet	Biotite	121 Garnet	Biotite
SiO_2	37.85	36.38	38.05	36.32	38.44	36.92
TiO_2	0.03	1.62	0.00	2.70	0.00	1.79
Al_2O_3	20.73	16.46	20.76	16.64	21.45	18.53
FeO^t	30.77	14.66	30.56	15.47	30.96	14.90
MnO	0.69	0.00	0.68	0.02	0.27	0.00
MgO	5.20	14.63	5.08	12.98	6.70	12.64
CaO	4.21	0.00	4.27	0.00	2.11	0.00
Na_2O	0.00	0.16	0.03	0.15	0.03	0.14
K_2O	0.01	8.97	0.02	9.61	0.01	9.66
Cr_2O_3	0.02	0.15	0.02	0.18	0.09	0.04
NiO	0.00	0.14	0.00	0.28	0.16	0.01
BaO	0.07	0.38	0.00	0.22	0.01	0.08
Total	99.59	93.56	99.47	94.58	100.24	94.71

	749 Garnet	Biotite	749 Garnet	Biotite	749 Garnet	Biotite
SiO_2	37.88	35.32	38.18	35.50	37.74	35.61
TiO_2	0.07	3.24	0.00	2.85	0.06	3.16
Al_2O_3	21.10	17.63	21.00	18.01	21.38	17.46
FeO^t	35.56	18.24	33.40	17.93	33.72	18.51
MnO	0.90	0.04	0.94	0.03	0.78	0.04
MgO	3.37	9.39	5.50	10.11	4.43	9.74
CaO	1.40	0.00	1.23	0.00	1.48	0.00
Na_2O	0.00	0.10	0.07	0.08	0.04	0.12
K_2O	0.01	9.51	0.03	9.60	0.03	9.47
Cr_2O_3	0.06	0.12	0.01	0.12	0.00	0.21
NiO	0.09	0.16	0.00	0.06	0.04	0.17
BaO	0.02	0.15	0.15	0.19	0.00	0.25
Total	100.45	93.90	100.52	94.48	99.70	94.75

UPPER SILLIMANITE ZONE

	69 Garnet	Biotite	768 Garnet	Biotite	121 Garnet	Biotite
SiO_2	38.06	36.01	37.89	34.80	38.83	39.08
TiO_2	0.03	2.31	0.11	3.53	0.07	1.32
Al_2O_3	21.24	17.61	21.08	18.15	21.60	17.09
FeO^t	33.97	19.74	36.46	17.80	30.94	16.76
MnO	1.48	0.10	0.64	0.03	0.50	0.01
MgO	3.83	9.27	3.74	9.47	6.12	11.68
CaO	2.99	0.00	1.19	0.00	2.67	0.00
Na_2O	0.03	0.26	0.01	0.13	0.03	0.10
K_2O	0.04	8.97	0.00	9.47	0.00	7.85
Cr_2O_3	0.12	0.04	0.08	0.18	0.11	0.03
NiO	0.04	0.00	0.07	0.08	0.02	0.08
BaO	0.00	0.00	0.00	0.01	0.07	0.03
Total	101.84	94.31	101.27	93.64	100.97	94.02

	8 Garnet	Biotite	106 Garnet	Biotite	106 Garnet	Biotite
SiO_2	37.01	35.78	37.15	33.61	37.32	33.61
TiO_2	0.28	1.42	0.00	2.55	0.10	2.55
Al_2O_3	20.65	18.67	21.06	18.86	20.67	18.86
FeO^t	35.30	21.43	38.24	23.46	38.93	23.46
MnO	0.94	0.00	0.19	0.03	0.21	0.03
MgO	3.12	8.89	2.03	5.57	2.08	5.57
CaO	1.90	0.00	2.09	0.00	2.20	0.00
Na_2O	0.04	0.07	0.02	0.07	0.05	0.07
K_2O	0.09	9.30	0.00	9.30	0.00	9.30
Cr_2O_3	0.05	0.00	0.02	0.04	0.00	0.04
NiO	0.00	0.06	0.11	0.22	0.17	0.22
BaO	0.12	0.03	0.08	0.00	0.00	0.00
Total	99.51	95.64	101.72	93.72	101.72	93.72

	111 Garnet	Biotite	111 Garnet	Biotite	111 Garnet	Biotite
SiO_2	37.40	35.19	38.00	35.45	37.59	35.45
TiO_2	0.07	2.69	0.08	2.41	0.03	2.41
Al_2O_3	20.87	20.37	20.82	18.78	21.25	18.78
FeO^t	34.82	19.65	36.11	21.34	35.87	21.34
MnO	0.76	0.07	0.63	0.07	0.61	0.07
MgO	2.64	7.12	3.08	7.40	3.39	7.40
CaO	2.53	0.00	2.01	0.00	2.24	0.00
Na_2O	0.03	0.16	0.06	0.15	0.12	0.15
K_2O	0.01	8.65	0.01	9.26	0.02	9.26
Cr_2O_3	0.05	0.23	0.14	0.11	0.04	0.11
NiO	0.00	0.13	0.00	0.00	0.04	0.00
BaO	0.06	0.00	0.00	0.06	0.00	0.06
Total	99.23	94.25	100.94	95.03	101.19	95.03

UPPER SILLIMANITE ZONE

	111 Garnet	Biotite	73 Garnet	Biotite	73 Garnet	Biotite
SiO_2	37.38	34.59	37.83	35.11	37.79	34.67
TiO_2	0.06	2.17	0.08	2.14	0.12	1.50
Al_2O_3	20.59	19.89	21.11	18.52	21.12	22.85
FeO^t	35.40	21.68	33.37	18.43	33.89	18.16
MnO	0.64	0.06	0.62	0.00	0.49	0.03
MgO	2.78	8.08	5.01	9.97	4.83	7.85
CaO	2.54	0.00	1.69	0.00	1.64	0.00
Na_2O	0.04	0.18	0.00	0.38	0.02	0.10
K_2O	0.01	8.44	0.00	8.91	0.00	7.49
Cr_2O_3	0.08	0.20	0.10	0.12	0.03	0.04
NiO	0.01	0.06	0.20	0.12	0.07	0.10
BaO	0.00	0.01	0.03	0.05	0.00	0.26
Total	99.53	95.36	100.05	93.74	100.00	93.05

	104 Garnet	Biotite	104 Garnet	Biotite	768 Garnet	Biotite
SiO_2	37.24	33.68	37.19	33.68	38.10	34.72
TiO_2	0.02	3.41	0.00	3.41	0.04	3.05
Al_2O_3	20.46	16.49	20.92	16.49	21.30	18.27
FeO^t	37.70	27.53	35.31	27.53	34.76	18.28
MnO	0.35	0.02	0.36	0.02	0.58	0.04
MgO	1.22	4.18	1.11	4.18	5.06	10.69
CaO	3.68	0.00	5.02	0.00	1.06	0.00
Na_2O	0.03	0.07	0.04	0.07	0.01	0.06
K_2O	0.01	9.50	0.01	9.50	0.03	9.42
Cr_2O_3	0.12	0.22	0.11	0.22	0.03	0.07
NiO	0.06	0.15	0.02	0.15	0.06	0.14
BaO	0.10	0.12	0.04	0.12	0.00	0.01
Total	100.99	95.37	100.13	95.37	101.05	94.76

	768 Garnet	Biotite	660 Garnet	Biotite	660 Garnet	Biotite
SiO_2	36.90	34.29	36.68	35.99	37.43	35.10
TiO_2	0.07	3.43	0.11	2.90	0.00	2.82
Al_2O_3	20.83	17.81	20.84	18.18	20.61	17.78
FeO^t	36.82	19.07	36.89	20.45	35.93	20.43
MnO	0.64	0.05	0.51	0.00	0.47	0.00
MgO	2.72	9.68	3.34	8.38	3.51	8.79
CaO	1.29	0.00	1.73	0.00	1.86	0.00
Na_2O	0.01	0.12	0.03	0.28	0.04	0.25
K_2O	0.04	9.41	0.01	8.99	0.02	9.05
Cr_2O_3	0.07	0.20	0.08	0.07	0.06	0.03
NiO	0.00	0.05	0.01	0.07	0.14	0.16
BaO	0.00	0.01	0.00	0.17	0.07	0.04
Total	99.39	94.11	100.23	95.47	100.15	94.47