DEPARTMENT OF MINES
SOUTH AUSTRALIA

MINERAL RESOURCES DIVISION

GEOLOGICAL INVESTIGATIONS OF A NICKEL OCCURRENCE IN BASIC TO ULTRABASIC ROCKS WEST OF TUMBY BAY.

by

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Rept.Bk.No. 76/9
G.S. No. 5686
D.M. No. 83/76

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DEPARTMENT OF MINES

SOUTH AUSTRALIA

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ABSTRACT

A basic to ultrabasic suite of diorites to peridotites crops out over an area of 0.7 km^2, 10 km west of Tumby Bay. Country rocks are dominantly quartz-feldspar gneisses and biotite schists. Highest geochemical values are chromium 2 000 ppm, nickel 1 500 ppm, and cobalt 150 ppm. in peridotites. Copper, lead and zinc occur in amounts up to 50, 80 and 150 ppm respectively, regardless of rock type.

The mineralogy is dominated by olivine, pyroxene, serpentine and plagioclase with quartz generally absent. Plagioclase is commonly bytownite or labradorite.

Metallic minerals are magnetite, pentlandite, chalcopyrite and pyrite with a volume ratio of 6:2:2:1; sulphides represent < 0.2 volume % of the total rock. 59% to 77% of the total nickel is within silicates, mainly olivine and serpentine. An intrusive magmatic origin appears most likely.

INTRODUCTION

A reported occurrence of nickel in ultrabasic rocks west of Tumby Bay on Eyre Peninsula on Mineral Claims 7452, 7453 and 7454 was investigated by C.D.A. Coin during investigations for a PhD thesis.

The purpose of the present investigations was:

(1) Review all available information of geological investigations in the area.

(2) Collect samples for further petrographic examination and chemical analyses.

Basic to ultrabasic and ultramafic rocks are exposed south of the main Tumby-Cummins road, 10 km. west - northwest of Tumby (Fig.1). The area is located at Lat. 34°21'36", Long. 136°00' on LINCOLN 1:250 000 sheet area and margins of Tumby and Cummins 1:63 360 sheet area, and is within the county of Flinders, hundred of Hutchinson, sections 290 and 329. Aerial photographs used for field locations were Tumby survey 1033, run 2, photos 9372-9382.

General aspects concerning climate, topography and cultural features have been dealt with in Johns (1961). Access is via the main Tumby-Cummins road. As part of the ultrabasic outcrop has been quarried for road metal, fragments and boulders of ultrabasic rocks can be found along the Tumby-Cummins road.

PREVIOUS INVESTIGATIONS

Regional geological investigations of southern Eyre Peninsula have variously placed these basic to ultrabasic rocks as members of the Flinders Group (Pacminex for Pechiney, 1969) or Hutchinson Group (Johns, 1961).

Available S.A. Dept. Mines LINCOLN 1:250 000 maps include:

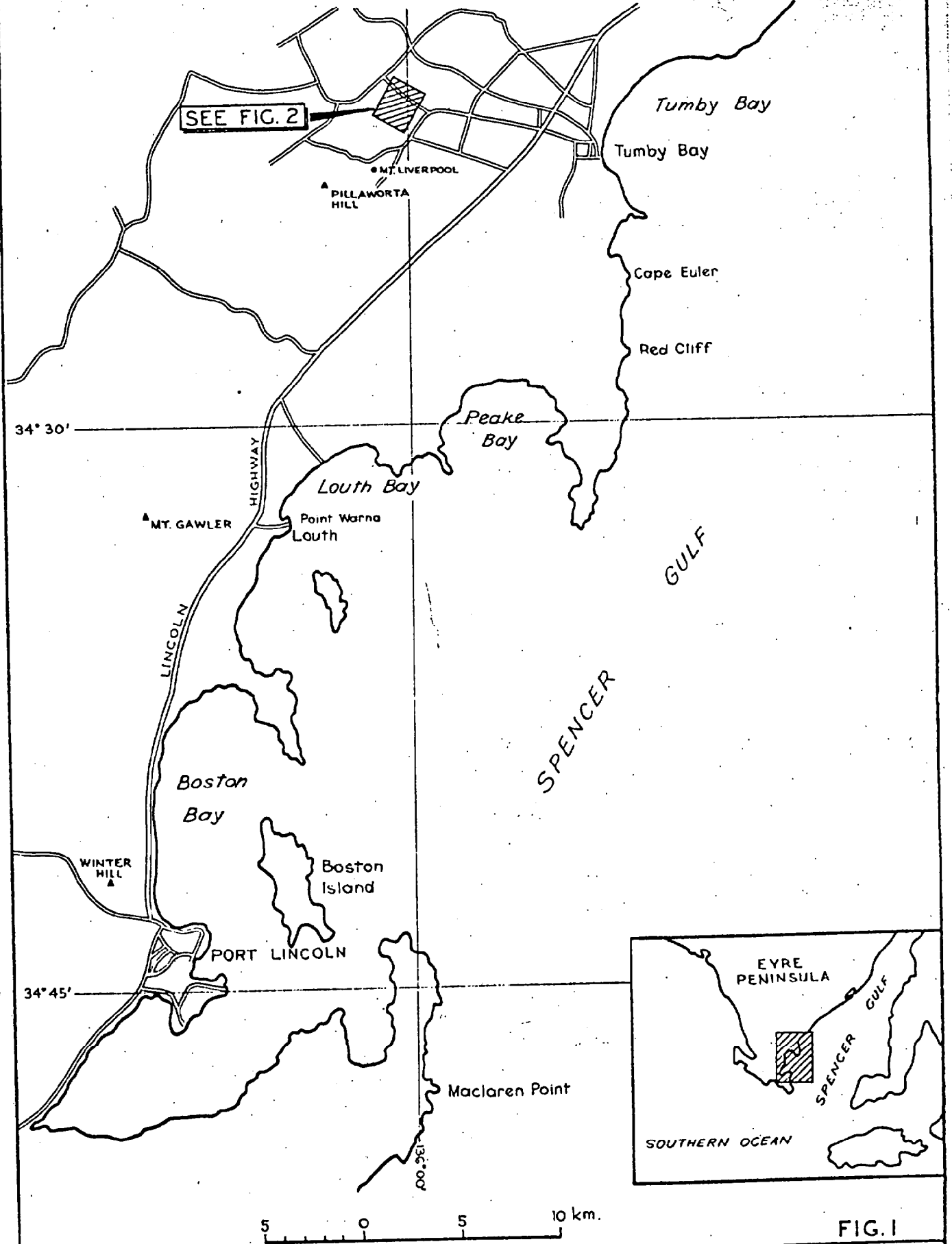


FIG. 1

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale : 1 : 250000
Compiled D.J.F.	NICKEL OCCURRENCE NEAR TUMBY BAY	Date : October 1975
Drn A.F. Ckd	LOCALITY MAP	Drg No. S12048

Geology.	Johns, R.K.	1958
Bouguer Anomaly Map.	Gerdes, R.	1973
Airborne Scintillometer Survey, (flight lines & anomalies).	Whitten, G.F.	1968
Aeromagnetic Map of Total Intensity.	Geophysics Section	1963

Tumby and Cummins 1:63 360 map sheets are also available for geology, airborne scintillometer survey and aeromagnetics.

Amphibolitic to gabbroic rocks, metamorphic gneisses and metasediments from southern Eyre Peninsula have been petrographically described by Tilley (1920, 1921, a,b,c). Rock types examined are amphibolites, quartz and orthoclase bearing amphibolites, garnet amphibolites, prehnite amphibolites, pyroxene bearing amphibolites and metadolerites; textural features include relict ophitic texture, clear metamorphic rims on labradoritic plagioclase and abundant dusty inclusions, in plagioclase, which were considered to be very fine grained pyroxene.

S.A. Department of Mines open file envelopes recording private company geological and geophysical investigations in the area of basic to ultrabasic rock outcrop are:

Company	Date	Tenure	Env.
Mines Exploration Pty.Ltd.	1961	S.M.L. 43	Plan L63-119/1
Pechiney(Aust.)Expl.Pty.Ltd.	1969	S.M.L.354	Env.1264 Vols. 1-5.
Aust. Anglo American Ltd.	1974	E.L. 106	Env.2378 Vols. 1-4.

Mines Exploration (1961) carried out an induced polarisation (I.P.) survey 5-6 km northeast of the basic to ultrabasic exposure, at Lat. 34°19'30"; Long. 136°3'20". The intervals tested are at a similar stratigraphic position the basic to ultrabasic rock occurrence. Numerous definite and weakly anomalous zones were recorded, some of which were associated with known hematitic quartzites and graphitic schists.

Pacminex (for Pechiney (1969)) included nickel in their initial orientation geochemistry and rock chip sampling of S.M.L. 354 but no significant results were obtained. Range of values for orientation geochemistry was 12-50 ppm nickel. Later reconnaissance stream sediment sampling did not include analysis for nickel. Anomalies found were mainly copper, but also included lead and zinc. The Coonta copper anomaly occurs close to and partly overlaps the known outcrop of basic to ultrabasic rocks, with the anomaly centre displaced to the west of the ultrabasic. Intensive geochemical sampling (soil and auger) indicated that the Coonta anomaly (and others nearby) is associated with metamorphosed amphibolites (Pacminex for Pechiney (1969)). Hematitic quartzites, associated with a second copper anomaly, were tested by drilling but with poor results.

Aust. Anglo American (1974) carried out an electromagnetic (E.M.) and aeromagnetic survey at 2 km flight spacing (in places stepped down to 500 m) and 130 m mean ground clearance. Known basic to ultrabasic outcrop correlated with zero E.M. response which is consistent with disseminated sulphide mineralisation (or none at all).

The central part of the basic to ultrabasic rock body is associated with a circular 5 000 gamma magnetic high but the northern and southern portions are characterised by magnetic lows. Magnetic lows are considered (by the author) to be from thinning out of gabbros and ultramafic peridotites to low magnetite diorites and acid gneisses.

Aust. Anglo. American's follow up stream sediment, rock chip and auger sampling, ground geological mapping and eventually limited percussion drilling concentrated on E.M. anomalies. As the known basic to ultrabasic outcrop area is not associated with an E.M. anomaly it was not closely examined. A sample collected by Aust. Anglo. American, and petrographically examined by W. Fander, was described as an olivine gabbro-norite or bronzite picrite. The sample is equivalent in mineralogy to some collected in the present investigation program.

Aust. Anglo. American included nickel in their analysis program of E.M. anomalies. Highest nickel was associated with hematitic quartzites and max. values recorded were 110 ppm (auger) and 30 ppm (rock chip). Aust. Anglo. American Ltd. did not continue investigations on the ultrabasic rocks, as other companies were stated to "have examined the ultrabasic for its tential as a nickel sulphide ore body, but rock samples gave very poor results". The company which investigated the ultrabasic rocks was not quoted by Aust. Anglo American and is not known.

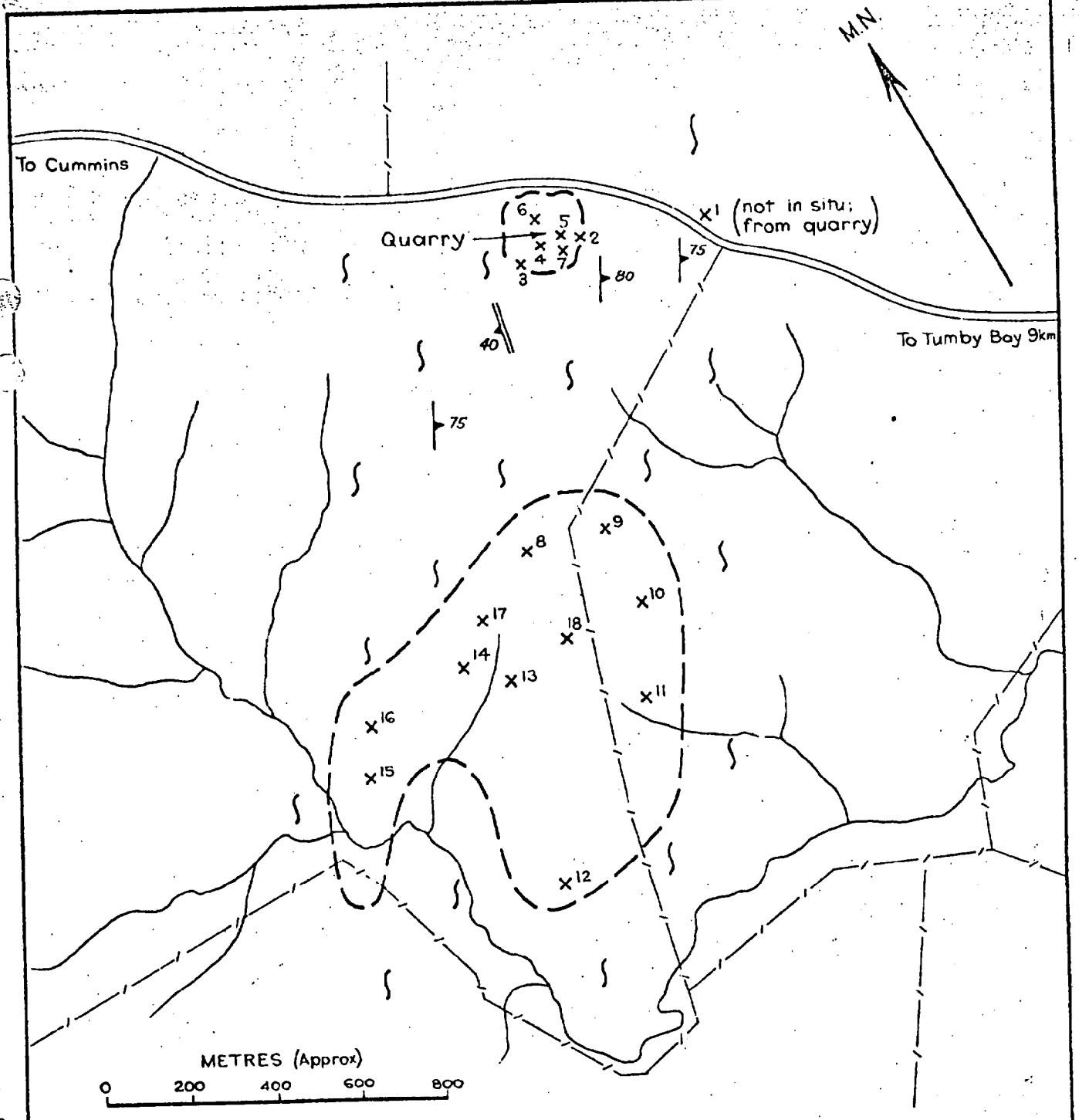
CURRENT INVESTIGATIONS

Results presented here were obtained during a three day geological mapping and sampling programme at Tumby Bay, Memory Cove and McLaren Point. Laboratory work, at A.M.D.E.L., included thin section petrography of six representative samples, polished section petrography and mineragraphy with electron microprobe analysis for nickel on three samples, and semiquantitative spectrographic analyses for 22 elements on 18 samples. Specimens from dioritic to doleritic dykes at Memory Cove and McLaren Point were included for comparison of mineralogy, chemistry and possible petrogenesis. A chart showing field sample number, rock type, petrography, report number and analysis number is included as Appendix A.

LOCAL GEOLOGY

Basic to ultrabasic rocks are exposed over an area 700 m by 1 000 m with a northerly plug-like extension of 150 m x 150 m near the Tumby-Cummins road (Fig.2). Basic (and perhaps ultrabasic) rocks probably extend to the south and north. Pacminex (for Pechiney, 1969) report amphibolites along strike of the gneissosity further north and south of the exposure. Coin (pers. comm.) has interpreted the main basic to ultrabasic rock body to extend approx. 3 km southwestward.

Country rocks in the area are dominantly quartz-feldspar gneisses with minor biotite schist bands. Ironstones and dolomites crop out to the west of the observed basics.



Exposure of dioritic to peridotitic rocks.

Quartz-feldspar gneisses, biotite schists, granofels and pegmatites.

40 Gneissosity

40 Axial plane to folded gneissosity

x12 Sample location and number

Fence

Road

Creek

Cultural and topographic features from enlarged aerial photograph. – Tumby, Survey 1033, Run 2, Photo 9382.

FIG. 2

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale : 1:13250
Compiled D.J.F.	NICKEL OCCURRENCE NEAR TUMBY BAY GEOLOGICAL SKETCH AND SAMPLE LOCATION PLAN	Date : October 1975
Drn A.F. Ckd		Drg No. S12049

General gneissosity orientation is dipping 80° towards 120°. Quartz feldspar pegmatites intruding the gneisses are common and often are associated with alkali feldspar blastesis and texture homogenisation in the formerly thinly banded gneisses. Refolding of the gneissosity occurs on a mesoscopic scale and an observed axial plane has an orientation of dipping 40° towards 280°.

The southeastern and northwestern boundaries of the exposure of basic to ultrabasic rocks appear parallel to the gneissosity orientation (i.e. dipping 80° towards 120°). A faint layering exists within the basic body and is apparently parallel to the SE and NW contacts with country rock; a variation in rock type from diorite to peridotite over tens of metres occurs across the layering.

An alteration zone in ultrabasic rocks at the quarry dips 49° towards 080° and contains a lineation which pitches 66° northerly. Shallow grooves and elongate steps define the lineation. The alteration zone is associated with chloritised schists, magnesite and serpentinite.

GEOCHEMISTRY

Eighteen samples were submitted to A.M.D.E.L. for semiquantitative spectrographic analysis - 15 samples from west of Tumby Bay and 3 from McLaren Point. Results are tabulated in Appendix B. Elements analysed for were:

a. Co, Cr, Ni, W, Mn, Mo

b. Cu, Pb, Zn, Ag, Cd, Ga, Ge

c. Au, P, Te

d. Rb

e. Al, Ca, Fe, Mg, Si

The more significant results include:

1. Chromium abundance ranges from 50 p.p.m. to 2000 p.p.m.
2. Nickel " " " 50 p.p.m. to 1500 p.p.m.
3. Copper, lead and zinc occur in amounts up to 50, 80 and 150 p.p.m. respectively.
4. Several specimens (A113/75, A121/75, A123/75, A124/75) have alumimium and/or calcium in amounts of less than 1%.
5. The consistency of gallium abundance (10-15 p.p.m.), in rocks that vary in alumina content from peridotites of less than 1% aluminium to diorites with greater than 50% plagioclase, appears unusual.

To determine possible relationships between elements, concentrations of various elements are plotted against each other and included as Appendix C. As expected, a positive (but poor) correlation exists between nickel and chromium, nickel and cobalt, and chromium and cobalt. A negative correlation exists between rubidium and nickel, and rubidium and chromium. No distinct trends appear to exist for plots of other elements.

MINERALOGY AND PETROGRAPHY

Six apparently representative samples were submitted to A.M.D.E.L. for thin section petrography and the results, (Appendix D) indicate a suite of dioritic to ultramafic rocks. Rock types vary from ultramafic lherzolites and harzburgites through dolerite-gabbros to diorites. All samples from Tumby Bay are completely void of quartz so the rocks represent a basic to ultrabasic suite. Quartz is only identified in a specimen from McLaren Point.

Peridotite varieties (P151/75, P152/75 and P155/75) consist of olivine, clino and/or orthopyroxene with lesser amounts of amphibole, phlogopite, opaques and plagioclase (bytownite). Olivine and orthopyroxene are regarded as early phases followed by clinopyroxene, phlogopite and opaques.

Dolerite-gabbro (sample P153/75) consists of predominant plagioclase laths (labradorite) with olivine, clino- and orthopyroxene. Olivine, labradorite and perhaps orthopyroxene appear to be the earliest crystallisation phases. Clinopyroxene is associated with alteration phases surrounding olivine.

Polished section and electron probe microanalysis of three samples (Appendix D) identified globule and scallop shaped patches of magnetite, pentlandite, chalcopyrite and pyrite with a volume ratio of 6: 2:2:1. Total sulphides are $< 0.2\%$ by volume but contain from 23% to 41% of the total nickel in the rocks.

At Tumby Bay maximum assay values of nickel and chromium are associated with ultramafic peridotites and values decrease with change of rock type from peridotite, through gabbro and dolerite, to diorite. A dolerite-gabbro from McLaren Point (A125/75) has nickel and chromium abundances equal to maximum peridotite values from Tumby Bay.

ORIGIN

The sampled population may not represent the whole rock body due to non-sampled poorly exposed units and gradational variation of rock types.

An intrusive magmatic origin is indicated by:

1. Strongly developed gneissosity in country rocks but little evidence of metamorphic structures within basic to ultramafic rocks.
2. Present mineralogy and rock types i.e. diorites, dolerites, gabbros and peridotites.
3. All samples either are, or appear to have been, holocrystalline.
4. Dominant grain size is medium to fine, with some coarse grained varieties.
5. Fabrics vary from allotriomorphic granular with equant anhedra to hypidiomorphic granular in some peridotites, to approaching panidiomorphic granular in diorites with abundant plagioclase laths.
6. Lack of pillow lava and quench textures.
7. Basics and mafics are associated with country rock quartzo-feldspathic gneisses, rather than volcanic and basaltic rocks.

8. Plug-like occurrence of the peridotite body at the quarry near the Tumby-Cummins road.
9. Olivine and serpentine reach abundances of 70% by volume in peridotites.
10. Several peridotite samples contain less than 1% aluminium and/or calcium.

Apparently conformable NW and SE contacts of the larger basic to mafic body, with the country rocks, suggest a sill-like form. Gradational variation of rock type from diorite to peridotite over tens of metres, forming broad bands parallel to the NW and SE margins may represent differentiation after emplacement.

OTHER S.A. OCCURRENCES

The possible existence of ~~another~~ other nickel-bearing ultramafics in Lower Proterozoic rocks in the Tarcoola area has been reported by Kennecott (1968 & 1970). At Blackfellow Hill near Mt. Christie, a low order nickel-copper anomaly from soil samples was associated with a montmorillonite - chlorite - magnesite rich zone.

Variations in nickel assay values are:-

1. up to 110 ppm in magnesite soil.
2. 130 - 210 ppm in rubble from a 0.3 m deep trench.
3. 400 - 500 ppm in rock chips from a 0.3 m deep trench.
4. 500 ppm from a 1.3 m deep auger hole
5. 400 ppm in montmorillonite.
6. 1400 ppm from altered tremolite - phlogopite rock.

Similar results for Lake Barry area (east of Mt. Christie).

	Lowest	highest	approx normal
Ni.	44	4200	700
Co.	5	350	100
Cu.	0	310	60
Cr.	40	790	350
Pb.	5	200	25
Ba.	70	10 000	800
Sr.	80	2500	800
Ti	50	20 000	10 000.

35 auger holes (depths of 12' to 36').

Rocks composed of montmorrillonite clay, phlogopite, altered pyroxene with lesser ? olivine, plag, apatite, ilmenite and magnetite.

Form of a circular plug, diameter of one half mile.

Kennecott Explr

S.M.L. 491

ENV. 1510 Vols 1-4.

DM 1122/70

Although alteration and replacement is near complete, an altered tremolite - phlogopite rock, a vesicular chalcedonic rock, ferruginised ultramafic and silcrete of ? ultramafic origin have been recognised. "Textures suggestive of olivine pseudomorphs" was also interpreted while the vesicular chalcedonic rock "could have been a forsterite marble originally".

Kennecott concluded that "this zone is interpreted as marking the position of a metamorphosed ultrabasic body intruded into banded iron formations".

CONCLUSIONS

Diorites, gabbros and ultramafic rocks crop out over an area of at least 0.7 km^2 . Highest nickel and chromium abundances occur in ultramafic lherzolites and harzburgites. Major nickel bearing phases are pentlandite, olivine and serpentine. Sulphides, up to 0.2% by volume, contain 20-40% of the whole rock nickel.

The presence, west of Tumby Bay, of ultramafic rocks with pentlandite, pyrite, chalcopyrite and magnetite, enhances the prospects for nickel sulphide ore bodies. The Blackfellow Hill occurrence near Mt. Christie suggests a more widespread distribution of ultramafic rocks on the Gawler Platform than previously known.

D.J. Flint.

D.J. FLINT

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SAMPLE NUMBER	ROCK TYPE	ANALYSIS NO.	PETROGRAPHY NO.
1033/2/9382/ 1	LHERZOLITE	A110/75	P151/75 P250/75
" 2	Serpentine in quartz		
" 3	Peridotite	A111/75	
" 4	Dolerite - gabbro	A112/75	
" 5	HARZBURGITE	A113/75	P152/75
" 6	Peridotite	A114/75	
" 7	Magnesite, serpentinite		
" 8	Diorite	A115/75	
" 9	Diorite	A116/75	
" 10	Peridotite	A117/75	P251/75
" 11	Diorite		
" 12	Dolerite	A118/75	
" 13	DOLERITE - GABBRO	A119/75	P153/75
" 14	Dolerite	A120/75	
" 15	Peridotite	A121/75	
" 16	DIORITE	A122/75	P154/75
" 17	HARZBURGITE	A123/75	P155/75 P252/75
" 18	Peridotite	A124/75	
Memory Cove 19	Dolerite - gabbro		
" 20	Dolerite - gabbro		
Mc Laren Point 21	Diorite	A125/75	
" 22	Diorite		
" 23	DIORITE	A126/75	P156/75
" 24	Diorite		
" 25	Dolerite - gabbro	A127/75	

Tumby Survey 1033/ Run 2 / Photo 9382/ Sample No.

Rock name in capitals based on thin section petrography.
Other rock names are from hand specimen observations.

↑ Thin section ↑ Polished section

APPENDIX A

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Compiled D.J.F.

Drn A.F. Ckd

NICKEL OCCURRENCE NEAR TUMBY BAY

SAMPLE SUMMARY SHEET

Scale :

Date : October 1975

Drg. No. S12050

750-6.N F132 O

APPENDIX B

amdel
The Australian Mineral Development Laboratories
Flemington Street, Frewville, South Australia 5063
Phone 79 1662, telex AA82520

Please address all correspondence to the Director
In reply quote: AN1/15/0 - 4360 /75

NATA CERTIFICATE

30 July 1975

The Director
Department of Mines
Box 38 Rundle Street PO
ADELAIDE SA 5000

A 59/75

REPORT AN 4360/75

YOUR REFERENCE:	Application dated 19/6/75
LOCATION:	Lincoln 1:250,000 survey sheet
IDENTIFICATION:	A110/75 to A127/75
DATE RECEIVED:	25 June 1975

Enquiries quoting AN 4360/75 to Officer in Charge please

Officer in Charge, Analytical Section: D.K. Rowley

for F.R. Hartley
Director

plm

AMDEL ANALYTICAL SERVICE

JOB: 4360/75 Semi-Quantitative Spectrographic Analysis Schemes A1,A2,A3,A4,A5,A6,A7,A8 & A9 BATCH: 1

Form 60 Results in ppm unless otherwise stated. Detection limits in brackets.

Sample No		A110/75	111	112	113	114	115	116
A1	Be(1)							
·	Co(5)	100	80	30	30	80	5	100
·	Cr(20)	1000	800	50	1000	800	100	300
·	Mn(10)	300	300	500	200	300	150	500
·	Mo(3)	x	x	x	x	x	x	x
	Nb(20)							
·	Ni(5)	500	400	50	100	500	50	200
	Re(50)							
	Ta(100)							
	Th(100)							
	V (10)							
·	W (50)	x	x	x	x	x	x	x
	Zr(10)							
A2	Ag(0.1)	x	x	x	x	x	x	x
	As(50)							
	Bi(1)							
·	Cd(3)	x	x	x	x	x	x	x
	Cu(1)							
·	Ga(1)	10	5	20	10	10	15	15
·	Ge(1)	x	x	x	x	x	x	x
	In(10)							
·	Pb(1)	20	1	20	5	1	30	3
	Sb(30)							
	Sn(1)							
·	Zn(20)	100	100	150	120	80	30	150
A3	Au(3)	x	x	x	x	x	x	x
·	P (100)	100	100	500	x	100	x	100

Sample No		A110/75	111	112	113	114	115	116
A3	Tl(1)							
A4	Li(1)							
	Na(50)							
A5	Cs(30)							
	K (5)							
·	Rb(10)	10	30	x	10	30	50	30
A6	Ba(50)							
	Ce(300)							
	Er(100)							
	Eu(50)							
	La(100)							
	Nd(300)							
	Pr(100)							
	Sc(50)							
	Sr(10)							
	Ti(100)							
	Y (10)							
A7	Hg(0.15)							
A8	B (3)							
A9	Al(100)	>1%	>1%	>1%	10,000	>1%	>1%	>1%
·	Ca(100)	>1%	>1%	>1%	10,000	>1%	>1%	>1%
·	Fe(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
·	Mg(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
·	Si(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
	U(5000)							

JOB: ...43609/75 Semi-Quantitative Spectrographic Analysis Schemes A1,A2,A3,A4,A5,A6,A7,A8 & A9 BATCH...2.....

Form 60 Results in ppm unless otherwise stated. Detection limits in brackets.

	Sample No	N117/75	118	117	120	121	122	123
A1	Be(1)							
	Co(5)	150	5	30	30	50	30	30
	Cr(20)	2000	100	1000	500	500	80	800
	Mn(10)	300	100	100	150	200	150	100
	Mo(3)	x	x	x	x	x	x	x
	Nb(20)							
	Ni(5)	1500	50	300	200	500	100	800
	Re(50)							
	Ta(100)							
	Th(100)							
	V (10)							
	W (50)	x	x	x	x	x	x	x
	Zr(10)							
A2	Ag(0.1)	x	x	x	x	x	x	x
	As(50)							
	Bi(1)							
	Cd(3)	x	x	x	x	x	x	x
	Cu(1)							
	Ga(1)	10	15	10	10	10	20	10
	Ge(1)	x	x	x	x	x	x	x
	In(10)							
	Pb(1)	80	5	1	3	10	20	20
	Sb(30)							
	Sn(1)							
	Zn(20)	80	50	80	20	120	50	150
A3	Au(3)	x	x	x	x	x	x	x
	P (100)	x	100	x	100	x	x	x
	Te(20)	x		x	x	x	x	x

	Sample No	N117/75	118	119	120	121	122	123
A3	Tl(1)							
A4	Li(1)							
	Na(50)							
A5	Cs(30)							
	K (5)							
	Rb(10)	3	50	x	20	10	20	10
A6	Ba(50)							
	Ce(300)							
	Er(100)							
	Eu(50)							
	La(100)							
	Nd(300)							
	Pr(100)							
	Sc(50)							
	Sr(10)							
	Ti(100)							
	Y (10)							
A7	Hg(0.15)							
A8	B (3)							
A9	Al(100)	>1%	>1%	>1%	>1%	1000	>1%	2000
	Ca(100)	>1%	>1%	>1%	>1%	>1%	>1%	1000
	Fe(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
	Mg(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
	Si(100)	>1%	>1%	>1%	>1%	>1%	>1%	>1%
	U(5000)							

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by more accurate analytical technique. = Not detected at limit quoted.

Job: A8600115 Semi-Quantitative Spectrographic Analysis Schemes A1,A2,A3,A4,A5,A6,A7,A8 & A9 Batch.....

Form 60 Results in ppm unless otherwise stated. Detection limits in brackets.

	Sample No	A12/15	125	126	127
A1	Be(1)				
	Co(5)	150	150	50	20
	Cr(20)	1000	1500	100	1000
	Mn(10)	300	300	300	300
	Mo(3)	x	x	x	x
	Nb(20)				
	Ni(5)	1000	1000	100	300
	Re(50)				
	Ta(100)				
	Th(100)				
	V (10)				
	W (50)	x	x	x	x
	Zr(10)				
A2	Ag(0.1)	x	x	x	x
	As(50)				
	Bi(1)				
	Cd(3)	x	x	x	x
	Cu(1)				
	Ga(1)	10	10	20	15
	Ge(1)	x	x	x	x
	In(10)				
	Pb(1)	30	1	3	50
	Sb(30)				
	Sn(1)				
	Zn(20)	80	80	80	100
A3	Au(3)	x	x	x	x
	P (100)	x	100	x	100
	Te(20)	x	x	x	x

	Sample No	A12/15	125	126	127
A3	Tl(1)				
A4	Li(1)				
	Na(50)				
A5	Cs(30)				
	K (5)				
	Rb(10)	10	10	50	20
A6	Ba(50)				
	Ce(300)				
	Er(100)				
	Eu(50)				
	La(100)				
	Nd(300)				
	Pr(100)				
	Sc(50)				
	Sr(10)				
	Ti(100)				
	Y (10)				
A7	Hg(0.15)				
A8	B (3)				
A9	Al(100)	5000	>1%	>1%	>1%
	Ca(100)	>1%	>1%	>1%	>1%
	Fe(100)	>1%	>1%	>1%	>1%
	Mg(100)	>1%	>1%	>1%	>1%
	Si(100)				
	U(5000)				

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by an appropriate accurate analytical technique. X = Not detected at limit quoted.

APPENDIX B

ammdel
The Australian Mineral Development Laboratories
Flemington Street, Frewville, South Australia 5063
Phone 79 1662, telex AA82520

Please address all correspondence to the Director
In reply quote: AN1/15/0 - 479/76

NATA CERTIFICATE

13th August, 1975.

The Director,
Department of Mines,
Box 38, Rundle Street P.O.,
ADELAIDE, S.A., 3000.

AS)75

REPORT AN 479/76

YOUR REFERENCE:	Application dated 7/8/75
LOCATION:	Lincoln, 1: 250.000.
IDENTIFICATION:	As listed
DATE RECEIVED:	8 August 1975

Enquiries quoting AN 479/76 to Officer in Charge please.

Officer in Charge, Analytical Section: D.K. Rowley,

for F.R. Hartley,
Director.

aps.

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

x = not detected at the limits quoted

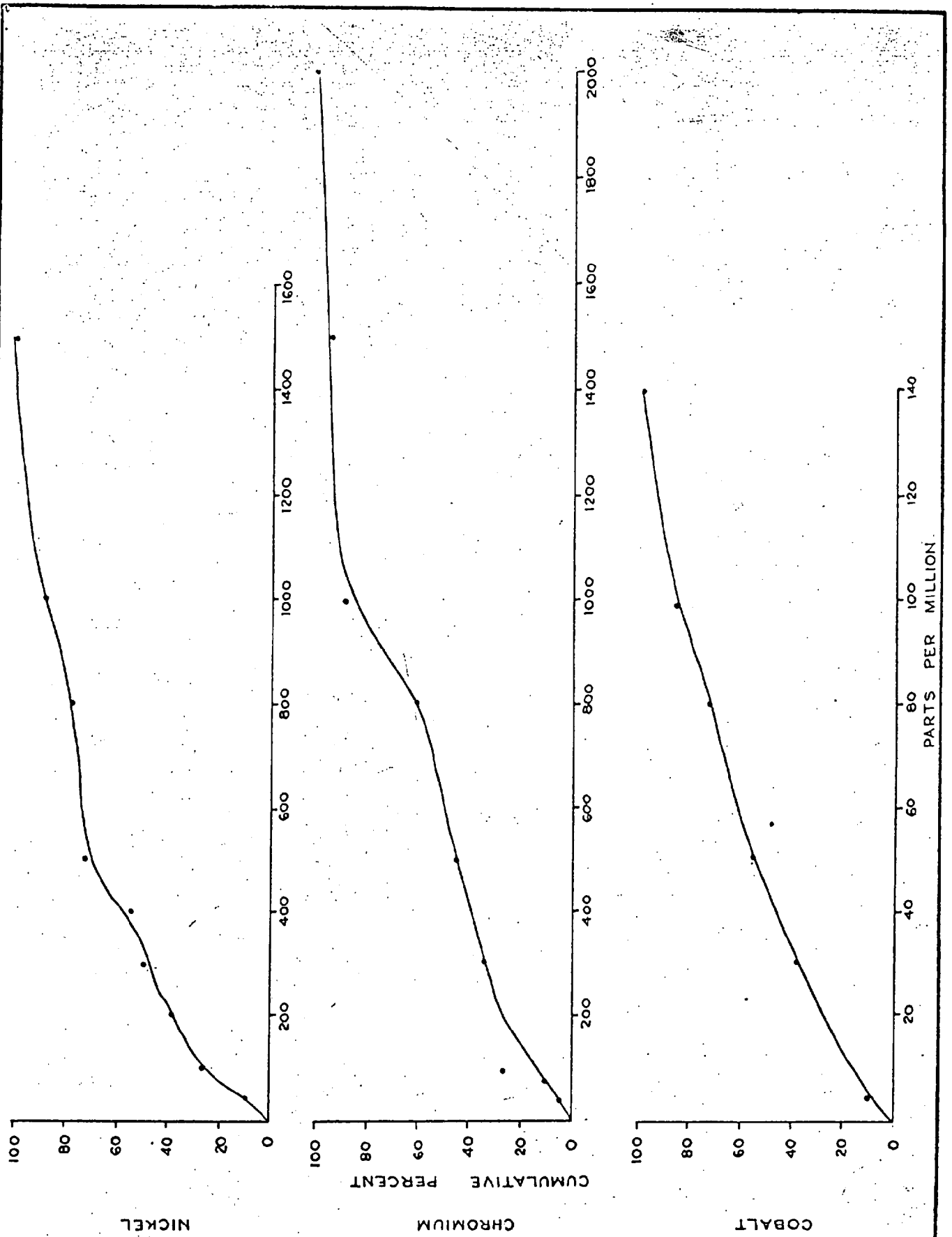
REPORT AN 479/76

91

Results in ppm unless otherwise stated. Detection limits in brackets.

Sample No	Cu (1)
15	20
11	30
12	50
13	20
14	20
15	20
16	30
17	30
18	30
19	5
20	20
21	20
22	30
23	10
24	20
5	30
26	50
27	30
S18	
D18	
A2	

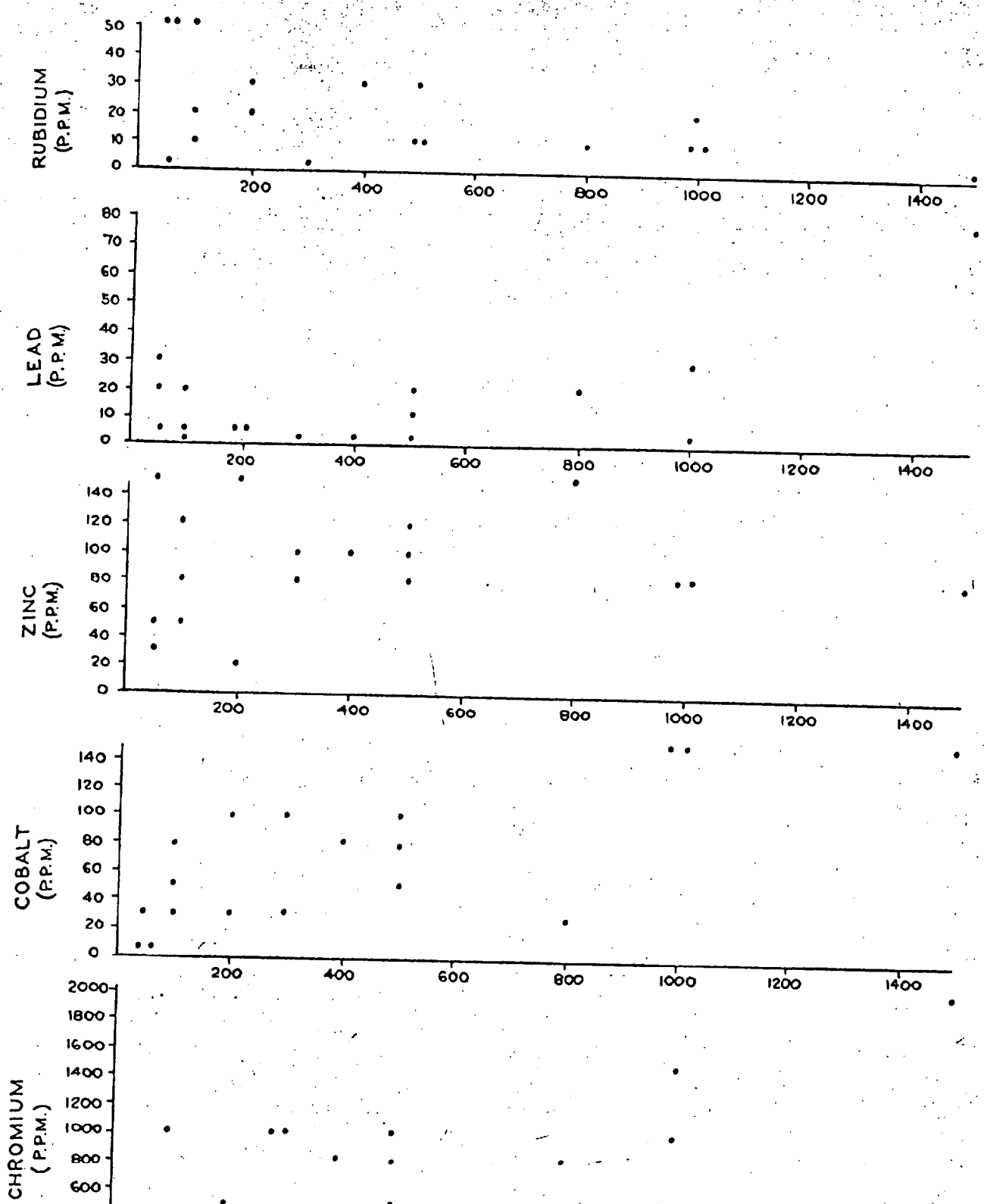
Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by an appropriate accurate analytical technique.



APPENDIX B

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled D.J.F.	NICKEL OCCURRENCE NEAR TUMBY BAY	Date : October 1975
Drn A.F. Ckd	CUMULATIVE PERCENT DIAGRAM NICKEL CHROMIUM COBALT	Drg. No. S12051

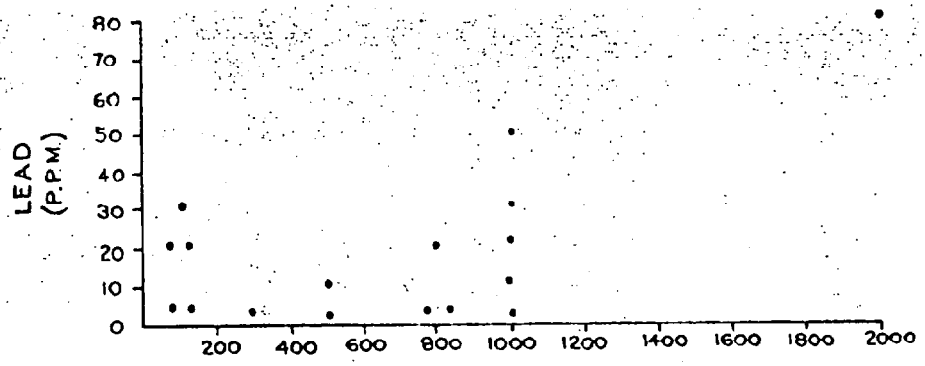
750-6.74 F332 O

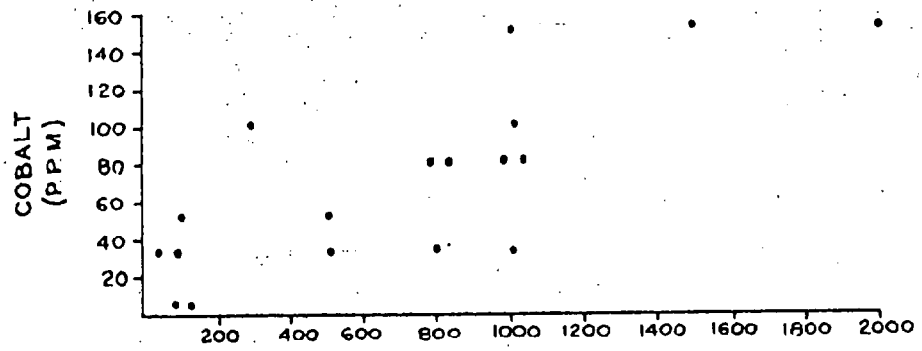


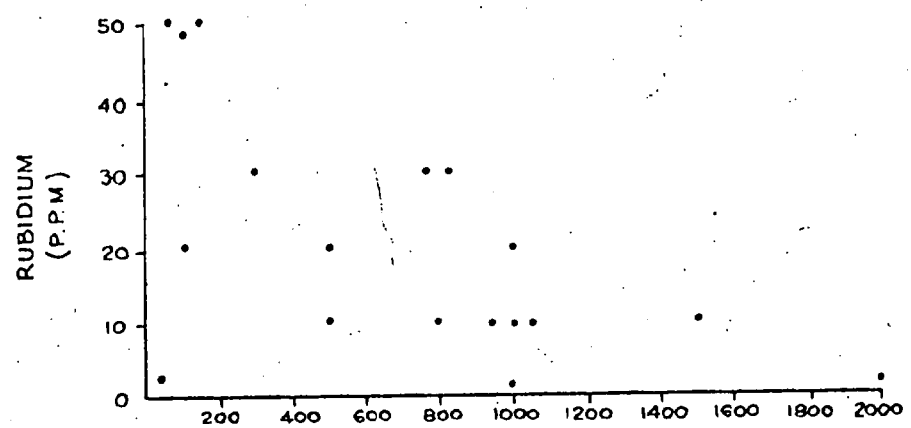
APPENDIX C

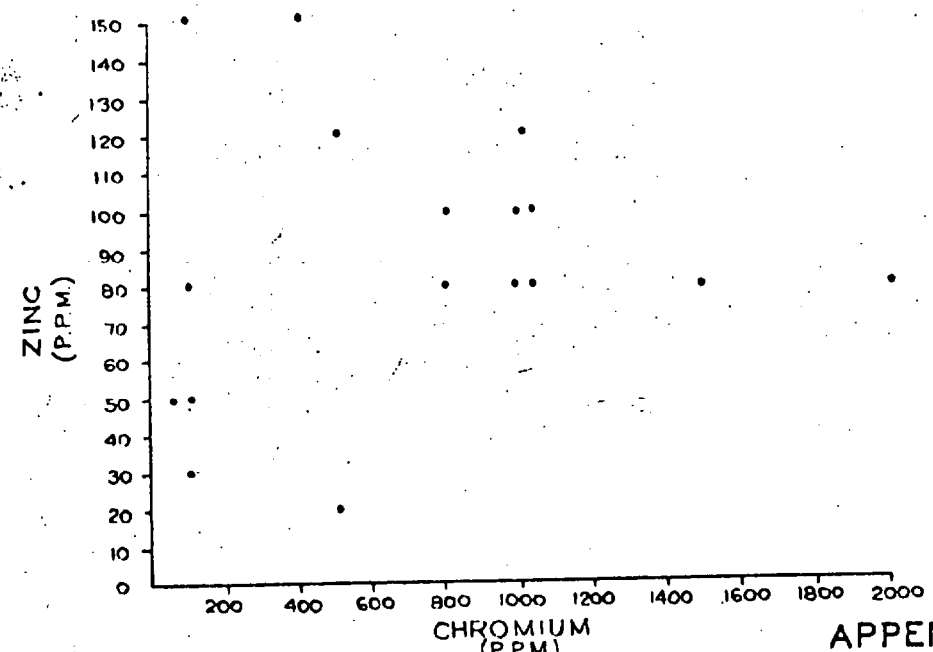
	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale :
Compiled D.J.F	NICKEL OCCURRENCE NEAR TUMBY BAY	Date : October 1975
Drn. A.F. Ckd	NICKEL CORRELATION DIAGRAM	Drg. No. S12052

750—6.74 F132 O









APPENDIX C

	DEPARTMENT OF MINES — SOUTH AUSTRALIA	Scale:
Compiled D.J.F.	NICKEL OCCURRENCE NEAR TUMBY BAY	Date: October 1975
Drn. A.F. | Ckd	CHROMIUM CORRELATION DIAGRAM	Drg. No. S12053

APPENDIX D

CSIRO
The Australian Mineral Development Laboratories
Flemington Street, Frewville, South Australia 5063
Phone Adelaide 79 1662, telex AA82520

Please address all correspondence to Frewville.
In reply quote: MP1/15/0

16th July, 1975

The Director,
Department of Mines,
Box 38, Rundle Street P.O.,
ADELAIDE, SA 5000

Attention: D.J. Flint

REPORT MP 4359/75

YOUR REFERENCE:	Application of 19/6/75
MATERIAL:	6 rocks
LOCALITY:	Eyre Peninsula
IDENTIFICATION:	P151-P156/75
DATE RECEIVED:	25-6-75
WORK REQUIRED:	Petrography

Investigation and Report by: Dr B.G. Steveson

Officer in Charge, Mineralogy/Petrology Section: Dr K.J. Henley

for F.R. Hartley
Director

mhb

EXAMINATION OF SIX INTERMEDIATE TO ULTRABASIC ROCKS

Sample: P151/75

Location:
1033/2/9382/1.

Rock Name:
Lherzolite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Serpentinized olivine	45
Orthopyroxene	20
Clinopyroxene	10
Phlogopite	10
Plagioclase	10
Opaques	5

The sample is a coarse-grained granular ultramafic rock which has undergone considerable alteration and which now contains a large proportion of serpentinized olivine.

The mafic minerals in the rock form equant anhedra which are approximately 0.8-2 mm in size. Olivine forms distinctly round and compact crystals characterized by broad irregular fissures which have been filled with serpentine. Some original olivine remains, however, and generally this constitutes about 70-80% of the area originally occupied by fresh olivine. As well as serpentine fine-grained dusty opaques have resulted from the alteration of the olivine. In one or two places in the thin section the olivine is rimmed by a fine-grained reaction product with adjacent less basic minerals and there are rather complex intergrowths of phlogopite and pyroxene which abut from olivine into adjacent plagioclase crystals. Some of these reaction products have radial textures away from the olivine and in some places the crystals of the secondary minerals have an extremely elongate irregular wiry appearance.

The clinopyroxene has a dull yellowish colour and orthopyroxene shows a little zonation in shades of colourless to a dull brown or pink. Some of the orthopyroxene crystals have a

marginal zone which is distinctly darker than the core of the crystals. The position of phlogopite in the rock is not entirely clear from examination of this thin section but the mineral forms irregular flakes which range in size from 0.2 mm to 1 mm. The phlogopite is intersected by seams of serpentine and is in some places rimmed by alteration products and hence it appears to be a primary mineral in the rock. The approximate composition of the plagioclase was determined by the Michel-Levy method; only about six suitable crystals are present in the thin section but two of these give a composition of bytownite.

In summary therefore the rock is an olivine-rich coarse-grained ultramafic igneous rock which contains subordinate amounts of two kinds of pyroxene, phlogopite and hence the sample has been termed a lherzolite. The olivine crystals in the rock show fairly extensive alteration to serpentine and opaques. The presence of these secondary minerals probably precludes the use of the rock for rubidium-strontium geochronology. A more efficient way of dating the crystallization of the sample is probably by the separation of plagioclase or phlogopite and potassium argon measurements.

Sample: P152/75; TSC14496

Location:
1033/2/9382/5.

Rock Name:
Harzburgite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Serpentinized olivine	65-70
Orthopyroxene	15
Clinopyroxene	5-10
Phlogopite	5
Opaques	5

This rock is significantly more altered than the rock described immediately above and plagioclase is probably represented by indefinite patches of secondary minerals.

Most of the rock consists of large equant crystals of olivine which have been partly replaced by serpentine.

In most cases the serpentine accounts for 30-80% of the original volume of the olivine crystals and this figure indicates the much greater alteration of this rock compared with sample P151/75. The textures displayed by the sample are similar to those of P151/75 although the orthopyroxene shows less development of rational crystal faces than in that sample. In some places the olivine in fact occupies rather large embayments in plates of orthopyroxene which are several millimetres in size. Phlogopite is confined to small irregular flakes which have rather pale brown colours. The rock contains some patches of bright brown secondary minerals which appear to have replaced a mineral of low birefringence and relatively low refractive index and it suggested that original plagioclase which comprised perhaps 5% of the original rock, has been altered during the thorough going serpentinization of the olivine.

This sample has been described as a harzburgite on the basis of the predominance of orthopyroxene over clinopyroxene, phlogopite and plagioclase; however, the rock is similar in many characteristics to the lherzolite described above. Serpentinization of olivine has been extensive and more than half of the olivine in the rock has been replaced during this alteration. Fine-grained dusty opaques have been produced during serpentinization and these can readily be distinguished from the more compact and larger crystals of opaque which originally crystallized in the ultramafic. The sample is not suitable for rubidium-strontium dating and in fact no mineral is either sufficiently abundant nor sufficiently fresh for separation and measurement of potassium and argon abundances.

Sample: P153/75; TSC14497

Location:
1033/2/9382/13.

Rock Name:
Dolerite-gabbro.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Plagioclase	55
Orthopyroxene	15-20
Clinopyroxene	10-15
Olivine	10
Phlogopite	2-5
Opaques	trace

This sample has a grain size of 0.5-1.5 mm and consists essentially of a granular aggregate of plagioclase laths, anhedral crystals of pyroxene and partially altered and replaced crystals of olivine. Some of the latter are more than 1.5 mm in size.

Olivine generally occurs in the centre of a broad reaction rim which appears to contain intimate intergrowths of pyroxene and ?amphibole. The pyroxene is present as anhedral crystals which commonly have irregular shapes defined by the prism faces of adjacent subhedral plagioclase laths. Orthopyroxene shows an overall brown turbidity and in some cases schiller structure whereas the clinopyroxene contains more irregular fractures and a less well developed schiller structure and cleavage. Orthopyroxene, particularly, is closely associated with the plagioclase in granular and intergranular aggregates whereas the clinopyroxene occurs more often with the olivine and associated reaction products.

The plagioclase occurs as subhedral tabular or lath-like crystals which are commonly 0.5-1 mm in size. Most of the crystals have a slight turbidity caused by the presence of very fine-grained dusty alteration products. Some crystals also show zonation in alteration in that they have clearer cores. Sericitic alteration of plagioclase is present but is not as abundant as the turbidity. Determination of the composition of the plagioclase by the Michel-Levy method gives a composition of labradorite (An_{64}, approximately).

Phlogopite occurs as rather small flakes some of which appear to be of secondary origin and to result from the alteration of primary mafic minerals and even in some cases of primary opaques.

This rock is a fairly coarse-grained dolerite or gabbro which contains olivine and two kinds of pyroxene. The olivine has undergone extensive alteration and is characterized by the presence of coronas of secondary minerals probably including pyroxene and amphibole. Phlogopite may be partially of secondary origin and partially primary in origin; this cannot be determined from the examination of this thin section alone. The dolerite probably has a relatively basic composition and is associated more with the alkaline type of basic rock rather than tholeiitic.

Sample: P154/75; TSC14498

Location:
1033/2/9382/16.

Rock Name:
Diorite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Plagioclase	45-50
Hornblende	45
Clinopyroxene	5
?Quartz	<2
Opaques	<2
Secondary minerals	2

This is a medium to coarse-grained igneous rock which has a granular holocrystalline texture. Pyroxene is present as crystals largely altered to hornblende and quartz occurs in small patches which have a significantly smaller grain size than the bulk of the material in the thin section.

Plagioclase occurs as both lath-like crystals and as equant anhedra. Some laths are 1-2 mm in length but most crystals of plagioclase in the rock are 0.5-1.2 mm in size. The plagioclase crystals have irregular margins against adjacent crystals and most show a little turbid alteration. In one or two places alteration products are present as irregular patches or bands where they completely obscure the underlying plagioclase. A combined Carlsbad/Albite twin gave extinction angles characteristic of labradorite (An_{64}). Clinopyroxene is present as small patches which have a common extinction position completely enclosed in hornblende. These hornblende crystals are relatively large and they are as much as 1 mm in size; the bulk of the hornblende in the rock, however, has a crystal size which ranges from about 0.4-0.8 mm and these smaller crystals are free from inclusions of pyroxene. It is clear from these textures that the rock contains a small amount of original clinopyroxene which was present as crystals about 1 mm in size but this mineral has been largely replaced by amphibole. The crystals of hornblende show pleochroism in shades of green and sometimes a rather brownish-green but there is no evidence of zonation of the crystals from optical examination of the thin section. In those parts of the thin section where hornblende is particularly abundant it generally encloses small

blebs of ?quartz or patches of opaques. The latter have a distinctly irregular shape (commonly showing large embayments) and there appears to be a distinct spacial association of dense aggregates of hornblende and these crystals of opaques.

Also present in the thin section are small patches of a yellowish material which is probably a secondary clay or alteration product and small patches of probably secondary opaques. Small crystals of a refractive highly birefringent mineral were also noted and it is likely that these are small crystals of secondary epidote.

The rock is a fairly typical intermediate igneous rock which contains amphibole as the principal mafic mineral. The rock is sodic rather than potassic in composition and is a typical diorite.

Sample: P155/75; TSC14499

Location:
1033/2/9382/17.

Rock Name:
Serpentinized hartzburgite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Serpentine	30-40
Amphibole	30
Olivine	15-20
Orthopyroxene	15
Opaques	5-7

This sample probably originally consisted largely of olivine with about 15% of pyroxene and hence was a hartzburgite; however, the rock has undergone extensive alteration and now consists largely of secondary serpentine and ?amphibole.

Serpentine occurs in numerous thin veinlets which transect the rock in an irregular fashion. In some places patches of serpentine are as much as 0.5 mm in size but for the most part the serpentine is confined to elongate areas or web-like patches. Where serpentine is particularly abundant in the thin section it completely encloses small equant patches of olivine many of which are about 0.05-0.3 mm in size. It is clear therefore that

the serpentine has developed by replacement of original olivine. Fine dusty opaque material has been associated with this alteration process. From the bulk extinction of isolated patches of olivine it can be seen that the original rock was coarse-grained and contained many crystals of olivine 1-3 mm in diameter. Much of the rock now consists of an aggregate of colourless elongate crystals which are generally about 0.2-0.4 mm in size. These crystals show one cleavage direction along the length of the crystal and the extinction angle from this cleavage is commonly about 10-20°; hence, it is concluded that this mineral is a secondary amphibole developed by alteration of original minerals in the rock. It is likely that the amphibole has developed at the expense of either olivine or clinopyroxene.

The other primary component of the rock preserved in the thin section is orthopyroxene; this mineral can be distinguished by the dark grey appearance in plain polarized light which is due to schiller structure. The original crystals of orthopyroxene were clearly 1-3 mm in size and have an irregular bulbous shape with large embayments of olivine.

In summary therefore, the thin section consists largely of secondary amphibole and serpentine with small amounts of relictolivine and orthopyroxene. It is likely that the original igneous rock contained about 15% orthopyroxene but it is not possible to distinguish unambiguously a relative proportion of olivine and clinopyroxene in the original ultramafic; however, it is thought more likely that the original rock was extemely rich in olivine and hence the rock has been classified as an serpentinized hartzburgite.

Sample: P156/75; TSC14500

Location:
McLaren Point/23.

Rock Name:
Diorite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Hornblende	50
Plagioclase	40
Biotite	5
Quartz	2-5
Opaques	<2

This rock has a rather fine-grained granular texture and consists very largely of hornblende and plagioclase. For the most part the plagioclase crystals range in size up to about 0.2 mm whereas the hornblende occurs in compact patches which have a grain size of approximately 0.02-0.05 mm.

Plagioclase occurs both as elongate lath-like crystals and as sma equant anhedra. Generally the plagioclase occurs in irregular patches in which plagioclase represents more than 80% of the material. The twinning in the plagioclase is poorly displayed and is commonly of the discontinuous type which is regarded as being due to deformation of the plagioclase. One or two crystals also have distinctly curved twin plane traces and show irregular extinction and hence the plagioclase gives the impression of considerable deformation of the rock. Twinning of the plagioclase is not sufficiently abundant for reliable determinations of the composition but comparison of the refractive index of the plagioclase with quartz suggests that the plagioclase is a relatively sodic variety, probably oligoclase. The quartz occurs with the plagioclase as small equant anhedral crystals which have smooth well defined boundaries rather more characteristic of metamorphic (granoblastic) quartz than primary igneous material.

As mentioned above the hornblende occurs as small crystals in massive aggregates so that overall the hornblende occupies patches which are sometimes as much as 1 mm in diameter and these are fairly sharply distinguished from colourless patches which contain largely plagioclase and quartz. The individual crystals of hornblende are however rather small and most are equant anhedra showing pleochroism in shades of yellowish-green to a bright apple-green. Biotite is generally associated with the hornblende in some parts of the thin section and it occurs as well developed flakes generally about 0.1-0.2 mm in length. Biotite shows pleochroism in shades ranging from pale yellow to a deep rust brown and it is likely that the biotite is a primary mineral of the igneous rock. The biotite does not appear to be randomly distributed throughout the thin section but is concentrated in some indefinite parts of the section. Opaque and semi-opaque materialsalso appear to be associated spatially with the biotite and hornblende.

This is a biotite-bearing diorite which contains hornblende as the most abundant mafic mineral. Quartz has been tentatively identified in the sample but is not an abundant constituent of the rock and hence the sample is a typical intermediate rather fine-grained igneous rock which has a somewhat sodic composition.

The sample has undergone some deformation and possibly recrystallization of plagioclase and hence it is probably not suitable for rubidium-strontium geochronology; however, biotite appears to be an original igneous precipitate and a concentrate of this mineral could be separated for potassium argon geochronology.

APPENDIX D

amdel
The Australian Mineral Development Laboratories

Flemington Street, Frewville, South Australia 5063
Phone Adelaide 79 1662, telex AA82520

Please address all correspondence to Frewville.
In reply quote: MP1022/76

14th November, 1975

The Director,
Department of Mines,
Box 38, Rundle Street P.O.,
ADELAIDE, SA 5000

A59/75

REPORT MP 1022/76

YOUR REFERENCE:	DM-C33 dated 29-9-75
MATERIAL:	Three crushed samples of ultrabasic rock
LOCALITY:	10 km NW of Tumby Bay, S. Aust
IDENTIFICATION:	A110/75, A117/75, A123/75
DATE RECEIVED:	1-10-75
WORK REQUIRED:	Determine the percentages and Ni contents of the minerals in the rocks and work out the nickel distributions

Investigation and Report by: Dr P.G. Moeskops

Officer in Charge, Mineralogy/Petrology Section: Dr K.J. Henley

for F.R. Hartley
Director

hb

NICKEL DISTRIBUTIONS IN THREE ULTRABASIC ROCKS

1. INTRODUCTION

Three crushed samples of slightly weathered ultrabasic rocks containing traces of sulphides were submitted to Amdel for determination of nickel distribution between the various phases contained in them (i.e. silicates, oxides and sulphides).

2. PROCEDURES AND RESULTS

Polished sections and polished thin sections were prepared from the three samples.

The proportions of all phases in the sections (except sulphide phases - present only in trace amounts) were determined by conventional point counting using a 'Swift' point counter (800 to 1000 points per section) and the amount of Ni in all phases (including the trace sulphide phases) was determined by electron-probe microanalysis (Table 1). These data, plus assumed specific gravity data were then used to calculate the percentages of Ni in the rocks due to all phases except the sulphides. The whole-rock Ni contents were then determined and the differences between the above mentioned calculated Ni values and the whole-rock Ni values were assumed to be due to the presence of traces of Ni sulphides. These data plus Ni distribution data are listed in Table 2.

Mineragraphic rock indicated that the three sections contain traces (i.e. $\leq$0.2%) of minute (2-20 μm) scallop-and-globule-shaped patches composed mainly of the assemblage magnetite-pentlandite-chalcopyrite-pyrite (volume ratio roughly 6:2:2:1). Ni contents of these four phases were also determined by electron-probe microanalysis (Table 1). Globule-and scallop-shaped pyrite and magnetite patches associated with the pentlandite patches were found to contain about 0.25% Ni; however, associated chalcopyrite was found to be devoid of Ni at the probe detection limit of 0.01%.

3. CONCLUSIONS

Data indicate that samples A110/75, A117/75 and A123/75 respectively contain 270, 270 and 530 ppm Ni in pentlandite (i.e. 23, 25 and 41 respectively of the total Ni in the rocks). Furthermore the whole-rock Ni values (i.e. 0.11 to 0.13%) are low compared with normal ultrabasic rocks which contain about 0.2 to 0.3% Ni.

TABLE 1: NI CONTENTS OF MINERAL GRAINS DETERMINED BY ELECTRON-PROBE MICROANALYSIS

	Sample A110/75 (PS23982)
Serpentine	0.13, 0.13, 0.17, 0.17, 0.18 Mean Ni = 0.16%
Olivine	0.22, 0.22, 0.22, 0.22, 0.24 Mean Ni = 0.22%
Orthopyroxene	0.04, 0.04, 0.04, 0.04, 0.05 Mean Ni = 0.04%
Clinopyroxene	Not determined - assumed to be as in A117/75
Plagioclase	0.0, 0.0, 0.0, 0.02, 0.04 Mean Ni = 0.02%
Serpentinization Magnetite	0.6, 0.0, 0.02, 0.08, 0.08 Mean Ni = 0.04%
Chromite	Mean Ni = 0.14%
Phlogopite	Not determined - assumed to be same as in A117/75
Pentlandite	28.8, 38.3, 31.3, 34.4 Mean Ni = 33.2%
	Sample A117/75 (PS23983)
Serpentine	0.10, 0.19, 0.10, 0.22, 0.23 Mean Ni = 0.19%
Olivine	0.24, 0.24, 0.24, 0.24, 0.25 Mean Ni = 0.24%
Orthopyroxene	0.05, 0.06, 0.06, 0.04, 0.05 Mean Ni = 0.05%
Clinopyroxene	0.03, 0.04, 0.04, 0.05, 0.06 Mean Ni = 0.04%
Tremolite (after clinopyroxene)	Mean Ni = 0.05%
Plagioclase	0.0, 0.02, 0.02, 0.03, 0.03, 0.03, 0.03, 0.04 Mean Ni = 0.03%

TABLE 1: (Cont.)

Serpentinization Magnetite	0.0, 0.04, 0.0, 0.02, 0.02 Mean Ni = 0.02%
Chromite	Mean Ni = 0.08%
Pentlandite	Mean Ni = 35.5%

Sample A123/75 (PS23984)

Serpentine	0.11, 0.13, 0.13, 0.13, 0.13, 0.15, 0.18, 0.19, 0.20, 0.22 Mean Ni = 0.16%
Olivine	0.24, 0.24, 0.25, 0.25, 0.27 Mean Ni = 0.25%
Orthopyroxene	0.0, 0.02, 0.02, 0.04, 0.05 Mean Ni = 0.03%
Clinopyroxene	0.04, 0.05, 0.06, 0.05, 0.07 Mean Ni = 0.05%
Plagioclase	0.04, 0.08, 0.08, 0.08, 0.10 Mean Ni = 0.08%
Serpentinization Magnetite	0.0, 0.03, 0.05, 0.08 Mean Ni = 0.04
Pentlandite	Mean Ni = 31.3%

Footnote

Pyrite and magnetite associated with the pentlandite contain about 0.25% Ni.

TABLE 2

Mineral	Assumed Sp.Gr.	Sample A110/75			Sample A117/75			Sample A123/75		
			Ni			Ni			Ni	
		Wt. %	Assay(%)	Dist.(%)	Wt. %	Assay(%)	Dist.(%)	Wt. %	Assay(%)	Dist.(%)
Serpentine	2.6	21.6	0.16	29	14.9	0.19	26	11.9	0.16	15
Olivine	3.4	15.2	0.22	28	10.6	0.24	23	8.3	0.25	16
Orthopyroxene	3.2	15.8	0.04	5	24.9	0.04	9	30.0	0.03	7
'Clinopyroxene'	3.2	15.7	0.04	5	16.6	0.04	6	37.2	0.05	24
Plagioclase	2.7	20.2	0.02	4	23.0	0.03	6	5.2	0.08	3
Magnetite	5.2	8.0	0.04	2	6.9	0.02	2	6.4	0.14	3
Chromite	4.5	1.6	0.14	2	1.2	0.14	1	1.0	0.14	1
Phlogopite	2.8	1.9	0.14	2	1.9	0.14	2	0.0	-	-
*Total		100.0	(0.093)	(77)	100.0	(0.083)	(75)	100.0	(0.077)	(59)
**Actual Head Assay			0.120	100		0.110	100		0.130	100
***Head Assay - Total			0.027	(23)		0.027	(25)		0.053	(41)

* Due to silicates and oxides.

** Total nickel.

*** Assumed to be due to trace of pentlandite.

'Clinopyroxene' includes clinopyroxene plus minor tremolite after clinopyroxene.