CRA EXPLORATION PTY. LIMITED
SIPOS MINING & INDUSTRY ENTERPRISES PTY. LIMITED

WOLLOGORANG FARM-IN & JOINT VENTURE

EL 7101 SIPOS I
Northern Territory

Partial Relinquishment Report
For Period Ending 26th November, 1995

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Map Reference: Calvert Hills SE 53-08

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TABLES

1. SUMMARY

EL 7101 Sipos I is situated in the SE McArthur Basin near the N.T.-Queensland border and constitutes part of the Wollogorang Farm-In and Joint Venture exploration area.

The tenement area includes mid-Proterozoic Tawallah Group sequences considered prospective for Redbank-style cupriferous breccia bodies and stratabound base metal deposits.

The following activities were completed during the years prior to relinquishment of tenure:

- Detailed stream sediment sampling
- Rock sampling
- Airborne magnetic and radiometric survey
- Ground magnetometry
- Percussion drilling
- Integrated field and petrographic studies by Mason Geoscience Pty. Ltd.
- Photogeological and structural analysis by Australian Photogeological Consultants
- DIGHEM survey over the southern portion of the tenement

2. CONCLUSIONS

Reconnaissance and follow-up exploration did not identify significantly anomalous mineralisation in E and NE portions of the licence area. These areas were subsequently surrendered as part of the statutory 50% relinquishment for the end of Year 5.

3. INTRODUCTION

EL 7101 is located within Wollogorang Station Pastoral Lease 780 in the SE McArthur Basin near the N.T.-Queensland border (Location Plan NTd 6222).

EL 7101, originally covering an area of 317 km^2 (97 blocks), was granted to Sipos Mining and Industry Enterprises Pty. Limited on 27th November 1990 for a period of six years. In late 1990 the exploration licence was offered to CRAE for farm-in and was incorporated into the Wollogorang Farm-In and Joint Venture Agreement under registration No. D5531, effective 4th October 1991. Exploration programmes are managed and funded by CRAE, who are responsible for title maintenance over the licence.

The tenement covers mid-Proterozoic Tawallah Group sequences considered prospective for Redbank-style cupriferous breccia deposits and stratabound base metal mineralisation.

Access to prospect areas is via station tracks in the central and eastern areas. Sections of track were upgraded to assist drill rig access.

The licence area is drained by tributaries of Settlement Creek in the SE of the EL. The region is of moderate relief, dominated by relatively flat-topped hills of the Wollagorang Formation over the majority of the EL.

This report summarises all exploration activities undertaken by CRAE within the relinquished portion of EL 7101, which covers an area of $77km^2$ (24 blocks). Detailed accounts of the exploration are documented in past CRAE reports as listed under "References".

4. REGIONAL GEOLOGY

EL 7101 is located in the southeastern portion of the Middle Proterozoic McArthur Basin. The geological succession of the region is summarised in Table 1. A summary of the stratigraphic sequences within the licence area is detailed below (including references from Jackson, MJ, et al, 1987).

The licence area is underlain by a succession of gently northward-dipping sediments and volcanics of the Tawallah Group. They are intruded by the Packsaddle Microganite in the north of the EL.

The oldest exposed formation of the Tawallah Group in EL 7101 is the Settlement Creek Volcanics, which outcrops along the northwestern margin of Settlement Creek valley on the southern border of the EL. Lithologies include andesitic and basaltic lava flows and sills, with interbedded volcaniclastics.

Overlying the Settlement Creek Volcanics is the arenite/dololutite/carbonate sequence of the Wollogorang Formation which outcrops extensively within the EL. It is subdivided into four lithological units: basal red shale (Unit 1), crystalline dolostone (Unit 2), dololutite (Unit 3) and an upper arenaceous unit (lithic arenite) with a medial sub-unit of "red siltstone, stromatolitic dolomite and dololutite" (Unit 4). The Wollogorang Formation is regionally base metal anomalous.

The Wollogorang Formation is overlain by the Gold Creek Volcanics which is dominated by basaltic lavas and sills, with tuffaceous arenite and siltstone interbeds. The Gold Creek Volcanics is of limited outcrop, occurring mainly in northern portions of the EL.

A felsic lava sequence termed the Hobblechain Rhyolite is well-exposed along the eastern boundary of the EL where it overlies the Gold Creek Volcanics. The Packsaddle Microgranite is a NNW trending intrusive into the Tawallah Group and is interpreted to be co-magmatic with the Hobblechain Rhyolite. The microgranite outcrops in the NE portion of the EL.

Table 1: Stratigraphy of EL 7101

Mid-Proterozoic	Tawallah Group	Packsaddle Microgranite	Porphyritic, fine-grained granite
		Hobblechain Rhyolite	Rhyolite, rhyolitic conglomerate
		Gold Creek Volcanics	Basalt, arenite, minor siltstone
		Wollogorang Formation	Dolomite, dololutite, siltstone, arenite
		Settlement Ck Volcanics	Andesite, basalt, tuffs/ volcaniclastics

5. EXPLORATION ACTIVITIES

5.1 Stream Sediment Sampling

A helicopter-supported -80# stream sediment sampling programme was conducted at a density of one sample per km^2. Follow-up sampling was carried out at selected anomalous areas. A total of 67 samples were collected in the relinquished portion of EL 7101. Samples were submitted to Amdel Laboratories, Darwin, and assayed by AAS for Ag, Cd,Co, Cr, Cu, Mn, Ni, Pb and Zn.

Sample locations are presented on Plan NTd 6285. Assay results are tabulated in Appendix 1.

5.2 Rock Sampling

A total of 63 rock samples were collected within the relinquished portion of EL 7101. These include channel, grab and petrographic samples, as described in appended sample ledgers and petrographic reports.

Rock sampling was conducted in several phases: at selected magnetic anomalies; during reconnaissance work; at known prospects; and as follow-up to stream sediment sampling.

Sample locations are presented on Plan NTd 6286. Rock sample ledgers and assay results are presented in Appendix 2.

Rock samples collected for petrographic work (Pontifex & Associates Pty. Ltd.) are described in Section 5.7.1 below.

5.3 Airborne Magnetic And Radiometric Survey

A detailed low-level airborne radiometric and magnetic survey was flown over the southern portion of EL 7101 by Kevron Geophysics in May 1992. Survey specifications are listed below:

Contractor	:	Kevron Geophysics
Survey Name	:	Wollogorang
Survey Area	:	Approximately 105 km^2
Flight line direction	:	0 - 180^0 AMG 090 - 270^0 AMG
Flight line spacing	:	300m
Tie line direction	:	Orthogonal to flight lines
Tie line spacing	:	5 000 metres
Mean terrain clearance	:	60 metres
Navigation	:	GPS Receiver (Ashtec) Doppler Navigation
Magnetometer	:	Cesium Vapour V-201 0.01nT resolution
Sample Interval	:	9 metres
Spectrometer	:	GR-800 Gamma Ray 33.6 litre (Nal)
Sample Interval	:	70 metres

Residual magnetic contours are presented on Plan NTd 6288. Radiometric data were not processed by the contractor and remain in analogue format.

The aeromagnetic data were merged with the open file 1978 CRAE Camel Creek airborne geophysical survey data (CRAE Report 9923) to provide complete airborne geophysical coverage over the Wollogorang Farm-In and Joint Venture Exploration Area.

5.4 Ground Magnetometry

Phase I:

Five discrete magnetic anomalies identified from image-processed aeromagnetic data (Targets 5, 8, 9, 10 and 11) occur in the NE portion of EL 7101 in the vicinity of the Packsaddle Microgranite (Plan NTd 6284). The magnetic anomalies were interpreted to represent magnetic accumulations possibly associated with Cu-Au skarn mineralisation. Field investigation of the aeromagnetic anomalies was undertaken.

Target 5, located on the northern boundary of EL 7101 (811000mE, 8110580mN), was recovered with 4.0 line km of ground magnetics. A ground response of 1800nT was recorded over Target 5 (Plan NTd 5267). Modelled results of the ground magnetic data suggested the causative source to be a subvertical, dyke-shaped body 80m deep, 100m wide and with a thickness of approximately 300m.

At Target 10, strongly magnetic quartz-magnetite "skarn" scree (40 0000-100 000 SI x 10^{-5}) was located in an area of contact metamorphosed Wollogorang Formation arenite/lutite.

No surficial magnetic source was located at Targets 8, 9, and 11, although investigations were of a cursory nature.

Phase II:

Interpretation of aeromagnetic data identified a series of distinct magnetic zones within the licence area. High amplitude, short strike-length magnetic anomalies occurring as a segmented, curvilinear zone were identified within the northern portion of the licence area (Palmer, 1992).

The magnetic anomalies were interpreted to represent a contact metamorphic, magnetite-dominant skarn front, developed at the Packsaddle Microgranite/ Wollogorang Formation contact. They were considered prospective for magnetite-hosted Cu-Au mineralisation.

Two aeromagnetic anomalies SIP1 and SIP 4 were selected for ground follow-up (Plan NTd 6287). Detailed (10m interval) total field ground magnetometry was conducted at each anomaly.

At SIP1 (previously Target 10) data was collected over a 1.75 line km grid. A small, discrete, shallow-sourced dipolar anomaly of 2800nT amplitude was recorded (Plan NTd 5814).

A total of 3.6 line km of data was collected over the SIP4 anomaly. A series of moderate amplitude, near-surface magnetic sources were recorded in an area devoid of outcrop (Plan NTd 5816).

5.5 RC Drilling Programme

A shallow-sourced ground magnetic anomaly SIP 4, located in the eastern central portion of the licence was tested by vertical percussion drill hole PD93SP4.

The drill hole intersected a sequence of siltstone and dolomitic siltstone to a depth of 12m and weathered, magnetite-bearing mafic volcanics to total depth of 28m. Magnetic susceptibilities ranging from 1 000-30 000 SI x 10^{-5} were recorded in the volcanics.

Fourteen drill chip samples were assayed by Amdel Laboratories for Ag, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn (AAS). No significant base metal contents were reported.

Drill hole locations are presented on Plan NTd 6287. Drill hole ledgers and assay results are presented in Appendix 3.

5.6 Aerial Photography

1:10 000 colour aerial photography was flown over the licence area by Qasco Northern Surveys, Darwin. The survey was flown to assist with structural interpretation and geological mapping.

5.7 Petrographic Studies

5.7.1 Reconnaissance Petrology

Two rock samples were collected for petrographic examination during regional reconnaissance work. Sample locations are presented on Plan NTd 6286. Mineralogical reports are included in Appendix 4.

The presence of migratory secondary copper minerals within permeable lithic quartz arenites of the 'upper' Wollogorang Formation was confirmed in sample 3746025, collected from a prospect in the central portion of the relinquished area.

Sample 2659018, collected at a prospect in the SW of the relinquished area, reported malachite, chalcocite, barite, pyrite and rare cuprite in a hydrothermal vein dominated by siderite and lesser calcite.

5.7.2 Integrated Field and Petrographic Studies

An integrated field and petrographic study in the SE McArthur Basin Project Area was undertaken by consultant D. R. Mason (Mason Geoscience Pty. Ltd.) to provide a base for understanding the genesis and exploration potential of rock units in the Mid-Proterozoic Tawallah Group. An amended Mason Geoscience Report No. 2014 containing data and information pertinent to relinquished portions of EL 7101 is presented in Appendix 5. Sample locations are presented on Plan NTd 6286.

Conclusions drawn from the study were:

- Small, intrusive, trachytic cryptodomes located NW and W of Wollogorang Station Homestead display features suggesting high-level subvolcanic emplacement. Fracture and pore-space controlled quartz-sulphide-barite-carbonate-copper mineralisation developed within these cryptodomes appears to post-date magma emplacement.

- The Packsaddle Microgranite and Hobblechain Rhyolite display similar petrographic features. The Hobblechain Rhyolite represents an ignimbrite sheet formed during a single cauldron-subsidence phase of the subvolcanic, intrusive microgranite.

- Wollogorang Unit 4 porous, quartzose sandstones appear to be a favourable host for syngenetic base metal sulphide deposition.

5.8 Photogeological Study

A detailed photogeological study over EL 7101 was undertaken by Australian Photogeological Consultants as part of a regional structural interpretation of the SE McArthur Basin. 1:25 000 and 1:10 000 scale aerial photography was used for the study. Results of the study are presented as Plan NTd 6216.

A summary of pertinent results is described below:

- Folding is mostly gentle and in most cases consists of subtly-defined flexuring/warping. Moderate to steeply-dipping fold limbs occur in a few areas immediately adjacent to WNW-ESE trending faults.

- A broad zone of WNW-ESE fracturing is evident in the NE sector of the EL. It appears to represent splay faulting at the southern end of a regional NW orientated fault.

- The mapped distribution of Redbank-type breccia pipes suggests a strong preferential E-W alignment.

- The outcrop pattern of the Packsaddle Microgranite indicates emplacement along a NW-SE trending fault zone, although there has been subsequent modification of the body by later fracturing.

- In the east of the licence area, outcrop of Hobblechain Rhyolite is almost identical in appearance to the Packsaddle Microgranite and in the SW may partially overlie it. This tentatively suggests that the two units may be contemporaneous.

5.9 Dighem Survey

A detailed airborne electromagnetic survey using the DIGHEM system was flown over the southern portion of EL 7101 by contractors Geoterrex Pty. Ltd. on 27th May 1995 (CRAE Survey No. NT92ME). The Geoterrex Logistics and Interpretation Report is included as Appendix 6. Survey specifications are as follows:

Survey Name	: Redbank East
Survey Area	: 19 km^2 (approx.)
Flight Line Direction	: 180 - 360 degrees AMG
Flight Line Spacing	: 100 metres
Terrain Clearance Helicopter	: 60 metres
Terrain Clearance Magnetometer	: 40 metres
Terrain Clearance EM sensor	: 30 metres
Flight Path Recovery	: Sercel real-time differential GPS
Aircraft	: Aerospatiale Squirrel Helicopter
EM System	: DIGHEM (multi-coil, five frequencies)
Recording Interval	: 0.1 seconds (approx. three metres)
Magnetometer	: Scintrex Caesium split-beam total field
Magnetic Sensitivity	: 0.01 nT
Recording Interval	: 0.1 seconds
Line Kilometres	: 190

The survey was undertaken to determine conductivity variations and magnetic character of Tawallah Group lithologies. The data was processed to produce maps which display the magnetic and conductive properties of the survey area (NTd Plan No's 6289 and 6290 respectively).

The magnetic character of the area is quite complex due to the flat lying and variable magnetic nature of the basalts of the Gold Creek Volcanics.

The extent of the Wollogorang Formation is defined by the higher conductivity response associated with black shale units. The influence of the strongly magnetic Settlement Creek Volcanics is noted in southern portions of the licence area where it underlies the Wollogorang Formation

No anomalous zones indicative of possible mineralisation, or of structural significance, were identified in the relinquished portion of EL 7101.

5.10 Rehabilitation

Minor clearing of vegetation and surface disturbance was conducted in order to provide drill rig access. The drill hole was sealed with concrete below ground level and the drill pad scarified to promote vegetation regrowth. Rehabilitation of access tracks was completed prior to the onset of the Wet Season.

6. REFERENCES

Jackson, MJ, et al, (1987)	Geology of the Southern McArthur Basin, NT, BMR Bulletin No. 220
Ahmad, M and Wygralak, AS (1989)	1:250 000 Metallogenic Map Series Explanatory Notes and Mineral Deposit Data Sheets Calvert Hills SE 53-08.
Mason Geoscience Pty. Ltd. (1994)	Integrated Field and Petrographic Studies South-East McArthur Basin Project (Rpt. No. 2014) CRAE Rpt. No. 20509
Palmer, DC (1991)	EL 7101 Sipos I, EL 7102 Sipos II Annual Report for Year Ending 26 November 1991 (CRAE Report No. 17701)
Palmer, DC (1992)	EL 7101 Sipos I, EL 7102 Sipos II Combined Second Annual Report for Year Ending 26th November, 1992 (CRAE Report No. 18432)
Palmer, DC (1993)	EL 7101 Sipos I, Third Annual Report for Year Ending 26th November, 1993 (CRAE Report No. 19414)
Palmer, DC and Menzies, DC, (1994)	EL 7101 Sipos I, Fourth Annual Report for Year Ending 26th November, 1994 (CRAE Report No. 20505)

7. KEYWORDS

SE McArthur Basin, Tawallah Group, Wollogorang Formation, Gold Creek Volcanics, Base Metals, Geochem Drainage, Geochem Rock, Geochem Drill, Geophys Magnetics, Geophys Radiometrics, Geophys DIGHEM, Petrology.

8. LOCATION

Calvert Hills	SE53-08	1:250 000 mapsheet
Wollogorang	6463	1:100 000 mapsheet

9. LIST OF DPO's

49199, 49200, 71004, 71021, 71024, 71034, 71050, 71115, 71139, 71224

10. LIST OF PLANS

Plan No.	Title	Scale
NTd 6222	EL 7101 Sipos I Location Plan	1:250 000
NTd 5267	EL 7101 Sipos I Magnetic Target 5 Ground Magnetic Survey - Total Field Profiles	1:10 000
NTd 5814	EL 7101 Sipos I Magnetic Anomaly SIP 1	1:5 000
NTd 5816	EL 7101 Sipos I Magnetic Anomaly SIP 4	1:5 000
NTd 6216	EL 7101 Sipos I Photogeological Interpretation Plan	1:100 000
NTd 6284	EL 7101 Sipos I Geology and Magnetic Anomaly Location Plan	1:100 000
NTd 6285	EL 7101 Sipos I -80# Stream Sediment Location Plan	1:50 000
NTd 6286	EL 7101 Sipos I Rock Sample Location Plan	1:50 000
NTd 6287	EL 7101 Sipos I Grid and Drill Hole Location Plan	1:50 000
NTd 6288	EL 7101 Sipos I Aeromagnetic Contour Plan	1:50 000
NTd 6289	EL 7101 Sipos I DIGHEM Survey Residual Magnetic Contours	1:25 000
NTd 6290	EL 7101 Sipos I DIGHEM Survey 6831 Hz Apparent Resistivity	1:25 000

APPENDIX 1

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

-80# Stream Sediment Ledgers & Assay Results

APPENDIX 2

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

Rock Sample Ledger and Assay Results

APPENDIX 3

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

RC Drill Ledger and Assay Results

APPENDIX 4

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

Mineralogical Reports

APPENDIX 5

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos

Integrated Field and Petrographic Studies
South-East McArthur Basin Project
Report 2014 Mason Geoscience Pty. Ltd.

APPENDIX 6

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

DIGHEM Survey
Logistics and Interpretation Report

APPENDIX 1

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

-80# Stream Sediment Ledgers & Assay Results

CRA EXPLORATION PTY LIMITED
STREAM SEDIMENT SAMPLE ASSAYS

Geologist:	DC Palmer	**Programme:**	1992 Reconnaissance Sampling
Laboratory:	Amdel, Darwin	**1:250 000 Sheet:**	Calvert Hills SE53-08
DPO:	71034	**1:100 000 Sheet:**	Wollogorang 6463

Sample	AMGE	AMGN	Ag	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	Fe
3318001	815119	105932	0.1	0.05	21	27	57	1210	8	36	40	3.01
3318002	813900	106200	0.1	0.05	40	31	95	1520	16	23	61	4.24
3318005	816622	104389	0.05	0.05	7	43	64	1970	17	36	45	4.2
3318006	815691	104041	0.1	0.05	7	39	51	670	15	18	53	2.73
3318007	815589	103435	0.05	0.05	7	46	5	290	3	4	12	1.04
3318008	816905	102352	0.1	0.05	16	47	40	770	17	33	68	3.52
3318009	816023	102597	0.05	0.05	28	46	60	2430	20	24	73	3.19
3318010	815113	102171	0.1	0.05	19	130	48	1510	35	22	61	2.85
3318011	815111	103693	0.1	0.05	29	42	76	1900	13	20	47	4.09
3318012	815080	103750	0.1	0.05	28	43	50	1800	17	15	33	2.59
3318013	814000	103420	0.05	0.05	13	50	34	500	10	12	32	2.6
3318014	814001	103404	0.05	0.05	18	38	48	900	14	14	34	2.76
3318015	813848	103295	0.05	0.05	19	35	45	810	9	15	18	1.96
3318016	814625	102445	0.1	0.1	12	45	47	420	16	35	89	3.42
3318017	812202	102762	0.1	0.05	40	26	62	1850	8	16	52	4.88
3318018	812339	102818	0.1	0.05	22	35	70	1000	16	12	37	2.85
3318019	812949	102813	0.1	0.05	24	43	99	1080	13	14	22	3.65
3318020	812640	102335	0.05	0.05	13	46	45	730	10	6	8	1.66
		DL	0.1	0.1	2	2	1	2	2	2	1	0.001
		UNIT	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%
		METHOD	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS

Sample	AMGE	AMGN	Ag	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	Fe
3318024	810146	100992	0.05	0.05	14	36	65	710	15	8	11	1.8
3318025	810044	100966	0.05	0.05	10	43	41	1100	9	11	12	1.61
3318026	810046	101070	0.05	0.05	16	37	54	750	11	10	11	1.42
3318032	807736	97701	0.1	0.1	17	50	67	1100	23	23	56	2.88
3318033	806763	97734	0.1	0.05	11	49	43	910	13	19	50	2.44
3318034	805523	97836	0.05	0.05	20	39	55	1080	12	12	29	3.13
3318056	806441	96254	0.05	0.05	8	69	52	410	19	21	39	2.46
3318057	806507	96246	0.05	0.05	17	73	60	1500	27	34	86	3.8
3318058	806399	96292	0.05	0.05	5	35	36	300	14	16	31	1.88
3318059	805047	96696	0.05	0.05	16	58	80	950	19	29	71	2.98
3318060	805044	96631	0.05	0.05	13	75	76	710	22	26	59	3.06
3318072	807228	103956	0.05	0.05	35	60	91	2420	28	29	54	4.41
3318076	807903	104525	0.05	0.05	22	54	71	900	24	29	70	3.56
3318077	806939	105102	0.05	0.05	10	38	43	450	8	20	23	1.96
3318078	806910	105133	0.05	0.05	29	42	64	1450	17	36	52	3.46
3318079	807453	104925	0.05	0.3	23	48	68	970	17	32	84	3.54
3318086	810938	107516	0.05	0.05	10	39	31	850	9	9	6	1.85
3318087	809642	97845	0.1	0.05	12	50	50	720	14	55	53	2.75
3318088	809265	98173	0.05	0.05	22	49	61	1540	22	29	64	2.94
3318089	810261	99051	0.1	0.05	8	43	37	490	10	30	56	1.56
3318090	812783	99596	0.1	0.05	9	41	24	350	10	12	22	1.99
3318091	815209	100930	0.05	0.05	10	52	42	560	14	17	23	2.18
3318092	812023	99774	0.05	0.05	16	36	49	2510	15	22	33	1.89
3318093	808628	98748	0.05	0.05	20	47	68	1560	20	33	72	2.85
3318094	807950	99268	0.05	0.05	15	48	55	1650	21	28	74	2.14
3318095	807880	99200	0.05	0.05	14	42	56	1560	15	27	66	2
		DL	0.1	0.1	2	2	1	2	2	2	1	0.001
		UNIT	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%
		METHOD	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS

Sample	AMGE	AMGN	Ag	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	Fe
3318096	807866	99150	0.05	0.05	20	43	83	2060	23	35	53	2.28
3318097	807881	99621	0.05	0.05	11	45	52	600	15	22	38	1.97
3318098	808036	99638	0.05	0.05	18	61	61	850	32	53	95	2.51
3318099	807350	99750	0.05	0.05	18	57	60	1530	26	30	76	2.49
3318100	807250	99575	0.05	0.05	11	59	48	690	25	21	57	2.16
3318107	805215	99076	0.05	0.05	33	46	92	2040	19	28	61	3.78
3318109	812050	109700	0.05	0.05	18	34	36	460	16	13	52	2.95
3318110	812150	109650	0.05	0.05	22	36	45	590	19	16	49	3.89
3318112	812150	108750	0.05	0.05	29	40	54	1650	19	14	36	3.49
3318113	811888	109084	0.05	0.05	24	36	40	1000	12	13	36	3.04
3318114	811900	109000	0.05	0.05	19	41	48	440	18	15	42	3.18
3318115	811385	108050	0.05	0.05	22	20	40	860	14	14	32	3.89
3318116	811395	107683	0.05	0.05	16	26	35	450	17	12	45	3.38
3318117	811200	107800	0.05	0.05	23	35	49	770	22	23	49	4.3
3319619	806200	99540	0.05	0.05	20	7	71	1620	8	32	79	3
3319623	808049	99647	0.05	0.05	14	10	49	1770	16	37	87	2.48
3319626	808274	99852	0.05	0.05	15	9	37	1810	24	35	49	2.18
3319627	808200	99720	0.05	0.05	17	10	49	1380	21	30	60	2.42
3319628	808575	99860	0.05	0.05	16	8	47	1450	16	30	82	2.38
3319635	805410	99651	0.05	0.05	25	3	125	1560	20	19	37	2.64
3319636	805300	99700	0.05	0.05	21	5	105	1430	17	24	38	2.7
3319647	805339	99647	0.05	0.05	29	8	155	3000	22	22	38	3.06
		DL	0.1	0.1	2	2	1	2	2	2	1	0.001
		UNIT	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%
		METHOD	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS

CRA EXPLORATION PTY LIMITED
STREAM SEDIMENT SAMPLE ASSAYS

Geologist: DC Palmer
Laboratory: Amdel
DPO: 71224

Programme: 1994 Reconnaissance Sampling
1:250 000 Sheet: Calvert Hills SE53-08
1:100 000 Sheet: Wollogorang 6463

Sample	AMGE	AMGN	Ag	As	Au	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Th	Ti	U	Zn
4124666	805055	8098898	0.3	5	<0.001	400	0.6	2800	0.4	25	25	115	44500	12300	20	2650	2200	0.8	370	12	640	15	0.5	5.4	4150	2.9	40
		DL	0.1	3	0.001	5	0.1	10	0.2	2	2	2	100	10	0.05	10	5	0.2	50	2	10	1	0.5	0.02	10	0.02	0.2
		UNIT	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
		SCHEME	IC3M	IC3M	FA3	XRF	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M	IC3M

APPENDIX 2

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

Rock Sample Ledger and Assay Results

CRA EXPLORATION PTY. LIMITED
ROCK ASSAY RESULTS

Tenement:	EL 7101 Sipos I	**Laboratory:**	Amdel, Darwin	**Programme:**	Follow-up Rock Sampling
Geologist:	D.C. Palmer 1992	**DPO:**	71050	**Map Reference:**	Calvert Hills SE 53-08
Date:	September 1992				

SAMPLE NO.	AMGE	AMGN	SAMPLE TYPE	WIDTH (m)	ROCK DESCRIPTION	Cd	Co	Cr	Cu	Fe	Mn	Ni	Ba	Au	Pb	Zn	Ag	As
3319624	808049	8099647	channel	4	Fissile, grey laminated ovoid-bearing dololutite	1.5	24	33	57	3.26	780	41	650		540	1260	0.05	40
3319625	808136	8099643	channel	2	Laminated black shale.	0.05	50	40	60	3.44	350	54	290		28	280	0.05	10
3319633	805700	8099650	channel	2	Grey to black lamianted shale/dololutite with minor concretions. 0-2m section	0.8	9	35	20	3.12	1190	26	280		185	270	0.05	60
3319634	805700	8099650	channel	2	as above 2-4m section.	1.4	12	50	15	4.02	850	33	270		130	280	0.05	40
3319645	805250	8099750	grab		Pink-brown bleached kaolinitic mudstone ?volcanic with iron-oxide voids.	0.05	65	1	500	1.09	310	53	470	<0.001	22	31	0.05	150
3319646	805268	8099615	grab		As above	0.05	35	1	260	1.11	260	13	430		63	75	0.3	10
					Method	AAS	AAS	AAS	AAS	AAS	AAS	AAS	XRF	FA3	AAS	AAS	AAS	AAS
					DL	0.1	2	2	1	5ppm	2	2	10	0.001	2	1	0.1	20
					Unit	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM

TAO:SIP:GEOCH:ROCK2.XLS

CRA EXPLORATION PTY LIMITED
ROCK CHIP ASSAYS

Tenement: Sipos I EL 7101
Geologists: Palmer DC, Roiko HJ

Date: May 1991
Laboratory: Amdel, Darwin
DPO: 49199

1:250 000 Sheet: Calvert Hills SE53-08
1:100 000 Sheet: Wollogorang 6463

Sample	AMGE	AMGN	Sample Type	Description	Cu	Pb	Zn	Ni	Co	Fe	Mn	Bi	Cr	Ag	Mo	As	Au	Pt	Pd	Sb	U	W	Ba
2659017	808821	8097693	Chip	Ferruginous, weathered barytic veined and gossanous dolomite with malachite encrustations. Ovoid Beds Wollogorang Formation (unit 3)	14.90%	800	1.17%	94	330	11.20	17 000	150	<4	8	120	1040	70	<1	<1	310	32	<1	0.39
2659019	808821	8097692	Chip	Grey fine laminated dololutite. Rare malachite Wollogorang Formation. Ovoid Beds Unit 3	5760	27	140	7	23	0.32	320	30	44	2	20	70	<1	<1	<1	20	16	<1	0.13
				Unit	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%
				Method	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	FA3	FA3	FA3	XRF1	XRF1	XRF1	XRF1
				DL	2ppm	4ppm	2ppm	4ppm	4ppm	5ppm	4ppm	10ppm	4ppm	1ppm	1ppm	50ppm	1ppb	5ppb	1ppb	4ppm	4ppm	10ppm	10ppm

TAO:SIP:GEOCH:ROCK1.XLS

CRA EXPLORATION PTY. LIMITED
ROCK ASSAY RESULTS

Tenement: EL 7101 Sipos I
Geophysicist: N. Stoltz
Date: October 1991
Laboratory: Amdel, Darwin
DPO: 71021
Programme: Follow-up Rock Sampling
Map Reference: Calvert Hills SE 53-08

Sample No.	AMGE	AMGN	Sample Type	Width (m)	Description	Mag.Susc. (SI x10 -5)	Cd	Co	Cr	Cu	Fe%	Mn	Ni	Au	Ba	W	Pb	Zn	Ag	As	Bi	Mo
3204695	811310	8110500	Channel	2	Red Fe stained siltstone	45	<1	13	82	13	8.86	1370	11	<0.001	980	10	12	14	<1	-1	5	<1
3204696	811320	8110490	Channel	10	Barren sandstone	10	<1	2	93	23	1.74	1690	14	0.001	300	5	2	19	<1	-1	5	<1
3204697	811330	8110490	Channel	2	Dolosiltstone/Dolarenite.	25	<1	12	35	18	1.45	3680	13	<0.001	360	5	2	11	<1	-1	5	<1
					Cherty stroms																	
3204698	811335	8110490	Channel	2	Dolosiltstone/Dolarenite.	20	<1	26	25	145	1.37	4740	12	0.001	640	5	5	1	<1	-1	5	<1
					Cherty stroms																	
3204699	811340	8110490	Channel	2	Interbedded dolarenite/Dolosiltstone	20	<1	26	27	130	1.18	3230	16	<0.001	600	5	2	12	<1	-1	5	<1
3204700	811350	8110500	Channel	2	Interbedded dolarenite/dolosiltstone	25	<1	38	30	410	1.63	2140	26	<0.001	360	5	105	520	<1	-1	5	4
					Abundant cherty stroms																	
3204701	811355	8110500	Channel	3	Interbedded dolarenite/dolosiltstone	20	<1	57	66	460	2.06	2520	31	<0.001	410	5	210	1170	1	-1	5	3
					Abundant cherty stroms and sandstone																	
3204702	811360	8110490	Channel	2	Interbedded dolarenite/dolosiltstone	40	<1	35	48	250	2.18	2250	21	<0.001	2200	5	7	45	<1	-1	5	1
					Abundant cherty stroms and sandstone																	
					Brecciated, Fe stained.																	
3204703	811365	8110490	Channel	2	Siltstone flake clasts. Brecciated in	20	<1	27	49	98	2.72	1930	21	0.001	590	10	10	66	<1	-1	5	<1
					sandstone matrix. Fe stained																	
3204704	811365	8110480	Channel	2	Barren sandstone	10	<1	18	48	52	1.25	1700	19	<0.001	450	5	6	21	<1	-1	5	2
3204705	811370	8110470	Channel	2	Granite	80	<1	5	38	120	1.99	350	13	<0.001	640	10	2	19	<1	-1	5	1
3204706	811000	8110600	Channel	2	Red siltstone, breccia in granite matrix	80	<1	84	46	100	9.66	7150	23	<0.001	1700	10	5	66	<1	-1	5	1
3204707	811000	8110580	Channel	1	Red siltstone, breccia in granite matrix	80	<1	82	45	96	9.54	7830	23	<0.001	1700	10	5	68	<1	-1	5	2
3204708	810800	8110700	Grab	1	Granite (Target 5)	80	<1	13	21	4	5.32	1665	10	<0.001	650	5	8	20	<1	-1	5	<1
3204709	810790	8110700	Grab	2	Red siltstone, brecciated (Target 5)	50	<1	8	45	9	6.92	155	11	0.002	580	5	9	16	<1	-1	5	<1

Sample No.	AMGE	AMGN	Sample Type	Width (m)	Description	Mag.Susc. (SI x10 -5)	Cd	Co	Cr	Cu	Fe%	Mn	Ni	Au	Ba	W	Pb	Zn	Ag	As	Bi	Mo
3204710	810790	8110700	Channel	2	Red siltstone, brecciated (Target 5)	50	<1	5	44	16	5.2	77	7	0.005	520	5	8	14	<1	-1	5	<1
3204711	810800	8110525	Grab		Red siltstone/sandstone (Target 5)		<1	11	57	58	8.4	310	16	<0.001	740	5	21	29	<1	-1	5	<1
3204712	810750	8110450	Grab	2	Volcanic and green vesicules (glauconite) Fe stained (Target 5)	78	<1	58	38	15	8.28	740	34	0.001	920	5	8	59	<1	-1	5	<1
3204713	810800	8110450	Grab	2	Volcanic and green vesicules (glauconite) Fe stained (Target 5)	75	<1	60	29	20	8.72	1030	29	0.003	830	10	14	35	<1	-1	5	<1
3204831	811300	8110500	Channel	5	Buff/green sandstone Barren. Upper Wollogorang	20	<1	2	87	17	2.34	170	15	<0.001	350	5	10	36	<1	-1	5	<1
					METHOD		AAS	AAS	AAS	AAS	AAS	AAS	AAS	FIRE	XRF	XRF	AAS	AAS	AAS	AAS	AAS	AAS
					DETECTION LIMIT		1	4	4	2	5	4	4	0.001	10	10	4	2	1	50	10	1
					UNITS		PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM

CRA EXPLORATION PTY. LIMITED
ROCK CHIP ASSAYS

Tenement: EL 7101 Sipos I
Geologist DC Palmer
Date: June 1991, October 1991

Laboratory: Amdel, Darwin
DPO: 71004, 71024

Programme: Follow-up Rock Sampling
Map Reference: Calvert Hills SE 53-08

Sample No.	AMGE	AMGN	Sample Type	Width (m)	Description	MAG SUSC. SI x10 -5	SCINT CPS	Cu	Pb	Zn	Ag	As	Ni	Co	Au	U	Th	Ba	Cr	Fe	Mn	Bi	Mo	W	Cd
3204816	816200	8101950	Channel	4	Pink volcanics from possible "plug" on side of hill (Target 10)			100	9	35	<1	25	15	15	<0.001			1140	41	2.12	540	5	1	5	<1
3204817	816000	8102950	Channel	2	Weathered Fe stained dolosiltstone/dolarenite Target 10	40-80		19	5	26	<1	25	35	14	<0.001			290	26	3.84	810	5	<1	5	<1
3204818	816000	8102940	Grab	-1	Green/purple/brown dolosiltstone/dolarenite Fe stained Target 10	2500		8	2	27	<1	25	36	11	<0.001			510	55	5.06	900	5	<1	5	<1
3204819	816010	8102940	Grab	-1	Weathered Fe stained green/brown dolarenite/ dolosiltstone. Target 10	2000		20	14	62	<1	25	42	28	<0.001			2100	39	11.5	790	5	<1	5	<1
3204820	816030	8102950	Channel	4	Quartz magnetite. Massive magnetite	40 000 - 100 000		19	15	36	<1	25	75	22	0.004			100	2	51	470	5	<1	5	<1
3204821	814800	8102800	Channel	5	Barren coarse sandstone			97	1030	120	<1	25	27	17	<0.001			370	240	1.72	1990	5	3	5	<1
3204822	814790	8102810	Grab	0.1	Cream/grey dolosiltstone from thin bed within sandstone			145	23	165	<1	25	19	14	<0.001			2200	17	6.76	1420	5	3	5	<1
3204823	814780	8102820	Channel	8	Fe Rich sandstone			51	46	135	<1	25	13	12	<0.001			310	23	1.36	1200	5	2	5	<1
3204824	814760	8102820	Channel	8	Fe rich sandstone			81	35	490	<1	25	51	20	<0.001			1660	19	3.52	2560	5	6	5	<1
3204825	814750	8102820	Channel	4	Cream/grey dolosiltstone			54	19	105	<1	25	15	9	<0.001			3300	12	1.49	770	5	9	10	<1
3204826	814740	8102810	Channel	4	Purple/pink Fe stained dolosiltstone		250	115	140	450	<1	130	37	20	<0.001			2300	21	9.5	1360	5	7	5	<1
3204827	814730	8102810	Channel	2	Purple/grey Fe stained dolosiltstone Ovoids		250	145	83	550	<1	200	52	20	<0.001			2800	14	5.64	2440	5	10	10	<1
3204828	814720	8102810	Channel	2	Red/grey Fe stained dolosiltstone		250	110	35	140	<1	25	30	20	<0.001			3300	8	3.94	2340	5	<1	5	<1
3204829	814710	8102810	Channel	2	Grey/red/buff Fe stained dolosiltstone/ dolarenite ovoids		250	59	46	175	<1	150	28	13	<0.001			2950	44	3.82	1350	5	2	5	<1
3204830	814700	8102810	Channel	2	Grey/buff Fe stained dolosiltstone ovoids		250	80	74	350	<1	60	42	11	<0.001			2550	40	2.36	1050	5	3	5	<1
3204018	816025	8102923	Chip		Interlayered micaceous, fissile red-brown SILTSTONE with crossbedded dolomitic ARENITE			7	10	41	<1	50	8	18	0.02	10	18	600	24	13.3	230	<10			
						Method		AAS	AAS	AAS	AAS	AAS	AAS	AAS	FA3	XRF1	XRF1	XRF1	AAS	AAS	AAS	AAS	AAS	XRF	AAS
						DL		PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM
						DL		2	4	2	1	50	4	4	0.001	4	4	10	4	5ppm	4	10	1	10	1

APPENDIX 3

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

RC Drill Ledger and Assay Results

CRA EXPLORATION PTY LIMITED

PD93SP4 DRILL LOG PROJECT EL 7101 Sipos I

CO-ORDINATES 6700mE 10220mN AZIMUTH ____ DRILLERS THOMPSON DRILLING COMMENCED 22/9/93 DEPTH 28m HOLE SIZE 5¼inch

LOGGED BY BH NEWELL INCLINATION -90° DRILL TYPE ATLAS COPCO B80 COMPLETED 22/9/93 CASING LEFT ____ DPO NOS 71139

Depth (m)		Core	Core			Sample	From	To	Rec.	Magnetic Susceptibility
From	To	Rec.	Size	Log	Geology	Number	(m)	(m)	(m)	SI x 10 -5
0	2				Grey sand, red brown laterite, yellow brown siltstone Fe stained	3746891	0	2		200
2	4				Yellow brown siltstone - drey green soapy chlorite altered siltstone	3746892	2	4		200
4	6				Gray green soapy choritel altered siltstone. Fe and manganese stained. Calcite vein at 5.5m	3746893	4	6		30
6	8				Cream coloured manganese stained dolomite with green stained Cu (?)	3746894	6	8		30
8	10				Chocolate brownn to grey green sandy siltstone, partly dolomitic	3746895	8	10		80
10	12				Yellow brown siltstone and sandy siltstone; Fe manganese stained. Some fine laminations	3746896	10	12		200
12	14				Light brown ferruginous weathered volcanic (accircular crystals) manganese stained	3746897	12	14		300
14	16				Yellow brown clay and grey green clay (magnetic)	3746898	14	16		3000
16	18				Kahki brown clay. Fragments of light grey & yellow brown layered mafic volcanic	3746899	16	18		1000
18	20				Green brown clay. Fragments of yellow green weathered mafic volcanic	3746900	18	20		2000
20	22				Light grey powder - fragments of dark grey green mafic volcanic. Magnetite crystals.	3746901	20	22		10000
22	24				Light - dark grey green mafic; fine grained; disseminated magnetite; rare pyrite	3746902	22	24		
24	26				Dare grey green mafic volcanic with magnetite crystals. Calcite veinlets	3746903	24	26		30000
26	28				Dark grey very fine grained mafic volcanic with fine magnetite, rare pyrite.	3746904	26	28		15000
						E of H				

SUMMARY 0-1m Sand & laterite

1-12m Siltstone, dolomite stln. Rare malachite

12-28m Mafic volcanic, disseminated magnetite, rare py

LOGGED BY BHN DATE 22/9/93

SHEET 1 OF 1

TAO:SIP:GEOL:DRIL:SIP4

Job: 3DN0942
O/N: DPO 71139

Final

ANALYTICAL REPORT

SAMPLE	Cu	Pb	Zn	As	Ag	Cd	Co
3746891	82	20	49	<50	<1	<1	33
3746892	120	43	81	<50	<1	<1	39
3746893	170	30	210	<50	<1	4	20
3746894	135	32	180	<50	<1	4	47
3746895	115	15	310	<50	<1	2	39
3746896	62	12	220	<50	<1	4	55
3746897	23	8	130	<50	<1	4	33
3746898	74	9	98	<50	<1	6	90
3746899	23	10	47	<50	<1	<1	56
3746900	40	12	49	<50	<1	<1	73
3746901	120	16	45	<50	<1	<1	120
3746902	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.	L.N.R.
3746903	14	10	32	<50	<1	<1	35
3746904	24	8	30	<50	<1	<1	35

UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	2	4	2	50	1	1	4
SCHEME	AA1	AA1	AA1	AA1	AA1	AA1	AA1

Job: 3DN0942
O/N: DPO 71139

Final

ANALYTICAL REPORT

SAMPLE	Fe	Mn	Ni	Cr
3746891	6.22%	1420	12	37
3746892	7.98%	3100	16	44
3746893	4.40%	3250	17	35
3746894	3.70%	3560	17	32
3746895	6.24%	6410	30	32
3746896	8.72%	5190	24	36
3746897	8.30%	6640	25	32
3746898	14.8%	1800	95	38
3746899	11.7%	1160	55	34
3746900	16.3%	1350	71	39
3746901	17.1%	1590	130	45
3746902	L.N.R.	L.N.R.	L.N.R.	L.N.R.
3746903	18.4%	1250	50	42
3746904	10.5%	1080	38	37
UNITS	ppm	ppm	ppm	ppm
DET.LIM	5	4	4	4
SCHEME	AA1	AA1	AA1	AA1

APPENDIX 4

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

Mineralogical Reports

Pontifex & Associates Pty. Ltd.

TEL. (08) 332 6744
A.H. (08) 31 3816
FAX (08) 332 5062

26 KENSINGTON ROAD, ROSE PARK
SOUTH AUSTRALIA

P.O. BOX 91, NORWOOD
SOUTH AUSTRALIA 5067

MINERALOGICAL REPORT NO. 5861

by A.C. Purvis, PhD

April 3rd 1991

TO:	David Palmer/H.J. Roiko CRA Exploration 18 km post, Stuart Hwy BERRIMAH NT 0828
COPY TO :	D.C. Palmer CRA Exploration Pty Ltd PO Box 39598 WINELLI NT 0821 Chief Info. Officer CRA Exploration Pty Ltd PO Box 3709 MANUKA ACT 2603
YOUR REFERENCE:	DPO 49200
MATERIAL:	Rock Samples (5)
IDENTIFICATION:	2659008, 010, 013, 016, 018
WORK REQUESTED:	Thin and polished section preparation and description.
SAMPLES & SECTIONS:	Returned to your Berrimah address with this report.

A.C. Purvis

PONTIFEX & ASSOCIATES PTY. LTD.

2659018

Heterogeneous agregate of hydrothermal 'vein' minerals, including zones of limonite stained probable siderite, with patches of calcite, malachite and barite, alternating with zones of malachite, some incorporating extremely fine inclusions of chalcocite, rarer cuprite, also calcite, and scattered limonite replicas after pyrite.

This is a heterogeneous rock of apparently vein or hydrothermal origin. The bulk of it is composed of limonite stained oxidised probable siderite grains, partly as curved crystals. Smaller areas of calcite, with barite and patches of malachite, are present within the siderite.

Larger, irregular patches of malachite and calcite are present to 40mm long. These contain small pyrite cubes, mostly pseudomorphically altered to limonite, but with rare fresh cores. Very minor azurite is present within the malachite.

One patch of malachite is crowded with abundant extremely fine (1 to 100 microns) chalcocite (variably 5 to 15% in different local micro domains), accompanied by rarer but equally fine cuprite. Fine needles of goethite or lepidocrocite accompany the chalcocite + cuprite inclusions in malachite.

Pontifex & Associates Pty. Ltd.

TELEPHONE (08) 332 6744
FAX (08) 332 5062

26 KENSINGTON ROAD, ROSE PARK
SOUTH AUSTRALIA 5067
A.C.N. 007 521 084

P.O. BOX 91, KENT TOWN
SOUTH AUSTRALIA 5071

MINERALOGICAL REPORT NO. 6390

by A.C. Purvis, PhD

June 22nd, 1993

TO:	Mr David Palmer / H.J. Roiko CRA Exploration Pty Ltd 18 km post, Stuart Hwy BERRIMAH NT 0828
COPY TO :	Mr A.J. Webb CRA Exploration Pty Ltd PO Box 39598 DARWIN NT 0800 Information Officer CRA Exploration Pty Ltd PO Box 3709 MANUKA ACT 2603
YOUR REFERENCE:	DPO No. 71115
MATERIAL:	Rock Samples
IDENTIFICATION:	746021 to 6025
WORK REQUESTED:	Polished thin section preparation and description, with comments as specified, selected photomicrographs.
SAMPLES & SECTIONS:	Returned to your Berrimah address with this report.

PONTIFEX & ASSOCIATES PTY. LTD.

3746025

Unsorted pebbly quartz sandstone with altered lithic, partly volcanic fragments; minor malachite and azurite, disseminated and in veins; also limonite and leucoxene.

This unsorted pebbly sandstone has rare large detrital grains to 15 mm long, in a quartz rich sandy matrix dominated by single crystal and polycrystalline quartz grains 0.2 to 2 mm in size. Grains of microcline and of granophyre are also present, as are abundant clay-limonite ± quartz altered lithic, partly volcanic, grains. The largest grain in this thin section is a largely leached, clay-limonite-quartz altered possibly glassy-volcanic grain. There is minor detrital muscovite, and a fine clay-limonite-quartz matrix.

Several poorly defined patches and veins of fine secondary copper minerals (malachite and azurite) occur in some of the fragments, in the matrix, and in fracture-veins. There is also some limonite which may be after fine pyrite, and leucoxene is disseminated.

APPENDIX 5

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos

Integrated Field and Petrographic Studies
South-East McArthur Basin Project
Report 2014 Mason Geoscience Pty. Ltd.

TITLE	**Integrated Field and Petrographic Studies, South-East McArthur Basin Project.**
REPORT #	2014
CLIENT	CRA Exploration Pty. Ltd.
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Integrated Field and Petrographic Studies,

South-East McArthur Basin Project

VOLUME 1

SUMMARY

Field and petrographic studies in the southeast McArthur Basin have provided bases for understanding the genesis and exploration potential of rock units in the mid-Proterozoic Tawallah Group.

Trachytic cryptodomes that intrude the Wollogorang Formation formed as minor differentiates from underlying basaltic magmas, possibly expressed as doleritic intrusions of the Settlement Creek Volcanics. Important corollaries of these genetic relationships are: i) The trachytic cryptodomes are similar in age to the Wollogorang Formation; ii) Doleritic sills in the Settlement Creek Volcanics may be of a similar age to the cryptodomes. Trachyte autobreccias formed during emplacement of the viscous silicic magmas, and breccia pores were later partly filled by genetically unrelated hydrothermal quartz-barite-sulphide mineralisation. Potential exploration objectives include known mineralised locations (China Workings, Dingo Rock), as well as possible subsurface brecciated cryptodomes.

Hobblechain Rhyolite formed as an ignimbrite in a single cooling unit. It differs in mineralogy, texture, and occurrence from the trachytic cryptodomes, and is considered to represent a deep crustal high-silica partial melt. No known mineralisation occurs within the Hobblechain Rhyolite, but it retains mineralisation potential as an impermeable cap horizon for reaction with hydrothermal fluids localised by faulting.

Packsaddle Microgranite is closely similar in mineralogy and texture to the Hobblechain Rhyolite. It represents the subvolcanic intrusive equivalent of the ignimbrite sheet, and both units formed during a single cauldron-subsidence event. Mineralisation is unknown within the Packsaddle intrusion, but magnesian-Fe(-Cu-Zn) skarns formed in the contact zone which remains prospective for such deposits.

Stratabound base-metals mineralisation occurs in a variety of rock types in the Wollogorang Formation. Porous quartzose sandstones were favourable horizons for deposition of base-metals (Cu-Pb-Zn-Co) sulphide mineralisation with associated gangue cements (quartz, dolomite, barite). Dolomitic rocks contain disseminated base-metal sulphides, but it is not known whether the metallic components were introduced or represent primary sedimentary materials.

Basic igneous rocks, including extrusive basalts and intrusive dolerites, are interspersed through the sedimentary rocks, in places warranting formational status. Most display low-grade alteration including destruction of primary ferromagnesian minerals (mainly pyroxene), with consequent liberation of trace base metals (Cu, Zn, Pb, Co). Although not specifically demonstrated in this work, it is considered that remobilisation of the metals in a basinal hydrothermal fluid is likely to have been enhanced by contributions from alkali- and Cl-rich evaporitic sediments within the sedimentary sequence. Redeposition of the metals occurred in suitable structures, and in or below suitable reactive horizons.

1. INTRODUCTION

Following telephone discussions with Mr. David Palmer, Mr. John Roiko, and Mr. Bruce Harvey (CRA Exploration Pty. Ltd., Darwin, NT) in March 1994, a contractual agreement was reached for Dr. Doug Mason of Mason Geoscience Pty. Ltd. to provide integrated field and petrological studies for particular areas of the southeast McArthur Basin project region.

Agreed objectives were:

i) Field studies of selected target areas to provide a semi-regional perspective on volcanic/igneous rock relationships and possible mineralisation controls.

ii) Elucidate the temporal and spatial relationships of target stratigraphic sequences and volcanic/igneous units within the "upper" portions of the Tawallah Group.

iii) Prepare thin and polished thin sections of selected rock samples, with detailed petrographic and mineragraphic descriptions and accompanying colour photomicrographs.

iv) Provide a comprehensive written report containing:

- All petrological data, geochemical data, field observations and petrogenetic interpretations.

- Recommendations for future exploration programs within the selected target areas.

Preliminary petrographic observations and interpretations were provided to Mr. David Palmer and Mr. John Roiko by telephone and facsimile communications.

This report contains the full results of these studies.

2. METHODS

2.1 Field Studies

The period 15-26 April 1994 was spent working with personnel of CRAE Pty. Ltd., in Darwin and at the field site in the southeast McArthur Basin in the vicinity of Wollogorang Station, near the Northern Territory - Queensland border. The studies have been confined to the upper parts of the mid-Proterozoic Tawallah Group, the oldest Group in the McArthur Basin (Jackson et al., 1987, Fig. 4).

In the field area, full support was provided by CRAE including helicopter and vehicle transport, and access to data sets. Rock samples were taken by sledge hammer and geological pick from suitable exposures of relevant rock units. Suitable sites for study were initially selected by CRAE personnel with experience in the area, and some more detailed studies were made by personal selection of particular sites. A Brunton compass was used to measure dips and strikes in some critical locations. All sample locations were identified by Australian Magnetic Grid (AMG) reference.

A total of 18 samples was collected, as listed Appendix 2 (Volume 2). Sample locations are presented on Plan NTd 6286.

2.2 Rock Assays

Samples were analysed for the regular suite of elements normally obtained by CRAE. The elements were Ag, As, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, V, Zn, Ba, U, Th, Au, Pt, and Pd. Not all samples were analysed for the last 5 elements.

Comments provided by the analytical laboratory indicate that K values >10000ppm may be suspect due to the particular technique used. Therefore, interpretations in this work involving K-rich rocks must be treated with caution.

2.3 Petrographic and Mineragraphic Descriptions

The samples selected for detailed microscopic study were divided into two groups and despatched to different laboratories (Pontifex & Associates; Amdel Limited) for more rapid preparation of sections.

Section offcuts were stained for K-feldspar using the conventional sodium cobaltinitrite method. Each offcut was etched in HF for ~5 seconds, rinsed, covered with freshly-made saturated solution of sodium cobaltinitrite, and finally rinsed. Where present, K-feldspar accepts a yellow stain.

Conventional transmitted polarised light microscopy was used to prepare routine petrographic descriptions from the thin sections. Additional mineragraphic observations were made using reflected light microscopy from the polished thin sections.

Colour photomicrographs were prepared of particular mineralogical and microtextural features deemed relevant to the objectives of the study.

3. DISCUSSION

3.1 Trachytic Cryptodomes

3.1.1 Field Characteristics and Distribution

A significant number of trachytic igneous bodies, variously termed "volcanic necks" or "plugs", occur in an area to the NW and W of Wollogorang Station (Orridge & Mason, 1975, Fig. 1). They have been the focus of some exploration interest, mainly due to the presence of Cu mineralisation at the China Workings location (see Table 1), and their possible relationships with mined Cu mineralisation at Redbank (Orridge & Mason, 1975; Knutson et al., 1979).

These bodies share consistent field characteristics:

i) They form rounded knob-like bodies that stand proud of the local erosional level. Some may only display a few metres of relief, but others are up to ~20-30m high.

ii) In hand specimen they are massive, fine- to medium-grained crystalline rocks, with a dull orange-pink colour. Beautifully spheroidal amygdales may be present in places, but are not common. They are filled mainly by quartz, but other phases may include malachite, clays (celadonite), and rare sulphide.

TABLE 1: SITES OF STUDIED TRACHYTIC CRYPTODOMES

Site	AMG E	AMG N	Comments
1	813000	8099600	Small knob north of Dingo Rock
2	811500	8098300	Small prominent knob, brecciated seds. but no trachytic rocks
3	808800	8097500	Small intrusive body with flow-banded surfaces

TABLE 2 : SAMPLES FROM CRYPTODOMES

Sample No.	AMG E	AMG N	Field Rock Name
4124261P	808800	8097500	Trachyte
4124276P	809800	8101500	Trachyte
4124262P	808800	8097500	Flow-banded trachyte flow breccia

Note: The suffix "P" attached to the sample number indicates a petrographic description is available in this report.

iii) Flow-banded finer-grained variants can be observed to grade rapidly over a distance of <1m downwards into the more massive rock type. These features are well-displayed at trachyte site 3 (Table 1).

iv) In places they clearly intrude and disrupt fine-grained, bedded to laminated sedimentary rocks of the Wollogorang Formation. Discordant relationships are observed at site 3 (Table 1). Hornfelsing of the wall rocks has not been observed: this is consistent with the relatively small size of the trachytic bodies (metres to tens of metres), and with the inferred near-surface level of emplacement.

v) Brecciation is commonly present. In some places it is very localised on the scale of centimetres, and may be accounted for by autobrecciation during emplacement. In other locations brecciation may be widespread throughout the body; crude E-W alignment of quartz-filled subvertical veins produces a crackle-breccia structure.

All of these features are consistent with a cryptodomal mode of emplacement for these bodies, that is, development of relatively small intrusive/extrusive igneous bodies at or near the contemporary depositional surface. In particular, the presence of intrusive relationships and the transitions from flow-banded to massive types are strongly suggestive of emplacement at very shallow levels. There is no evidence that these rocks formed extensive sheet-like bodies such as lava flows. Rather, they appear to have formed shallow intrusive to extrusive bodies of limited size, which is entirely consistent with their silicic bulk compositions of high viscosity.

The trachytic cryptodomes are distributed in a wide region, but commonly within the Wollogorang Formation. There is no evidence that they occur in stratigraphically higher formations. They may therefore be similar in age to the Wollogorang Formation. Their distribution is considered significant, because it allows them to be associated with suitable basaltic parental magma sources at depth, such as the Settlement Creek Volcanics.

4.1.2 Mineralisation

Mineralisation, where present, occurs as breccia- and vein-fillings, and fillings in amygdales. Quartz is by far the most common mineral, and is abundant at all sites. It fills or partly fills localised breccia pores, or it may be the principal mineral in a wider vein network. Bright green malachite may be abundant locally, but is highly irregular in distribution. Barite, where present, may accompany the quartz and malachite in the breccia fillings.

K-feldspar is notably absent from the vein- and breccia-fillings. Rarely, K-feldspar occurs in trace amounts on some vein walls but is absent from thicker veins. This suggests that some alkali exchange occurred between the K-rich wall rock and vein solutions, resulting in deposition of K-feldspar only in thinner veins where higher degrees of exchange occurred with wall rock. The general lack of K-feldspar in the quartz-rich veins suggests that potassium was not abundant in the hydrothermal fluids, and was therefore not available for pervasive alteration of the wall rock. This is consistent with the petrographic observations (see below) that most of the K-feldspar is of relict primary origin.

Clearly, rock preparation in the form of brecciation or fracturing was very important in allowing access of metal-bearing hydrothermal fluids into the cryptodomes.

3.1.3 Petrography

Petrographic study of approximately 20 trachytic rock samples reveals the following significant features:

i) The rocks display a massive, aphyric igneous texture (PLATES 14-15). Phenocrysts of any type are notably absent. Some samples are sparsely amygdaloidal, but vesiculation was not common during emplacement.

ii) Orthoclase is the dominant mineral, commonly occurring in two modes: as a network of simply-twinned, subhedral prismatic crystals, and as anhedral interstitial aggregates (PLATE 15). The textural forms of the orthoclase are consistent with an essentially primary igneous occurrence. This is supported by the common presence of moderately abundant acicular apatite crystals within the interstitial orthoclase.

iii) Plagioclase was present as a primary igneous phase in most samples. It formed elongated prismatic crystals, but commonly displays replacement by minute illitic clay flecks (PLATE 15). Replacement by orthoclase is not common, but it may be mantled by orthoclase. Variation in the ratio of inferred primary plagioclase / orthoclase suggests that a range of primary compositions was developed in these rocks: from monzonitic compositions in which subequal proportions of plagioclase and orthoclase were present, to syenitic compositions in which plagioclase was minor or absent and orthoclase commensurately more abundant. These variable feldspar proportions are reflected in the variable rock type names given to these samples in the petrographic descriptions.

iv) Primary quartz may have been present in variable amounts. Particular features that support the interpretation that at least some quartz was primary are: relatively uniform distribution, interstitial occurrence, single-crystal (as distinct from polycrystalline) form of many interstitial grains, and projection of accessory apatite needles from interstitial orthoclase into quartz.

v) Ferromagnesian crystal sites are notably absent, except for accessory magnetite and ilmenite. Cubic compared with lath-like morphologies provide petrographic distinction of the two primary Fe-Ti oxide phases (PLATE 15). Skeletal cubic morphologies are commonly displayed by the magnetite, a feature consistent with relatively rapid crystallisation in a shallow intrusive magma.

All of these features suggest that the trachytic rocks represent a range of relatively evolved subvolcanic rock types that are related to each other by normal magmatic differentiation processes.

3.1.4 Alteration

Pervasive alteration is common in all samples, but varies in intensity from low to moderate. Particular petrographic features of the alteration are:

i) Plagioclase (where present) has suffered partial to complete replacement by minute illitic clay or sericite flecks and, rarely, by orthoclase.

ii) Orthoclase commonly displays a diffuse buff-coloured incipient alteration of optically indeterminate nature: it most likely is submicron-sized hematite, but may also include clays.

iii) Quartz may fill continuous and discontinuous veins, and some interstitial quartz patches are polycrystalline in nature. Most quartz occurs as fillings of breccia pore spaces (see vi below). Small opaque grains may occur in the quartz (PLATE 14).

iv) The Fe-Ti oxide accessory crystal sites (magnetite, ilmenite) have commonly suffered complete replacement by microgranular leucoxene, and small rutile crystals may occur within polycrystalline interstitial quartz patches.

v) Very rarely, equant apatite crystals may occur within thin, discontinuous quartz patches.

vi) Brecciation is commonly localised, but may be pervasive through some of the cryptodomes. At that location, a crackle-breccia quartz vein network is developed, grossly oriented subvertical and E-W. These structures lie subparallel to the "Redbank trend", and therefore appear to be later superimposed structures.

3.1.5 Assays

Selected assays for all trachytic rock samples are presented in Table 3.

TABLE 3: SELECTED ASSAYS FOR TRACHYTIC ROCK SAMPLES

SAMPLE	Ag	As	Ba	Ca	Co	Cr	Cu	K
Detection limit	0.5	3	5	10	2	2	2	5
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
4124261P	1	30	3400	2100	4	35	160	16000
4124262P	<1	13	870	3150	11	30	260	18000
4124276P	<1	15	4850	49500	145	6	710	16700

SAMPLE	Mg	Mn	Mo	Na	P	Pb	V	Zn
Detection limit	10	5	2	10	10	5	2	10
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
4124261P	2050	100	4	690	1300	25	165	12
4124262P	1400	115	9	420	1820	60	80	14
4124276P	20000	1220	2	830	2050	<5	300	15

Note: All assays are presented in ppm units for consistency. 1000ppm = 0.1%.

Some significant points emerge:

i) Potassium consistently ranges within rather narrow limits (~1.5-2.0% K). This supports an essentially primary elemental signature, and reflects the relatively high abundance of relict primary orthoclase in the rocks. If pervasive alteration were responsible for the distribution of orthoclase, a much more variable range of K contents would be expected. (But note the caution with respect to K analyses in this suite).

ii) The base metals display widely variable levels of abundance. Cu commonly lies in the hundreds of ppm range, and ranges into percentage levels where malachite is abundant in breccia pore fillings. Pb and Zn display sympathetic variations (Fig. 1), but their mineral sites have not been specifically determined in this study. It is likely they are present in small amounts as galena and sphalerite, or oxidation phases derived from them.

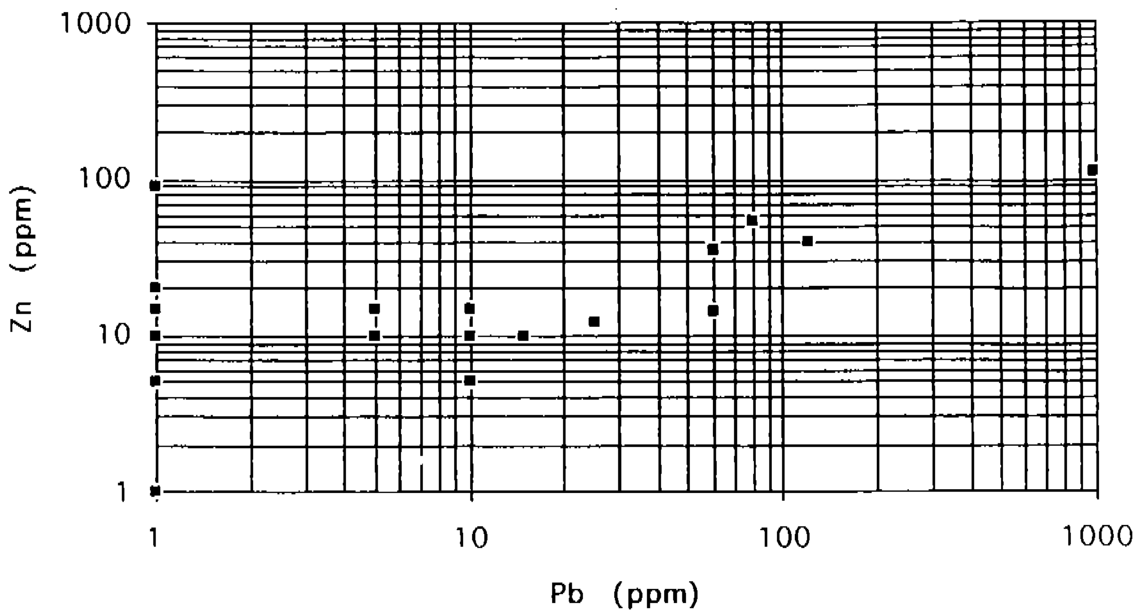

FIG.1: Plot of Zn vs Pb for trachytic rock samples. For plotting purposes, arbitrary values of 1ppm Pb were assigned to those samples with Pb below the detection limit.

iii) Ag and As are uniformly low, but are more abundant in those samples rich in Cu, Pb and Zn. Clearly, these elements are displaying their chalcophilic behaviour in the sulphide-bearing alteration systems that have affected the trachytic rocks.

iv) The transition metals display variable behaviour. Cr and V are relatively constant, owing to relative immobility under the low-grade alteration conditions that have affected the trachytic rocks. In contrast, Co displays major increases up to hundreds of ppm in those samples rich in Cu, Pb and Zn; Co thus displays geochemical behaviour in these rocks more akin to the chalcophilic base metals than to the "immobile" transition metals.

3.1.6 Petrogenesis

The petrogenesis of the trachytic rocks may be inferred from the characteristics described above:

i) The field characteristics indicate that only relatively small quantities of trachytic magma gained access to their level of emplacement, but they gained access over a wide area tens of km in lateral extent. Although impossible to demonstrate, it is also likely that the trachytic magmas were originally generated in relatively small amounts, such as produced by differentiation of basaltic magma (~5% of original bulk).

ii) The petrographic features indicate that the trachytic magmas were magmatically related, most probably by simple differentiation processes. Further, their lack of phenocrysts is strong indication that *they were generated within a short distance of their final level of emplacement*. All magmas are at or near their liquidus temperature when generated (i.e.

they are not superheated), and any significant uprise accompanied by cooling will cause crystallisation of near-liquidus phases. Porphyritic textures are therefore common in magmas that have risen a significant distance from their source.

3.1.7 Conclusions and Exploration Prospects

i) The trachytic rocks formed by high-level subvolcanic emplacement of cogenetic evolved felsic magmas.

ii) The felsic magmas formed by differentiation from a nearby, more mafic parental magma. Suitable magmas occur in the Settlement Creek Volcanics, located within tens to a few hundred metres stratigraphically beneath the cryptodomes.

iii) Mineralisation (quartz-barite-sulphide) is unrelated to the magmatic evolution of the trachytic rocks. Rather, it is related to subsequent circulation of hydrothermal fluids, possibly of basinal origin, with deposition in suitably prepared structural sites, particularly trachytic autobreccia pore spaces, and in fracture systems related to the "Redbank trend". Subsequent oxidation has modified the primary hydrothermal assemblage, producing abundant malachite. A mitigating observation is that, in places, pore-filling minerals are absent only centimetres from pores that are completely filled. This indicates that hydrothermal fluids gained only partial access to the prepared wall rock, and must limit the prospects for complete mineral development in all breccia sites.

iv) Prospects for mineralisation include the following:

- Large breccia bodies that have accepted abundant pore-filling mineralisation.

- Subsurface occurrences of brecciated cryptodomes should be considered as targets. They may be difficult to identify geophysically, given their small size compared with the large bulk of basaltic or doleritic rock from which they were derived and above which they are inferred to occur.

3.2 Packsaddle Microgranite

3.2.1 Previous Work

Early work (Yates, 1972) identified the intrusive nature of the Packsaddle Microgranite, with vertical flow banding at the chilled contacts, recrystallisation of dolomites in wall rocks of the Wollogorang Formation, and doming of the enclosing Gold Creek Volcanics (Yates, 1972, p.12). Thin contact aureoles were reported by Jackson et al. (1987, p.44).

The comagmatic relationship between the Packsaddle Microgranite and the Hobblechain Rhyolite was also proposed by early workers. Yates (1972) considered that the Hobblechain Rhyolite is "extrusive equivalent of Packsaddle Microgranite" (Yates, 1972, Table 1). Grimes and Sweet (1979, Table 2) note that the Hobblechain Rhyolite "appears to merge to W into Pgr with which it is comagmatic."

Ahmad and Wygralak (1989), referencing the work of Darby (1986), note that "...the Packsaddle Microgranite and Hobblechain Rhyolite are probably comagmatic...".

3.2.2 Field Characteristics

Two traverses have been conducted through the Packsaddle Microgranite: one through the centre of the body down the gorge cut by Redbank Creek, and one on the eastern margin of the Packsaddle Microgranite where it grades into Hobblechain Rhyolite.

In hand specimen, the Packsaddle Microgranite is virtually indistinguishable from the principal rock type of the Hobblechain Rhyolite. It contains the same uniformly distributed cream to pink or brown feldspar crystals and translucent grey quartz crystals in a pinkish to mauvish brown groundmass. These macroscopic similarities made it impossible to distinguish a contact between the two units at the eastern boundary of the Packsaddle Microgranite.

3.2.3 Petrography

The petrographic features of the Packsaddle Microgranite are very similar to those described for the principal rhyolite porphyry of the Hobblechain Rhyolite. Partly resorbed quartz phenocrysts, and partly clay- and hematite-altered orthoclase phenocrysts, are sparsely scattered through a recrystallised micrographic groundmass dominated by orthoclase and quartz.

Small accessory zircon crystals are present. They are identical in form and abundance to those observed in the Hobblechain Rhyolite. These observations substantiate the very similar Zr abundances in both units (~400ppm; Knutson et al., 1979, Table 2).

In general, the groundmass texture of the Packsaddle Microgranite is very similar to that observed in higher levels of the Hobblechain Rhyolite. This is consistent with more intense degrees of recrystallisation in the upper parts of the Hobblechain ignimbrite, compared with basal parts where finer-grained devitrified basal-surge tuffs are present. Slight variations are observed in the groundmass: samples taken near the contact or in marginal dyke rock display finer-grained groundmasses.

3.2.4 Assays

Assays for one sample of Hobblechain Rhyolite is presented in Table 4.

TABLE 4: ASSAYS FOR HOBBLECHAIN RHYOLITE

SAMPLE	ROCK NAME	FORMATION	Ca	K	Mg	Na	Ni	Cu	Pb	Zn
Det. Limit			10	5	10	10	2	2	5	10
Unit			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
4124023P	Rhyolite porphyry	Hobblechain	360	15300	940	1750	7	7	10	13

3.2.5 Prospects for Exploration

There appear to be few prospects for exploration *within* the Packsaddle Microgranite. This is attributed to the single intrusive event (lack of multi-phase intrusive activity) operating in a very shallow crustal environment.

Prospects for Fe(-Cu-Zn) skarn mineralisation in the Packsaddle aureole are reasonably good, given that such mineralisation has been demonstrated by previous drilling and the present petrographic work. Such mineralisation is most likely to occur in direct contact with suitable reactive wall rocks, particularly dolomites of the Wollogorang Formation. The clear association of chalcopyrite with magnetite provides a strong geophysical objective for exploration: the larger and more intense the geomagnetic response, the more abundant magnetite is likely to be, with increased likelihood of higher abundances of chalcopyrite and minor sphalerite. These considerations suggest some particular guides to locating potential skarn ore sites:

i) More intense magnetic anomalies within the contact aureole.

ii) Coincidence of Wollogorang Formation dolomites with the contact aureole.

iii) Any structural feature (e.g. fault) within or marginal to the Packsaddle Microgranite that may have allowed fluid migration deeper into the adjacent Wollogorang Formation. As noted above, the prospective retrogressive hydrothermal alteration zone *is wider than* the initial thermal metamorphic aureole.

iv) Shelving contacts of the Packsaddle Microgranite, if detectable, would provide enhanced opportunity for alteration of subjacent, overlying country rocks. Current understanding of the Packsaddle contacts suggests they are subvertical, but some effort should be applied to determine whether shelving contacts might be detectable by particular geophysical signatures.

3.3 Stratabound Mineralisation

3.3.1 Background

The potential for stratabound base-metals mineralisation in the region has been vigorously explored by CRAE personnel in the current SE McArthur Basin Project. Although no specific brief has been provided in this present study to canvas this style of mineralisation, particular aspects will be addressed here owing to the nature of specific prospects visited and sampled.

3.3.2 Mineralisation in Sandstones

Several prospects involving mineralised sandstones have been investigated by CRAE, including JJ Prospect, Sandstone Prospect, and "un-named Cu show". A consistent feature of these prospects is the presence of quartzose sandstone with disseminated fine-grained malachite in interparticle pore spaces. The sandstones commonly lie in the upper part of the Wollogorang Formation, and may lie within Unit 4 of that Formation. Specific sites investigated are listed in Table 7.

TABLE 7: MINERALISED SANDSTONE SITES

Site	AMG(E)	AMG(N)	Prospect name
1	809800	8101500	Sandstone Prospect
2	811500	8100500	Un-named Cu show

Petrographic study of some of these samples provides the following summary conclusions:

i) *Mineralisation formed during cementation.* The presence of relict small grains of pyrite and chalcopyrite confirm that Fe- and Cu-sulphides formed, together with more abundant quartz, dolomite, or both, during hydrothermal cementation (PLATE 38). This is not a trivial observation, because the abundance of secondary malachite and iron oxides might encourage the incorrect interpretation that all of the Cu was introduced as secondary remobilised material from an external source. The nature of the principal cementing phase varies from location to location, and may vary within a particular location. Quartz forms optically continuous overgrowths on clastic quartz grains (PLATES 39, 41), and dolomite forms relatively coarse-grained pore fillings that, in places, display dog-tooth open space-filling textures. These textures clearly indicate that hydrothermal fluids of variable composition gained access to high-porosity clean quartzose sandstones, and deposited abundant cement with variable amounts of Fe- and Cu-bearing sulphides.

ii) *Redistribution of metals occurred in response to oxidation.* This has resulted in significant redistribution of Cu in particular, with malachite forming widely scattered pore fillings and fracture fillings (PLATE 38). The importance of the phenomenon is that it has generated an upgraded oxidised ore zone.

Selected assays for sandstone samples are presented in Table 8.

Notable features evident in the sandstone assays include:

i) Widely variable abundances of many elements reflect the variable nature of the cementing minerals. As a porous rock passively accepting cement mineral deposition, the resulting analyses directly reflect the nature of the hydrothermal solutions from which the cementing minerals formed.

ii) Ca and Mg range to high values, reflecting the variable abundance of dolomite cement; variable high abundances of Fe reflect variable degrees of hematitic alteration (at least partly oxidation).

iii) Some Cu-rich sandstones are also highly anomalous in As, Co, Mo and Ni. The mineralogical sites for these elements have not been identified in this study, but presumably reflect an exotic sulphide assemblage, now significant oxidised. The linear relationship between Co and As (Fig. 3) suggests the presence of Co-As-bearing minerals (e.g. cobaltite) in the assemblage.

TABLE 8: SELECTED ASSAYS FOR SANDSTONE SAMPLES

SAMPLE	ROCK NAME	As	Ba	Ca	Co	Cr	Cu	Fe
Det. Limit		3	5	10	2	2	2	100
Unit		ppm	ppm	ppm	ppm	ppm	ppm	ppm
4124277P	Mineralised sandstone	35	10900	490	60	40	85500	21500
4124278P	Feldspathic sandstone	<3	140	190	2	11	700	12400
4124279P	Lithic sandstone	16	290	99000	20	70	13700	17100
4124281P	Quartzose sandstone	<3	145	27000	6	9	120	13500

SAMPLE	ROCK NAME	Mg	Mn	Mo	Ni	Pb	Zn
Det. Limit		10	5	2	2	5	10
Unit		ppm	ppm	ppm	ppm	ppm	ppm
4124277P	Mineralised sandstone	7700	180	<2	25	<5	30
4124278P	Feldspathic sandstone	380	70	<2	6	<5	5
4124279P	Lithic sandstone	56000	3300	<2	10	5	7
4124281P	Quartzose sandstone	15300	1220	<2	6	5	6

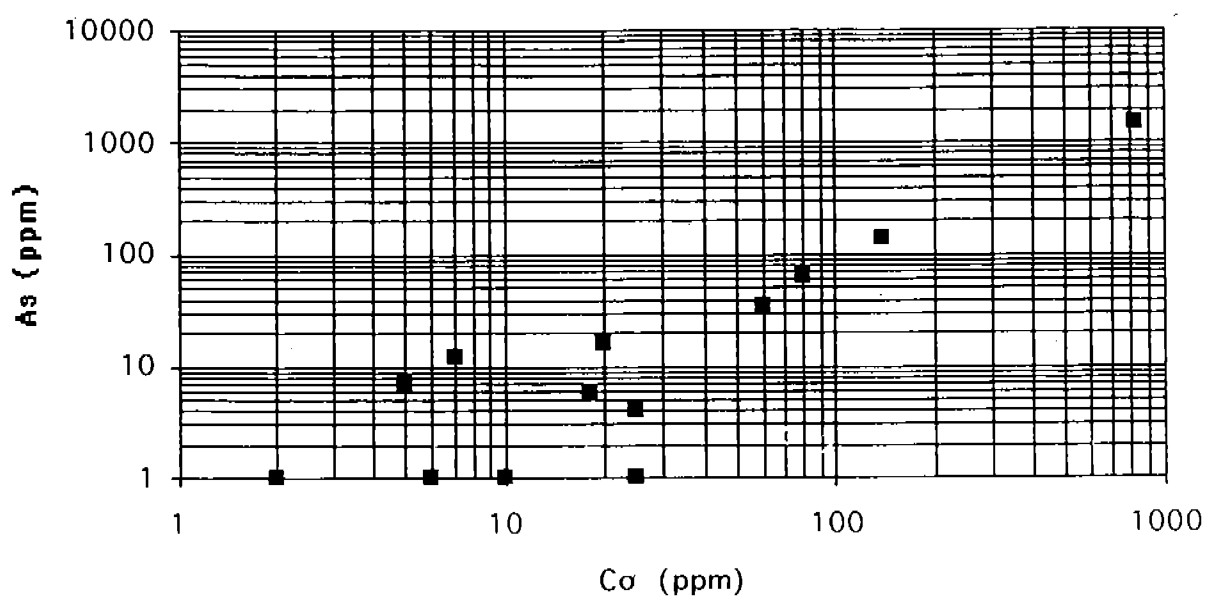

FIG.3: As vs Co in sandstones. Values of As below the detection limit have arbitrarily been assigned the value of 1ppm for plotting purposes.

iv) Ba mostly falls in the hundreds of ppm range, and may be attributed to the constant modest amount of clastic K-feldspar in the sandstones. Rarely (e.g. sample 4124277), very high Ba values suggest the presence of significant amounts of barite in the cementing mineral assemblage. This, together with the abundant quartz, provides mineralogical similarities with the breccia-filling assemblage in the trachytic cryptodomes.

3.3.3 Mineralisation in Dolomites

Base-metals mineralisation (mainly Cu) has been identified in dolomitic rocks, commonly associated with nearby mineralised sandstones. Only a limited number of polished thin sections were prepared for these samples, so detailed mineragraphic information is limited. Particular sample observations include:

i) Sample 4124263. Small disseminated opaque aggregates are sparsely disseminated through the even-grained granular dolomite.

ii) Sample 4124282. Mineragraphic observations in this sample confirm that chalcopyrite and lesser pyrite are disseminated in significant amounts throughout the rock (PLATE 44). The grains are uniformly small (<0.1mm), and commonly are ~10-20μm in size, similar in size to the small dolomite grains of the body of the rock. Slightly coarser-grained sulphides occur in slightly coarser-grained dolomite patches, confirming the relationship between dolomite recrystallisation and development of sulphides. The sulphides also occur in trace amount as coarser grains in discordant thin calcite veins.

All of the petrographic and mineragraphic observations support the thesis that the sulphides formed *at the time of dolomite development in the laminated sedimentary sequence.* Although veins may be present in some samples, they are never rich in sulphides, and therefore appear not to have been responsible for significant sulphide introduction into the rock body. Rather, the minor amount of sulphides in veins would suggest that minor redistribution of metals *from* wall rocks *into* veins occurred during vein development at dolomite-formation time. It cannot be determined at this level of study whether the metallic components (Fe, Cu) of the sulphides were present as part of the primary composition of the sediments, or whether they were introduced during diagenesis or later basin-wide alteration. In either case, the mineralisation may be referred to as *sediment-hosted stratabound base-metals mineralisation.* This is consistent with knowledge gained by CRAE that particular sedimentary horizons are regionally anomalous for particular metals.

Selected assays for dolomitic samples are presented in Table 9.

TABLE 9: SELECTED ASSAYS FOR DOLOMITES

SAMPLE	ROCK NAME	As	Ba	Ca	Co	Cu	Fe	Mg	Mn	Pb	Zn
Det. Limit		3	5	10	2	2	100	10	5	5	10
Unit		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
4124036P	Laminated dolomite	4	25	170000	5	95	32000	107000	5000	<5	<2
4124263P	Dolomite	35	2200	130000	18	13	19300	62000	3750	15	17
4124282P	Cherty dolomite	6	460	176000	25	550	35000	97000	4850	<5	<2

Particular features of the assays include:

i) Consistently high Ca and Mg values are expected from these dolomite-rich rocks, but the elevated Fe and Mn values appear to reflect a sideritic component in the carbonate. The Fe and Mn, like the Ca and Mg, may have been part of the primary composition of the sediment.

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5. PETROGRAPHIC DESCRIPTIONS

Petrographic descriptions of samples in the relinquished portion of the licence area are presented in the following pages.

SAMPLE : 4124035P (?Wollogorang Formation, 813000E 8096000N)

SECTION NO. : C61626 (4124035)

HAND SPECIMEN : The rock sample is composed of uniformly very fine-grained pinkish grey and pink laminae.

The section offcut produced a strong yellow positive stain for K-feldspar, indicating it occurs throughout the fine-grained rock in all laminae.

ROCK NAME: **Tuffaceous laminated meta-sediment**

ROUTINE PETROGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	10-35	Alteration/metamorphic
Orthoclase	80-65	Alteration/metamorphic
Clays	10-0	Alteration/metamorphic
Leucoxene	Tr	Alteration./metamorphic

In thin section, this sample displays a layered sedimentary structure and a fine-grained recrystallised metamorphic texture.

Orthoclase and quartz comprise most of all laminae. Orthoclase occurs as small anhedral anhedral grains that form a granoblastic mosaic throughout all laminae. It is most abundant in the finer-grained laminae, where it is accompanied by minor equally small quartz grains and diffuse yellowish patches of clay. In coarser laminae, orthoclase is less abundant and quartz forms more abundant, somewhat rounded grains that may represent relict clastic particles.

Leucoxene is present in all laminae as very fine, granular aggregates.

INTEPRETATION:

This sample represents a very fine sedimentary rock, most likely formed by distal accumulation of ash and minor quartz particles from acid volcanic eruptions.

Subsequent to deposition, the laminated assemblage recrystallised to a fine granoblastic mosaic of orthoclase + quartz + minor clays + leucoxene. The primary lamination was preserved, and small subrounded quartz particles in coarser laminae may be preserved clastic particles.

SAMPLE : 4124036 (?Wollogorang Formation, 813000E 8096000N)

SECTION NO. : C61627 (4124036)

HAND SPECIMEN : The rock sample is composed of uniformly fine-grained, pale brownish cream dolomite that is weakly laminated. Minor discordant poorly-defined dolomite veins contain fine-grained silvery sulphide grains (pyrite).

The section offcut failed to accept the stain for K-feldspar, suggesting it is absent.

ROCK NAME: **Laminated dolomite**

ROUTINE PETROGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Dolomite	95	Alteration/metamorphic
Quartz	2	Alteration/metamorphic
Orthoclase	Tr	Alteration/metamorphic
Opaques	Tr	Alteration/metamorphic
Dolomite	3	Alteration veins
Opaques	Tr	Alteration veins

In thin section, this sample displays a fine-grained granular metamorphic texture, with minor poorly-defined veining.

Dolomite completely dominates the rock. It occurs mostly as very small anhedral grains that build a sutured mosaic of slightly variable grain size throughout the rock. Grain size variation contributes to definition of a weak layering in the rock.

A minor amount of dolomite occurs as coarser blocky crystals that fill diffuse discordant veins that cut the layering.

Orthoclase is present in minor amount as small anhedral grains that are concentrated in discontinuous thin laminae. It is generally absent from most of the rock.

Quartz occurs in minor amount as very fine-grained mosaics that are concentrated in discontinuous laminae or lenses.

Opaques are present in trace amount. Minute equant crystals (?pyrite) are very sparsely disseminated through the rock, and larger grains and aggregates occur in the coarser dolomite veins.

INTERPRETATION:

The sample represents a weakly layered calcareous sediment of chemical sedimentary origin that has suffered low-grade metamorphic recrystallisation and alteration to the assemblage dolomite + minor quartz + orthoclase + opaques (?pyrite).

The fine-grained discontinuous laminae of quartz and orthoclase are considered to represent primary sedimentary components, of chemical sedimentary or volcanic origin.

SAMPLE : 4124261P (Wollogorang Formation, 808800E 8097500N)

SECTION NO. : 4124261

HAND SPECIMEN : The rock sample is uniformly fine-grained, massive, and pale creamish pink in colour. In places it is locally brecciated, with small terminated quartz crystals, dull green celadonite, and malachite fillings. In the field, it intrudes layered dolomitic rocks of Unit ?2 of Wollogorang Fm.

The section offcut accepted a strong pervasive yellow stain for K-feldspar, indicating it occurs throughout the rock, but not in breccia fillings.

ROCK NAME : **Altered micro-syenite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Orthoclase	93	Relict igneous
Quartz	5	Alteration / vein-filling
Leucoxene	1	Alteration
Goethite	Tr	Alteration (oxidation)
Clays (pale green; ?celadonite)	1	Vein-fillings

In thin section, this sample displays a massive, aphyric, felted igneous texture that has been slightly modified by alteration.

Orthoclase completely dominates the rock. It occurs as randomly-oriented, bladed crystals ~0.2-0.4mm long, and interstitial anhedral grains. Many crystals display simple twinning, and there are no features to suggest that primary plagioclase was present in any significant amount.

Quartz occurs as small interstitial grains, very sparsely and irregularly scattered through the rock. Most quartz occurs as relatively coarse-grained fillings in variably-oriented, bifurcating veins. It is notable that fluid inclusions of any kind are virtually absent from the quartz.

Leucoxene occurs as small granules that are sparsely but uniformly distributed through the rock. They do not appear to have formed by replacement of precursor Fe-Ti oxide or ferromagnesian grains, but appear simply to be disseminated through the feldspar. A very small amount also occurs in some of the quartz-rich veins.

Pale green fibrous clay (?celadonite) occurs as ragged aggregates in some quartz-rich veins.

INTERPRETATION:

This sample represents a silicic, alkalic magma that most probably formed by differentiation from a relatively potassic basaltic parent. The lack of phenocrysts is notable, a consistent feature of the pink intrusive (cryptodomal) rocks of the small intrusive bodies. This particular sample differs in lacking apatite as an accessory phase, and primary Fe-Ti oxide sites appear to have been destroyed during low-grade pervasive alteration. The integrity of the primary feldspar, however, appears to have been essentially retained. During the alteration event, quartz + minor clays + leucoxene were deposited in the local breccia cavities. The alteration assemblage (which includes clay) confirms the relatively low-temperature nature of the alteration.

SAMPLE : 4124262P (Wollogorang Formation, 808800E 8097500N)

SECTION NO. : 4124262

HAND SPECIMEN : The rock sample is a fine-grained, pale pinkish brown rock that displays prominent lamination (flow-banding) that is locally brecciated. Vughy quartz fills or partly fills the breccia pores and thin veinlets.

The section offcut accepted a strong pervasive yellow stain for K-feldspar throughout the rock, except for the breccia pore fillings and veins.

ROCK NAME: **Altered flow-banded trachyte**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Orthoclase	89	Alteration (from ?glass)
Quartz	10	Alteration / vein-filling
Leucoxene	Tr	Alteration
Apatite	Tr	Vein-filling
Opaques (incl. goethite)	Tr	Vein-filling

In thin section, this sample displays a fine-grained, massive, granular texture that may represent devitrification from glassy precursor.

Orthoclase is abundant. It occurs as small anhedral grains, a few tens of microns in size, forming a mosaic throughout the rock. Variable abundance of orthoclase and quartz defines the lamination observed in hand specimen.

Quartz occurs as small anhedral interstitial grains, and as coarser -grained vein fillings. In the veins, quartz may form euhedral terminated crystals that project into vughy cavities, but most veins are completely filled.

Apatite occurs in trace amount as relatively large subhedral crystals in quartz veins. It has not been observed in the wall rock.

Opaques are present in trace amount as small angular grains in quartz veins, and as small disseminated grains or aggregates in the wall rock. All appear to have suffered partial to complete replacement by dark reddish brown goethite.

INTERPRETATION:

This sample represents relatively quickly cooled trachytic magma, which developed flow-banding during emplacement as a shallow-level subvolcanic intrusive body. In the field, the trachytic body clearly intrudes nearby Wollogorang Formation dolomites. Localised brecciation occurred during emplacement by auto-fragmentation. Subsequent low-grade alteration generated the assemblage quartz + minor opaques + apatite. At a much later time, near-surface oxidation resulted in replacement of the opaques by goethite.

SAMPLE : 4124263P (Wollogorang Formation, Unit ?3, 808800E 8097500N)

SECTION NO. : 4124263

HAND SPECIMEN : The sample is a uniformly fine-grained, pale brownish cream rock in which diffuse dark brown patches tend to be entrained within the plane of bedding.

The section offcut failed to accept the stain for K-feldspar, suggesting it is absent.

ROCK NAME : **Dolomite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Dolomite	90	Alteration
Quartz	5	Alteration / veinlets
Goethite	5	Alteration (oxidation)
Calcite	Tr	Vein-filling

In thin section, this sample displays a uniformly fine-grained granular texture with thin, discontinuous veinlets.

Dolomite completely dominates the rock. It forms small anhedral grains <0.2mm in size, building a granular mosaic throughout the rock. It has a somewhat turbid appearance. In large patches, diffuse brown goethite pervades the rock, and may represent local patches of oxidised Fe-rich carbonate.

A trace of clear calcite occurs as small angular grains in quartz veins.

Quartz occurs in two forms. Some occurs as small anhedral grains that are sparsely disseminated through the rock. Some occurs as coarser anhedral grains that fill discontinuous, tortuous veinlets.

Goethite occurs as diffuse patches in the rock (see above), but also forms discrete angular grains that might represent precursor opaques such as sulphide.

INTERPRETATION:

This sample represents a carbonate sedimentary rock that has suffered recrystallisation to the assemblage dolomite + minor quartz. Fractures were filled by coarser-grained quartz + trace calcite.

It is notable that this sample shows no sign of contact metamorphism, despite being sampled <2m from a nearby trachyte contact (see 4124261 and 4124262). This is consistent with the small size of the trachytic body. All of the alteration features of the dolomite are compatible with development during diagenesis or other low-grade basin-wide alteration event.

SAMPLE : 4124264P (Wollogorang Formation, Unit ?3, 808800E 8097500N)

SECTION NO. : 4124264

HAND SPECIMEN : The rock sample is composed of thin laminae, mostly cream and clay-like, but also translucent grey and siliceous.

The section offcut failed to accept the stain for K-feldspar.

ROCK NAME : **Laminated feldspathic and siliceous sediments**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Feldspar	98-0	Alteration
Quartz	2-100	Alteration
Goethite	1	Alteration (oxidation)

In thin section, this sample displays fine-grained clastic sedimentary textures that have been modified by alteration and veining.

Feldspathic laminae are composed almost entirely of small anhedral feldspar grains. Since it failed to accept the stain for K-feldspar, it is likely to be albite. This is consistent with its cream to white colour in hand specimen. Scattered through the feldspathic laminae are small angular crystal fragments of quartz, which have the appearance of relict clastic particles. Small leucoxene granules are disseminated through the bands.

Quartz occurs in different sites. Most occurs in quartz-rich laminae, where it forms anhedral grains uniformly ~0.1-0.2mm in size, building a granoblastic mosaic through such laminae. Elsewhere, quartz fills thin discordant veinlets in which it displays open space-filling textures (terminated quartz crystals project into centres of veins).

Goethite occurs in dense, dark brown to opaque aggregates that may occur within laminae or at bedding contacts between laminae. It is possible that the goethite has formed by oxidation of very fine-grained opaque precursor mineral (e.g. pyrite).

INTERPRETATION:

This sample represents thinly bedded, fine-grained sediments of feldspathic and siliceous compositions. Their origins are obscure, but a volcanic contribution to the feldspathic laminae is probable.

SAMPLE : 4124265P (?Wollogorang Formation, Sandstone Prospect, 809800E 8101500N)

SECTION NO. : 4124265

HAND SPECIMEN : The rock sample is composed of pinkish brown sandy sedimentary rock with small wispy lithic fragments. Fine green malachite stains poorly-defined foliation (bedding) planes.

The section offcut accepted a weak yellow stain for K-feldspar, indicating it occurs as small scattered fragments.

ROCK NAME : **Mineralised calc-arenite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	55	Clastic particles
Lithics	10	Clastic particles
Microcline	3	Clastic particles
Muscovite	Tr	Clastic particles
Tourmaline	Tr	Clastic particles
Dolomite	32	Sedimentary matrix
Malachite	Tr	Alteration

In thin section, this sample displays a relatively coarse-grained clastic sedimentary texture, with only minimal alteration.

Quartz occurs as subrounded to subangular particles whose size range (~0.1-0.8mm, average ~0.4mm) indicates only a moderate degree of sorting.

Lithic fragments are moderately abundant. Some fine-grained cherty and feldspathic volcanic fragments are subrounded and similar in size to the quartz. Larger argillaceous fragments several mm long are angular, wispy, and apparently of intra-formational origin (i.e. rip-up clasts) and are aligned within the bedding plane.

Microcline occurs as rounded particles, similar in size to quartz.

Muscovite forms small clear plates sparsely scattered through the rock.

Tourmaline, pleochroic in greenish browns, forms rare small subrounded particles.

Dolomite is abundant, occurring as a fine-grained cement throughout the rock. In places it is slightly coarser-grained.

Malachite is uncommon, forming very fine-grained dark green aggregates entrained along foliation planes or in diffuse patches.

INTERPRETATION:

This sample represents poorly-sorted arenaceous sedimentary materials derived mainly from an acid crystalline source terrain. In the field, it represents the matrix that hosts large angular trachyte boulders (see sample 4124276). It is considered that the trachyte boulders were dumped vigorously from another source (e.g. nearby emergent cryptodomal structures), as they are not represented in the arenaceous matrix fraction.

It is notable that the dolomitic matrix is fine-grained and pervasive, showing no open space-filling textures. It indicates the presence of a primary carbonate matrix at the time of sedimentation, rather than subsequent filling of pores. Subsequent alteration appears to be limited to deposition of malachite along foliation planes.

SAMPLE : 4124276P (Wollogorang Formation, Sandstone Prospect, 809800E 8101500N)

SECTION NO. : 4124276

HAND SPECIMEN : The rock sample is fine-grained, massive, pinkish brown, and crystalline in appearance. It occurs as a large angular boulder in a coarse sedimentary breccia, of which sample 4124265 represents the sandy matrix.

The section offcut accepted a strong pervasive yellow stain for K-feldspar, indicating it occurs throughout the rock.

ROCK NAME : **Altered micro-monzonite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Plagioclase (incl. sericite)	51	Relict igneous (alteration)
Orthoclase	30	Igneous
Apatite	Tr	Igneous
Leucoxene	2	Alteration
Dolomite	15	Alteration
Chlorite	1	Alteration
Goethite	1	Alteration (oxidation)

In thin section, this sample displays a moderately well-preserved even-grained felted to intersertal igneous texture that has been modified by subsequent alteration.

Plagioclase was abundant in the primary rock, forming small randomly-oriented lath-like to prismatic crystals ~0.2mm long. All have suffered partial to complete replacement by minute sericite flecks.

Orthoclase is moderately abundant, occurring as anhedral interstitial grains and aggregates that fill interstices between the plagioclase prisms. All of the orthoclase displays an orange colour suggestive of incipient submicroscopic oxidation (?hematitic alteration).

Apatite builds acicular crystals concentrated within the interstitial orthoclase.

Leucoxene occurs as turbid dark grey granular aggregates that have replaced precursor primary Fe-Ti oxide crystals. Two types of precursor crystals are identifiable: most are equant blocky crystals up to ~0.2mm in size, representing primary Ti-magnetite; some display highly acicular crystals forms suggestive of primary ilmenite.

Dolomite forms granular replacement patches and aggregates that are irregularly scattered through the rock.

Chlorite occurs in minor amount as fine-grained massive small aggregates.

Goethite occurs as replacements of subhedral small blocky opaque crystals (?pyrite) that were sparsely and irregularly scattered along fractures. A trace of hematite is present as very fine granular patches disseminated through the rock.

INTERPRETATION:

This sample represents a shallow subvolcanic igneous rock of relatively felsic, alkalic composition. Its mineralogy and texture are suggestive of derivation by crystal fractionation from a K-rich basaltic precursor.

Certain petrographic features of this sample are similar to those observed in other micro-monzonitic and micro-syenitic rocks in the region: interstitial orthoclase with associated acicular apatite; the presence of two primary Fe-Ti oxide phases (Ti-magnetite > ilmenite).

This sample clearly displays relict primary plagioclase and orthoclase in subequal abundances, confirming identification of a monzonitic composition.

It should be noted that alteration in this sample is essentially dolomite + sericite + leucoxene, and dolomite is abundant in the sandy matrix of the sedimentary breccia (see sample 4124265).

SAMPLE : 4124277P (Wollogorang Formation, Sandstone Prospect, 809800E 8101500N)

SECTION NO. : 4124277

HAND SPECIMEN : The rock sample is composed of poorly-sorted sandy detrital materials that include abundant quartz particles and moderately abundant lithic fragments. Bright green malachite pervades the rock in diffuse patches.

The section offcut accepted a positive yellow stain in small scattered rounded particles. It also accepted a diffuse yellow stain in sericite-rich muddy patches: this is not a proper stain, but is an artifact arising from the abundant phyllosilicate flakes.

ROCK NAME : **Mineralised greywacke**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	40	Clastic particles
Lithics	5	Clastic particles
Microcline	2	Clastic particles
Muscovite	1	Clastic particles
Zircon	Tr	Clastic particles
Argillite	38	Sedimentary matrix
Malachite	10	Alteration cement
Quartz	2	Alteration cement
Goethite	2	Alteration

In thin section, this sample displays a very poorly-sorted arenaceous sedimentary texture with abundant silty to muddy matrix. Mineralisation and oxidation processes have modified the primary texture.

Quartz is abundant, occurring mainly as subrounded to subangular crystal fragments that range from ~0.1mm up to ~1mm in size. It is irregularly distributed through the rock, with no layering evident.

Lithic fragments are present in minor amount. They include coarse-grained polycrystalline metamorphic vein quartz, fine-gained cherty siliceous meta-sediments, graphic intergrowths for quartz and orthoclase from a silicic granitoid, and turbid K-feldspar-rich fragments from subvolcanic trachytic rocks.

Microcline is present as sparsely scattered subrounded crystal fragments, similar in size and shape to quartz but displaying its typical combined albite and pericline ("tartan") twinning.

Muscovite forms small flakes that are concentrated in the argillaceous areas of the matrix. There, fine-grained sericite is abundant, and fine quartz and feldspar particles may also be present.

Quartz also occurs as a cement, forming overgrowths on rounded clastic quartz particles, and forming euhedral terminated crystals in malachite-rich patches.

Malachite occurs mostly as relatively coarse-grained aggregates that fill ragged patches, interstices between clastic particles, and thin veinlets that cut the rock. The veinlets form a subparallel set, suggesting that fracturing may have been important in establishing a network for deposition of malachite. Centres of larger malachite patches contain dark reddish brown goethite patches which may represent relict sulphide sites.

INTERPRETATION:

This sample represents a coarse-grained, very poorly-sorted sedimentary rock that formed by rapid deposition of a wide range of clastic materials. In the field, it represents the matrix that binds large angular trachytic boulders (see sample 4124276). Clearly, clastic materials were derived from different sources: most of the arenaceous materials were derived from an acid crystalline source, but the trachytic boulders originated from nearby newly-emergent cryptodomal structures.

Following deposition and burial, the rock body suffered invasion by hydrothermal fluids, which resulted in deposition of quartz + sulphides in interparticle pores. Subsequent near-surface weathering caused oxidation, with re-distribution of Cu and other components in malachite and goethite.

SAMPLE : 4124278P (Wollogorang Formation, Unit ?4, Sandstone Prospect, 809800E 8101500N)

SECTION NO. : 4124278

HAND SPECIMEN : The rock sample is a tough, competent, pinkish brown sandstone that is even-grained and flecked with small white feldspar grains.

The section offcut accepted a weak positive yellow stain for K-feldspar, indicating it occurs in minor amount as small disseminated grains.

ROCK NAME : **Silica-cemented quartzose sandstone**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	65	Clastic particles
Lithics	5	Clastic particles
Microcline	2	Clastic particles
Tourmaline	Tr	Clastic particles
Quartz	26	Cement
Opaques	Tr	Cement
Goethite	2	Alteration (oxidation)

In thin section, this sample displays a well-preserved coarse arenaceous sedimentary texture that is well-sorted, and modified by a quartz cement.

Quartz dominates the rock, and occurs in two forms:

i) Much occurs as subrounded to subangular particles that range from ~0.1mm up to ~0.8mm (average ~0.4mm). All particles have a thin ferruginous rim, which is responsible for the pinkish brown colour in hand specimen.

ii) A considerable amount of quartz occurs as a cement. Much forms optically continuous overgrowths on clastic quartz particles. The overgrowths in most instances meet in interparticle pores, completely filling them and reducing the porosity of the rock greatly.

Lithic fragments are present in minor amount. They include fine-grained cherty meta-sediments, fine-grained silty meta-sediments, and coarser-grained feldspathic igneous types.

Microcline occurs as particles, similar in size and shape to quartz. It displays its typical "tartan" twinning.

Tourmaline is rare, occurring as small subrounded particles that are pleochroic in blues, and greenish browns.

Opaques form rounded grains that occur within the quartz cement. Their identity must remain uncertain without reflected light observations, but they may be pyrite or other sulphides.

INTERPRETATION:

This sample represents a well-sorted, compositionally mature arenaceous clastic sediment that was originally composed of abundant quartz, minor lithic fragments and microcline, and accessory tourmaline. Most of the particles were coated by fine ferruginous materials prior to deposition.

Following deposition and deep burial, hydrothermal fluids flowed through the porous sandstone, resulting in deposition of a quartz cement. A trace of sulphide may have formed with the quartz. Subsequent near-surface oxidation may have enhanced the reddish colour of the rock.

SAMPLE : 4124279P (Un-named Cu show, Unit 4 of Wollogorang Formation, 809800E 8101500N)

SECTION NO. : 4124279

HAND SPECIMEN : The rock sample is composed of subrounded cream lithic fragments and quartz particles that are firmly cemented in a tough, compact , pale-coloured coarse clastic rock. The sample occurs as a layer within a finer-grained siltstone sequence.

The section offcut accepted a positive yellow stain in some scattered lithic fragments.

ROCK NAME : **Dolomite-cemented calc-rudite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	25	Clastic particles
Lithics (dolomite)	35	Clastic particles
Lithics (trachyte)	5	Clastic particles
Lithics (siliceous meta-sediments)	2	Clastic particles
Lithics (graphic granite)	Tr	Clastic particles
Microcline	1	Clastic particles
Muscovite	1	Clastic particles
Tourmaline	Tr	Clastic particles
Dolomite	29	Sedimentary matrix
Dolomite	2	Alteration cement

In thin section, this sample displays a coarse clastic sedimentary texture that has suffered only mild alteration in the form of dolomitic cementation.

Lithic fragments are abundant. Large subrounded fragments of dolomite up to ~1cm in size are composed of an equigranular mosaic of dolomite, with weak lamination. Trachytic fragments of angular to rounded shape are orange in colour, and are composed of orthoclase that displays variable degrees of devitrification, from fine spherulitic to fine micrographic. Siliceous meta-sedimentary rock fragments are rounded in shape, and are composed of anhedral quartz grains of variable grain size (cherty to coarsely polycrystalline). Rare medium-grained graphic granite fragments are composed of orthoclase and quartz in poor micrographic texture.

Other clastic particles are dominated by quartz, which occurs as angular to rounded particles ranging widely in size up to ~1mm. Microcline forms subrounded crystal fragments of similar size. Tourmaline is rare, forming small subrounded particles pleochroic in greens. Muscovite occurs as clear flakes up to ~0.4mm in size.

The matrix of the rock is composed mainly of fine-grained dolomite which forms anhedral grains building a mosaic throughout the matrix. It has the appearance of a primary sedimentary matrix rather than subsequent cement, but a minor amount of coarser dolomite crystals fill small cavities in the matrix.

INTERPRETATION:

This sample represents coarse clastic materials that were derived from acid crystalline, volcanic and sedimentary sources, producing the polymictic assemblage presently observed. The clasts were deposited with a primary carbonate cement. Subsequent alteration appears to be limited to a minor amount of matrix dissolution and redeposition.

SAMPLE : 4124280P (Un-named Cu show, Unit 4 of Wollogorang Formation, 809800E 8101500N)

SECTION NO. : 4124280

HAND SPECIMEN : The rock sample is a uniformly fine-grained, non-laminated siltstone that is reddish brown in colour. It occurs stratigraphically beneath sandstone at this location.

The section offcut accepted a weak stain for K-feldspar in small particles sparsely scattered through the rock.

ROCK NAME : **Ferruginised calc-siltstone**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	20	Clastic particles
Microcline	2	Clastic particles
Lithics (trachyte)	2	Clastic particles
Lithics (dolomite)	1	Clastic particles
Muscovite	2	Clastic particles
Tourmaline	Tr	Clastic particles
Dolomite	33	Sedimentary matrix
Goethite	40	Alteration (?oxidation)

In thin section, this sample displays a moderately well-sorted, fine-grained clastic sedimentary texture.

Clastic particles are dominated by quartz, which forms angular to subrounded particles ~0.1-0.4m in size (average ~0.15mm). Microcline also forms subrounded particles. Lithic fragments are dominated by fine-grained, orange particles of trachytic composition and texture. Minor fragments of fine-grained dolomite tend to be angular in shape rather than rounded, suggesting a proximal source. Pleochroic green tourmaline fragments are sparsely distributed throughout the rock, as are small flakes of colourless muscovite.

The matrix is composed mostly of small, anhedral dolomite grains which form a mosaic. In patches and particular ill-defined bands, dark reddish brown goethite is abundant.

INTERPRETATION:

This sample represents the silty clastic fraction derived from diverse sources (distal acid crystalline source, trachytic volcanic source, proximal carbonate sedimentary source) that was deposited in a carbonate sedimentary environment producing a carbonate matrix. The abundant Fe-oxides may have been deposited as part of the matrix of particular bands, but near-surface weathering effects have caused at least partial redistribution of the iron.

SAMPLE : 4124281P (Un-named Cu show, Unit 4 of Wollogorang Formation, 809800E 8101500N)

SECTION NO. : 4124281

HAND SPECIMEN : The rock sample is a uniformly even-grained, medium-grained, pale grey sandstone through which are scattered small cream particles. The rock has a tough, competent, well-cemented appearance. It occurs stratigraphically above the finer-grained silty mineralised horizon in this location.

The section offcut accepted a positive yellow stain for K-feldspar in uniformly distributed small particles throughout the rock.

ROCK NAME : **Quartz-dolomite-cemented quartzose sandstone**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	60	Clastic particles
Microcline	5	Clastic particles
Tourmaline	Tr	Clastic particles
Lithics	3	Clastic particles
Quartz	26	Alteration cement
Dolomite	5	Alteration cement
Clay (green)	1	Alteration cement

In thin section, this sample displays a well-preserved even-grained arenaceous clastic sedimentary texture that has been modified by extensive cementation.

Quartz occurs in two forms. Well-sorted clastic particles of quartz are abundant, forming rounded to subrounded particles ~0.4mm in average size. Quartz also occurs as a cement, in which optically continuous overgrowths have formed on clastic quartz particles. The interparticle pores have been completely filled.

Other clastic components are dominated by microcline, which occurs uniformly distributed as particles in similar in size and shape to quartz. Some microcline particles have been partly to completely replaced by dolomite. Tourmaline occurs as rare subrounded particles, pleochroic in greens. Lithic fragments are composed of fine siliceous meta-sediments, rare fine-grained trachytic fragments, and rare micrographic intergrowths of quartz and orthoclase.

Dolomite forms plates that fill interparticle pores, and in places has partly replaced microcline.

INTERPRETATION:

This sample represents a relative clean sandstone that was originally composed of abundant quartz, lesser microcline, and minor other clastic particles. The lack of a primary matrix resulted in a highly porous sandy sediment, allowing subsequent circulation of fluids to deposit quartz, minor dolomite, and accessory clays as a strong cement.

SAMPLE : 4124282P (Un-named Cu show, Unit 4 of Wollogorang Formation, 809800E 8101500N)

SECTION NO. : 4124282

HAND SPECIMEN : The rock sample is a uniformly very fine-grained pinkish grey dolomitic rock with patchy internal structure, and rare thin veinlets. Very fine-grained specks and discontinuous thin veinlets of bright yellow sulphide are disseminated through the rock.

The section offcut failed to accept the stain for K-feldspar.

ROCK NAME : **Cu-mineralised dolomite**

PETROGRAPHY and MINERAGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Dolomite	96	Alteration
Quartz	1	Alteration
Chalcopyrite	2	Alteration
Marcasite	1	Alteration

In polished thin section, this sample displays a uniformly fine-grained recrystallised texture. Dolomite completely dominates the rock, occurring mainly as minute anhedral grains of micron size, forming a dense mosaic throughout the rock. A minor amount occurs as larger ragged grains that fill patches and through-going veins.

Minor quartz is present as small anhedral grains sparsely disseminated through the rock.

Sulphides are present in minor amount. Chalcopyrite forms small elongated grains and ragged grains disseminated throughout the rock, and also forms larger blades and ragged grains up to ~0.4mm in size in the coarser-grained dolomite patches and veins. Marcasite may form discrete bladed crystals, but it more commonly is closely intergrown with chalcopyrite in small ragged disseminated aggregates. The marcasite is readily distinguished from pyrite, as it displays its characteristic anisotropism and bladed crystal forms.

INTERPRETATION:

This sample represents a fine carbonate sedimentary rock, of chemical sedimentary origin, that has recrystallised to the uniformly fine assemblage of dolomite + minor quartz + chalcopyrite + marcasite. It is possible that the metallic components were part of the primary chemical sedimentary materials, as there is no indication that they were introduced.

The sample occurs interbedded in a reddish silty horizon (see 4124280, ferruginised calc-siltstone). Both samples provide a consistent interpretation of carbonate sedimentation, of fine and coarser facies. It appears that the sulphide mineralisation has favoured the fine carbonate facies in this location, and may have been part of the primary chemical sedimentary materials.

SAMPLE : 4124283P (Un-named Cu show, Unit 4 of Wollogorang Formation, 809800E 8101500N)

SECTION NO. : 4124283

HAND SPECIMEN : The rock sample is a uniformly very fine-grained, relatively soft, cream-coloured rock with no lamination but a moderately developed platy foliation. Green fine-grained malachite coats the foliation, and orange Fe-oxides and black Mn-oxides have formed along the foliation and elsewhere in patches through the rock.

The section offcut accepted a false yellow stain for K-feldspar by absorption of sodium cobaltinitrite into the sericite-rich rock.

ROCK NAME : **Weathered Cu-mineralised silty argillite**

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

Mineral	Vol.%	Origin
Quartz	10	Clastic particles
Lithics	1	Clastic particles
Microcline	Tr	Clastic particles
Muscovite	Tr	Clastic particles
Sericite	73	Alteration
Fe-Mn oxides	10	Alteration (oxidation)
Malachite	1	Alteration (oxidation)
Voids	5	Solution cavities (oxidation)

In thin section, this sample displays a relict fine-grained clastic sedimentary texture with poor lamination, modified by subsequent incipient recrystallisation and later oxidation.

Sericite (fine-grained white mica) occurs abundantly throughout the rock. It is uniformly very fine-grained (micron size), forming minute flecks of random orientation. It has a pale brownish colour.

Clastic particles are concentrated in patches and poorly-defined layers. Quartz occurs as angular to subrounded particles that range from minute sizes up to ~0.4mm. Microcline forms subrounded particles of similar size. Lithic fragments are uncommon: fine-grained pale brown trachytic fragments are most common lithics, and fine-grained cherty meta-sediments are also present. Muscovite forms small colourless flakes in trace amount.

Dark brown to opaque diffuse patches of Fe- and Mn-oxides are scattered through the rock, along fractures, and in solution cavities. Some of these may have been primary alteration sulphide grains, but they are too poorly preserved for identification.

Malachite forms fine-grained aggregates concentrated along fractures and in solution cavities with Fe- and Mn-oxides.

INTERPRETATION:

This sample represents an argillaceous sedimentary rock that was composed mainly of clays with lesser silty clastic components (quartz, lithics, microcline, muscovite). Relatively rapid deposition is suggested by the poor layering.

Following deposition and burial, low-grade alteration of a regional nature affected the rock, generating abundant fine-grained sericite from the muddy matrix. Subsequent near-surface weathering caused redistribution of components, especially Fe, Mn and Cu which were redeposited along fractures and in solution cavities.

Integrated Field and Petrographic Studies,

South-East McArthur Basin Project.

VOLUME 2 : APPENDICES

SAMPLE	AMG EAST	AMG NORTH	ROCK TYPE	FORMATION	MEMBER	SECTION
4124023	816300E	8101400N	Rhyolite Porphyry	Hobblechain Rhyolite	top	TS
4124035	813000E	8096000N	Laminated tuffaceous sed.	Wollogorang Fm		TS
4124036	813000E	8096000N	Laminated dolomite	Wollogorang Fm		TS
4124043	811500E	8098300N	Cherty sedimentary breccia	Wollogorang Fm		-
4124044	811500E	8098300N	Laminated ?tuffaceous sed.	Wollogorang Fm		-
4124261	808800E	8097500N	Trachyte	?Wollogorang Fm		TS
4124262	808800E	8097500N	Flow-banded flow breccia	?Wollogorang Fm		TS
4124263	808800E	8097500N	Dolomite	Wollogorang Fm	?Unit 2 or 3	TS
4124264	808800E	8097500N	?Tuffaceous sediment	Wollogorang Fm	?Unit 2	TS
4124265	809800E	8101500N	Mineralised sandstone	Wollogorang Fm	?Unit 4	TS
4124276	809800E	8101500N	Trachyte	Wollogorang Fm	?upper	TS
4124277	809800E	8101500N	Mineralised sandstone	Wollogorang Fm	?upper	TS
4124278	809800E	8101500N	Feldspathic sandstone	Wollogorang Fm	?upper	TS
4124279	811500E	8100500N	Lithic sandstone	Wollogorang Fm	?upper	TS
4124280	811500E	8100500N	Siltstone	Wollogorang Fm	?upper	TS
4124281	811500E	8100500N	Quartz sandstone	Wollogorang Fm	?Unit 4	TS
4124282	811500E	8100500N	Cherty dolomite	Wollogorang Fm	?upper	PTS
4124283	811500E	8100500N	Mineralised siltstone	Wollogorang Fm	?upper	TS

PLATE 8: LOCATION 809800E 8101500N (Sandstone Prospect)
This view displays the crude subhorizontal bedding in sedimentary breccia, with green malachite staining fractures (lower part of outcrop). The pink boulders are identical in composition and texture to the trachytic rocks of the cryptodomes, suggesting that such a source was available nearby. Most of the matrix materials are sand-sized fragments dominated by quartz with minor K-feldspar, muscovite and accessory tourmaline, indicative of an acid crystalline source for those clastic materials.

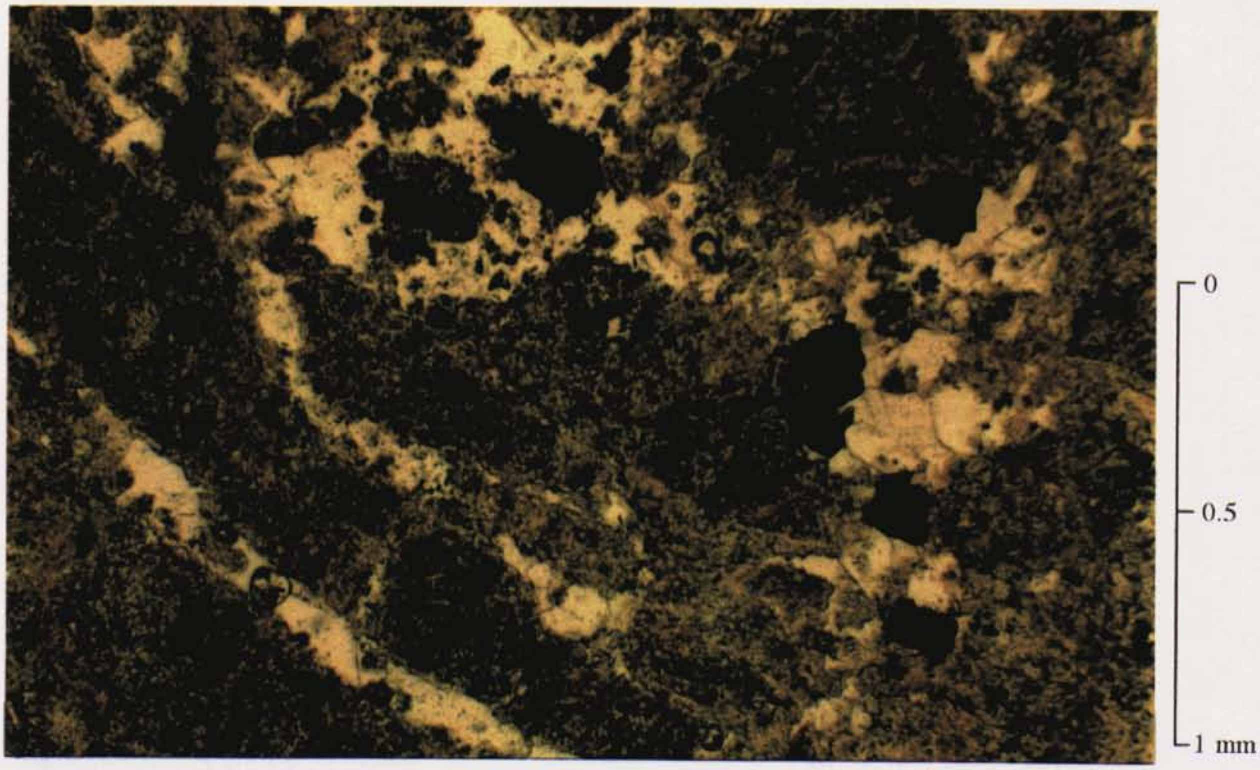


PLATE 14: SAMPLE 4124261 (Transmitted plane polarised light, x5, 22/3)
Opaque grains (black) may occur with quartz that fills fractures, patches, and breccia pores cutting turbid trachyitic wall rock (pale brown).

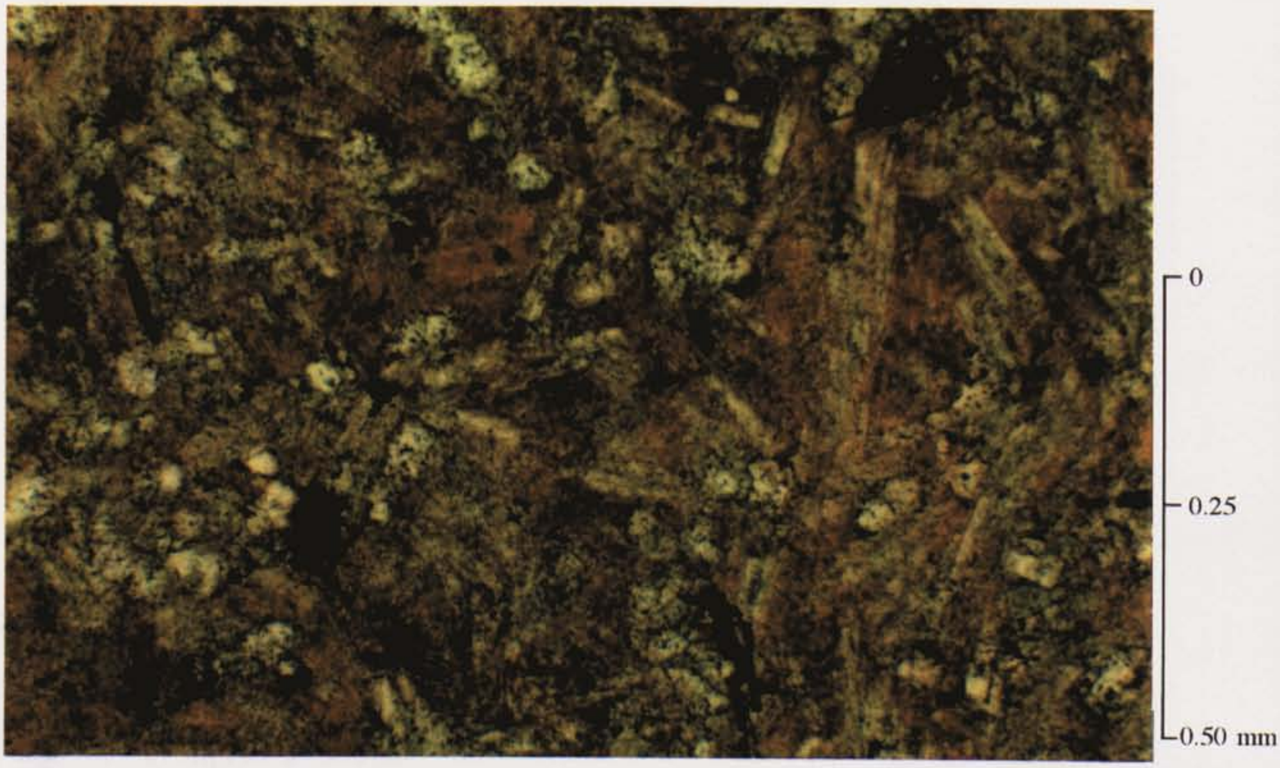


PLATE 15: SAMPLE 4124276 (Transmitted plane polarised light, x10, 3/4)
Relict primary plagioclase (clear laths) and interstitial orthoclase (turbid orange-red) are clearly distinguishable. The rock clearly contained two primary feldspars when it initially consolidated. The sample represents a boulder in a coarse clastic sediment (see PLATE 8).

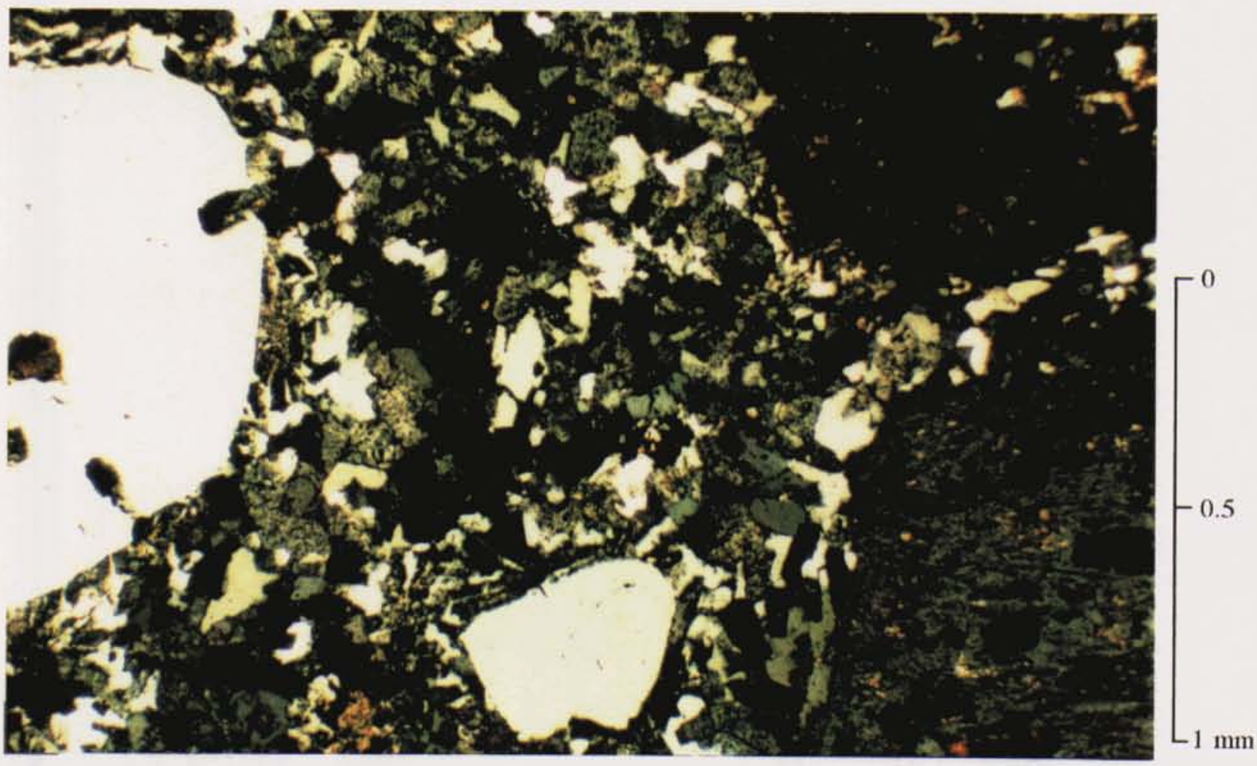


PLATE 17: SAMPLE 4124023 (Transmitted light, crossed polarisers, x5, 8/3)
Phenocrysts of quartz (left, bottom) and orthoclase (bottom right) lie in a recrystallised groundmass of quartz (white) and orthoclase (grey). The coarser grain size of the groundmass reflects slower cooling in the upper part of the ignimbrite sheet (top of Mt. Borroloola).

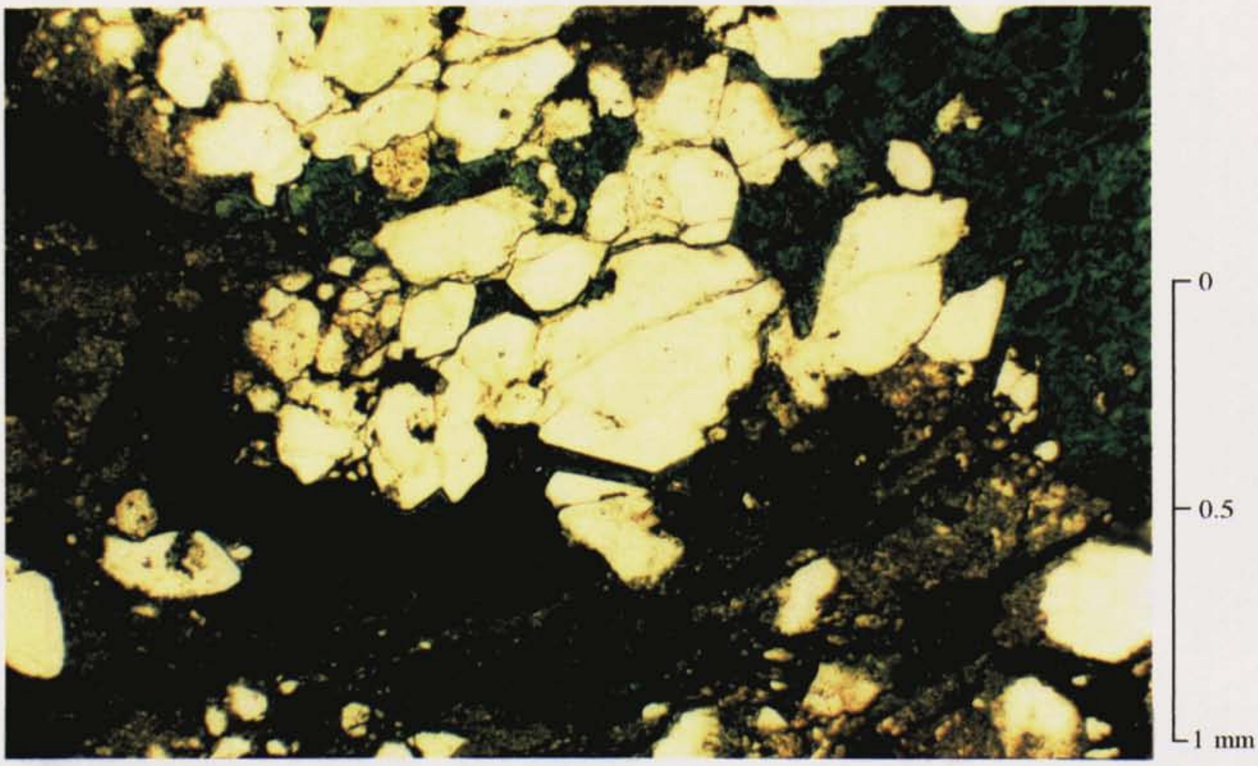


PLATE 38: SAMPLE 4124277 (Transmitted plane polarised light, x5, 4/4)
Malachite (bright green) may form patches that fill particle pores in this sandstone, or it may fill thin fractures cutting the rock (bottom). The malachite has formed by oxidation from primary chalcopyrite, which formed part of the cement.

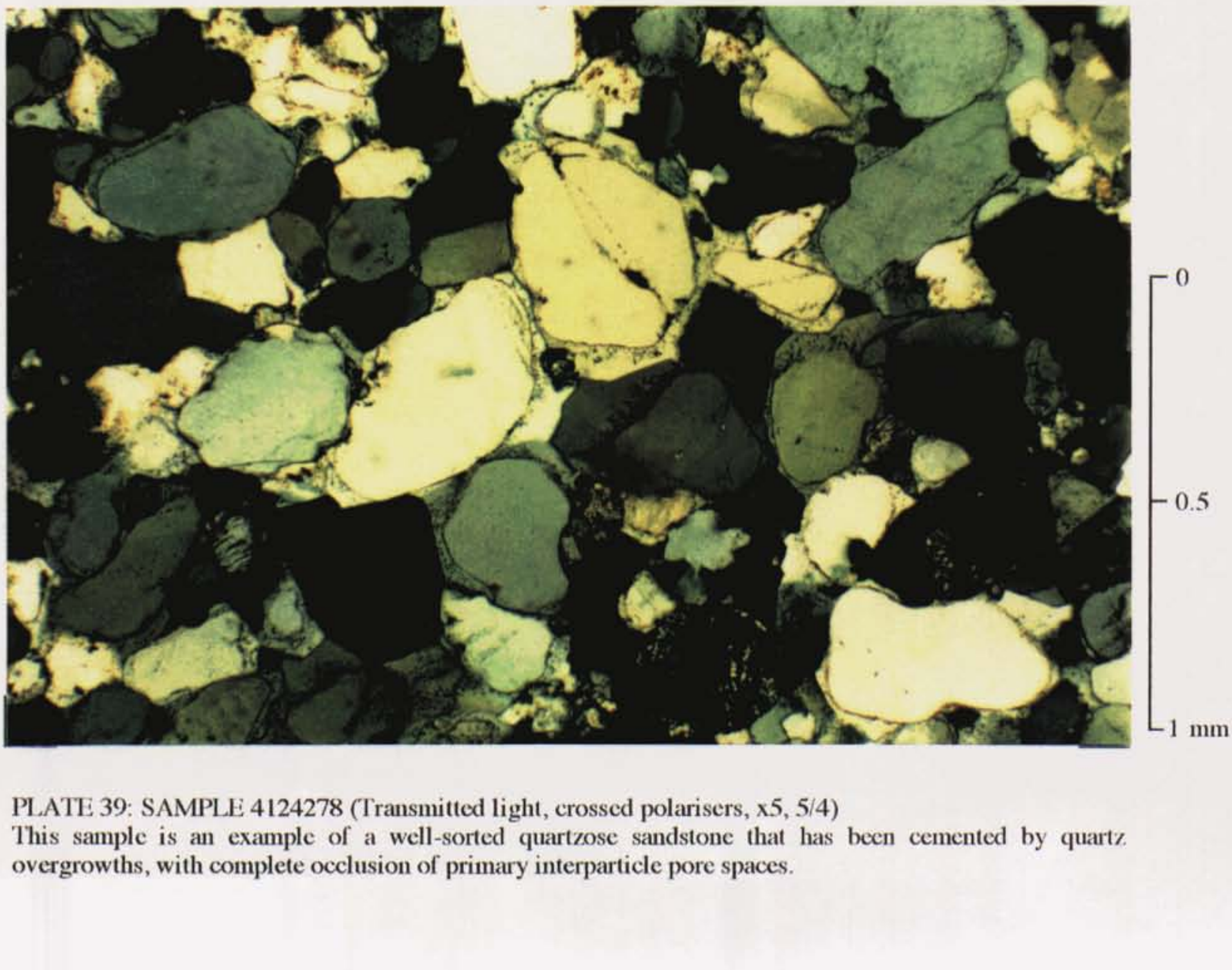


PLATE 39: SAMPLE 4124278 (Transmitted light, crossed polarisers, x5, 5/4)
This sample is an example of a well-sorted quartzose sandstone that has been cemented by quartz overgrowths, with complete occlusion of primary interparticle pore spaces.

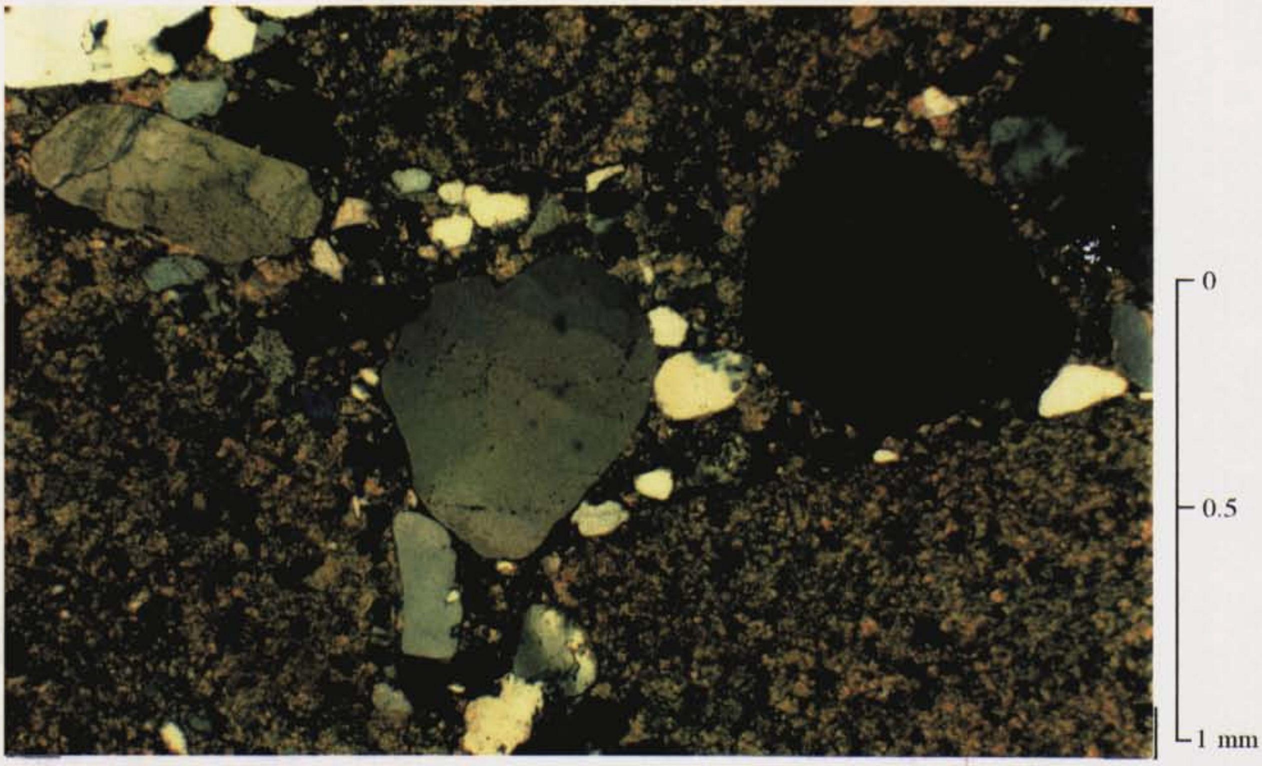


PLATE 40: SAMPLE 4124279 (Transmitted light, crossed polarisers, x5, 6/4)
This sandstone contains abundant rounded dolomite fragments (top, left, right) in a sandy matrix that has been cemented by dolomite.

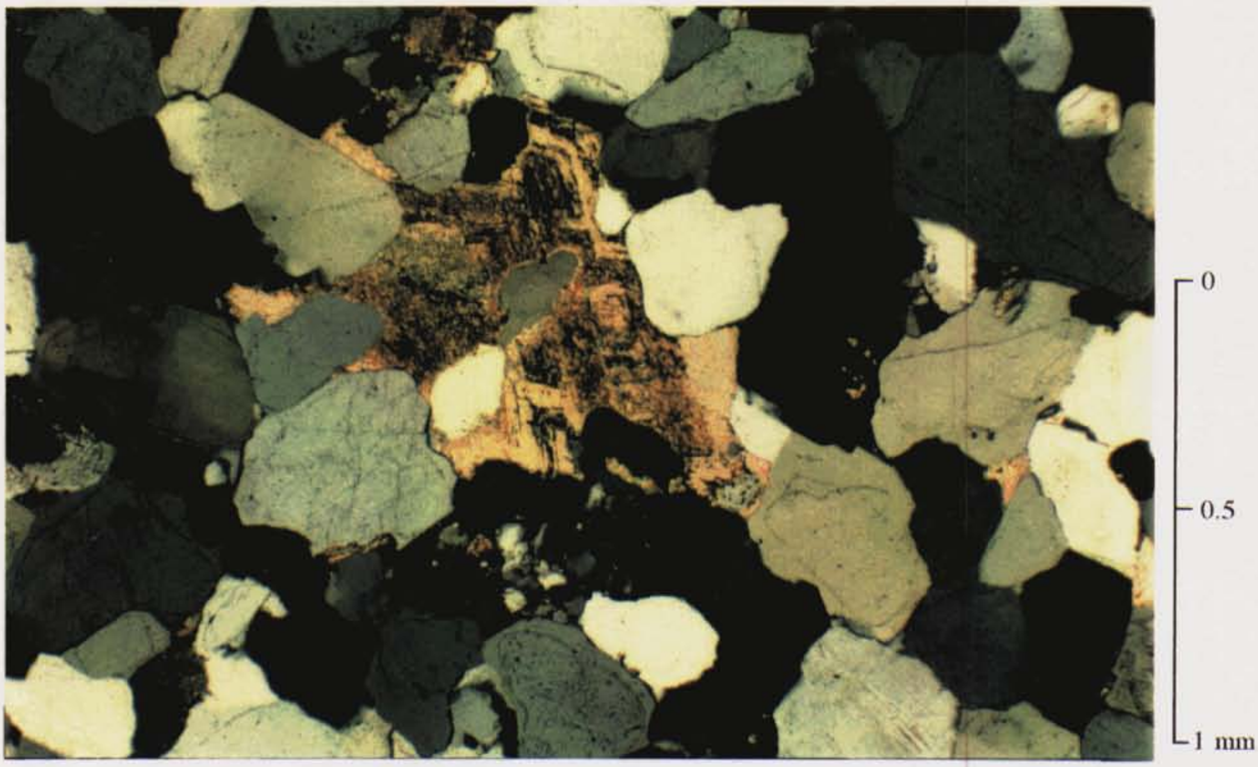


PLATE 41: SAMPLE 4124281 (Transmitted light, crossed polarisers, x5, 7/4)
This sandstone has been thoroughly cemented by abundant quartz overgrowths on clastic quartz particles (centre right, centre left) , with lesser dolomite (pale pastel colours, centre).

PLATE 42: SAMPLE 4124006 (Transmitted plane polarised light, x10, 2/3)
This laminated dolomite displays minute opaque grains in the finer-grained band (bottom). The opaques most likely are sulphides, and formed within the band at the time of dolomite recrystallisation.

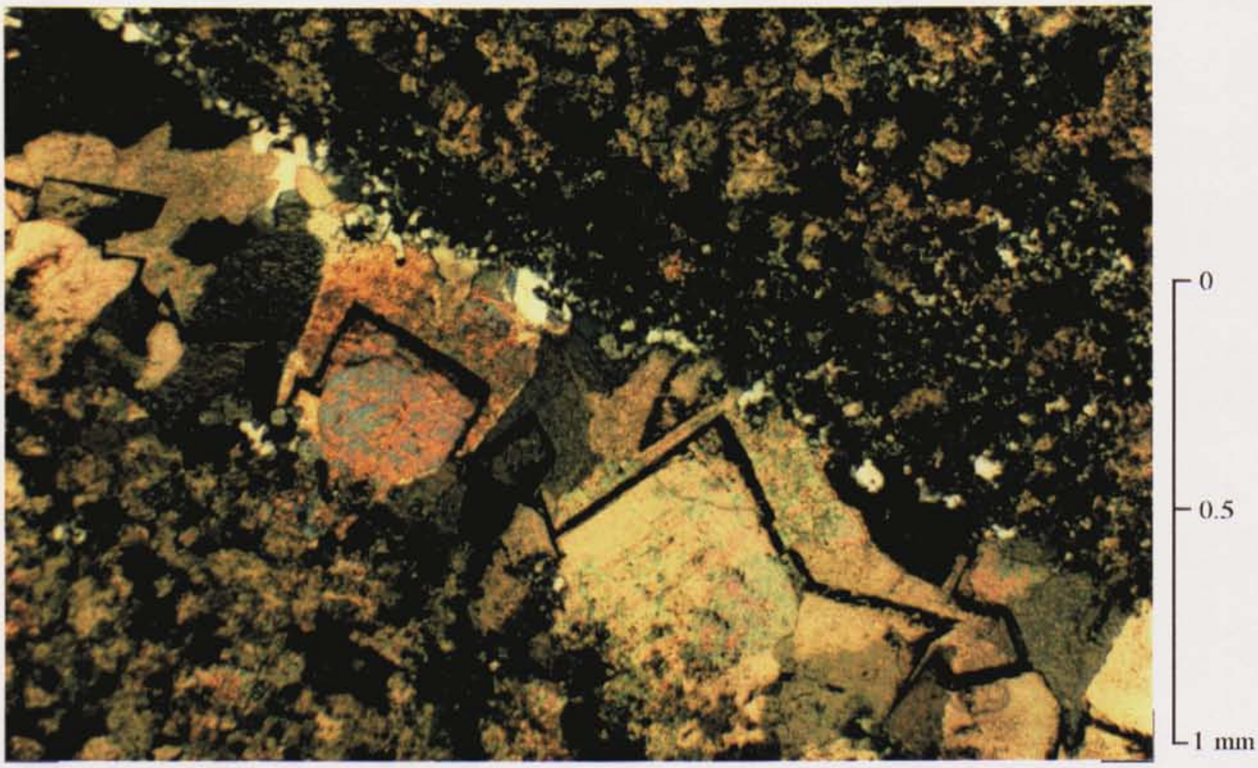


PLATE 43: SAMPLE 4124041 (Transmitted light, crossed polarisers, x5, 15/3)
A vein cutting dolomite is filled by dog-tooth dolomite (pastel colours) and minor quartz (white to pale grey). The hematite outlines on the vein dolomite are similar to those observed in dolomite-cemented sandstone (see PLATE 36), and suggest that oxidation occurred during vein deposition.

SAMPLE	Ag	As	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	V	Zn	Ba	U	Th	Au	AuDp1	Pt	Pd
4124023P	<1	8	<5	360	<1	<2	90	7	32000	15300	940	75	2	1750	7	120	10	7	13	820	4	30	<0.01		<0.005	<0.001
4124035P	<1	5	<5	2900	<1	30	35	1160	12900	12800	2650	740	<2	300	40	710	10	60	35	175	8	13	<0.01		<0.005	0.002
4124036P	1	4	<5	170000	<1	5	13	95	32000	10700	107000	5000	<2	250	8	380	<5	15	<2	25	3	<2	<0.01		<0.005	<0.001
4124043	<1	70	10	200	<1	19	160	510	7900	11500	580	170	20	930	19	300	500	40	30	2900	8	7	<0.01	<0.01	<0.005	<0.001
4124044	2	130	<5	310	<1	25	25	160	9400	13900	250	100	25	940	6	550	430	40	16	7000	8	9	<0.01		<0.005	<0.001
4124261P	1	30	<5	2100	<1	4	35	160	10000	16000	2050	100	4	690	5	1300	25	165	12	3400	6	10	<0.01		<0.005	0.001
4124262P	<1	13	<5	3150	<1	11	30	260	11200	18000	1400	115	9	420	6	1820	60	80	14	870	7	14	<0.01		<0.005	0.003
4124263P	<1	35	<5	130000	<1	18	30	13	19300	16700	62000	3750	5	490	7	430	15	35	17	2200	5	7	<0.01		<0.005	0.003
4124264P	<1	90	<5	1980	<1	45	20	45	11100	17400	990	1180	8	550	8	860	30	60	40	2100	7	8	<0.01		<0.005	0.001
4124265P	4	140	<5	32500	<1	140	25	18500	19200	19600	23500	980	<2	610	19	510	<5	80	19	470	4	8	<0.01		<0.005	0.001
4124276P	<1	15	<5	49500	<1	145	6	710	21500	16700	20000	1220	2	830	8	2050	<5	300	15	4850	3	5	<0.01		<0.005	0.001
4124277P	17	35	<5	490	<1	60	40	85500	21500	17000	7700	180	<2	630	25	510	<5	85	30	10900	6	9	<0.01		<0.005	0.001
4124278P	<1	<3	<5	190	<1	2	11	700	12400	3750	380	70	<2	170	6	75	<5	9	5	140	2	2	<0.01		<0.005	0.001
4124279P	2	16	<5	99000	<1	20	70	13700	17100	17900	56000	3300	<2	520	10	440	5	35	7	290	6	9	<0.01		<0.005	0.001
4124280P	<1	13	<5	16000	<1	95	35	430	80500	11600	20000	2100	2	700	25	460	10	70	20	6800	9	15	<0.01		<0.005	0.001
4124281P	<1	<3	<5	27000	<1	6	9	120	13500	8400	15300	1220	<2	230	6	340	5	9	6	145	3	3	<0.01		<0.005	0.002
4124282P	<1	6	<5	176000	<1	25	15	550	35000	10900	97000	4850	<2	480	9	210	<5	30	<2	460	3	<2	<0.01		<0.005	<0.001
4124283P	1	25	<5	340	<1	55	55	27500	28500	10900	7100	2850	<2	790	25	1440	<5	105	30	1240	6	20	<0.01		<0.005	0.001
Method	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	XRF1L	XRF1L	XRF1L	FA1	FA1	FA3	FA3
Detection Limit	0.5	3	5	10	1	2	2	2	100	5	10	5	2	10	2	10	5	2	10	5	2	2	0.01	0.01	0.005	0.001
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm

APPENDIX 6

Wollogorang Farm-In & Joint Venture

EL 7101 Sipos I

DIGHEM Survey
Logistics and Interpretation Report

LOGISTICS AND INTERPRETATION OF A DIGHEM^V SURVEY FOR CRA EXPLORATION PTY LTD AUSTRALIAN MAP SHEET CALVERT HILLS SE 53-08

Sipos I

JOB NO. 4-738
October,1995

Compiled by Michael Hallett
GEOTERREX PTY. LTD.
7-9 GEORGE PLACE,
ARTARMON NSW 2064
AUSTRALIA

ABSTRACT

This report describes the results and logistics of a DIGHEM^{V} airborne geophysical survey carried out for CRA Exploration Pty Ltd over an area in the Gulf Country near the NT-Queensland border. Total coverage amounted to 190 line km. The survey was flown during May, 1995.

The purpose of the survey was to detect zones of conductive mineralisation and to provide information that could be used to map the geology and structure of the survey area. This was accomplished by using a DIGHEM^{V} multi-coil, multi-frequency electromagnetic system, supplemented by a high sensitivity Cesium magnetometer. The information from these sensors was processed to produce maps which display the magnetic and conductive properties of the survey area. A GPS electronic navigation system, utilising a UHF link, ensured accurate positioning of the geophysical data.

CONTENTS

1. INTRODUCTION

A DIGHEM^V electromagnetic / resistivity / magnetic survey was flown for CRA Exploration Pty Ltd during May, 1995 over the southern portion of EL 7101.

The survey area is located on the Australian 1 : 250 000 Map sheet: Calvert Hills SE 53-8.

Tie-lines were flown in an orthogonal direction to production lines.

Area	Line direction	Line Spacing (m)	Line kilometres
Sipos I	0 / 180°	100	190

The survey employed the DIGHEM^V electromagnetic system. Ancillary equipment consisted of a magnetometer, radar altimeter, video camera, analogue and digital recorders and an electronic navigation system. The instrumentation was installed in an Eurocopter AS350B turbine helicopter (Registration VH AFO) which was provided by Helicopter Resources Ltd. The helicopter flew at an average airspeed of 100 km/h with an EM bird height of approximately 30 m.

Section 2 provides details on the survey equipment, the data channels, their respective sensitivities and the navigation / flight path recovery procedure. Noise levels of less than 2 ppm are generally maintained for wind speeds up to 35 km/h. Higher winds may cause the system to be grounded because excessive bird swinging produces difficulties in flying the helicopter. The swinging results from the 5 m^2 of area which is presented by the bird to broadside gusts.

2. SURVEY EQUIPMENT

This section provides a brief description of the geophysical instruments used to acquire the survey data:

2.1 Electromagnetic System

Model: DIGHEM^{V}

Type: Towed bird, symmetric dipole configuration operated at a nominal survey altitude of 30 metres. Coil separation is 8 metres for 450 Hz, 900 Hz, 5500 Hz and 7200 Hz, and 6.3 metres for the 56 000 Hz coil-pair. The actual frequencies used on the survey are tuned to optimise signal / noise levels and as such may be varied from survey to survey.

Coil orientations/frequencies:	Nominal Frequencies	Actual Survey Frequencies
Vertical coaxial	900 Hz	917 Hz
Horizontal coplanar	450 Hz	475 Hz
Vertical coaxial	5500 Hz	5545 Hz
Horizontal coplanar	7200 Hz	6831 Hz
Horizontal coplanar	56000 Hz	53960 Hz

Channels recorded:
5 inphase channels
5 quadrature channels
2 monitor channels

Sensitivity:
0.06 ppm at 450 Hz
0.06 ppm at 900 Hz
0.10 ppm at 5500 Hz
0.10 ppm at 7200 Hz
0.30 ppm at 56 000 Hz

Sample rate: 10 per second

The electromagnetic system utilises a multi-coil coaxial / coplanar technique to energise conductors in different directions. The coaxial coils are vertical with their axes in the flight direction. The coplanar coils are horizontal. The secondary fields are sensed simultaneously by means of receiver coils which are maximum coupled to their respective transmitter coils. The system yields an inphase and a quadrature channel from each transmitter-receiver coil-pair.

2.2 Magnetometer

Model: Picodas 3340

Type: Optically pumped Cesium vapour

Sensitivity: 0.01 nT

Sample rate: 10 per second

The magnetometer sensor is towed in a bird 20 m below the helicopter.

2.3 Magnetic Base Station

Model:	Scintrex MEP-710
Type:	Digital recording Cesium vapour
Sensitivity:	0.01 nT
Sample rate:	1 per second

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronised with that of the airborne system to permit subsequent removal of diurnal drift.

2.4 Radar Altimeter

Manufacturer:	Honeywell/Sperry
Type:	AA 220
Sensitivity:	0.3 m

The radar altimeter measures the vertical distance between the helicopter and the ground. This information is used in the processing algorithm which determines conductor depth.

2.5 Analogue Recorder

Manufacturer:	RMS Instruments
Type:	DGR33 dot-matrix graphics recorder
Resolution:	4 x 4 dots / mm
Speed:	1.5 mm / sec

The analogue profiles are recorded on chart paper in the aircraft during the survey. Table 2-1 lists the geophysical data channels and the vertical scale of each profile.

Table 2-1. The Analogue Profiles

Channel Name	Parameter	Scale units/mm	Designation on digital profile
1X9I	coaxial inphase (900 Hz)	2.5 ppm	CXI (900 Hz)
1X9Q	coaxial quad (900 Hz)	2.5 ppm	CXQ (900 Hz)
2P4I	coplanar inphase (450 Hz)	2.5 ppm	CPI (450 Hz)
2P4Q	coplanar quad (450 Hz)	2.5 ppm	CPQ (450 Hz)
3P7I	coplanar inphase (7200 Hz)	5 ppm	CPI (7200 Hz)
3P7Q	coplanar quad (7200 Hz)	5 ppm	CPQ (7200 Hz)
4X5I	coaxial inphase (5500 Hz)	5 ppm	CXI (5500 Hz)
4X5Q	coaxial quad (5500 Hz)	5 ppm	CXQ (5500 Hz)
5P5I	coplanar inphase(56000 Hz)	10 ppm	CPI (56 kHz)
5P5Q	coplanar quad (56000 Hz)	10 ppm	CPQ (56 kHz)
ALTR	altimeter	3 m	ALT
MAGC	magnetics, coarse	20 nT	MAG
MAGF	magnetics, fine	2.0 nT	
CXSP	coaxial spherics monitor		CXS
CPSP	coplanar spherics monitor		CPS
CXPL	coaxial powerline monitor		CXP
CPPL	coplanar powerline monitor		CPP

Table 2-2. The Digital Profiles

Channel Name	Observed parameters	Scale: units/cm
Mag and alt		
cmag	coarse magnetics	100 nT
fmag	fine magnetics	20 nT
alt	bird height	20 m
Processed amplitude data		
4xsp	Atmospheric noise monitor	1000 ppm
56ki	Horizontal coplanar coil pair; 56 000 Hz inphase	80 ppm
56kq	Horizontal coplanar coil pair; 56 000 Hz quadrature	80 ppm
720i	Horizontal coplanar coil pair; 7200 Hz inphase	80 ppm
720q	Horizontal coplanar coil pair; 7200 Hz quadrature	80 ppm
550i	Vertical coaxial coil pair; 5500 Hz inphase	40 ppm
550q	Vertical coaxial coil pair; 5500 Hz quadrature	40 ppm
900i	Vertical coaxial coil pair; 900 Hz inphase	20 ppm
900q	Vertical coaxial coil pair; 900 Hz quadrature	20 ppm
450i	Horizontal coplanar coil pair; 450 Hz inphase	20 ppm
450q	Horizontal coplanar coil pair; 450 Hz quadrature	20 ppm
50Hz	50 Hz Powerline monitor	1000 ppm
Apparent Depth	**(of the calculated half-space)**	
idif	Inphase difference	25 ppm
qdif	Quadrature difference	25 ppm
56k	56 000 Hz	25 ppm
7200	7200 Hz	25 ppm
5500	5500 Hz	25 ppm
900	900 Hz	25 ppm
450	450 Hz	25 ppm
Apparent Resistivity	**(of the calculated halfspace)**	
56k	56 000 Hz	1 cm / decade
7200	7200 Hz	1 cm / decade
5500	5500 Hz	1 cm / decade
900	900 Hz	1 cm / decade
450	450 Hz	1 cm / decade

2.7 Digital Data Acquisition System

Manufacturer: RMS Instruments

Model: DGR 33

Recorder: RMS TCR-12, 6400 bpi, tape cartridge recorder

The digital data are used to generate several computed parameters. Both measured and computed parameters are plotted as "multi-channel stacked profiles" during data processing. These parameters are shown in Table 2-2. In Table 2-2, the log resistivity scale of 0.06 decade/mm means that the resistivity changes by an order of magnitude in 16.6 mm. The resistivities at 0, 33 and 67 mm up from the bottom of the digital profile are respectively 1, 100 and 10 000 ohm m.

2.8 Tracking Camera

Type: Panasonic Video

Model: AG 2400 / WVCD132

Fiducial numbers are recorded continuously and are displayed on the margin of each image. This procedure ensures accurate correlation of analogue and digital data with respect to visible features on the ground.

2.9 Navigation System (RT-DGPS)

Model: Sercel NR106, Real-time differential positioning

Type: SPS (L1 band), 10-channel, C/A code, 1575.42 MHz.

Sensitivity: -132 dBm, 0.5 second update

Accuracy: < 5 metres in differential mode,
± 50 metres in S/A (non differential) mode

The Global Positioning System (GPS) is a line of sight, satellite navigation system which utilises time-coded signals from at least four of the twenty-four NAVSTAR satellites. In the differential mode, two GPS receivers are used. The base station unit is used as a reference which transmits real-time corrections to the mobile unit in the aircraft, via a UHF radio datalink. The on-board system calculates the flight path of the helicopter while providing real-time guidance. The raw XYZ data are recorded for both receivers, thereby permitting post-survey processing for an accuracy of approximately 5 metres.

Although the base station receiver is able to calculate its own latitude and longitude, a higher degree of accuracy can be obtained if the reference unit is established on a known benchmark or triangulation point. The GPS records data relative to the WGS84 ellipsoid, which is the basis of the revised North American Datum (NAD83). Conversion software is used to transform the WGS84 coordinates to the system displayed on the base maps.

2.10 Field Workstation

Manufacturer: Dighem

Model: FWS: V2.65

Type: 80486 based PC

A portable PC-based field workstation is used at the survey base to verify data quality and completeness. Flight tapes are dumped to a hard drive to permit the creation of a database. This process allows the field operators to display both the positional (flight path) and geophysical data on a screen or printer.

3. PRODUCTS AND PROCESSING TECHNIQUES

The following products are available from the survey data. Those which are not part of the survey contract may be acquired later. Most parameters can be displayed as contours, profiles or in colour.

3.1 Resistivity

The apparent resistivity in ohm m can be generated from the inphase and quadrature EM components for any of the frequencies, using a pseudo-layer halfspace model. A resistivity map portrays all the EM information for that frequency over the entire survey area. This contrasts with the electromagnetic anomaly map which provides information only over interpreted conductors. The large dynamic range makes the resistivity parameter an excellent mapping tool.

3.2 Total Field Magnetics

The aeromagnetic data are corrected for diurnal variation using the magnetic base station data. The regional IGRF has been removed from the data.

3.3 Multi-channel Stacked Profiles

Distance-based profiles of the digitally recorded geophysical data are generated and plotted by computer. These profiles also contain the calculated parameters which are used in the interpretation process. These are produced as worksheets prior to interpretation, and are also be presented in the final corrected form after interpretation. The profiles display electromagnetic anomalies with their respective interpretive symbols.

3.4 Contour and Colour Map Displays

The geophysical data are interpolated onto a regular grid using a modified Akima spline technique. The resulting grid is suitable for generating contour maps of excellent quality. The grid cell size is usually 25% of the line interval.

Colour maps are produced by interpolating the grid down to the pixel size. The parameter is then incremented with respect to specific amplitude ranges to provide colour "contour" maps. Colour maps of the total magnetic field are particularly useful in defining the lithology of the survey area.

3.5 Survey Products

1. Preliminary Products 1 : 25 000 scale

XYZ Prelim resisitivities.

Total field magnetic contours (colour image with blackline contours).

Flightpath maps.

2. Final Products 1 : 25 000 scale

Flightpath map (on paper).

Contour map of magnetics and flightpath (on film).

Total field magnetics contour map with IGRF removed (colour on paper).

Resistivity Maps, 450 Hz, 900 Hz, 5500 Hz, 7200 Hz and 56 000 Hz (excepting Moyle 450 Hz)(colour on paper)

Survey report.

Multi-channel stacked profiles (colour on paper).

Digital located data and *.gxf grids on exabyte tape.

Digital GDT of magnetics and resistivities in VISION format (on floppy).

3. Additional Products

Analogue chart records

Flight path video cassettes

Note: Other products can be produced from existing survey data, if requested.

4. SURVEY RESULTS

4.1 General

The survey results are presented on separate map sheets for each parameter plotted at a scale of 1 : 25 000.

Wide bedrock conductors or flat-lying conductive units, whether from surficial or bedrock sources, may give rise to very broad anomalous responses on the EM profiles. These broad conductors, which more closely approximate a half space model, will be maximum coupled to the horizontal (coplanar) coil-pair and are most evident on the resistivity parameter. Resistivity maps, therefore, may be the most valuable maps, in areas where broad or flat-lying conductors are considered to be of importance. Contoured resistivity maps, based on the 450 Hz, 7200 Hz and 56 000 Hz coplanar data and 900 Hz and 5500 Hz coaxial data are included with this report.

Excellent resolution and discrimination of conductors was accomplished by using a fast sampling rate of 0.1 sec.

Resistivity lows which occur near the ends of the survey lines (ie., outside the survey area), should be viewed with caution. Some of these could be due to aerodynamic noise, ie., bird bending, which is created by abnormal stresses to which the bird is subjected during the climb and turn of the aircraft between lines. Such aerodynamic noise is usually manifested on the coaxial inphase channel only, although severe stresses can affect the coplanar inphase channels as well.

4.2 Magnetics

A Scintrex MEP-710 Cesium vapour magnetometer was operated at the survey base to record diurnal variations of the earth's magnetic field. The clock of the base station was synchronised with that of the airborne system to permit subsequent removal of diurnal drift.

The background magnetic level has been adjusted to match the International Geomagnetic Reference Field (IGRF) for the survey area. The IGRF gradient across the survey block is left intact. This procedure ensures that the magnetic contours will match contours from any adjacent surveys which have been processed in a similar manner. Maps of the vertical magnetic derivative can also be prepared from existing survey data, if requested.

The total field magnetic data have been presented as contours on the base maps using a contour interval of 1, 10 and 100 nT. The maps show the underlying magnetic properties of the rock units underlying the survey area.

There is some evidence on the magnetic map(s) which suggests that the survey area has been subjected to deformation and/or alteration. These structural complexities are evident on the contour maps as variations in magnetic intensity, irregular patterns, and as offsets or changes in strike direction. Some of the more prominent linear features are also evident on the topographic base map.

If a specific magnetic intensity can be assigned to the rock type which is believed to host the target mineralisation, it may be possible to select areas of higher priority on the basis of the total field magnetic data. This is based on the assumption that the magnetite content of the host rocks will give rise to a limited range of contour values which will permit differentiation of various lithological units.

The magnetic results, in conjunction with the other geophysical parameters can provide valuable information which can be used to effectively map the geology and structure in the survey areas.

4.3 Resistivity

Resistivity maps, which display the conductive properties of the survey area, were produced from the 450 Hz, 7200 Hz and 56 000 Hz coplanar data and from the 900 Hz and 5500 Hz coaxial data. The resistivity ranges are:

Area	450 Hz	900 Hz	5500 Hz	7200 Hz	56 000 Hz
Sipos I	140 - 350	100 - 420	35 - 326	25 - 230	5 - 110

These cut-offs eliminate the meaningless higher resistivities which would result from very small EM amplitudes. The minimum resistivity value is 0.000017 times the frequency. This minimum resistivity cut-off eliminates errors due to the lack of an absolute phase control for the EM data. Many of the resistivity lows are probably related to bedrock features, rather than conductive overburden. There are some areas, however, where contour patterns appear to be strongly influenced by conductive surficial material.

There are other resistivity lows in the area. Some of these are quite extensive and often reflect "formational" conductors which may be of minor interest as direct exploration targets. However, attention may be focused on areas where these zones appear to be faulted or folded or where anomaly characteristics differ along strike.

4.4 Electromagnetics

In areas where EM responses are evident primarily on the quadrature components, zones of poor conductivity are indicated. Where these responses are coincident with magnetic anomalies, it is possible that the inphase component amplitudes have been suppressed by the effects of magnetite. Most of these poorly-conductive magnetic features give rise to resistivity anomalies which are only slightly below background. If it is expected that poorly-conductive economic mineralisation may be associated with magnetite-rich units, most of these weakly anomalous features will be of interest. In areas where magnetite causes the inphase components to become negative, the apparent conductance and depth of EM anomalies may be unreliable.

It is often difficult to assess the relative merits of EM anomalies on the basis of conductance. It is recommended that an attempt be made to compile a suite of geophysical "signatures" over areas of interest.

A complete assessment and evaluation of the survey data should be carried out by one or more qualified professionals who have access to, and can provide a meaningful compilation of, all available geophysical, geological and geochemical data.

4.5 Interpretation

General notes

Geological structures can be illuminated by geophysical responses. Large regions of low resistivity and regions of higher magnetic response have been indicated on the interpretation maps by the conductive and magnetic zone boundary lines. Structural data revealed by linear magnetic trends have been illustrated. Local geological studies are essential in establishing the significance and meaning of these correlations and these interpretations should not be viewed in isolation. Geological ground-truthing and sampling of the anomalous areas concerned would yield valuable information with which to compare to the geophysical data.

Some areas of correlating anomalous electromagnetic character (especially in the higher frequency data), with discrete magnetic anomalies have been marked on the maps. The magnetic anomalies may be of higher, or lower magnetic character than the surrounding region, with corresponding lower resistivity. Generally where there are single, discrete divergences from the surrounding area they have been noted as they may reflect remanence from the weathered clays derived from kimberlites or kimberlitic material of lower magnetic than the surrounding material.

5. BACKGROUND INFORMATION

This section provides background information on parameters which are available from the survey data. Those which have not been supplied as survey products may be generated later from raw data on the digital archive tape.

5.1 ELECTROMAGNETICS

DIGHEM electromagnetic responses fall into two general classes, discrete and broad. The discrete class consists of sharp, well-defined anomalies from discrete conductors such as sulfide lenses, kimberlite pipe clays and steeply dipping sheets of graphite or sulphides. The broad class consists of wide anomalies from conductors having a large horizontal surface such as flatly dipping graphite or sulfide sheets, saline water-saturated sedimentary formations, conductive overburden and rock, and geothermal zones. A vertical conductive slab with a width of 200 m would straddle these two classes.

The vertical sheet (half plane) is the most common model used for the analysis of discrete conductors. The conductive earth (half space) model is suitable for broad conductors. Resistivity contour maps result from the use of the second model. A later section entitled **Resistivity Mapping** describes the method further, including the effect of using it on anomalies caused by discrete conductors such as sulfide bodies.

5.1.1 Conductor Analysis

The conductance value is a geological parameter because it is a characteristic of the conductor alone. It generally is independent of frequency, flying height or depth of burial, apart from the averaging over a greater portion of the conductor as height increases. Small anomalies from deeply buried strong conductors are not confused with small anomalies from shallow weak conductors because the former will have larger conductance values.

Conductive overburden generally produces broad EM responses which may not be shown as anomalies on the EM maps. However, patchy conductive overburden in otherwise resistive areas can yield discrete anomalies for conducting clays which have resistivities as low as 50 ohm m. In areas where ground resistivities are below 10 ohm m, anomalies caused by weathering variations and similar causes can have any conductance grade.

The presence of sphalerite or gangue can result in ore deposits having weak to moderate conductances. As an example, the three million ton lead-zinc deposit of Restigouche Mining Corporation near Bathurst, Canada, yielded a well-defined , low grade conductor. The 10 percent by volume of sphalerite occurs as a coating around the fine grained massive pyrite, thereby inhibiting electrical conduction.

Faults, fractures and shear zones may produce anomalies which typically have low conductances. Conductive rock formations can also yield anomalies. The conductive materials in such rock formations can be salt water, weathered products such as clays, original depositional clays, and carbonaceous material.

A further interpretation can be presented on an EM map by means of line-to-line correlation of anomalies, which is based on a comparison of anomaly shapes on adjacent lines. This provides conductor axes which may define the geological structure over portions of the survey area. The absence of conductor axes in an area implies that anomalies could not be correlated from line to line with reasonable confidence.

Since discrete bodies normally are the targets of EM surveys, local base (or zero) levels are used to compute local anomaly amplitudes. This contrasts with the use of true zero levels which are used to compute true EM amplitudes. Local anomaly amplitudes are shown in the EM anomaly list and these can be used to compute the vertical sheet parameters of conductance and depth.

5.1.2 The thickness parameter

DIGHEM can provide an indication of the thickness of a steeply dipping conductor. The amplitude of the coplanar anomaly (eg., CPI channel on the digital profile) increases relative to the coaxial anomaly (eg., CXI) as the apparent thickness increases, ie., the thickness in the horizontal plane. (The thickness is equal to the conductor width if the conductor dips at 90 degrees and strikes at right angles to the flight line.) This report refers to a conductor as thin when the thickness is likely to be less than 3 m, and thick when in excess of 10 m. For example, in base metal exploration in steeply dipping geology, thick conductors can be high priority targets because many massive sulfide ore bodies are thick, whereas non-economic bedrock conductors are often thin. The system cannot sense the thickness when the strike of the conductor is sub-parallel to the flight line, when the conductor has a shallow dip, when the anomaly amplitudes are small, or when the resistivity of the environment is below 100 ohm m.

5.1.3 Resistivity mapping

Areas of widespread conductivity are commonly encountered during surveys. In such areas, anomalies can be generated by decreases of only 5 m in survey altitude as well as by increases in conductivity. The typical flight record in conductive areas is characterised by inphase and quadrature channels which are continuously active. Local EM peaks reflect either increases in conductivity of the earth or decreases in survey altitude. For such conductive areas, apparent resistivity profiles and contour maps are necessary for the correct interpretation of the airborne data. The advantage of the resistivity parameter is that anomalies caused by altitude changes are virtually eliminated, so the resistivity data reflect only those anomalies caused by conductivity changes. The resistivity analysis also helps the interpreter to differentiate between conductive trends in the bedrock and those patterns typical of conductive overburden. For example, discrete conductors will generally appear as narrow lows on the contour map and broad conductors (eg., overburden) will appear as wide lows.

The resistivity profiles and the resistivity contour maps present the apparent resistivity using the so-called pseudo-layer (or buried) half space model defined by Fraser (1978)[1]. This model consists of a resistive layer overlying a conductive half space. The depth channels give the apparent depth below surface of the conductive material. The apparent depth is simply the apparent thickness of the overlying resistive layer. The apparent depth (or thickness) parameter will be positive when the upper layer is more resistive than the underlying material, in which case the apparent depth may be quite close to the true depth.

The apparent depth will be negative when the upper layer is more conductive than the underlying material, and will be zero when a homogeneous half space exists. The apparent depth parameter must be interpreted cautiously because it will contain any errors which may exist in the measured altitude of the EM bird (eg., as caused by a dense tree cover). The inputs to the resistivity algorithm are the inphase and quadrature components of the coplanar coil-pair. The outputs are the apparent resistivity of the conductive half space (the source) and the sensor-source distance. The flying height is not an input variable, and the output resistivity and sensor-source distance are independent of the flying height. The apparent depth, discussed above, is simply the sensor-source distance minus the measured altitude or flying height. Consequently, errors in the measured altitude will affect the apparent depth parameter but not the apparent resistivity parameter.

[1] Resistivity mapping with an airborne multicoil electromagnetic system: Geophysics, v. 43, p.144-172

The apparent depth parameter is a useful indicator of simple layering in areas lacking a heavy tree cover. However, little quantitative use has been made of negative apparent depths because the absolute value of the negative depth is not a measure of the thickness of the conductive upper layer and, therefore, is not meaningful physically. Qualitatively, a negative apparent depth estimate usually shows that the EM anomaly is caused by conductive overburden. Consequently, the apparent depth channel can be of significant help in distinguishing between overburden and bedrock conductors.

The resistivity map often yields more useful information on conductivity distributions than an EM map. In comparing resistivity maps with EM maps, keep in mind the following:

(a) The resistivity map portrays the apparent value of the earth's resistivity, where resistivity = 1/conductivity.

(b) The EM map portrays anomalies in the earth's resistivity. An anomaly by definition is a change from the norm and so the EM map displays anomalies, (i) over narrow, conductive bodies and (ii) over the boundary zone between two wide formations of differing conductivity.

The resistivity map might be likened to a total field map and EM maps to a horizontal gradient in the direction of flight[2].

5.1.4 Reduction of geologic noise

Geologic noise refers to unwanted geophysical responses. For purposes of airborne EM surveying, geologic noise refers to EM responses caused by conductive overburden and magnetic permeability. It was mentioned previously that the EM difference channels (ie., channel idif for inphase and qdif for quadrature) tend to eliminate the response of conductive overburden. This marked a unique development in airborne EM technology, as DIGHEM is the only EM system which yields channels having an exceptionally high degree of immunity to conductive overburden.

Magnetite produces a form of geological noise on the inphase channels of all EM systems. Rocks containing less than 1% magnetite can yield negative inphase anomalies caused by magnetic permeability. When magnetite is widely distributed throughout a survey area, the inphase EM channels may continuously rise and fall, reflecting variations in the magnetite percentage, flying height, and overburden thickness. This can lead to difficulties in recognising deeply buried bedrock conductors, particularly if conductive overburden also exists. However, the response of broadly distributed magnetite generally vanishes on the inphase difference channel idif. This feature can be a significant aid in the recognition of conductors which occur in rocks containing accessory magnetite.

5.1.5 EM magnetite mapping

The information content of DIGHEM data consists of a combination of conductive eddy current responses and magnetic permeability responses. The secondary field resulting from conductive eddy current flow is frequency-dependent and consists of both inphase and quadrature components, which are positive in sign. On the other hand, the secondary field resulting from magnetic permeability is independent of frequency and consists of only an inphase component which is negative in sign. When magnetic permeability manifests itself by decreasing the measured amount of positive inphase, its presence may be difficult to recognise. However, when it manifests itself by yielding a negative inphase anomaly (eg., in the absence of eddy current flow), its presence is assured. In this latter case, the negative component can be used to estimate the percent magnetite content.

[2] The gradient analogy is only valid with regard to the identification of anomalous locations.

A magnetite mapping technique was developed for the coplanar coil-pair of DIGHEM. The technique yields a channel which displays apparent weight percent magnetite according to a homogeneous half space model.[3] The method can be complementary to magnetometer mapping in certain cases. Compared to magnetometry, it is far less sensitive but is more able to resolve closely spaced magnetite zones, as well as providing an estimate of the amount of magnetite in the rock. The method is sensitive to 1/4% magnetite by weight when the EM sensor is at a height of 30 m above a magnetitic half space. It can individually resolve steep dipping narrow magnetite-rich bands which are separated by 60 m. Unlike magnetometry, the EM magnetite method is unaffected by remanent magnetism or magnetic latitude.

The EM magnetite mapping technique provides estimates of magnetite content which are usually correct within a factor of 2 when the magnetite is fairly uniformly distributed. EM magnetite maps can be generated when magnetic permeability is evident as negative inphase responses on the data profiles.

Like magnetometry, the EM magnetite method maps only bedrock features, provided that the overburden is characterised by a general lack of magnetite. This contrasts with resistivity mapping which portrays the combined effect of bedrock and overburden.

5.2 MAGNETICS

In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulphides than one that is non-magnetic. However, sulfide ore bodies may be non-magnetic (eg., the Kidd Creek deposit near Timmins, Canada) as well as magnetic (eg., the Mattabi deposit near Sturgeon Lake, Canada). The same principle applies to kimberlite mapping.

The magnetometer data are digitally recorded in the aircraft to an accuracy of 0.01 nT for Cesium magnetometers. The digital tape is processed by computer to yield a total field magnetic contour map. When warranted, the magnetic data may also be treated mathematically to enhance the magnetic response of the near-surface geology, and an enhanced magnetic contour map is then produced.

Any of a number of filter operators may be applied to the magnetic data, to yield vertical derivatives, continuations, magnetic susceptibility, etc. These may be displayed in contour, colour or shadow.

[3] Refer to Fraser, 1981, Magnetite mapping with a multi-coil airborne electromagnetic system: Geophysics, v. 46, p. 1579-1594.

6. CONCLUSIONS AND RECOMMENDATIONS

This report provides a very brief description of the survey results and describes the equipment, procedures and logistics of the survey.

The survey was successful in locating a conductors which may warrant additional work. The map included with this report displays the magnetic and conductive properties of the survey area. It is recommended that the survey results be reviewed in detail, in conjunction with all available geophysical, geological and geochemical information. Particular reference should be made to the computer generated data profiles which clearly define the characteristics of the individual anomalies.

Many anomalies in the area are moderately weak and poorly-defined. In some survey areas, anomalies are quite distinct and strong. Many have been attributed to conductive overburden or deep weathering, although a few appear to be associated with conductive within the regolith.

It is also recommended that image processing of existing geophysical data be considered, in order to extract the maximum amount of information from the survey results. Current software and imaging techniques often provide valuable information on structure and lithology, which may not be clearly evident on the contour and colour maps. These techniques can yield images which define subtle, but significant, structural details.

APPENDIX

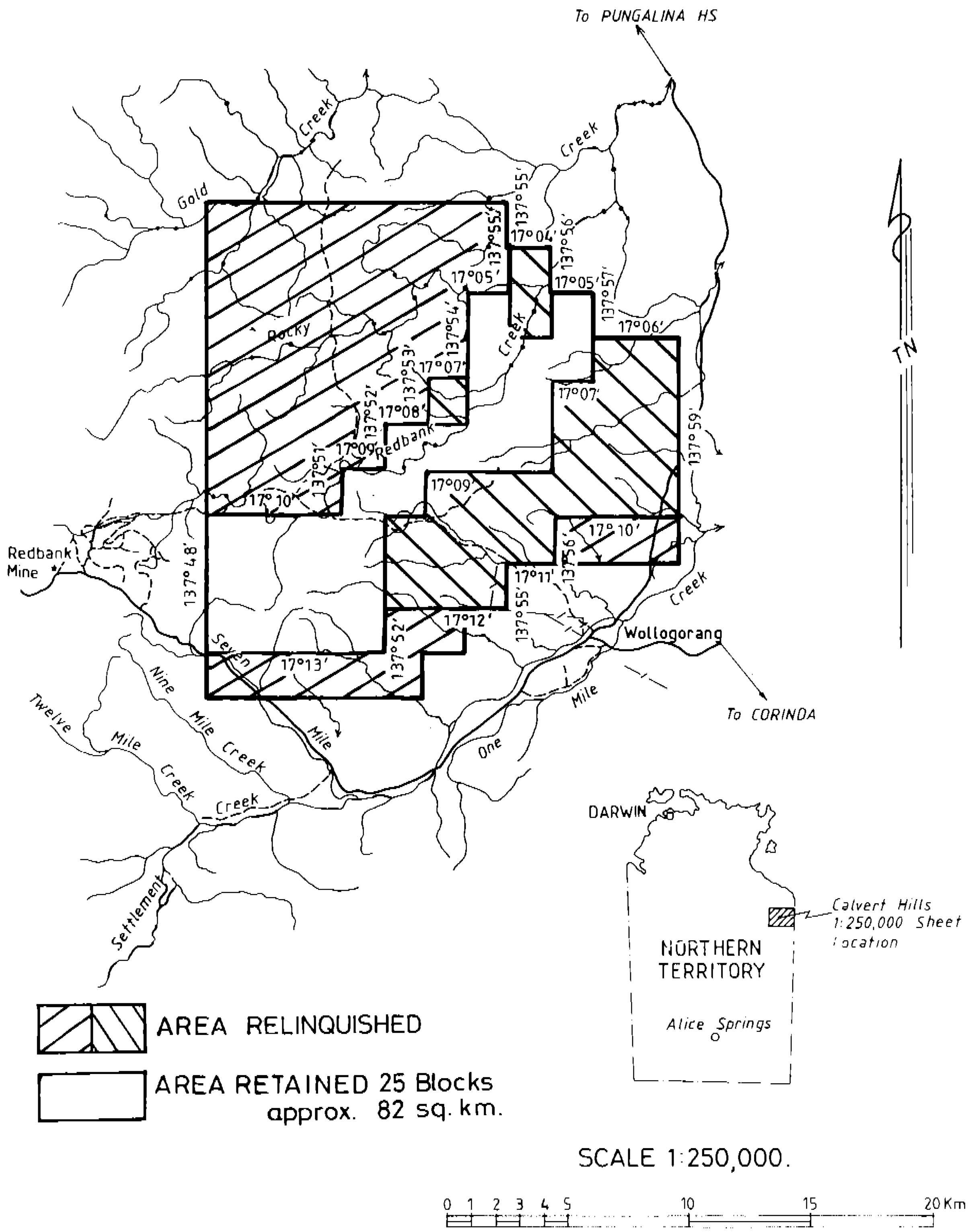
LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a DIGHEM^V airborne geophysical survey carried out for CRAE Exploration Pty Ltd, in the Gulf Country near the NT-Queensland border.

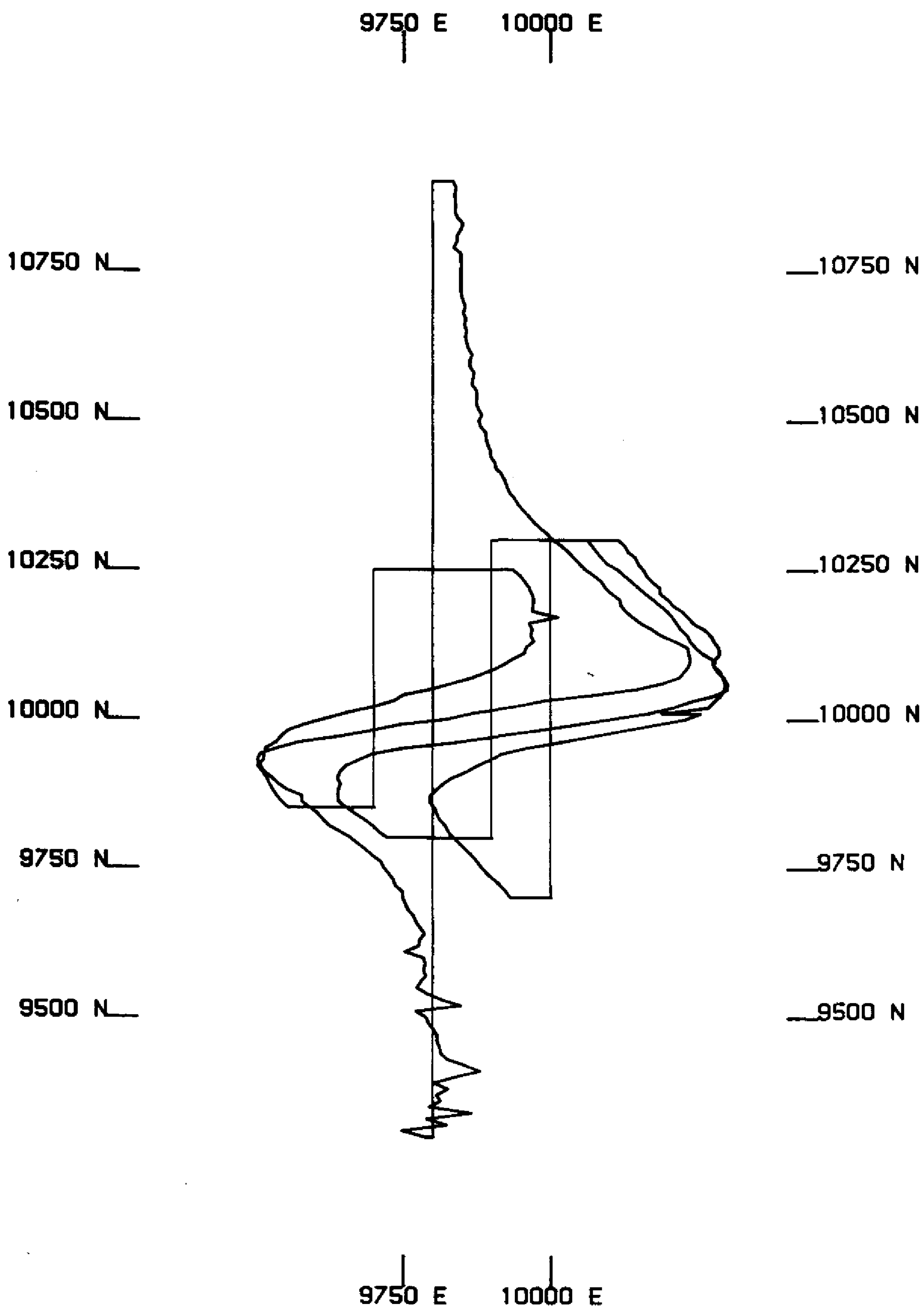
Steve Kilty	Director of Technical Services
Mick Drewett	Survey Supervisor / Crew Chief
Don Ellis	Geophysical Operator/Field Dataperson
Adrian Pate	Pilot (Helicopter Resources Ltd.)
Martin Schneider	Data Processing Supervisor
Doug Morrison	Data Quality Control Supervisor
Marina Popvic	Data Processor
Michael Hallett	Interpretation Geophysicist

The survey consisted of 190 line km of coverage, flown during May 1995.

All personnel are employees of Geoterrex Pty Ltd, except for the pilot who is an employee of Helicopter Resources Ltd.



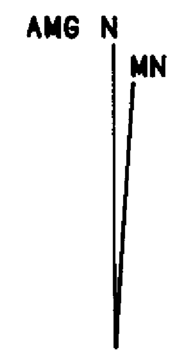
CRA EXPLORATION PTY LIMITED	
EL 7101 WOLLOGORANG J/V SIPOS I LOCATION PLAN (REDUCTION OF AREA)	
REFERENCE SE 53-08 CALVERT HILLS	
SCALE 1:250,000.	DATE Dec. 1995
AUTHOR DJL	REPORT 21550
DRAWN TTN./SRJ	PLAN No NTd 6222



DATA AQUISITION

INSTRUMENT : SCINTREX MP3
OPERATOR : EMS
SURVEY DATE : SEPTEMBER 1991
DIURNAL CORRECTION : NOT APPLIED
READING INTERVAL : 10 metres

VERTICAL SCALE : 250 nT/cm



GRID NORTH = 356 MAGNETIC

10 000E 10 000N : 811000mE 8110580mN

CRA EXPLORATION PTY LIMITED

SIPOS MINING EL 7101

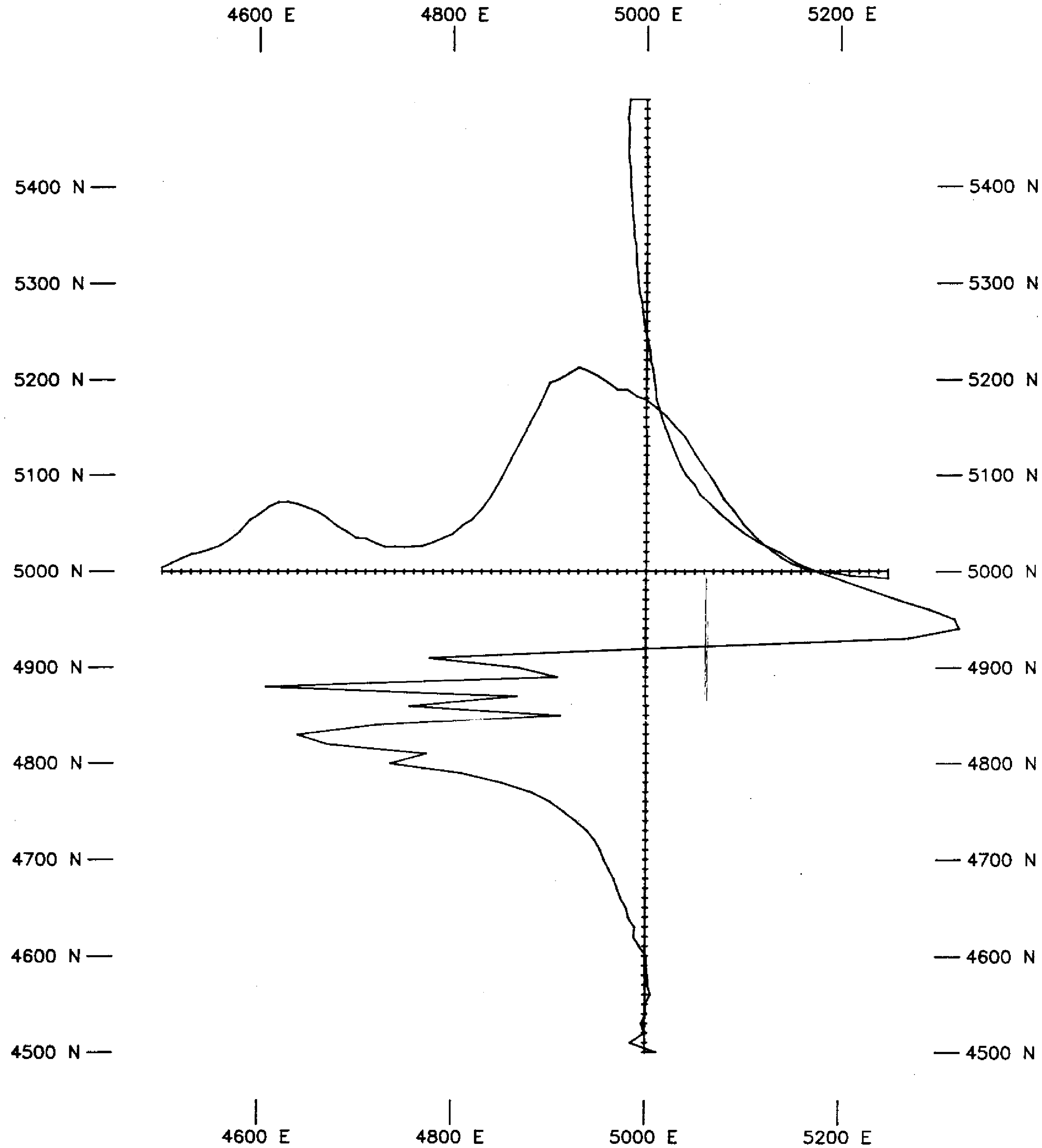
MAGNETIC TARGET 5

GROUND MAGNETIC SURVEY

TOTAL FIELD PROFILES

AUTHOR	DRAWN	DATE	SCALE	REPORT
DJL	EMS	18.10.91	1:10000	21550

REF. CALVERT HILLS SE 53-8 | DIRECTORY | PLAN No.Ntd 5267

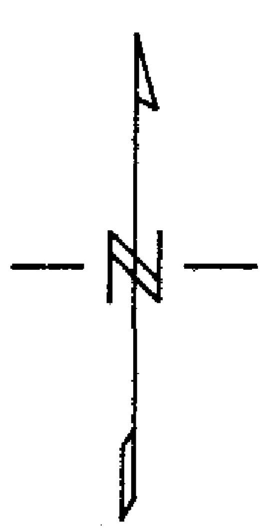


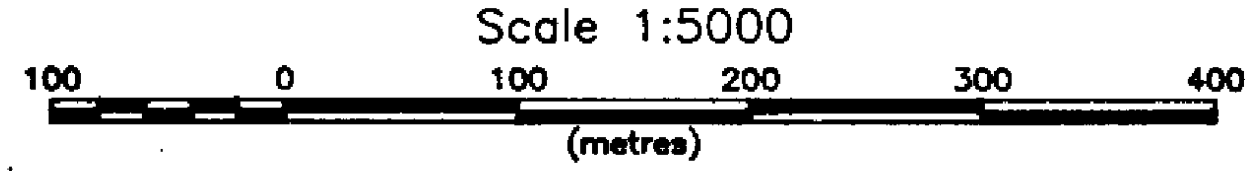
DATA ACQUISITION

Instrument : Scintrex MP3
Base Station : Scintrex MP3
Operator : AB
Sample Interval : 10 metres
Grid Origin : 5000E 5000N
AMG of Origin : 816145mE 8103110mN Zone 53

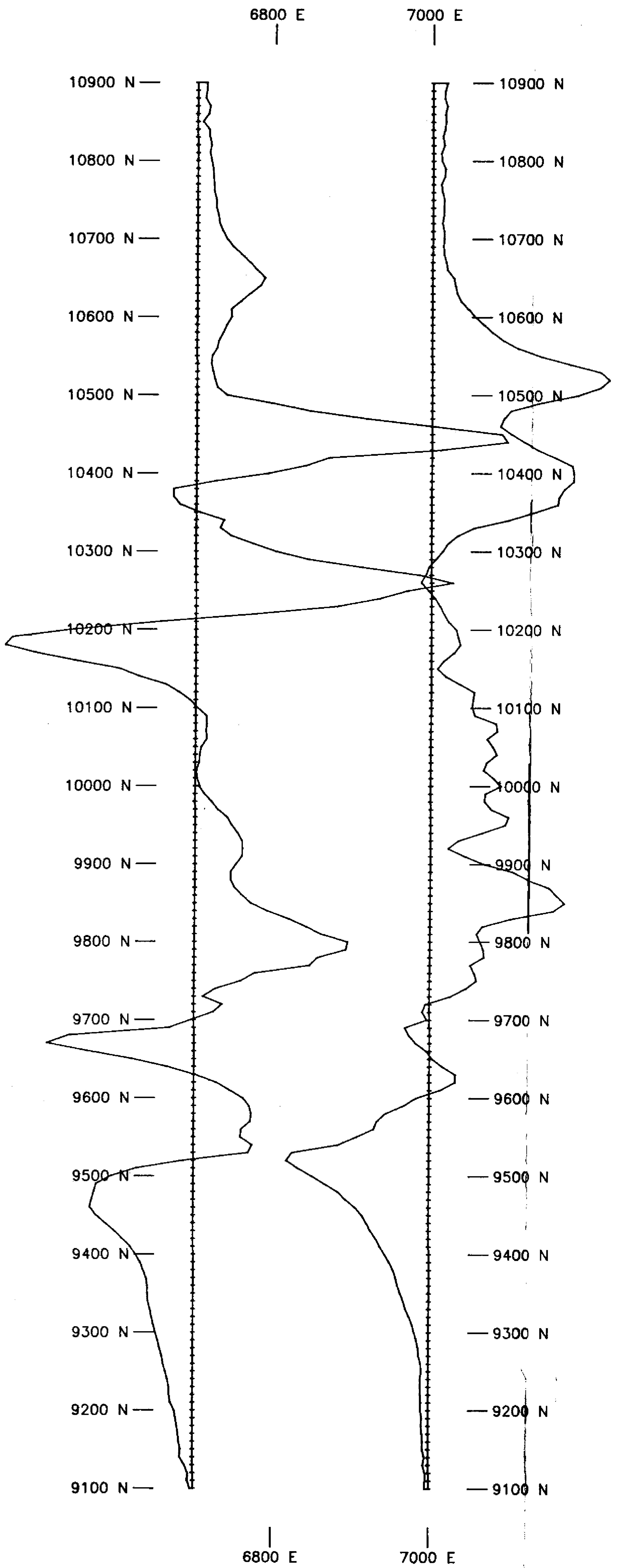
DATA PROCESSING

Diurnal Corrections Applied
Profile Base Level : 50000 nT
Vertical Scale : 200 nT/cm (incr. grid east)





CRA EXPLORATION PTY LIMITED	
WOLLOGORANG FARM-IN & J/V EL7101 SIPOS I GROUND MAGNETIC PROFILES MAGNETIC ANOMALY SIP1	
REFERENCE CALVERT HILLS SE5308	
SCALE 1:5000	DATE 3/6/93
AUTHOR DJL	REPORT 21550
DRAWN A Bisset	PLAN No. NTd 5814

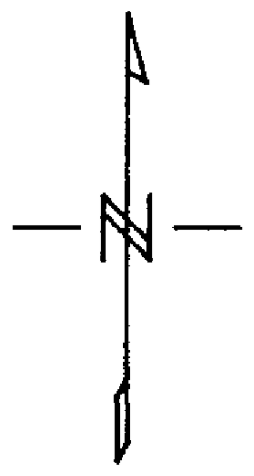


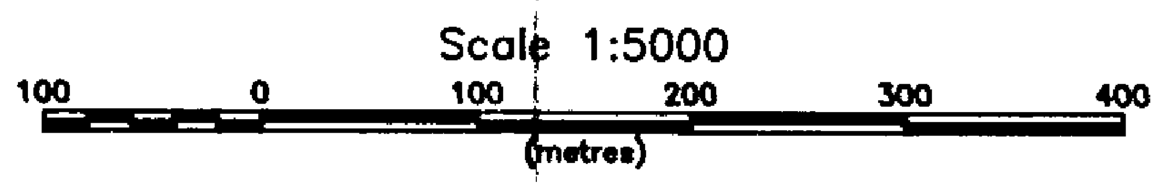
DATA ACQUISITION

Instrument : Scintrex MP3
Base Station : Scintrex MP3
Operator : AB
Sample Interval : 10 metres
Grid Origin : 7000E 10000N
AMG of Origin : 814570mE 8102935mN Zone 53

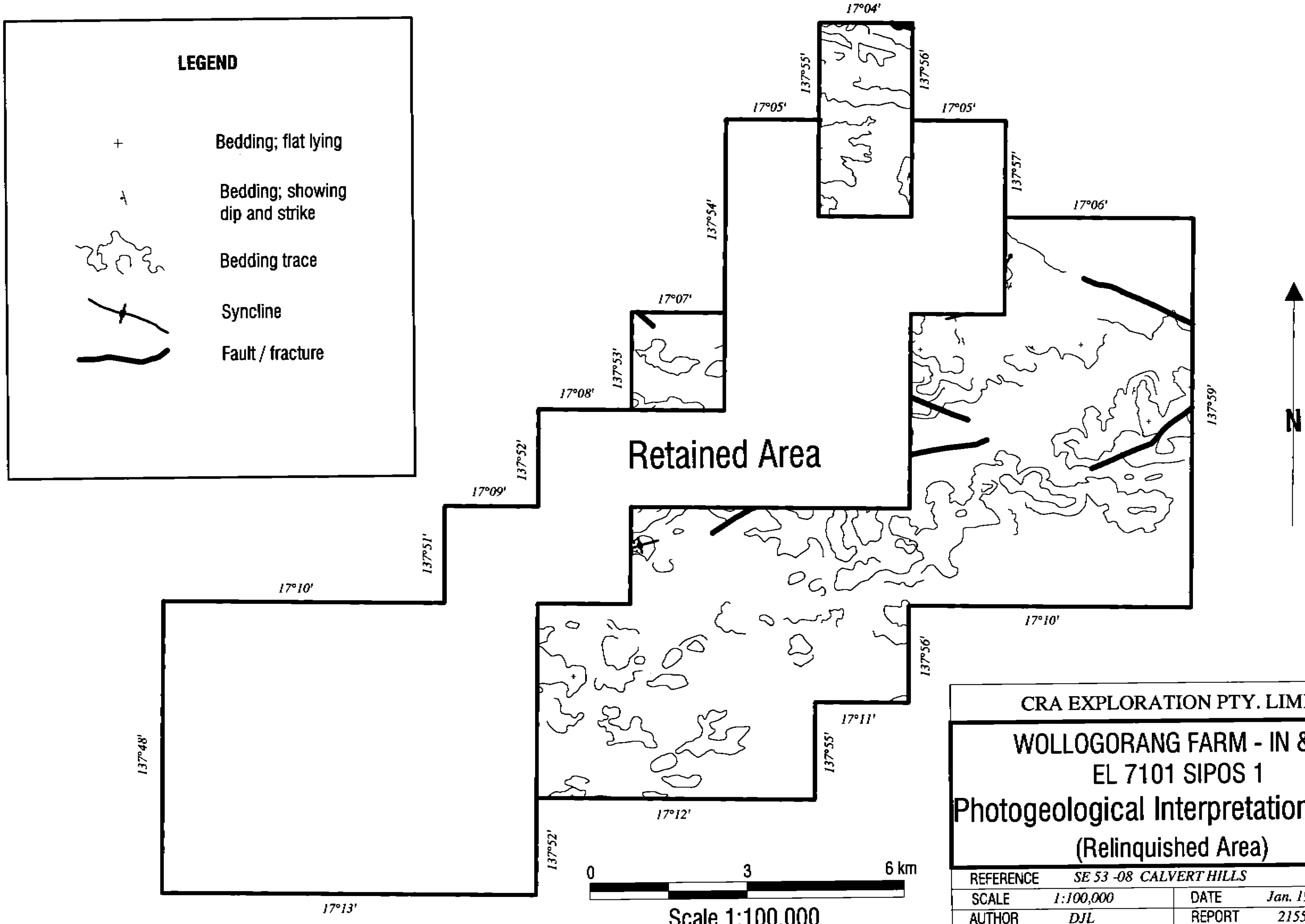
DATA PROCESSING

Diurnal Corrections Applied
Profile Base Level : 49800 nT
Vertical Scale : 150 nT/cm (incr. grid east)





CRA EXPLORATION PTY LIMITED	
WOLLOGORANG FARM-IN & J/V EL7101 SIPOS I GROUND MAGNETIC PROFILES MAGNETIC ANOMALY SIP 4	
REFERENCE CALVERT HILLS SE5308	
SCALE 1:5000	DATE 3/6/93
AUTHOR DJL	REPORT 21550
DRAWN ATB	PLAN No. NTd 5816



CRA EXPLORATION PTY. LIMITED

WOLLOGORANG FARM - IN & JV
EL 7101 SIPOS 1
Photogeological Interpretation Plan
(Relinquished Area)

REFERENCE	SE 53 -08 CALVERT HILLS		
SCALE	1:100,000	DATE	Jan. 1996
AUTHOR	DJL	REPORT	21550
DRAWN	TTN	PLAN No.	NTd 6216